



Published by:

RSSB

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GM/GN2613
Guidance on Rolling Stock Subsystem and Interfaces to DC Conductor
Rail Energy Subsystem
Issue One: September 2015
Rail Industry Guidance Note for GM/RT2113



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Guidance on Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem

Issue record

Issue	Date	Comments
One	September 2015	Original document. Gives guidance on interpreting the requirements of GM/RT2113 issue one.

Superseded documents

The following Railway Group documents are superseded, either in whole or in part as indicated:

Superseded documents	Sections superseded	Date when sections are superseded
GE/RT8025 issue one Electrical Protective Provisions for Electrified Lines	B5.5, B5.6	04 June 2016 for new vehicles, and from 03 June 2017 for previously authorised designs
GM/RT2304 issue three Equipotential Bonding of Rail Vehicles to Running Rail Potential	All	

GE/RT8025 issue one Electrical Protective Provisions for Electrified Lines, ceases to be in force and is withdrawn as of 04 June 2016 for new vehicles of new designs, and from 03 June 2017 for new vehicles of previously authorised designs.

GM/RT2304 issue three Equipotential Bonding of Rail Vehicles to Running Rail Potential, ceases to be in force and is withdrawn as of 04 June 2016 for new vehicles of new designs, and from 03 June 2017 for new vehicles of previously authorised designs.

Supply

The authoritative version of this document is available at www.rssb.co.uk/railway-group-standards. Enquiries on this document can be forwarded to enquirydesk@rssb.co.uk.

Guidance on Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem

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Part 1 Introduction

G 1.1 Purpose of this document

- G 1.1.1 This document gives guidance on interpreting the requirements of Railway Group Standard GM/RT2113 issue one Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem. It does not constitute a recommended method of meeting any set of mandatory requirements.

G 1.2 The structure of this document

- G 1.2.1 All requirements from Railway Group Standard GM/RT2113 issue one are reproduced with a grey background in this document.
- G 1.2.2 Guidance is provided as a series of sequentially numbered clauses prefixed 'G' immediately below the greyed text to which it relates.
- G 1.2.3 Specific responsibilities and compliance requirements are laid down in the Railway Group Standard itself.

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G 1.4 Approval and authorisation of this document

- G 1.4.1 The content of this document was approved by a Multifunctional Standards Committee on 02 July 2015.
- G 1.4.2 This document was authorised by RSSB on 05 August 2015.

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Part 2 Guidance on Requirements for all Vehicles that Traverse 750 V DC Electrified Lines

G 2.1 Bonding

Extract from GM/RT2113

Section 2.1 Bonding

- 2.1.1 Protective bonding shall be provided on all rail vehicles that traverse the 750 V DC electrified lines. The bonding shall be provided as set out in BS EN 50153:2014 clause 6.4, except as permitted by 2.1.2 below.
- 2.1.2 Protective bonding shall be provided to prevent damage to the vehicle caused by the creation of parallel paths for DC return current, as set out in 2.1.4. It is permissible for rail vehicles that traverse 750 V DC electrified lines to have only a single protective bonding path between the vehicle's main body structure and the running rail.
- 2.1.3 Bonding connections and vehicle circuit breakers shall be designed taking into account the following parameters:
- a) A maximum prospective sustained short circuit fault level at the vehicle of 200 kA.
 - b) A maximum short circuit fault level when interrupted at 20 ms of 64 kA and a time constant T1, as set out in BS EN 60077-3:2002 clause 5.3.4.
 - c) The bonding shall be designed to withstand the following strategy for reclosing of the track feeder circuit breakers after a short circuit fault has occurred:
 - i) Reclosure of the track feeder circuit breakers after 15 seconds has elapsed.
 - ii) If the track feeder circuit breaker then trips on closure, a delay of at least 15 seconds before a second reclosure of the track feeder circuit breakers.
 - iii) If the track feeder circuit breaker trips on closure a second time, a delay period of at least one minute before any further reclosure of the track feeder circuit breakers.
- 2.1.4 Vehicle bonding shall be provided on the basis that a maximum total DC traction load current of 9 kA is flowing in the running rails of any section of track over which a train may pass.

G 2.1.1 Rationale: This defines the requirements for electrical bonding of vehicles, for safety. (This document does not cover requirements for vehicles operating on 1500 V DC or 750 V DC overhead line systems.)

G 2.1.2 The option set out in 2.1.2 offers the possibility of using only a single protective bonding path to limit the current that could flow in the bodywork of vehicles operating on the DC system if two bonds are used. Additional maintenance or duplication of individual bonds may be necessary for reliability. Steps should be taken to avoid electrical damage to axle and motor bearings. Fitting of axle end brush gear connected directly to the bogie frame or vehicle body significantly reduces the current through wheel bearings. The vehicle design should take into account that 9 kA may flow in the rails under a vehicle, and that the design should consider current flowing in unintended paths, such as through low resistance paths between vehicles. The limit of 9 kA has been established by system modelling undertaken internally by RSSB.

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- G 2.1.3 Where axle end brush gear is provided with two independently sprung brushes for protective bonding, each brush can be considered as an independent bonding path. Where this arrangement is used to provide two independent bonding paths, then two independent cable connections should also be provided between the brushes and vehicle or bogie.
- G 2.1.4 750 V DC electric rail vehicles are normally fitted with main circuit breakers that disconnect all 750 V loads on the train, except essential voltage measurement devices, and that meet the requirements of BS EN 60077-3:2002 with a rated short circuit breaking capacity of 200 kA, as set out in BS EN 60077-3:2002 clause 5.3.5.2 (the rated time constant T1 being selected from those set out in BS EN 60077-3:2002 clause 5.3.4).
- G 2.1.5 If the value of rated short circuit breaking capacity set out in G 2.1.4 is impracticable, a value of at least 100 kA should be used following a risk assessment. On detection of a short circuit fault within the electric rail vehicle, the relevant main circuit breaker is tripped without any intentional delay.
- G 2.1.6 Where rail vehicles traverse infrastructure of London Underground Limited (LUL) that is equipped with a 4th rail, this may be at a potential of up to 900 V with respect to earth and / or the running rails. Electrical clearances appropriate to this voltage between the vehicle and the 4th rail should be applied, in addition to the mechanical clearance required for operation on the Great Britain (GB) mainline railway. The positional dimensions of the 4th rail are set out in GL/RT1212 Appendix D.

G 2.2 Heat emissions from train-mounted equipment

Extract from GM/RT2113

Section 2.2 Heat emissions from train-mounted equipment

- 2.2.1 Where heat from vehicles is emitted below or to the side of a vehicle, it shall not raise the surface temperature of the guard board to greater than 70 degrees Celsius for more than 5 minutes. Dimensions of the guard boarding are as set out in GL/RT1212.

- G 2.2.1 Rationale: Hot emissions from a vehicle might cause damage to vulnerable conductor rail system components.
- G 2.2.2 The 70 degrees Celsius temperature is calculated starting from an ambient of 40 degrees Celsius. The temperature to be measured is the surface temperature of the guard board. Temperature rise of the guard board due to the heat emitted from the vehicle may be calculated with the dimensions of the guard board, as set out in GL/RT1212 clause 3.3.

G 2.3 Electrical clearance

Extract from GM/RT2113

Section 2.3 Electrical clearance

- 2.3.1 The minimum static electrical clearance shall be 75 mm. The minimum passing (dynamic) electrical clearance shall be 25 mm.

- G 2.3.1 Rationale: These parameters provide for mechanical compatibility between the current collector and the conductor rail.
- G 2.3.2 See definitions for meaning of 'static electrical clearance' and 'passing electrical clearance'.

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Part 3 Guidance on Electrical Requirements for 750 V DC Electric Rail Vehicles

G 3.1 System voltage

Extract from GM/RT2113

Section 3.1 System voltage

- 3.1.1 750 V DC electric rail vehicles shall be designed on the basis that the conductor rail and therefore the current collector is positive with respect to the traction return rail.
- 3.1.2 750 V DC electric rail vehicles shall operate over the voltage range, as specified in BS EN 50163:2004+A1:2007 clause 4.1, including the special national condition for the United Kingdom (UK) with respect to low voltage, as set out in BS EN 50163:2004+A1:2007 Annex B.
- 3.1.3 For 750 V DC electric rail vehicles that will only operate over routes compliant with BS EN 50163:2004+A1:2007 clause 4.1, excluding the special national conditions for the UK, it is permissible to omit compliance with the special national condition for UK low voltage set out in BS EN 50163:2004+A1:2007 Annex B.

- G 3.1.1 Rationale: These voltage parameters provide for compatibility between 750 V DC electric rail vehicles and the infrastructure.
- G 3.1.2 The extended voltage range is specified in the Special National Condition provided 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 3.1.3 Where compatibility with legacy rolling stock having a voltage limit of less than 1000 V is required, there is 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 GL/RT1212 clause 2.1.3.
- G 3.1.4 Transient voltage performance is determined by insulation co-ordination and has minimum dielectric withstand values (impulse and power frequency) selected in accordance with BS EN 50124-1:2001, as set out in 3.7.1

G 3.2 Maximum train current

Extract from GM/RT2113

Section 3.2 Maximum train current

- 3.2.1 In the absence of a published maximum train current for a particular route, a value of 6.8 kA shall be assumed for design purposes.

- G 3.2.1 Rationale: This defines the maximum current the power supply system would provide for a single train.
- G 3.2.2 The maximum allowable train current is published in the Register of Infrastructure.
- G 3.2.3 The value of 6.800 kA (approximately 5 MW) is the existing value and is consistent with BS EN 50388:2012. However, for both economics and delivery of service demand, other values may be appropriate, and a traction current limitation device is required, as set out in 3.4

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G 3.3 Automatic train current regulation

Extract from GM/RT2113

Section 3.3 Automatic train current regulation

3.3.1 750 V DC electric rail vehicles shall be fitted with automatic regulation control of train current with line voltage, as set out in BS EN 50388:2012 clause 7.2.

G 3.3.1 Rationale: Automatic train current regulation provides stable electrical power to the train in abnormal electrical supply or operating conditions.

G 3.3.2 The requirement for a device to be fitted to rolling stock that allows the setting of the maximum train current is published in the Register of Infrastructure.

G 3.4 Train current limitation device

Extract from GM/RT2113

Section 3.4 Train current limitation device

3.4.1 750 V DC electric rail vehicles shall be fitted with a power or current limitation device, as set out in BS EN 50388:2012 clause 7.3.

3.4.2 It shall be possible for the driver to limit the power or current demand to half the actual train power or current when operating on a degraded power supply.

3.4.3 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 current for the route.

G 3.4.1 Rationale: A train current limitation device should be provided to facilitate operation on weak power supply networks.

G 3.4.2 The requirement for a device to be fitted to rolling stock, that allows a selectable current limit, is published in the Register of Infrastructure.

G 3.5 Current collector

Extract from GM/RT2113

3.5 Current collector

3.5.1 Current collectors shall be positioned to collect current from a conductor rail system compliant with GL/RT1212.

3.5.2 Current collectors at the extreme end of any locomotive or single vehicles that can operate from the 3rd rail supply, shall be interconnected.

3.5.3 Current collectors on multiple units shall be connected to provide acceptable gapping performance.

G 3.5.1 Rationale: (3.5.1) This achieves mechanical compatibility between the current collector and the conductor rail.

G 3.5.2 Rationale: (3.5.2 and 3.5.3) Positioning of current collectors should be compatible with the infrastructure and protects against:

- a) Isolation of the train from the infrastructure power source.
- b) Damage to electrification system components.
- c) Bridging of isolation mechanisms.

G 3.5.3 In addition to the current being drawn by the train from the system, a through current of up to 7.5 kA may be present when the vehicle / unit breaks current at a gap.

G 3.5.4 Current collectors are normally designed to withstand a current of 2 kA for five minutes.

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- G 3.5.5 The use of split circuits to minimise single current collector current draw at conductor rail gaps may be considered.
- G 3.5.6 The current collector shoe should be provided with mechanical protection of the cable connected to the shoe gear.
- G 3.5.7 The design of the current collector cabling installation should take account of the possibility of arc propagation, and the use of metal conduits or cable enclosure should be avoided. Arc shielding should be used to protect areas that are likely to be affected by arcing from shoe gear and associated cabling, particularly vulnerable components such as axle boxes.
- G 3.5.8 In some cases, trains will bridge gaps between two conductor rail sections, where a substation track breaker has tripped. This results in currents flowing through the train that would normally be contained in the trackside installation and cabling. To accommodate this condition the train installation should be able to accommodate the currents specified. Protective devices such as shoe fuses or circuit breakers should be included to protect the bus line cabling.
- G 3.5.9 An assessment should be undertaken, by the train operator, to confirm that, when a train is stopped at a signal or a station:
- a) The current collectors on the train do not span a conductor rail gap that could be providing safety isolation between sections.
- And
- b) The train does not become stalled in the conductor rail gap.
- G 3.5.10 Information on conductor rail layouts is available from the infrastructure manager. Where current collectors are connected together, then the interconnections could carry all or a proportion of the current carried by the conductor rail. The current collectors of LUL 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.

Extract from GM/RT2113

3.5 Current collector

- 3.5.4 Where retractable current collectors are provided, to avoid arcing, current collectors shall only be retracted or deployed once all vehicle loads, other than essential voltage measurement devices, are disconnected.

- G 3.5.11 Rationale: This provides protection against excessive arcing when retracting or deploying current collectors.

Extract from GM/RT2113

3.5 Current collector

- 3.5.5 When controlled from the operative cab, current collectors shall be retracted or deployed on all vehicles of a train.

- G 3.5.12 Rationale: This results in rolling stock with retractable current collectors being operated in a configuration which is compatible with fixed equipment located on track on both AC electrified and non-electrified lines. This allows the rolling stock to remain in gauge for all routes over which it may operate.