



This document contains one or more pages which contain colour.

Published by:

**RSSB
Block 2
Angel Square
1 Torrens Street
London
EC1V 1NY**

**© Copyright 2014
Rail Safety and Standards Board Limited**

GN

GL/GN1610

**Guidance on AC Energy Subsystem and Interfaces to Rolling Stock
Subsystem**

Issue One: December 2014

Rail Industry Guidance Note for GL/RT1210



**Documents
Document Sharing Hub**

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

Issue record

Issue	Date	Comments
One	December 2014	Original document Provides rationale and guidance on the requirements in GL/RT1210 issue one

Superseded documents

This Rail Industry Guidance Note does not supersede any other Railway Group documents.

Supply

The authoritative version of this document is available at www.rgsonline.co.uk.
Uncontrolled copies of this document can be obtained from Communications, RSSB, Block 2, Angel Square, 1 Torrens Street, London EC1V 1NY, telephone 020 3142 5400 or e-mail enquirydesk@rssb.co.uk. Other Standards and associated documents can also be viewed at www.rgsonline.co.uk.

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

Contents

Section	Description	Page
Part 1	Introduction	5
G 1.1	Purpose of this document	5
G 1.2	The structure of this document	5
G 1.3	Copyright	5
G 1.4	Approval and authorisation of this document	5
Part 2	Guidance on Electrical Requirements	6
G 2.1	Technical requirements	6
G 2.2	Safety requirements	12
G 2.3	Safety warning signs	15
Part 3	Guidance on Mechanical Requirements	17
G 3.1	Overhead contact line geometry and gauging	17
G 3.2	Contact line and current collector zones	23
G 3.3	Contact wire	24
G 3.4	Current collection	24
G 3.5	Pantograph spacing	26
G 3.6	Separation sections and section insulators	28
G 3.7	Compatibility with train exhaust gas emissions	31
G 3.8	Trackside pantograph monitoring sites	31
G 3.9	Assessment of the Overhead Contact Line (OCL)	31
Part 4	Application of this Document	33
4.1	Application – infrastructure managers	33
4.2	Application – railway undertakings	33
4.3	Health and safety responsibilities	33
Appendices		
Appendix A	Open Points	34
Appendix B	Short Neutral Section Signage	35
Appendix C	Location of the Automatic Power Control (APC) Track Magnet	37
Appendix D	AC System Characteristic for Rolling Stock Compatibility	40
Appendix E	Speed Conversions	42
Definitions		43
Abbreviations		47
References		49
Tables		
Table 1	Fault current characteristics – target system	7
Table 2	Fault current characteristics for compatibility with existing rail vehicles	7
Table 3	Minimum height of exposed live parts at road level crossings and private level crossings	19
Table 4	Minimum height of exposed live parts at footpath and bridle path level crossings	19
Table 5	Electrical clearance (EC) for overhead line electrification	21
Table 6	Mechanical clearance for overhead line electrification	21
Table 7	Pantograph minimum spacing related to speed for lines where the ENE TSI is applicable	26
Table A.1	List of open points	34
Table D.1	AC system characteristic for rolling stock compatibility	40
Table E.1	INF, RST and ENE speed conversions	42

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

Tables (Guidance)

Table G 1	Minimum pantograph spacing for lines where the ENE TSI is applicable	27
------------------	--	----

Figures

Figure B.1	Typical arrangement of track signs and track magnets	35
Figure C.1	Position of APC magnets	37
Figure C.2	Representation of flux planes	38
Figure C.3	Relationship between the APC receiver and the APC track magnet	39

Figures (Guidance)

Figure G 1	Overhead contact line and current collector zones	24
-------------------	---	----

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

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/RT1210 issue one AC 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/RT1210 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.

G 1.3 Copyright

- G 1.3.1 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.
- G 1.3.2 RSSB members are granted copyright licence in accordance with the Constitution Agreement relating to Rail Safety and Standards Board Limited.
- G 1.3.3 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 Standards may be reproduced.

G 1.4 Approval and authorisation of this document

- G 1.4.1 The content of this document was approved by Energy (ENE) Standards Committee on 04 September 2014.
- G 1.4.2 This document was authorised by RSSB on 03 November 2014.

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

Part 2 Guidance on Electrical Requirements

G 2.1 Technical requirements

Extract from GL/RT1210

2.1.1 System voltage

- 2.1.1.1 The system voltage shall comply with the requirements of EN 50163:2004+A1:2007 clause 4.1, applicable to the 25 kV AC 50 Hz system, excluding the UK special national condition set out in Annex B of EN 50163:2004+A1:2007.
- 2.1.1.2 The minimum value of 'mean useful voltage at the pantograph' shall be 22 kV for lines speeds of less than or equal to 200 km/h, and 22.5 kV for lines speeds greater than 200 km/h calculated using the method set out in EN 50388:2012 clauses 8.2 and 8.4.

G 2.1.1 Rationale: These requirements support compatibility between the energy subsystem and the traction system of the trains and are aligned with the energy subsystem Technical Specification for Interoperability (ENE TSI) requirements. They are set so that the train's specified performance can be achieved with traction equipment working in the voltage range defined. These requirements are consistent with existing design practice to design a power supply that meets operational and aspirational timetable requirements, so that overall journey timings in the working timetable can be realised.

G 2.1.2 The system nominal voltage and maximum permanent voltage is published in the Register of Infrastructure.

G 2.1.3 EN 50163:2004+A1:2007 describes the power supply equipment being operated according to standard rules. Good practice for design is where:

- a) 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.

And

- b) 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 2.1.4 Where necessary, for compatibility with some existing classes of electric vehicles operating on a route, and where it promotes the long-term best interests of the mainline railway as a whole, a deviation may be sought to limit U_{max2} .

G 2.1.5 The method for calculating 'mean useful voltage at the pantograph' is set out in EN 50388:2012 clause 8.2, and the acceptance criteria are set out in EN 50388:2012 clause 8.5.

Extract from GL/RT1210

2.1.2 Frequency

- 2.1.2.1 The nominal system frequency shall be 50 Hz. The frequency range shall remain within the limits specified in EN 50163:2004+A1:2007 clause 4.2, for systems with 'synchronous connections'.

G 2.1.6 Rationale: This requirement supports compatibility between the energy subsystem and the train. This is based on existing practice, and is consistent with the ENE TSI requirements. This requirement defines the working range within which the equipment is expected to operate.

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

- G 2.1.7 System nominal frequency is published in the Register of Infrastructure.
- G 2.1.8 Normally, the nominal frequency in Great Britain (GB) may differ from 50 Hz within the limits declared within the Electricity Safety, Quality and Continuity Regulations 2002. These limits (and those for exceptional circumstances) are set out below and are identical to the limits set out in EN 50163:2004+A1:2007, for systems with 'synchronous connections':
- a) Maximum frequency: 50.5 Hz.
 - b) Minimum frequency: 49.5 Hz.
- G 2.1.9 In exceptional circumstances, the frequency can vary between 47 Hz and 52 Hz, as set out in section CC.6.1.3 of the Grid Code, published by the National Grid. When the system frequency is below 49.5 Hz or above 50.5 Hz, the infrastructure manager (IM) is expected to manage any risks to infrastructure assets, including audio frequency signalling and communication systems, from harmonics generated and / or conducted by trains operating from the traction supply.

Extract from GL/RT1210

2.1.3 Short circuit fault levels

2.1.3.1 Where all rail vehicles using the route are compatible with the parameters set out in Table 1, the maximum values for short circuit faults between the energy subsystem overhead contact line (OCL) (including other 25 kV conductors) and infrastructure or vehicles connected to the traction return rail, and falling within the contact line zone, as set out in 3.2.1, shall comply with Table 1.

Maximum rms fault current [EN50388:2012, clause 11.2]	Maximum fault duration with back-up protection	Maximum fault duration with main protection operating	Maximum number of reclosures permitted	Maximum cumulative fault duration with main protection operating and maximum number of reclosures
15 kA	1 s	200 ms	2	600 ms

Table 1 Fault current characteristics – target system

2.1.3.2 Where all rail vehicles using the route are not yet compatible with the parameters set out in Table 1, the maximum values for short circuit faults between the energy subsystem OCL (including other 25 kV conductors) and infrastructure or vehicles connected to the traction return rail, and falling within the contact line zone, as set out in 3.2.1, shall comply with Table 2.

Maximum rms fault current	Maximum fault duration with back-up protection	Maximum fault duration with main protection operating	Maximum number of reclosures permitted (see Note 1)	Maximum cumulative fault duration with main protection operating and maximum number of reclosures
6 kA	1 s	250 ms	2	750 ms
12 kA	1 s	250 ms	1	500 ms
15 kA	0.65 s	150 ms	1	300 ms

Note 1: Where vehicles are not yet compatible, the allowable number of reclosures is limited. See 2.1.5.3.

Table 2 Fault current characteristics for compatibility with existing rail vehicles

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

- | | |
|---------|---|
| 2.1.3.3 | The magnitude of the maximum peak current associated with the maximum short circuit fault levels set out in 2.1.3.1 and 2.1.3.2 shall not exceed 2.5 times the values of the maximum root mean squared (rms) fault current set out in Tables 1 and 2. |
| 2.1.3.4 | The maximum circuit time constant (relating to the X/R ratio) at the contact line is an open point. |

- G 2.1.10 Rationale: These requirements support compatibility between the energy subsystem and the traction system of the train. Clause 2.1.3.1 is consistent with the ENE TSI. These requirements define parameters, so that equipment on trains (for example, the vehicle main circuit breaker and bonding) can be adequately rated. In addition, the fault level is also relevant when considering aspects such as touch voltages.
- G 2.1.11 The historic value of rms short circuit fault level has been 6 kA, but some recent installations have, or plan to increase this to, 12 kA. An increase to 15 kA is foreseen and is consistent with the ENE TSI. Systems with a higher short circuit fault level are more efficient and allow greater power to be transmitted via the OCL. The maximum peak fault current multiplier is consistent with the multiplier used for a rail vehicle main circuit breaker complying with EN 60077-4:2003 clause 5.3.6.1.
- G 2.1.12 For compatibility with existing rail vehicles the rating of the main circuit breaker(s) should be considered in conjunction with the fault values set out in 2.1.3.2. Some main circuit breakers fitted to existing rolling stock operating on the network are only capable of breaking a maximum fault level of 10 kA.
- G 2.1.13 When considering the effective touch voltage, in accordance with EN 50122-1:2011 clause 9.1.3, the maximum impedance between the vehicle body and running rail can be assumed to be 40 mΩ. For touch voltage calculations the impedance between the wheel and running rail can be assumed to be insignificant.
- G 2.1.14 The requirements set out in 2.1.3.1 to 2.1.3.4 are not fully specified in the ENE TSI requirements. These parameters, on which the ENE TSI is silent, are specified in terms of what could be reasonably expected when maximum asymmetry of the AC waveform occurs, where the maximum peak current is 2.5 times rms fault level and the waveform returns to a symmetrical condition over several cycles according to the value of the circuit's time constant. It is necessary to know the maximum short circuit time constant that can exist so that the main circuit breaker on electric rail vehicles can be correctly specified.
- G 2.1.15 Currently, there is no agreed value for the maximum time constant on the existing GB mainline railway. However, it is anticipated that the maximum value is likely to be in the range of 120 ms to 240 ms. The maximum time constant and maximum rms current may vary by route. Similarly, there is currently no agreed value for the maximum time constant for future new, renewed and upgraded parts of the GB mainline railway.
- G 2.1.16 The existing rolling stock technical standard EN 60077-4:2003 and associated standard EN 62271-100:2009+A1:2012 have provisions for a standard time constant value of 45 ms and special case time constants of 60 ms, 75 ms and 120 ms. Existing rolling stock may have only been certified at the standard time constant value of 45 ms.
- G 2.1.17 Generally, a fault requires two trackside circuit breakers to operate to fully clear a fault. If one of those is initiated by a 'back-up' protection device, the fault duration could be as long as 750 ms. The maximum duration of short circuits of one second recognises the possibility of a catastrophic but rare failure of the power system protection.
- G 2.1.18 When an IM plans to increase the existing maximum value of rms and peak current, clearance time duration, or to change the time constant to a higher value, a compatibility assessment, as set out in GE/RT8270, with rail vehicles and other affected assets, such as systems on stations, should be undertaken.

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

Extract from GL/RT1210

2.1.4 Electrical protection co-ordination

- 2.1.4.1 Substation and sectioning location protection systems shall meet the requirements of EN 50388:2012 clause 11.2.
- 2.1.4.2 The disconnection times for the energy subsystem equipment under short circuit fault conditions shall be within the maximum values set out in 2.1.3.1 and 2.1.3.2, with the electrical protection system operating normally or where back-up protection operates.

- G 2.1.19 Rationale: These requirements define co-ordination of the electrical protection system for the energy subsystem and the electrical protection system of the train and are based on existing practice. These requirements are so that equipment is designed to comply with the specified limits. Exposure to excessive let-through energy could result in failure of equipment, or premature ageing. Inadequate co-ordination of the electrical protection systems also results in disruption and delay. Protection clearance times also determine the allowable touch voltages, as set out in EN 50122-1:2011+A1:2011 section 9.
- G 2.1.20 When a fault occurs on a train, which is not cleared by the rail vehicle circuit breakers, the pantograph OCL interface should 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, without, as a minimum, exposing staff and passengers to risk.
- G 2.1.21 If a design value of 200 ms (for clearance under normal operation) is used, it corresponds to a maximum permissible effective touch voltage ($U_{te, max}$) of 645 V, as set out in EN 50122-1:2011 Table 4. The disconnection times for short-circuits, set out in 2.1.4.2, correspond to a situation with low impedance at the point of fault. In cases where the point of fault is high impedance, disconnection times can become longer.
- G 2.1.22 Backup protection operates on infrequent occasions when faults on the power supply system are not cleared by the primary protection, and in most cases would imply a failure of the primary protection.

Extract from GL/RT1210

2.1.5 Loss of line voltage and reclosure procedure

- 2.1.5.1 When the power supply to the OCL is switched off (for example, by a protection system) and is to be restored, the switching process and timing shall be as set out in EN 50388:2012 clause 11.3. Reclosure shall not be attempted within three seconds.
- 2.1.5.2 The reclosure sequence shall be one reclosure of the track feeder circuit breakers after at least a three second delay following the initial trip.
- 2.1.5.3 When the track feeder breaker trips on closure and reclosure is permitted, as set out in 2.1.3.1 and 2.1.3.2, there shall be a delay of at least one minute before any subsequent reclosure of the track feeder circuit breaker.
- 2.1.5.4 When main protection is not available, or if back-up protection operates, reclosure shall not take place without further investigation or testing to ensure the fault condition is no longer present.

- G 2.1.23 Rationale: These requirements support compatibility between the energy subsystem and the traction system of the train. They are based on existing practice and are compatible with the ENE TSI requirements. These requirements define provisions in the event of loss of supply to give a timely restoration of normal operations so that the overall service timings are maintained and unaffected by such events.
- G 2.1.24 The requirements for reclosure are not fully specified in the ENE TSI. The reclosure may be initiated manually following a procedure or by using an automatic reclosing system.

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

Extract from GL/RT1210

2.1.6 Train current and power factor

- 2.1.6.1 The energy subsystem shall be designed to operate with a maximum allowable train current for each train of not less than 300 A (I_{max}), at any voltage in the range, as set out in EN 50388:2012 clause 7.2, Figure 1.
- 2.1.6.2 The energy subsystem design shall be compatible with traction units having a power factor as set out in EN 50388:2012 clauses 6.2 and 6.3. Where the energy subsystem is required to support the operation of non-TSI compliant rolling stock, the design shall take account of their power factors.

- G 2.1.25 Rationale: These requirements support compatibility between the energy subsystem and the train. They are based on existing practice and are compatible with the ENE TSI requirements. These requirements define a traction system capable of supplying power to compliant trains. The fitting of a current limiting device on the train permits a powerful train to operate at limited current on routes with limited electrical capacity and under perturbed feeding conditions.
- G 2.1.26 The maximum allowable train current, and the requirement for a device to be fitted to a rail vehicle allowing the setting of the maximum train current, is published in the Register of Infrastructure.
- G 2.1.27 The energy subsystem has historically been designed to support a single train current of 270 A (EMU) and 300 A (other trains). The maximum allowable train current set out in 2.1.6.1 is consistent with the values specified in EN 50388:2012, Annex F. The energy subsystem is designed allowing for diversity, with trains operating to a timetable but not assuming that all trains will draw 300 amps concurrently.
- G 2.1.28 To facilitate compatibility, the Locomotives and Passenger Carriages (LOC&PAS) TSI requires a current limiting device to be fitted to trains with a power demand of greater than 2 MW (approximately 80 A).

Extract from GL/RT1210

2.1.7 Regeneration compatibility

- 2.1.7.1 The AC energy subsystem shall permit the use of regenerative braking.

- G 2.1.29 Rationale: This requirement supports compatibility between the energy subsystem and the train and is based on existing practice. Clause 2.1.7.1 is consistent with the ENE TSI requirements. This requirement defines that the use of regenerative braking energy on trains is possible so that overall energy usage can be minimised and consequently reduce the carbon footprint. The energy subsystem should be able to receive regenerated energy if the train is capable of producing it.
- G 2.1.30 Regenerative braking is expected to be the normal mode of operation, for reasons of energy efficiency and minimising wear on mechanical braking systems; only by exception should the use of regenerative braking be restricted.
- G 2.1.31 Exceptionally, when the use of regenerative braking is not currently possible on certain sections of line, this is published in the Register of Infrastructure. This includes those routes where limitations are required on the train's maximum allowable voltage and current necessary to support compatibility with infrastructure or legacy electric vehicles.

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

Extract from GL/RT1210

2.1.8 Electrical insulation co-ordination

2.1.8.1 Insulation which separates 25 kV exposed live parts of the OCL from earth shall have the following dielectric withstand rating values, except where 3.1.7.3 results in a reduced value. These values are co-ordinated with the values set out in EN 50124-1:2001+A2:2005:

a) Basic insulation:

- Rated impulse voltage (U_{Ni}) = 200 kV peak. Corresponding to an air clearance of 370 mm assuming the worst case dielectric condition of the electrodes.

b) Functional insulation:

- Rated impulse voltage (U_{Ni}) $\geq$ 145 kV peak. Corresponding to an air clearance of 270 mm assuming the worst case dielectric condition of the electrodes.

c) Reinforced insulation:

- Rated impulse voltage (U_{Ni}) $\geq$ 320 kV peak. Corresponding to an air clearance of 600 mm.

G 2.1.32 Rationale: This requirement supports compatibility between the energy subsystem and the traction system of the train and is based on existing practice. It defines requirements for equipment working in this environment to have sufficient electrical withstand capability. In addition, it defines that when the trains and energy subsystem are combined, satisfactory electrical withstand performance at railway system level is achieved. This requirement also supports the Operational Concept for the GB Mainline Railway principle 9, that the workforce is to be separated from the particular hazards associated with the electrified railway. This minimises the possibility of disruptive discharge with the associated safety and performance risks.

G 2.1.33 The rated impulse values are selected from EN 50124-1:2001+A2:2005, Table A.2. These values are based on overvoltage category OV4 and a rated insulation voltage (U_{Nm}) of 27.5 kV, which is equal to the highest permanent voltage present on the system (U_{max1}). Where justified by an assessment of the risk, reduced dielectric withstand rating can be used as set out in GL/RT1210, clause 3.1.7.4, in cases where the provision of insulation in air, in accordance with 2.1.8.1 a), would be uneconomic, such as OCL in existing tunnels and at overline bridges with limited infrastructure clearances.

G 2.1.34 These clauses relate to the co-ordination of insulation between exposed live parts and earth. This requirement cannot be applied to section insulators when one normally live part is earthed.

G 2.1.35 The electrical impulse levels set out in 2.1.8.1 are co-ordinated with the dimensional requirements set out in 2.2.2, 2.2.3, 3.1.5 and 3.1.7.

Extract from GL/RT1210

2.1.9 Harmonic overvoltages on the overhead line

2.1.9.1 In order to achieve electrical compatibility between the energy subsystem and electric rail vehicles, harmonic overvoltages shall be limited below critical values, as set out in EN 50388:2012 clause 10.4.

G 2.1.36 Rationale: These requirements and associated assessment support compatibility between the energy subsystem and the traction system of the train. These requirements are based on existing practice and are consistent with the ENE TSI. These requirements and associated assessment permit the rail vehicles to operate without undue electrical interaction / interference between the train(s) and the power supply equipment. The interaction is a complex issue that requires a specific assessment of compatibility.

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

- G 2.1.37 The worst case (highest) impedance of the OCL for each route is needed to permit a compatibility assessment to be undertaken in accordance with EN 50388:2012 clause 10. It should be made available by the IM, who supports the assessment of compatibility on behalf of both parties.
- G 2.1.38 The maximum impedance of the OCL is not a value that is currently defined across the network; however, a maximum overhead line impedance of 15 k-ohm between 2 kHz and 20 kHz has been selected as a suitable value to for assessing compatibility with rolling stock.

G 2.2 Safety requirements

Extract from GL/RT1210

2.2.1 Protective provisions against direct contact – general

- 2.2.1.1 Protective provisions against direct contact with exposed live parts of the energy subsystem shall comply with the requirements set out in EN 50122-1:2011+A1:2011 clause 5.1. The protective provisions shall be by safety clearances or, where the safety clearances are not achievable, by obstacles.
- 2.2.1.2 Return conductors shall be treated as high voltage equipment in relation to protective provisions against direct contact.

- G 2.2.1 Rationale: These requirements support the Operational Concept for the GB Mainline Railway principle 9 that the workforce is to be separated from the particular hazards associated with the electrified railway. This is a cross-boundary issue in that the hazard belongs to one duty holder, while the workforce with potential exposure belongs to other duty holders. The requirements give a consistent approach and common operational rules across the GB mainline railway. These are based on existing practice, and are consistent with the ENE TSI requirements. These requirements manage the general risk from electrocution arising from high voltages by ensuring the clearances from normal standing surfaces, such as station platforms, are such that people do not come into direct contact or close proximity to exposed live parts. Where staff are required to work adjacent to high voltage equipment, their employers will, where necessary, as required by legislation, put appropriate safeguards in place.
- G 2.2.2 Overhead contact line and other exposed live parts should be designed, constructed and maintained such that the exposed live parts are positioned so as to minimise the potential for injury.
- G 2.2.3 Exposed live parts should be indicated so that they may be readily identified by trained staff, so that safety clearances can be complied with.

Extract from GL/RT1210

2.2.2 Protective provisions against direct contact – protection by clearance

- 2.2.2.1 Exposed live parts of the energy subsystem, including a pantograph head (complying with 3.1.6.1 and in contact with the contact line), shall comply, at all locations, except where 2.2.2.2 applies, with the clearance requirements set out in EN 50122-1:2011+A1:2011 clause 5.2.1, using the public area dimensions in Figure 4. The United Kingdom special national condition relating to clause 5.2.1, as set out in EN 50122-1:2011+A1:2011 Annex G, shall not be used.

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

- 2.2.2.2 It is permissible, where existing physical features of a particular site constrain the gauge (for example, overline bridges and tunnels) and it is not reasonably practicable to modify them or the public platform area, for a pantograph head, conforming to 3.1.6.1, which is in contact with the contact line, to encroach into the area defined in EN 50122-1:2011+A1:2011 clause 5.2, Figure 4 (public area), provided that reinforced insulation in accordance with 2.1.8.1 c) is maintained between persons, including any foreseeable objects they may be carrying, and the nearest part of the pantograph head, where justified by a risk assessment complying with the Common Safety Method for Risk Evaluation and Assessment (CSM RA) and the application of appropriate safety measures. Requirements for other live parts of the train-mounted equipment are set out in GL/RT2111 clause 3.16.1.
- 2.2.2.3 With the exception of routes electrified using the auto-transformer system, exposed live parts shall be positioned no lower than 5.2 m above any standing surface, under the worst conditions of temperature and loading, at those locations where the lateral distance from the live parts to the closest running rail is greater than 3 m.
- 2.2.2.4 For routes electrified using the auto-transformer system, exposed live parts shall be positioned no lower than 5.2 m above any standing surface, under the worst conditions of temperature and loading, at those locations where the lateral distance from the live parts to the closest running rail is greater than 5 m.
- 2.2.2.5 In the case of return conductors, where the safety clearances set out in 2.2.2.1 cannot be achieved, the return conductor shall be protected by an obstacle, as set out in 2.2.3, or insulated to achieve a rated insulation voltage of 3 kV (rms).

- G 2.2.4 Rationale: These requirements support the Operational Concept for the GB Mainline Railway principle 9 that the workforce is to be separated from the particular hazards associated with the electrified railway. This is a cross-boundary issue in that the hazard belongs to one duty holder, while the workforce with potential exposure belongs to another duty holder. It is also required to give a consistent approach and common operational rules across the GB mainline railway. These are based on existing practice, and are consistent with the ENE TSI requirements. These requirements (in conjunction with the GE/RT8000 Rule Book) are intended to prevent exposure to harm from exposed live parts. This is achieved by providing adequate separation between the exposed live equipment and standing surfaces. These requirements also contribute to passenger and public safety.
- G 2.2.5 The requirement set out in 2.2.2.1 is co-ordinated with 2.1.8. Compliance with the specified Euronorm requirements provides an air clearance (which includes a margin of safety) between the limit of arm's reach and exposed live parts, which satisfies the requirements for reinforced insulation, as set out in EN 50124-1:2001+A2:2005, when based on a rated impulse voltage of 200 kV.
- G 2.2.6 Clearance requirements for protective provisions against direct contact use the 'public area' dimension set out in EN 50122-1:2011+A1:2011. These have been selected because, in addition to situations such as station platforms, there are many other parts of the operational railway where there are foreseeable situations when the public can be expected to be present, for example detraining passengers (when authorised and unauthorised), trespass, occupational crossings etc. The 'restricted area dimensions' in EN 50122-1:2011+A1:2011 are unsuitable for the main parts of the operational railway, as they would require additional training, and the behaviour of staff to be constrained (so that nothing is raised above head height) in order to provide adequate clearances. This constraint would be in conflict with certain mandated aspects within the Rule Book module G.
- G 2.2.7 The pantograph head position, when static, is determined mainly by the contact wire height / position and track cant rather than something which is mainly influenced by the rolling stock.

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

- G 2.2.8 In EN 50122-1:2011+A1:2011 the dimensions are based upon touching in a straight line without the use of objects. It may be appropriate to make an additional allowance for the use of hand tools. To facilitate consistent application of the risk assessment process, industry workshops are planned to support application of this process. This will form a basis for future guidance.
- G 2.2.9 Application of 2.2.2.2 may limit the stock able to use a route to only the lowest of electric units, and may prevent access to the line for freight vehicles and locomotives.

Extract from GL/RT1210

2.2.3 Protective provisions against direct contact – protection by obstacles (screens)

- 2.2.3.1 If the clearances set out in 2.2.2 cannot be achieved, protection by an obstacle shall be provided in accordance with EN 50122-1:2011+A1:2011 clauses 5.3.1 to 5.3.3.
- 2.2.3.2 Using an electrical clearance in accordance with Table 5, the nearest proximity in air, between an exposed live part and an obstacle, shall be determined in accordance with EN 50122-1:2011+A1:2011 clause 5.3.1.
- 2.2.3.3 For routes electrified using the auto-transformer system, where protection by clearance or protection by obstacles cannot be achieved, the feeder conductor shall be an insulated and screened cable, meeting the requirement for basic insulation set out in 2.1.8.1a).

- G 2.2.10 Rationale: These requirements support the Operational Concept for the GB Mainline Railway principle 9, that the workforce is to be separated from the particular hazards associated with the electrified railway. This is a cross-boundary issue in that the hazard belongs to one duty holder, while the workforce with potential exposure belongs to other duty holders. It is also required to give a consistent approach and common operational rules across the GB mainline railway. In this case, the requirement specified here is slightly more restrictive than the ENE TSI to reflect the requirements of the UK railway. The ENE TSI in this case reflects a minimum requirement. These requirements are to prevent exposure to danger from high voltages through direct contact with, or entering the danger zone around, exposed live parts by placing a physical barrier between personnel and the exposed live parts. These requirements also contribute to passenger and public safety.
- G 2.2.11 In EN 50122-1:2011+A1:2011 clause 5.2.2, exceptions for working persons are given to allow alternative controls to be applied in areas used 'solely for the execution of work'.
- G 2.2.12 In EN 50122-1:2011+A1:2011 the dimensions are based upon touching in a straight line without the use of objects. It may be appropriate to make an additional allowance for the use of hand tools. Obstacles are designed in order not to facilitate climbing.
- G 2.2.13 The dimension of 370 mm in 2.2.3.2, to be used in place of the electrical clearance, as set out in EN 50119:2009+A1:2013, has been obtained from EN 50124-1:2001+A2:2005 Table A3. The specified dimension provides basic insulation and the corresponding rated impulse voltage of 200 kV is co-ordinated with 2.1.8 of this document.
- G 2.2.14 The impedance between the rail vehicle body and the protective conductor of the fixed installation (traction return rail) for existing vehicles is likely to be up to 40 mΩ.

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

Extract from GL/RT1210

2.2.4 Indirect contact, exposed conductive parts, touch voltages and rail potential

- 2.2.4.1 Protection against electric shock shall be achieved by compliance with the touch voltage requirements set out in EN 50122-1:2011+A1:2011 clauses 6.1, 6.2.1, 9.1 and 9.2.

G 2.2.15 Rationale: This requirement is to prevent exposure to dangerous touch voltages.

G 2.3 Safety warning signs

G 2.3.1 Operational signs

Extract from GL/RT1210

2.3.1 Warning to crews on trains approaching a neutral section forming a phase separation section

- 2.3.1.1 At phase separation sections, signs AJ01z and AJ02z, as set out in GI/RT7033, shall be provided (see Appendix B). 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 2.3.2 Rationale: Warning signs are required at OCL phase separation sections (neutral sections) to advise the operator of a train of the action necessary to pass through the OCL phase separation section. This requirement is to provide sufficient warning to the driver to withdraw the power to the train prior to crossing the automatic power control (APC) magnet.

Extract from GL/RT1210

2.3.2 Warning to crews on trains of a traction system changeover

- 2.3.2.1 On the approach to an electrical changeover from 750 V DC to 25 kV AC, signs AJ04z and AJ05z, as set out in GI/RT7033, 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 2.3.3 Rationale: Warning signs are required at OCL 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. This is to give a smooth operational changeover between energy subsystems and adequate continuity of supply to the train.

G 2.3.4 At the end of a 25 kV AC electrified line with an electrical system changeover to another AC electrical system, signs AJ04z and AJ05z are used. Changeover to a DC electrical system uses signs AJ04z and AJ06z, as set out in GL/RT1212.

Extract from GL/RT1210

2.3.3 Overhead contact line structure identification plate

- 2.3.3.1 Every OCL structure shall be provided with an identification plate giving the structure reference code (unique within the area). The size and location shall be such that the text shall be readable from the cab of a train at rest.

G 2.3.5 Rationale: Overhead contact line structures should be easily identified so that staff can give a precise location by a common position reference of any fault with the OCL to the signaller or electrical control room, as required in GE/RT8000.

Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem

- G 2.3.6 Signs should preferably be located so that maintenance is possible without the requirement for the exposed live parts to be isolated.
- G 2.3.7 Structure identification plates normally consist of letters representing an electrical control room area, a number representing distance in kilometre intervals and a number representing the individual structure within a kilometre interval, arranged over three lines of text. In future the alpha labelling might align to the Engineers Line Reference (ELR).