RAIB
Rail Accident Investigation Branch

Rail Accident Report

Train passed over Lydney level crossing with crossing barriers raised
23 March 2011

Department for Transport

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December 2011

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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Train passed over Lydney level crossing with crossing barriers raised, 23 March 2011

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Summary

At approximately 14:24 hrs on Wednesday 23 March 2011, train number 1M68, the 13:45 hrs service from Cardiff to Nottingham, passed over Lydney manually controlled barrier (MCB) level crossing while the barriers were in the raised position. This crossing is on the main line between Gloucester and Newport. The railway signal protecting the level crossing was showing green, and the train was travelling at 59 mph (94 km/h). The red flashing lights intended to instruct road users to stop were operating and there were no road vehicles on the crossing. No injuries or damage resulted from the incident.

The crossing keeper had raised the up side barrier manually during the 90 minutes before the incident, due to a defect in the equipment controlling the barrier motors. Shortly before the incident, the crossing keeper lowered the barriers for a train approaching from the direction of Gloucester. He then raised both barriers manually just before the Cardiff to Nottingham train arrived at the crossing. An annunciator (buzzer) intended to warn the crossing keeper about approaching trains did not give the usual warning.

The railway signals protecting Lydney crossing should have been placed at danger before the barriers could be raised safely. The crossing keeper had no facility to control these signals, and did not inform signallers at Newport who could have kept the signals at danger while the barriers were raised. Several possible reasons for not informing the signaller have been identified.

The RAIB has made recommendations to Network Rail relating to the adequacy of instructions and training given to crossing keepers and signallers; and, the process used for on-going assessment of staff competencies. The RAIB has also recommended that Network Rail should modify standards for new and upgraded crossings so that protecting signals always display a stop aspect when the crossing barriers are raised.

Preface

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.

Key definitions

3 All dimensions in this report are given in metric units. Speeds are given in imperial units in accordance with normal railway practice. In this case the equivalent metric value is also given.

4 The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B.

5 The *up* direction refers to trains travelling towards Gloucester; the *down* direction refers to trains travelling towards Newport.

The incident

Summary of the incident

6 At 14:24 hrs on 23 March 2011, train number 1M68, the 13:45 hrs service from Cardiff to Nottingham, passed over Lydney manually controlled barrier (MCB) level crossing in Gloucestershire while the barriers were raised.

7 The train comprised a 2-car, class 170, diesel multiple unit. It was travelling under *proceed* signals and at 59 mph (94 km/h) when it went over the crossing.

8 No casualties, and no damage, resulted from the incident.

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

Organisations involved

9 Network Rail owned, operated and maintained the railway infrastructure at the incident site. Network Rail also employed the crossing keepers who worked at Lydney level crossing and the signallers who worked at Newport.

10 The train was being operated by CrossCountry Trains.

11 Network Rail and CrossCountry Trains freely co-operated with the investigation.

Location

12 The incident occurred at Lydney level crossing, which lies between Gloucester and Newport on the main line linking South Wales with Birmingham (figure 1). The crossing is on the southern edge of Lydney and is used by all road traffic travelling to and from two commercial areas and Lydney Harbour (figure 2).

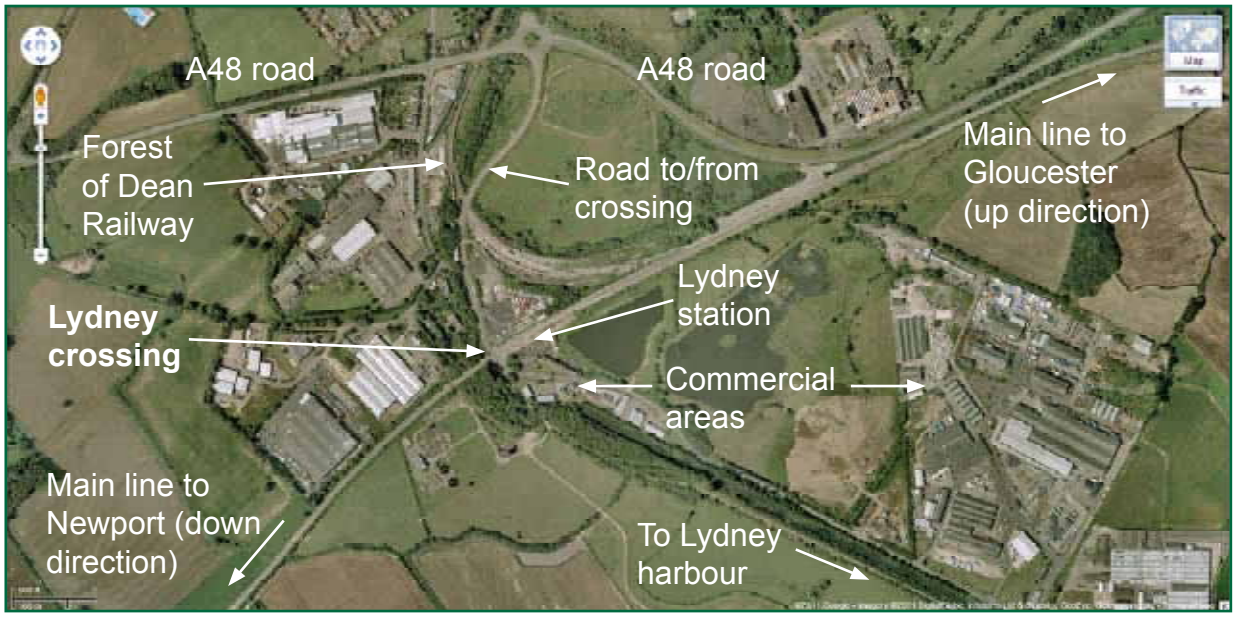


Figure 2: Aerial overview

13 Two railway lines, the up and down main lines, pass over the crossing and through Lydney station, which is close to the east side of the crossing. The maximum permitted speed for trains on both lines at Lydney crossing is 60 mph (96 km/h).

14 Lydney crossing is protected by two barriers, each extending across the full width of the roadway and normally power operated. They are controlled by a crossing keeper located in an adjacent former signal box (now designated Lydney Crossing Ground Frame) on the up (north) side of the railway, immediately west of the crossing (figure 3).

15 The Lydney crossing keeper also controls Awre level crossing, about 5.2 miles (8.3 km) east of Lydney, using closed circuit television.

External circumstances

16 The weather was dry, sunny and calm at the time of the incident.

17 Road traffic was relatively heavy at the time of the incident because it occurred close to the shift change time in some of the factories served by the road over the level crossing.

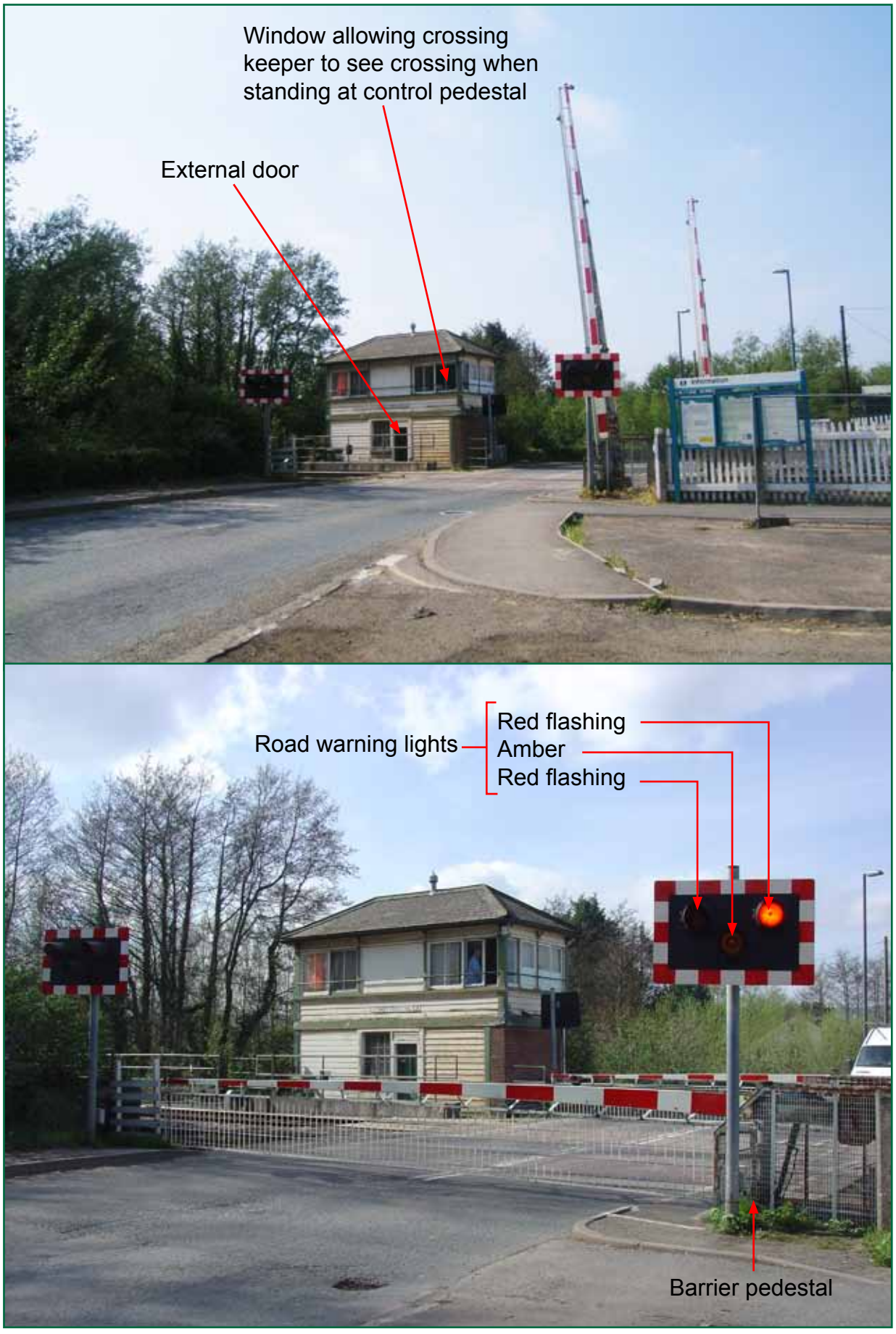


Figure 3: Lydney crossing and crossing box

Train involved

18 The 13:45 hrs Cardiff to Nottingham train, reporting number 1M68, was being operated by a 2-car, class 170, diesel multiple unit number 170116.

19 The RAIB has found no evidence to link the condition or operation of the train with the incident.

Infrastructure equipment involved

20 Lydney level crossing is within the area controlled by Newport signal box. The up and down main lines are continuously *track circuited* and are provided with *three aspect signals* commissioned in 1968. Electrical circuitry uses *relays* to provide the *interlocking* intended to prevent unsafe operation of signal and level crossing controls.

21 The barriers and associated control equipment at Lydney were installed, as a replacement for crossing gates, in 1974. The crossing barriers are driven up and down by a hydraulic pump powered by an electric motor. This equipment is contained in the *barrier pedestals* which also support the hinged end of the barriers. Barrier positions (eg fully raised and fully lowered) are detected by contacts (switches) in a *circuit controller* mounted on the barrier pedestal. These contacts form part of the interlocking circuitry.

22 The signals protecting Lydney crossing (signal number N165 on the up line and signal number N184 on the down line, figure 4) were operating automatically at the time of the incident. In this condition, they return to danger after the passage of each train. They *clear* (change from a red aspect to a proceed aspect) when another train approaches if the interlocking detects:

- the relevant track circuits beyond the signal are clear;
- at least one of the track circuits on the approach to the Lydney area is occupied; and
- the contacts in the circuit controller detect that the level crossing barriers are in the fully lowered position (paragraph 25)[1].

23 The equipment in the crossing keeper's box for controlling Lydney crossing includes:

- lower and raise buttons on a *control pedestal* adjacent to a window which allows the crossing keeper to observe the crossing when operating the controls (figures 5 and 6);
- a diagram showing the track layout, the location of signals and, by using indicator lamps, the position of trains near the crossing (figure 7); and
- an *annunciator* (buzzer) which advises the crossing keeper when the barriers need to be lowered, and advises the crossing keeper when the interlocking prevents the barriers from responding to the raise button because a train is approaching.

[1] Other criteria, not relevant to the incident, must also be met before the signals will clear.

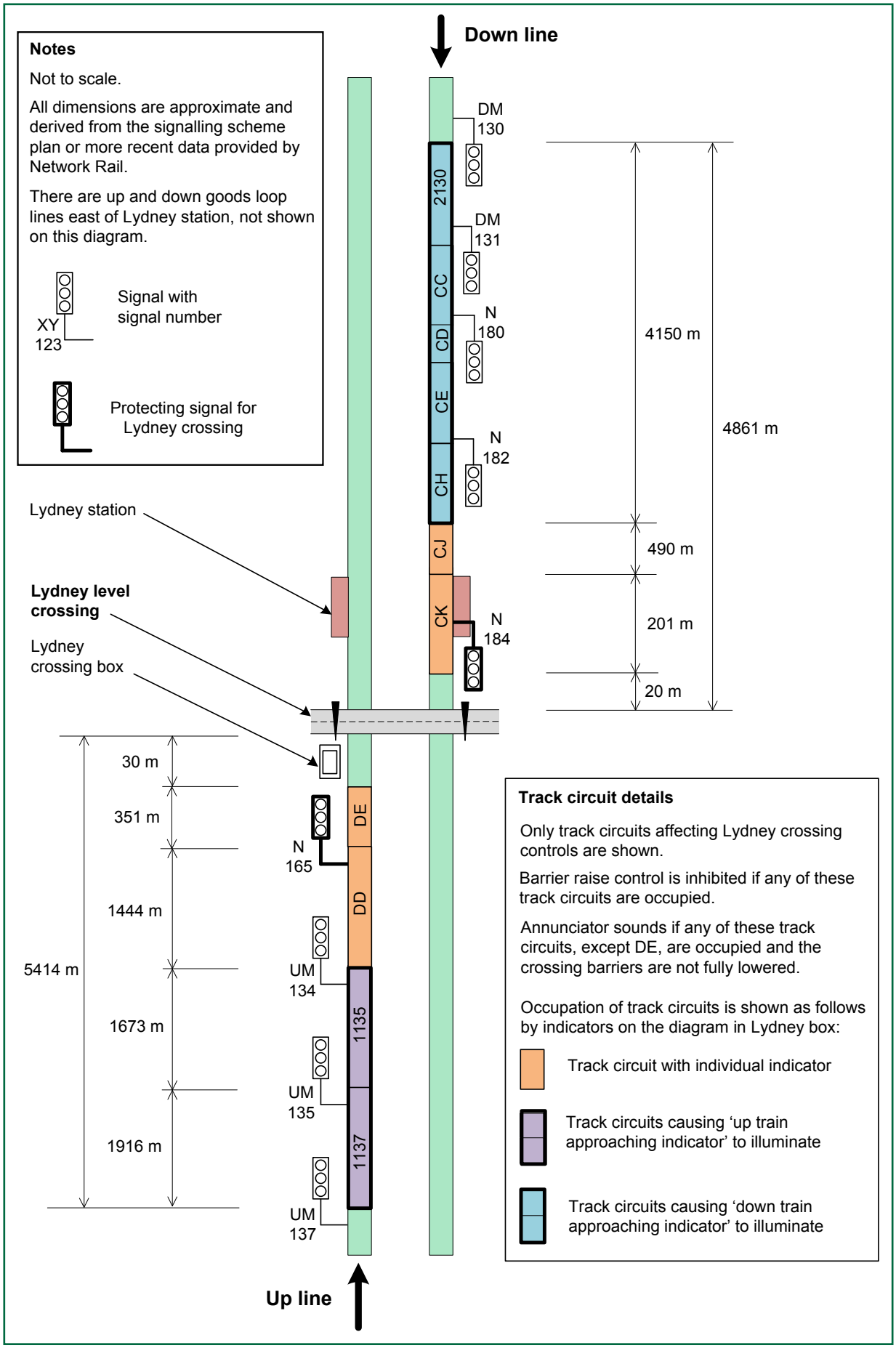


Figure 4: Lydney crossing signalling layout

24 The crossing keeper at Lydney has no means of manually controlling the *protecting signals* for Lydney crossing, except an emergency release switch (ERS) not intended for use during manual operation of the barriers[2]. The aspects displayed by these protecting signals are not visible from the box; and there are no aspect repeaters in the box.

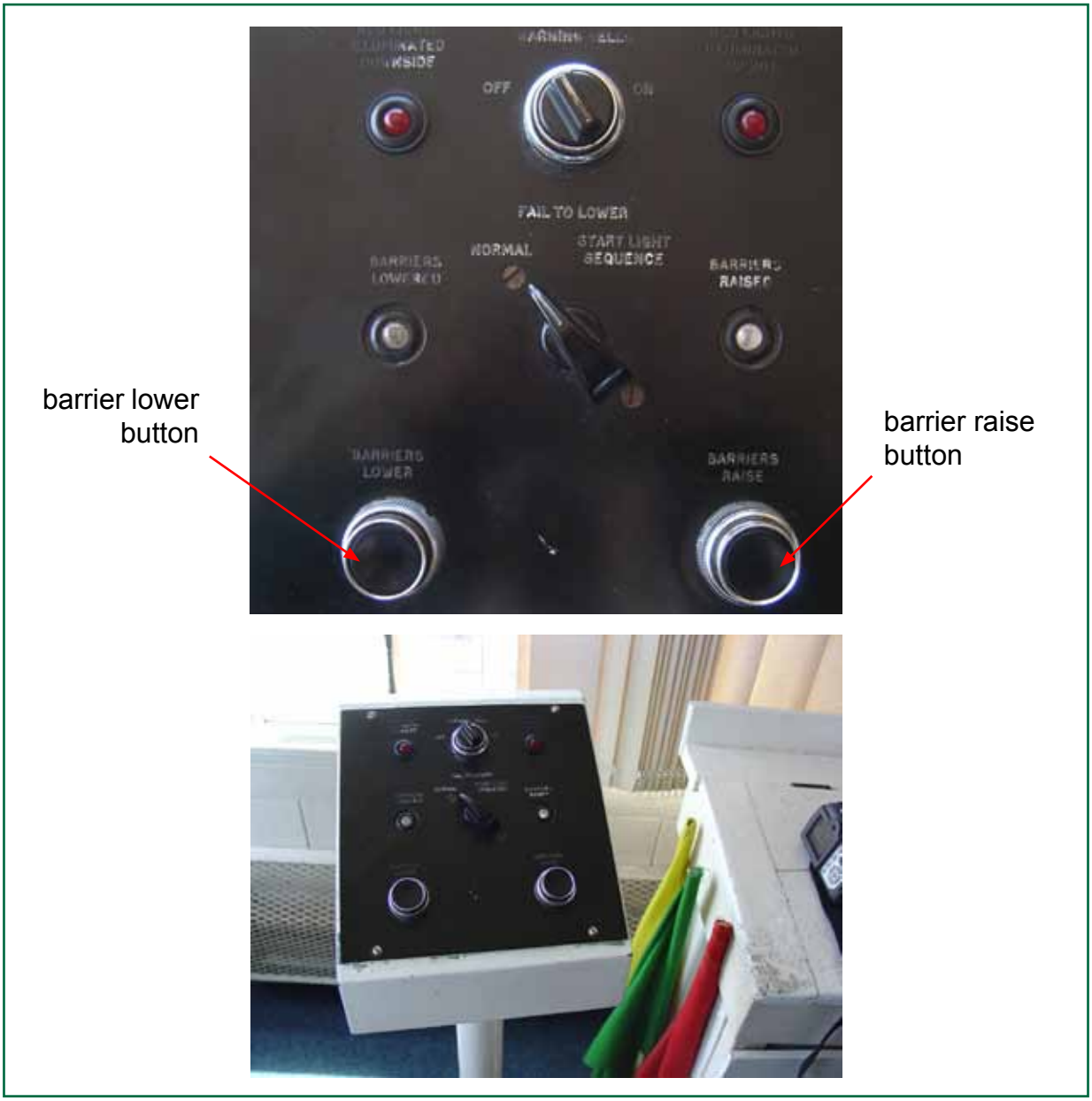


Figure 5: Lydney crossing control pedestal

[2] The ERS provides a means of raising the barriers if raising has been inhibited because a track circuit is showing occupied due to a track circuit defect, a broken down train or engineering work. Operation of the ERS includes safety features intended to reduce the risk of trains reaching the crossing after the barriers have been raised. These features include putting the protecting signals to danger.

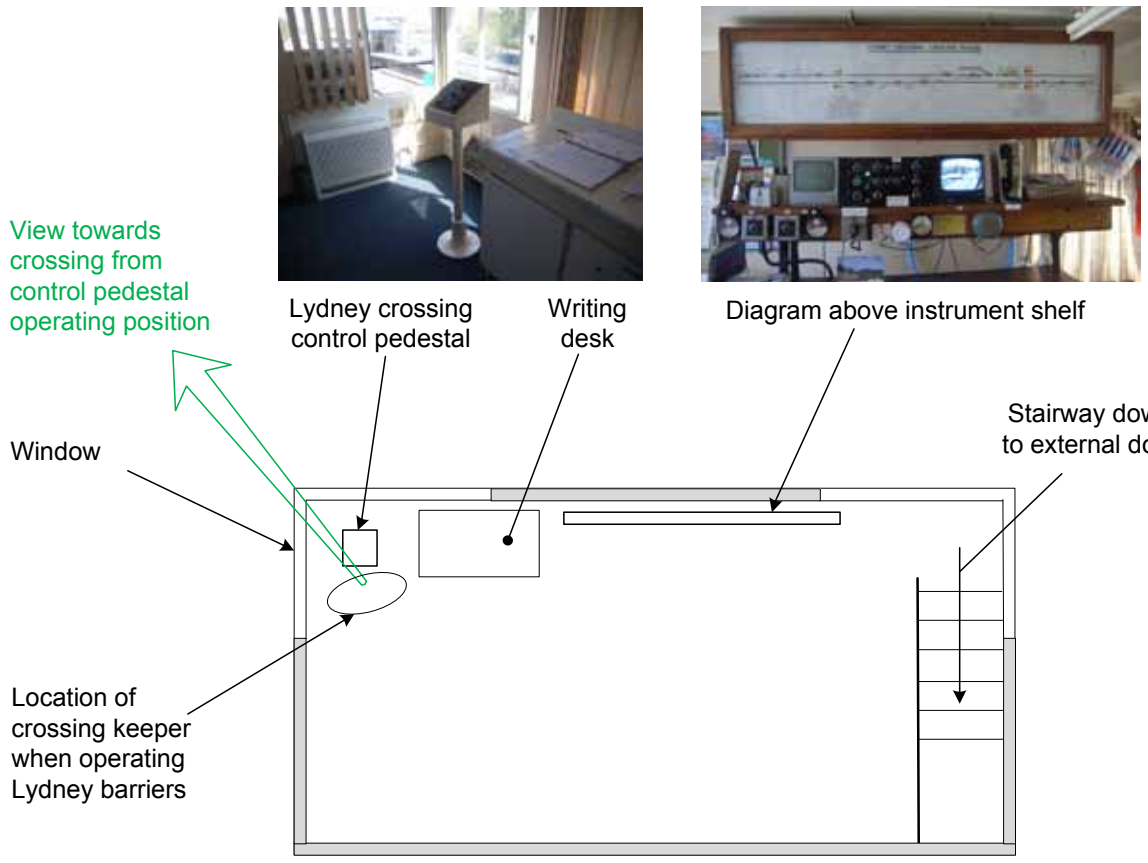


Figure 6: Crossing box operating floor

25 Direct observation of the crossing by the RAIB and inspection of Network Rail documents show that the crossing is normally operated as described below, starting from a situation where the barriers are raised and there are no trains nearby:

- the annunciator is triggered when an up train enters track circuit 1137 (or a down train enters track circuit 2130, figure 4);
- the keeper presses the lower button on the control pedestal;
- amber lights are displayed to road vehicles for approximately three seconds before flashing red lights are illuminated (figure 3);
- the barriers begin to lower about five seconds after the red lights start flashing;
- when the barriers are fully lowered, the annunciator stops sounding;
- when the barriers are fully lowered, the protecting signal clears without any further action by the crossing keeper;
- after the train passes the protecting signal, it returns to red; and
- after the train has passed over the crossing, the keeper presses the raise button, the barriers return to the fully raised position and the road warning lights stop flashing.

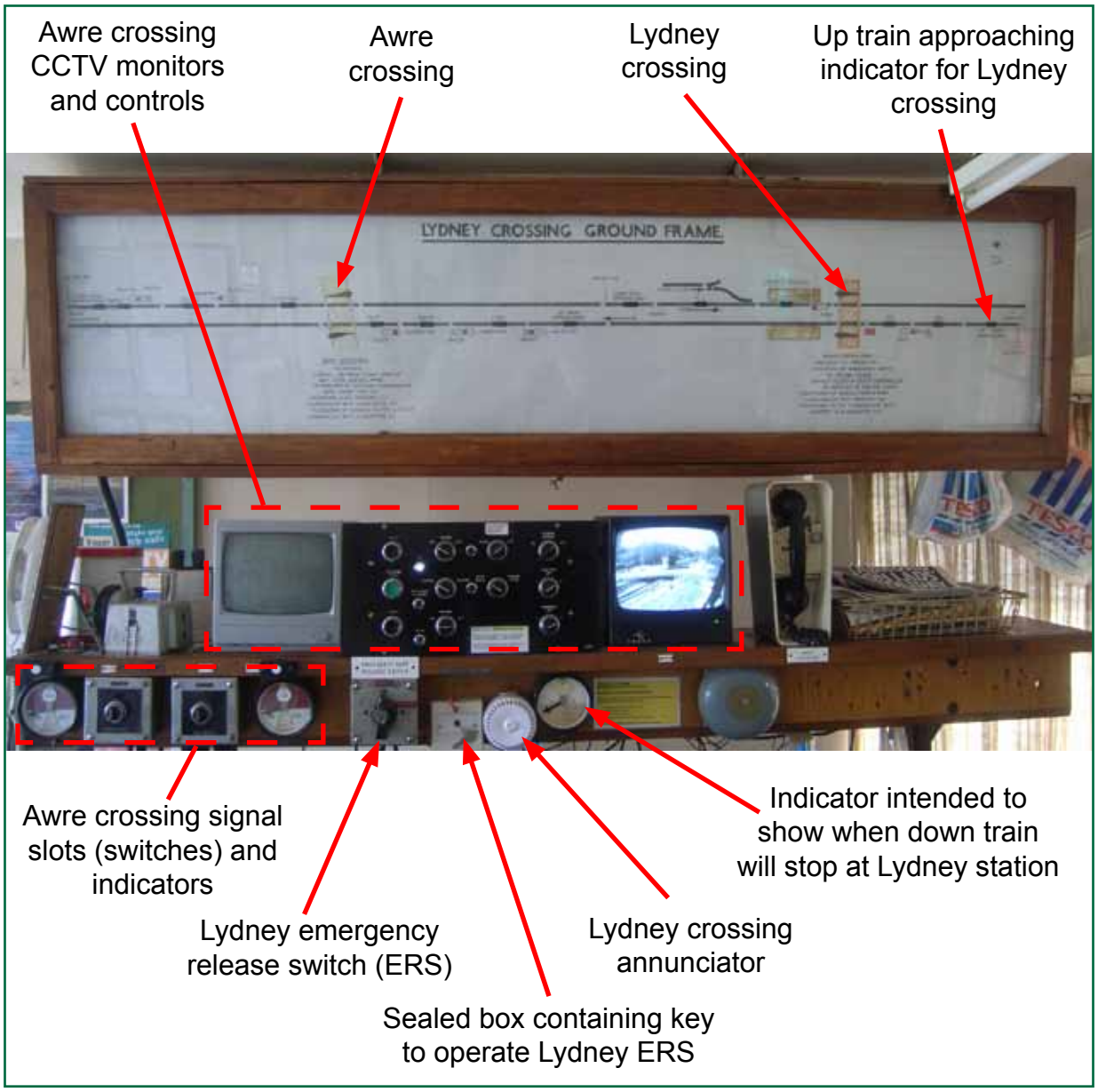


Figure 7: Diagram and instrument shelf

26 If a second train approaches the crossing (ie enters track circuit 1137 or 2130) while the barriers are still lowered, the annunciator does not sound and the protecting signal applicable to this train clears with no further action by the keeper. (Clearance of this signal is delayed, if necessary, to maintain safe separation of trains). If the keeper presses the raise button before this train reaches the crossing, the barriers do not rise, and the annunciator sounds to advise that a second train is approaching.

27 Inhibiting the raising of the barriers prevents the crossing keeper from raising the barriers with the pedestal control after the train driver has received signal aspects indicating that the line is clear over the level crossing.

28 In order to avoid delaying trains, the annunciator track circuits begin approximately five kilometres (three miles) from the crossing. This means that the barriers are normally lowered in time for a train driver to see green aspects at both the protecting signal, and at the preceding signal.

29 The protecting signals are controlled from Newport signal box and are provided with an auto-working facility which was in use during the incident. Controls in Newport panel box allow signallers to hold the protecting signals at danger. These controls were available, but not in use, at the time of the incident.

Staff involved

30 The crossing keeper on duty when the incident occurred was described by his managers as competent and very reliable in the routine competency assessments undertaken by his line managers. He had been a railwayman for 41 years and had been a guard before becoming a crossing keeper at Caldicot in 1987. He had been a relief crossing keeper at Lydney since 1995 and, due to staff shortages, had worked eight shifts at this location in the three weeks before the incident.

Events preceding the incident

31 On the day of the incident, the crossing had been operating normally until 13:00 hrs, about 90 minutes before the incident (table 1). *Data logger* records and witness evidence show that the crossing keeper was pressing the raise button once only to start the raise sequence. The raise sequence, including automatic extinguishing of the red flashing road lights, was completed eight or nine seconds after the raise button had been pressed.

32 After train 2G58 passed the crossing at 13:00 hrs[3], the raise button was pressed twice[4] during the early part of the raise sequence and pressed again, about two minutes later, to complete the sequence by extinguishing the red flashing road lights. Lydney crossing keepers are taught to try the raise button twice before raising the barriers manually, by operating valves in the hydraulic system and then lifting the barriers up. The time taken for raising the barriers for train 2G58, and the sequence of button presses, lead the RAIB to conclude that the up side barrier was raised manually on this occasion.

33 The data logger records that the barriers were then lowered and raised normally at 13:03 hrs. As no train passed the crossing at this time, this might have been a test by the crossing keeper which appeared to show that the problem encountered at 13:00 hrs had cleared.

34 The barriers were next lowered for train 6V67 which passed the crossing at 13:13 hrs. The data logger records a raise time of about one minute – longer than the eight or nine seconds usually required but less than the two minutes required for train 2G58. The normal single press of the raise button was sufficient to start the barriers rising, but a further press was required to stop the red flashing road lights. Although there is no evidence explaining these events, it is likely that road vehicles waiting at the barriers moved forward when their drivers saw the barriers rise, and the crossing keeper only became aware that the lights were still flashing when subsequent road vehicles stopped at the crossing.

[3] The description of this, and subsequent, events relies on data logger output where this conflicts with witness evidence. The rationale for relying on data logger evidence is given in Appendix H.

[4] Multiple pressing of the raise button at the start of a raise sequence is only recorded by the data logger when, as in this instance, these presses are separated by operation of the barrier lower button.

Time	Train	Train type	Barrier raise time (min:sec)	Raise button operation	Likely mode of operation
12:22 hrs	2L55	Down passenger	00:09	Once	Normal operation
12:27 hrs	1M64	Up passenger	00:08	Once	
12:44 hrs	1V07	Down passenger	00:09	Once	
13:00 hrs	2G58	Up passenger	02:14	Twice to start raise, once after barriers raised	Up side barrier raised manually due to fault
13:03 hrs	no train	None	00.09	Once	Test indicating fault at 13:00 hrs was temporary
13:13 hrs	6V67	Down freight	01:04	Once to start raise, once after barriers raised	Powered raise but additional press of raise button required to extinguish red flashing road lights.
13:26 hrs	1M99	Up passenger	00:58	Once to start raise, once after barriers raised	
13:59 hrs	2G60	Up passenger	01:09	Once to start raise, once after barriers raised	
14:15 hrs	1V08	Down passenger	02:55	Twice to start raise, once after barriers raised	Up side barrier raised manually due to fault
14:22 hrs	2L59	Down passenger	01:42	Barriers raised manually, see paragraphs 38 to 43	
14:24 hrs	1M68	Up passenger	Incident train		

Table 1: Lydney crossing events

35 The crossing keeper reported a barrier fault to Network Rail *fault control* centre immediately after train 6V67 passed the crossing. He did not report it to the signallers at Newport.

36 The barriers were then lowered for two further trains which passed over the crossing at 13:26 hrs and 13:59 hrs. In both instances the data logger shows a sequence of button pushes, and a duration, similar to that recorded for train 6V67 and it is likely that the crossing operated in a similar manner.

37 The next train to reach Lydney crossing was train 1V08 which arrived at 14:15 hrs. The raise button was pressed twice to initiate the sequence and pressed again, about three minutes later, to complete the sequence by extinguishing the red flashing road lights. The RAIB consider it most likely that the up barrier was raised manually for the reasons given in paragraph 32.

Events during the incident

38 At 14:19 hrs, the crossing keeper lowered the barriers for train 2L59, a down train which arrived at Lydney station, as scheduled, at 14:21 hrs and departed about a minute later. The train left track circuit CK, the final track circuit inhibiting powered raising of the barriers, at 14:22:11 hrs[5] and the crossing keeper then watched it pass over the crossing before he pressed the barrier raise button at 14:22:23 hrs.

39 Before the raise button was pressed, train 1M68 had occupied track circuit 1137 on the up line at 14:21:46 hrs. As usual when the barriers were already lowered, this had caused the up line protecting signal (signal N165) to clear without the annunciator sounding.

40 The barriers did not respond when the crossing keeper pressed the raise button. Witness evidence is that the annunciator did not sound (to alert the keeper that the barriers were remaining down because another train was approaching, paragraph 26). The data logger does not monitor the annunciator but the witness evidence is considered reliable.

41 Witness evidence and data logger information show that the crossing keeper then left the box to raise the barriers manually, unaware that the 'up train approaching' indicator was illuminated on the diagram. He lifted the barriers to the raised position and applied securing hooks to keep them in this position. Road traffic then began to use the crossing although, unknown to the crossing keeper, the red road warning lights were still flashing. The crossing keeper waited for a gap in the road traffic so that he could cross the road and return to the box. As he waited, the annunciator started to sound. The crossing keeper believed that he needed to operate a pedestal control in order to start the road warning lights and hurried to the box before pressing the barrier lower button at 14:24:05 hrs.

42 The barriers did not lower automatically as the crossing keeper had not removed the securing hooks. As he again left the box to do this, train 1M68 passed over the crossing at 14:24:17 hrs while the crossing barriers were in the raised position.

43 Data logger records show that the red lights warning road traffic were flashing correctly when train 2L59 passed over the crossing and continued to flash until after train 1M68 passed over the crossing.

Events after the incident

44 After the incident, the crossing keeper pressed the raise button to stop the red flashing road lights. He then telephoned the signaller at Newport. They agreed that the signaller would keep the crossing protecting signals at danger and only allow trains to pass these signals after the crossing keeper had told him that the crossing barriers were correctly lowered.

Consequences of the incident

45 The incident caused no injuries, no damage and had no significant effect on train services.

[5] Times for occupation and leaving track circuits are taken from data collected and stored by Network Rail's Control Centre of the Future (CCF) system. Times relating to level crossing operation are from the data logger output with an adjustment, provided by Network Rail, because the data logger and CCF clocks were not synchronised.

The investigation

Sources of evidence

46 The following sources of evidence were used:

- interviews with witnesses;
- data from a logger monitoring level crossing operation;
- data from Network Rail's Control Centre of the Future (CCF) which collects information about the time at which trains reach selected points on the network;
- the train's on train data recorder;
- site photographs;
- level crossing orders;
- government regulations relating to level crossings;
- industry standards and guidance relating to level crossings;
- the Network Rail level crossing file;
- level crossing maintenance records; and
- a review of previous RAIB investigations that had relevance to this incident.

Key facts and analysis

Identification of the immediate cause[6]

47 **The level crossing barriers were raised manually while a train was approaching the crossing and the protecting signals were showing a proceed aspect.**

Identification of causal[7] and contributory factors[8]

Crossing keeper unaware of train approaching when he raised the barriers

Annunciator sounding

48 **The annunciator did not sound when the crossing keeper pressed the barrier raise control. This is a causal factor.**

49 The annunciator should have warned the crossing keeper that train 1M68 was approaching when he pressed the barrier raise button after train 2L59 had passed over the crossing at about 14:22 hrs. Witness evidence, and the crossing keeper's actions, show that it did not sound at this time.

50 The operation of the annunciator when the raise button was pressed depended on inputs from track circuits showing that train 1M68 was approaching, and inputs from the circuit controller on the barrier pedestal showing that the barriers were in the lowered position. The state of track circuits was not recorded by the data logger but they evidently operated correctly in order to prevent the barriers rising in response to the barrier raise button.

51 The data logger records show that the contacts needed to trigger the annunciator were working correctly when the crossing keeper pressed the raise button. This means that there is no direct relationship between the silent annunciator and the circuit controller defects which necessitated manual operation of the barrier during the 90 minutes before the incident (paragraph 120). No defects were found in the annunciator itself during Network Rail's post-incident testing. Witness evidence and fault records show that the annunciator unit was generally reliable. It had only failed once since March 2010 when, on 22 July 2010, it stopped sounding due to a defective electrical connection.

[6] The condition, event or behaviour that directly resulted in the occurrence.

[7] Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.

[8] Any condition, event or behaviour that affected or sustained the occurrence, or exacerbated the outcome. Eliminating one or more of these factors would not have prevented the occurrence but their presence made it more likely, or changed the outcome.

52 Network Rail undertook full functional testing of the crossing after the incident. This testing was undertaken after the defective contacts on the barrier pedestal were replaced, and before RAIB attended site (RAIB did not attend immediately after the incident because, although a serious incident[9], Network Rail did not report it to RAIB until the following day). Network Rail's testing did not reveal a fault which would explain why the annunciator failed to sound when expected. Possible reasons include a temporary high resistance electrical contact (ie a dirty electrical contact), or poor connections in the disorganised wiring seen beneath the instrument shelf (figure 8).

Figure 8: Disorganised wiring beneath the instrument shelf on 7 April 2011

53 The failure to sound is a causal factor because it is unlikely that the crossing keeper would have raised the barriers manually before the arrival of train 1M68 if the annunciator had behaved normally. A future failure of the annunciator is unlikely to result in a safety incident because the annunciator is only intended to advise the crossing keeper about trains in the vicinity of the level crossing; it is not intended to indicate that it is safe to raise the barriers manually (see action taken, paragraph 152).

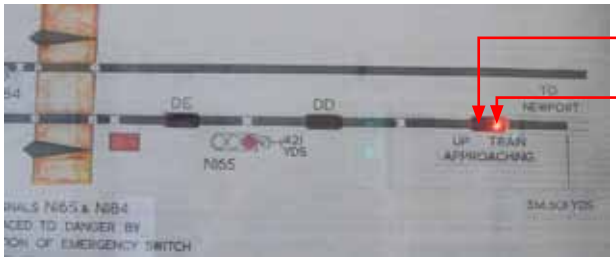
Train not seen on diagram

54 **When viewing the diagram, the crossing keeper did not see the illuminated indicator lamps which should have shown that a train was approaching. This is a causal factor.**

55 Before leaving the box to raise the barriers after train 2L59 passed, the crossing keeper could have looked at the diagram to determine whether any of the train approaching indicators were illuminated. If the indicators were operating correctly, train 1M68 should have illuminated two lamps in the "up train approaching" indicator (the indicator includes two lamps so that an indication is still provided if one lamp fails, figures 7 and 9). The crossing keeper stated that he looked at the diagram and did not observe any illuminated indicators.

[9] The RAIB believes that this incident fell within the definition of Schedule 1(9) of the Railways (Accident Investigation and Reporting) Regulations, ie 'an accident or incident which under slightly different conditions might have led to a death, serious injury or extensive damage', and therefore should have been notified to the RAIB immediately Network Rail became aware of it.

V1



V2

V3

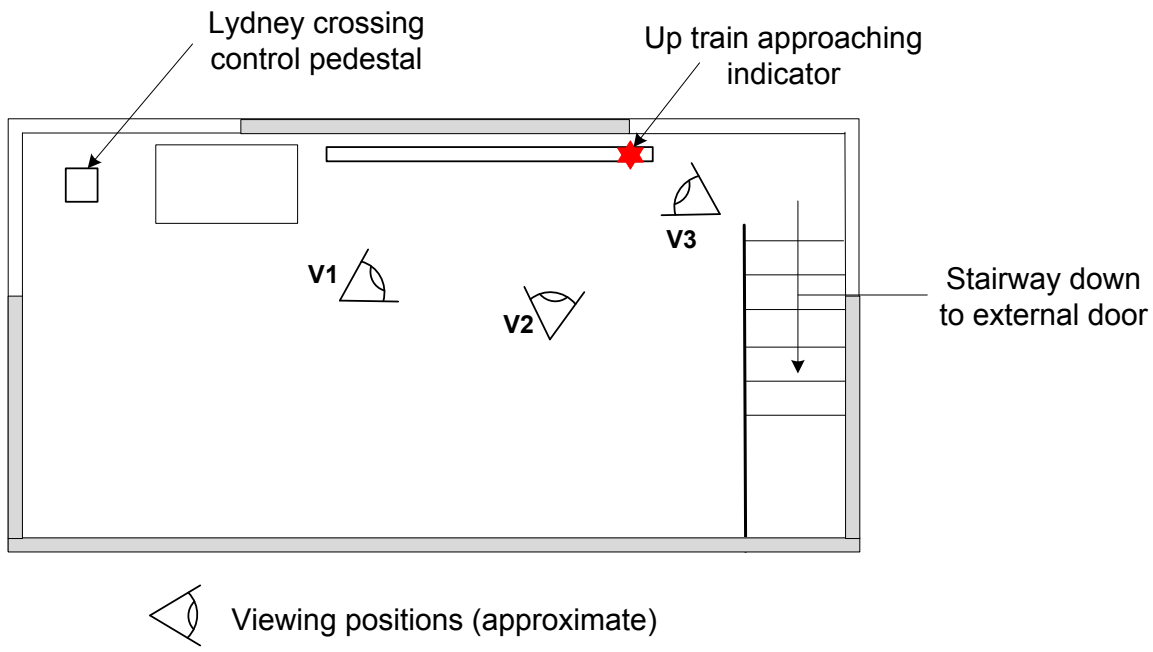


Figure 9: Visibility of up train approaching indicator

56 The defective circuit controller (paragraph 120) would not have affected correct operation of the diagram lamps. Post-incident testing by Network Rail (paragraph 52) showed that the diagram lamp circuits were functioning correctly, but did not record whether one or both lamps were operational in the "up train approaching" indicator.

57 It is possible that the crossing keeper did not observe the illuminated indicator for one, or more, of the following reasons:

- the indicator was less conspicuous than intended (paragraph 59);
- when the annunciator did not sound, the crossing keeper sub-consciously assumed this was due to a recurrence of the recent barrier problem (paragraph 31 to 37), and not due to another train approaching; and/or
- the crossing keeper did not properly examine the diagram.

58 Post-incident examination by the RAIB showed that one of the two lamps in the up train approaching indicator was defective (figure 9) and the surface layer of the diagram was detached from the backboard around this indicator.

59 When the crossing keeper was deciding whether to raise the barriers manually, train 1M68 was occupying track circuit 1137 and this would have illuminated the up train approaching indicator. Post-incident testing by RAIB showed that, when viewed from directly in front, this indication was easily seen although the left-hand lamp was defective (figure 9, view V2). Viewed from the left (view V1), conspicuity of the indication was poor because the detached surface layer partially obscured the illuminated lamp. Viewed from the right (view V3), the defective lamp and the detached surface layer meant that it was difficult to see that the indicator was illuminated.

60 The crossing keeper was standing at the control pedestal when the barriers did not respond to the raise button. He then moved towards the stairway in order to leave the box and raise the barriers manually. It is possible that, while doing this, he viewed the diagram and, due to the diagram and indicator defects, gained the impression that the indicator was not lit.

61 Although not directly relevant to the incident, RAIB's post-incident examination of the Lydney diagram found that the detached surface layer affected visibility of other indicators, and seven of the fourteen indicators on the diagram contained a defective indicator lamp.

Trains arriving without operation of box controls

62 **The crossing was designed so that, once the barriers had been lowered for a train, signals would clear for a subsequent train without the crossing keeper operating any controls. This is a causal factor.**

63 The standard Western Region (WR) barrier design installed at Lydney in 1974 had been designed on the basis that lowering the barriers would allow clearance of the signals protecting the level crossing. There was no requirement for the crossing keeper to operate any signal switches, or to confirm that the crossing was unobstructed, before a train could be signalled over the crossing.

64 Lydney was one of the last MCB level crossings to be installed without the crossing operator having to operate a separate control to clear the appropriate protecting signal for each train movement over the crossing. Where crossing keepers are provided with these controls, the signaller at the supervising signal box must also operate controls (or have activated automatic working) before the protecting signal will clear.

65 The 'Requirements of the Secretary of State for the Environment for Public Crossings Equipped with Manually Controlled Barriers' (1973) were in force at the time that Lydney crossing was installed. They did not require crossing keepers to have separate controls for the protecting signals.

66 In September 1975, the British Railways Chief Signal & Telecommunications Engineer's Department issued 'Principles for Manned Barrier Crossings' which, amongst other things, required separate control of signals by crossing keepers. This requirement was not retrospective, but has been applied when WR crossings have been upgraded. By the time of the incident, Lydney was the only crossing of this type on Network Rail infrastructure where a crossing keeper did not have separate controls for the signals.

67 If the crossing keeper had been required to operate a signal control before train 1M68 could reach the crossing, it is very likely that he would have checked that this control was in the 'signal on' (signal at danger) position before he tried to raise the barriers manually. This means that the absence of a separate signal control was a causal factor in the incident.

Informing the Newport signaller

68 **The crossing keeper did not contact the Newport signaller who was the only person able to keep the Lydney protecting signals at danger. This is a possible causal factor.**

69 The design of the crossing controls at Lydney meant that the barriers could only be raised safely by hand if the protecting signals were held at danger by a control at Newport signal box (paragraph 29). This was because:

- the crossing keeper had no means of preventing the signals clearing when the barriers were in the lowered position (except for the emergency release switch not intended for use during manual operation of the barriers, paragraph 24); and
- even if the crossing keeper checked that no trains were shown on his diagram before leaving the box, a train could reach the track circuits needed to clear the protecting signals before the keeper had started to raise the barriers (paragraph 26).

70 There are two reasons why a crossing keeper must contact the signaller before raising the barriers manually:

- the signaller must place the protecting signals at danger before the barriers can be raised safely, and
- the signaller must be advised of the possible delay to train services because manual operation is slower than powered operation.

71 Witness evidence, and recordings of telephone calls between Lydney and Newport boxes, show that, on the day of the incident, the crossing keeper did not advise the signaller that he was operating Lydney crossing barriers by hand.

72 RAIB consider that one or more of the following factors contributed to this omission:

- distraction by road traffic (paragraph 75);
- the crossing keeper did not appreciate that advising the signaller was necessary for the safe manual operation of the barriers (paragraph 78);
- inadequate box instructions (paragraph 85); and
- shortcomings in the competency reassessment process (paragraph 93).

73 Neither fatigue, nor the influence of drugs and alcohol, are considered to have affected the crossing keeper's behaviour. Network Rail records show that he had a rest day two days before the incident and had worked day shifts not exceeding eight hours for more than a week before the incident. He had started work at 06:00 hrs on the day of the incident, and there is no evidence that he was acting in a fatigued manner at the time of the incident. Routine post-incident testing found that he was not under the influence of drugs or alcohol.

74 Not informing the Newport signaller is only a possible causal factor because, even if the crossing keeper had contacted the Newport signaller, the signaller might not have placed the protecting signals at danger before the barriers were raised manually (paragraphs 79 to 82).

Distraction by road and rail traffic

75 **The crossing keeper may have been distracted by a desire to avoid delaying road traffic. This is a possible causal factor.**

76 The crossing keeper stated that, when raising the barriers for the incident train at about 14:23 hrs, he was anxious to avoid delays to the relatively heavy road traffic (paragraph 17). The evidence suggests this as a possible reason why he did not inform the signaller.

77 While this could be a factor on this occasion, it does not explain why he omitted to contact the signaller when manually operating the up side barrier during the 90 minutes before the incident (paragraph 31 to 37). Road traffic is considered only a possible causal factor because its influence is uncertain and it does not explain events earlier in the day.

Importance of Newport signaller

78 **The crossing keeper did not appreciate that communication with the signaller was essential to allow safe manual operation of Lydney barriers. This is a possible causal factor because the signaller might not have held the protecting signals at danger.**

79 Witness evidence indicates that the incident crossing keeper, and other crossing keepers working at Lydney, understood that Newport signallers must be advised of delays associated with manual operation of the Lydney barriers.

80 Voice recordings show that the incident crossing keeper, some other Lydney crossing keepers, and some Newport signallers, were unaware that safe manual operation of Lydney barriers depended on the crossing keeper contacting the Newport signaller (paragraph 70). Witness evidence is that the incident crossing keeper believed that he could rely on the annunciator and diagram indicators when deciding whether it was safe to operate Lydney barriers manually.

81 The RAIB obtained voice recordings relating to four days on which Lydney crossing was operated manually in the six weeks before the incident – the barriers were raised manually at least once on each of these days. On two days, 8 February 2011 and 6 March 2011, the signaller and crossing keeper liaised by telephone so that the signaller kept the protecting signals at danger on every occasion that the barriers were raised by hand.

82 On the other two days, 4 March 2011 and 5 March 2011, the signallers and crossing keepers spoke about manual operation, but the protecting signals were not held at danger when the barriers were being raised by hand. Neither of the staff involved on 4 March were also involved in the conversations on 5 March. The incident crossing keeper was not involved on either of these days.

83 The incident crossing keeper had operated Lydney barriers manually on 5 August 2009 (paragraphs 93 to 99). The RAIB obtained voice recordings relating to this event. These show that the incident crossing keeper and the signaller understood that trains might be delayed, but the protecting signals were not held at danger when the barriers were being raised and lowered manually.

84 The incident crossing keeper was unaware that railway safety depended on him contacting the Newport signaller before each occasion that Lydney barriers were raised manually. He also knew that contacting Newport signallers could result in a delay. The combined effect of these issues is at least a partial explanation of why he did not contact the signaller first.

Inadequate box instructions

85 **The instructions provided for crossing keepers and signallers did not make clear that the Lydney crossing keeper must contact the Newport signaller, and the signaller must protect the crossing, before the barriers were raised manually. The absence, at Lydney crossing box and Newport signal box, of adequate instructions to cover the manual operation of the barriers at Lydney, is a probable causal factor.**

86 Instructions, known as *box instructions,* are issued to crossing boxes and signal boxes. They contain requirements specific to each location which must be applied by crossing keepers and signallers. The Lydney box instructions applicable at the time of the incident are reproduced in Appendix D.

87 The instructions for Lydney box contained only one relevant reference to the crossing keeper informing the Newport signaller if there were equipment defects at Lydney crossing. The reference was at paragraph 8.1, under the heading 'Crossing abuse/mis-use and failure of equipment'. The relevant text was '[the crossing keeper] must report any abuse, mis-use or any equipment defects to the signaller and if possible to the operations and fault controls at Cardiff'.

88 The text of paragraph 8.1 gave no indication that informing the signaller was essential before the barriers could be safely raised manually. The instructions for manual operation of the barriers contained in paragraph 6 of the box instructions do not mention contacting the signaller.

89 Neither the rule book[10], nor other documents, contained a general requirement that signallers should always hold protecting signals at danger when a crossing keeper was working barriers manually. The rule book only required signallers to do this in some circumstances. These did not include instances when, as during the incident, the only defect is a failure of the barriers to operate under power.

90 Although there is no written rule that signallers should hold protecting signals at danger when crossing keepers are operating barriers manually, voice recordings show that some signallers routinely do this when advised that Lydney crossing is to be operated manually. Local signalling managers responsible for Lydney crossing believed that both signallers and crossing keepers should have understood that signallers should hold protecting signals at danger in these circumstances. Voice communication records (paragraph 80 to 83) show that a significant number of signallers and crossing keepers were unaware of this.

91 It is probable that the incident crossing keeper would have contacted the signaller if the box instructions had made clear that this was essential before the barriers could be safely raised manually. This is a probable causal factor for the incident.

92 If Newport box instructions had included a requirement for the Newport signaller to operate protecting signals, it is probable that this procedure would have been implemented when the incident crossing keeper operated Lydney barriers manually on 5 August 2009 (paragraph 83). It is possible that this would have alerted the incident crossing keeper to the importance of informing the signaller when operating Lydney barriers manually. The absence of appropriate instructions in Newport box instructions is therefore a possible reason for the crossing keeper being unaware that informing the signaller was a safety critical action.

Competency & assessment

93 **Routine competency assessments did not reveal that some crossing keepers were unaware that railway safety depended on them contacting the signaller before raising barriers manually. This is a possible causal factor.**

94 There was no formal system for recording details of training required, and given to, crossing keepers when the incident keeper was trained to operate Lydney crossing equipment in 1995. He was taught by experienced crossing keepers and then assessed by a signalling manager. It is likely that he was taught to contact the Newport signaller before raising Lydney barriers manually; but not told that this should result in the signaller providing the signal protection needed before the barriers could be safely raised manually.

95 Formal systems for training, initial assessment and routine assessment of crossing keepers had been introduced by 2000. At the time of the incident, most crossing keepers, including the incident crossing keeper, were subject to an annual assessment cycle. The incident crossing keeper had been formally assessed on 5 July 2010, less than a year before the incident. He also held an authority to operate Lydney crossing valid until 22 May 2012. Annual assessment of Lydney crossing keepers was undertaken by their line manager, the local operations manager.

[10] The rule book, Railway Group Standard GE/RT8000, is published by the Rail Safety and Standards Board. The requirements described above have not been significantly amended since the incident.

96 Network Rail's Operations Manual (NR/L3/OCS/041, June 2010) contains procedures for the routine assessment of staff[11]. Procedure 4-01 gives general requirements including a definition that evidence for assessing competence 'can include direct and indirect observations, written records, log books, practical and written tests'. The components used in an individual assessment is left to the assessor's discretion. Procedure 4-05 gives specific elements to be considered when assessing crossing keepers, these include 'managing infrastructure and equipment failures'.

97 Routine assessments of Lydney crossing keepers were based on collecting evidence that individuals understood, and were applying, rules applicable to all crossing keepers and the box instructions for Lydney.

98 When assessed in July 2010, the incident crossing keeper was considered competent to manage infrastructure and equipment failure, based on evidence in the *occurrence book* kept in Lydney box. Crossing keepers were required to record various types of event in this book and the assessment relied on an entry showing that the incident crossing keeper had operated Lydney barriers manually on 5 August 2009.

99 RAIB have obtained voice recordings of the conversations on 5 August 2009 between the incident crossing keeper and Newport signal box. Possible delays due to manual operation were mentioned, but the signaller was not contacted on each occasion the crossing was operated manually and the signaller did not hold the protecting signals at danger while this was being done.

100 The local operations manager undertaking the July 2010 assessment stated that he was aware that safe manual operation of Lydney barriers depended on the crossing keeper contacting the Newport signaller, but he did not listen to this voice recording. The wording of Procedure 4-01 implies, and witness evidence confirms, that assessors were not required to check that recorded activities were undertaken correctly. The local operations manager's duties include dealing with abnormal events so he would be aware of most instances when accidents (and, if detected, incidents) had been caused by his crossing keepers. It is probable that, as on other occasions (paragraph 80 to 83), no-one recognised that a potentially unsafe situation had been created by omitting to hold the protecting signals at danger on 5 August 2009.

101 The most recent written test on box instructions in the incident crossing keeper's personal file was completed on 7 August 2009. This included a question 'who would you report an equipment failure to?'. His answer was 'panel signaller – fault control'; the panel signaller was located at Newport and his answer, which was consistent with box instruction 8.1, was marked as correct. This written test did not include any questions about manual operation of Lydney barriers and so did not establish whether the crossing keeper knew that the safety of this operation depended on him contacting the signaller before raising the barriers, rather than minimising road delays by contacting the signaller after raising the barriers.

[11] Current requirements are similar to those at the time of the incident.

102 The written test was partly based on information contained in the box instructions so shortcomings in the box instructions (paragraph 85) may explain why the written test did not establish whether the crossing keeper understood the importance of contacting the signaller. A similar situation might occur when staff are assessed verbally.

103 The assessment process did not establish whether the incident crossing keeper was aware of the importance of contacting the signaller before manually raising Lydney barriers. This shortcoming was a possible cause of the incident because, even when advised about manual operation of Lydney barriers, signallers did not always provide signal protection (paragraphs 69 and 80). The shortcoming was not specific to the incident crossing keeper and could be a factor in other crossing keepers not contacting the signaller on every occasion they operated the crossing manually (paragraph 82).

Mistaken belief that raising barriers set protecting signals to danger

104 **The crossing keeper incorrectly believed that manually raising the barriers would ensure that the protecting signals showed a stop aspect. This is a causal factor.**

105 The crossing was designed on the basis that the barriers must be in the fully lowered position before the protecting signals could clear (paragraph 25). After the protecting signal(s) had cleared, interlocking was intended to prevent the barriers from rising in response to the raise button until after a train had reached the level crossing (paragraph 27). Manual raising of the barriers was still possible while the train was approaching the crossing. This would not cause the protecting signals to revert to danger but, provided that the crossing was operating as designed, the annunciator would sound in the crossing keeper's box.

106 Witness evidence is that the incident crossing keeper, other Lydney crossing keepers and some signalling managers expected the protecting signals to return to danger if a barrier was raised manually when a train was approaching. This incorrect understanding of the crossing equipment meant that, when manually raising the barrier during the incident, the crossing keeper believed that protection was being provided by the signals.

107 Permitting barriers to be raised manually without the protecting signals returning to danger automatically remains current Network Rail design practice for MCB crossings. This is because level crossing designers understand that the relevant Network Rail standard only relates to the operation of barriers using the normal controls.

108 The relevant standard is NR/L3/SIG/30018 (signalling design: technical details: level crossings, September 2009). Paragraph 11.11.2 of this standard states '[railway] signals shall be interlocked with the barriers so that it is not possible to clear the signals unless the road is fully closed by the barriers...It shall not be possible to raise the barriers unless the signals are replaced to red'. The standard does not state whether this requirement is limited to normal operation, or whether it also applies in other (degraded) modes of operation.

109 Senior Network Rail staff have said that the standard is not applied to degraded operation because of experience gained when barrier crossings were first introduced in the UK. These crossings required the barriers to be detected in the fully down position before the protecting signals would clear. Some early crossings also required continuous down detection to maintain proceed aspects at the protecting signals. This meant that protecting signals would revert to danger if the barriers were raised manually.

110 The requirement for continuous down detection was omitted when experience showed that down detection was sometimes lost because members of the public disturbed the barriers. This resulted in an unacceptable number of instances when the protecting signals reverted to danger, and train drivers saw red aspects without any warning. Signal reversions are stressful for train drivers and can result in them losing confidence in the signalling system. A consequence of omitting continuous down detection is that protecting signals do not revert to danger if barriers are raised manually due to equipment failure.

111 The omission of continuous down detection has been accepted by industry regulatory bodies (formerly the Railway Inspectorate, now the Office of Rail Regulation (ORR), Appendix E).

112 The decision to omit continuous down detection was made before formal risk assessment techniques were in routine use. Neither Network Rail, nor its predecessors, have undertaken a formal risk assessment of this decision against levels of safety appropriate to modern equipment.

113 If Lydney crossing signals had returned to danger when the barriers were raised manually during the incident, the approaching train would have been stopped before it reached the crossing. It is likely that a control of this type would have returned signal UM134 to yellow, and signal N165 to red, as soon as the first barrier was lifted from the horizontal position. It is not known exactly when the first barrier was lifted during the incident but the crossing keeper had raised both barriers and returned to his box 1 minute 42 seconds after first pressing the raise button. As train 1M68 passed signal UM134 about 43 seconds after the raise button was first pressed, it is possible that the driver would have seen this signal change to a yellow aspect. He would have seen the red aspect of signal N165 in time to stop before reaching the crossing, although possibly not before passing signal N165.

Defective barriers

114 **It is probable that recent barrier failures encouraged the crossing keeper to incorrectly assume that another failure had occurred when the barriers did not respond to the raise button. This is a probable contributory factor.**

115 Witness evidence from signalling staff, equipment defect records and technical assessments by Network Rail level crossing engineers show that the crossing equipment at Lydney needed replacement because of unreliability associated with the age of the equipment. The installation was 37 years old at the time of the incident and there had been no significant modification to the equipment in this period.

116 A Network Rail level crossing renewal remit dated 2005 shows that it intended to replace the equipment at Lydney crossing in 2009. The availability of funds for this work was confirmed in a 2006 project remit. These, and a subsequent remit issued in January 2008, envisaged that the crossing would continue to be operated by a crossing keeper located in Lydney box.

117 Between January 2008 and October 2009, Network Rail decided that modernisation of Lydney crossing would be deferred until 2012, when it would be undertaken as part of the Newport Area Signalling Replacement project with the crossing being controlled from a control centre in South Wales. Progress with this project is described in paragraph 153.

118 Barrier defects necessitating manual operation of Lydney crossing barriers were recorded on 17 separate occasions in the 13 months immediately preceding the incident (Appendix F). The problems were generally related to the contacts located in the circuit controller used to detect the barrier position (paragraph 21). The records provided by Network Rail do not always show how these problems were resolved. Where recorded, the problems were usually resolved by adjusting, or replacing, the contacts. Witness evidence is that similar problems were experienced at other installations using similar circuit controller arrangements.

119 The up side (northern) barrier had been operated manually by the incident crossing keeper at least once, probably twice, and possibly more often, in the 90 minutes preceding the incident. The barriers were certainly behaving abnormally throughout this period (paragraph 31 to 37).

120 Post-incident testing by Network Rail found that problems with the up side barrier on the day of the incident were due to one (or more) defective contacts in the circuit controller. The circuit controller was replaced before the crossing was returned to normal operation.

121 It is probable that the history of problems with the up side barrier encouraged the crossing keeper to believe that a defect, rather than an approaching train, had prevented the barriers rising when he pressed the raise button after the passage of train 2L59 at 14:22 hrs.

Identification of underlying factors[12]

122 The RAIB has identified two possible underlying factors:

- deficiencies in the process for providing box instructions; and
- risks introduced by railway infrastructure and railway staff were not considered when assessing risks at level crossings.

Box instructions incorrect/incomplete

123 **Omission of information from Lydney box instructions is a possible explanation for the crossing keeper's actions. As other errors and inconsistencies have been found in box instructions, the process for providing these instructions is an underlying factor.**

[12] Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

124 The Lydney box instructions did not make clear that safety of the railway depended on the crossing keeper informing the Newport signaller before Lydney barriers could be operated manually (paragraphs 86 to 91). Newport box instructions did not inform signallers that they must hold Lydney crossing protecting signals at danger when Lydney barriers were being operated manually (paragraph 92).

125 Lydney box instructions current at the time of the incident included the following inconsistencies with the equipment and operating procedures at Lydney box. Where marked with an asterisk (*), similar wording was included in the 1988 version of the instructions – the oldest version available from Network Rail.

- The box instructions stated that the crossing keeper should check that Lydney's protecting signals return to danger after trains passed over the crossing. However, the keeper could not see the aspects displayed by these signals, and the box equipment did not include repeaters showing whether they were at danger.
- The box instructions stated that Newport signallers would operate an indicator in Lydney box which showed when a down train would be stopping at Lydney station; the instructions also said that barriers should not be lowered for these trains until they arrive at the station*. The indicator was provided, but witness evidence is that it had not been used for several years.
- The instructions did not state that the annunciator remained silent if a train approached when the barriers were already lowered*.
- The instructions did not state that the annunciator would sound if the barriers were raised manually when signals had been cleared for an approaching train*. (This feature is similar to the audible warning given to a crossing operator by modern installations when a barrier pedestal door is opened to allow manual raising of the barriers.)
- The instructions state that, if raised, the crossing barriers will automatically lower if the electrical power supply fails. The barriers actually remain in the raised position unless they descend very slowly due to leakage within the hydraulic system.
- The instructions state that the key required for manual operation of the barriers was in a box with a glass front which must be broken to access the key*. The key had been readily available from an unprotected hook since 1995 and possibly earlier. (It was common practice for signalling controls to be protected by a glass plate if particular care was needed before the control was used. It is not known whether a glass fronted box was originally provided at Lydney.)
- Crossing keepers were instructed to lock the barriers in the down position, using a chain, if the barriers had been lowered manually. This was not normally done when Lydney barriers were lowered manually.
- If the barriers could not be closed across the road, the crossing keeper was instructed to implement specified precautions and then clear the protecting signal. The crossing keeper has no signal controls, and interlocking prevents the signaller clearing the protecting signal if the barriers are not fully lowered.
- The instructions state that signalling technicians will sign the occurrence book when undertaking work affecting the crossing*. This does not usually happen, particularly when the technicians are working away from the box and liaise with the crossing keeper by phone.

126 The procedures for updating and checking box instructions had varied since the barriers were installed in 1974. In recent years, this has been included in Network Rail's operations manual (NR/L3/OCS/041) as procedure 2-04. In addition to processes for modifying box instructions when changes were made to infrastructure and operating methods, procedure 2-04 requires that box instructions should be reviewed by the local operations manager so that they "remain fit for purpose". An annual review interval had been specified until the procedure was updated on 5 March 2011 and the interval was increased to five years.

127 The last review of Lydney box instructions before the incident was in January 2010. This did not identify any of the discrepancies identified in paragraph 125. Details of reviews before January 2010 are not available as this was the first review undertaken after a Network Rail functional audit found that box instructions at Lydney, and surrounding boxes, were not being reviewed by local operations managers.

128 The January 2010 review had been carried out by a local operations manager who had previously worked as a crossing keeper at Lydney. Witness evidence is that, when reviewing box instructions, the local operations managers concentrated on amendments associated with any recent changes to infrastructure and operating methods. There had been no such changes when the box instructions were reviewed in January 2010.

129 Network Rail's operating procedures include various checks on work carried out by local operations managers. These procedures do not include any checks relating to their box instruction reviews.

130 Revision records attached to some versions of Lydney box instructions issued between 1988 and 2007 show that box instructions were being standardised during this period. It is likely that this process had introduced some standard paragraphs which were not applicable to the equipment at Lydney.

131 Although most of the discrepancies found in the box instructions should have been apparent to a member of operating staff familiar with the location, some of the discrepancies would only have been apparent to a signal engineer. There is no requirement for signal engineers to routinely review existing box instructions. They are sometimes involved with modifying instructions if equipment has been modified. There is a formal process for involving signal engineers in preparation of box instructions being prepared as part of the Newport Area Signalling Replacement project.

132 RAIB reviewed the box instructions valid in March 2011 for three other crossings with similarities to Lydney. These were at Caldicot, Puxton & Worle and Causeway (Steventon). Inconsistencies, and occasional discrepancies, were observed in these instructions (Appendix G).

Level crossing risk assessment

133 **Network Rail's level crossing risk assessment process did not recognise, and then mitigate, risks associated with equipment failure, possible staff errors or deficient procedures at Lydney. This is a possible underlying factor.**

134 Network Rail routinely assesses level crossing risks in accordance with the standard NR/L2/OPS/100. This procedure does not include consideration of the risks associated with railway infrastructure, railway operating procedures and the performance of railway staff. The procedure does not require the input from signal engineers which would be needed to recognise some equipment related risks. Similar issues were identified during the RAIB's investigation into the accident at Moreton-on-Lugg on 16 January 2010, and led to an RAIB recommendation reproduced in paragraph 156.

135 It is possible that consideration of these issues would have identified the risks at Lydney associated with the absence of signal controls in the crossing box (paragraph 63) and shortcomings in the box instructions (paragraphs 124 and 125).

Discounted factor

Distraction by visitor

136 A railway chaplain arrived at Lydney box shortly after mid-day for a pastoral visit. This was one of the routine visits which railway chaplains make to various railway operating locations. He was in the box for most of the time until the incident occurred.

137 There is no evidence to indicate that the crossing keeper was being distracted by the chaplain at the time of the incident. Witness evidence shows that, when visiting other signal boxes, the chaplain took appropriate measures to avoid distracting staff when they were undertaking operational duties.

Previous occurrences of a similar character

138 Data provided by RSSB shows that, in the ten years before the Lydney incident, there were two other incidents where a crossing keeper or signaller caused a barrier to rise, or start to rise, as a train passed over a MCB level crossing being operated in degraded mode. Neither of these incidents occurred at Lydney and neither resulted in damage or injury.

139 RAIB has investigated a fatal accident caused by a signaller's error at Moreton-on-Lugg, near Hereford, on 16 January 2010. Although the infrastructure at this location differs significantly from that at Lydney, and there are significant differences in the accident causation, there is some overlap in the underlying factor relating to understanding, and mitigating, level crossing risk due to railway related activities.

140 The RAIB's report on the Moreton-on-Lugg accident describes the Network Rail level crossing risk assessment process and states 'the lack of regular liaison between the operational risk team and signalling engineers made it less likely that the risk associated with signaller error, and the potential mitigation would be considered'. The associated recommendation is reproduced in paragraph 156 of this report.

Observations[13]

Training and competency documentation

141 The material being used to train new Lydney crossing keepers at the time of the incident did not describe the requirements for degraded working at this location. This is not a causal factor for the incident because training material of this type was not being used when, in 1995, the incident crossing keeper was trained to operate Lydney crossing.

142 The training material used to train new crossing keepers on Lydney crossing was prepared in 2005. The introduction to the training material states that it should contain 'a catalogue of information about specific signalling equipment that is controlled by this location' and, in addition to descriptions of signals, 'should include details of any additional equipment that is relevant to the trainee signaller'. The context indicates that signaller includes crossing keeper.

143 The training material included a brief description of normal barrier operation but does not mention manual operation. The unusual lack of separate signal controls (paragraphs 64 to 66) was relevant to trainees so should have been included in the training material.

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

Summary of conclusions

Immediate cause

144 The level crossing barriers were raised while a train was approaching and the protecting signals were showing a proceed aspect (**paragraph 47**).

Causal factors

145 The causal factors were:

a The annunciator did not sound when the crossing keeper pressed the barrier raise control (**paragraph 48**, no recommendation).

b When viewing the diagram, the crossing keeper did not see the illuminated indicator lamps which should have shown that a train was approaching (**paragraph 54**, no recommendation as action already taken, paragraphs 151 and 152).

c The crossing was designed so that, once the barriers had been lowered for a train, signals would clear for a subsequent train without the crossing keeper operating any controls (**paragraph 62**, no recommendation as action taken locally (paragraph 152) and no other similar crossings remain on Network Rail infrastructure).

d The crossing keeper did not appreciate that communication with the signaller was essential to allow safe manual operation of Lydney barriers (**paragraph 78, Recommendations 1 and 2**).

e The crossing keeper believed that manually raising the barriers would ensure that the protecting signals showed a stop aspect (**paragraph 104, Recommendations 1 and 3**).

146 A probable causal factor is that the box instructions at Lydney and Newport did not make clear that the crossing keeper must contact the Newport signaller, and the signaller must protect the crossing, before the barriers were raised manually (**paragraph 85, Recommendation 1**).

147 It is possible that the following factors were causal:

a The crossing keeper did not contact the Newport signaller (**paragraph 68, Recommendations 1, 2 & 3**).

b The crossing keeper may have been distracted by a desire to avoid delaying road traffic (**paragraph 75**, no recommendation).

c Routine competency checks did not reveal that crossing keepers were unaware that railway safety depended on them contacting the signaller before raising barriers manually (**paragraph 93, Recommendation 2**).

Contributory factors

148 The recent barrier failures are a contributory factor because it is possible that they encouraged the crossing keeper to incorrectly assume that a similar failure had occurred when the barriers did not respond to the raise button (**paragraph 114**, no recommendation as replacement in progress, paragraph 153).

Underlying factors

149 Underlying factors were:

a Omission of information from Lydney box instructions is a possible explanation for the crossing keeper's actions. As other errors and inconsistencies have been found in box instructions, the process for providing, and checking, these instructions is a possible underlying factor (**paragraph 123, Recommendation 1**).

b Network Rail's level crossing risk assessment process did not recognise, and then mitigate, risks associated with the equipment provided at Lydney level crossing, possible staff errors or deficient procedures (**paragraph 133**, covered by previous recommendation, paragraph 156).

Additional observations

150 Although not linked to the Lydney incident on 23 March 2011, the RAIB observes that the material used to train new Lydney crossing keepers did not describe the location specific requirements for degraded working (**paragraph 141, Recommendation 1**).

Actions reported as taken, or in hand, that address factors which otherwise would have resulted in a RAIB recommendation

151 RAIB wrote to Network Rail, on 18 April 2011, giving the preliminary findings of the RAIB's investigation. On 12 May 2011, following a further visit to Lydney, the RAIB advised Network Rail that the Lydney diagram was defective.

152 Network Rail has issued instructions to Lydney crossing keepers, and to Newport signallers, describing the correct procedure to adopt when Lydney crossing barriers are being operated manually. Following the RAIB's email on 12 May 2011, Network Rail repaired the diagram surface, and replaced defective indicator lamps, in Lydney box so that the indicators are clearly visible.

153 The Newport Area Signalling Replacement project was being implemented when the incident occurred and (at the time of writing this report) Network Rail expects that the equipment at Lydney crossing will be replaced, and operated remotely from a new control centre at Cardiff, from late 2012. The new installation will include separate signal controls, or equivalent equipment, for Lydney crossing.

154 Network Rail is modifying some of the box instructions to resolve the inconsistencies shown in Appendix G.

155 RAIB will, as part of its routine liaison with Network Rail staff responsible for incident reporting, reiterate the need for prompt reporting of events similar to the Lydney incident.

Previous recommendation relevant to this investigation

156 The following recommendation, which addresses the factor identified in paragraphs 133 to 135, was made by the RAIB as a result of investigating the accident at Moreton-on-Lugg on 16 January 2010. It is recommendation 2 of the RAIB report number 04/2011, published in February 2011, and is not remade so as to avoid duplication:

Network Rail should enhance its level crossing risk management process to include identification, assessment and management of the risk associated with:

- *human error by signallers and crossing keepers;*
- *operational arrangements, in particular with regard to the ability of operators to cope with interruptions, such as telephone calls, and other out-of-course events;*
- *equipment design, in particular where it is not compliant with latest design standards; and*
- *maintenance and inspection arrangements, particularly where these are used to identify and remedy any equipment functional and performance deficiency.*

The process should allow for sufficient liaison between the relevant engineering and operational departments.

When addressing risks identified by the implementation of the revised process, Network Rail should prioritise the implementation of required mitigation measures to level crossings where consequences of operator error are severe and not protected by engineered safeguards.

157 The Railways (Accident Investigation and Reporting) Regulations require the relevant safety authority, in this instance the ORR, to notify RAIB of the measures taken in response to RAIB recommendations. At the time of writing, the RAIB was awaiting a report from the ORR providing details of the measures that have been taken, or are proposed, by Network Rail.

Recommendations

158 The following recommendations are made:[14]

Recommendations to address causal, contributory, and underlying factors

1 *This recommendation is intended to provide crossing and signal box instructions and training material which reflect equipment, routine operating practices and procedures required during degraded working.*

Network Rail should modify procedures so that:

a. routine reviews and updating of signal and crossing box instructions include verification, by engineering staff, that the instructions are compatible with the equipment provided;

b. there is clear guidance on the information to be contained in all box instructions;

c. training material is reviewed, and updated as necessary, concurrently with the associated box instructions; and

d. reviews of box instructions and associated training material should be subject to checking, at least on a sample basis.

(paragraphs 145d, 145e, 146, 147a, 149a and 150.)

2 *The intent of this recommendation is that, when accepting documentary evidence that an individual (such as a crossing keeper) has dealt with particular situations in a competent manner, a sample of these situations should be reviewed to ensure that the individual actually acted appropriately.*

Network Rail should review and, if necessary, amend and/or augment existing processes so that, when documentary evidence is used to verify safety-critical competencies of operations staff, appropriate evidence (such as voice recordings) is examined for at least a proportion of the events covered by these documents (paragraphs 145d, 147a, and 147c).

continued

[14] 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 ORR to enable it to carry out its duties under regulation 12(2) to:

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

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

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

3 *The intent of this recommendation is that, for both normal and degraded operating modes, signals protecting new and upgraded MCB crossings should return to danger if the crossing barriers are raised significantly above the fully lowered position.*

Network Rail should modify its standards and design practice so that signals protecting new MCB level crossings, and signals protecting MCB crossings upgraded in future, always show a stop aspect when the barriers are raised significantly above the fully lowered position (paragraph 145e).

Appendices

Appendix A - Glossary of abbreviations and acronyms

CCF	Control Centre of the Future
ERS	Emergency Release Switch
MCB	Manually Controlled Barrier (level crossing)
ORR	Office of Rail Regulation
WR	Western Region (British Railways)

Appendix B - Glossary of terms

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

Approach locking	Ensuring that a route remains available for a train after a driver has seen signals aspects indicating that it is available. At Lydney, this requires that the crossing barriers cannot be raised after a driver has seen signal aspects indicating that the level crossing is available for trains.
Annunciator	Buzzer.
Barrier pedestal	The pedestal which supports both the hinged end of a level crossing barrier and some barrier equipment.
Box instructions	A document prepared for each signal and crossing box to provide signallers/crossing keepers with location specific information. A copy of the relevant box instructions is kept in each signal/crossing box.
Circuit controller	A device, connected to rotating equipment, which makes and breaks electrical circuits depending on the amount of rotation of the equipment.
Clear (for a colour light signal)	The action of changing from a stop aspect to a proceed aspect. Also, showing a proceed aspect.
Control pedestal	At Lydney, the pedestal within the crossing box from which Lydney barriers were controlled.
Data logger	Equipment recording the times at which there are changes in the state of the relays (switches) which control signals and level crossing equipment.
Down (direction of travel)	At Lydney, towards Newport.
Fault control	An office to which all railway infrastructure faults and failures in area are reported to enable a response to be made.
Interlocking	A general term applied to equipment that controls the setting and releasing of signals, points and other apparatus to prevent an unsafe condition of the signalling system arising during the passage of trains.*
Occurrence book	A document used by crossing keepers and signallers to record events at level crossings that they are responsible for.
Proceed (signal aspect)	A green or yellow aspect permitting trains to pass a signal.
Protecting signal	A signal which displays a stop aspect until it is safe for a train to use a level crossing, junction or similar feature.

Relay	An electromechanical device that utilises an electromagnet to make and break related sets of electrical contacts.*
Three aspect signal	A colour light signal capable of displaying three aspects. These are red (stop), yellow (caution, may need to stop at next signal) and green (not required to stop at next signal).
Track circuit	An electrical or electronic device used to detect the absence of a train on a defined section of track using the running rails in an electric circuit.*
Up (direction of travel)	At Lydney, towards Gloucester.

Appendix C - Data logger

The RAIB has used information from a data logger to help establish the likely sequence of barrier operation before and during the incident. The data logger is connected to relays in the level crossing circuitry, and records when these change state. Changes in state are caused by events (eg barriers reaching the fully lowered position), or as part of the process needed to trigger actions (eg starting a barrier motor).

RAIB critically examined the data logger output provided by Network Rail, because RAIB could not inspect the data logger immediately after the incident, and because RAIB became aware of errors in the output provided by the data logger.

Network Rail reports that a data logger was first installed at Lydney level crossing in March 2010. Shortly afterwards, maintenance staff found that this data logger was defective and it was replaced.

Network Rail carried out a functional test of the replacement data logger after installation and after the incident. The post-incident testing showed that records relating to two relays had been transposed, because wiring from the data logger to these relays had been reversed. Network Rail has not established why this transposition was not found during functional testing after installation of the replacement logger.

Network Rail then corrected the transposed data logger output before supplying it to RAIB. RAIB examined the output provided by Network Rail and have established that, when the barriers were operating normally, the output showed appropriate changes of relay state. This leads RAIB to conclude that this output is reliable.

Although the data logger is considered reliable, the recorded data reflects relay state changes triggered by incorrect operation of contacts (paragraph 120). RAIB have made appropriate allowances for this when using the data logger output.

Appendix D - Lydney box instructions

NETWORK RAIL

WESTERN ROUTE

INSTRUCTIONS TO THE CROSSING KEEPER AT

LYDNEY

CONTENTS PAGE

The Lydney box instructions relating to operation of Awre CCTV level crossing, including the associated index on page 2 of the instructions, have not been reproduced in the RAIB report.

Part 1: Instructions Relating To Lydney Crossing

1. Location

This crossing is situated between Gloucester and Chepstow stations

and is 19 miles 792 yards from Gloucester, and
7 miles 1606 yards from Chepstow.

The Down direction is from Gloucester to Chepstow
The Up direction is from Chepstow to Gloucester

NOTE. All references to 'the Signaller' in these Part 1 instructions refer to the Signaller in Newport Panel Signal box.

2. Change of Crossing Keeper

2.1 When taking duty you must:

(a) ensure that you have received the necessary information from the Crossing Keeper you are relieving;
(b) enter your signature with the words "*ON DUTY AT ..... HOURS*" in the Occurrence Book.

2.2 When you are being relieved you must:

(a) ensure your relief is in a fit and proper condition to take charge;
(b) tell your relief whether the equipment is in order, whether any trains are approaching, and give him any other necessary information;
(c) enter your signature with the words "*OFF DUTY AT ..... HOURS*" in the Occurrence Book;
(d) leave as soon as your relief has taken charge.

3. Opening and Closing of Line

3.1 When the line opens for traffic you must advise the Signaller that you have commenced duty;

3.2 When the line is closed and the barriers are left open to road traffic, before leaving duty you must advise the Signaller and check that the last train has passed.

INSTRUCTIONS TO THE CROSSING KEEPER AT LYDNEY

4. Working of Barriers

4.1 The barriers must be normally open to road traffic. When a "Train approaching" indication is received, the barriers must be operated without delaying trains. Before opening the barriers to road traffic, you must ensure that any train which has passed over the crossing was complete with tail lamp, the protecting signals are at danger and the signal switches are in the normal position;

4.2 A separate "Train approaching" indicator is provided for down stopping trains. When "stopping" is selected by the Newport Signaller, you must lower the barriers for a Down stopping train as soon as it comes to a stand at Lydney station;

4.3 If it is not possible to close and secure the barriers across the roadway due to failure or damage, you must advise the Signaller and obtain an assurance that trains will be cautioned. The protecting signal may be cleared when it is safe for the train to proceed, but not until the train is closely approaching the signal. Road traffic must not be permitted to pass over the crossing until it is safe to do so;

4.4 If for any reason the "Train approaching" indication is cancelled or withdrawn you must first establish with the Newport Signaller the reason for this before the crossing is used for road traffic.

5. Checking of Indicators

The full sequence of indicator operation must be checked for the first train in each direction after 0900 daily. An entry must be made in the Occurrence Book showing the times and result of each check.

6. Emergency Working of Barriers

6.1 When the electrical supply fails the barriers automatically fall into the lowered position.

6.2 You must break the glass of the glass fronted box and remove the key to the hydraulic equipment covers. You must then go to each barrier in turn, remove the back of the barrier mechanism guard and unlock and sufficiently expose the barrier hydraulic release valves to enable them to be turned to the fully open position. You must then replace and relock the hydraulic apparatus covers. The barriers will then be free to be operated by hand.

6.3 When operated, the barriers must be moved to the full extent of their travel. Before lowering the barriers you must stop all traffic approaching the crossing and turn the special 'fail to lower' switch to the 'start light sequence' position. When the barriers have been fully lowered, you must secure the top of each barrier by means of the chain and padlock provided for the purpose.

6.4 When the barriers are required to be raised by hand raise each barrier by hand and secure it in the "Up" position using the special lock rod provided to the rear of each barrier pivot.

7. Resumption of Normal Working

7.1 Normal working may be resumed after the barriers have been brought to the "Up" position and the Signalling Technician has assured himself that the hydraulic equipment covers are securely locked, barrier mechanism guard replaced and the key has been returned to the glass-fronted box with the glass replaced.

7.2 An entry to the effect that all the apparatus is satisfactory and that normal working is being resumed must be made in the Occurrence Book and signed by the Signalling Technician and countersigned by you.

8. Crossing abuse/mis-use and failure of equipment

8.1 You must report any abuse, misuse or any equipment defects to the Signaller, and if possible to the Operations and Fault Controls at Cardiff. You must also make an entry on the Occurrence Sheets, showing the time that the abuse/misuse or equipment failure took place. In the event of equipment failure you must also record when this has been rectified.

8.2 If the road signals indicator does not become illuminated after the "Lower" button is pressed, you must treat the red road traffic signals as failed and, if practicable, immediately stop the lowering sequence. You must then lower the barriers sufficiently to indicate your intention to road users and, after a short pause, continue to lower them carefully until fully lowered.

8.3 The Signaller must be informed of the circumstances, and if it is necessary for the protecting signal to be passed at danger, you must give the Signaller an assurance that the barriers have been lowered.

8.4 If a barrier(s) fails to rise, the raising sequence must be stopped immediately and the barriers must be lowered as soon as it is safe to do so. The defective barrier(s) must then be raised manually.

8.5 The barriers must not be left unattended during a failure unless they are secured to prevent them lowering and the pedestal doors are closed.

9. Maintenance of Barriers

Routine examination of the barriers by the Technician must be carried out between trains.

10. Signal and Telecommunications Work affecting Normal Operation of Signalling Equipment

Before allowing work to start which will interfere with the normal operation of level crossing equipment, you must make an appropriate entry in the Occurrence Book, which must be countersigned by the Signalling Technician before work starts.

Authorised by: _____
Area Operations Manager, Cardiff

11. Stopping Trains in an Emergency

If it necessary to stop an approaching train in emergency, you must operate the Emergency Release Switch; exhibit a red hand signal and advise the Signaller. If no train is approaching the Signaller must be advised,

12. Single Line Working

12.1 You must make an entry in the Occurrence Book indicating on which line trains will run when you are advised that Single Line Working is introduced;

12.2. The signals for trains proceeding over the crossing in the right direction must be worked if possible. Should this not be possible the Signaller will authorise each Driver to pass the signal at Danger, having first obtained your assurance that the crossing is closed to road traffic and is clear.

12.3 Trains in the wrong direction will approach cautiously. Provided that you have closed the crossing to road traffic and it is clear, you must exhibit a green hand signal to each Driver.

12.4 You must record in the Occurrence Book when you are advised that Single Line Working is withdrawn.

13. Engineers Possession of the Line

13.1 You must make an entry in the Occurrence Book when advised by the Signaller that the Engineer has been granted or given up Possession of a running line.

13.2 Movements on the line concerned will not pass over the level crossing in either direction until the Driver is satisfied it is safe to do so.

14. Reminder Appliances

15.1 You must use a reminder appliance on the lever controlling any signalling or level crossing equipment which is disconnected or defective;

15.2 The reminder appliance must not be removed until normal working is resumed.

Authorised by:
Area Operations Manager, Cardiff

15. Emergency Release Switch

A special switch is provided for use in an emergency and this may be operated after inserting the key which is kept in a glass fronted box. Operation of this switch will immediately place signals N.165 and N.184 at danger and, after a period of two minutes will enable the barriers to be raised. In the event of a failure of equipment or a power failure you should obtain the Signaller's permission before breaking the glass of the key box.

In an emergency, you must use the switch to stop rail traffic but you must advise the Signaller of your reasons for doing so as soon as possible. If the barriers have been raised under these conditions they must be lowered before returning the switch to the normal position.

16. Working during Falling Snow

When fog or falling snow is experienced you must advise the Newport Signaller who will, if necessary, arrange for signal lights and spectacles to be cleared of snow.

17. Power Off Alarm

There is a power "on" indication and alarm which will ring if there is a power failure. The bell is silenced by turning the switch to "off". On restoring the power, the bell will ring and a lamp will light. The bell is silenced by turning the switch to "on".

Appendix E - Historical background

The railway through Lydney was constructed by the South Wales Railway and opened in 1852. The level crossing was provided with gates worked from an adjacent cabin, under the terms of the Act of Parliament which authorised the building of the line, until modernisation took place in 1974.

The lifting barriers were authorised by an Order (the Lydney Station Level Crossing Order) made on 14 February 1974 under section 124 of the Transport Act 1968. This sets down detailed requirements for the equipment and protection arrangements for the level crossing, and remains in force (with one subsequent minor amendment) at the time of writing.

The Order was drawn up taking account of the 'Requirements of the Secretary of State for the Environment for public level crossings equipped with manually controlled barriers', issued in April 1973. The content of this document has been updated and re-issued under various titles since 1973. The current version is contained in the ORR's 'Railway Safety Publication 7, Level Crossings: a guide for managers, designers and operators', issued in August 2011.

The wording in these documents relevant to the interlocking between the protecting signals and the barriers is:

- 1973 Requirements: 3.1 'It shall not be possible to raise the barriers until the signals are replaced to Danger."
- 1974 Order: (14) '…it shall not be possible to raise the barriers from their position across the carriageway unless the protecting signals are at danger…'
- 2011 Guide: Chapter 2, para 54: "Interlock these signals with the lifting barriers so that it is not possible to clear the signals unless the road is fully closed by the barriers. It should not be possible to raise the barriers unless the signals are set at Stop and are free of *approach locking*, or the train has passed the signal and traversed the crossing."

Witness evidence is that level crossing designers understood that these provisions applied only to the power operation of barriers in normal circumstances. They did not envisage that there should be arrangements enforcing the return of signals to danger if the 'down' detection of the barriers was lost, or by extension if the barriers were deliberately raised by hand. The reasons behind this are discussed in paragraphs 108 to 111.

Recent level crossing Orders (now made under the Level Crossings Act 1983) have codified this practice: for example, the Order for Midgham level crossing, made in 2005, says 'protecting signals shall be interlocked with the barriers so that it shall not be possible, other than by hand, to raise the barriers from their positions across the carriageways unless the protecting signals are set at danger'.

Appendix F - Lydney barrier fault records

Date	Source*	Fault description, duration and remedial work.
10 March 2010	fault control	Up side barrier failure, 2 hours duration, contacts adjusted.
13 March 2010	fault control	Up side barrier failure, 4 hours duration, microswitch adjusted.
14 March 2010	NR inv.	Up side barrier not raising, duration & resolution not recorded.
21 March 2010	NR inv.	Down side barrier not raising, duration & resolution not recorded.
22 March 2010	NR inv.	Down side barrier not raising, duration & resolution not recorded.
4 April 2010	NR inv.	Up side barrier not raising, duration & resolution not recorded.
21 May 2010	NR inv.	Down side barrier not raising, duration & resolution not recorded.
22 May 2010	fault control	Barriers not raising, duration & resolution not recorded; probably repaired before fault reported on the next day.
23 May 2010	fault control	Barriers not raising, duration & resolution not recorded.
8 June 2010	fault control	Up side barrier failure, 6 hours duration, travel/microswitch adjusted.
15 June 2010	fault control	Barriers not raising, duration & resolution not recorded.
5 February 2011	fault control	Barriers failed down, no fault found, possibly due to high winds.
8 February 2011	fault control	Up barrier failed, 1.5 hours duration, new contact assembly fitted.
4 March 2011	occ. book	Up barrier failed, 1.5 hours duration, adjustments made but detail not recorded.
6 March 2011	occ. book	Up barrier failed, duration & resolution not recorded.
7 March 2011	occ. book	Up barrier failed, 1.5 hours duration, resolution not recorded.
23 March 2011	occ. book	Up barrier failed; incident occurred about 1.5 hours after this occurred. New contact assembly (circuit controller) fitted.
Post-incident events		
24 March 2011	occ. book	Down side barrier failed, duration 6 hours including short period when fault self corrected, resolution not recorded.
25 March 2011	occ. book	Down side barrier failed, duration 8 hours including short period when fault self corrected, resolution not recorded.
5 April 2011	occ. book	Barriers “slamming down” – normal working not affected.
6 April 2011	occ. book	Down side barrier failed, duration 2.5 hours, resolution not recorded.

* The following sources have been used. Some events are shown in more than one source. In these instances, only one source is listed above.

- fault control = from Network Rail’s fault control database.
- NR inv. = from Network Rail formal investigation report covering the 23 March 2011 incident.
- occ. book = occurrence book entry made by Lydney crossing keeper.

Appendix G - Comparison of box instructions

G.1 Crossing Box Instructions

RAIB studied selected elements of the box instructions, equipment and operating practices applicable in June 2011 at four crossing boxes on Network Rail's Western route. RAIB identified the following inconsistencies.

G.2 Box instructions inconsistent with operating practices

Box instructions and operating practices are inconsistent at locations marked 'X' in the table below. The instruction is not applicable, or consistent with operating practice, at other locations. The RAIB study did not include establishing how the box instructions and/or the operating practices should be modified to achieve consistency.

Instruction and RAIB observation	Location			
	Caldicot	Lydney	Causeway	Puxton & Worle
Instruction: barriers should be secured with chains and padlocks when they have been lowered manually for the passage of trains. Observation: the barriers are not normally locked down when they are being lowered and raised by hand for each train.		X	X	X
Instruction: barriers fall automatically if the electrical supply fails. Observation: barriers remain in the raised position because they are hydraulically operated (alternatively, if there is a leak in the hydraulic system, the barriers lower gradually).	X	X		
Instruction: the key required to raise barriers manually is kept in a break-glass-to-access box. Observation: the key is hung on an unprotected hook.	X	X		
Instruction: crossing keepers should "ensure that...the protecting signals are at danger and the signal switches are in the normal position" before raising barriers for road traffic. Observation: the crossing keeper has no means of determining whether the protecting signals are at danger.		X		
Instruction: an indicator, operated by Newport signallers, is provided in Lydney box to advise crossing keepers when a train on the down line will be stopping at Lydney station. The box instruction describes how this should be used to avoid barriers being lowered for an excessive period while a train is stopped at Lydney station. Observation: the indicator is not used and is not operated by Newport signallers.		X		

Instruction and RAIB observation	Location			
	Caldicot	Lydney	Causeway	Puxton & Worle
Instruction: a warning bell normally sounds when a train approaches but does not do so if two trains arrive close together in the up direction. Observation: the bell does not sound for a second closely following trains in the down direction.	X			
Instruction: varying requirements for signalling technicians to sign the occurrence book when working on barrier and signalling equipment. Observation: technicians often work on equipment without signing the occurrence book – they normally liaise with the crossing keeper in person or by phone.	X	X	X	X
Instruction: explicit or implied requirement that emergency working should be implemented if technicians are working on barriers. Observation: emergency working, as described in the box instructions, is often not implemented during maintenance work. When emergency working is not implemented, crossing keepers use reminder appliances as a prompt for them to ensure that the technicians are clear of equipment before the crossing controls are operated. The use of reminder appliances for this purpose is not explicitly mentioned in any of the box instructions.	X		X	
Instruction: if a fault prevents normal barrier operation, the instructions require (or suggest) attendance of a signal technician before normal operation resumes. Observation: if a fault self-corrects before a technician arrives, crossing keepers reinstate normal working without waiting for the technician.	X	X	X	X

G.3 Inconsistencies between instructions for different boxes

The following requirements are applicable at all, or almost all, locations visited by RAIB. The requirements are not included in the box instructions for some of the locations where they are relevant. If the subject matter is covered by general training, or by other means, it may be appropriate to omit the requirement from all box instructions. RAIB's findings are summarised below using the following key:

✓ = requirement applicable and given in box instructions for this location;

O = requirement applicable, but not in box instructions for this location;

n/a = requirement not applicable, and not in box instructions, at this location.

Requirement *and RAIB note*	Location			
	Caldicot	Lydney	Causeway	Puxton & Worle
Normal operation of the crossing can continue, relying on signal switch positions, if signal indicators are known to be defective. *The signal switches are used by the crossing keeper to control the aspect of the protecting signals. The signal indicators show the crossing keeper whether the protecting signals are actually showing a stop aspect*.	O	n/a	O	✓
Crossing keeper to inform the signaller if the crossing keeper becomes aware that the protecting signal is defective.	O	O	O	✓
Instructions for manual operation of barriers include an explicit requirement for crossing keeper to contact the signaller before raising barriers manually.	O	O	O	✓
Instructions given for manual operation explicitly include requirement for crossing keeper to place signals to danger.	✓	n/a	O	✓
Instructions given for passing trains over the crossing under caution if the barriers cannot be lowered.	✓	✓	✓	O
Instructions state that the red warning lights on the barrier must be illuminated during darkness, fog and falling snow. *There is no other instruction about these lights and the crossing keeper cannot switch them on or off. The crossing keeper could report any defects.*	✓	O	✓	✓
Instructions are given for leaving the barriers unattended if defective.	✓	✓	✓	O
Label, signed and dated, to be attached to track circuit indicators if defective or if they will not operate in the usual manner due to an unusual train movement.	O	O	O	✓
Phone to signaller to be tested daily. *There is a phone at all locations.*	O	O	✓	O

Appendix H - Key documents

Railway Inspectorate publication (April 1973)	Requirements of the Secretary of State for the Environment for public level crossings equipped with manually controlled barriers
Office of Rail Regulation publication (August 2011)	Railway Safety Publication 7, Level Crossings: a guide for managers, designers and operators
Network Rail standard NR/L2/OPS/100 (June 2008)	Provision, risk assessment & review of level crossings
Network Rail standard NR/L3/OCS/041 (revised quarterly since 2009 and twice annually in earlier years)	The Operations Manual (includes numbered procedures)
Network Rail standard NR/L3/SIG/30018 (September 2009)	Signalling design: technical details: level crossings

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