Rail Accident Investigation Branch

RAIB Bulletin 03/2013

Signal NW36 passed at danger at Norton-on-Tees West, 16 January 2013

Description of the incident

1 At about 07:45 hrs on Wednesday 16 January 2013, train 1A60, the 06:45 hrs Grand Central Railway service from Sunderland to London King's Cross, passed signal NW36 at danger at Norton-on-Tees West and passed over a level crossing adjacent to Norton-on-Tees West signal box. The barriers were still raised and the crossing was open to road traffic. The Norton-on-Tees West signaller saw that two cars, one in each direction, had stopped at the level crossing as train 1A60 was passing over it. The train should have stopped at signal NW36. The driver of train 1A60 was unaware that he had passed the signal at danger and the train continued on its journey. It was not stopped until it reached Bowesfield, around 3.5 miles (5.6 km) beyond Norton-on-Tees West. There were no other trains in the area at the time of the incident, so there was no risk of a collision between trains.

The location and method of operation

2 Signal NW36 is a semaphore stop signal (see paragraphs 3 and 5) located near Norton-on-Tees West signal box on the line from Ferryhill. Norton-on-Tees West, Norton-on-Tees East and Norton-on-Tees South junctions form a triangle with passenger trains normally only running between Norton-on-Tees South and Norton-on-Tees East and vice versa (figures 1 and 2). The signal box at Norton-on-Tees East is normally closed, only being opened if trains are required to run between Norton-on-Tees East and Norton-on-Tees West. The line from Ferryhill (on the East Coast Main Line) to Norton-on-Tees South via Norton-on-Tees West is normally used by freight trains, but is occasionally used as a diversionary route for passenger trains.

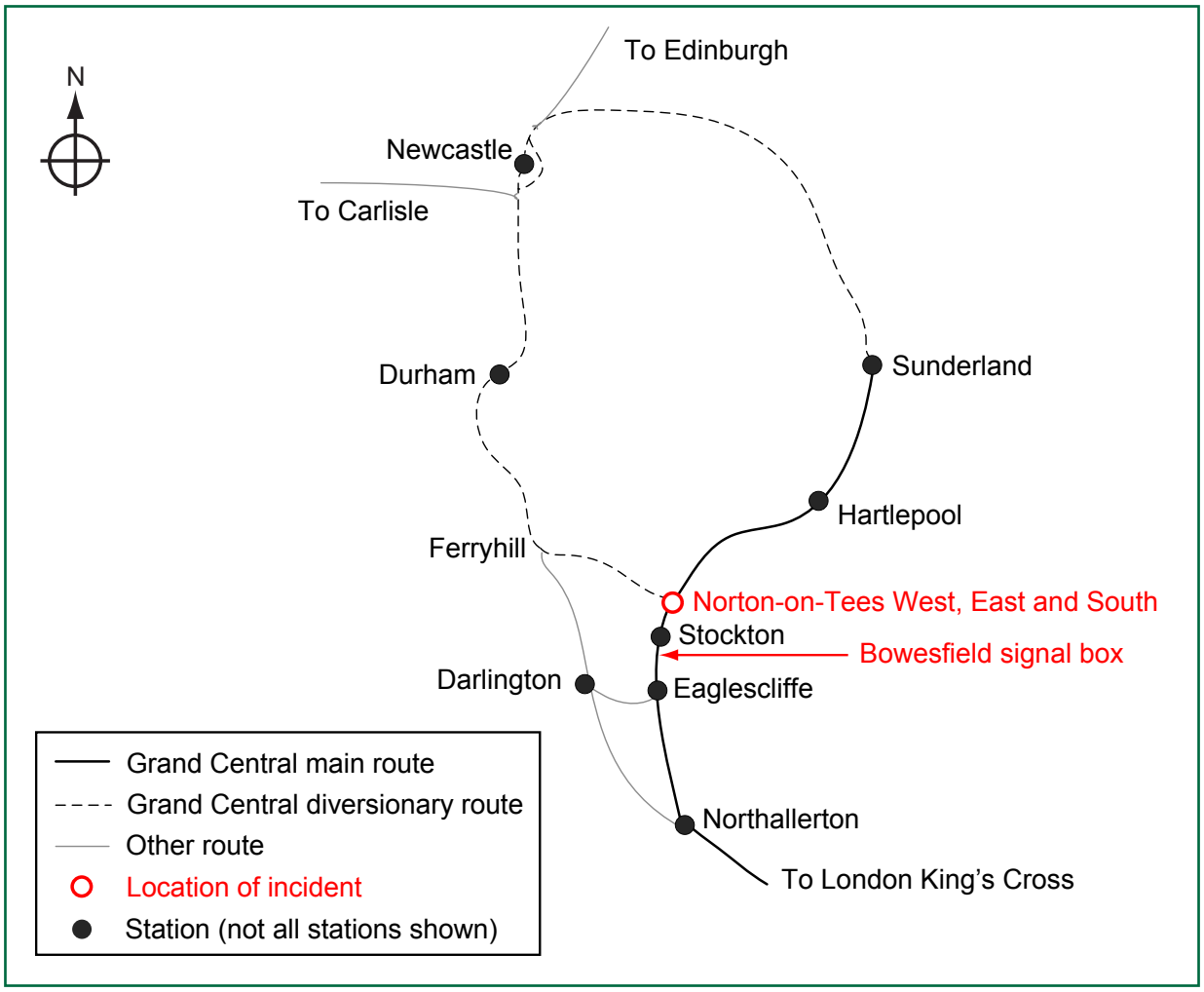

Figure 1: The main and diversionary routes used by Grand Central services between Sunderland and Norton-on-Tees (not to scale).

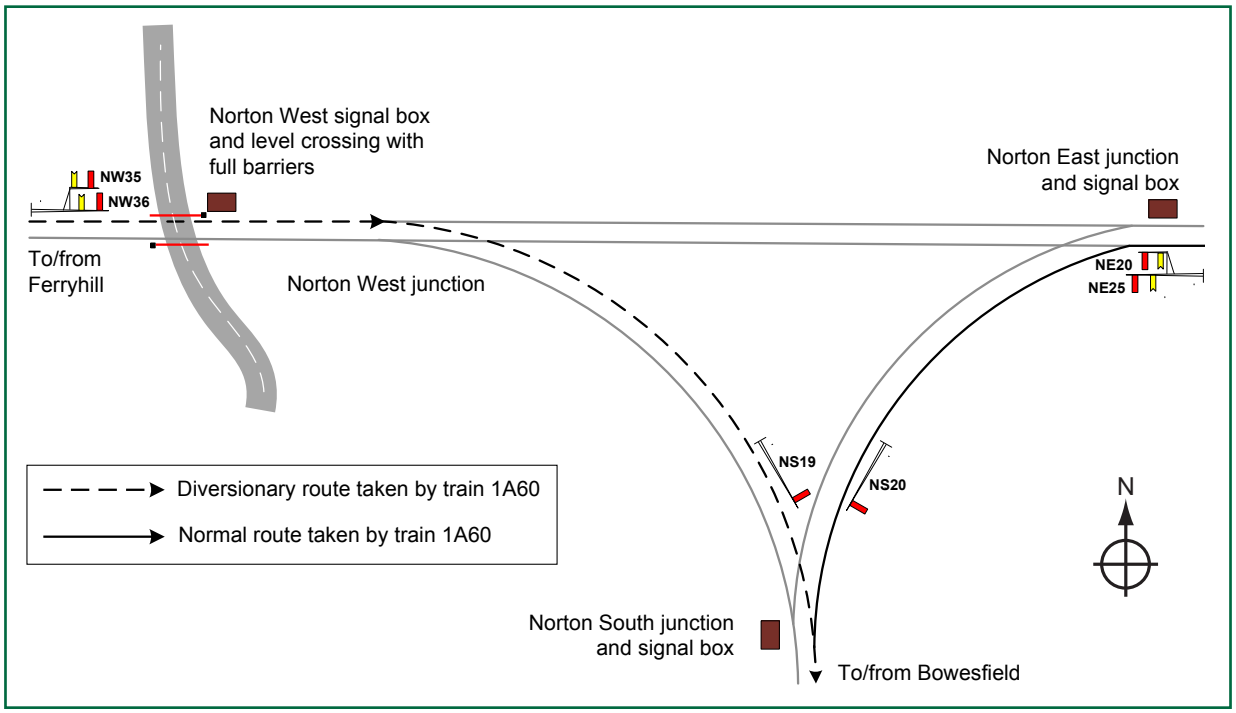

Figure 2: Key features of the route between Norton-on-Tees West, Norton-on-Tees South and Norton-on-Tees East (not to scale and not all signals shown).

3 A semaphore stop signal generally comprises a moveable rectangular arm coloured red with a vertical white stripe towards its outer end. When the arm of a semaphore stop signal is raised or lowered at 45º, the signal is referred to as being 'off', and a train is permitted to pass it. When it is in the horizontal position, it is referred to as being 'on', and the driver must stop at it. Semaphore stop signal NW36 (see figure 3) is controlled by the signaller at Norton-on-Tees West signal box and functions as the home signal[1] for Norton-on-Tees West, and the section signal[2] for the line between Norton-on-Tees West and Norton-on-Tees South. If signal NW36 is off (ie in the raised position), it indicates to the driver that a route is set towards Norton-on-Tees South and that it is also safe to proceed over the level crossing ahead. Another semaphore stop signal, NW35, is mounted on the same structure. When signal NW35 is off, it indicates to the driver that a route is set towards Norton-on-Tees East and that it is also safe to proceed over the level crossing ahead. Thus the driver of a train approaching the signal gantry at Norton-on-Tees West is informed about which route has been set for the train by whether signal NW35 or signal NW36 is off.

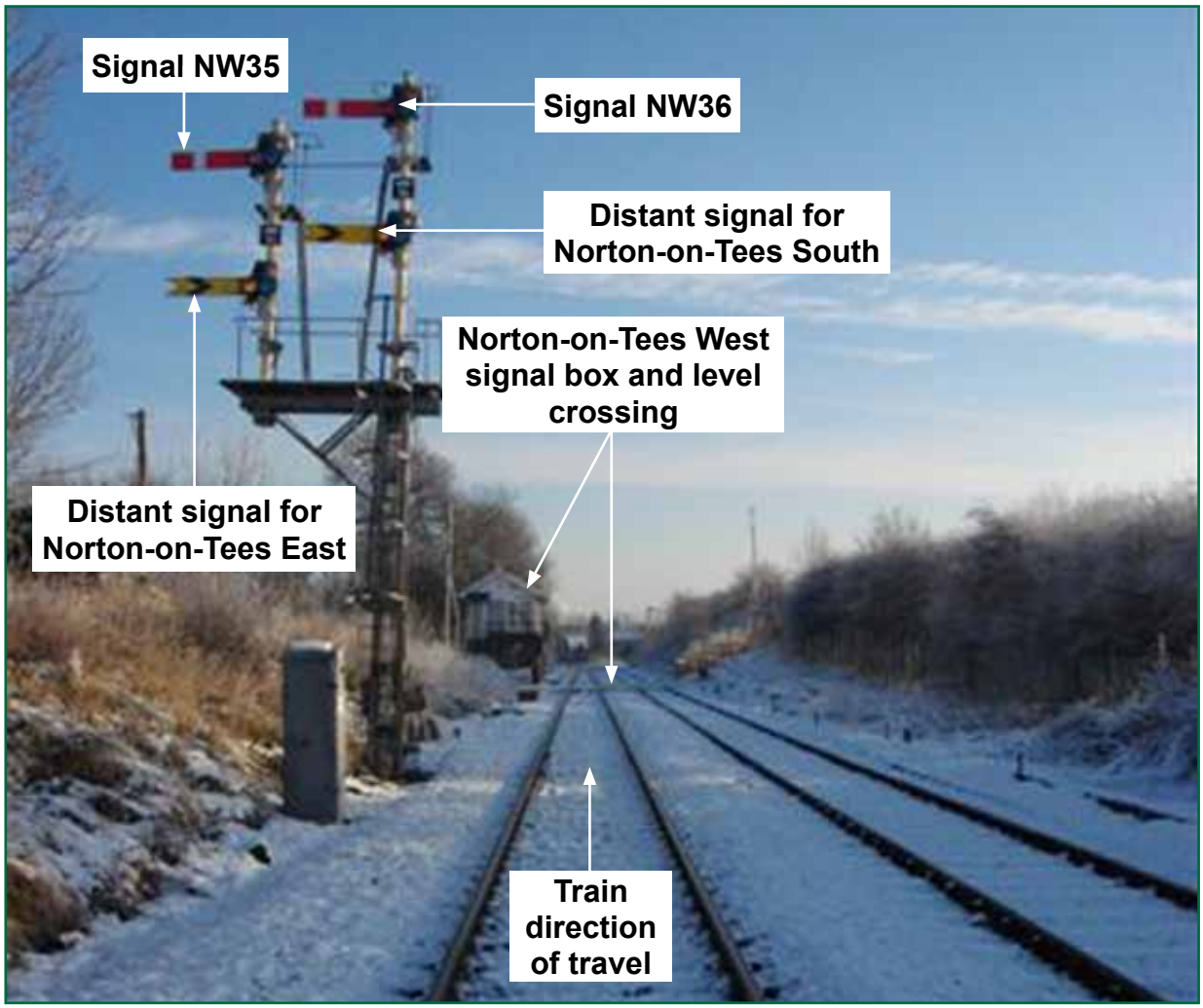

Figure 3: The signal structure at Norton-on-Tees West. Signal NW36 is the top right-hand signal. The distant signal for Norton-on-Tees South is directly below it.

[1] A home signal is the first stop signal on the approach to a signal box in an area signalled by the absolute block system.

[2] A section signal is a stop signal that controls access to the next signal section in an area signalled by the absolute block system.

4 Immediately below signals NW35 and NW36 are semaphore distant signals. A distant signal generally comprises a rectangular arm coloured yellow with a 'v'-notched end and a black 'v' marking towards its outer end. Drivers do not have to stop at semaphore distant signals, which exist to advise drivers of the position of stop signals ahead (signals NS19 and NS18 in the case of the route towards Norton-on-Tees South). If a semaphore distant signal is on, it informs the driver that the next stop signal ahead is also on. If a semaphore distant signal is off, it tells the driver that all the stop signals associated with the distant signal are also off.

5 When it is dark, a driver may be unable to see the position of a semaphore signal arm. Lamps are provided adjacent to the signal post, which display different coloured aspects according to the position of the arm. When a semaphore stop signal is on, a red light is displayed. When it is off, a green light is displayed. When a semaphore distant signal is on, a yellow light is displayed. When it is off, a green light is displayed.

6 Thus when a driver approaches a semaphore stop signal mounted above a semaphore distant signal in hours of darkness, a red light will be displayed above a yellow light when both signals are on. If the stop signal is off and the distant signal on, a green light will be displayed above a yellow light.

7 The level crossing barriers are interlocked with signals NW36 and NW35 so that neither signal can be moved to the off position unless the barriers are correctly lowered across the road.

8 The route between Ferryhill and Norton-on-Tees West has no track circuits[3] until the short section of track between Norton-on-Tees West signals NW35/NW36 and Norton-on-Tees West signal box (a distance of 50 metres). The signaller is therefore not able to identify the location of an approaching train until it can actually be seen at around 400 metres on the approach to the signal box, or 350 metres before it reaches signals NW35/NW36.

9 The lines between Ferryhill and Norton-on-Tees West, and Norton-on-Tees West and Norton-on-Tees South are signalled in accordance with the absolute block regulations. This means that when a train is to be routed from Norton-on-Tees West to Norton-on-Tees South, the following sequence of actions is necessary before signal NW36 can be moved to the off position (simplified to those actions relevant to the incident):

a) The signaller at Norton-on-Tees West offers the train to the signaller at Norton-on-Tees South, on the block instrument[4] by tapping a bell-code[5] that is heard in the signal box at Norton-on-Tees South.

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[3] Track circuits are low-voltage electrical circuits used in the operation of signalling equipment to provide information on the presence or otherwise of a train.

[4] A block instrument is a device which often incorporates a tapper used by the signaller to send a defined code on a single-stroke bell (referred to as a 'bell-code') to the signaller at the next signal box, and a three-position indicator that describes the status of the line between the two signal boxes. The indicator is operated by a switch in the block instrument at the other signal box. The status of the line shown on the indicator can be 'normal' (no train present), 'line clear' (the signallers have agreed that a train can pass between the two boxes, but it has not yet arrived) and 'train on line' (a train is occupying the section between the two boxes).

[5] There are many different bell codes, which are differentiated from each other by the number of beats and by the way in which the beats are grouped, eg 4-5-5 is the bell code for a train proceeding without authority.

b) If the signaller at Norton-on-Tees South is in a position to do so, he will accept the train by repeating the bell-code and placing the block instrument to 'line clear' (he does not respond if he is not able to accept the train).

c) Once the signaller at Norton-on-Tees West has received 'line clear' from Norton-on-Tees South, he lowers the level crossing barriers and is then able to clear signal NW36 to the off position.

d) When the approaching train has passed signal NW36, the signaller at Norton-on-Tees West sends the 'train entering section' bell-code to Norton-on-Tees South.

e) The signaller at Norton-on-Tees South acknowledges the bell-code and places the block instrument to 'train on line'. The signaller at Norton-on-Tees South now knows that the train is approaching. The section of line between Norton-on-Tees South and Bowesfield is operated under the track circuit block system, and the signaller at Norton-on-Tees South can clear signal NS19 for a train to proceed towards Bowesfield providing that the section ahead is not occupied by another train.

Sequence of events

10 The driver of train 1A60 booked on duty at Sunderland depot and was informed by the controller[6] that owing to a broken rail south of Sunderland, his train would not take its normal route south to Stockton via Hartlepool and Norton-on-Tees East Junction, but would instead be diverted via Durham, Ferryhill and Norton-on-Tees West Junction, regaining its usual route at Norton-on-Tees South Junction.

11 The signaller at Norton-on-Tees West was not aware that train 1A60 had been diverted until it was offered to him by the signaller at Ferryhill. As was normal for trains approaching from Ferryhill, the signaller at Norton-on-Tees West did not immediately offer the train to the signaller at Norton-on-Tees South when he received 'train entering section' from Ferryhill because he did not intend to lower the barriers at the level crossing and clear signal NW36 until the train was close. The section between Ferryhill and Norton-on-Tees West is 10 miles (16 km) in length, and he wished to minimise the time that the crossing would be closed to road traffic. He did, however, send the signaller at Norton-on-Tees South a non-standard[7] bell code which indicated that a train was on its way from Ferryhill, as was normal practice amongst the Norton-on-Tees signallers. It was intended to act as a preliminary warning to the signaller at Norton-on-Tees South, who was not required to take any action other than be aware.

[6] Another train operator, Cross Country, provides the control function for Grand Central Railway.

[7] The signallers' local managers were aware that this local non-standard bell code existed. It had been in use for many years, long before the current local management team were established, and originated from a period of time when a significant number of freight trains used the route. No signal box special instruction had been approved by Network Rail for this method of work.

12 As train 1A60 approached signal NW36, the driver looked for the right-hand pair of signals (for the route to Norton-on-Tees South) and focused on the yellow light on the distant signal. Even though the driver recognised that signal NW36 was showing a red light (ie 'stop'), the driver was thinking ahead to the next stop signal towards Norton-on-Tees South. The on-train data recorder fitted to train 1A60 recorded that signal NW36 was passed at danger at a speed of 25 mph (40 km/h). The line speed on the approach to Norton-on-Tees West Junction is 40 mph (64 km/h) reducing to 25 mph (40 km/h) through the junction towards Norton-on-Tees South.

13 The signaller at Norton-on-Tees West had not noticed train 1A60 approaching and therefore did not lower the level crossing barriers and clear signal NW36. The signaller heard the relay associated with the track circuit beyond the signal (paragraph 8) 'click' and turned to see train 1A60 passing over the level crossing (located 53 metres beyond signal NW36).

14 Train 1A60 continued towards Norton-on-Tees South. The signaller at Norton-on-Tees West attempted to send the bell code for 'train proceeding without authority' to the signaller at Norton-on-Tees South, but did not mark the pauses clearly (see footnote 5 to paragraph 9a) and the latter did not understand the bell-code. The signaller at Norton-on-Tees South saw that train 1A60 was approaching and assumed that he had accepted it (without checking the block instrument (paragraph 9b), which would have indicated otherwise) and operated the lever to clear signal NS19. Train 1A60 was therefore able to continue towards Stockton and Bowesfield.

15 The signallers at Norton-on-Tees West and Norton-on-Tees South then spoke to each other by telephone and established that signal NW36 had been passed at danger. The signaller at Norton-on-Tees South telephoned the signaller at Bowesfield and told him to stop train 1A60 so that the necessary steps could be taken to make an initial investigation into the circumstances of the incident.

RAIB investigation

The actions of the driver of train 1A60

16 The driver of train 1A60 had been instructed on semaphore signalling during his initial training in 2008. The assessments that he undertook during his training indicated that the driver had understood the meaning of the different types of signal, including the configuration of stop signal above distant signal and the associated lights displayed during hours of darkness. The driver was also assessed on his knowledge of the semaphore signalling on the diversionary route in the Norton-on-Tees area when he was initially deemed competent on the route in October 2010. Since qualifying, the driver had been reassessed on semaphore signalling as part of Grand Central Railways' competence management system. This reassessment focused on the basic principles of semaphore signalling. There was no requirement to re-assess the driver's knowledge of the semaphore signalling on the diversionary route around Norton-on-Tees after the initial assessment of his route knowledge.

17 The driver misread signal NW36, focusing on the yellow light displayed on the distant signal rather than the red light displayed on the stop signal mounted above. It is possible that he approached signal NW36 with a pre-conceived idea that his train would be routed past it and towards Norton-on-Tees South and signal NS19. When he saw the yellow light, he misunderstood this to mean that he was able to proceed towards signal NS19.

18 The driver was familiar with the diversionary route, and had last worked over it in December 2012. The driver's familiarity with the route may have contributed to the signal being passed at danger because he stated that he could not recall ever having been stopped at signal NW36 during previous journeys. Knowing that trains were rarely routed from Norton-on-Tees East to Norton-on-Tees West, he would not have expected to have to stop at Norton-on-Tees West.

19 The configuration of a semaphore stop signal over a semaphore distant signal was something that the driver of train 1A60 would have seen on the normal route south from Sunderland at Billingham, Norton-on-Tees and Norton-on-Tees East. However, it would have been unusual for him to encounter the stop signal at Norton-on-Tees East in the on position because Norton-on-Tees East signal box is normally closed (paragraph 2) and the signals worked from it are left in the off position.

20 The incident occurred before sunrise (which was at 08:17 hrs on 16 January at nearby Stockton), so the driver was largely dependent on seeing and understanding the meaning of the lights displayed by the signals rather than the orientation of the arms. The RAIB observed that from 300 - 400 metres, the yellow light of the distant signal appeared brighter than the red light of signal NW36 above it and, even in daylight, the trees behind the signal structure had the effect of making the lights stand out more than the actual orientation of the signal arms (figure 4).

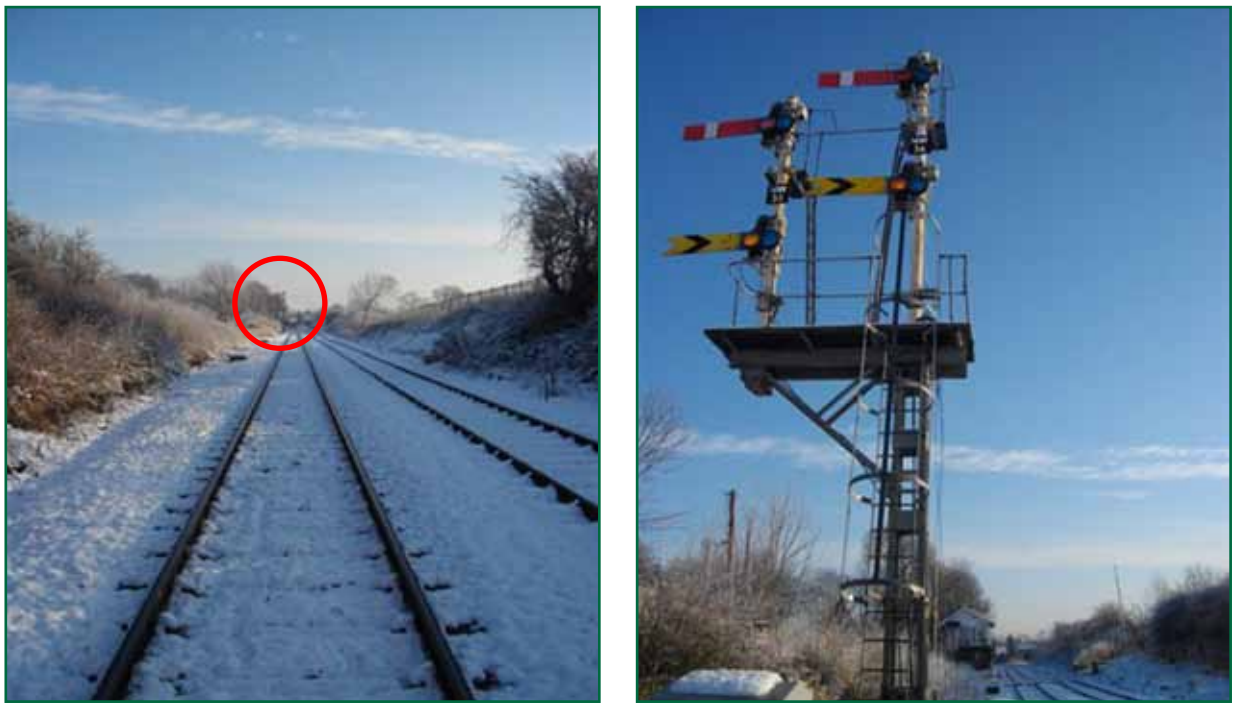

Figure 4: Trees providing a dark background behind the signal structure (left) and the red and yellow light lenses of signal NW36 and the distant signal below (right). Note that the photographs are taken during daylight and not at drivers' eye level.

21 The driver did not realise he had passed signal NW36 at danger. He also did not notice that the barriers at the level crossing at Norton-on-Tees West signal box were raised. This was probably because he was focusing on controlling the train's speed to 25 mph (40 km/h) through the junction.

Previous relevant incident

22 On 2 December 2009, a train operated by Grand Central Railway passed a semaphore stop signal at danger without authority at Seaham between Sunderland and Hartlepool. The signal involved had a 'stop above distant' configuration similar to signal NW36, although it only comprised one stop signal and one distant signal. A joint investigation between Network Rail and Grand Central Railway identified that the driver had misunderstood the meaning of the signals. The driver involved was experienced, having worked for a freight train operator for six years before joining Grand Central Railway. Although it had not been responsible for his original training, Grand Central Railway had assessed the driver's competence in semaphore signalling, but had not identified that he did not fully understand the meaning of the configuration that he encountered on 2 December 2009. Following the incident at Seaham, Grand Central Railway issued a briefing notice to its drivers about the causes. The driver of train 1A60 could not recall the details of the briefing but did remember the incident at Seaham.

Infrastructure issues

23 The driver of train 1A60 received a caution indication and an audible warning[8] at the distant signal located just under ¾ mile (around 1.2 kilometres) from signal NW36. However, this signal was a 'fixed distant' signal, which meant that irrespective of whether signal NW36 was on or off, the driver would always receive a warning. The fixed distant signal did not provide any additional information to drivers about the actual status of signal NW36, although drivers are trained to respond to it by assuming that signal NW36 is on until its actual status can be confirmed.

24 Where a semaphore stop signal (such as signal NW36) is located above a semaphore distant signal, a driver may see one of three possible combinations of lights when approaching in hours of darkness:

a. green (stop signal) above green (distant signal) – the driver can pass the stop signal and is advised that all stop signals associated with the distant signal are also off;

b. green (stop signal) above yellow (distant signal) – the driver can pass the stop signal, but is advised that the next stop signal is on; or

c. red (stop signal) above yellow (distant signal) – the train must stop at the stop signal.

25 Slotting[9] prevents a red (stop signal) above a green (distant signal) combination from being displayed.

[8] The audible warning was from the Automatic Warning System (AWS). The purpose of the AWS is to give train drivers in-cab information on the approach to AWS fitted signals and speed restrictions. For example, when approaching a semaphore distant signal in the 'off' position, a bell sounds in the driving cab and the AWS visual indicator will show black. When approaching a semaphore distant signal in the 'on' position, a warning horn is sounded in the cab and the AWS visual indicator will show black with yellow segments. If the train driver does not acknowledge an AWS warning by pressing the AWS reset button within a set time period (1.9 or 3 seconds depending on the type of train), the emergency brakes will apply to stop the train.

[9] In this case, the use of weight bars on the signal post to prevent conflicting indications being displayed.

26 The combination of a red light above a yellow light is one that is not encountered by drivers when operating in areas where colour light signalling is installed. The yellow light of the distant arm of signal NW36 was closest to the driver's eye-line and stood out more clearly than the red. While the driver of train 1A60 worked over semaphore-signalled routes almost every shift, and thus passed through other locations where there was a stop signal above a distant signal, he rarely encountered them in any configuration other than both being off (ie displaying two green lights in hours of darkness).

27 Another factor associated with the interpretation of semaphore signals where a stop signal is located above a distant signal, is that drivers are simultaneously being presented with information of immediate relevance (conveyed by the position of the stop signal) and information of secondary relevance (regarding the position of the next stop signal, conveyed by the position of the distant signal). It is possible that drivers might focus on the information being conveyed by the distant signal and lose focus on the stop signal they are approaching.

28 Signal NW36 was not equipped with the train protection and warning system (TPWS), which would have automatically applied the train's brakes when the signal was passed at danger. Signal NW36 was not selected for fitment of TPWS because:

a. the interlocking arrangements prevent a train continuing head-on towards another train, ie if a train is routed from Norton-on-Tees East to Norton-on-Tees West, signal NW36 would be on and the points at Norton-on-Tees West would be set so that if a train passed signal NW36 in the on position, it would be routed towards Norton-on-Tees East, thereby avoiding the conflict; and

b. TPWS equipment is not required where the only potential for collision is with the rear of another train, on the same track, travelling in the same direction.

29 The signallers at Norton-on-Tees West are reliant upon their own vigilance to detect the approach of trains from Ferryhill. There are no audible alarms or visual indications in the signal box to inform the signaller when a train is approaching. If a signaller is carrying out other tasks, or becomes distracted, the signal will remain at danger. This has the potential to create a 'SPAD trap' for drivers who may have become accustomed to seeing clear signals on the approach to Norton-on-Tees West.

The actions of the signallers at Norton-on-Tees West and Norton-on-Tees South

30 The signaller on duty at Norton-on-Tees West had around 5 years experience. He had only worked at Norton-on-Tees West signal box. The signaller on duty at Norton-on-Tees South had around 12 years experience in that role and had been trained to work at several boxes in the Norton-on-Tees area. Network Rail had no concerns about the competence of either signaller. Both had been subject to Network Rail's competence management system, which features six-monthly assessments on designated topics. In 2011 both signallers were assessed on dealing with a train passing a signal at danger and not stopping. Both signallers successfully passed the assessment.

31 For the reasons stated in paragraph 29, the signaller at Norton-on-Tees West was not aware of the approach of train 1A60 until it had passed signal NW36. He tried to warn the signaller at Norton-on-Tees South of the unauthorised approach of train 1A60, but in the heat of the moment, sent a bell code that was not understood by the Norton-on-Tees South signaller.

32 The signaller at Norton-on-Tees South should not have cleared signal NS19 as train 1A60 approached. He did so because he became confused about whether he had given permission for train 1A60 to approach. Had he looked at the block instrument (paragraph 9b), he would have realised that he had not done so, and maintained signal NS19 at danger. It is likely that the driver of train 1A60 would have stopped at signal NS19 because he had seen the associated distant signal showing a yellow light and he had seen signal NS19 in the on position when it first came into view.

33 One possible explanation for the Norton-on-Tees South signaller's confusion was the use of the non-standard bell-code by the signaller at Norton-on-Tees West (paragraph 11). If the signaller at Norton-on-Tees South was not aware that train 1A60 was expected, it is unlikely that he would have had any reason to assume that he had made a mistake when he received the bell-code that was sent by the signaller at Norton-on-Tees West after train 1A60 had passed signal NW36 at danger.

34 The Norton-on-Tees area is to be re-signalled in about two years time. As part of this work the semaphore signals will be replaced by colour lights and the signal boxes will be decommissioned, with the operation of the signals and associated equipment being transferred to a signalling centre. In the meantime, Network Rail has instructed the signallers not to use the non-standard bell-code but to instead communicate with each other by telephone. Grand Central Railway briefed its drivers on the circumstances of this incident. The brief included diagrams that explained the meanings of semaphore signals which feature a stop signal above a distant signal including the combination of lights displayed during darkness.

Learning points[10]

35 The RAIB has decided not to conduct a full investigation as it does not believe that an investigation would lead to the identification of any further recommendations. However, this incident provides some important learning points for the rail industry to consider:

a) Areas currently signalled using semaphore signals are being progressively converted to colour light signalling, and drivers may thus be exposed to semaphore signalling, and its operational characteristics, less often. This emphasises the importance of train operating companies reviewing training and route assessments for drivers on semaphore signalling, and importantly, how that competence is maintained. Factors for consideration include drivers' understanding of the meanings of semaphore signals where a stop signal for one signal box and the distant signal for the next signal box are located one above the other, and the differences in interpreting these signals in daylight and darkness.

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

b) Drivers need to be aware when they are approaching parts of a route when enhanced levels of concentration are necessary. A high standard of non-technical skills[11] may assist drivers in improving their awareness of their current situation, and planning the appropriate actions necessary to ensure the continued safe working of the train.

c) Infrastructure managers need to take the necessary action to ensure they are aware of non-standard signalling practices and consider the potential hazards associated with their use to determine the benefits and the risk. Having done so, Network Rail can decide whether to implement them formally, for example by issuing signal box special instructions, or to prohibit their use.

d) Simulation provides an opportunity for signallers to practise non-standard and emergency situations that they might encounter rarely, such as a train failing to stop after passing a semaphore stop signal which is on. The RAIB made a recommendation to Network Rail about the use of simulators to test signallers' responses to rarely-experienced scenarios in its investigation of a SPAD at Lewes on 30 November 2006 (RAIB report 25/2006 (part 2) available at (www.raib.gov.uk). In response to this particular recommendation, Network Rail incorporated simulation of rarely-experienced scenarios into its competence management system for signallers. This included using computer-based simulation of a semaphore signalled area. However, at signal boxes such as Norton-on-Tees West and Norton-on-Tees South, there is benefit to be obtained from signallers also practising some abnormal or emergency scenarios at the signal boxes they work at or other similar locations because it enables them to use the actual equipment that will be used in practice.

[11] Non-technical skills are generic skills that help people to anticipate, identify and mitigate against errors. Improved performance in non-technical skills can be achieved by all grades of staff, whether experienced or inexperienced, and improvements can be achieved by individuals who already have a good level of performance as well as those for whom further development is necessary to reach a satisfactory level. Further information is available at www.rssb.co.uk/EXPERTISE/HF/Pages/NON-TECHNICALSKILLS.aspx

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