THE INTRODUCTION OF AXLE COUNTERS IN THE UK

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SUMMARY

In the UK, there has recently been a more widespread use of axle counters as a direct replacement for track circuits due to the perceived whole-life cost of ownership benefit. This paper discusses the ongoing process in the UK, including: the process for safety approval; the management of reset and restoration; the mitigation of risks associated with the replacement of track circuits with axle counters (such as loss of broken rail detection); and the need for changes to the processes associated with managing engineering work.

The key conclusions of this paper are that the process by which axle counters have been introduced in the UK has successfully ensured that risks have been managed to a level that is equal to or lower than the equivalent risks with the fitment of track circuits. However, it is still too early to be sure that the expected benefits in whole-life cost of ownership will be fully realised, given the costs associated with the requirements for the risk management activities outlined in this paper.

INTRODUCTION

The introduction of modern rolling stock and traction systems in the UK has led to increasing difficulties with the safe and reliable operation of track circuits.

Rolling stock units are lighter as a result of the extensive use of aluminium extrusions, and have an increased tendency to bounce, thereby reducing the continuous contact with the rails. Improved wheel/rail interface management has meant that rolling stock is less likely to move from side to side as it progresses, with the result that the rail surface is not kept as clean. The change to disc brakes, rather than clasp brakes, also means that the wheel surfaces are not kept as clean.

Modern traction systems have compounded the problems, with an increasing reliance on A.C. induction motors which tend to generate a large amount of undesirable frequencies that are passed into the track and can interfere with the track circuit operation.

One consequence of this has been an increasing use of axle counters, which are seen as providing a number of benefits, such as:

- Independence from contamination of the rail surfaces;
- No requirement for insulated joints;
- No requirement for rail bonding;
- Train detection independent of ballast resistance;
- Reduced susceptibility to electromagnetic interference;
- Less restriction on the length of track sections; and
- Higher reliability (primarily due to the above factors).

Axle counters have been used for some time to overcome particular problems with track circuits, such as in wet tunnel environments and on metal structures such as bridges.

The UK mainline rail infrastructure controller, Network Rail, began the more widespread use of axle counters as a direct replacement for track circuits at the end of the 1990s on the West Coast Route Modernisation (WCRM) project.

Network Rail believed that axle counters could offer a significant (10:1) cost of ownership benefit over track circuits [1], and experience from Germany suggested that the latest types of axle counters were twice as reliable as the latest types of track circuits [2].

This more widespread use of axle counters highlighted the need to consistently and appropriately manage the risks introduced by the change in technology, and this paper discusses this ongoing process on Network Rail, the lessons
learned so far, and the implications for the ongoing deployment of axle counters elsewhere.

DEFINITIONS

Network Rail – Where referred to in this document, ‘Network Rail’ refers to both the current incarnation of the company, and its previous existence as Railtrack prior to October 2002.

Safety Case – Where referred to in this document as part of either a ‘Concept Safety Case’ or an ‘Application Safety Case’, this relates to an ‘Engineering Safety Case’ as defined in ‘The Yellow Book’ [3], and not Railtrack’s overall ‘Railway Safety Case’ as required under UK regulations [4].

SAFETY APPROVAL

It was decided that such a fundamental change in the method of train detection on Network Rail controlled infrastructure would require a ‘Concept Safety Case’, which would be equivalent to a ‘Generic Application Safety Case’ as defined in the European standard EN 50129 ‘Safety related electronic systems for signalling’ [5].

Individual signalling schemes that wished to employ axle counters as an alternative to track circuits would require an ‘Application Safety Case’, which would be equivalent to a ‘Specific Application Safety Case’ as defined in EN 50129 [5].

The specific requirement for an axle counter concept safety case, as well as individual axle counter scheme application safety cases, is mandated upon Network Rail as part of Railway Group Standard GE/RT8217 ‘Introduction and Use of Axle Counters – Managing the Risk’ [6].

The axe counter concept safety case [7] demonstrated that the risks associated with axle counters could be made as low, or lower than, those associated with track circuits, and provided a framework for individual application safety cases to demonstrate that the type of axle counter system being commissioned on a particular project reduces the risks to ALARP (relative to the provision or retention of track circuits).

The framework within the concept safety case [7] for producing application safety cases includes a requirement for compliance with Railway Group Standard GE/RT8217 [6] in terms of managing the risks associated with the following key issues:

- Reset and restoration to service;
- Emergency protection;
- Broken rail detection;
- Detection of obstructions; and
- Engineering activities.

A further Railway Group Standard, GK/RT0217 [8], defines the technical and design requirements for axle counters that must also be addressed within an application safety case.

Network Rail’s compliance with Group Standards GE/RT8217 [6] and GK/RT0217 [8], as well as the requirements of the concept safety case [7], is currently achieved by the use of the mandatory company standard NR/SP/SIG/10129 ‘Requirement Specification for Train Detection Using Axle Counters’ [9], along with a number of supporting standards, including particularly NR/GN/SIG/11900 ‘Application Manual for Axle Counters’ [10] and NR/GN/SIG/11901 ‘Axle Counter Application Manual Design Requirements’ [11].

As stated in NR/SP/SIG/10129 [9], it is anticipated that in complying with this standard, a project will automatically meet the requirements of the concept safety case without the need for an application safety case. However, at the time of writing, application safety cases are still produced for new signalling schemes using axle counters on Network Rail controlled infrastructure.

RISK MANAGEMENT - KEY ISSUES

Reset and Restoration to Service

There are different types of reset and restoration processes available for the different legacy axle counter systems that have been in use in the UK since the 1970s. However, a standard set of principles have emerged within Network Rail for the latest axle counter systems that are being employed on a widespread basis as a direct replacement for track circuits.

For ‘in-service’ reset and restoration, Network Rail has applied the principle of aspect restriction to provide the main protection against train collision. Aspect restriction functionality is provided via the interlocking to ensure that after a signaller has ‘reset’ an erroneously ‘occupied’ section, a train must ‘sweep’ through the section under a restricted aspect (normally red) before the
interlocking will 'restore' the section for normal train operations.

In this way, the axle counter subsystem is responsible for the 'reset' function, whilst the interlocking is separately responsible for the 'restore' function.

For a signaller to reset a section that is shown as occupied (either through being in a 'disturbed' state or through showing erroneously 'occupied') a number of specific steps are required in order to ensure key principles are adhered to. These include:

• Rule Book requirements to protect the track section (e.g. reminder collars, auto-working inhibited, etc.) are put in place for the duration of the reset and restoration process;

• Independent verification is required by a second signaller / duty manager of the correct axle counter section to be restored, and confirmation that, to the best of his knowledge, the section is physically unoccupied;

• A log is completed for every axle counter section reset and restoration activity, and signed by both the signaller and independent verifier;

• The signaller initiated request to reset the axle counter section is 'conditional' upon the last count being in an outward direction from the section;

• If successful, the 'reset' axle counter section will indicate clear to the interlocking, but the interlocking will apply aspect restriction, ensuring that main signals controlling access to the section remain at their most restrictive aspect; and

• The next train (operating under the restricted aspect) will be required to examine the line in accordance with Rule Book requirements, and the passage of this train will then clear the aspect restriction for the route and 'restore' the section in the interlocking.

Emergency Protection

In a track-circuited area there is the opportunity for train crew or others to use track circuit operating clips in an emergency to ‘shunt’ a track circuit in order to set the associated protecting signals to danger. Obviously track circuit operating clips do not function with axle counters.

As a result, when replacing track circuits with axle counters, alternative methods of protection are required by GE/RT8217 [6] to mitigate the overall risk of a secondary collision to a level that is equal to or lower than it would be if track circuits and track circuit operating clips were in use.

The primary method of mitigation recommended by GE/RT8217 [6] is to ensure that a method of immediate, reliable and continuously available communication between the train crew and the signaller is provided.

Radio is available for all train crews operating in axle counter areas. This is achieved through a number of different systems, which include the National Radio Network (NRN) and Cab Secure Radio (CSR). It is planned for these systems to eventually be replaced by the widespread application of a national GSM-R system, which is currently being introduced.

In axle counter areas where the GSM-R trackside infrastructure has already been installed, a hand-held ‘voice-only’ GSM-R application, Interim Voice Radio System (IVRS), is being employed until the wider roll-out of the full in-cab fitted GSM-R system.

In axle counter areas where IVRS is not available, additional line-side phones are installed to ensure that communication points are available at fixed and frequent intervals.

Broken Rail Detection

As stated in GE/RT8217 [6], track circuits have an inherent ability, incidental to their main function, to detect some broken rails. Axle counters do not have this ability, and so alternative mitigation measures are required to ensure that the overall risk of derailment due to a broken rail is no higher on an axle counter fitted line than the risk that existed before the introduction of axle counters.

The axle counter concept safety case [7] noted that studies on the number of broken rails first detected by track circuits produced a variety of results, with values ranging from ~25% to ~80%, depending on the track circuit configuration.

The axle counter concept safety case [7] also recommended that the principal strategy for risk mitigation should be the detection of rail defects before breaks occur, and not the detection of rail breaks.
Two mitigation methods are normally applied by Network Rail and documented within an application safety case to provide compliance with GE/RT8217 [6]:

- Removal of any redundant Insulated Rail Joints (IRJs) within six months of the commissioning of the axle counter system; and
- Investigation of, and if required, a revision of the management of rail in the axle counter area.

For example, in the Rugby-Nuneaton project (as documented in the application safety case [12]), 118 IRJs were required to be removed.

An investigation into the number of rail breaks in the Rugby-Nuneaton area found that only one rail break had occurred between March 1997 and March 2008, which occurred at a weld, and was found by a patrolman and not detected by the track circuit [12].

As a result, there was no requirement to amend the existing rail management system in the area, which already included:

- The operation of an Ultrasonic Test Train every 8 weeks; and
- Renewal of pre-1976 rail within 5 years.

Detection of Obstructions

As stated in GE/RT8217 [6], track circuits have an inherent, albeit limited, ability, incidental to their main function, to detect certain types of obstruction, such as landslips. Axle counters do not have this ability, and so alternative mitigation measures are required to ensure that the overall risk of a train colliding with an obstruction on the line is equal to, or lower than, the risk of such a collision if that same line was fitted with track circuits.

GE/RT8217 [6] requires that factors including: the likelihood of vandalism; the likelihood of landslips; the proximity to public roads and airports; and the likelihood of flooding are taken into consideration in the application safety case.

The axle counter concept safety case [7] concluded that the contribution of track circuits in this area was generally too small to warrant any compensatory measures if axle counters were used in place of track circuits, and to date, none of the areas where axle counters have been introduced on a wide scale have required additional controls to mitigate the risk of obstructions.

Engineering Activities

GE/RT8217 [6] includes two particular areas of requirements associated with engineering activities in axle counter areas:

- the removal of axle counter heads, where necessary, to protect the axle counter equipment and to permit maintenance activities (e.g. tamping) to be executed properly; and
- the disturbance of axle counter heads by engineering plant and machines and/or the risk of leaving plant on the track.


The engineering works manual [13] specifies the activities that require the routine removal and replacement of axle counter heads by the signal technician, and this includes specifically: re-railing, tamping, regulating dynamic track stabilising, re-lying, re-ballasting and grinding. Work is currently underway to approve specific types of vehicles to undertake tamping and grinding without the requirement to remove and replace axle counter heads.

The engineering works manual [13] provides detailed instructions for the specific management of engineering works in axle counter areas. This process is referred to as ‘Engineering Vehicle Management’ (EVM). Different categories of engineering work are specified within the manual [13] to provide appropriate controls for the risks associated with different types of possessions.

Where the possession involves multiple trains or any single other self-propelled on-track vehicle (such as road-rail vehicles, motorised trolleys, etc.), an examination of the line is required.

Where work within an engineering possession is restricted to the use of hand-operated trolleys and/or hand tools, or where a single, fixed-formation train is used, the EVM process does not require a separate examination of the line to supplement the hand-back process.

Where an examination of the line is required, an ‘Examination Agent’ (EA) is appointed to
undertake an examination of the full length of the possession area on completion of engineering works. Multiple EAs and Engineering Examination Vehicles (EEVs) are used for the examination of large possession areas.

The EVM process has proved effective in managing the identified risks associated with vehicles and plant being left on track at the end of engineering works. However, where there is a requirement for an examination of the line, the process has resulted in a reduction in available productive working time within engineering possessions.

As a result, recent work on Network Rail has focussed on the possibility of using new technology, such as GPS tracking and Radio Frequency Identification (RFID) tags, to track engineering vehicles and eliminate the requirement for a separate examination of the line.

Whilst these technological solutions are investigated, attention has focussed on optimising the EVM process for examining the line, including: the introduction of additional trackside access and egress points; more effective use of multiple EAs and EEVs; and the provision of more robust mechanisms for the manual reporting of vehicle locations.

It should be noted that the improvements in possession management, required as part of the introduction of axle counters, have provided significant benefits in risk management over previous processes, and Network Rail are currently considering the wider application of EVM processes in non-axle counter areas.

CONCLUSIONS

The process by which axle counters have been introduced in the UK has been successful in ensuring that risks are managed to a level that is equal to or lower than the equivalent risks with the fitment of track circuits.

However, this process has necessitated the introduction of a number of controls and procedures. Some of these have had implications for costs, resource requirements and working practices, whilst others have led to the early introduction of safety systems that have provided benefits beyond the management of axle counters.

In particular, the following areas have been key:

- The requirement for an application safety case has proved both expensive and time-consuming, but is considered to have been effective for managing risks in initial implementations;
- The need for ‘aspect restriction’ has required additional interlocking controls, but these are not considered significant in the context of major re-signalling schemes (which is largely when train detection system renewals take place);
- The introduction of axle counters has had a positive impact on the roll-out of GSM-R communication systems, and this provides wider safety benefits beyond those associated with managing axle counter areas;
- The renewed focus on prevention rather than detection of rail breaks is seen to be an improvement on previous rail management regimes; and
- Careful thought needs to be given to the processes associated with the management of engineering activities, as the need to ensure the line is clear on completion of works can impose significant restrictions on the available productive working time.

Overall, the consensus in the UK appears to be that the widespread introduction of axle counters is an inevitability given the limitations of track circuit technologies, and the process by which Network Rail has undertaken safety approval provides an ideal framework for the ongoing roll-out of axle counters.

However, it is still too early to be sure that the expected benefits in whole-life cost of ownership will be fully realised, given the costs associated with the requirements for the risk management activities outlined in this paper.

REFERENCES


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