RAIL SAFETY AND STANDARDS BOARD

DRAFT

Railway Group Standard

GMRT2113 | Issue Two | March 2026 [proposed] | Draft 1T

Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem

This document sets out requirements as national technical rules (NTRs) for rolling stock that traverses the Great Britain (GB) mainline 750 V direct current (dc) conductor rail energy subsystem and includes requirements for compatibility between vehicle subsystems and the dc conductor rail energy subsystem.

Published by **Rail Safety and Standards Board**

Railway Group Standard
GMRT2113
Issue: Two **Draft:** 1T
Date: March 2026 [proposed]

Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem

Synopsis

This document sets out requirements as national technical rules (NTRs) for rolling stock that traverses the Great Britain (GB) mainline 750 V direct current (dc) conductor rail energy subsystem and includes requirements for compatibility between vehicle subsystems and the dc conductor rail energy subsystem.

Copyright in the Railway Group documents is owned by Rail Safety and Standards Board Limited. All rights are hereby reserved. No Railway Group document (in whole or in part) may be reproduced, stored in a retrieval system, or transmitted, in any form or means, without the prior written permission of Rail Safety and Standards Board Limited, or as expressly permitted by law.

RSSB members are granted copyright licence in accordance with the Constitution Agreement relating to Rail Safety and Standards Board Limited.

In circumstances where Rail Safety and Standards Board Limited has granted a particular person or organisation permission to copy extracts from Railway Group documents, Rail Safety and Standards Board Limited accepts no responsibility for, nor any liability in connection with, the use of such extracts, or any claims arising therefrom. This disclaimer applies to all forms of media in which extracts from Railway Group documents may be reproduced.

Published by RSSB

© Copyright 2026
Rail Safety and Standards Board Limited

Issue record

Issue	Date	Comments
One	September 2015	Original document. Replaced GERT8025 issue one and GMRT2304 issue three.
Two	March 2026 [proposed]	Replaces issue one and sets out new requirements for dc energy data collection and measurement. Guidance incorporated from GMGN2613.

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Superseded documents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
GMRT2113 issue one	2.1, 2.3, Part 3 (excluding 3.5.5), Part 4 (excluding 4.4.2)	March 2026 [proposed]
GMGN2613 issue one	2.1, 2.3 Part 3 (excluding G 3.5.12), Part 4 (excluding G 4.4.2)	March 2026 [proposed]

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/

Contents

Part 1 Purpose and Introduction

1.1 Purpose

1.1.1 This document sets out requirements for rolling stock traversing the Great Britain (GB) mainline 750 V direct current (dc) conductor rail energy subsystem. This document does not set out requirements for vehicles connecting to, or operating on, overhead contact line railways with a nominal voltage of 750 V dc or 1500 V dc.

1.1.2 The requirements in this document support specific case 7.3.2.10 set out in the Locomotive and Passenger (LOC&PAS) National Technical Specification Notice (NTSN), and provide for compatibility with the requirements set out in GLRT1212, which are supplementary to the Energy (ENE) NTSN.

1.1.3 This document contains 'open points', which are requirements that have not yet been specified, but which are within the scope of the document.

1.2 Introduction

1.2.1 Background

1.2.1.1 The Energy (ENE) National Technical Specification Notice (NTSN) specifies the following power systems: AC 25 kV 50 Hz system, AC 15 kV 16.7 Hz system, DC 3 kV system and 1.5 kV system. As a consequence, requirements set out in the Locomotive and Passenger (LOC&PAS) NTSN are related to these four systems only.

1.2.1.2 This document therefore sets out requirements for rolling stock interfacing with the 750 V dc conductor rail energy subsystem to provide for compatibility with existing infrastructure and is intended to achieve the same principles of interoperability as the requirements set out in the NTSNs for the GB mainline 25 kV ac overhead contact line energy subsystem.

1.2.1.3 Where there is a reference in any Euronorm (EN) or NTSN to a speed in km/h, refer to RIS-2715-RST which provides a table of speed conversions from km/h to mph.

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 national technical rules (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 support UK specific cases for GB in NTSNs; and
b) To enable technical compatibility between vehicles that conform to the requirements of the LOC&PAS NTSN and the existing 750 V dc conductor rail energy subsystem.

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 Related requirements in other documents

1.2.4.1 The following Railway Group Standards contain requirements that are related to the scope of this document:

a) GLRT1212 DC Conductor Rail Energy Subsystem and Interfaces to Rolling Stock Subsystem
b) GMRT2132 On-board Energy Metering for Billing Purposes
c) GERT8073 Application of Standard Vehicle Gauges.

1.2.5 Supporting documents

1.2.5.1 The following Rail Industry Standards support the requirements in this Railway Group Standard:

a) RIS-2716-RST Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem
b) RIS-1852-ENE DC Conductor Rail Energy Subsystem and Interfaces to Rolling Stock Subsystem.

1.3 Approval and authorisation of this document

1.3.1 The content of this document will be approved by Rolling Stock Standards Committee on 13 November 2025 [proposed].

1.3.2 This document will be authorised by RSSB on 17 December 2025 [proposed].

Part 2 Requirements for all rail vehicles

2.1 Protection against external electrical hazards

2.1.1 Rolling stock subsystems and components that can carry dc energy subsystem fault currents shall be capable of withstanding the short circuit fault levels for the dc conductor rail energy subsystems.

2.1.2 It is permissible to install a single main protective bonding path between the vehicle's main body and one bogie for rail vehicles that operate over lines that include the 750 V dc conductor rail energy subsystem.

Rationale

G 2.1.3 LOC&PAS NTSN 2021 clause 4.2.8.2.10 sets out requirements for electrical protection of the train, which protects both systems and people, but this does not include the 750 V dc conductor rail energy subsystem as a target system. Requirements *2.1.1* and *2.1.2* are the equivalent requirements for the 750 V direct current dc conductor rail energy subsystem

G 2.1.4 Requirements *2.1.1* to *2.1.2* provide electrical protection through system bonding which provides a safe return path for fault currents, controls touch potentials and is adequately rated.

G 2.1.5 Requirement *2.1.2* permits a single main protective bonding path for vehicles interfacing with the 750 V dc conductor rail energy subsystem, whereas typically two bonds are used for compatibility with 25 kV ac systems.

Guidance

G 2.1.6 The issue of short circuit fault levels for the dc conductor rail energy subsystem is an open point in this document. In GMRT2113 issue one and GLRT1212 issue one, a maximum prospective short circuit peak current value of 200 kA, with a short circuit fault level when broken at 20 ms not exceeding 64 kA, was set out to support the design of vehicle bonding. Additionally, an assumed initial rate of rise of 10 kA/ms has since been provided by Network Rail to support future system design. These values have since been identified as useful but not necessarily definitive worst-case values for all infrastructure locations due to differences in equipment arrangements. It is important to discuss these values with the infrastructure manager when designing vehicle bonds.

G 2.1.7 The reclosure sequence of track feeder circuit breakers is an open point in this document. In GMRT2113 issue one and GLRT1212 issue one, the following strategy for the reclosure of track feeder circuit breakers was set out to allow for bonding design:

a) A reclosure of the track feeder circuit breakers after 15 seconds has elapsed;
b) A delay of at least 15 seconds before a second reclosure of the track feeder circuit breakers; and
c) A delay period of at least one minute before any further reclosure of the track feeder circuit breaker.

G 2.1.8 When designing rolling stock bonding for compatibility with the dc energy subsystem, the infrastructure manager can provide values to support adequate bonding design which supplements the guidance given in *G 2.1.6* and *G 2.1.7*.

G 2.1.9 Requirement *2.1.2* offers the possibility of using only a single protective bonding path, which results in the current flow being limited in the bodywork of vehicles interfacing with the 750 V dc conductor rail energy subsystem in comparison to when two separate bonding paths are distributed along the vehicle's length. Additional maintenance or duplication of individual bonds might, however, be necessary for reliability.

G 2.1.10 System design can avoid damage caused by electrical currents to axle and motor bearings.

G 2.1.11 Axle end brush gear connected directly to the bogie frame or the vehicle body significantly reduces potentially damaging current through wheel bearings.

G 2.1.12 If axle end brush gear is installed with two independently sprung brushes for protective bonding, each brush can be considered as an independent bonding path if two independent cable connections are also provided between the brushes, and vehicle or bogie.

G 2.1.13 Vehicle designs have historically taken into account 9 kA that can flow in the rails under a vehicle, and these designs consider current flowing in unintended paths, such as through low resistance paths between vehicles. The limit of 9 kA was established by historical RSSB system modelling, and this value is exceeded under fault and transient conditions.

G 2.1.14 Traction currents flowing in an across track cable, or cables grouped together at a single location, have historically been designed to limit current flow to 10 kA to reduce the impact of electromagnetic interference with onboard equipment. This value is not guaranteed however, as it can not be readily assessed, and is exceeded in fault and transient conditions.

2.2 Protection against internal electrical hazards

2.2.1 Rolling stock and its electrically live components shall be designed such that direct or indirect contact with train staff and passengers is prevented, both in normal operating conditions and in cases of equipment failure, by the application of protective bonding as set out BS EN 50153:2014+A2:2020.

Rationale

G 2.2.2 LOC&PAS NTSN 2021 clause 4.2.8.4 refers to the relevant clauses of BS EN 50153:2014+A2:2020 for protection against electrical hazards for personal safety, which only considers the target subsystems. As a result, 750 V dc electrical hazards are not within the scope of the LOC&PAS NTSN 2021 and requirements as national technical rules (NTRs) are necessary for technical compatibility and safety.

Guidance

G 2.2.3 For 750 V dc, the applicable requirements in BS EN 50153:2014+A2:2020 are those associated with band III voltages for 750 V dc, which results in smaller physical clearance distances than are required for 25 kV ac.

G 2.2.4 BS EN 50153:2014+A2:2020 Annex A sets out a special national condition for France that classes 750 V dc as a band IV voltage. This results in additional protection measures being applied for 750 V dc systems which are considered good practice to adopt for the purposes of safety, particularly with regard to access to live 750 V dc equipment by maintenance staff.

Part 3 Electrical requirements for 750 V dc electric rail vehicles

3.1 Short circuit fault protection

3.1.1 Rolling stock circuit breakers and any associated fusegear shall be designed to interrupt short circuit faults:

a) Taking into account the maximum fault current that may be experienced at the interface between the conductor rail and collector shoe; and
b) Based on the maximum train set internal short circuit fault current.

3.1.2 When specifying circuit breakers and fusegear to interrupt short circuit faults for maximum train set internal fault currents, it is permissible to take into account the train set internal resistance.

Rationale

G 3.1.3 Rolling stock circuit breakers and associated fusegear are designed to disconnect all 750 V dc loads on the train, except essential voltage measurement devices, both in normal operating conditions and in cases of equipment failure. The objective of requirement *3.1.1* is to provide this protection based on the value of the current the train may reasonably be able to detect internally and also at the interface with the 750 V dc conductor rail energy subsystem.

G 3.1.4 Rolling stock circuit breakers are typically designed to detect onboard faults and interrupt currents based on internal train resistance, and therefore are typically installed in association with fusegear to provide adequate disconnection from the supply.

Guidance

G 3.1.5 BS EN IEC 60077-3:2019 sets out requirements and guidance for dc circuit breakers, the main contacts of which are connected to dc power circuits, auxiliary circuits, or both.

G 3.1.6 The maximum fault current that can be experienced at the interface between the conductor rail and collector shoe is an open point in this document. Historically, a maximum peak current value of 64 kA has been used to design circuit breakers and associated fusegear. Additionally, indicative values of a maximum fault duration of 20 ms with an assumed initial rate of rise of 10 kA/ms have been provided by Network Rail to support system design, but with the caveat that these are not accurate values for all infrastructure locations.

G 3.1.7 Where rolling stock is fitted with an input filter and without a pre-charge device that is intended for operation on a line which has a minimum conductor rail and substation inductance of 2 millihenries (mH), compliance with BS EN 50388-1:2022 clause 11.5 can help to reduce instances of nuisance tripping of track feeder circuit breakers.

3.2 Voltage

3.2.1 750 V dc electric rail vehicles shall be designed to interface with a conductor rail that is positive with respect to the return rail.

3.2.2 750 V dc electric rail vehicles shall operate over the voltage range as specified in BS EN 50163:2004+A3:2022:

a) Clause 4.1; and
b) Annex B, the special national condition for the United Kingdom (UK).

3.2.3 It is permissible to omit compliance with BS EN 50163:2004+A3:2022 Annex B, as set out in *3.2.2*, if the electric rail vehicle is intended to only operate over routes compliant with BS EN 50163:2004+A3:2022 clause 4.1.

3.2.4 The value of the 750 V dc conductor rail energy subsystem line voltage at the current collector shall be available in the driving cab when it is active.

Rationale

G 3.2.5 Requirements *3.2.1* to *3.2.3* provide for technical compatibility between rolling stock dc subsystems and the 750 V direct current dc conductor rail energy subsystem

G 3.2.6 LOC&PAS NTSN 2021 clause 4.2.8.2.2 sets out requirements for the operation of rolling stock within a range of voltages, but this does not include the 750 V dc conductor rail energy subsystem as a target subsystem. Requirements *3.2.1* to *3.2.3* are the equivalent requirements as NTRs for rolling stock to achieve technical compatibility with the 750 V dc conductor rail energy subsystem

G 3.2.7 LOC&PAS NTSN 2021 specific case 7.3.2.10 permits electric units to be designed only for operation on lines using ground level conductor rails operating at 750 V dc. Requirements *3.2.1* to *3.2.3* are requirements to address this specific case.

G 3.2.8 LOC&PAS NTSN 2021 clause 4.2.8.2.2(2) sets out a requirement for the actual line voltage to be available in the driving cab in driving configuration. Requirement *3.2.4* is the equivalent requirement as an NTR.

Guidance

G 3.2.9 The extended voltage range set out in BS EN 50163:2004+A3:2022 Annex B as a special national condition provides for compatibility with existing infrastructure constraints on legacy routes. This defines the low voltage range for which trains are expected to continue to work without damage under conditions that could exist infrequently and for short periods of time.

G 3.2.10 Where compatibility with legacy rolling stock having a voltage limit of less than 1000 V dc is required, there might be provision within the electrification infrastructure to enable the upper, non-permanent voltage limit, U_{max2}, at the conductor rail to be constrained, as set out in GLRT1212.

G 3.2.11 Transient and over voltage performance is determined by insulation co-ordination. Minimum dielectric withstand values for impulse and power frequency can be selected in accordance with BS EN 50124-1:2017.

3.3 Current

3.3.1 The maximum train set current (I_{max}) shall be:

a) No greater than a value set out in GLRT1212 issue two, clause 2.4; or
b) The value specified by the infrastructure manager for the intended lines of operation.

3.3.2 The maximum train set current assessed in *3.3.1* shall be recorded in the technical documentation for the locomotive or electrical multiple unit.

3.3.3 750 V dc electric traction units shall be equipped with a power or current limitation device, as set out in BS EN 50388-1:2022 clause 7.2.

3.3.4 750 V dc electric traction units shall be equipped with automatic regulation of the current within abnormal operation conditions regarding voltage, as set out in BS EN 50388-1:2022 clause 7.3.

3.3.5 Multiple units and locomotives designed for multiple operation shall have the facility to limit the maximum current demand of the whole train to the maximum train set current for the route.

Rationale

G 3.3.6 Requirement *3.3.1* sets out the maximum train set current to provide for train set technical compatibility.

G 3.3.7 Historically, the maximum permitted current for most lines on the GB mainline 750 V dc electrified railway is approximately 6.8 kA, or 5 MW, which is consistent with the value set out in BS EN 50388-1:2022 Table D.1. for GB. However, for both economics and delivery of service demand, other values can be appropriate and this can be controlled by a traction current limitation device, as is set out in *3.3.3*. For multiple unit train formations, the maximum train set current is often managed by limiting the maximum train length for a particular route with limited power supply capability.

G 3.3.8 LOC&PAS NTSN 2021 clause 4.2.8.2.4(1) sets out a requirement for rolling stock to be equipped with a power or current limitation device, and clause 4.2.8.2.4(2) sets out a requirement for rolling stock to be equipped with automatic regulation of the current within abnormal operating conditions regarding voltage. As LOC&PAS NTSN 2021 does not include the 750 V dc conductor rail energy subsystem as a target system, clauses 4.2.8.2.4(1) and 4.2.8.2.4(2) are not applicable, therefore requirements as NTRs are necessary so that current and power are limited as appropriate.

G 3.3.9 Automatic train current regulation helps support continued operation of the electric traction power supply in operating conditions when the voltage at the current collector is below a particular value and the train current draw needs to be limited.

G 3.3.10 A train power or current limitation device provides a facility which aids technical compatibility between a train and the electrical infrastructure which is supplying it as it operates over the network, when different current limits exist.

Guidance

G 3.3.11 The current limit set out in *3.3.1* for a train set in motion does not provide for technical compatibility across the entire GB mainline 750 V dc conductor rail energy subsystem, as limits can be lower or higher depending on the line; however, when requirements *3.3.1* and *3.3.3* are applied together, technical compatibility is provided across the network.

G 3.3.12 Train set current at standstill is an open point in this document. Current at standstill includes, but is not limited to, auxiliary systems, battery charging and moving the train from a standing start. This current consumption is not the same across all fleet types and the maximum current at standstill can be limited by the infrastructure on a line. Working with other railway undertakings and the infrastructure manager, taking into account the timetable for a route, can assist in understanding the maximum train set current that can be drawn at a location.

G 3.3.13 RSSB research project T1185 (2021) gives:

a) An indication of the power levels that can be transferred across third rail current collector/conductor interfaces at standstill;
b) Indication, in the absence of defined temperature limits, that the conductor rail interface is unlikely to present a constraint to fast charging;
c) Identified key infrastructure and rolling stock constraints to fast charging; and
d) Established gaps in electrification system component ratings that need to be addressed to support future assessments of system capacity for fast charging applications.

G 3.3.14 RSSB research project T1185 (2021) demonstrated that for contact forces of 200 N or greater, dc currents of up to 2250 A and 1750 A for 15 minutes can be drawn across 150 lb/yd steel and 17.8 kg/m aluminium-steel composite (ASC) conductor rail interfaces respectively. However, contact forces vary across rolling stock and conductor rails vary from route to route and capacity might not be available to support these values.

3.4 Power regeneration

3.4.1 750 V dc electric rail vehicles shall be capable of power regeneration into the 750 V dc conductor rail energy subsystem.

3.4.2 It is permissible to use power regeneration to charge onboard traction batteries.

3.4.3 The regenerative brake shall include a function to prevent operation in areas where regenerative braking is not permitted on the 750 V dc conductor rail energy subsystem.

3.4.4 750 V dc electric rail vehicles shall not initiate regenerative braking if the voltage of the 750 V dc conductor rail energy subsystem is less than 550 V dc.

3.4.5 Regeneration shall cease on 750 V dc electric rail vehicles if regeneration has been initiated and the voltage of the 750 V dc conductor rail energy subsystem falls below 500 V dc.

3.4.6 750 V dc electric rail vehicles shall not initiate regenerative braking or continue to regenerate if the voltage of the 750 V dc conductor rail energy subsystem detected at the vehicle is above 900 V.

3.4.7 The upper voltage limit for regeneration shall be adjustable in a maximum of 50 V steps.

3.4.8 Each regenerating traction unit shall:

a) Be controllable with respect to voltage at a fixed but selected control impedance;
b) Be fitted with automatic detectors which measure line current and voltage;
c) Stop regenerating into the conductor rail within 200 ms if the impedance of the conductor rail, as seen from the current collector, is less than the value defined by the control impedance; and
d) Be fitted with the capability for the regenerative control impedance to be selectable between the values of 0.05 Ω and 0.2 Ω in steps of 0.01 Ω with an accuracy of ±3 % , including all transducers.

3.4.9 The maximum regenerative braking current of a traction unit shall be no greater than the maximum traction motoring current.

Rationale

G 3.4.10 There is no requirement in LOC&PAS NTSN 2021 for regenerative braking to be installed on rail vehicles. However, it is provided as an option for dynamic braking. Without setting out requirements for power regeneration for both the rolling stock and energy system, the technology will become unused and result in the 750 V dc conductor rail energy subsystem being unable to cope with the demand on its supply due to the greater energy demands of modern rolling stock systems.

G 3.4.11 Where requirements are set out in LOC&PAS NTSN 2021 for regenerative braking in clauses 4.2.4.4.4 and 4.2.8.2.3, requirements *3.4.3* to *3.4.5* are the equivalent requirements as NTRs for rolling stock to achieve technical compatibility with the 750 V dc conductor rail energy subsystem.

G 3.4.12 Energy efficiency and utilisation of regenerative braking energy reduces the overall energy consumption and the carbon footprint for the railway.

G 3.4.13 The capability to isolate regenerative braking protects the infrastructure against damage where regenerative braking is prohibited.

G 3.4.14 Trains regenerating into unsupplied lines that are disconnected from a power supply can give rise to danger, for example, in an emergency. Low voltage shut off of regenerative braking is therefore required, as set out in *3.4.4* and *3.4.5*.

Guidance

G 3.4.15 Inhibiting the regenerative braking function is not intended to prevent the use of rheostatic braking where fitted. Inhibiting the regenerative braking function means that the regenerative brake power to the 750 V dc conductor rail energy subsystem is zero, but it can still be providing power to onboard storage.

G 3.4.16 The energy system normally permits the use of regenerative braking, but it can be necessary to limit either current or voltage, or both, to be compatible. These features can be adjustable to facilitate compatibility with existing infrastructure and traction units. An example of this control is shown in Appendix C and the adjustments for regenerative braking can be made in software.

G 3.4.17 The infrastructure manager can provide information where the use of regenerative braking is not possible on certain sections of line.

G 3.4.18 Figure 1 gives guidance, as a graph, on regenerative braking characteristics.

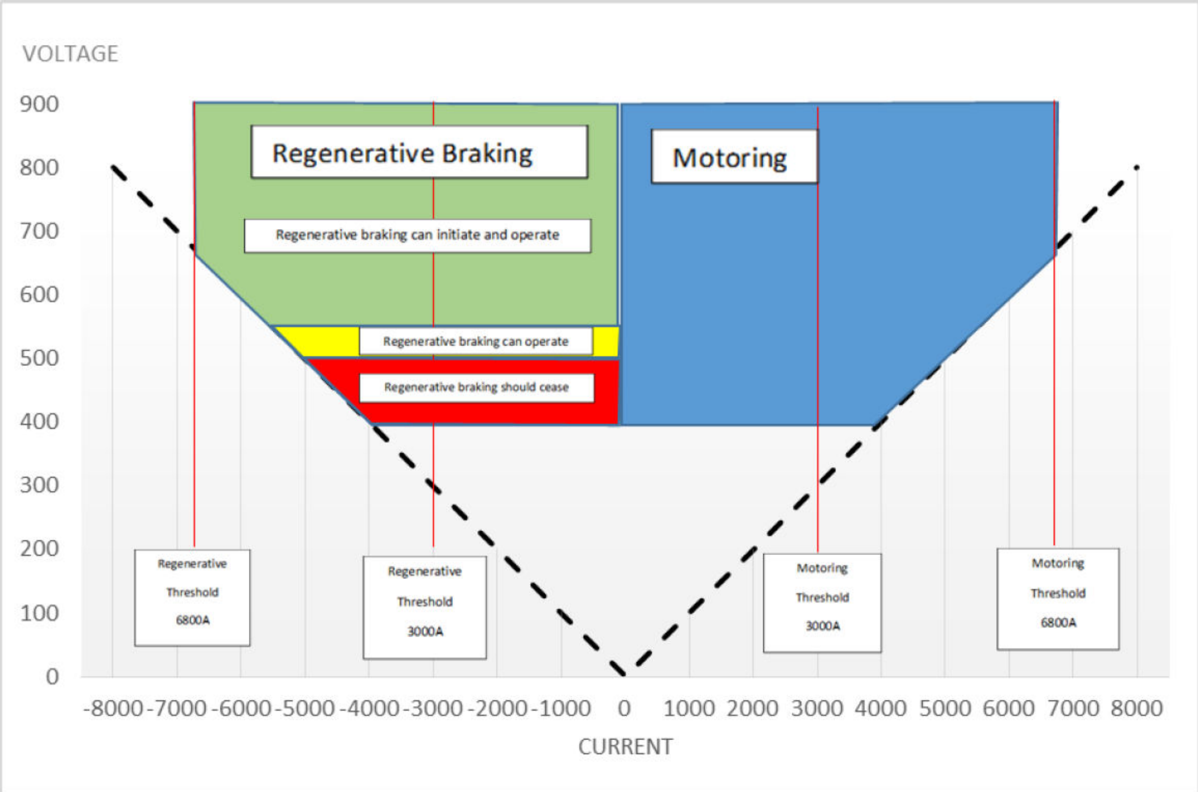

Figure 1: Regenerative braking characteristics

G 3.4.19 The term selectable when used in 3.4.8 means that this selection of a parameter value can be undertaken as a maintenance action and is not required to be undertaken while the vehicle is operating.

3.5 Separation of external power supplies

3.5.1 The 750 V dc conductor rail energy subsystem shall not be connected to any other external power supply through a vehicle.

Rationale

G 3.5.2 This requirement provides a means of achieving technical compatibility with the 750 V dc conductor rail energy subsystem, where another supply, such as an ac energy subsystem, can exist at the same location.

G 3.5.3 Connection of two different power supplies through a vehicle can give rise to danger due to supply and component incompatibility.

Guidance

G 3.5.4 Requirement *3.5.1* is normally achieved by interlocking the respective supplies in the changeover control.

G 3.5.5 Requirement *3.5.1* permits independent traction power supplies, such as traction batteries, to be charged.

3.6 Data collection and measurement

3.6.1 750 V dc electric rail vehicles shall be equipped with an on-board energy measurement system in accordance with:

a) LOC&PAS NTSN 2021, clauses 4.2.8.2.8.1, 4.2.8.2.8.2 and 4.2.8.2.8.3, with any references to the overhead contact line (OCL) being interpreted as the 750 V dc conductor rail energy subsystem; and
b) GMRT2132 issue one, clauses 2.5 and 2.6.

3.6.2 It is permissible to use the train control and management systems (TCMS) to measure, handle and transmit compiled energy billing data (CEBD) sets to the onground data collecting system (DCS).

Rationale

G 3.6.3 Requirements *3.6.1* and *3.6.2* are necessary so that infrastructure managers can bill railway undertakings (RUs) for the energy that they use to power rolling stock.

G 3.6.4 As the LOC&PAS NTSN 2021 clause 4.2.8.2.8 sets out requirements for an onboard energy measurement system for billing purposes, but is specific to active and reactive electric energy taken from or returned during regenerative braking to the OCL. As LOC&PAS NTSN 2011 does not include the 750 V dc conductor rail energy subsystem as a target subsystem, clause 4.2.8.2.8 is not applicable, therefore, requirements as NTRs are necessary, so that energy billing is performed on rolling stock that operates using an interface to the GB on-ground system for traction energy billing and settlement.

Guidance

G 3.6.5 LOC&PAS NTSN 2021 clause 4.2.8.2.8 sets out requirements for an onboard energy measurement system with reference to the BS EN 50463 series standards. To provide for future compatibility, it may be beneficial to install energy metering systems that can transmit data in the formats set out in:

- GMRT2132; and
- The BS EN 50463 series standards.

Part 4 Mechanical requirements for 750 V dc electric rail vehicles

4.1 Geometry

4.1.1 The width of a collector shoe shall be 100 mm ± 5 mm.

4.1.2 A collector shoe measured from the track centre line shall have:

a) A maximum outer face dimension of 1202 mm; and
b) A minimum inner face dimension of 1032 mm.

4.1.3 The length of a collector shoe shall be between 300 mm and 360 mm.

4.1.4 The included angle between the contact surface and leading and trailing faces of a collector shoe shall be nominally 90˚.

Rationale

G 4.1.5 Requirements *4.1.1* to *4.1.4* provide for mechanical compatibility between a collector shoe and the 750 V dc conductor rail energy subsystem.

G 4.1.6 LOC&PAS NTSN 2021 clause 4.2.8.2.9.2 sets out requirements for pantograph head geometry and clause 4.2.8.2.9.4.1 sets out a requirement for contact strip geometry. Requirements *4.1.1* to *4.1.4* are the equivalent requirements as NTRs for rolling stock to achieve technical compatibility with the 750 V dc conductor rail energy subsystem.

Guidance

G 4.1.7 The 90˚ angle at the front edge of a collector shoe helps with the removal of ice and debris from the conductor rails.

4.2 Gauging

4.2.1 Current collectors shall be capable of being raised and retained, using a retracting system or manually, to within the lower sector vehicle gauge base profile as set out in GERT8073.

Rationale

G 4.2.2 Requirement *4.2.1* prevents infringement of the lower sector gauge and potential impact with infrastructure when the current collector is not in operation.

G 4.2.3 LOC&PAS NTSN 2021 clause 4.2.8.2.9.10 sets out requirements for pantograph lowering. Requirement *4.2.1* is the equivalent requirement as a NTR for rolling stock to achieve technical compatibility with the 750 V dc conductor rail energy subsystem; however, where LOC&PAS NTSN 2021 clause 4.2.8.2.9.10 requires lowering of the pantograph to achieve a dynamic insulating distance, this requirement is set out for vehicle gauging purposes.

Guidance

G 4.2.4 Current collectors that are not retracted once a vehicle is operating on a non-electrified or ac route can collide with infrastructure features such as ballast and automatic power control magnets.

G 4.2.5 The manual lifting of a current collector and fixing it in its upper position is a way of meeting requirement *4.2.1* where this is an infrequent occurrence.

G 4.2.6 RIS-2716-RST sets out requirements and guidance for retractable current collectors and their working height.

4.3 Current collector working height

4.3.1 The setting of the down-stop shall prevent any part of a current collector going below 34.5 mm above the plane of the running rails under all dynamic operating conditions.

4.3.2 The maximum height of the collection face of a deployed collector shoe shall be 227 mm above the plane of the running rails.

Rationale

G 4.3.3 Requirements *4.3.1* and *4.3.2* restrict the height range of a collector shoe so that it is compatible with the possible heights of the conductor rail.

G 4.3.4 LOC&PAS NTSN 2021 clause 4.2.8.2.9.1.2 sets out requirements for the working range in height of the pantograph. Requirements *4.3.1* and *4.3.2* are the equivalent requirements as NTRs for rolling stock to achieve technical compatibility with the 750 V dc conductor rail energy subsystem.

Guidance

G 4.3.5 The maximum height of the current collector set out in *4.3.2* is based upon:

a) A maximum conductor rail height of 116 mm above the plane of the running rails;
b) The maximum overshoot at a facing ramp end under dynamic conditions;
c) A ramp gradient of 1:30;
d) A current collector velocity equal to the vehicle's maximum design speed of 160 km/h; and
e) The down-force on the current collector being provided solely by gravity.

G 4.3.6 The maximum height of a collector shoe can be reduced by fitting a sprung arrangement to limit upward overshoot.

4.4 Materials, wear and frangibility

4.4.1 The collector shoe material forming an interface with the conductor rail head shall be grey cast iron to BS EN 1561:2011 or spheroidal graphite cast iron to BS EN 1563:2011.

4.4.2 A weak link shall be designed in the current collector that results in a clean mechanical break being made when it is subjected to a longitudinal impact energy greater than 500 joules.

4.4.3 The electrical connection between the vehicle and current collector shall be a weak link and designed to minimise the risk from arcing and flashover from the live parts after fracture.

Rationale

G 4.4.4 The materials set out in requirement *4.4.1* are compatible with conductor rail materials and optimise current collection and wear.

G 4.4.5 LOC&PAS NTSN 2021 clause 4.2.8.2.9.4.2 sets out requirements for pantograph contact strip material. Requirement *4.4.1* is the equivalent requirement as an NTR for rolling stock to achieve technical compatibility with the 750 V dc conductor rail energy subsystem.

G 4.4.6 Weak links, also referred to as frangible joints, are designed to fracture in a controlled manner to limit damage from either a rolling stock or infrastructure defect.

Guidance

G 4.4.7 Current collector equipment can be identified by adding a vehicle numbering to weak links. After a weak link fracture, it is important to be able to trace their origin, so repairs can be performed.

G 4.4.8 A 20 kN longitudinal proof load has always been applied to a weak link to demonstrate complete collector integrity.

G 4.4.9 Current collector cabling installations have historically taken into account the possibility of arc propagation, and the use of metal conduits or cable enclosures has typically been avoided. Arc shielding can protect areas that are likely to be affected by arcing from collector shoes and associated cabling, particularly vulnerable components such as axle bearings.

4.5 Current collector

4.5.1 Current collectors at the end of traction units that operate from the third rail supply shall be interconnected.

4.5.2 Retractable current collectors shall be prevented from being retracted or deployed until all vehicle loads, other than essential voltage measurement devices, have been disconnected.

Rationale

G 4.5.3 Interconnecting current connector equipment protects against the disconnection of the train from the fixed energy subsystem.

G 4.5.4 Requirement *4.5.2* provides protection against excessive arcing when retracting or deploying current collectors.

G 4.5.5 LOC&PAS NTSN 2021 clause 4.2.8.2.9.10 sets out requirements for pantograph lowering. Requirement *4.5.2* is the equivalent requirement as an NTR for rolling stock to achieve technical compatibility with the 750 V dc conductor rail energy subsystem.

Guidance

G 4.5.6 Information on conductor rail layouts is available from the infrastructure manager. Where current collectors are connected together, the interconnections can carry all or a proportion of the current carried by the conductor rail. The current collectors of

London Underground Limited stock, and some other classes of electric rail vehicles, are not interconnected between vehicles for reasons of safety when operating in tunnels, or because the vehicles concerned are single self-contained traction vehicles, such as locomotives.

G 4.5.7 Current collectors are normally designed to withstand a current of 2 kA for five minutes.

G 4.5.8 The minimum spacing between interconnected current collectors is an open point in this document.

G 4.5.9 GLRT1212 issue two, clause 3.11.1, is an open point regarding the design of 750 V dc conductor rail energy subsystem conductor rail layout. This does not set out the maximum distance for the gap between two consecutive conductor rails on a line. As this dimension is unknown, it is not possible to set out the minimum spacing between adjacent collector equipment installations on a vehicle.

4.6 Force, behaviour and performance

4.6.1 The maximum static contact force between the collector shoe and the conductor rail shall be 300 N.

4.6.2 The minimum static contact force between the collector shoe and the conductor rail shall be 30 N.

4.6.3 The maximum dynamic requirements for current collectors shall be:

a) 1500 N peak vertical dynamic contact force, excluding ramp ends; and
b) 40 kN peak dynamic contact force at ramp ends; and
c) Such that the longitudinal impact energies do not exceed 300 J.

4.6.4 The total vertical effective mass of moving parts within the current collector mechanism shall not exceed 15 kg.

Rationale

G 4.6.5 Requirements *4.6.1* to *4.6.4* provide for mechanical compatibility between the collector shoe and the conductor rail.

G 4.6.6 LOC&PAS NTSN 2021 clause 4.2.8.2.9.6 sets out requirements for pantograph contact force and dynamic behaviour. Requirements *4.6.1* to *4.6.4* are the equivalent requirements as NTRs for rolling stock to achieve technical compatibility with the 750 V dc conductor rail energy subsystem.

Guidance

G 4.6.7 The forces set out in *4.6.1* to *4.6.4* also apply when current collectors are being lowered on the move.

G 4.6.8 A higher collector shoe contact force, up to the limit set out in *4.6.1*,can:

a) Assist in ice clearance; and
b) Be beneficial in cases where very light collector shoes are in use.

G 4.6.9 The moving parts of a current collector mechanism are those which are connected from a fixed pivot point, typically labelled as the shoearm, collector shoe holder and collector shoe.

Part 5 Application of this document

5.1 Scope

5.1.1 If a change to a vehicle is considered new, renewed or upgraded as defined in the Railways (Interoperability) Regulations 2011 (as amended), then all or part of the vehicle is required to comply with the LOC&PAS NTSN 2021 and other relevant NTSNs and NTRs, unless given exemptions allowed for in the Regulations.

5.1.2 The requirements of this document apply to all new and modified (excluding like-for-like replacement of components) rolling stock dc subsystems.

5.1.3 Action to bring existing rolling stock dc 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 the following:

a) Rolling stock that operates solely on 25 kV ac or unelectrified lines;
b) On-track plant within the scope of RIS-1530-PLT;
c) On-track machines within the scope set out in GMRT2400; and
d) On-track machines fitted with shoes for safety purposes.

5.3 General enter into force date

5.3.1 The requirements in this document enter into force from 06 June 2026 [proposed].

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 Standards Code.

5.6.2 In the case where NTSN compliance is required for a new, renewed or upgraded vehicle or structural subsystem, the process for any exemptions needed is set out in the RIR 2011.

5.7 User's responsibilities

5.7.1 Industry experts representing railway industry stakeholders are involved in the process for setting the content of documents that are prepared in accordance with the procedures set out in the Railway Standards Code and Manual.

5.7.2 Users of documents published by RSSB are expected to be competent or should take specialist advice before following or applying any practices or principles contained within them and are reminded of the need to consider their own responsibilities to ensure safe systems of work and operation, health and safety at work and compliance with their own duties under health and safety legislation. While documents published by RSSB can be used to help inform and devise safe practices and systems of work, their content has not been designed or prepared for:

a) Reliance by any specific person or organisation; and
b) Application or use in all possible operational or working environments.

5.7.3 No representation, warranty, guarantee, confirmation or other assurance is given or made (whether expressly or implicitly) 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.

5.7.4 Users and duty holders remain responsible at all times for assessing the suitability, adequacy and extent of any measures they choose to implement or adopt and RSSB does not accept, and expressly disclaims, all and any liability and responsibility except for any liability which cannot legally be limited.

Appendices

Appendix A Open Points

A.1 Open Points

Note: The content of this appendix is provided as guidance in support of the open points given in parts 2, 3 and 4 of this document.

Guidance

G A.1.1 The open points in GMRT2113 are set out in Table 1, which also indicates where guidance on industry practice relating to each open point is given.

Open point	Section of GMRT2113	Additional information
The short circuit fault current characteristics at the conductor rail	*2.1*, *3.1*	*G 3.1.6*, *G 2.1.6*
The reclosure sequence of track feeder circuit breakers	*2.1*	*G 2.1.7*
Train set current at standstill	*3.3*	*G 3.3.12*
The minimum spacing between interconnected current collectors	*4.5*	*G 4.5.9*

Table 1: Open points

Definitions

circuit breaker	Mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified duration and breaking currents under specified abnormal circuit conditions such as those of short circuit. Source: *IEC 60050-441, definition 441-14-20*
collection face	The face of a collector shoe which interfaces with a conductor rail.
collector shoe	Part of the shoegear making contact with the conductor rail. Source: *IEC 60050-811, definition 811-32-20*
contact force	Force applied by the current collector to the conductor rail.
contact line	Conductor system for supplying electric energy to vehicles through current collecting equipment. Source: *IEC 60050-811, definition 811-33-01*
current collector	Equipment fitted to the vehicle and intended to collect current from a contact wire or conductor rail. Source: *IEC 60050-811, definition 811-32-01*
750 V dc conductor rail energy subsystem	The DC conductor rail energy subsystem consists of: a) 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. b) Sectioning locations: electrical equipment located at intermediate locations between substations to supply and parallel contact lines, and to provide protection, isolation and auxiliary supplies. c) 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. d) 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.
defect	Non-fulfilment of specified or intended usage requirements, which can prevent a component or part of a system from accomplishing its design purpose.

	Note: A defect can lead to a fault in a component or system.
direct contact	Electric contact of human beings or livestock with live parts. Source: *IEC 60050-195, definition 195-06-03*
electric shock	Physiological effect resulting from an electric current passing through a human body or livestock. Source: *IEC 60050-811, definition 195-01-04*
failure	An unwanted event where the system or component cannot, or is prevented from, functioning and / or performing as required. Source: *RIS-0707-CCS*
fault	Impairment of a component, or part of a system, to perform a required function, which may lead to an error. **Note:** this includes 'transient faults' which may occur once and subsequently disappear. **Note:** The fault can present itself via an indication to users.
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.
indirect contact	Electric contact of human beings or livestock with exposed-conductive-parts that have become live under fault conditions.Source: *IEC 60050-811, definition 195-06-04*
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*
interface	The common physical or conceptual boundary between two systems or between two parts of the same system. Source: *IEC 60050-811, definition 716-01-07*
live part	Conductor or conductive part intended to be energized in normal use. Source: *IEC 60050-811, definition 811-36-26* **Note:** This concept does not necessarily imply a risk of electric shock. **Note:** By convention, this does not include the running rails and parts connected to them.

plane of the running rails	An imaginary surface co-planar with the top of both rails of a track.
protective bonding	Equipotential bonding for the purposes of electrical safety.
railway undertaking (RU)	Has the meaning given to the term 'transport undertaking' in the Railways and Other Guided Transport Systems (Safety) Regulations 2006 as amended, but is limited to 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. Source*: ROGS*
rolling stock	All vehicles with or without motors. Source: *IEC 60050-811, definition 811-02-01*
shoearm	An insulated component of the conductor collector which is fixed by a pivot at one end to a H bracket on the underside of a bogie and holds the collector shoe in position on the conductor rail
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.
touch voltage	Voltage between conductive parts when touched simultaneously by a person or animal. Source: *IEV 826-11-0*
touch voltage	Voltage between conductive parts when touched simultaneously by a person or livestock. Source:*IEC 60050-195, definition 195-05-11* **Note:** The value of the touch voltage is influenced by the impedance of the human being or the livestock in electric contact with these conductive parts.
traction unit	Locomotive, motor coach or train unit. Source: *IEC 60050-811, definition 811-02-04*
train set	Combination of vehicles coupled together, including banking locomotives. Source: *BS EN 50388-1:2022, definition 3.1.12*
vehicle	Any single item of rolling stock, e.g. a locomotive, a coach or a wagon. Source: *BS EN 50388-1:2022, definition 3.1.15*
weak link	Area of the collector shoe holder or collector shoe which is bound to break as a result of an impact with a foreign body. Note that the weak link, as a frangible section, is calibrated to break when the energy to be absorbed in the equipment exceeds the limit at which the frangible section is bound to be compromised. Source: *BS EN 50702:2021, definition 3.6*

References

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

Railway Safety and Standards Board (2024), Railway Standards Code

Railway Safety and Standards Board (2024), Railway Standards Code

Documents referenced in the text

Railway Group Standards

GERT8073	Application of Standard Vehicle Gauges
GLRT1212	DC Conductor Rail Energy Subsystem and Interfaces to Rolling Stock Subsystem
GMRT2132	On-board Energy Metering for Billing Purposes
GMRT2400	Engineering Design of On-Track Machines in Running Mode

RSSB documents

RIS-1530-PLT	On-Track Plant, Trolleys and Associated Equipment
RIS-1852-ENE	Rail Industry Standard for DC Conductor Rail Energy Subsystem and Interfaces to Rolling Stock Subsystem
RIS-2700-RST	Verification of Conformity of Engineering Change to Rail Vehicles
RIS-2716-RST	Rail Industry Standard for Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem
T1185 (2021)	DECARB: Current Limit at Stand Still

Other references

BS EN 1561:2011	Founding. Grey cast irons
BS EN 1563:2011	Founding. Spheroidal graphite cast irons
BS EN 50124-1:2017	Railway applications. Insulation coordination. Basic requirements. Clearances and creepage distances for all electrical and electronic equipment
BS EN 50153:2014 +A2:2020	Railway applications. Rolling stock. Protective provisions relating to electrical hazards
BS EN 50163:2004 +A3:2022	Railway applications. Supply voltages of traction systems
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. General

BS EN 50463 series standards	Railway applications. Energy measurement on board train.
BS EN IEC 60077-3:2019	Railway applications. Electric equipment for rolling stock. Electrotechnical components. Rules for DC circuit-breakers
ENE NTSN 2021	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 2021	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.

Other relevant documents

OTH-PING-10 (2021)	Managing ice on the conductor rail