Railway Accident Investigation Unit Ireland

Investigation Report

Bearing failure on a train at Connolly Station, 18th October 2011

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Reader guide

All dimensions and speeds in this report are given using the International System of Units (SI Units). Where the normal railway practice, in some railway organisations, is to use imperial dimensions; imperial dimensions are used and the SI Unit is also given.

All abbreviations and technical terms (which appear in italics the first time they appear in the report) are explained in the glossary.

Descriptions and figures may be simplified in order illustrate concepts to non technical readers.

Report preface

The RAIU is an independent investigation unit within the Railway Safety Commission (RSC) which conducts investigations into railway accidents and incidents on the national heavy rail network, the light rail network, heritage railways and industrial railways in Ireland. Investigations are carried out in accordance with the Railway Safety Directive 2004/49/EC and the Railway Safety Act 2005.

The RAIU investigates all serious accidents. A serious accident means any train collision or derailment of trains, resulting in the death of at least one person or *serious injuries* to five or more persons or *extensive damage* to rolling stock, the infrastructure or the environment, and any other similar accident with an obvious impact on railway safety regulation or the management of safety.

The RAIU may investigate and report on accidents and incidents which under slightly different conditions might have led to a serious accident.

The purpose of RAIU investigations is to make safety recommendations, based on the findings of investigations, in order to prevent accidents and incidents in the future and improve railway safety. It is not the purpose of an RAIU investigation to attribute blame or liability.

Summary

At 17:45 on the 18th October 2011, the 16:10 service from Belfast to Dublin passed a Hot Axlebox Detector near Drogheda triggering an alarm on the Sligo and Northern Signalman's panel in Centralised Traffic Control. The Sligo and Northern Signalman advised the Suburban Signalman of the alarm, who then contacted the Train Driver to request that the train be stopped and inspected. The Train Driver inspected all of the axleboxes on the train and found no issues. The train was then allowed to continue its journey to Connolly Station. When the train arrived at Connolly Station it was inspected by a member of maintenance staff, one of the axleboxes on the locomotive was found to be red hot and smoking. An axle journal bearing on the locomotive, which was positioned at the rear of the train, had failed.

The immediate cause of the bearing failure could not be determined due to the extensive damage to the bearing, which can occur following substantial overheating and deformation of the material as in this case.

The contributory factors identified were:

- The Train Driver could not identify the presence of the fault with the bearing when inspecting the axlebox;
- The information provided by the Signalman to the Train Driver did not include the type of hot axlebox detector alarm and which axlebox on the train triggered the alarm, rendering the task of identifying the overheating the axlebox unnecessarily more difficult;
- The lack of technical support provided by Fleet Technical Services following the hot axlebox detector alarm allowed the bearing to remain in service with no further monitoring until the train reached its destination.

The underlying factors identified were:

- There were no controls in place to address the subjective observation of overheating bearings by train drivers;
- The competency management system for signalmen in Centralised Traffic Control did not address the competency assessment of signalmen in relation to hot axlebox detector alarms;
- There were no procedures in place governing Fleet Technical Services support following hot axlebox detector alarms.

The following three new safety recommendations, relating to the occurrence, are made:

- Iarnród Éireann should put in place provisions to assist train drivers with the task of identifying if there is a fault present with an axlebox;
- Iarnród Éireann should ensure the competency management system for signalmen includes the assessment of HABD related functions they perform;

- Iarnród Éireann should put in place formal procedures governing the role of Fleet Technical Services staff in relation to hot axlebox detectors.

Two further new safety recommendations, relating to additional observations were made during the investigation but not relating to the occurrence, were also made.

Contents

The occurrence

Summary of the occurrence

1 At 17:45 on the 18th October 2011, the 16:10 service from Belfast to Dublin, train identification number A131, passed the Drogheda Up *Hot Axlebox Detector* (HABD) located at 28 miles 1509 yards, which monitors the temperature of *axleboxes* on trains as they pass in order to detect faults. The last axle on the train triggered a HABD alarm, which was displayed on the Sligo and Northern Signalman's panel in Centralised Traffic Control (CTC). The Sligo and Northern Signalman advised the *controlling signalman* for the section the train was in, the Suburban Signalman, of the alarm. The Suburban Signalman then contacted the Train Driver requesting that the train be stopped and all axleboxes be inspected to check for a fault and advised the Train Driver that he had *signal protection* on the Down line.

2 The Train Driver brought the train to a stop near the 26 ¾ *milepost*. As a precaution, the *Train Guard* put the *Track Circuit Operating Device* on the opposite track, which simulates the presence of a train, to provide signal protection for the Train Driver when walking along the right side of the train. The Train Driver exited the driving cab and inspected all the axleboxes on the train for excessive heat by placing his hand near them, starting by walking back along the left side of the train in the direction of travel and then walking back along the right side of the train. The Train Guard joined the Train Driver as he was inspecting the right side of the train.

3 Whilst the Train Driver was inspecting the train, the Suburban Signalman advised the Suburban Traffic Regulator of the HABD alarm. The Suburban Traffic Regulator then advised the Locomotive Controller, who contacted the Chief Mechanical Engineer's Department (CME) maintenance staff based at Connolly Station requesting they inspect the train when it arrived into Connolly Station. The Locomotive Controller also advised CME staff in Inchicore Works of the HABD alarm. A senior member of Fleet Technical Services (FTS), *Senior FTS*, contacted the Suburban Traffic Regulator requesting information on the rolling stock involved and its condition. Independent of the actions of the Senior FTS, the Manager FTS contacted the CTC Duty Manager to confirm that the alarm was genuine.

4 Once the Train Driver had completed the inspection of the train, he contacted the Suburban Signalman and advised him that there was no fault found. The Train Driver was given permission to proceed to Connolly Station. The train continued at normal line speed for 22 kilometres (km) reaching a maximum speed of approximately 135 kilometres per hour (km/h). At this point, approximately 11 km from Connolly Station, the train began to reduce speed as it was travelling behind a commuter train that was stopping at all stations, the train continued its journey at speeds of less than 50 km/h.

5 The train arrived in Connolly station at 18:33 where it was inspected by a member of CME maintenance staff. The last axlebox on the right side of the train was found to be red hot and smoking. It had suffered a failed bearing. Figure 1 shows the locomotive and Figure 2 shows bearing and its axlebox after they had cooled.

Figure 1 - Locomotive 233

Figure 2 - Failed bearing in axlebox

Description of the railway

Infrastructure

6 The Dublin to Belfast line is double track comprised of a combination of c*ontinuous welded rail* and *jointed rail* laid on ballasted track. The line is approximately 113 ½ miles (182 km) long with locations identified by their distance in miles and yards from the 0 milepost at Connolly station. The line forms part of the IÉ network from the 0 milepost to 59 miles 1034 yards and part of the Northern Ireland Railways (NIR) network beyond this point.

7 The maximum permissible line speed is 145 km/h with sections restricted to lower speed limits.

Signalling and communications

8 Signalling on the Dublin to Belfast line on the IÉ network is *Track Circuit Block* with *colour light signals*. The signals are a combination of two, three and four aspect signals. Authorisation for the movement of trains on the IÉ network along the Dublin to Belfast line is controlled from CTC via two controlling signalmen's panels, namely the Sligo and Northern and Suburban Signalmen's panels.

9 Communication between the controlling signalman and train drivers on the Dublin to Belfast line is by means of a train cab secure radio system and *signal post telephones*.

10 The HABD systems on the IÉ network are wayside systems. They are Phoenix MB systems, manufactured by Signal & System Technik and installed between 2006 and 2009 at thirty two locations throughout the IÉ network.

Rolling stock

11 The train involved was a passenger train, consisting of *Driving Van Trailer* (DVT) 9003 followed by passenger carriages 9104, 9401, 9215, 9203, 9201 and 9208 propelled by locomotive 233. It had a mass of approximately 371,300 kilograms (kg), an overall length of approximately 185 metres (m) and a total of 34 axles.

12 The DVT was manufactured by DeDietrich and entered passenger service in 1996.

13 The passenger carriages were manufactured by DeDietrich and entered service in 1996.

14 Locomotive 233 is a class 201 locomotive, these were manufactured by General Motors and entered service in 1994. The class 201 locomotives are 20.9 m long, have a mass of 108,000 kg and a maximum speed of 161 km/h. They are fitted with two bogies, each with three axles.

15 The failed bearing was positioned on the last axle of the locomotive in the direction of travel, on the right side of the train. The locomotive had operated for 9,400 km since the bearing was fitted.

Operations

16 The train was being driven by the Train Driver with onboard support provided by a Train Guard. The movement of trains on the Dublin to Belfast line between the 0 miles and 59 miles 1034 yards is controlled by two signalmen based in CTC. The Sligo and Northern Signalman controls movements between 31 ¼ milepost and 59 miles 1034 yards. The Suburban Signalman controls movements between the 31 ¼ milepost and the 0 milepost at Dublin Connolly Station.

Relevant parties

Parties involved in the occurrence

17 IÉ is the *railway undertaking* that owns and operates mainline railway services in Ireland. IÉ is also the railway *infrastructure manager*, managing the design, installation, testing, inspection, maintenance and renewal of the railway's physical assets.

18 The IÉ departments associated with this accident are:

- The Intercity and Commuter Network Department (ICCN) – responsible for the supervision and operation of trains on the mainline, excluding the Dublin Area Rapid Transit (DART) Network. This includes the supervision of train drivers and the control of train movements through CTC in Dublin and regional controlling signal cabins;

- The CME – responsible for the specification, purchasing, commissioning and maintenance of rolling stock, including management of the maintenance depots, associated personnel and procedures. This includes provision of support within the CME and to the ICCN on technical matters through its FTS staff;
- The Signalling, Electrical and Telecommunications Department (SET) – responsible for the specification, purchasing, commissioning and maintenance of signalling, electrical and telecommunications equipment, including the control panels used by signalmen and HABD systems.

19 The roles involved are detailed below are the:

- Train Driver – The driver of the train at the time of the accident;
- Sligo and Northern Signalman – The controlling signalman for the Dublin to Belfast line between 31 ¼ miles and 59 miles 1034 yards;
- Suburban Signalman – The controlling signalman for the Dublin to Belfast line between 31 ¼ miles and 0 miles at Connolly station;
- Suburban Traffic Regulator – The *traffic regulator* for the Dublin to Belfast line between 31 ¼ miles and 0 miles at Connolly station;
- Locomotive Controller – A traffic regulator responsible for managing the interface with the CME to facilitate train operations;
- CTC Duty Manager – The manager responsible for overseeing CTC;
- Senior FTS – The member of the CME FTS team available to provide technical support;
- Manager FTS – The manager responsible for overseeing FTS within the CME;
- *Fitter* – The train maintenance worker in the Wheelshop that fitted the bearing that subsequently failed;
- *Production Executive* – The train maintenance supervisor in the Wheelshop who released the wheelset with the bearing that subsequently failed for use.

Other relevant parties

20 The Railway Safety Commission (RSC) is the *national safety authority*, which is responsible for the regulatory oversight of railway safety in Ireland in accordance with the Railway Safety Act 2005 (Government of Ireland, 2005) and European Railway Safety Directive (European Union, 2004). The RSC is responsible for issuing approvals to railways, including IÉ, to allow their operation as well as for auditing and monitoring the *safety management systems* of those railways.

21 Timken is the bearing manufacturer and the bearing maintainer, carrying out *reconditioning* and *remanufacturing* of bearings.

22 NIR is the railway undertaking that owns and operates mainline railway services in Northern Ireland. NIR is also the railway infrastructure manager, managing the design, installation, testing, inspection, maintenance and renewal of the railway's physical assets in Northern Ireland. NIR jointly operates passenger services between Dublin and Belfast with IÉ and is also the owner of two of the class 201 locomotives.

Fatalities, injuries and material damage

Fatalities

23 There were no fatalities as a result of this accident.

Injuries

24 There were no injuries as a result of this accident.

Material damage

25 The axle journal bearing was destroyed. The *axle journal*, axlebox, pedestal liners and axlebox springs suffered heat damage and were not suitable for further use.

External circumstances

26 The weather at the time of the accident was dry with a maximum temperature of 11.4 degrees Celsius (°C).

RAIU investigation

Decision to investigate

27 At 11:24 on the 20th October 2011 the RAIU was notified of the bearing failure. A preliminary examination was carried out and based on the potential for the failure to have led to a derailment, a decision to investigate under article 19 (2) of the European Railway Safety Directive (EC, 2004) was made.

Scope of the investigation

28 The scope of the RAIU investigation included:

- Establishing the sequence of events that led to the bearing failure;
- Establishing, in so far as is possible, the immediate cause, contributory factors and underlying factors that lead to the bearing failure;
- Examining the relevant elements of IÉ's safety management system;
- Examining the pertinent information available from the relevant parties and third parties;
- Examining any other significant safety deficiencies identified as a result of this investigation.

Investigation and evidence

29 The RAIU investigation included examination of:

- The condition of the railway subsystems involved;
- The safety management system in place and its implementation;
- The evidence of persons with information that could assist with the investigation;
- The available records of the relevant parties;
- The information recorded by *data loggers*;
- Other possible sources of evidence that may not have been involved in the occurrence.

30 The technical support of the Transportation Safety Board of Canada (TSB) was provided throughout the course of the investigation, under its memorandum of understanding with the RAIU, due to the TSB's expertise in the area of bearing failure. ESR Technology was contracted to carry out metallurgical examination work as part of the investigation.

Focus of the investigation report

31 Based on the RAIU investigation, the key areas of interest relating to IÉ's safety management system under its obligations as identified in the European Railway Safety Directive (EC, 2004) can be summarised as follows:

- The management of safety risk to ensure the maintenance and enhancement of safety;
- The procedures to ensure compliance with standards or other prescriptive conditions;
- The training and competency management of staff.

Evidence

Management of safety risk

32 IÉ manages safety risk through standard IE-SMS-006 'Policy and Principles for the Management of Safety Risk' (IÉ, 2011c), which requires that each department:

- Ensure that a risk register exists that captures all foreseeable hazards and that it is deemed to be complete and up to date;
- Bring any risks of a strategic nature, or with cross departmental causes or consequences to the attention of the Chief Safety and Security Officer and other relevant departments.

33 Risk is managed at a company level by IÉ through the Network Wide Risk Model (NWRM), which is a tool that assesses the level of safety risk to customers, staff, neighbours and trespassers arising from IÉ's assets and activities. Based on inputs provided by each department and occurrence data, the NWRM identifies the top contributors to safety risk and their contribution to the overall risk factor. The RAIU reviewed the last report generated based on the NWRM prior to the occurrence, NWRM 2010 Report, reference J1095/Doc007 (IÉ, 2010a). The report contained a list of top risk contributors. Axle/axlebox faults features on this list, this includes bearing failure. It should be noted that axle/axlebox faults is one of the risk contributors that contributes least to the list of top risk contributors. (IÉ, 2010a)

34 The CME has asset ratings for each type of rolling stock covering their design, current condition and future deterioration, this information feeds into the NWRM. The RAIU reviewed the data for the class 201 locomotives, which showed that IÉ assigned the bearings the best rating. It should be noted that the highest design rating was awarded although the bearings were not fitted with condition monitoring equipment intended to detect a failing bearing, which, although not commonly used, provide continuous monitoring of bearings for faults.

35 Bearing faults following a HABD alarm were fed into the NWRM data. However, bearing failures found during maintenance inspections were found not to have been fed into the NWRM, which would affect the accuracy of the risk rating.

36 The management of risk relating to bearing failure on the IÉ network is through the maintenance regime, the use of HABDs and train driver inspections following a HABD alarm.

Bearing

Description

37 The failed bearing, bearing 794130, was an *axle journal* mounted class F *tapered roller bearing* manufactured by Timken in August 1994. The components of a tapered roller bearing are shown in Figure 3. It consists of:

- A backing ring pressed up against the shoulder of the axle journal;
- An inboard seal that retains the bearing lubricating grease whilst preventing the ingress of water or debris, the seal rubs against the outer surface of the inboard seal wear ring, which rotates with the axle;
- An inboard cone which is pressed onto the axle journal. The assembly is comprised of a tapered raceway on which its rollers rotate within a cage that provides roller separation;
- A cone spacer to maintain the gap between the cones;
- An outboard cone which is pressed onto the axle journal. The assembly is comprised of a tapered raceway on which its rollers rotate within a cage that provides roller separation;
- An outboard seal that retains the bearing lubricating grease whilst preventing the ingress of water or debris, the seal rubs against the outer surface of the outboard seal wear ring, which rotates with the axle;
- A cup that provides the outer raceways for the rollers from both cones to move along and an exterior cup surface that supports to load transmitted through the axlebox;
- An end cap, secured in place by three end cap screws that have been passed through a locking plate with taps that are bent up against the sides of the screws when the bearing is in place.

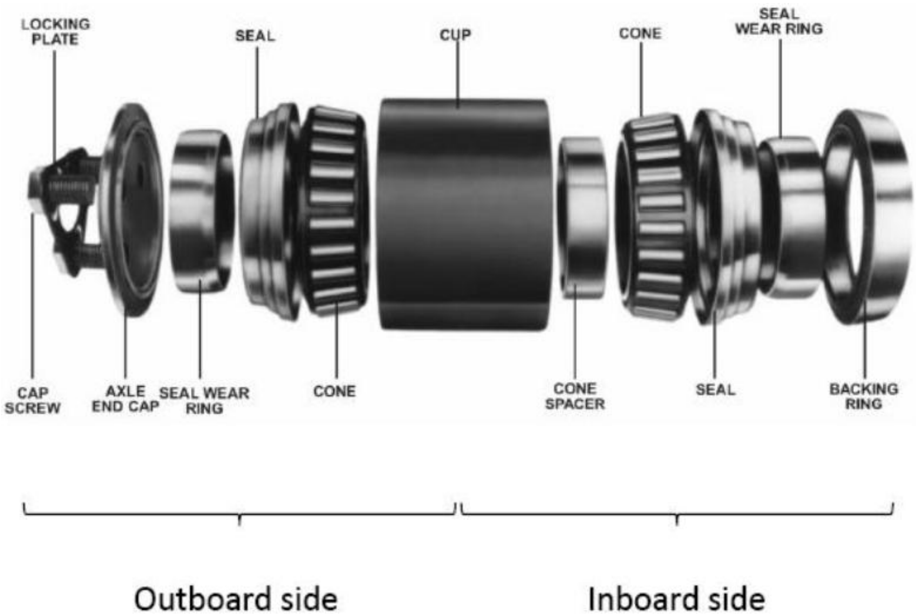

Figure 3 – Tapered roller bearing components

38 Timken advised the RAIU that the normal operating temperature range for a class F bearing is between 20°C and 45°C above ambient temperature. It should be noted that this is not the temperature of the axlebox. IÉ have advised that the normal temperature reading for class 201 locomotives axleboxes is in the region of 20°C.

39 It was not possible to establish the complete operating or maintenance history of the bearing. This type of bearing has been used by IÉ on class 071 and 201 locomotives, both of which are still in service. They were also used for class 121, 141 and 181 locomotives, which are no longer in service. Bearing reconditioning was carried out by IÉ until 2005 for the class F bearings. The bearing outboard and inboard cones were dated, December 2006 and February 2006 respectively, hence, it was possible to determine that the bearing had been remanufactured by Timken. The only reconditioning marking on the bearing was from August 2011. Timken's records did not show any other reconditioning or remanufacturing of the bearing and incorrectly log both cones as being dated February 2006. Based on maintenance records provided by Timken from an older version of their database, it was possible to establish that pitting on the cup was identified in May 2005 following which it was removed from the useable stock of components and remanufactured by Timken in July 2007.

Maintenance

40 Locomotive 233 had undergone maintenance and entered passenger service on the 7th October 2011. As part of this maintenance its bogies, including their wheelsets, were overhauled. The procedures governing the maintenance work to be carried out by IÉ is detailed in Component Overhaul Instructions and the procedures governing the bearing reconditioning work to be carried out by Timken is detailed in Timken's own procedures. The maintenance records were reviewed by RAIU and no issues were identified.

41 The maintenance records for *wheelset* 507XV09 indicate that bearing 794130, had been reconditioned on the 1st August 2011 by Timken, it was then fitted to axle 507XV09 on the 22nd September 2011. As part of this work, the journal diameter of the axle was measured, the axle journal *run out* was measured at the end of the journal, the *end play* before fitting as recorded by Timken was logged and the end play when mounted on the journal was checked and logged. Completeness of the wheelset maintenance records was verified by the Production Executive on the 22nd September 2012, following this check wheelset 507XV09 was released from the Wheelshop for use. No unacceptable measurements were noted by RAIU with these records.

42 The bearings on wheelset 507XV09 were fitted with axleboxes and mounted on bogie 496 in the Bogieshop. The bogie was then fitted to locomotive 233, a test run was completed on the 6th October 2011 and the locomotive was released for passenger service.

43 Locomotive 233 subsequently underwent a weekly inspection on the 14th October 2011. As part of this the axlebox was visually inspected, no faults were recorded.

Post occurrence equipment inspection

44 The bogie with the failed bearing was examined for defects that could have affected the bearing and no issues were identified.

45 No issues of concern were identified with the five other bearings from the bogie or their fitting.

46 The axlebox was examined, there were no signs of abnormal wear or witness marks indicating abnormal contact between the bearing and the axlebox or movement of the bearing within the axlebox.

47 The condition of the wheels on the wheelset with the failed bearing was examined. There were wheel flats around the circumference of the wheel treads but the wheel flats were within IÉ's acceptable tolerances and none were of sufficient size to cause excessive impact loading on the bearing.

48 The axle was manufactured in November 2008. The condition of the axle was examined. Other than damage to the axle journal in the failed bearing position, the axle was in good condition. The axle journal in the failed bearing position was scored due to attempts to press the bearing off the axle. The axle journal runout exceeded the maximum limit, however, this may have been as a result of the bearing failure. The axle journal diameter was below the minimum diameter in parts, however, this may be as a result of damage sustained. There was a witness mark in the paint on the shoulder of the axle that matched the dimensions of the backing ring, indicating that the bearing had been fully pressed onto the axle journal.

49 The condition of the bearing is shown in Figures 3 to 6 and detailed below:

- The grease was lost;
- The backing ring suffered no visible damage;
- The inboard seal was deformed with part of its garter spring protruding, the inboard seal wear ring was in situ;
- The inboard cone had a skewed cage with lipping evident on the sections between the rollers, its rollers were all damaged with several fused to the cup, its raceway surface was covered in smeared metal from the rollers. See Figures 5 and 7;
- The cone spacer was in situ, see Figure 6;

- The outboard cone had a broken cage, the majority of its rollers were missing with several that had fused to cup in load zone, its raceway surface was covered with smeared metal from the rollers. See Figures 5 and 7;
- The outboard seal was missing, the seal wear ring in situ. See Figure 4;
- The cup was fractured along its complete width at a position approximately ninety degrees from the centre of the load zone at the top of the bearing where it supports the axlebox, see Figure 4. Metallurgical examination of the cup carried out by ESR Technology on behalf of the RAIU showed no evidence of fatigue and there was no evidence of the cup having been subject to an impact (ESR, 2012). Rollers and sections of the cages of both the outboard and inboard cones were fused to the cup in the area of the load zone, see Figure 7;
- The end cap was in situ with the end cap screws and locking tabs in place, it had suffered flash corrosion as shown in Figure 4.

Figure 4 – Bearing on axle journal

Figure 5 - Inside of bearing

Figure 6 - Bearing cone raceways

Figure 7 - Bearing cup raceways

Bearing failure modes

50 The International Organisation of Standardisation (ISO) has developed International standard ISO 15243, Rolling bearings - Damage and failures - Terms, characteristics and causes (ISO, 2004), which classifies the bearing failure causes into categories, these are:

- Lubricant;
- Operating condition;
- Mounting;
- Design;
- Handling;
- Manufacture;
- Material.

51 It should be noted that ISO 15243 advises that where there is extensive damage to the bearing or it has suffered a catastrophic failure, the evidence identifying the cause of the failure is likely to be lost, making it impossible to identify the primary cause of the failure. (ISO, 2004)

Hot Axlebox Detectors

Purpose of HABD systems

52 The purpose of HABD systems is to monitor the heat level generated by an axlebox in service in order to detect increases in temperature that may potentially indicate a bearing failure. The European Committee for Standardisation (CEN) has developed European standard EN 15437-1 'Railway applications – Axlebox condition monitoring – Interface and design requirements – Part 1: Track side equipment and rolling stock axlebox' (CEN, 2009) on *wayside HABDs*, which are HABDs positioned on the track rather than on the rolling stock. EN 15437-1 identifies that failed axle bearings create a hazard to the safe operation of the railway. One of the indications that a bearing is about to fail is an increase in the heat it is generating. HABDs are internationally recognised as one of the ways to manage the risk that this presents. Sensors measure the *thermal radiation* emitted by the axleboxes of rolling stock as it is travelling and trigger alarms based on predefined criteria. (CEN, 2009)

53 EN 15437-1 identifies four possible HABD alarm types and what they indicate:

- Hot temperature alarm – triggered when an axlebox temperature has exceeded a preset hot temperature level;
- Warm temperature alarm – triggered when an axlebox temperature has exceeded a preset warm temperature level;
- Differential temperature alarm – triggered when the temperature difference between the left and right axleboxes of a wheelset has exceeded a preset differential temperature level;
- Train side differential temperature alarm – triggered when the temperature difference between an axlebox and the average temperature of all the axleboxes along its side of the train exceeds a preset train side differential temperature level. (CEN, 2009)

54 EN 15437-1 also identifies that the level of thermal radiation emitted by an axlebox is influenced by the emissivity of the axlebox surface. This is influenced by its material, design, surface finish and operational conditions. (CEN, 2009)

HABDs on the IÉ network

55 The SET Asset Plan SET-TMS-7021, Hot Axle Box Detector System, (IÉ, 2011b) identifies the main issues relating to the HABDs on the IÉ network. The HABDs have eight infrared sensors that scan the underside of axleboxes over a width of 0.12 m monitoring the temperature of axle journal mounted bearings. They are capable of triggering three alarms, namely a Warm Alarm, a Hot Alarm and a Differential Alarm. The Warm and Hot Alarm temperature thresholds were both set to 100°C by IÉ, giving only one alarm threshold. A Differential Alarm is triggered for a difference in temperature that exceeds 40°C. According to SET-TMS-7021 the HABD alarm settings are determined by the CME and are regularly reviewed based on actual train data. The HABD system cannot identify the type of rolling stock, hence alarm thresholds are set allowing for all vehicle and axlebox types. (IÉ, 2011b)

56 According to SET-TMS-7021, HABDs are provided at a nominal spacing of 50 km on the IÉ network. There are exceptions to this in the case of lightly used lines and several locations on the Dublin to Cork line. (IÉ, 2011b)

57 There were four HABDs located on the Dublin to Belfast line at the time of the occurrence. These were located on both the *Up line* and *Down line* near Drogheda at 28 miles 1509 yards and near Dundalk at 52 miles, they are referred to as the Drogheda Up and Down HABDs and the Dundalk Up and Down HABDs respectively.

58 At the time of the accident, there were no further HABDs on the remaining 100 km from Dundalk to Belfast, which enters the NIR network 12 km beyond the Dundalk Up and Down HABDs. An acoustic bearing monitoring device was in situ on the NIR network at 110 ¾ miles, however, it had not yet been commissioned. Use of this system requires a vehicle identification system in order to identify the vehicle for effective monitoring.

59 SET-TMS-7021 identifies several significant issues in relation to the HABD system, these are:

- Axle/Axlebox faults contribute to the train defect category risk in the NWRM with the potential of a catastrophic axlebox failure to result in the derailment of a train. This risk is mitigated by routine maintenance and the monitoring of the temperatures of the axleboxes in service by the HABDs;

- Wayside HABDs provide for monitoring the temperature of axleboxes at particular locations along a route. A catastrophic axlebox failure can develop over a relatively short distance, well within the nominal 50 km spacing of the wayside detectors. The main mitigation for axlebox failures is routine maintenance and inspection of bearings. The HABDs provide for overall monitoring and reporting where parameters fall outside of predefined levels;
- Train driver inspections following the activation of a HABD alarm are subjective. It is difficult for the driver to identify if one axlebox is hotter that any other unless its temperature is significantly elevated. This risk is mitigated by the fact that the CME FTS staff are also notified of the alarm by the HABD system, which sends an e-mail with the particular train data. The CME FTS can provide support and review the data for the train at previous HABDs to determine the best course of action to be taken;
- No specific instructions exist to cover out of service HABDs. The SET plans to issue an instruction to cover this scenario to ensure that the risk of not detecting a hot axlebox during outages of a HABD system is minimised. (IÉ, 2011b)

60 The issues relating to subjective observation by train drivers and out of service HABDs originate from IÉ’s historic knowledge and experience of using wayside HABD systems.

61 SET-TMS-7021 also identifies the possibility of future system enhancements for HABD monitoring, including a vehicle identification system to allow the vehicle identity to be recorded with the HABD data. This would allow wheelsets to be identified, facilitating monitoring of suspected axlebox issues and trending of individual axlebox performance. (IÉ, 2011b)

Monitoring of HABDs

62 HABD monitoring is carried out through the controlling signalman’s panel with HABD alarms triggering a message on the panel. The controlling signalman can then access details of the HABD readings for the entire train and details of the alarm. According to section 51, Hot Axle Box Detectors, of IÉ’s Train Signalling Regulations and General Instructions to Signalmen (IÉ, 2007), the controlling signalman advises the train driver to stop the train, gives the train driver the location of the axlebox that triggered the alarm and ensure it is safe for the train driver to inspect the train. In the event that no fault is found, the controlling signalman should advise the train driver to examine the adjacent axleboxes.

63 No formal instructions were found to exist for train drivers on checking for a hot axlebox. Train drivers normally check for excessive heat from the axlebox by placing the back of their hand near the end as advised in their initial training.

64 The instructions for CTC in the event that a hot axlebox is found are included in Section B, Part 1 of IÉ's General Appendix (IÉ, 2011d). This requires that the traffic regulator informs CME maintenance staff of the fault.

65 There were no procedures in place to address situations where no fault is found by a train driver following a HABD alarm to address the possibility that a fault was present yet not evident to the train driver.

66 No procedures were found to exist to address communication between IÉ and NIR on the inspection of axleboxes in the event of a HABD alarm.

67 The HABD system also transmits the details of the alarm to all senior technical staff within the CME, including FTS staff. The type of rolling stock that triggered the alarm is identified based on the number of axles, the timetable and contact with CTC. No procedures were found to exist to address the providing technical support to ICCN by FTS following a HABD alarm. IÉ have advised that the normal process following a HABD alarm is that either the manager or a senior member of the FTS team follow up on the reported HABD alert with CTC and based on the available information FTS may contact the train driver through CTC.

68 FTS were responsible for the ongoing monitoring of the HABD system to identify axlebox faults. At the time of the occurrence, there was no procedure in place to manage this. FTS monitors axlebox temperatures recorded by the HABD system on a daily basis, Monday to Friday. FTS also monitors HABD alarms. Recording of the monitoring of HABD alarms by FTS began in September 2011, therefore, it was not possible to review the trends relating to the identification of axlebox faults based on HABD alarms prior to the accident.

69 In the case of HABD monitoring for the Drogheda Up HABD, this was positioned on the Sligo and Northern Signalman's panel although the controlling signalman for the section was the Suburban Signalman. This meant that the Sligo and Northern Signalman was required to contact the Suburban Signalman and provide details of the alarm.

Drogheda Up HABD alarm

70 A Differential Alarm was triggered at the Drogheda Up HABD by the last axle on the train. The Drogheda HABD system recorded an axlebox temperature of 87°C for the position of the failed bearing and an axlebox temperature of 22 °C for the other end of the axle, giving a differential temperature of 65°C. A graphical record of the eight point temperature reading for the failed bearing's position is shown in Figure 8, which shows that the alarm was triggered by the sixth sensor registering a temperature spike of 87.8°C. The sensors are referred to as channels 1 to 8 with channel 1 being to the inboard side of the bearing.

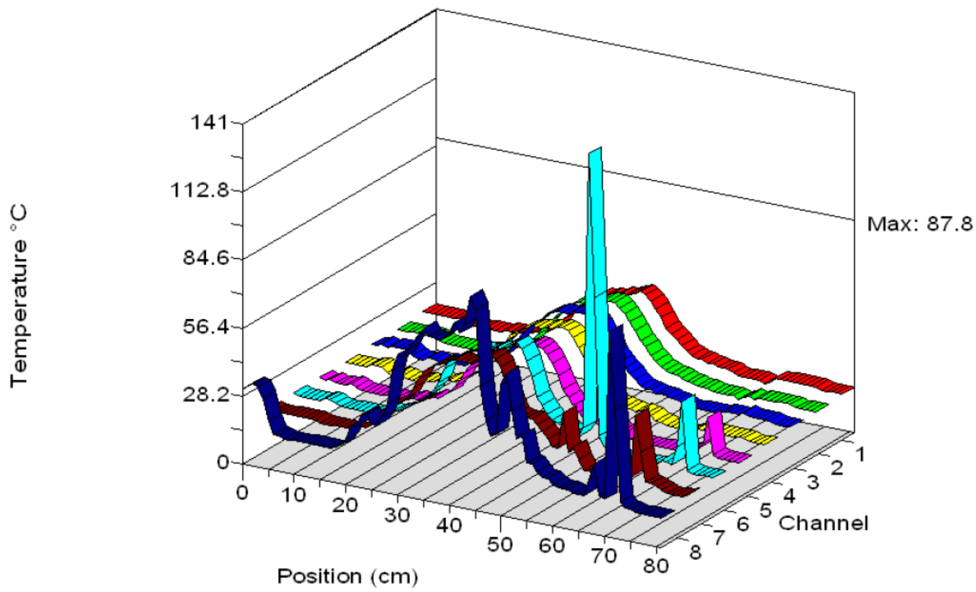

Figure 8 – Drogheda Up HABD temperature readings

71 No details of the HABD alarm given in paragraph 70 were provided to the Train Driver by the Suburban Signalman. Normal practice in CTC following a HABD alarm was found to be that the signalmen would advise train drivers to stop and inspect the complete train, the location or type of alarm were not given. According to IÉ, this was an informal practice in CTC that resulted from the lack of reliability of the previous HABD system. The practice did not change with the installation of the new HABD systems, which were more reliable.

72 The Senior FTS made contact with the Traffic Regulator in CTC to ascertain which vehicle had triggered the alarm. No issue was raised by the Senior FTS in relation to the 87°C temperature reading at Drogheda Up HABD. The Manager FTS advised CTC that the alarm was genuine, however, no instruction was given to CTC on what action to take. Checking the temperature reading for the axlebox at Dundalk Up HABD and the train side differential temperature for the locomotive was not required. No instruction was given to CTC on the action to take following the HABD alarm.

73 The train side differential temperature for Locomotive 233 was examined by RAIU. Given that the axleboxes and bearings differ along the train, comparison of the temperature readings was limited to the locomotive. The average temperature reading for the other five axleboxes along the same side of the locomotive was 14.5°C, giving a differential temperature of 73°C.

74 The HABD temperatures recorded for the locomotive since entering service on the 7th October 2011 with the bearing that subsequently failed were reviewed by the RAIU. There were two noteworthy temperature readings recorded for the failed bearing's position over the twelve days of operation, these would not have created concern normally but were of interest in the context of the bearing failure. In the following instances the axlebox temperatures were not in line with the other axleboxes on the same side of the locomotive:

- Dundalk Down HABD, 8th October at 10:40 – A temperature of 31°C was recorded whilst the average temperature on same side of the locomotive was 17.8°C, giving a differential temperature of 13.2°C;
- Dundalk Up HABD, 18th October at 17:23 – A temperature of 35°C was recorded whilst the average temperature for the other five axleboxes on the same side of the locomotive was 22°C, giving a differential temperature of 13°C. This was twenty two minutes before the differential alarm was triggered at the Drogheda Up HABD.

Staff training and competency management

75 Staff training and competency is addressed at a company level through standard IE-SMS-004 'Policy and Principles for Training, Competence and Fitness' (IÉ, 2010b).

76 IE-SMS-004 includes the following requirements:

- Approval of technical training courses before they are implemented;
- Assessment and approval of training providers;
- Establishment of departmental standards/procedures for the training and competence management of safety critical roles;
- Co-ordination and delivery of training in a planned and structured way to meet the requirements for staff engaged in safety critical tasks;
- Establishment of departmental standards/procedures for the training of staff that perform safety critical tasks for technical, operating and route specific rules/procedures;
- Establishment of a process for the approval of safety courses;
- Establishment of departmental standards/procedures for the competence management of safety critical roles, including processes to deal with initial assessment of competence, post qualification assessments and ongoing competence;
- The content, degree, methodology and frequency of assessments must take into account the level of risk each role has to railway operations. (IÉ, 2010b)

77 The ICCN was found to implement IE-SMS-004 through Railway Safety Standard 16 ‘Competency Management System – Train Drivers’, reference RSS16, (IÉ, 2008) for train drivers and Railway Safety Standard 45 ‘Competency Management System – CTC Signallers’, reference RSS 45, (IÉ, 2009) for signalmen.

78 IÉ advised the RAIU that examining axleboxes for faults is addressed in initial driver training, however, it was not addressed in refresher training. The Train Driver qualified on the 20th April 2002. Since then no training or competency assessment was carried out in relation to HABD alarms.

79 The competency assessment of signalmen relating to the HABD system was not found to have been addressed in RSS 45.

80 The CME implements IE-SMS-004 through CME-SMS-004, ‘Safety management standard, Competency assessments and training’ (IÉ, 2010b). The following issues relating to its implementation were found:

- CME-SMS-004 had not been briefed out to all staff responsible for implementing it although most were briefed, the Production Executive was not briefed;
- Training was being carried out using the Component Overhaul Instructions, however, it was conducted with no training plan by other maintenance staff without guidance;
- Training was time based rather than content based, meaning that the amount of hands on training staff would receive would vary with demand for that type of maintenance activity.

81 The competency requirements for new and existing staff were identified in section 5.1.3, which states:

‘Any new recruit and/or any relocation of either craft persons or supervisors between identifiably different types of CME Locations as described in CME Safety Management Standard CME-SMS-001 - “Safety Management System” will require a Safety Critical Competency assessment before such a person can take up their duties’. (IÉ, 2010b)

82 To allow for the gradual competency assessment of existing staff section 5.4.5.1 of CME-SMS-004 was found to include a condition relating to the competency assessment of existing staff which would expire in December 2012. Section 5.4.5.1 was found to be unclear in its meaning in relation to the training and competency assessment of existing staff, stating:

‘All employees with existing rolling stock Maintenance knowledge are assumed to be competent and will systematically be assessed against this Standard within the period 2 January 2009 to December 2012’.

83 The Fitter that mounted the bearing on the axle journal had moved from the Fleet Casualty Repair (FCR) Shop to the Wheelshop in February 2011. He commenced fitting bearings in July 2011. He was found to have been working with no direct supervision whilst not assessed as competent under CME-SMS-004 although the task was considered as safety critical.

84 The Production Executive responsible for verifying maintenance work as complete in order to release wheelsets from the Wheelshop transferred into the Wheelshop in August 2011, he had previously been working in the FCR Shop. He was found not to have been assessed as competent under CME-SMS-004 although the task was considered as safety critical.

Sources of evidence not involved in the occurrence

85 Station Closed Circuit Television (CCTV) along the route of the train was reviewed to check for signs of the bearing failure after it had triggered the Differential Alarm at Drogheda Up HABD. CCTV at Clongriffin Station, which is located 8 km before Connolly station along the train's route, showed an orange glow was emanating from the axlebox indicating that the bearing had failed at this point. No other CCTV from stations before or after Clongriffin Station recorded evidence of the bearing failure.

Other similar occurrences

86 The available information on the history of bearing failures and faults on IÉ rolling stock was reviewed. The available information is limited as the monitoring of HABD alarms, including whether or not faults were found, has only been recorded since September 2011 and historic information on failures has not been retained other that where reports exist. IÉ advised the RAIU that there have been no other bearing failures on the class 201 locomotives.

87 The following bearings failures occurred:

- 26th May 2010 – Following a HABD alarm, freight wagon 24141 was found to have an overheated axlebox. The same axlebox had triggered HABD alarms twice previous on the 22nd and 25th May 2010 and all three alarms were for temperatures in excess of 130°C. The bearing was found to have suffered a fractured cup and a damaged inboard seal;
- 27th September 2010 – During a routine maintenance examination, a temperature strip on an axlebox used to facilitate monitoring of axlebox temperatures on the class 2700 Diesel Multiple Units (DMUs) was found to have recorded a temperature in excess of 99°C. The bearing was found to have suffered a cage failure;
- 2008 – There was a trend of bearing failures on class 2700 DMUs.

- 10th January 2008 – Freight wagon 31005 derailed due to a burnt off journal. The RAIU investigated this occurrence. The HABD alarm settings were found to be ineffective and the maintenance regime was not robust. IÉ has since altered its HABD alarm settings and overhauled its maintenance arrangements in the Wheelshop;
- 27th January 2007 – A class 2700 DMU suffered a bearing failure;
- 2nd February 2005 – A class 2800 DMU suffered a bearing failure as a result of a pinched seal;
- 8th & 9th February 2005 – There were two bearing failures on class 2800 DMUs as a result of missing end caps, which were not fitted when the bearings were mounted on the axles;
- 28th December 2002 – A DeDietrich carriage triggered a HABD alarm and an overheating bearing was identified by a member of CME maintenance staff. The same bearing had triggered a HABD alarm earlier the same day;
- 17th November 2002 – The end cap for a bearing on a DeDietrich carriage was found to have come off the axle during a maintenance inspection;
- 2002 & 2003 – The outboard seal was found by maintenance staff to be coming away from the bearing for five bearings on four different Mark III carriages due to axle journal faults;
- 6th August 2002 – A failed bearing was observed on a Mark III carriage by CME staff inspecting the train. The train had passed a HABD detector without triggering an alarm, however, the HABD was found not to have been functional;
- March 1993 – A freight wagon on a train transporting ammonia suffered an overheated bearing.

88 The following bearing faults have occurred since the bearing failure on the 18th October 2011:

- 25th October 2011 – A HABD alarm was triggered by a class 22000 DMU. No heat was initially evident to the train driver, therefore, under the advice of FTS, the train was allowed to continue at a reduced speed and the train was stopped for further inspection every 16 km. The bearing was subsequently removed following inspection by CME staff;
- 3rd March 2012 – Locomotive 227 triggered a HABD Differential Alarm, upon inspection grease was found to be leaking, the relevant bearings were replaced;
- 6th April 2012 – Locomotive 223 triggered a HABD Differential Alarm. The bogie was removed and the wheelset was inspected by a member of FTS. The axle journal diameter was found to be below specification in line with the area of inboard cone and the axle was scrapped. Locomotive 223 had previously triggered a HABD Differential Alarm on the 19th February 2012 following which grease was found to be weeping and the bearings on the relevant wheelset were replaced, as part of this the axle journal diameters were measured on both journals at three positions and no issues were identified. On the 18th March 2012, locomotive 223 had also triggered a HABD Differential Alarm, no fault was found and the train was allowed to continue.

Analysis

Failure of the bearing

89 Each of the cause categories identified in ISO 15243 was examined (paragraph 50), however, the extent of the damage meant that conclusive determinations could not be made as to the cause of the bearing failure.

90 The findings relating to each cause category are as follows:

- Lubricant – This was lost in the failure (paragraph 49), hence its condition could not be established. However, as the grease was only applied on the 1st August 2011 (paragraph 41) and there are no known issues relating to the grease used for the class F bearings (paragraphs 87 & 88), it is unlikely that this was a factor;
- Operating condition – There were no faults identified with the operation of the train or its components that would have affected the operating condition of the bearing (paragraphs 44 to 49);
- Mounting – The presence of the witness mark on the axle from the backing ring (paragraph 48), the lack of an indication that the end cap screws were loosening (paragraph 49) and the recorded mounted end play (paragraph 41) all indicate that the bearing was correctly mounted on the axle journal;
- Design – The class F bearing has been in use for the class 201 locomotive since their introduction without any significant issues developing (paragraphs 87 & 88), hence the presence of a design issue is considered unlikely;
- Handling – Examination of the cup bearing revealed no evidence of an impact (paragraph 49);
- Manufacture – No manufacturing defects were identified, including reconditioning or remanufacturing defects, although due to the extensive damage to the bearing, this could not be eliminated as a factor;
- Material – No structural defects with the materials used were identified.

91 The normal operating temperature range for a class F bearing as advised by Timken is 20-45°C above ambient temperature (paragraph 38). Hence, it is likely that when the HABD Differential Alarm was triggered by Drogheda Up HABD the bearing was already in distress as the temperature reading for the axlebox was 87°C, the differential temperature was 65°C and the train side differential temperature for the locomotive was 73°C (paragraph 73). This is further supported by the axlebox temperature recorded at the Dundalk Up HABD, which was 35°C compared with the train side average for the locomotive of 22°C (paragraph 74). The train side differential of 13°C for the locomotive at Dundalk Up HABD, which would not have been a concern by itself, does indicate that the bearing that subsequently failed was not operating in line with the other bearings that should have been subject to the same operating conditions. It was not possible to determine at what point the bearing failed. However, the orange glow emanating from the axlebox shown on CCTV at Clongriffin Station (paragraph 85) indicates that it is likely that the bearing had already failed 8 km before it reached Connolly Station, following which its condition would have continued to deteriorate until it was removed from service at its destination.

Bearing condition monitoring

92 As identified in IE-SET-7012, the ability to identify a bearing defect relies on maintenance inspections, monitoring of HABDs and train driver inspections following a HABD alarm (paragraph 59), however, the controls in place were found not to be sufficiently robust to allow hot axleboxes to be detected as demonstrated below.

93 The ability of the Train Driver to identify excessive heat emanating from a bearing relied on the transfer of heat to the end cap given the enclosed design of the axlebox shown in Figure 2. As shown by the eight point reading from the Drogheda Up HABD in Figure 8, the temperature reading from the sensor closest to the end cap was lower than that of the sensor that triggered the alarm, hence it is likely that sufficient heat was not present to allow the Train Driver identify the overheating bearing. In addition, as noted in IE-SET-7021, train driver detection of heat emanating from an axlebox is subjective (paragraph 59), however, no additional provisions were made to assist train drivers in this task, such as the temperature stickers used on the class 2700 DMUs (paragraph 87).

94 The ability of the Train Driver to detect the overheating axlebox was further hampered by the lack of information provided by the Suburban Signalman in CTC (paragraph 71). The practice in CTC of not advising train drivers of the location of an axlebox that triggered a HABD alarm (paragraph 71) meant that the Train Driver had to check all 68 axleboxes on the train rather than focusing on the relevant axlebox. In addition, the lack of information on the type of alarm meant that the Train Driver did not know that he was dealing with a Differential Alarm and hence that level of heat present would not be as substantial as for a Hot Alarm, which are only triggered by a temperature of 100°C (paragraph 55).

95 The HABD alarm for the Drogheda Up HABD being positioned on the Sligo and Northern panel rather than the Suburban panel (paragraph 69), introduced an additional unnecessary step in the process for informing the Train Driver of the alarm. It also meant that the controlling signalman did not have all of the alarm information readily available to assist with management of the alarm.

96 FTS is responsible for providing technical supporting in relation to HABD alarms. However, there were no procedures in place governing the assistance to be provided by FTS following a HABD alarm or for the ongoing monitoring of HABDs (paragraph 67). In this instance, no support was found to have been provided (paragraph 72), meaning that the detection of the overheating axlebox was solely reliant on the ability of the Train Driver to observe this. Had FTS been provided with a procedure detailing the action that should be taken following a HABD alarm, further deterioration of the condition of the bearing could have been avoided. Reviewing the train side differential temperature for the locomotive of 73°C and the slightly elevated temperature reading of 35°C at Dundalk Up HABD (paragraphs 73 & 74) should have corroborated the validity of the Differential Alarm at Drogheda Up HABD and led FTS to put controls in place to further monitor the condition of the axlebox or remove it from service.

Competency management of safety critical staff

97 The implementation of the company level standard on training and competency management, IE-SMS-004, (paragraphs 75 & 76) was not found to be robust in its management of competencies in relation to bearing failure risk as shown below.

98 Train drivers received initial training on hot axlebox inspection (paragraph 78), however this was not addressed as part of ongoing competency management (paragraph 78) requiring train drivers to rely on their initial training that may have occurred years earlier. The checks carried out by the Train Driver in this instance were found to be in line with initial training (paragraph 63).

99 Competency assessment of CTC signalmen was found not to address HABD alarms (paragraph 79). An informal practice of not notifying train drivers of the axlebox that had triggered a HABD alarm had been adopted in CTC whereby signalmen were not adhering to the instructions set out in the train signalling regulations and general instructions to signalmen and having train drivers inspect a complete train following a HABD alarm (paragraph 71). Had the competency of signalmen in CTC been assessed in relation to their management of HABD alarms, this may have highlighted the informal practice that had developed in CTC.

100 CME standard CME-SMS-004 on the training and competency management of CME staff was found to have not been implemented for all CME staff. Two members of staff carrying out safety critical tasks were found to have been permitted to work without supervision whilst not passed out as competent (paragraphs 83 & 84). It should be noted that no faults were found with their work in this instance. Both members of staff were trained by existing staff carrying out the role, however, the absence of a training plan allows for inconsistency in training as the maintenance staff responsible for its implementation do so without structured guidance (paragraph 80). In addition, the training was time based (paragraph 80) rather than content based allowing the amount of hands on training staff would receive to vary with demand for that type of maintenance activity.

101 The lack of implementation of CME-SMS-004 may have been due to poor clarity in the standard, which was found not to have been briefed out to all staff responsible for its implementation including the Production Executive (paragraph 80). CME-SMS-004 was found to be ambiguous in its meaning in relation to the competency of existing rolling stock maintenance staff in section 5.4.5.1, which states 'All employees with existing rolling stock Maintenance knowledge are assumed to be competent' (paragraph 82). This does not clearly identify whether they are considered competent in relation to tasks they have already been undertaking or if they are considered competent for all tasks.

Conclusions

Failure of the bearing

102 Given the condition of the bearing it was not possible to determine the cause of its failure (paragraphs 89 & 90). However, based on other evidence it is likely that the bearing was in distress when it passed the Dundalk Up HABD and that it had already failed as it passed the CCTV at Clongriffin Station 8 km before it reached Connolly Station (paragraph 91).

Bearing condition monitoring

103 IÉ's safety management system was not effective in managing the risks relating to bearing failures (paragraph 92).

104 No provisions were made to address the subjective observation of overheating axleboxes by train drivers (paragraph 93).

105 As a result of an informal practice that had developed in CTC, the Train Driver was not advised of the type of HABD alarm or the location of the axlebox that triggered it, making the task of identifying an overheating axlebox unnecessarily more difficult (paragraph 94).

106 The HABD alarm was not located on the controlling signalman's panel, hence, the alarm details were not readily available to the Suburban Signalman (paragraph 95).

107 The lack of procedures governing the assistance provided by FTS following a HABD alarm resulted in the subjective observation by the Train Driver being the only means of identifying a potential bearing failure (paragraph 96).

Competency management of safety critical staff

108 The ongoing competency assessment of train drivers was found not to address HABD alarms, however, in this instance the instructions given to train drivers as part of their initial training were adhered to by the Train Driver (paragraph 98).

109 The ongoing competency management of signalmen was found not to address HABD alarms, allowing the informal practice in CTC of advising train drivers to inspect the full train following a HABD alarm to go unnoticed (paragraph 99).

110 The competency management standard CME-SMS-004 was not found to have been correctly implemented for safety critical CME maintenance staff working in the Wheelshop (paragraph 100). This may have been as a result of ambiguity in the standard relating to the competency assessment of existing staff (paragraph 101).

Immediate cause, causal factors, contributory factors and underlying factors

111 The *immediate cause* of the bearing failure could not be determined due to the extensive damage to the bearing, which can occur following substantial overheating and deformation of the material as in this case.

112 The *contributory factors* (CoFs) identified were:

- CoF-01 – The Train Driver could not identify the presence of the fault with the bearing when inspecting the axleboxes;
- CoF-02 – The information provided by the Signalman to the Train Driver did not include the type of hot axlebox detector alarm and the axlebox that triggered the alarm, rendering the task of identifying the overheating the axlebox unnecessarily more difficult;
- CoF-03 – The lack of technical support provided by FTS following the hot axlebox detector alarm allowed the bearing to remain in service with no further monitoring until the train reached its destination.

113 The *underlying factors* (UFs) identified were:

- UF-01 – There were no controls in place to address the subjective observation of overheating bearings by train drivers;
- UF-02 – The competency management system for signalmen in CTC did not address the competency assessment of signalmen in relation to HABD alarms;
- UF-03 – There were no procedures in place governing FTS support following HABD alarms.

114 The following additional observations (AOs), not relating to the occurrence, were made during the investigation:

- AO-01 – The competency management system for CME maintenance staff was not found to have been correctly implemented;
- AO-02 – The competency management system for train drivers was found not to address the ongoing competency assessment of train drivers in relation to the inspection of axleboxes following a HABD alarm.

Relevant actions already taken or in progress

Actions taken by IÉ

115 IÉ have advised the RAIU that the following actions have taken place to address the issues raised during this investigation.

116 The maintenance record form for the Wheelshop has been update to include:

- Sign off of use of feeler gauge between bearing back seal ring and axle radius;
- Sign off of achievement of guidance bearing push on force;
- Specific bearing push on force achieved.

117 All supervisors in the Bogie shop, Wheelshop and FCR Shop have been re-briefed on CME-SMS-004.

118 The Fitter has been competency assessed in relation to fitting bearings. Compliance with CME-SMS-004 is monitored closely and a competence management plan has been implemented.

119 A fleet check of cartridge bearings fitted by staff not in compliance with CME-SMS-004 was carried out. All vehicles were inspected by FTS and were found to be within specification.

120 Post bogie replacement all vehicles are required to go on an out road trial under CME supervision. Procedures have been developed and issued by FTS.

121 Additional Timken training is to be rolled out covering: Bearing fitting, typical damage, typical failure modes, inspection criteria, etc. Many of the staff have also undergone training in the use of precision measuring equipment.

122 At overhaul, the class 201 locomotives are to be fitted with new bearings rather than reconditioned bearings.

123 The axleboxes on all rolling stock have been fitted with temperature strips that record the maximum temperature that the axlebox has reached.

124 A feasibility study for funding of an acoustic bearing monitoring system that may allow early detection of bearing faults has been carried out.

125 HABD guidance for CTC and train drivers has been produced.

126 The monitoring of the Drogheda Up HABD has been moved from the Sligo and Northern Signalman's panel to the Suburban Signalman's panel.

Actions taken by the RSC

127 An inspection under Section 50 (7) of the Railway Safety Act 2005 (Government of Ireland, 2005) was carried out. This involved a detailed review of IÉ Technical Standards, depot inspections and interviews with numerous IÉ personnel. The report was completed in March 2012 and formally issued to IÉ on the 26th March 2012.

Safety recommendations

General description

128 In accordance with the Railway Safety Act 2005 (Government of Ireland, 2005) and the European railway safety directive (European Union, 2004), safety recommendations are addressed to the national safety authority, the RSC. The safety recommendation is directed to party identified in each safety recommendation.

129 As a result of the RAIU investigation five new safety recommendations are made, three relating to the occurrence and two relating to additional observations.

New safety recommendations relating to the occurrence

130 Based on the challenges facing train drivers when attempting to determine if an axlebox has a fault as identified in CoF-01 and UF-01, the following safety recommendation is made in order to improve the management of safety risk:

IÉ should put in place provisions to assist train drivers with the task of identifying if there is a fault present with an axlebox.

131 As identified in CoF-02 and UF-02, an informal practice had developed in CTC in relation to the functions of signalmen relating to HABD alarms that went unnoticed, based on this the following safety recommendation is made in order to improve the training and competency management of staff:

IÉ should ensure the competency management system for signalmen includes the assessment of HABD related functions they perform.

132 Based on the lack of technical support provided by FTS as a result of the omission of procedures governing their task in relation to HABDs as identified in CoF-03 and UF-03, the following safety recommendation is made in order to ensure procedures are in place for compliance with standards or other prescriptive conditions:

IÉ should put in place formal procedures governing the role of FTS staff in relation to HABDs.

New safety recommendations relating to the additional observations

133 As identified in AO-01, the CME's competency management system was not found to have been correctly implemented, based on this the following safety recommendation is made in order to improve the training and competency management of staff:

IÉ should ensure that a robust system is put in place for the competency assessment of safety critical rolling stock maintenance staff.

134 As identified in AO-02, the ongoing competency assessment of train drivers in relation to their duties following a HABD alarm is not assessed, based on this the following safety recommendation is made in order to improve the training and competency management of staff:

IÉ should update its competency management system for train drivers to include assessment of their competency in relation to their tasks following a HABD alarm.

Additional information

List of abbreviations

°C	Degrees Celcius
AO	Additional observation
CCTV	Closed Circuit Television
CEN	European Committee for Standardisation
CME	Chief Mechanical Engineer’s Department
CoF	Contributory factor
CTC	Centralised Traffic Control
DART	Dublin Area Rapid Transit
DMU	Diesel Multiple Unit
DVT	Driving Van Trailer
FCR	Fleet Casualty Repair
FTS	Fleet Technical Services
HABD	Hot Axlebox Detector
ICCN	Intercity and Commuter Network Department
IÉ	Iarnród Éireann
ISO	International Organisation of Standardisation
kg	Kilogram
km/h	Kilometres per hour
m	Metre
NIR	Northern Ireland Railways
NWRM	Network Wide Risk Model
RAIU	Railway Accident Investigation Unit
RSC	Railway Safety Commission
SET	Signalling, Electrical and Telecommunications Department
SI Units	International System of Units
UF	Underlying factor

Glossary of terms

Accident	An unwanted or unintended sudden event or a specific chain of such events which have harmful consequences including collisions, derailments, level-crossing accidents, accidents to persons caused by rolling stock in motion, fires and others.
Axle journal	The sections at the ends of the axle that the bearings are mounted onto.
Axlebox	The structure that houses the journal bearing allowing it to support the necessary load.

Bogie	A structure that contains the wheelsets of a rail vehicle.
Causal factors	Any factor(s) necessary for an occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.
Colour light signals	Signals that convey movement authority to train drivers by means of coloured lights.
Continuous welded rail	Sections of rail that are welded together.
Contributory factors	Any factor(s) that affects, sustains or exacerbates the outcome of an occurrence. Eliminating one or more of these factor(s) would not have prevented the occurrence but their presence made it more likely, or changed the outcome.
Controlling signalman	The signalman designated to control a specific section of track.
Data logger	A system that records data relating to a device or activity.
Down line	The line on which trains normally travel away from Dublin.
Driving Van Trailer	A railway vehicle that allows a train to be controlled from the leading end when being propelled by a locomotive.
Extensive damage	Damage that can be immediately assessed by the RAIU to cost at least €2,000,000 in total.
Fitter	A member of CME rolling stock maintenance staff.
Senior Fleet Technical Services	A technician responsible for providing technical support relating to rolling stock to CME staff and ICCN staff.
Endplay	The relative lateral movement of a bearing’s inner and outer raceways.
Hot Axlebox Detector	A device that monitors the temperature of axleboxes and identifies axleboxes that exceed predefined temperature limits.
Immediate cause	The situation, event or behaviour that directly results in the occurrence.
Incident	Any occurrence, other than an accident or serious accident, associated with the operation of trains and affecting the safety of operation.
Infrastructure Manager	Organisation that is responsible for the establishment and maintenance of railway infrastructure, including the management of infrastructure control and safety systems.
Jointed rail	Sections of rail that are bolted together.
Load zone	The section of the bearing supporting the load.
Milepost	A post used to denote a location on a railway line using miles from a fixed point known as the 0 milepost.
National Safety Authority	The national body entrusted with the tasks regarding railway safety in accordance with European directive 2004/49/EC.
Production Executive	A CME maintenance supervisor responsible for overseeing the maintenance activities of fitters.
Railway	Organisation that operates trains.

Undertaking	
Reconditioning	The disassembly, inspection, reassembly and greasing of a bearing using the same components.
Remanufacturing	The assembly of a bearing using a combination of new or repaired components, which may not originate from the same bearing.
Rolling stock	Railway vehicles.
Run out	The displacement around the circumference of the axle journal from a line through the centre of the axle journal.
Safety management system	The organisation and arrangements established by an infrastructure manager or railway undertaking to ensure the safe management of its operations.
Serious injury	Any injury requiring hospitalisation for over 24 hours.
Signal post telephone	Telephone positioned on a signal post that allows communication with the controlling signalman.
Signal protection	Protection of a section of track from approaching trains by means of the signalling system.
Tapered roller bearing	A form of roller bearing with rollers that rotate on a tapered raceway to allow vertical and lateral loading.
Thermal radiation	Energy radiated as electromagnetic waves from a heat source.
Track Circuit Block	A signalling system that uses track circuits to confirm the absence of trains in order to control the movement of trains.
Track Circuit Operating Device	A device used to provide signal protection by allowing the presence of a train to be simulated on track signalled using track circuits.
Traction	Means of providing power to move railway vehicles.
Traffic Regulator	The operational support staff based at CTC responsible for managing operational issues affecting train services.
Train Guard	Onboard train staff responsible for assisting the train driver with the safe management of train operations.
Underlying factors	Any factor(s) associated with the overall management systems, organisational arrangements or the regulatory structure.
Up line	The line on which trains normally travel towards Dublin.
Wayside Hot Axlebox Detector	A hot axlebox detector positioned on the track.
Wheelset	Two rail wheels mounted on an axle connecting them, this may include or exclude the bearings mounted on the axle journals.

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