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GMRT2111
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Rolling Stock Subsystem and Interfaces to AC Energy Subsystem

Synopsis

This document sets out interface requirements to the alternating current (ac) energy subsystem for all rolling stock operating over the Great Britain (GB) mainline 25 kV ac electrified railway.

Published by RSSB

Issue record

Issue	Date	Comments
One	December 2014	Original document. This document has been developed under project 09/013a to identify existing in-scope requirements and reduce costs associated with establishing compatibility between energy and rolling stock subsystems. The document retains in scope requirements from GERT8025 issue one, GMRT2181 issue three and GMRT2304 issue three and specifies new requirements needed to establish electrical compatibility between the two subsystems.
Two	September 2019	Replaces issue one. Revisions to sections 4.7-4.9 relating to pantograph/overhead contact line (OCL) mechanical interaction to align with TSI requirements and compatibility with non-TSI OCL.
Three	December 2022	Replaces issue two. Significant updates have been carried out to the sections and rationalisation of all requirements has taken place, including the removal of several requirements that cannot be considered as national technical rules. Guidance only sections of this standard are in place to support the Locomotive and Passenger (LOC&PAS) national technical specification notice (NTSN).

Revisions have not been marked by a vertical black line in this issue because the document has been revised throughout.

Superseded documents

The following Railway Group documents are superseded, either in whole or in part as indicated:

Superseded documents	Sections superseded	Date when sections are superseded
GMRT2111 Issue Two	2.2, 2.4, 3.1, 3.2, 3.3, 3.4, 3.8, 3.9, 3.10, 3.11, 3.12, 3.15, 3.16, 4.2, 4.3, 4.4, 4.5, 4.6, 4.8, 4.9, 4.10, 4.11, 4.12	04/03/2023

Superseded documents	Sections superseded	Date when sections are superseded
GMGN2611 Issue Two	G 2.2, G 2.4, G 3.1, G 3.2, G 3.3, G 3.4, G 3.8, G 3.9, G 3.10, G 3.11, G 3.12, G 3.15, G 3.16, G 4.2, G 4.3, G 4.4, G 4.5, G 4.6, G 4.8, G 4.9, G 4.10, G 4.11, G 4.12	04/03/2023

Supply

The authoritative version of this document is available at www.rssb.co.uk/standards-catalogue. Enquiries on this document can be submitted through the RSSB Customer Self-Service Portal https://customer-portal.rssb.co.uk/

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Part 1 Purpose and Introduction

1.1 Purpose

1.1.1 This document is applicable to rolling stock operating over the Great Britain (GB) mainline 25 kV ac electrified railway and sets out the interface requirements to the ac energy subsystem.

1.1.2 This document contains 'open points', as set out in *Appendix A*, to address requirements that have not yet been specified but which are within the scope of the document. They apply to 25 kV electric rail vehicles.

1.2 Introduction

1.2.1 Background

1.2.1.1 This document supplements the national technical specification notice (NTSN) requirements for interoperability and the migration towards operation on electrification systems that are compliant with the NTSNs and national technical rules (NTR) for the GB mainline 25 kV ac electrified railway, while continuing to give compatibility with existing infrastructure. This document includes requirements for rolling stock technical compatibility with all ac energy subsystems. As the existing ac energy subsystems which predate GLRT1210 are not ENE NTSN compliant, this has resulted in additional rolling stock requirements for technical compatibility with the ac interface.

1.2.2 Principles

1.2.2.1 The requirements of this document are based on the following principles.

1.2.2.2 This document sets out requirements that meet the characteristics of NTRs and are applicable to the GB mainline railway system. Compliance with NTRs is required under the Railways Interoperability Regulations 2011 (as amended).

1.2.2.3 The NTRs in this document are used for the following purposes:

a) To fill identified open points in NTSNs.
b) To support GB or United Kingdom (UK) specific cases in NTSNs.
c) To enable technical compatibility between rolling stock vehicles and legacy ac energy subsystems.

1.2.3 Structure of this document

1.2.3.1 Where relevant, the national technical rules relating to relevant NTSN parameters have been identified together with the relevant clause from the NTSN.

1.2.3.2 This document sets out a series of requirements that are sequentially numbered. This document also sets out the rationale for the requirement, explaining why the requirement is needed and its purpose and, where relevant, guidance to support the requirement. The rationale and the guidance are prefixed by the letter ‘G’.

1.2.3.3 Some subjects do not have specific requirements but the subject is addressed through guidance only and, where this is the case, it is distinguished under a heading of 'Guidance' and is prefixed by the letter 'G'.

1.2.4 Supporting documents

1.2.4.1 The following Railway Group documents support this Railway Group Standard:

a) RIS-2715-RST 'Rail Industry Standard on Rolling Stock Subsystem and Interfaces to AC Energy Subsystem'
b) GLRT1210 'AC Energy Subsystem and Interfaces to Rolling Stock Subsystem'
c) RIS-1853-ENE 'Rail Industry Standard on AC Energy Subsystem and Interface to Rolling Stock Subsystem'
d) GIRT7020 'GB requirements for Platform Height, Platform Offset and Platform Width'
e) GMRT2173 'Size of Vehicles and Position of Equipment'
f) RIS-2773-RST 'Formats and Methods for Defining Vehicle Gauging Data'

1.3 Approval and authorisation of this document

1.3.1 The content of this document was approved by Rolling Stock Standards Committee on 04 November 2022 .

1.3.2 This document will be authorised by RSSB on 01 December 2022.

Part 2 Requirements for all rail vehicles required to operate under 25 kV ac electrified lines

2.1 Clearance to 25 kV overhead contact line

Guidance

G 2.1.1 Electrical insulation by either air clearance, or by other means that achieve the same electrical performance, is set out in GLRT1210 for 25 kV overhead contact line (OCL) heights, which includes a reduced minimum OCL height when surge arrestors are used. These ac energy subsystem requirements address the electrical clearance between all rail vehicle parts intended or not intended for connection to the OCL, including any parts that have been disconnected from the OCL and any exposed live part of the OCL, provided a vehicle complies with the requirements set out in GMRT2173 and part 3 of RIS-2773-RST.

G 2.1.2 Other uninsulated live rail vehicle parts energised at 25kV ac (such as parts of measurement devices) are typically located laterally within the envelope defined by the pantograph's live parts. Therefore, they have adequate clearance to any adjacent infrastructure which can be at earth potential.

G 2.1.3 As the OCL height approaches the minimum permitted values, the risk of flashover to the vehicle increases.

G 2.1.4 Where alternative means of electrical insulation is considered in the design of rail vehicles, it is considered good practice to apply the degree of pollution appropriate to the system as set out in BS EN 50124-1:2017 Table A.4.

G 2.1.5 When carrying out absolute gauging for route compatibility against wire heights, particularly non standard heights, historic practice in some parts of the industry has been to demonstrate at least 200 mm electrical clearance between the vehicle and the OCL unless other mitigations have been identified through risk assessment which have therefore permitted a reduced clearance value.

2.2 Shore supplies

2.2.1 Where 400/415 V AC shore supplies are fitted, they shall:

a) Be three phase with no neutral; and
b) Provide 600 A per phase; and
c) Have a three phase three pin plug and receptacle with auxiliary contacts for interlocking.

2.2.2 Where 1000 V AC shore supplies are fitted, they shall:

a) Be single phase with two wires; and
b) Provide 600 A; and
c) Have two single pole 1000 V plugs and receptacles with auxiliary contacts for interlocking.

Rationale

G 2.2.3 Locomotive and Passenger (LOC&PAS) national technical specification notice (NTSN) clause 4.2.11.6 sets out requirements for shore supplies. Permission is also given in LOC&PAS NTSN UK specific case 7.3.2.24 for national technical rules to be set out for 400 V shore supplies. Requirement *2.2.1* is in place to address the specific case.

G 2.2.4 Legacy 1000 V shore supplies are installed on the GB mainline 25 kV ac electrified railway. Requirement *2.2.2* is in place for technical compatibility with these legacy shore supply systems.

Guidance

G 2.2.5 *Table 1* gives guidance on British Rail catalogue numbers for legacy shore supply plugs and receptacles for both the train and shore side. These are example components but other compatible components can be used.

Component	Legacy 400 / 415 V System	Legacy 1000 V System
Train plug	-	90/11401
Train receptacle	64/724	64/360
Shore plug	64/725	64/2419
Shore receptacle	-	64/2418

Table 1: Catalogue numbers for legacy shore supply plugs and receptacles

Part 3 Electrical requirements for 25 kV electric rail vehicles

3.1 System voltage and frequency

3.1.1 Rolling stock intended to operate on the GB mainline 25 kV ac electrified railway shall comply with the UK special national condition voltage limits set out in BS EN 50163:2004 Annex B clause 4.1 for U_{min2}.

Rationale

G 3.1.2 Requirement *3.1.1* addresses LOC&PAS NTSN GB specific case 7.3.2.11 through acknowledgment of the voltage ranges required by LOC&PAS NTSN clause 4.2.8.2.2 with reference to ENE NTSN clause 4.2.3 and BS EN 50163:2004 clause 4.1, and confirms the use of the values for U_{min2} .

Guidance

G 3.1.3 The LOC&PAS NTSN requires electric units to be able to operate within the range of at least one of the voltage and frequency systems defined in ENE NTSN clause 4.2.3, for which the voltage and frequency for GB mainline is ac 25 kV, 50 Hz.

G 3.1.4 Permitted short and long term upper and lower voltage limits are summarised in BS EN 50163:2004 Table 1.

G 3.1.5 As much of the GB mainline 25 kV ac electrified railway has been upgraded since the UK special national condition limits were set, it is expected that the voltage values of the ac energy subsystem as set out in the ENE NTSN will apply on most routes. Lower values set out in the UK special national condition are likely to be present on a limited number of routes and are only likely to be experienced occasionally.

G 3.1.6 BS EN 50163:2004 clause 4.2 sets out frequency limits for 50 Hz systems. RIS-1853-ENE sets out requirements and guidance for the type of connection used on the GB mainline 25 kV ac electrified railway.

G 3.1.7 LOC&PAS NTSN clause 4.2.8.2.2(2) sets out a requirement for the actual value of the line voltage to be available in the driver's cab in driving configuration. The measuring device to determine this is not considered a 25 kV load.

3.2 Maximum allowable current

3.2.1 Train set current (I_{max}) shall be no greater than 300 A, except where higher values are permitted on the GB mainline 25 kV ac electrified railway as set out in the Register of Infrastructure (RINF).

Rationale

G 3.2.2 The maximum current for a particular line is available from the RINF or the IM. The maximum permitted current for most lines on the GB mainline 25 kV ac electrified railway is 300 A and is provided as an informative value in BS EN 50388-1:2022 Annex D.

G 3.2.3 Permission is given in this requirement for train sets to draw more than 300 A from the ac energy subsystem where higher values are declared for a line.

G 3.2.4 Where some train sets require current demand in excess of 300 A, the energy subsystem needs to be compatible with this higher value.

G 3.2.5 Where the energy subsystem requires train sets to demand less than 300 A, the rolling stock needs to be compatible with this lower value.

Guidance

G 3.2.6 A facility to set the maximum current as set out in LOC&PAS NTSN clause 4.2.8.2.4 allows different values to be selected for different routes, thus permitting different classes of train sets to be used across the GB mainline 25 kV ac electrified railway. Methods by which this function might be achieved include:

a) A variable current power controller where different positions selected by the driver allow different current limits;
b) Driver selectable current demand profiles, either by provision of a switch or via the Train Control and Management System (TCMS);
c) Automatically selected current demand limits by off vehicle systems, for example, by European Traffic Control Systems (ETCS) or Radio Frequency Identification (RFID) tags;
d) Selectable current limits adjusted during maintenance; or
e) Automatic variation of the current limit dependent on the train set formation.

G 3.2.7 The current limit set out in *3.2.1* does not provide for technical compatibility across the entire legacy ac electrified network as limits can be lower or higher depending on the route.

G 3.2.8 LOC&PAS NTSN clause 4.2.8.2.4(2) sets out a requirement for the regulation of maximum power and current from the OCL, which is with respect to the OCL voltage.

3.3 Automatic connection and disconnection of 25 kV loads

3.3.1 Automatic power control (APC) shall be used to control the in-feed circuit breakers on vehicles intended for operation on lines up to and including speeds of 250 km/h (155 mph).

3.3.2 In-feed circuit breakers of pantograph(s) in use shall automatically open on 25 kV electric rail vehicles(s) on the detection of the approach APC magnet as defined in GLRT1210.

3.3.3 Each train in-feed circuit breaker associated with a pantograph opened on the detection of an approach APC magnet shall open within 150 milliseconds (ms) of the vehicle receiving the trigger signal.

3.3.4 Each train in-feed circuit breaker shall close on the detection of a retreat APC magnet as defined in GLRT1210.

3.3.5 The APC receiver shall be positioned, vertically and laterally (across track), in accordance with the dimensions set out in *Figure 1*.

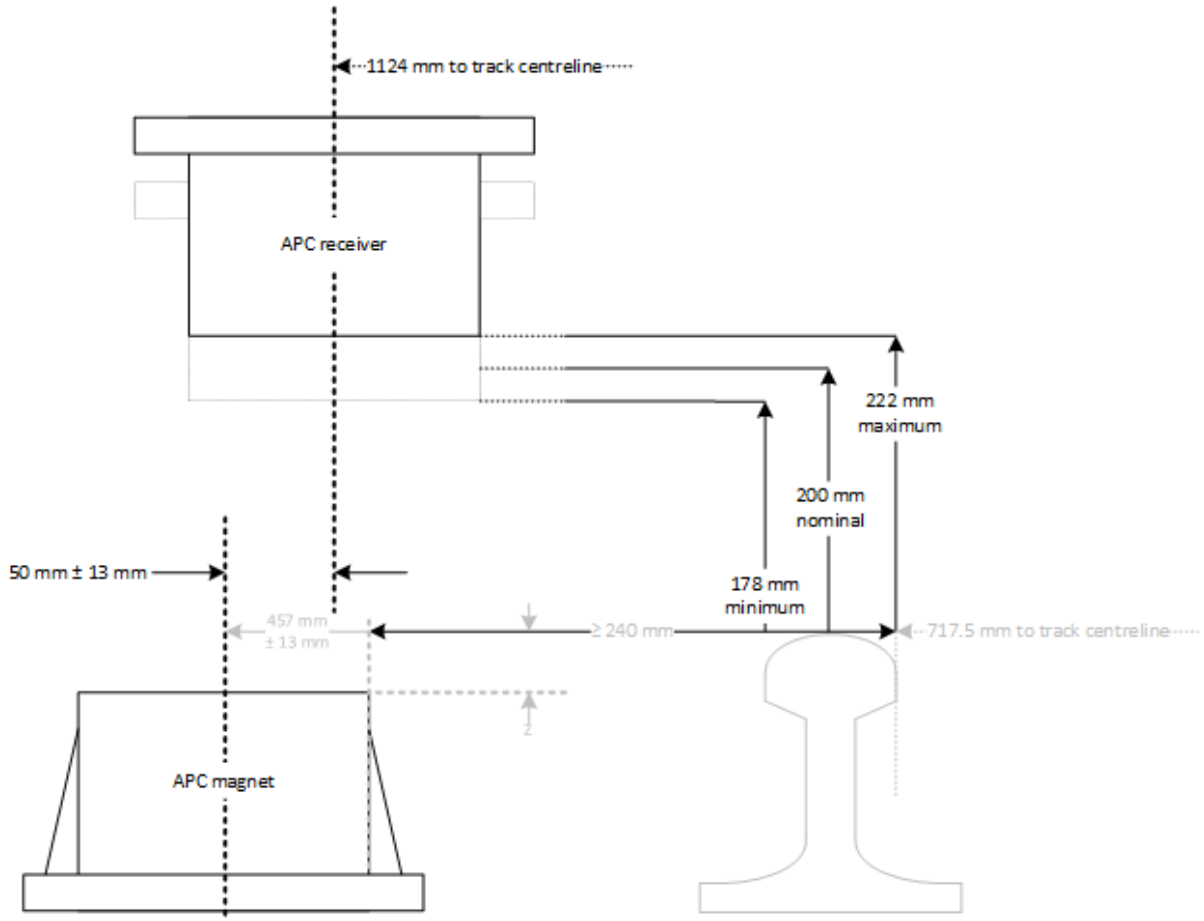

Figure 1: Relationship between the APC receiver and the APC track magnet

3.3.6 The along-track longitudinal distance between the centre line of the APC receiver and the centre line of its associated pantograph head shall not exceed 7.75 m

3.3.7 Detection of a vertically oriented south polarity magnetic flux of greater than 2.5 mT at the base of the receiver shall initiate the operation of the train in-feed circuit breaker.

3.3.8 The APC receiver shall detect the signal from the APC magnet within 2.5 ms if the maximum vehicle design speed is greater than 160 km/h (100 mph).

3.3.9 The APC receiver shall detect the signal from the APC magnet within 4.5 ms if the maximum vehicle design speed is less than or equal to 160 km/h (100 mph).

3.3.10 Having been detected, the APC system shall prevent the same magnet from being detected again for the same in-feed circuit breaker operation.

Rationale

G 3.3.11 LOC&PAS NTSN clause 4.2.8.2.9.8 requires that trains are designed to be able to move from one power supply system and section at one phase, to an adjacent system with a different power supply system or a different phase, without bridging them.

G 3.3.12 GB has a long-established system that provides APC to prevent incidents and asset damage at neutral sections, and is fitted to all 25 kV traction units regardless of maximum design speed. This is the recognised default form of APC of 25 kV loads.

G 3.3.13 Requirements relating to APC are functional parameters that provide a means to achieve technical compatibility between the electrification system and the pantograph and traction system on the train, and define the way the APC receiver operates in conjunction with the fixed equipment at trackside forming the fixed part of the APC system.

G 3.3.14 Detection of a magnet twice can result in an open train in-feed circuit breaker being reclosed on approach to a neutral section, resulting in neutral section damage.

Guidance

G 3.3.15 An APC function can be integrated within ETCS, as set out in LOC&PAS NTSN clause 4.2.8.2.9.8(5), as the use of ETCS increases and matures.

G 3.3.16 The GB APC system includes a toggle feature and is designed so that the first pulse encountered on the approach to a neutral section opens the train in-feed circuit breaker and disconnects the train's electrical equipment from the pantograph. The next pulse closes the train in-feed circuit breaker and reconnects the train's electrical equipment to the OCL.

G 3.3.17 System functionality and response times permit compatibility between the rail vehicle and the ac energy subsystem, and enables the positioning of: the location trigger, the operation of the circuit breaker and the beginning and end of neutral sections.

G 3.3.18 Setting a maximum distance between the receiver and pantograph location and maximum response times according to vehicle speed informs the positioning of the track magnets that trigger the operation of the in-feed circuit breaker at the correct position relative to the pantograph and neutral sections.

G 3.3.19 Disconnection from the ac supply prior to the train reaching the neutral section reduces the likelihood of neutral section flashovers.

G 3.3.20 150 ms is the total time from receiving the signal from the track to the breaker being open. It comprises the receiver detection time, together with the train in-feed circuit breaker operation time.

G 3.3.21 LOC&PAS NTSN clause 4.2.8.2.9.8(4) requires that the TCMS is able to receive neutral section data from the ETCS on vehicles fitted with ETCS that has APC functionality.

G 3.3.22 APC is only configured to recognise signals from south-polarity magnetic fields oriented in the vertical direction and is insensitive to fields oriented in other directions.

G 3.3.23 Specifying minimum magnetic flux detection limits according to speed and polarity is a means of achieving technical compatibility between the APC receiver and the track magnets.

G 3.3.24 If an APC receiver is capable of detecting a vertically oriented magnetic flux of less than 1.5 mT with a south polarity presented at the base-sensitive point of the receiver, it can result in the incorrect operation of the in-feed circuit breaker.

G 3.3.25 Routine maintenance can include a functional check of the vehicle APC system, including the passing of activating magnets in succession under the APC receiver.

G 3.3.26 The rail vehicle-mounted APC receiver is usually fixed to a bogie frame to achieve the appropriate height above rail level and the lateral distance from the centre line of the track.

G 3.3.27 The distance from the track magnets to the neutral sections depends on the maximum permitted line speed. These distances are set out in GLRT1210.

G 3.3.28 LOC&PAS NTSN clause 5.3.12 sets out requirements for the main circuit breaker with respect to the voltage and current capacity, and tripping performance to be assessed at interoperability constituent (IC) level in accordance with BS EN 50388:2012 clause 11. The main circuit breaker is also referred to as the in-feed circuit breaker.

G 3.3.29 RSSB research report T951 (2012) gives further information on the APC magnet and receiver interface.

G 3.3.30 GLRT1210 sets out requirements and guidance for trackside APC magnets.

3.4 Separation of external power supplies

3.4.1 The 25 kV ac energy supply shall not be connected to any other external traction energy supply through a vehicle.

Rationale

G 3.4.2 This requirement provides a means of achieving technical compatibility with the GB mainline 25 kV ac electrified railway where another supply, such as 750 V dc, can exist at the same location.

Guidance

G 3.4.3 This is normally achieved by interlocks with the respective supplies in the changeover control.

3.5 Placement of 25 kV exposed live parts on a vehicle relative to a standing surface

Guidance

G 3.5.1 LOC&PAS NTSN clause 4.2.8.4 sets out a requirement for protection against electrical hazards. This refers to the relevant clauses of BS EN 50153:2014, which are those related to voltages greater than 1000 V (band IV voltages in BS EN 50153:2014). This includes the application of clause 5.3.2.2, which further references BS EN 50122-1:2012, figure 4, as the method by which protection against electrical hazards by clearance can be achieved. BS EN 50122-1:2022 clause 5.4 sets out a new method for rolling stock for protection against electrical hazards, but this is not referenced by the LOC&PAS NTSN. BS EN 50122-1:2022 clause 5.4 can however be implemented in addition to BS EN 50122-1:2012, figure 4, as good practice.

G 3.5.2 ENE NTSN clause 4.2.18 sets out a requirement for electrical safety of the OCL system. This requirement extends it to exposed live parts on the roof of rolling stock and provides technical compatibility between the rolling stock subsystem and infrastructure. The implementation of this requirement also mitigates direct contact with live parts of the rolling stock subsystem from a standing surface in public areas.

G 3.5.3 Providing the worst-case conditions for platform height, OCL height and track cant over the GB mainline 25 kV ac electrified railway on which a traction unit can operate assists ac energy subsystem designers in carrying out safety assessments.

G 3.5.4 Providing appropriate clearance or an obstacle between a standing surface and exposed live parts of a traction unit reduces both the risk of arcing between the rolling stock and infrastructure and the risk of electric shock to both the public and personnel.

G 3.5.5 The pantograph head position, when static and in contact with the OCL, is determined mainly by the contact wire height / position and track cant, rather than something which is mainly influenced by the rolling stock.

G 3.5.6 GIRT7020 sets out requirements for heights of platforms. RSSB research report T866 (2011) gives an indication of the range of platform heights that exist on Network Rail managed infrastructure. GLRT1210 issue three Table 1 sets out permitted OCL heights.

G 3.5.7 Pantographs are typically not located above external doors.

3.6 Fault current clearance

3.6.1 25 kV electric rail vehicles shall be fitted with train in-feed circuit breakers that meet all the requirements of BS EN 60077-4:2003, where the short circuit current is the maximum root mean squared (rms) current for the route in a circuit having a maximum time constant.

Rationale

G 3.6.2 Having train fitted protection that operates wherever possible in advance of ac energy subsystem circuit breakers minimises on-board equipment damage and loss of supply to other trains that could adversely affect the service.

Guidance

G 3.6.3 The maximum time constant of the ac energy subsystem and the ability for train in-feed circuit breakers to interrupt asymmetric fault currents are 'open points'. *Appendix A* references the guidance on the 'open points'.

G 3.6.4 There is currently no agreed value for the maximum time constant on the existing GB mainline 25 kV ac electrified railway. However, it is anticipated that the maximum value is likely to be in the range of 120 ms to 240 ms. The maximum time constant and maximum rms current can vary by location.

G 3.6.5 There is currently no agreed value for the maximum time constant for future new, renewed and upgraded parts of the GB mainline 25 kV ac electrified railway. BS EN 60077-4:2003 and associated standard BS EN 62271-100:2009+A1:2012 have

provisions for a standard time constant value of 45 ms and special case time constants of 60 ms, 75 ms and 120 ms.

G 3.6.6 For the short circuit breaking condition, the percentage dc component of the ac waveform is determined in accordance with BS EN 62271-100:2009+A1:2012 Figure 9, corresponding to a circuit time constant τ. If the train in-feed circuit breaker is self-tripping, the dc component is determined at the point corresponding to the minimum opening time of the train in-feed circuit breaker, or if tripped solely by any form of auxiliary power, it is determined by the minimum opening time of the train in-feed circuit breaker plus one half cycle of rated frequency.

G 3.6.7 The circuit time constant from which the percentage of dc component is determined, is given to permit testing in accordance with BS EN 60077-4:2003. The tests are to prove the train in-feed circuit breaker's ability to break short circuit currents when the ac waveform is substantially distorted under the worst case asymmetric condition. This distortion of the ac waveform is a result of the electrification system characteristics (X/R ratio), and a high level of dc off-set which can be present for several cycles immediately after the inception of a short circuit. The level of dc offset which occurs is also dependent upon the point in the ac voltage waveform when the fault occurs.

G 3.6.8 Fault current clearance can also take into consideration the possible adverse impact on other systems, such as the lineside signalling and telecoms systems in the affected area.

Part 4 Mechanical and pantograph bonding requirements for 25 kV electric rail vehicles

4.1 Pantograph profiles

Guidance

G 4.1.1 LOC&PAS NTSN GB specific case 7.3.2.14 permits the use of an alternative pantograph profile to that defined in clause 4.2.8.2.9.2. This alternative profile is set out in BS EN 50367:2012 Annex B.2. Figure B.6, and is commonly referred to as the 'B.6. profile'. LOC&PAS NTSN requirements for independently suspended collector strips also apply to the B.6. profile.

G 4.1.2 It is good practice to fit wear strips of sufficient length to prevent hook under when running on the OCL of the GB mainline network. These wear strips are fitted within the existing profile set out in BS EN 50367:2012. The wear strips are shown in *Figure 2*.

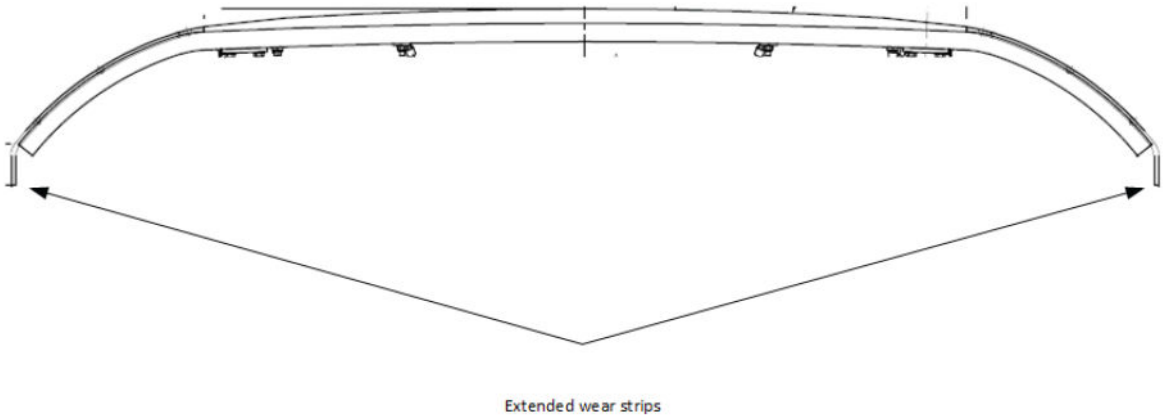

Figure 2: Extended wear strips

G 4.1.3 It is normal practice in GB for the contact wire to occasionally run off the carbon collector strip and onto the pantograph horn and conduct current.

4.2 Pantograph head width

4.2.1 For pantographs with multiple collector strips, the minimum along-track head width of the pantograph shall be no less than 200 mm.

4.2.2 The maximum along-track head width of a pantograph shall be no greater than 450 mm, except where greater widths are permitted for the GB mainline 25 kV ac electrified railway as set out in the RINF.

Rationale

G 4.2.3 LOC&PAS NTSN clause 4.2.8.2.9.2(4) restricts the along-track head width of a pantograph head to 650 mm to prevent the bridging of insulators in neutral sections.

G 4.2.4 GB ac energy subsystems that are not compliant with the ENE NTSN can have insulators shorter than might be required for a head width of 650 mm. Limiting the maximum along-track head width provides technical compatibility with legacy GB ac energy subsystems.

Guidance

G 4.2.5 If an insulator at a neutral section is bridged due to the use of a pantograph with a head width exceeding 450 mm, a flashover of a section to earth can occur.

G 4.2.6 Pantograph characteristics that are permitted on a route, such as head width, are identified in the RINF.

4.3 Pantograph force distribution

Guidance

G 4.3.1 Pantographs designed with multiple collector strips benefit from:

a) All collector strips being in contact with the OCL; and
b) An even force applied across all of the collector strips.

These features prevent higher wear rate occurring on one collector strip relative to the others.

G 4.3.2 A freedom of head rotation so that pantograph heads with multiple collector strips can maintain contact with the OCL and distribute the contact force evenly may be considered in pantograph design.

4.4 Pantograph mechanical operation

4.4.1 Pantographs mounted on traction units shall be capable of achieving mechanical contact with the minimum and maximum contact wire heights over the range as set out in GLRT1210 issue three Table 1.

Rationale

G 4.4.2 LOC&PAS NTSN UK specific case 7.3.2.13 permits a pantograph's mechanical contact with the OCL to be at an extended range of heights in accordance with national technical rules. This requirement addresses the UK specific case and provides a means of achieving technical compatibility with the OCL heights applied on the GB mainline 25 kV ac electrified railway.

Guidance

G 4.4.3 The maximum contact wire height set out in GLRT1210, regardless of maximum speed, is 6200 mm considering dynamic uplift from a typical static limit of 5940 mm including OCL and track tolerances.

G 4.4.4 LOC&PAS NTSN UK specific case 7.3.2.16 sets out a requirement for pantographs to be assessed to collect current in the range of 4700 mm to 4900 mm. Requirement *4.4.1* supports this assessment considering the inherently lower wire height range required on the GB mainline 25 kV ac electrified railway.

G 4.4.5 RSSB research project T1105 (2016) gives information on mathematical models that support accurate pantograph to OCL simulations.

4.5 Pantograph lowering

4.5.1 All pantographs shall be equipped with an automatic dropping device (ADD) that lowers the pantograph, as defined in BS EN 50206-1:2010 clause 4.8.

4.5.2 The overheight detection value shall:

a) Be defined in the vehicle technical file; and
b) Not be greater than 7000 mm.

Rationale

G 4.5.3 LOC&PAS NTSN clause 4.2.8.2.9.10(4) requires electric units to be equipped with an ADD if the maximum design speed is higher than 160 km/h (100 mph) or require more than one pantograph raised in operation with a maximum design speed higher than 120 km/h (70 mph). The LOC&PAS NTSN also permits other electric units to be equipped with an ADD.

G 4.5.4 All 25 kV electric vehicles operating on the GB mainline 25 kV ac electrified railway have been fitted with an ADD regardless of maximum speed to support operating principles relating to potential hazards associated with dewirement events.

G 4.5.5 As the maximum pantograph working height in GB is lower than that required by LOC&PAS NTSN, these requirements complement the OCL height requirements permitted by GB specific case 7.3.2.13.

G 4.5.6 Pantograph heads are susceptible to damage. This requirement reduces the risk of a damaged pantograph head from causing subsequent damage to the OCL or to the pantograph and reduces risk of flashover between the OCL and other areas of the pantograph arrangement.

Guidance

G 4.5.7 Some traction units have a flashing vacuum circuit breaker (VCB) light to indicate ADD operation. This type of indication is no longer preferred as it can be misinterpreted by a driver.

G 4.5.8 Pantograph technology may include methods of forcibly pushing down the pantograph, such as the spring loading of the lower pantograph arm towards the vehicle body in the event of a control or power system failure ('knuckle down').

G 4.5.9 Image recognition systems can be added to improve detection of pantograph upper arm and head collapses, pantograph heads misaligned or not in the correct position and pantograph horn damage.

G 4.5.10 The nominal threshold setting is determined according to the known variability of the pantograph height settings and sensitivity of the height detection mechanism. It is intended to prevent overheight detection from operating in normal operation with wire heights up to 6200 mm but is activated as soon as practical when above this height to minimise damage associated with abnormal travel.

G 4.5.11 Minor carbon chips, or damage experienced in normal operation, are not considered as reasons for the ADD system to function.

G 4.5.12 One means of detecting extensive damage to carbons is to pressurise the pantograph head and use a drop in pressure to trigger the auto-drop system.

4.6 Static contact force

Guidance

G 4.6.1 Clause 4.2.8.2.9.5(2) of the LOC&PAS NTSN requires that the static contact force is adjustable within a range of 60-90N (for ac systems). This force range is compatible with the permitted range of mean contact forces at zero speed for all lines whether they comply with corresponding NTSN requirements or not.

4.7 Dynamic contact force and current collection

Guidance

G 4.7.1 The NTSN process and parameters ensure compatibility when both subsystems comply with corresponding NTSN requirements, but do not give an assurance of compatibility when one subsystem does not comply.

G 4.7.2 The LOC&PAS NTSN refers to the ENE TSI with respect to key parameters concerning dynamic behaviour and current collection quality.

G 4.7.3 Compliance with the respective NTSNs for the LOC&PAS and ENE subsystems assures compatibility between these subsystems through controls within compatible parameters. For example: the maximum permitted contact force exerted by the pantograph against the OCL is less than the minimum contact force that the OCL is required to withstand.

G 4.7.4 In the case of a new or modified vehicle introduced on infrastructure that has not been designed to, or assessed against, the ENE NTSN, it is necessary to assess compatibility between the interfacing systems for the attributes defined in the NTSNs.

G 4.7.5 The current collection behaviour is assessed via simulations and verification of the model on a representative section of overhead contact system.

G 4.7.6 Details of a representative section of overhead contact system provided by the infrastructure manager will facilitate the analysis.

G 4.7.7 There can be a significant difference between the variation in contact forces generated by a single pantograph and multiple pantographs raised in tandem. Vibrations induced in the OCL by a leading pantograph generate additional disturbance at the OCL/head interface resulting in increased force variation.

G 4.7.8 Each pantograph in a train consist is expected to operate within the dynamic contact force limits and therefore the 'worst-case' pantograph location is determined by analysis and used for compliance demonstration.

Part 5 Application of this document

5.1 Scope

5.1.1 If a vehicle is considered new, renewal or upgrade as defined in the Railways (Interoperability) Regulations 2011 (as amended), then all or part of the vehicle is required to comply with LOC&PAS NTSN and other relevant NTSNs and NTRs, unless given exemptions allowed for in the Regulations.

5.1.2 Action to bring existing rolling stock ac subsystems into compliance with the requirements of this document is not required.

5.2 Exclusions from scope

5.2.1 The requirements in this document are not applicable to:

a) Possession-only rail vehicles.
b) General Contract of Use (GCU) wagons.

5.3 General enter into force date

5.3.1 The requirements in this document enter into force from 04 March 2023 [proposed].

5.4 Applicability of requirements for projects already underway

5.4.1 The Office of Rail and Road (ORR) can be contacted for clarification on the applicable requirements where a project seeking authorisation for placing into service is already underway when this document enters into force.

5.5 Deviations

5.5.1 Where it is considered not reasonably practicable to comply with the requirements of this document, permission to comply with a specified alternative should be sought in accordance with the deviation process set out in the Railway Group Standard Code.

5.5.2 In the case where NTSN compliance is required for a new, renewed or upgraded vehicle or structural subsystem, the exemption process to be followed is set out in the Railways (Interoperability) Regulations 2011 (as amended).

5.6 Health and safety responsibilities

5.6.1 Users of documents published by RSSB are reminded of the need to consider their own responsibilities to ensure health and safety at work and their own duties under health and safety legislation. RSSB does not warrant that compliance with all or any documents published by RSSB is sufficient in itself to ensure safe systems of work or operation or to satisfy such responsibilities or duties.

Appendices

Appendix A Open Points

A.1 Rolling Stock and Energy Open Points

Guidance

G A.1.1 The open points in GMRT2111 are set out in *Table 2*, which also indicates where guidance on industry practice relating to each open point is given.

Open point	Section of GMRT2111	Additional information
The ability for rolling stock in-feed circuit breakers to interrupt asymmetric fault currents.	*3.6.1*	*G 3.6.4*, *G 3.6.5*, *G 3.6.6*, *G 3.6.7*
Maximum circuit time constant of the infrastructure.	*3.6.1*	*G 3.6.4*, *G 3.6.5*, *G 3.6.6*, *G 3.6.7*

Table 2: List of open points

Definitions

alternating current (ac) energy subsystem	The ENE NTSN states that the ac energy subsystem consists of: Substations: connected on the primary side to the high-voltage grid, with transformation of the high-voltage to a voltage and / or conversion to a power supply system suitable for the trains. On the secondary side, substations are connected to the railway contact line system. Sectioning locations: electrical equipment located at intermediate locations between substations to supply and parallel contact lines, and to provide protection, isolation and auxiliary supplies. Separation sections: equipment required to provide the transition between electrically different systems or between different phases of the same electrical system. Contact line system: a system that distributes the electrical energy to the trains running on the route and transmits it to the trains by means of current collectors. The contact line system is also equipped with manually or remotely controlled disconnectors which are required to isolate sections or groups of the contact line system according to operational necessity. Feeder lines are also part of the contact line system. Return circuit: all conductors which form the intended path for the traction return current and which are additionally used under fault conditions. Therefore, so far as this aspect is concerned, the return circuit is part of the energy subsystem and has an interface with the infrastructure subsystem.
contact force	Vertical force applied by the pantograph to the OCL. Source: *BS EN 50367:2006*
electric shock	Physiological effect resulting from an electric current passing through a human or animal body Source: IEV 195-01-04.
European Train Control System (ETCS)	The signalling, control and train protection part of the European Rail Traffic Management System designed to provide interoperability and standardisation across European railways.
failure	Loss of ability to perform as required. Source: IEV 192-03-01. **Note:** A failure of an item is an event that results in a fault of that item. **Note:** Qualifiers, such as catastrophic, critical, major, minor, marginal and insignificant, may be used to categorise failures according to the severity of consequences, the choice and definitions of severity criteria depending upon the field of application. **Note:** Qualifiers, such as misuse, mishandling and weakness, may be used to categorise failures according to the cause of failure.

gauge	Set of rules, including a reference contour and its associated calculation rules allowing defining the outer dimensions of the vehicle and the space to be cleared by the infrastructure. Source: *ENE NTSN.* **Note:** According to the calculation method implemented, the gauge will be a static, kinematic or dynamic.
gauging	The process by which swept envelopes of a vehicle or a standard vehicle gauge are used to determine clearances on a section of track between the vehicle and fixed infrastructure and between the vehicle and vehicles on adjacent tracks.
GB mainline railway	'Mainline railway' has the meaning given to it in the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (as amended) and the associated exclusions. 'GB mainline railway' is the mainline railway network excluding any railway in Northern Ireland, the Channel Tunnel, the dedicated high-speed railway between London St Pancras International Station and the Channel Tunnel, and any other exclusions determined by the Secretary of State.
infrastructure manager (IM)	Infrastructure manager has the meaning given to it in the Railways and Other Guided Transport Systems (Safety) Regulations 2006, save that for the purpose of the Code, the term is limited to those infrastructure managers who hold a safety authorisation issued in respect of the mainline railway.
interoperability constituent (IC)	An elementary component, group of components, subassembly or complete assembly of equipment incorporated or intended to be incorporated into a subsystem. Interoperability constituents are placed on the market with an intended area of use and are assessed for conformity independently of the subsystem.
knuckle down	The lowering of a raised pantograph in the event of a control or power system failure involving the spring loading of the lower pantograph arm towards the vehicle body.
maximum contact wire height	Maximum possible contact wire height, which the pantograph is required to reach, in all conditions. Source: *EN 50119:2009+A1:2013*
minimum contact wire height	A minimum value of the contact wire height in the span in order to avoid the arcing between one or more contact wires and vehicles in all conditions. Source: *EN 50119:2009+A1:2013, ENE NTSN*
neutral section	section of a contact line provided with a sectioning point at each end, to prevent successive electrical sections differing in voltage, phase or frequency being connected together by the passage of pantographs (may also be referred to as 'phase separation section'). Source: *BS EN 50367:2020*

overhead contact line (OCL)	Contact line placed above (or beside) the upper limit of the rail vehicle gauge and supplying vehicles with electric energy through roof-mounted current collection equipment. Sources: *IEV 811-33-02, ENE NTSN* **Note:** Where this includes, in addition to all current-collecting conductors, the following elements: reinforcing feeders; cross-track feeders; disconnectors; section insulators; overvoltage protection devices; supports that are not insulated from the conductors; insulators connected to live parts; along-track feeders; conductors connected permanently to the contact line for supply of other electrical equipment; earth wires and return conductors.
overheight	The maximum vertical reach of a pantograph it its highest point. Can also be called overreach.
Radio Frequency Identification (RFID)	A method of storing and retrieving data via electromagnetic transmission to a radio-frequency-compatible integrated circuit.
railway undertaking (RU)	Any private or public undertaking, the principal business of which is to provide rail transport services for goods and/or passengers, with a requirement that the undertaking must ensure traction; this also includes undertakings which provide traction only.
register of infrastructure (RINF)	A register that shall be maintained in accordance with regulation 35 of the Railways (Interoperability) Regulations 2011 (as amended).
traction unit	A general term denoting a locomotive, motor-coach or train-unit, inclusive of electric multiple units (EMUs).
trainset	A combination of vehicles coupled together.
Train Control and Management System (TCMS)	The on-board software that provides some train controls and monitoring functionality.
U_{min}	Minimum supply voltage on charge.

Abbreviations

ac	Alternating current.
ADD	Automatic dropping device.
APC	Automatic power control.
dc	Direct current.
ENE	Energy subsystem.
ETCS	European train control system.
IM	Infrastructure manager.
LOC&PAS	Locomotive and passenger carriages. Part of the rolling stock subsystem.
ms	Milliseconds.
NTSN	National technical specification notice.
OCL	Overhead contact line.
RINF	Register of infrastructure.
rms	Root mean squared.
RST	Rolling stock subsystem.
TCMS	Train control and management system.
VCB	Vacuum circuit breaker.

References

The Standards catalogue gives the current issue number and status of documents published by RSSB: http://www.rssb.co.uk/railway-group-standards.

RGSC 01	Railway Group Standards Code
RGSC 02	Standards Manual

Documents referenced in the text

Railway Group Standards

GMRT2173	Size of Vehicles and Position of Equipment.
GLRT1210	AC Energy Subsystem and Interfaces to Rolling Stock Subsystem.
GIRT7020	GB Requirements for Platform Height, Platform Offset and Platform Width.

RSSB documents

RIS-2715-RST	Rail Industry Standard on Rolling Stock Subsystem and Interfaces to AC Energy Subsystem.
RIS-1853-ENE	Rail Industry Standard on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem.
RIS-2773-RST	Format and Methods for Defining Vehicle Gauging Data.

Other references

BS EN 50122-1:2022	Railway applications — Fixed installations — Electrical safety, earthing and the return circuit. Part 1: Protective provisions against electric shock.
BS EN 50124-1:2017	Railway applications — Insulation coordination. Part 1: Basic requirements — Clearances and creepage distances for all electrical and electronic equipment.
BS EN 50163:2004	Railway applications — Supply voltages of traction systems.
BS EN 50206-1:2010	Raliway applications — Rolling stock — Pantographs: Characteristics and tests. Part 1: Pantographs for main line vehicles.
BS EN 50367:2012	Railway applications — Current collection systems — Technical criteria for the interaction between pantograph and overhead line (to achieve free access).
BS EN 50388-1:2022	Railway applications – Fixed installations – Electrical supply and earthing systems for public transport equipment and ancillary apparatus (Fixed installations).

BS EN 62271-100:2009+A1:2012	High-voltage switchgear and controlgear. Part 100: Alternating current circuit-breakers.
BS EN 50388:2012	Railway Applications — Power supply and rolling stock — Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability.
BS EN 60077-4:2003	Railway applications — Electric equipment for rolling stock. Part 4: Electrotechnical components — Rules for AC circuit-breakers.
EN 50119:2009+A1:2013	Railway applications. Fixed installations. Electric traction overhead contact lines.
ENE NTSN	Energy National Technical Specification Notice (ENE NTSN). Published by the Secretary of State on 1 January 2021 pursuant to regulation 3B of the Railways (Interoperability) Regulations 2011. This Notice replaces and substantially reproduces the provisions of Commission Regulation (EU) 1301/2014 of 18 November 2014 (the ENE TSI) and includes relevant amendments made by Corrigendum of 20 January 2015, Commission Implementing Regulation (EU) 2018/868 of 13 June 2018, and Commission Regulation (EU) 2019/776 which came into force in June 2019.
International Electrotechnical Vocabulary (IEV)	*IEC 60050*. This document is used for many of the definitions as shown by the citation beginning *IEV*.
LOC&PAS NTSN	Locomotive and Passenger National Technical Specification Notice (LOC&PAS NTSN). Published by the Secretary of State on 1 January 2021 pursuant to regulation 3B of the Railways (Interoperability) Regulations 2011. This NTSN replaces and substantially reproduces the provisions of Commission Regulation (EU) 1302/2014 (the LOC&PAS TSI), and includes relevant amendments made by Commission Implementing Regulation (EU) 2019/776 which came into force in June 2019.
RIR	Railways (Interoperability) Regulations 2011 (as amended).
ROGS	Railways and Other Guided Transport Systems (Safety) Regulations 2006 (as amended).
T866 (2011)	Investigation of platform edge positions on the GB network.
T951 (2012)	Investigation of the Automatic Power Control magnet and receiver system interface.

Other relevant documents

Railway Group Standards

GMRT2400	Engineering Design of On-Track Machines in Running Mode.
GMRT2113	Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem.

RSSB documents

RIS-0703-CCS	Signalling Layout and Signal Aspect Sequence Requirements.
RIS-0713-CCS	Lineside Signalling Layout Driveability Assessment Requirements.
RIS-0758-CCS	Lineside Signal Aspects and Indications.
RIS-3215-TOM	Weekly Operating Notice, Periodical Operating Notice and the Sectional Appendix