Railway Group Standard
GLRT1210
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AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

Synopsis

This document sets out requirements for the alternating current (ac) energy subsystem and the interfaces to rolling stock operating over the ac electrified railway.

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Issue record

Issue	Date	Comments
One	06/12/2014	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 three and GLRT1254 issue three and specifies new requirements needed to establish electrical compatibility between the two subsystems.
Two	07/12/2019	Revisions to sections 3.4 and 3.5 relating to pantograph/overhead contact line (OCL) mechanical interaction to align with TSI requirements and compatibility with non-TSI OCL. Previously published amendments and clarifications from issue one have also been incorporated.
Three	03/12/2022 [Proposed]	Revision of all sections including removal of several requirements that do not meet the criteria for national technical rules. Some requirements transferred to new Rail Industry Standard RIS-1853-ENE.

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Superseded documents

The following Railway Group documents are superseded, either in whole or in part as indicated:

Superseded documents	Sections superseded	Date when sections are superseded
GLRT1210 issue two	2.1.3, 2.1.4, 2.1.6, 2.2.1, 2.2.2, 2.2.3, 3.1.1, 3.1.2, 3.1.3, 3.1.4, 3.1.5, 3.1.6, 3.1.7, 3.2.1, 3.3.1, 3.4.1, 3.5.1, 3.6.1, 3.6.2, 3.7.1, 3.9.1	04/03/2023 [Proposed]

Superseded documents	Sections superseded	Date when sections are superseded
GLGN1610 issue two	G2.1.25 to G2.1.28, G 2.2.1 to G2.2.3, G2.2.4 to G2.2.16, G2.2 17 to G2.2.21, G2.3.2, G2.3.3, G2.3.4, G2.3.5 to G2.3.7, G3.1.1 to G3.1.13, G3.1.14 to G3.1.19, G3.1.20 to G3.1.22, G3.1.23 to G3.1.33, G3.3.1 to G3.3.4, G3.6.1 to G3.6.14, G3.7.1, G3.7.2, G3.9.1	04/03/2023 [Proposed]

Supply

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Contents

List of Figures

List of Tables

Part 1 Purpose and Introduction

1.1 Purpose

1.1.1 This document contains requirements for a new, renewed or upgraded (ac) energy subsystem, which includes its interfaces with the rolling stock subsystem.

1.1.2 These requirements supplement those in the Energy (ENE) National Technical Specification Notice (NTSN).

1.1.3 This document contains 'open points', as set out in *Appendix A*, to address aspects for which requirements have not yet been specified but which are within the scope of this document.

1.2 Introduction

1.2.1 Background

1.2.1.1 This document contains requirements which are used in conjunction with the ENE NTSN and which support migration towards an interoperable system for the Great Britain (GB) mainline 25 kV ac electrified railway, while continuing to give compatibility with rolling stock which predate the ENE NTSN / TSI.

1.2.2 Principles

1.2.2.1 The requirements of this document are based on:

a) Addressing UK specific cases in NTSNs; and
b) Enabling technical compatibility either between a new, renewed or upgraded energy subsystem that conforms to the requirements of the ENE NTSN and existing vehicles that do not conform.

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’.

1.2.4 Supporting documents

1.2.4.1 The following RSSB documents support this Railway Group Standard:

a) GMRT2111 'Rolling Stock Subsystem and Interfaces to AC Energy Subsystem'
b) GMRT2173 'Size of Vehicles and Position of Equipment'
c) RIS-1853-ENE 'Rail Industry Standard on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem'
d) RIS-2715-RST 'Rail Industry Standard on Rolling Stock Subsystem and Interfaces to AC Energy Subsystem'.

Note: GLRT1210 issue 2, Table 9 (AC system characteristic for rolling stock compatibility) and Table 10 (Speed Conversions) have been included in RIS-1853-ENE, issue 1.

1.3 Approval and authorisation of this document

1.3.1 The content of this document will be approved by ENE Standards Committee on 10 November 2022 (proposed).

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

Part 2 Power supply (electrical requirements)

2.1 Parameters relating to power system performance

2.1.1 Maximum train set current

2.1.1.1 The energy subsystem shall be designed to operate with a maximum allowable train set current for each train set of not less than 300 A (I_{max}).

Rationale

G 2.1.1.2 The maximum train set current defines minimum design requirements expected of the energy subsystem such that it can reasonably support a train set operating up to the maximum current limit.

Guidance

G 2.1.1.3 The maximum allowable train set current is referred to as the maximum allowable train current in the ENE NTSN.

G 2.1.1.4 The UK verification procedure carried out by a designated body is not required against clause *2.1.1.1*. Confirmation of maximum train set current capability by a simple statement within the technical file for the subsystem is sufficient, given the low degree of complexity and low risk of non-conformance.

G 2.1.1.5 The maximum allowable train set current refers to train sets as set out in clause 3.2 of BS EN 50388-1:2022.

2.2 Electrical protection co-ordination arrangements

2.2.1 Short circuit fault characteristics

Guidance

G 2.2.1.1 The ENE NTSN and BS EN 50388-1:2022 sets out requirements for a maximum fault current magnitude of 15 kA. Currently there is no definitive value for short circuit fault duration detailed in BS EN 50388-1: 2022 or the ENE NTSN.

G 2.2.1.2 RSSB research report T1001 (2014) explains the potential impact that short circuit fault current levels and fault clearance durations may have on existing rolling stock not conforming to relevant NTSNs under normal and fault conditions. It also provides further guidance for bonding ac vehicles and the associated assumptions about the power system performance under fault conditions.

G 2.2.1.3 The maximum circuit time constant (relating to the X/R ratio) at the contact line is an open point.

Part 3 Mechanical requirements

3.1 Contact wire

3.1.1 Contact wire height

3.1.1.1 The contact wire height shall be as set out in *Table 1*.

Description	V < 250 [km/h]
Nominal contact wire height [HCW_{nom}]	4700 mm
Minimum contact wire height [HCW_{min}]	4165 mm, or; 4040 mm with surge arresters (as set out in 3.1.1.2)
Maximum contact wire height [HCW_{max}]	6200 mm

Table 1: Contact Wire Height

Note: For the relation between contact wire heights and pantograph working height see BS EN 50119:2020, Figure 3.

3.1.1.2 Surge arresters connected to the overhead contact line system shall include the following characteristics:

- Discharge current 8/20 μs ≥ 10 kA
- Rated impulse withstand ≥ 200 kV
- Residual voltage U_{res} ≤ 81 kV.

3.1.1.3 Minimum contact wire height dimensions apply to track without vertical curvature and take into account a vehicle profile height of 3965 mm. HCW_{min} in Table 1 shall be increased for track with vertical curvature to maintain electrical clearances of 200 mm (without surge arrester) and 75 mm (with surge arrester) respectively to the vehicle profile of a train.

Rationale

G 3.1.1.4 These requirements address ENE NTSN specific case 7.4.2.9.2 contact wire height (4.2.9.1). These requirements also support technical compatibility by establishing the minimum air gap between a live contact wire and other parts of rail vehicles, to manage the risk of flashover to an acceptable level.

G 3.1.1.5 A minimum contact wire height value of 4165 mm is supported by long term operational experience covering numerous locations across the GB mainline railway. The use of the minimum contact wire height of 4165 mm corresponds to a standard gauge height of 3965 mm, as set out in GERT8073, plus a static clearance of 200 mm for electrical withstand purposes. This static air gap will withstand a rated impulse voltage of approximately 105 kV (see BS EN 50124-1:2017, Table A.3).

G 3.1.1.6 Deviation applications against GLRT1210 issue one and two demonstrated that the minimum contact wire height with surge arresters provides a clearance of 75 mm for electrical withstand purposes. The combination of a surge arrester and reduced air gaps will withstand a rated impulse voltage of 200 kV, for power frequency voltages up to U_{max3} (in accordance with BS EN 50163:2004+A3:2022) and harmonic overvoltages from a distorted 50 Hz sine wave in accordance with the value set out in BS EN 50388-1:2022 without the protected air gap flashing over.

G 3.1.1.7 Surge arrester characteristics are derived from deviation applications and supporting technical and test data.

Guidance

G 3.1.1.8 Contact wire heights at HCW_{min} in Table 1 are values which need to be complied with throughout the lifetime of the OCL. Consequently, the design needs to take into account the necessary maintenance regime and tolerances (for track and OCL) which can support ongoing compliance with these minimum contact wire height dimensions.

G 3.1.1.9 It is good practice when using of a contact wire height below 4165 mm to take account of operational factors and the local features (for example the location of line side signals, hand points), which can give rise to an electrical hazard resulting from an energised contact line, if traincrew or others need to board and alight from rail vehicles or On-Track Machines (OTM) on an operational railway at these locations.

G 3.1.1.10 In locations where contact wire is below 4165 mm, it is also good practice to consider providing signage to remind staff who might need to board or alight from rail vehicles or OTMs of the associated electrical hazard.

G 3.1.1.11 As the contact wire height is reduced towards the minimum permitted dimension, it is envisaged that because of the smaller clearance dimensions between live parts of the overhead contact line and rail vehicles, that other engineering controls that provide a more robust means of controlling track position might be needed.

G 3.1.1.12 At these locations, the assessment of workforce safety could identify the need for safety related application conditions to mitigate risk.

G 3.1.1.13 Product requirements relevant to surge arresters are included in BS EN 60099.

G 3.1.1.14 A design development phase assessment for contact wire height is not carried out if the overhead contact line has been certified as an interoperability constituent or as a component of the energy subsystem using an intermediate statement of verification (as set out in part 4 of this document).

G 3.1.1.15 In accordance with Table B.1 of the ENE NTSN, there is no requirement for a production phase assessment if dynamic testing for construction errors is undertaken (see clause 6.2.4.5 (5) of the ENE NTSN).

G 3.1.1.16 When applicable, the UK verification procedure carried out by the designated body to assess compliance of the subsystem with 3.1.1.1 and 3.1.1.2 is fulfilled through a design development and production phase assessment. In the design development phase, assessment of nominal, maximum and minimum contact wire height is a check of design evidence (such as design rules, drawing and calculations) to demonstrate that contact wire heights are designed in accordance with limits in Table 1. For the production phase assessment, measurement of dynamic behaviour to identify allocation design and construction errors is not typically used for operational line speeds up to 120 km/h (ac systems). In this case, alternative methods for identifying construction errors such as measurement of the OCL geometry according to *Table 1* can be used to fulfil the production phase assessment.

3.1.2 Contact wire height at level crossings

3.1.2.1 At vehicle level crossings, the minimum contact wire height from the top of the rail level shall be:

a) 5.8 m; or
b) 5.6 m, where justified by a risk assessment and the application of any necessary safety measures.

3.1.2.2 At bridleways, the minimum contact wire height shall be 5.2 m.

3.1.2.3 At footpaths accessible to pedestrians only and used by members of the public (or others without specialist knowledge of the electrical risk), the contact wire height shall not be less than HCW_{min} as set out in *Table 1*.

Rationale

G 3.1.2.4 4.2.9.1 (3) of the ENE NTSN requires contact wire height at level crossings to be specified by national technical rules. These contact wire height requirements set out in 3.1.2.1 are consistent with a UK notional maximum road vehicle height of 5 m. This provides an air gap corresponding to an impulse withstand of about 320 kV, which is equivalent to reinforced insulation for 25 kV systems. These dimensions also reflect recent practice, and are consistent with requirements in The Electricity Safety, Quality and Continuity Regulations (ESQCR), Design Manual for Roads and Bridges (DMRB) and The Highway Code.

G 3.1.2.5 Contact wire heights at footpaths accessible to pedestrians only and used by members of the public (or others without specialist knowledge of the electrical risk), will exceed the minimum dimensional requirements for a public area standing surface as set out in the ENE NTSN and the associated requirements in BS EN 50122-1.

Guidance

G 3.1.2.6 In accordance with Table B.1 of the ENE NTSN, there is no requirement for a production phase assessment if dynamic testing for construction errors is mandatory (see clause 6.2.4.5 (5) of the ENE NTSN). The verification process outlined in clause *3.1.1* also applies to contact wire height.

G 3.1.2.7 The Land Reform (Scotland) Act 2003 permits horse riders to cross or use most areas of land throughout Scotland, provided they do so responsibly. Therefore any railway footpath crossing for pedestrians in Scotland could be used by a mounted horse rider and thus require the minimum contact wire height for bridleways to be applied in Scotland. Where mitigation, such as height or width restrictions, precludes a horse from being ridden across the railway, then the minimum wire height for bridleways would not apply.

G 3.1.2.8 At footpaths referred to in clause *3.1.2.3*, other engineering controls might be needed to manage site specific risks of electric shocks, particularly where wire heights are provided below the value of 5.2 m, if local conditions and expected usage means a greater allowance for hand held objects in BS EN 50122-1:2022 is appropriate. RIS-ENE-1853 contains requirements and guidance for warning signs at level crossings in the presence of live overhead wires. For an illustration of HCW_{min}, see Figure 1 of BS EN 50119:2020.

3.1.3 Contact wire lateral deviation and pantograph gauge

3.1.3.1 No part of the energy subsystem shall enter the kinematic pantograph gauge except for the contact wire.

3.1.3.2 The kinematic pantograph gauge shall be established using the requirements set out in GMRT2173.

Rationale

G 3.1.3.3 These requirements address UK specific case 7.4.2.9.3 pantograph gauge (4.2.10). The pantograph gauge supports technical compatibility between the energy and rolling stock subsystems. The sway of the pantograph, which defines the pantograph gauge, is determined using the methodology set out in GMRT2173.

Guidance

G 3.1.3.4 The energy subsystem in the context of *3.1.3.1* regarding exclusion from the kinematic pantograph gauge does not apply to parts of contact line components which need to be directly attached to the contact wire. This includes items such as droppers, in-line insulators, steady arms.

G 3.1.3.5 Electrical clearances are intended to be considered by the infrastructure manager or project entity. These electrical clearances are added to the pantograph sway envelope. The dimensioning of electrical clearances in relation to safety and performance are identified in BS EN 50122-1:2022 and BS EN 50119:2020 respectively.

G 3.1.3.6 The UK verification procedure carried out by the designated body to assess compliance of the subsystem with requirements in clause *3.1.3* are fulfilled through a design development phase assessment. This assessment is a check that the design evidence such as design rules for pantograph gauge are in accordance with the methodology for pantograph sway set out in GMRT2173. A sample check of design evidence (such as drawings, calculations) is also carried out to demonstrate that pantograph gauge designs are being applied in accordance with the design rules.

G 3.1.3.7 The OCL geometry requirements in the ENE NTSN and in this railway group standard are provided so that OCL designs are compatible with the pantograph profiles as set out in BS EN 50367:2020 Figures A.6 and B.6. The maximum lateral deviation of the contact wire of 400 mm in ENE NTSN clause 4.2.9.2 provides compatibility with both profiles. The UK specific case 7.4.2.9.3 for maximum lateral deviation of the contact wire is not used because the ENE NTSN requirements apply.

G 3.1.3.8 Further guidance on pantograph gauge and encroachment is set out in RIS-2773-RST.

G 3.1.3.9 The calculation for pantograph head encroachment is an open point.

G 3.1.3.10 In applying the pantograph sway limits in GMRT2173 to the inside of a curve, cant excess can be considered to be the negative of cant deficiency and the sway. The sway values may be considered to be symmetrical across the track centre line.

3.2 Section insulators and separation sections

3.2.1 Section insulator limiting dimensions

3.2.1.1 Each section insulator (SI) shall be dimensioned to permit pantograph heads with individual contact strips of a minimum width of 25 mm and pantograph heads with single strips of a minimum width of 80 mm to pass smoothly and without losing electrical contact.

Rationale

G 3.2.1.2 This requirement is intended to support mechanical and electrical compatibility between the SIs and pantographs, including single strip (narrow) pantograph heads and multiple strip pantograph heads with a minimum of 25 mm for each strip. The along-track insulation in an SI is arranged such that a single strip pantograph head can pass through the SI without loss of electrical contact during transition.

Guidance

G 3.2.1.3 The UK verification procedure carried out by the designated body to assess compliance of the subsystem with *3.2.1.1* is fulfilled through a design development phase assessment, such as using basic design drawings and specifications.

3.2.2 Phase separation for line speeds, v < 250 km/h

3.2.2.1 Automatic power control (APC) magnets shall be provided on each side of the track as shown in *Figure 1* of Appendix B, and are positioned as set out in GIRT7073.

3.2.2.2 APC magnets shall not be located between any running rails of a set of tracks, or in any other location that could interfere with the correct operation of the automatic warning system (AWS) equipment.

3.2.2.3 The upper surface of the APC magnet shall:

a) Have a minimum magnetic field strength as set out in *Table 2* and illustrated in *Figure 2*; and
b) Have a magnetic field strength that extends over a rectangular plane extending 100 mm laterally and 100 mm longitudinally from the magnet centre; and
c) Be a 'south pole'.

Height above rail level	Minimum magnetic field strength	Comment
178 mm	3.8 mT	Minimum receiver height, trains with worn wheels

Height above rail level	Minimum magnetic field strength	Comment
200 mm	3.3 mT	Nominal receiver height
222 mm	2.9 mT	Maximum receiver height, trains with new wheels

Table 2: Magnetic field strength for the automatic power control magnet

3.2.2.4 The along-track location of the APC magnet on approach and retreat to the phase separation section, shown as 'A' and 'B' in *Appendix B Figure 1* shall be determined by the formula:

$$Distance_{APC\text{-}NS} = D / 2 + Receiver_{offset} + (t \times 1.1 \times v_{speed})$$

Parameter	Value	Comment
$Distance_{APC\text{-}NS}$	To be calculated [m]	Minimum distance (APC to phase separation section centre line)
D	To be calculated [m]	D overall length of phase separation section as distance between adjacent systems/phases including overlapping parts taking into account the contact wire uplift by pantograph passage and electrical clearances in accordance with BS EN 50119:2020, 5.1.3
$Receiver_{offset}$	7.75 m	This value is a constant based on historical practice
t	0.150 s	This value is a constant based on historical practice
v_{speed}	V_{speed} is based on the maximum line speed at a given location [m/s]	Vehicle speed (m/s): note that 10 % overspeed is added by the formula

Table 3: Parameters for calculating the along track distance of the APC magnet relative to the phase separation section centre line

3.2.2.5 The location of the APC magnet on the retreat from the neutral section, shown as 'B' in *Figure 1*, on a uni-directional line shall be no closer than 7.75 m plus half the length of the phase separation section, in metres, from the centre line of the neutral section.

Rationale

G 3.2.2.6 These requirements support technical compatibility between the trackside APC equipment and on-train APC equipment at phase separation sections. The power control through the phase separation section is governed by the APC system. This is required so that power is not drawn by the train as the pantograph moves between electrical sections which are derived from two sources which are not intended to be connected together. The minimum field strengths of APC magnets in Table 2 are compatible with the sensitivity of the receiver, as set out in GMRT2111. These provisions cover various arrangements of phase separation sections.

G 3.2.2.7 At junctions, there is a risk that APC magnets which are installed outside the running rails on a set of tracks, fall within the running rails on another line. The requirement 3.2.2.2 is included to prevent such occurrences.

Guidance

G 3.2.2.8 Signage at phase separation sections is set out in RIS-1853-ENE.

G 3.2.2.9 Phase separation sections are also referred to as 'neutral sections'.

G 3.2.2.10 The choice of phase separation type is made in accordance with requirements in the ENE NTSN. There are different types of phase separations in use within the GB mainline railway as recorded in the register of infrastructure (RINF).

G 3.2.2.11 RIS-2713-RST sets out requirements and guidance to support the introduction and operation of multi-mode rolling stock onto the Great Britain (GB) mainline railway.

G 3.2.2.12 APC magnets are not located between any running rails because the magnets used for APC are similar to those used for AWS, and there is the possibility that, if incorrectly located, this could cause an unintended operation of the AWS equipment.

G 3.2.2.13 It is good practice for the signals on the approach to the phase separation section to be placed in such a way that a train set starting from rest at the signal will have enough momentum to pass through the neutral section successfully.

G 3.2.2.14 The formula for calculating this distance takes into account route gradient, accelerating force available at the driving wheels and minimum coasting speed through the neutral section. The distance required from a standstill start is intended to be calculated assuming a required minimum speed at which the train detects the APC magnet and enters the neutral section. Typically 4.5 m/s is assumed although a lower speed can be used in calculations.

G 3.2.2.15 The above distance between the signal and the APC magnet can be calculated using the formula:

Distance $S_{signal\text{-}APC} = v^2/2a$

where: v is typically 4.5 m/s and a = acceleration in m/s^2 taking into account the gradient and rolling resistance.

G 3.2.2.16 The signal after the phase separation section is placed in a location so that the train pantograph is clear of the phase separation section and re-energized at the point where it would come to a stand at the signal, thereby mitigating the risk of a train coming to a stand without power. The same principle applies to a train set with multiple pantographs.

G 3.2.2.17 The calculation is governed by the train formation, the position of the pantograph, the stopping position of the train considering professional driving techniques, and assistance of dead traction units by operating units from behind for loco-hauled trains.

G 3.2.2.18 On electric multiple units, pantographs are often controlled by their own dedicated APC receivers. Locomotives often have one APC receiver linked to the control of more than one pantograph.

G 3.2.2.19 The UK verification procedure carried out by the designated body to assess compliance of the subsystem with requirements in clause *3.2.2* is fulfilled through a design phase assessment. The design phase assessment is a check that design evidence (such as drawings and calculations) for the along-track location of the APC magnets on approach and retreat to the phase separation section fulfil the requirements set out in clause *3.2.2.4*.

G 3.2.2.20 APC magnets are source of EMF. For further information see GLGN1620.

3.3 Protective provisions against electric shock

3.3.1 Protective provisions against direct contact

3.3.1.1 It is permissible when 7.4.2.9.4. of the ENE NTSN applies (for public areas only) to comply with the protective provisions against direct contact as set out in BS EN 50122-1:2022, 5.1, 5.2, 5.3 applicable to public areas.

3.3.1.2 When *3.3.1.1* applies, the design procedure to achieve protection against direct contact to exposed live parts of the energy subsystem, including live parts of a pantograph head, shall follow the process set out in BS EN 50122-1:2022 clause 5.1.2 and Figure 3.

Rationale

G 3.3.1.3 These requirements satisfy UK specific case 7.4.2.9.4 of the ENE NTSN applying only to the existing mainline network in Great Britain with historical assets that constrain the gauge. It provides an alternative option to control the hazard of direct contact with live parts in public areas at standing surfaces, in place of the reference to BS EN 50122-1:2011+A1:2011 clause 5.2.1 in clause 4.2.18 of the ENE NTSN.

Guidance

G 3.3.1.4 Clause *3.3.1.2* is intended to enable project entities to take a more flexible approach to managing protective provisions against direct contact. BS EN 50122-1:2022 contains a clearance value of 3.6 m from a standing surface which may be reduced by exception to 3.5 m as set out in BS EN 50122-1:2022 Annex A.

G 3.3.1.5 The requirements set out in *3.3.1* of GLRT1210 and 4.2.18 of the ENE NTSN include the protection of persons from direct contact electric shock from an OCL or live parts of a pantograph head in public areas. These requirements help meet safety obligations arising from the railway's interoperability legislation. However, other legal obligations such as The Management of Health and Safety at Work Regulations 1999 and The Railways and Other Guided Transport Systems (Safety) Regulations 2006 (as amended) that are not within the scope of interoperability legislation are also relevant to the management of safety in public areas. Consequently, mitigation measures might be needed which are additional to those set out in this document and the ENE NTSN.

G 3.3.1.6 At locations such as overbridges on electrified lines, it is good practice to take a coordinated approach to risk management and mitigation. This can include for example, risks arising from live parts of the OCL, trespass and road vehicle incursions.

G 3.3.1.7 Experience gained through deviation applications against GLRT1210 issues one and two demonstrated that the application of alternative approaches to protective provisions against direct contact at standing surfaces can, where appropriate, negate the need for parapet modifications.

G 3.3.1.8 Previously, clearance requirements for protective provisions against direct contact applied 'at all locations' including public and non-public areas. These requirements have been revised to align with the scope of clause 5.2.1 of the ENE NTSN, which is restricted to public areas only. Protective provisions against direct contact electric shock in non-public areas including those for workforce safety are determined by the project entity. These provisions contribute to meeting the essential requirement for safety applicable to the ENE subsystem as set out in the Railway Interoperability Regulations 2011 (as amended). This aspect is not addressed in the ENE NTSN.

G 3.3.1.9 The UK verification procedure carried out by the designated body to assess compliance of the subsystem with requirements in *3.3.1.1* and *3.3.1.2* is fulfilled for public area locations, through an assessment at the design phase, and where applicable, at the production phase. In the design phase, assessment is a check of design evidence (such as drawings, clearance calculations and design reports) to demonstrate that the basic design of protective provisions against direct contact is in accordance with BS EN 50122-1:2022, 5.1, 5.2, 5.3. Where required, a production phase is a check for the existence of rules and procedures to confirm that the energy subsystem is installed as designed. This might be supported by a sample of further evidence confirming that installations are in accordance with designs (such as red line drawings and as-built drawings). In accordance with Table B.1, Appendix B of the ENE NTSN, a production phase assessment is not carried out when protective provision against electric shock in public areas has already been checked by another independent body, such as an assessment body in accordance with the Common Safety Method for Risk Evalulation and Assessment (CSM RA).

G 3.3.1.10 With reference to ENE NTSN clause 4.2.18, if booster transformer return conductors are provided in public areas and are uninsulated then they are treated as live conductors for the purposes of dimensioning clearances to standing surfaces.

3.3.2 Protective provisions against indirect contact

Guidance

G 3.3.2.1 Clause 4.2.18 of ENE NTSN and its associated reference to BS EN 50122-1:2011+A1:2011 clause 6.2 indicates the use of national values for the overhead contact line zone (OCLZ) when determining the extent of bonding to protect against a broken contact or catenary wire. For the GB mainline railway, these values are set out in RIS-1853-ENE.

3.4 Compatibility with train exhaust emissions

Guidance

G 3.4.1 The compatibility of contact systems with train exhaust emissions is an open point.

G 3.4.2 The requirement for train exhaust emissions is set out in GMRT2130.

G 3.4.3 This requirement helps support technical compatibility between hot exhaust from internal combustion engines of rail vehicles (rolling stock subsystem) and vulnerable components in the overhead contact line by defining locations where hot exhaust gases can be present. It is good practice to locate vulnerable OCL components in a position where they are not directly exposed to temperatures outside their intended working range.

G 3.4.4 The requirement to operate a heritage train when below vulnerable OCL features is set out in RIS-3440-TOM.

Part 4 Assessment of the Overhead Contact Line (OCL)

4.1 Assessment of the OCL including a UK specific case

4.1.1 An OCL which also includes a UK specific case, shall be assessed using one of the following approaches:

a) As a part of the energy subsystem (where the OCL is covered by an ISV); or
b) An interoperability constituent (IC).

4.1.2 The assessment of an OCL shall include the following:

a) Contact wire height as set out in *3.1.1* of this document; and
b) Maximum lateral deviation and pantograph gauge as set out in ENE NTSN clause 4.2.9.2 and clause 3.1.3 of this document.

4.1.3 When carrying out the assessment for simulation of dynamic behaviour and quality of current collection, as set out in ENE NTSN 6.1.4.1 (2) (b) and (c), the following shall be used:

a) Two different NTSN compliant pantographs. These pantographs can include UK specific cases as set out in the LOC&PAS NTSN, 7.3.2;

4.1.4 The assessment process set out in ENE NTSN, section 6 for the measurement of dynamic behaviour and quality of current collection shall use:

a) For ENE NTSN 6.1.4.1 (3) (c):
   i) One of the pantographs chosen for the simulation in ENE NTSN 6.1.4.1 (3), as amended by 4.1.3; and
   ii) Rolling stock that allows the applicable speed for the OCL to be achieved on the representative section of route.

b) For ENE NTSN 6.1.4.1 (3) (d):
   i) The worst-case interaction performance derived from simulations, or if measurement of this case is not practicable, it is permitted to use an alternative representative pantograph configuration from those in *4.1.3*.

4.1.5 The assessment process set out in ENE NTSN, section 6 for assessment of dynamic behaviour and quality of current collection, for integration into a subsystem, shall use for ENE NTSN 6.2.4.5 (3), a pantograph that:

a) Is NTSN compliant; or
b) Complies with UK specific cases contained within the LOC&PAS NTSN and that meets the mean contact force required by ENE NTSN 4.2.11.

Rationale

G 4.1.6 These requirements enable an OCL which includes a UK specific case set out in section 7.2.4 of the ENE NTSN to be assessed appropriately as part of the verification activity. They support certification of an OCL as an IC and as a part of the energy subsystem.

G 4.1.7 The requirements are based on the content of sections 5.2 and 6 of the ENE NTSN. These requirements enable UK specific cases applicable to the OCL to be taken into account appropriately when undertaking simulation and measurement as set out in section 6 of the NTSN.

G 4.1.8 Within *4.1.4*, the requirements recognise that it might not be practicable to physically replicate the worst-case identified during simulation, when undertaking on-track testing of an OCL design. In such circumstances, it permits the use of an alternative case from the simulation, so that measurements can be taken.

Guidance

G 4.1.9 For the purposes of placing the OCL as an IC on the market after the EU exit implementation period completion date, the UK's national procedure was replaced by the NTSN concerning the assessment of interoperability constituents against UK specific cases.

G 4.1.10 The assessment process set out in section 6 of the Energy NTSN is applied but amended where required in accordance with section 4.1.

G 4.1.11 The approach set out in *4.1.1a)* is used where the OCL design has already been placed on the market and it has a intermediate statement of verification (ISV).

G 4.1.12 The approach set out in *4.1.1b)* is used where an ISV certificate for the OCL design did not previously exist or where modifications to an ISV are required.

G 4.1.13 Simulations might include pantographs that do not hold an IC or ISV certification provided they fulfil other requirements in the LOC&PAS NTSN.

G 4.1.14 It is good practice to evaluate technical compatiblity of any additional pantograph for which the OCL is to be assessed at route level. RSSB research project T1244 contains a compatibility matrix that supports such an assessment. Where appropriate, it is also good practice to use pantographs for testing that are representative of future operation and meet LOC&PAS UK specific case requirements.

G 4.1.15 Dynamic testing in accordance with clause 6.1.4.1 (b) of the ENE NTSN is verified using contact wire uplift and either mean contact force and standard deviation or percentage arcing. It is not necessary to have the OCL energised for dynamic testing unless the percentage arcing method is used as set out in the ENE NTSN.

Part 5 Application of this document

5.1 Scope

5.1.1 If an ENE subsystem is considered new, renewed or upgraded as defined in RIR, then all or part of the subsystem is required to comply with the relevant NTSNs and national technical rules, unless an exemption is granted in accordance with RIR.

5.1.2 The requirements of this document as national technical rules are relevant to aspects of the ENE subsystem to which *5.1.1* applies.

5.1.3 Action to bring an existing ENE subsystem into compliance with the requirements of this document is not required.

5.2 Exclusions from scope

5.2.1 There are no exclusions from the scope.

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 Exceptions to general enter into force date

5.4.1 There are no exceptions to the general enter into force date.

5.5 Applicability of requirements for projects already underway

5.5.1 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.

5.6 Deviations

5.6.1 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.

5.6.2 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).

5.7 Health and safety responsibilities

5.7.1 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 Open Points

Guidance

G A.1.1 The open points in GLRT1210 are set out in Table 4, which also indicates where information on industry practice relating to each open point is given.

Open Point	Section of GLRT1210	Additional information
The maximum circuit time constant (relating to the X/R ratio) at the contact line is an open point	*G 2.2.1.2*	See RIS-1853-ENE.
Pantograph head encroachment	*G 3.1.3.9*	The calculation for encroachment is set out in RIS-2773-RST.
Compatibility of contact systems with train exhaust emissions	*G 3.4.1*	See RIS-1853-ENE.

Table 4: List of open points

Appendix B Separation section

B.1 Phase separation section

Guidance

G B.1.1 **Note:** The content of this appendix supports requirements for phase separation set out in clause *3.2.2*

G B.1.2 Typical arrangement of track signs and track magnets (see *Figure 1*).

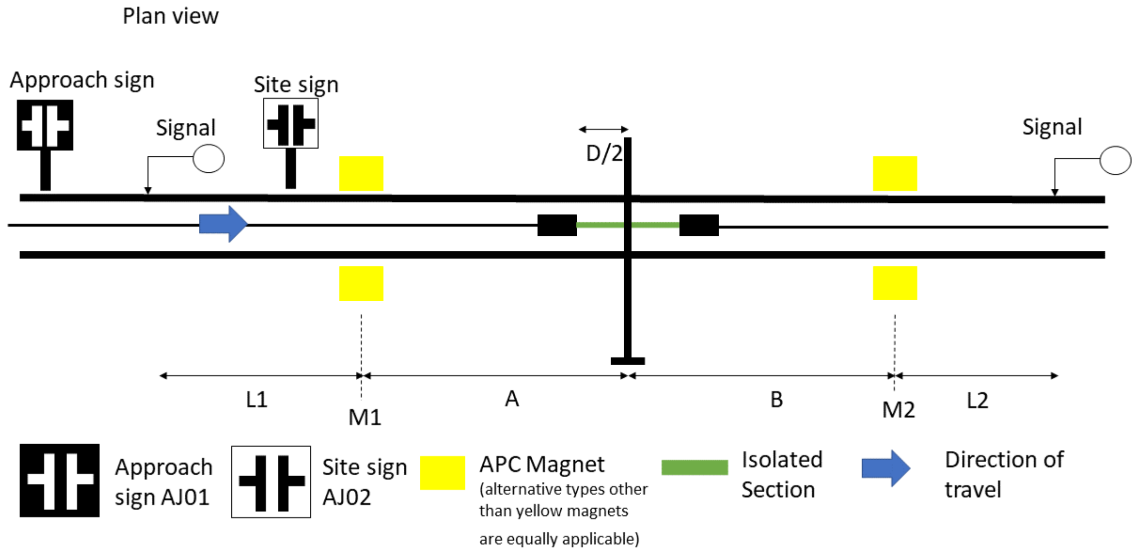

Figure 1: Typical arrangement of track signs and track magnets

A Distance between the approach magnet and the phase separation section centre line

B Distance between the retreat magnet and the phase separation section centre line

A and B Form the 'Dead Section'

M1 Approach magnet

M2 Retreat magnet

L1 Distance between the signal on approach and the magnet

L2 Distance between the magnet and signal beyond

D Overall length of the phase separation section as distance between adjacent systems/phases

Appendix C Location of the Automatic Power Control Track Magnet

C.1 Location of the Automatic Power Control Track Magnet

Guidance

G C.1.1 **Note:** The content of this appendix supports requirements for locating APC magnets at phase separation sections as set out in clause *3.2.2*

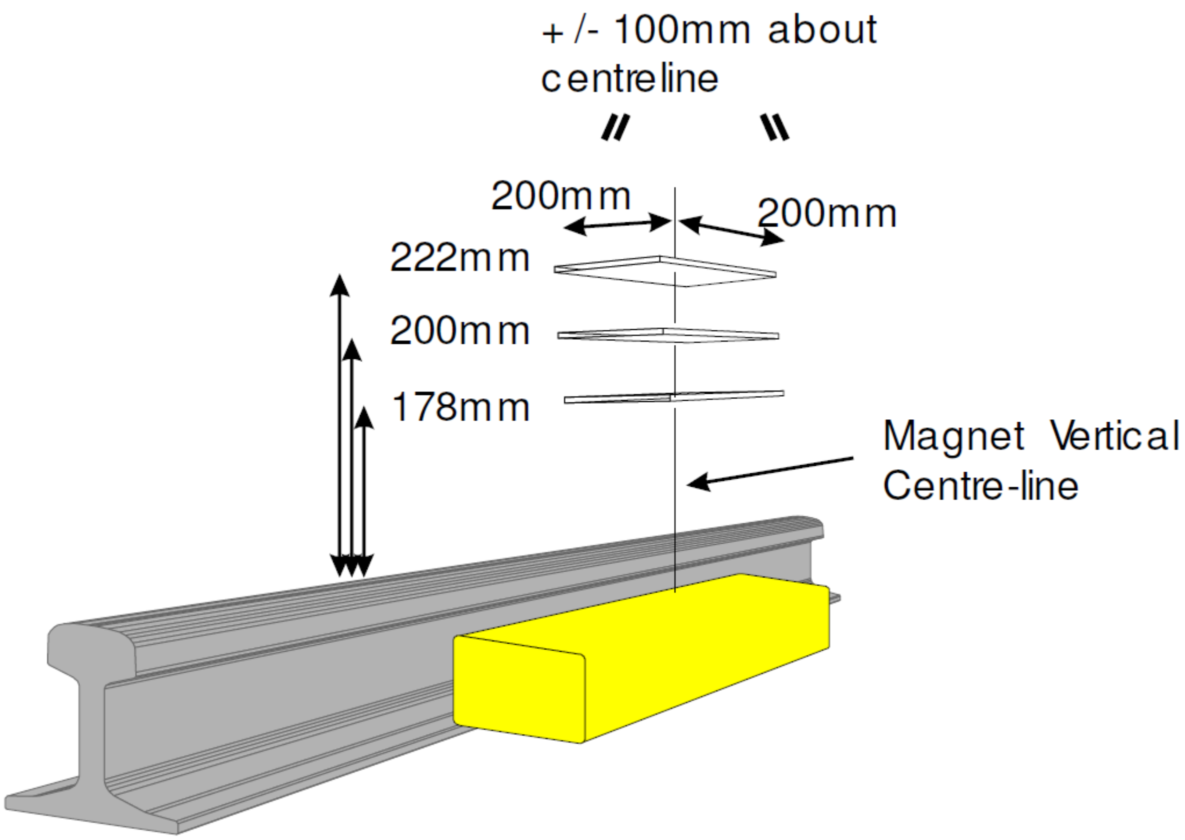

Figure 2: Representation of flux planes

Note: The content of this section is provided for information only

G C.1.2 Relationship between the APC receiver and the APC track magnet.

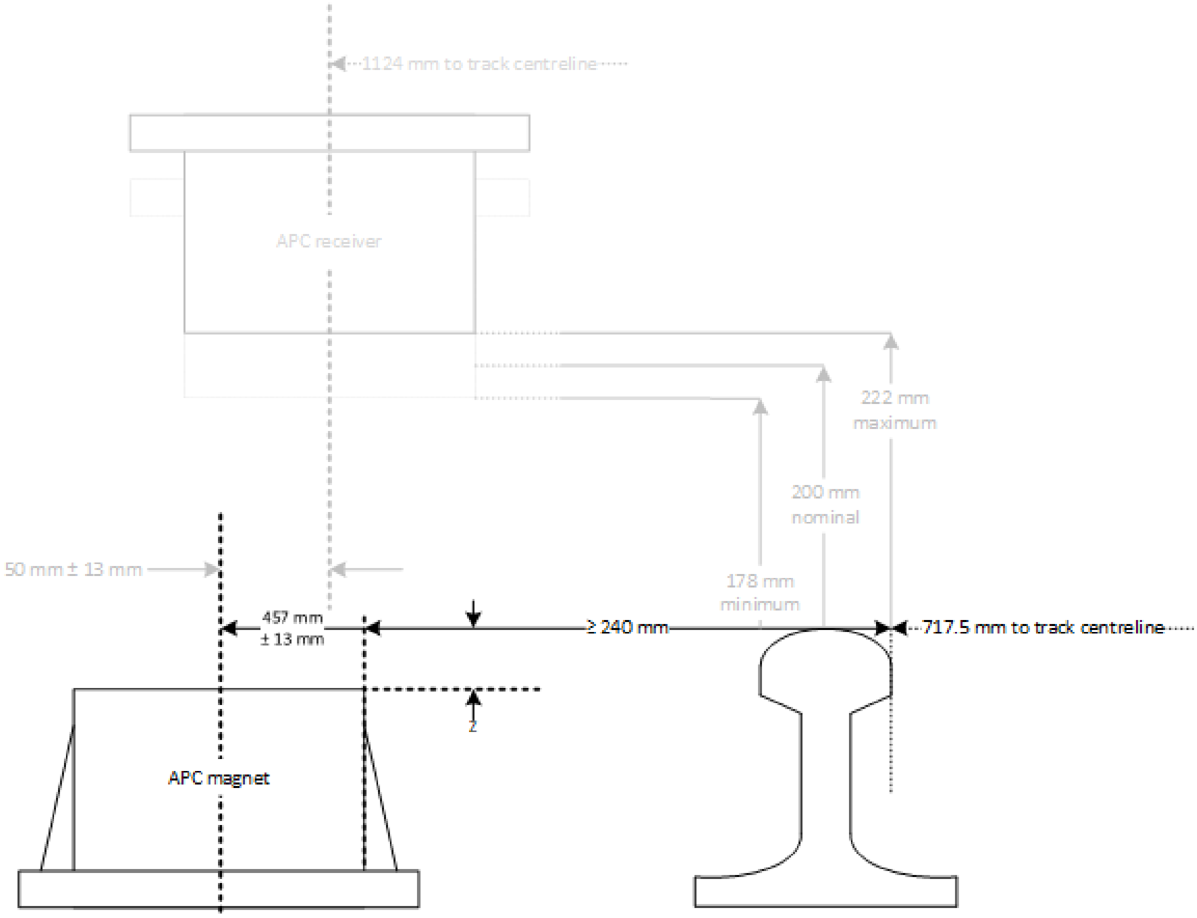

Figure 3: Relationship between the APC receiver and the APC track magnet

Note: APC track magnets are provided on both sides of the track.

Receiver across track dimension based on fitment to rail vehicle bogie.

Different magnet types are available.

Z dimensions (the dimension between the top of the rail and top of the APC magnet) differ depending on the type of APC magnet being fitted. For standard strength yellow magnets: Lowered position Z = 19 mm ± 6 mm or Standard position Z = 45 mm ± 6 mm. For extra strength green magnet: Lowered position Z = 19 mm ± 6 mm. For super strength white magnets: Z = -35 mm ± 15 mm.

Definitions

alternating current (AC) energy subsystem	The Energy NTSN (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.
Automatic Warning System (AWS)	A system that gives train drivers in-cab warnings of the approach to signals, reductions in permissible speed and temporary/ emergency speed restrictions, and to apply the brakes in the event that a train driver does not acknowledge cautionary warnings given by the system within the specified time. Source: *GERT8075*
Common Safety Method for Risk Evaluation and Assessment (CSM RA)	Commission Implementing Regulation (EU) No 402/2013 on the common safety method for risk evaluation and assessment.
contact force	Vertical force applied by the pantograph to the OCL. Source: *BS EN 50367:2006*
contact line system	The system that distributes the electrical energy to the trains running on the route and transmits it to the trains by means of current collectors. Source: *ENE NTSN*
contact wire uplift	Vertical upward movement of the contact wire due to the force produced from the pantograph. Sources: *EN 50119:2009+A1:2013, ENE NTSN*

direct contact	Electric contact of persons or animals with live parts or sufficiently close that danger may arise. *source: IEV ref 195-06-03-modified*
electric shock	Physiological effect resulting from an electric current passing through a human or animal body *Source: IEV 195-01-04*
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.
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.
high voltage (HV)	The set of voltage levels in excess of low voltage. Source: *IEV 601-01-27*
indirect contact	Electric contact of human beings or livestock with exposed-conductive-parts that have become live under fault conditions.
infrastructure manager (IM)	Has the meaning given to it in the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (as amended), but is limited to those infrastructure managers who hold a safety authorisation issued in respect of the mainline railway. Source: *ROGS*
infrastructure subsystem (INF)	The infrastructure part of a control, command and signalling (CCS) system that also includes a corresponding trainborne subsystem.
International Electrotechnical Vocabulary (IEV)	*IEC 60050*. This document is used for many of the definitions as shown by the citation beginning *IEV*.
lateral deviation	Deviation of the contact wire from the track centre line under action of a crosswind. Source: *EN 50367:2012, ENE TSI.*
level crossing	An intersection at the same elevation of a road, footpath or bridleway and one or more rail tracks. Source: *IEV 821-07-01*, modified
line speed	Maximum speed measured in kilometres per hour for which a line has been designed. Source: *ENE TSI.*
live part	Any conductor and any conductive part of electrical equipment intended to be energised in normal use. *Source:IEV 195-02-19 modified*

	Note: Insulators are considered to be live parts
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*
mean contact force	Statistical mean value of the contact force. Source: *BS EN 50367:2006*
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*
minimum design contact wire height	Theoretical contact wire height, including tolerances, designed to ensure that the minimum contact wire height is always achieved. Source: *EN 50119:2009+A1:2013*
National Technical Specification Notice (NTSN)	Document published by the Secretary of State pursuant to regulation 3B of the Railways (Interoperability) Regulations 2011 (as amended) which sets out the standards, technical specifications and technical rules in use in the United Kingdom as amended or varied from time to time. These may be standards to be complied with in relation to the design, construction, placing in service, upgrading, renewal, operation and maintenance of the parts of the rail system. For the purposes of these Regulations, the essential requirements for a project subsystem conforms with applicable National Technical Specification Notices and National Technical Rules. Source: *RIR*
nominal contact wire height	The height of the contact wire at a support which is used preferentially when there is no external constraint causing a contact wire to deviate vertically and is the height to which it returns after being varied to accommodate a constraint *Source: BS EN 50119:2022 modified* **Note:** The height is referenced to the top surface of the rails. Typically, constraints include physical route features such as level crossings (increasing the contact wire height) and tunnels or overbridges (decreasing the contact wire height).
nominal voltage	Value of the voltage by which the electrical installation or part of the electrical installation is designated and identified. Source: *IEV 826-11-01*
Open Point	Parameters that have been formally identified as in scope of a NTSN or Railway Group Standard for which no common requirement has been agreed.
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.
public area	Standing surface to which the public has intentional access. Examples include platforms, level crossings and pedestrian bridges.
rail vehicle	Any vehicle, moving either under its own power (locomotives fixed formation units and multiple units) or hauled by another vehicle (coaches, railcar trailers, vans and wagons), on-track machine, road-rail vehicle or rail-mounted maintenance machine.
rated impulse voltage (U_{Ni})	Impulse voltage value assigned to the system or part of it, characterising the specified withstand capability of its insulation against transient overvoltages.*Source: EN 50124-1:2001+A2:2005, 1.3.2.7 modified*
register of infrastructure (RINF)	A register that shall be maintained in accordance with regulation 35 of the Railways (Interoperability) Regulations 2011 (as amended).
register of infrastructure (RINF)	A register that shall be maintained in accordance with regulation 35 of the Railways (Interoperability) Regulations 2011 (as amended).
reinforced insulation	Insulation of hazardous-live-parts, which provides a degree of protection against electric shock equivalent to double insulation. **Note:** Reinforced insulation may comprise several layers which cannot be tested singly as basic insulation or supplementary insulation. *Source: IEV ref 195-06-09*
return circuit	All conductors which form the intended path for the traction return current. **Note:** 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. Source: *ENE NTSN*
return conductor	Conductor, mounted on insulators, paralleling the track return system and connected to the running rails at periodic intervals, Source: *EN 50122-1:2011+A1:2011 modified.*
subsystem [railway system]	A subdivision (in whole or in part) of the railway system as specified in the Railways (Interoperability) Regulations 2011 (as amended). Subsystems can be structural or functional.

Technical Specification for Interoperability (TSI)	A specification adopted by the European Commission to cover each subsystem or part subsystem to meet the essential requirements and ensure the interoperability of the EU rail system.
train set	Combination of vehicles coupled together, including banking locomotives.
train	An operational formation consisting of one or more units. Source: *LOC&PAS NTSN*
UK verification procedure	The assessment procedure referred to in regulation 17 and Schedule 4 of the RIR 2011 (as amended). In the context of this document, it is carried out by a designated body.

Abbreviations

ac	alternating current
APC	Automatic power control
ARL	Above rail level
dc	direct current
ENE	Energy subsystem
IC	Interoperability constituent
LOC & PAS	Locomotive and passenger carriages. Part of the RST subsystem
OCL	Overhead contact line
RST	Rolling stock subsystem
SI	Section insulator
TCL	track centre line

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

GERT8073	Application of Standard Vehicle Gauges
GIRT7073	Requirements for the Position of Infrastructure and for Defining and Maintaining Clearances
GMRT2111	Rolling Stock Subsystem and Interfaces to AC Energy Subsystem
GMRT2130	Vehicle Fire, Safety and Evacuation
GMRT2173	Size of Vehicles and Position of Equipment

RSSB documents

GLGN1610	Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem
RIS-1853-ENE	Rail Industry Standard on ac energy subsystem and interfaces to rolling stock subsystem
RIS-2713-RST	System Requirements for the Introduction and Operation of Multi-Mode Rolling Stock
RIS-2715-RST	Rail Industry Standard on Rolling Stock Subsystem and Interfaces to AC Energy Subsystem
RIS-2773-RST	Format and Methods for Defining Vehicle Gauging Data
T1001 RSSB (2014)	Review of Existing Rolling Stock Against New and Upgraded Electrification Compliant with the Energy TSI

Other references

BS EN 50119:2020	Railway applications. Fixed installations. Electric traction overhead contact lines
BS EN 50122-1:2011+A1:2011	Railway applications. Fixed installations. Electrical safety, earthing and the return circuit. Part 1: Protective provisions against electric shock
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. Basic requirements. Clearances and creepage distances for all electrical and electronic equipment
BS EN 50163:2004+A3:2022	Railway applications. Supply voltages of traction systems
BS EN 50367:2020	Railway applications - Fixed installations and rolling stock - Criteria to achieve technical compatibility between pantographs and overhead contact line
BS EN 50388-1:2022	Railway Applications. Fixed installations and rolling stock. Technical criteria for the coordination between electric traction power supply systems and rolling stock to achieve interoperability
BS EN 60099 series	Surge arresters
DMRB	The Design Manual for Roads and Bridges
IEV 60050 series	International Electrotechnical Vocabulary (IEV) available on line as 'Electropedia'
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
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
Regulation 402/2013	Commission Implementing Regulation (EU) No 402/2013 of 30 April 2013 on the Common Safety Method for Risk Evaluation and Assessment
	The Highway Code

Other relevant documents

Railway Group Standards

GLRT1212	DC Conductor Rail Energy Subsystem and Interfaces to Rolling Stock Subsystem

GMRT2113	Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem

RSSB documents

GMGN2613	Guidance on Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem
RIS-0713-CCS	Lineside Signalling Layout Driveability Assessment Requirements
RIS-0758-CCS	Lineside Signal Aspects and Indications

Other references

BS EN 50153:2014+A1:2017	Railway applications. Rolling stock. Protective provisions relating to electrical hazards
BS EN 50318:2018	Railway applications. Current collection systems - Validation of simulation of the dynamic interaction between pantograph and overhead contact line
IEC 60479-1:2018	Effects of current on human beings and livestock - Part 1: General aspects
SI 1999/3242	The Management of Health and Safety at Work Regulations 1999
SI 2002/2665	The Electricity Safety, Quality and Continuity Regulations 2002
SI 2011/3066	The Railways (Interoperability) Regulations 2011