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

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Rail Industry Guidance Note for GL/RT1212



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

Issue record

Issue	Date	Comments
One	September 2015	Original document. Gives guidance on interpreting the requirements of GL/RT1212 issue one.

Superseded documents

The following Railway Group Standards are superseded, either in whole or in part as indicated:

Superseded documents	Sections superseded	Date when sections are superseded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	Part of B 5.5	05 December 2015
GL/RT1254 issue one Electrified Lines Traction Bonding	Part of section 5	05 December 2015
GM/RT1041 issue one Warning Signs and Notices for Electrified Lines	All	05 December 2015

GE/RT8025 issue one Electrical Protective Provisions for Electrified Lines, ceases to be in force and is withdrawn as of 03 June 2017.

GL/RT1254 issue one Electrified Lines Traction Bonding, ceases to be in force and is withdrawn as of 05 December 2015.

GM/RT1041 issue one Warning Signs and Notices for Electrified Lines, ceases to be in force and is withdrawn as of 05 December 2015.

Supply

The authoritative version of this document is available at www.rgsonline.co.uk. Enquiries on this document can be forwarded to enquirydesk@rssb.co.uk.

Guidance on DC Conductor Rail Energy Subsystem and Interfaces to Rolling Stock 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 GL/RT1212 issue one DC Conductor Rail Energy Subsystem and Interfaces to Rolling Stock 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 GL/RT1212 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.

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

Part 2 Guidance on Electrical Requirements

G 2.1 System voltage

Extract from GL/RT1212

Section 2.1 System voltage

- 2.1.1 The system voltage shall comply with the requirements set out in BS EN 50163:2004+A1:2007 clause 4.1 applicable to 750 V DC systems, excluding the special national condition for the United Kingdom referred to in clause 4.1 and set out in Annex B of BS EN 50163:2004+A1:2007.
- 2.1.2 The energy subsystem shall be configured so that the contact line is at a positive potential with respect to the traction return rail.
- 2.1.3 It is permissible that, where rolling stock is operated which is incapable of withstanding the maximum non-permanent voltage set out in 2.1.1, the upper non-permanent voltage limit $U_{\max 2}$ shall be reduced so that the voltage at the DC current collector shall not exceed 850 V when a train is present.
- 2.1.4 The minimum value of $U_{\text{mean useful}}$ at the DC current collector shall be 675 V. This shall be calculated using the method set out in BS EN 50388:2012, clauses 8.2, 8.3 and 8.4, where the phrase 'at the pantograph' shall be interpreted as meaning 'at the DC current collector'.

- G 2.1.1 Rationale: This specification of the voltage enables the compatibility between the energy subsystem and the traction system of the trains to be achieved. (This document does not cover requirements for 1500 V DC systems.)
- G 2.1.2 The system nominal voltage and maximum permanent voltage is published in the Register of Infrastructure.
- G 2.1.3 The voltage limits corresponding to 'normal operation' apply when the system is fully operational and also when one or more non-adjacent single outages of the traction supply system occur.
- G 2.1.4 The voltage limits corresponding to 'abnormal operation' apply when the system is degraded when two or more adjacent single outages of the traction supply system occur.
- G 2.1.5 For upgrades and renewals to the DC conductor rail electrification systems the requirement of this document is to bring the system voltage into line with the requirements set out in BS EN 50163:2004+A1:2007 without the use of the special national condition. Some parts of the existing network are built to the range specified in the special national condition.
- G 2.1.6 When the upper non-permanent voltage limit $U_{\max 2}$ is constrained so that the voltage at the substation bus bar does not exceed 900 V with no load, this results in a voltage of approximately 850 V at the train's DC current collector even if the train is only taking auxiliary load, unless regeneration is taking place.

G 2.2 Short circuit fault levels

Extract from GL/RT1212

Section 2.2 Short circuit fault levels

- 2.2.1 The maximum prospective sustained short circuit fault level at the track shall not exceed 200 kA. The short circuit fault level when broken at 20 ms shall not exceed 64 kA.

- G 2.2.1 Rationale: The specification of short circuit fault level conditions enables equipment to be designed to withstand the excursion without damage.

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- G 2.2.2 The maximum fault level values currently set out in BS EN 50388:2012 clause 11, applicable to the 750 V DC conductor rail systems, are too low for the type of application used in the UK and are therefore inappropriate. The values set out in 2.2.1 of GL/RT1212 are the values used to define fault levels for the Great Britain (GB) systems.

G 2.3 Electrical protection coordination

Extract from GL/RT1212

Section 2.3 Electrical protection coordination

- 2.3.1 The substation and track paralleling hut protection systems shall meet the requirements set out in BS EN 50388:2012 Table 7.
- 2.3.2 The disconnection time for the energy subsystem equipment under short circuit fault conditions at the contact line shall be within the range 10 ms to 200 ms with the electrical protection system operating normally. An additional 500 ms time delay is permissible on infrequent occasions under conditions where back-up protection operates.

- G 2.3.1 Rationale: The specification of disconnection times enables equipment to be designed to withstand short circuit conditions.
- G 2.3.2 When a fault occurs on a train, which is not cleared by the traction unit circuit breakers, the DC current collector / conductor rail interface is designed to be able to withstand the passage of the worst case fault current that can flow when a short circuit fault occurs within a traction unit.
- G 2.3.3 Generally, a fault requires two circuit breakers to operate to fully clear a fault. If back-up protection devices operate, the fault duration could be as long as one second.
- G 2.3.4 The additional time delay takes into consideration that clearance may be initiated by back-up protection.
- G 2.3.5 The term 'infrequent' is used to describe faults on the power supply system that are not detected by the primary protection, and which are rare events, and in most cases would imply a failure of the primary protection.

G 2.4 Loss of line voltage and reclosure sequence

Extract from GL/RT1212

Section 2.4 Loss of line voltage and reclosure procedure

- 2.4.1 When the power supply to the contact line is switched off (for example, by a protection system) and is to be restored, the reclosure shall not be attempted until at least 15 seconds has elapsed.
- 2.4.2 If the track feeder circuit breaker trips on closure, there shall be a delay period of at least 15 seconds before reclosure of the track feeder circuit breakers.
- 2.4.3 If the track feeder circuit breaker trips on closure a second time, there shall be a delay period of at least one minute before the subsequent reclosure of the track feeder circuit breakers.

- G 2.4.1 Rationale: Constraint on the number of energy supply restoration attempts to avoid excessive imposed stresses in the energy system and ensure loss of supply events results in speedy restoration of normal operations. Traction equipment on trains is also designed to withstand the stresses imposed by the defined traction supply reclosure sequence.
- G 2.4.2 The infrastructure manager can determine if the re-closure is initiated manually following a procedure, or if an automatic reclosing system is used. The procedure that is used to reclose circuit breakers feeding depots and sidings is subject to specific consideration of the risks at that site.

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G 2.5 Train current

Extract from GL/RT1212

Section 2.5 Train current

- 2.5.1 The energy subsystem shall be designed to operate with a maximum allowable train current for each train of not less than 6.8 kA.
- 2.5.2 Where it is designated that the route is to be designed to a lower value of maximum allowable train current for each train, this shall be published in the Register of Infrastructure.

G 2.5.1 Rationale: This enables the maximum current demand on the energy subsystem to be derived.

G 2.5.2 The energy subsystem has historically been designed to support a single train current of 6.8 kA. The maximum allowable train current set out in 2.5.1 is consistent with the values set out in BS EN 50388:2012, Annex F. However, the optimum value can be determined by a whole life assessment of the traffic demands of the route. The value of maximum allowable train current for each train is published in the Register of Infrastructure.

G 2.5.3 Trains are fitted with a train current limiting device to facilitate operation on routes with limited electrical capacity and under perturbed feeding conditions.

G 2.6 Running rail and across track cable current

Extract from GL/RT1212

Section 2.6 Running rail and across track cable current

- 2.6.1 The maximum total DC traction current flowing in the running rails beneath a train shall not exceed 9 kA.
- 2.6.2 The maximum DC traction load current flowing in an across track cable, or cables grouped together at a single location, over which any train may pass, shall not exceed 10 kA.

G 2.6.1 Rationale: (2.6.1) This specifies the limits of the current that can flow in the infrastructure and enables rolling stock design to take account of any stray currents that may flow through the vehicle.

G 2.6.2 Rationale: (2.6.2) This limits the magnetic field produced by a cable running across the track to protect against unintentional operation of on-board systems such as the Automatic Warning System (AWS) or Automatic Power Control (APC).

G 2.6.3 This current limit is used as a basis for rolling stock bonding design purposes and is based upon a determination of the worst case current for a typical section of railway. The limit of 9 kA has been established by system modelling undertaken internally by RSSB.

G 2.6.4 Limiting the maximum current flowing in an across track cable prevents the creation of a magnetic field from the cable of a magnitude that might cause mal-operation of the AWS equipment. The current limit of 10 kA has been previously established as the level which AWS receivers could detect.

G 2.7 Regeneration capability

Extract from GL/RT1212

Section 2.7 Regeneration capability

- 2.7.1 The DC conductor rail energy subsystem shall be designed to permit the use of regenerative braking.

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- G 2.7.1 Rationale: Provision of regenerative braking energy on trains minimises energy usage and reduces the carbon footprint of the railway system as a whole.
- G 2.7.2 Regenerative braking is expected to be the norm. Only by exception should the use of regenerative braking be restricted.
- G 2.7.3 Exceptionally, when the use of regenerative braking is not possible on certain sections of the line, this is published in the Register of Infrastructure.
- G 2.7.4 The maximum allowable regenerative braking voltage and current may need to be limited on some routes because of restrictions associated with legacy vehicles or infrastructure limitations.

G 2.8 Electrical insulation coordination

Extract from GL/RT1212

Section 2.8 Electrical insulation coordination

- 2.8.1 Insulation which separates 750 V live parts from earth or the return circuit shall have the minimum dielectric withstand rating values as set out in BS EN 50124-1:2001.

- G 2.8.1 Rationale: Insulation is provided to protect against damage or harm by preventing unintentional electrical discharges.

G 2.9 Safety requirements

G 2.9.1 Protective provisions, direct contact – exposed live parts in stations

Extract from GL/RT1212

Section 2.9.1 Protective provisions, direct contact – exposed live parts in stations

- 2.9.1.1 Protective provisions against direct contact with live parts of the energy subsystem shall be provided by safety clearances or, where the safety clearances are not achievable, by obstacles.
- 2.9.1.2 The live conductor rail shall not be located adjacent to station platforms, except where it is not reasonably practicable. In this case, protective guard boarding shall be provided throughout the length of conductor rail adjacent to the platform.

- G 2.9.1.1 Rationale: (2.9.1.1) Obstacles include the provision of screens or insulated guard boards.
- G 2.9.1.2 Rationale: (2.9.1.2) Locating the conductor rail on the far side of the track which is adjacent to a station platform, provides a degree of protection against harm from direct contact with live parts for persons on the station platform (for example, in circumstances where a person might fall from the platform). In cases where the conductor needs to be placed adjacent to a station platform, the guard boarding provides a more limited degree of protection against harm from direct contact with live parts.
- G 2.9.1.3 Typical railway specific provisions against electric shock in conductor rail systems are set out in BS EN 50122-1:2011 clause 5.5, and where there is a risk from contact with live parts of the conductor rail equipment, provisions against electric shock are set out in BS EN 50122-1:2011 clauses 5.5.1 and 5.5.6.
- G 2.9.1.4 At public and private level crossings, provisions against electric shock are set out in BS EN 50122-1:2011 clause 5.5.5.
- G 2.9.1.5 Protection against the danger arising from exposed conductive parts of traction and non-traction power supply equipment, and components of the contact line equipment within the DC current collector zone, is set out in BS EN 50122-1:2011, clauses 6.1, 6.2.2 and 6.2.3 as applicable to conductor rail systems.

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G 2.9.2 Protective provisions – touch voltages

Extract from GL/RT1212

Section 2.9.2 Protective provisions – touch voltages

2.9.2.1 Protection against electric shock shall be provided by compliance with the touch voltage requirements set out in BS EN 50122-1:2011, clauses 6.1, 6.2.2, 9.1 and 9.3.

G 2.9.2.1 Rationale: This provides protection against exposure to dangerous touch voltages.

G 2.10 Electrical clearances

G 2.10.1 Clearance for live parts of conductor rail equipment to structures, and conductor rail equipment to vehicles

Extract from GL/RT1212

Section 2.10.1 Clearance for live parts of conductor rail equipment to structures, and conductor rail equipment to vehicles

2.10.1.1 With the exception of insulated guard boarding, the minimum static electrical clearance shall be 75 mm and the minimum passing electrical clearance shall be 25 mm.

G 2.10.1.1 Rationale: This provides protection against harm and / or damage from exposure to disruptive electrical discharges.

G 2.10.1.2 Clearance between the live conductor rail equipment and the train is controlled by the lower sector gauge of the rolling stock. Generally, the worst case clearance is between a low hanging collector shoe and diverging rails at crossovers.

G 2.10.1.3 The minimum passing clearance of 25 mm applies to free hanging shoes passing over diverging rails at turnouts. It is possible for diverging rails to be higher than the running rails due to the wear of the rails on which the train is running.

G 2.10.1.4 The lower sector gauge defines the lowest position of the collector shoe to be 34.5 mm above rail level. The dimensions have been selected such that when a train is operating on worn rails, the collector shoe will have adequate clearance to pass over a section of unworn rail on a diverging or crossing line that is up to 9.5 mm higher.

G 2.10.1.5 In the past, a differential of up to 15 mm has been used assuming the free hanging collector shoes to be 40 mm above rail level.

G 2.11 Safety warning signs

G 2.11.1 Warning to crews on trains of a traction system changeover

Extract from GL/RT1212

Section 2.11.1 Warning to crews on trains of a traction system changeover

2.11.1.1 On the approach to an electrical changeover to 750 V DC, signs AJ04 and AJ06 and, where necessary, AJ03, shall be provided. Signs shall be placed at the trackside and readable for a minimum of two seconds at the highest permissible (including enhanced permissible) speed approaching the location concerned.

G 2.11.1.1 Rationale: Warning signs are used at contact line system separation sections to advise the operator of a train to prepare for, and undertake, the action necessary to pass through the system separation section.

G 2.11.1.2 The signs used at the transition from a 750 V DC conductor rail system to a 25 kV AC system are set out in GL/RT1210. The signs are now defined in a catalogue available at <http://www.rssb.co.uk/rqs/signs>.

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G 2.11.2 Short circuiting bar, and hook switch operating tools

Extract from GL/RT1212

Section 2.11.2 Short circuiting bar, and hook switch operating tools

2.11.2.1 The specification for the following equipment appropriate for each route shall be provided:

- a) Short circuiting bars.
- b) Hook switch operating tools.

G 2.11.2.1 Rationale: This specifies the equipment to be used to switch off the power in the energy system in emergency conditions.

G 2.11.2.2 The procedures to switch off traction power supply in an emergency using a short circuit bar are set out in GE/RT8000 Module AC paragraph 6.3 'Using a short-circuiting bar'.

G 2.11.3 Use of short circuiting bar

Extract from GL/RT1212

Section 2.11.3 Use of short circuiting bar

2.11.3.1 In areas where the use of a short circuiting bar is prohibited, guard boarding shall be provided or an insulating shroud shall be fitted to the underside of the conductor rail.

G 2.11.3.1 Rationale: This identifies places where short circuit bars are not to be used.

G 2.11.3.2 Where guard boarding is provided for this purpose, a single board between conductor rail and running can be used.

G 2.11.4 Tunnel emergency circuits

Extract from GL/RT1212

Section 2.11.4 Tunnel emergency circuits

2.11.4.1 On lines where emergency tunnel pinch wires are provided, the use of the pinch wires shall remove power from the conductor rail(s) on all affected lines and prevent inadvertent re-energisation.

G 2.11.4.1 Rationale: Pinch wires enable the driver of a train to remove the power supply in an emergency without having to leave the cab of the train.

G 2.11.4.2 If operation of the isolation system requires special equipment such as telephone handsets, details of the compatible equipment and operating instructions should be made available.

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Part 3 Guidance on Mechanical Requirements

G 3.1 Conductor rail geometry

G 3.1.1 Conductor rail

Extract from GL/RT1212

Section 3.1.1 Conductor rail

3.1.1.1 The width of the conductor rail top contact face shall be a minimum of 80 mm.

3.1.1.2 The upper surface of the conductor rail shall be either flat, or convex with a nominal radius not less than 400 mm.

G 3.1.1.1 Rationale: This establishes compatibility between the conductor rail and the working range of the DC current collector.

G 3.1.1.2 The above dimensions allow the use of either steel or aluminium rail and include some tolerance in the design of head width.

G 3.1.1.3 Steel conductor rail of either 106 lb/yd or 150 lb/yd has been previously used, the profile of which is shown in Appendix E, Figure E.1.

G 3.1.1.4 Aluminium conductor rail fitted with a stainless steel cap has been previously used, the profile of which is shown in Appendix E, Figure E.2.

G 3.1.2 Conductor rail geometry on plain line

Extract from GL/RT1212

Section 3.1.2 Conductor rail geometry on plain line

3.1.2.1 The static and dynamic position of the top of the conductor rail, relative to the gauge face of the running rails and the plane of the upper surface of the running rails, shall comply with the position limits set out in Table 1 and as shown in Figure 1. It is permissible for ongoing demonstration of compliance with this requirement to use either static or dynamic measurement.

Dimension	Static position limits	Dynamic position limits
Vertical height (above plane of running rails)	76 +10, -3 mm	76 +34, -20 mm
Maximum rate of change of vertical height (facing or trailing)	5 mm per m	10 mm per m
Lateral position (gauge face to centre line of conductor rail)	405 ± 10 mm	405 ± 20 mm

Table 1 3rd rail positive conductor rail position limits relative to running rails