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GLGN1600
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Guidance on the Energy TSI

Synopsis
This document gives guidance on interpreting the requirements of the Energy Technical Specification for Interoperability 2014 (ENE TSI), Commission Regulation (EU) No. 1301/2014 for application to the GB mainline railway.

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Issue Record

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<td>This document provides guidance on the merged Energy TSI (high speed and conventional rail) as associated with the GB mainline railway and supersedes the previous guidance note GEGN8600 which was associated with the conventional rail energy TSI only.</td>
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This document will be updated when necessary by distribution of a complete replacement.

Superseded Documents

The following Rail Industry Guidance Note is superseded, either in whole or in part as indicated:

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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.
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Part 1 Introduction

1.1 Purpose

1.1.1 This document provides guidance to the Energy (Technical Specification for Interoperability (TSI) (2015) only.

1.1.2 To demonstrate compliance of an energy subsystem with the Energy TSI in Great Britain (GB) it is necessary to combine the requirements contained within the Energy TSI with the requirements notified by the Department for Transport (DfT) as National Technical Rule (NTRs).

1.1.3 The NTRs applicable to the ENE TSI provide the rules which are the specific cases for the UK mainline railway; rules to fill open points in the referenced standards; and rules for compatibility with the existing UK mainline railway.

1.1.4 For the 25 kV AC energy subsystem, the notified NTRs are contained within GLRT1210 (associated guidance note GLGN1610) and GMRT2173 for pantograph gauging purposes (associated guidance note GEGN8573) as identified in the table provided in Appendix A (Table of Correspondence with National Technical Rules) of this document.

1.1.5 This document gives specific guidance for the 25 kV AC energy subsystem on lines with a 1435 mm track gauge, but references that the whole of the GB 600/750 V DC conductor rail energy subsystem is included in a specific case, for which the notified NTRs are contained within GLRT1212 and associated guidance is provided in guidance note GLGN1612.

1.1.6 This document provides guidance to the Energy Technical Specification for Interoperability (ENE TSI) Commission Regulation (EU) No. 1301/2014 for application to GB mainline railways associated with new construction, renewal and upgrade of existing GB mainline railway energy subsystems and does not set out requirements. This document also incorporates guidance associated with Safety in Rail Tunnel (SRT) TSI Commission Regulation (EU) No. 1303/2014 relating to the energy subsystem, as well as including requirements from Rolling Stock – locomotives and passenger rolling stock TSI Commission Regulation (EU) No. 1302/2014 (LOC & PAS TSI) where these help to clarify the requirements in the ENE TSI.

1.1.7 This document also gives guidance to clarify terms that are particular to GB and indicates where there are specific cases. It supplements the European Rail Agency Application Guide to the ENE TSI.

1.1.8 This document is to assist contracting or project entities and conformity assessment bodies in understanding their responsibilities in relation to interpreting and applying the technical requirements of the ENE TSI. It does not constitute a recommended method of meeting any set of mandatory requirements.

The ENE TSI is used in conjunction with the notified NTRs to meet the essential requirements set out in Directive 2008/57/EC. Clauses 25 to 37 in Commission Recommendation 2014/897/EU give further guidance on the essential requirements and how standards are used to meet them.

1.1.9 More generally, Directive 2008/57/EC permits Member States to draw up NTRs to support TSIs application within their Member State, under the following circumstances:

a) To support a specific case.
b) To fill an open point.
c) Derogations to the TSI.
d) For technical compatibility between legacy subsystems that do not conform to the requirements of the TSI.

1.1.10 Where a notified NTR is utilised for an energy subsystem, then assessment needs to be undertaken by a Designated Body (DeBo) and the requirements of the NTR substitute for, or supplement, the requirements in the TSI.
1.1.11 The list of NNTRs that support the ENE TSI can be found on the DfT website.

1.1.12 Specific cases describe special provisions that are needed and authorised on particular networks of each Member State. They allow individual Member States to vary the requirements of the TSI to ensure that the requirements align to the national requirements, where compliance to the TSI would result in either disproportionately high costs or where, as in the UK, the space envelope occupied by the railway does not allow for a full compliance. Specific cases can either be temporary (T case) with a defined time limit or permanent (P case).

1.1.13 All the specific cases in the ENE TSI for GB mainline railway are permanent. Specific cases for the UK are listed in section 7.4.2 of the ENE TSI but, in this guidance note, these clauses have been brought forward to be shown alongside their relevant technical requirement. The specific case in the TSI may either specify the requirements, or state that the requirement is in accordance with the NTRs notified for this purpose. In the latter case, the NTRs are set out in a list published on the DfT website or, when it is completed, in the NOTIFIT database managed by the European Rail Agency (ERA).

1.1.14 This guidance note, and other documentation refers to the ERA. The name was changed in 2016 to the European Union Agency for Rail.

1.2 Structure of this document

1.2.1 Relevant text from the ENE TSI is reproduced with a grey background in this document. Corresponding extracts from the LOC & PAS TSI and the Safety in Railway Tunnels (SRT) TSI are included where these are relevant, and aid understanding of the ENE TSI. The LOC & PAS TSI refers to European Norms (ENs) by a reference to Appendix J-1 of that TSI. These references are cited in full in the text of this guidance note.

1.2.2 Guidance is provided as a series of sequentially numbered clauses immediately below the greyed text to which it relates.

1.2.3 Sufficient TSI text is reproduced to put the guidance in context but not all the TSI text is included.

1.2.4 Where GB specific cases or particular assessment requirements are included in the ENE TSI, the text of these is included in this document immediately following the main clause to which the specific case refers and is then followed by any related guidance. Where it aids understanding of the interface, the corresponding clauses from the LOC & PAS TSI have also been included.

1.3 Related documents

1.3.1 This guidance note references GLRT1210 AC Energy Subsystem and Interfaces to Rolling Stock Subsystem, and GMRT2111 Rolling Stock Subsystem and Interface to AC Energy Subsystem, and their respective guidance notes GLGN1610 for the energy subsystem and GMGN2611 for the rolling stock subsystem.

1.3.2 This guidance note also references the GMRT2132 On-board Energy Metering for Billing Purposes, in respect of the open point relating to energy metering; GMRT2173 Requirements for the Size of Vehicles and Position of Equipment, and associated guidance note GEGN8573 Guidance on Gauging and Platform Distances, in respect of the specific case relating to pantograph movements.

1.4 Approval and Authorisation

1.4.1 The content of this document was approved by Energy Standards Committee (ENE SC) on 03 November 2016.
1.4.2 This document was authorised by RSSB on 26 January 2017 [proposed].
Part 2 Guidance on the ENE TSI Chapters 1, 2, 3 and General Topics

2.1 Relationship between the Interoperability Directive and ENE TSI

2.1.1 The current Interoperability Directive (2008/57/EC) was issued on 17 June 2008 and was transposed within the UK as the Railways (Interoperability) Regulations 2011 (RIR2011), a regulation issued under Transport Act 2000. There have been subsequent amendments to regulations which affect both Interoperability Directive and RIR2011. These are: The Railways (Interoperability) (Amendment) Regulations 2013 and The Railways (Interoperability) (Amendment) Regulations 2015.

2.1.2 Annex II of the Interoperability Directive lists the four structural and three functional TSIs. Annex III of the Interoperability Directive mandates the need to fulfil essential requirements categorised under general requirements (safety, reliability and availability, health, environmental protection and technical compatibility) and requirements specific in each subsystem (infrastructure, energy, control, command and signalling (CCS), rolling stock, maintenance, operations and traffic management and telematics).

2.1.3 The TSIs (of which ENE is one) are issued as commission regulations or decisions under the Interoperability Directive and therefore become mandatory without the requirement for transposition into UK law. The ENE TSI sets out its legal status under the Interoperability Directive (2008/57/EC), as a regulation adopted by the EU.

2.1.4 The preamble before Article 1 of the ENE TSI details its legal status, and Article 2 in particular relates to the scope and its extension to include all railways. Articles 1 – 12 of the regulations define the obligations that need to be fulfilled.

2.1.5 The technical scope of the ENE TSI is defined within section 1, together with the geographical scope as well as the content of the ENE TSI. With the issuing of this revision, the scope of the TSI has been extended to all railways (rather than the trans-European networks (TENs) network) and includes all the GB mainline railway unless excluded by the Member State in an ‘Approved List of Exclusions from the scope of the Railways (Interoperability) Regulations 2011’.

2.1.6 The requirement for a Register of Infrastructure (RINF) is set out in Commission Implementing Decision 2014/880/EU [489] of 26 November 2014 on the common specifications of the register of railway infrastructure. This decision defines a schedule of the relevant parameters that align with those defined in the TSIs, which are populated when a route is authorised after completion, renewal or upgrading. The parameters for the energy subsystem are set out in section 1.1.1.2 of the table. The register may also be populated on a voluntary basis using the relevant parameters set out in the TSI for existing lines.

2.1.7 When applying the TSI to an upgrade or renewal of the energy subsystem, there is a need to establish the extent of application of the TSI in accordance with RIR 2011, section 13.

<table>
<thead>
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<td>1. General requirements</td>
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<tr>
<td>1.1. Safety</td>
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<tr>
<td>1.1.1. The design, construction or assembly, maintenance and monitoring of safety-critical components, and more particularly of the components involved in train movements must be such as to guarantee safety at the level corresponding to the aims laid down for the network, including those for specific degraded situations.</td>
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</table>
1.1.2. The parameters involved in the wheel/rail contact must meet the stability requirements needed in order to guarantee safe movement at the maximum authorised speed. The parameters of brake equipment must guarantee that it is possible to stop within a given brake distance at the maximum authorised speed.

1.1.3. The components used must withstand any normal or exceptional stresses that have been specified during their period in service. The safety repercussions of any accidental failures must be limited by appropriate means.

1.1.4. The design of fixed installations and rolling stock and the choice of the materials used must be aimed at limiting the generation, propagation and effects of fire and smoke in the event of a fire.

1.1.5. Any devices intended to be handled by users must be so designed as not to impair the safe operation of the devices or the health and safety of users if used in a foreseeable manner, albeit not in accordance with the posted instructions.

1.2. Reliability and availability

The monitoring and maintenance of fixed or movable components that are involved in train movements must be organised, carried out and quantified in such a manner as to maintain their operation under the intended conditions.

1.3. Health

1.3.1. Materials likely, by virtue of the way they are used, to constitute a health hazard to those having access to them must not be used in trains and railway infrastructures.

1.3.2. Those materials must be selected, deployed and used in such a way as to restrict the emission of harmful and dangerous fumes or gases, particularly in the event of fire.

1.4. Environmental protection

1.4.1. The environmental impact of establishment and operation of the rail system must be assessed and taken into account at the design stage of the system in accordance with the Community provisions in force.

1.4.2. The materials used in the trains and infrastructures must prevent the emission of fumes or gases which are harmful and dangerous to the environment, particularly in the event of fire.

1.4.3. The rolling stock and energy-supply systems must be designed and manufactured in such a way as to be electromagnetically compatible with the installations, equipment and public or private networks with which they might interfere.

1.4.4. Operation of the rail system must respect existing regulations on noise pollution.

1.4.5. Operation of the rail system must not give rise to an inadmissible level of ground vibrations for the activities and areas close to the infrastructure and in a normal state of maintenance.

1.5. Technical compatibility

The technical characteristics of the infrastructure and fixed installations must be compatible with each other and with those of the trains to be used on the rail system. If compliance with these characteristics proves difficult on certain sections of the network, temporary solutions, which ensure compatibility in the future, may be implemented.

2 Requirements specific to each subsystem (extract from 2008/57/EC Annex III)

2.2. Energy
Guidance on the Energy TSI

Interoperability Directive 2008/57/EC

2.2.1. Safety Operation of the energy-supply systems must not impair the safety either of trains or of persons (users, operating staff, trackside dwellers and third parties).

2.2.2. Environmental protection The functioning of the electrical or thermal energy-supply systems must not interfere with the environment beyond the specified limits.

2.2.3. Technical compatibility The electricity/thermal energy supply systems used must: — enable trains to achieve the specified performance levels, - in the case of electricity energy supply systems, be compatible with the collection devices fitted to the trains.

2.1.8 Annex III of the Interoperability Directive sets out the essential requirements under the general requirements of safety, reliability and availability, health, environmental protection and technical compatibility. It also defines additional requirements specific to energy, CCS, rolling stock, maintenance, operations, traffic management and telematics.

2.1.9 Conformity with the requirements set out in the TSI and, where applicable, NTRs is a prerequisite for an application for authorisation. However, these standards alone are not sufficient to ensure compliance with all the essential requirements of the Directive. In addition, other UK legislation may impose requirements affecting the energy subsystem, for example, some aspects of health and safety.

2.1.10 Commission recommendation 2014/897/EU gives clarification of regulatory separation between placing in service and putting in use. Additionally, for the GB mainline railway, GERT8270 supports this process.

2.2 ENE TSI scope extension

2.2.1 Merging of two TSIs into one

2.2.1.1 As of the 01 January 2015 the ENE TSI now applies to all new subsystems, and upgrades or renewals to existing subsystems on the entire GB mainline railway network in the scope of the Railway (Interoperability) Regulations 2011, and not just to subsystems on the part of the network classified as part of the trans-European network (TEN), as in previous TSIs.

2.2.1.2 The DfT provides information on the precise geographical scope on their website (see references).

2.2.1.3 The ENE TSI now covers requirements for both high speed and conventional speed rail system networks. The high speed and conventional rail infrastructure requirements were previously set out in separate TSIs: the High Speed ENE TSI and the Conventional Rail ENE TSI. The updated ENE TSI effectively merges the technical scope of the two previous TSIs into one document and extends the scope.

2.3 ENE TSI chapter 2

2.3.1 Interfaces of ENE TSI with other TSIs

2.3.1.1 The ENE TSI has been developed by ERA to be in harmony with other TSIs. Key interfaces exist with the LOC & PAS, Infrastructure (INS), and CCS TSIs.

2.3.1.2 The Safety in Rail Tunnels TSI (SRT TSI) also includes requirements related to the energy subsystem, which for completeness are referenced in this document.
2.4 ENE TSI general topics

2.4.1 Numeric values

2.4.1.1 The ENE TSI uses the standard European notation for numeric values with ‘comma’ (,) as the decimal point and ‘space’ ( ) as the thousands delimiter. Thus, for example, 2,5 mm/m is to be understood as 2.5 mm/m and 1 435 mm is to be understood as 1435 mm.
Part 3 Guidance on ENE TSI Chapter 4 and UK (GB) Specific Cases in Chapter 7

3.1 Characterisation of the subsystem

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<tr>
<td>4 Characterisation of the subsystem</td>
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<tr>
<td>4.1 Introduction</td>
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</table>

(1) The whole rail system, to which Directive 2008/57/EC applies and of which the energy subsystem is a part, is an integrated system whose consistency needs to be verified. This consistency must be checked, in particular, with regard to the specifications of the energy subsystem, its interfaces vis-à-vis the system in which it is integrated, as well as the operating and maintenance rules. The functional and technical specifications of the subsystem and its interfaces, described in points 4.2 and 4.3, do not impose the use of specific technologies or technical solutions, except where this is strictly necessary for the interoperability of the rail network.

(2) Innovative solutions for interoperability, which do not fulfil requirements specified in this TSI and are not assessable as stated in this TSI, require new specifications and/or new assessment methods. In order to allow technological innovation, these specifications and assessment methods shall be developed by the process for innovative solutions described in points 6.1.3 and 6.2.3.

(3) Taking account of all the applicable essential requirements, the energy subsystem is characterised by the specifications set out in points 4.2 to 4.7.

(4) Procedures for the EC verification of the energy subsystem are indicated in point 6.2.4 and Appendix B, Table B.1, of this TSI.

(5) For specific cases, see point 7.4.

(6) Where reference is made to EN standards in this TSI, any variations called ‘national deviations’ or ‘special national conditions’ in the EN standards are not applicable and do not form part of this TSI.

3.1.1 Part 4 of the ENE TSI provides the functional and technical specification. Clause 4.1 highlights that technological innovation is allowed and the process for utilising innovative solutions is within Part 6 of the TSI, including the EC verification of the energy subsystem. Specific cases are in Part 7 of the ENE TSI.

3.1.2 Only the main text of the European Standards (ENs) apply when referenced in the ENE TSI as noted in (6). The ENE TSI identifies a number of specific cases which are fulfilled by the notification of specific clauses within the NTRs. These NTRs may refer to both the clauses and national conditions within ENs. Annex E of the ENE TSI lists all referenced ENs.

3.1.3 The UK National Implementation Plan for the ENE TSI states that any future electrification of the GB network will use the 25 kV single-phase AC system. This guidance note therefore only covers the 25 kV single phase AC system. The National Implementation Plan is considered to include basic requirements for all new, upgraded and renewal projects. More details on the National Implementation Plan are in Chapter 7 of the TSI.

3.1.4 The NTRs associated with the GB mainline railway energy subsystem are set out in GLRT1210. A table is provided at Appendix A of this Guidance Note showing the related NTRs for the energy subsystem.

3.1.5 The GB 600/750 V DC conductor rail system is still permitted to be used under a specific case (7.4.2.9.1.) to the ENE TSI. The NTRs associated with this system are set out in GLRT1212. However, before
3.1.6 The Tyne and Wear metro system utilises the 1.5 kV DC system (including parts where there is interworking over Network Rail infrastructure) but it is excluded from the scope of the TSI as a metropolitan railway. See the ‘Approved list of exclusions from the scope of the Railways (Interoperability) Regulations 2011’.

3.2 Functional and technical specifications

<table>
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<td><strong>4.2. Functional and technical specifications of the subsystem</strong></td>
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<tr>
<td>4.2.1. General provisions</td>
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<tr>
<td>General provisions The performance to be achieved by the energy subsystem is specified at least by the required performance of the rail system with respect to:</td>
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<tr>
<td>(a) maximum line speed;</td>
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<tr>
<td>(b) type(s) of train;</td>
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<tr>
<td>(c) train service requirements;</td>
</tr>
<tr>
<td>(d) power demand of the trains at the pantographs.</td>
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3.2.1 This general clause indicates that the design of the electrification system is to be appropriate for the type of traffic that the line is intended to handle. Consideration should be given to future traffic demands. There is no requirement to design a ‘uniform’ system if doing so will be uneconomic, and any future traffic considerations need to take this into account.

3.2.2 The Register of Infrastructure (RINF) records the parameters to which the line has been authorised. The database that forms the Register of Infrastructure is restrictive in the data that can be recorded and permitting only the basic parameters of a line to be entered, although in some cases it is possible to repeat entries for the same track section to record multiple system conditions. Permissible operation conditions that are not recorded in the register such as differential speed limits for different types of rolling stock and environmental conditions (such as high wind) are then a matter of technical compatibility and operational rules. The Register of Infrastructure is being populated and maintained on behalf of the Member State by Network Rail.

3.2.3 The TSI requires that the system will be maintained in conformance with the authorisation and any changes due to service pattern need to respect this authorisation, otherwise a revised authorisation will be required.

3.2.4 As part of the technical submission to NoBo, project entities will state the intended objectives and required capability from the system so that the system design can be validated against these requirements. This will define the projects’ baseline assumptions such that where timetable / stock change impacts these characteristics, then the need to demonstrate that the required parameters are still maintained, can be done without extensive review of project documentation.
3.3 Basic parameters characterising the energy subsystem

**ENE TSI**

4.2.2. Basic parameters characterising the energy subsystem

The basic parameters characterising the energy subsystem are:

4.2.2.1. Power supply:
(a) Voltage and frequency (4.2.3);
(b) Parameters relating to supply system performance (4.2.4);
(c) Current capacity, DC systems, trains at standstill (4.2.5);
(d) Regenerative braking (4.2.6);
(e) Electrical protection coordination arrangements (4.2.7);
(f) Harmonics and dynamic effects for AC traction power supply systems (4.2.8)

4.2.2.2. Geometry of the OCL and quality of current collection:
(a) Geometry of the overhead contact line (4.2.9);
(b) Pantograph gauge (4.2.10);
(c) Mean contact force (4.2.11);
(d) Dynamic behaviour and quality of current collection (4.2.12);
(e) Pantograph spacing for overhead contact line design (4.2.13);
(f) Contact wire material (4.2.14);
(g) Phase separation sections (4.2.15);
(h) System separation sections (4.2.16).

4.2.2.3. On-ground energy data collecting system (4.2.17)
4.2.2.4. Protective provisions against electric shock (4.2.18)

3.3.1 This section sets out the parameters that are elaborated further on in the document, and contains no mandatory requirements

3.4 Voltage and frequency

**ENE TSI**

4.2.3. Voltage and frequency

(1) The voltage and frequency of the energy subsystem shall be one of the four systems, specified in accordance with Section 7:
(a) AC 25 kV, 50 Hz;
(b) AC 15 kV, 16.7 Hz;
(c) DC 3 kV;
ENE TSI

(d) DC 1.5 kV.

(2) The values and limits of the voltage and frequency shall comply with EN 50163:2004, clause 4 for the selected system.

ENE TSI Specific Case (GB)

7.4.2.9.1. Voltage and frequency (4.2.3) P case

It is permissible to continue to upgrade, renew and extend networks equipped with the electrification system operating at 600/750 V DC and utilising conductor rails in a three and/or four rail configuration in accordance with the national technical rules notified for this purpose.

Specific case for the United Kingdom of Great Britain and Northern Ireland, applying only to the mainline network in Great Britain.

LOC & PAS TSI Specific Case (GB)

7.3.2.11. Operation within range of voltages and frequencies (4.2.8.2.2) P case

It is permissible for electric units to be equipped with automatic regulation within abnormal operation condition regarding voltage as set out in the national technical rule notified for this purpose.

This specific case does not prevent the access of TSI compliant rolling stock to the national network.

3.4.1 The ENE TSI allows for four systems, 25 kV 50 Hz single phase and 15 kV 16.7 Hz for AC systems and 1.5 kV overhead and 3 kV overhead for DC systems; however, for line speeds above 250 km/h, only the AC systems will be utilised.

3.4.2 For GB mainline railway, the national implementation plan requires the use of the 25 kV AC system of electrification as set out in GLRT1210.

3.4.3 In relation to the LOC & PAS TSI, clause 7.3.2.11, historically, electric trains used in GB have been specified to operate (but at a reduced performance) at a pantograph voltage between 12.5 kV and 17.5 kV.

In implementing the ENE TSI, GB is moving to a position where voltages below 17.5 kV will no longer be present on the network. On existing infrastructure, voltages below 17.5 kV may still occasionally be present. Any trains required to operate on existing infrastructure may still need to be capable of operating in this extended range.

3.5 Maximum train current

ENE TSI

4.2.4. Parameters relating to supply system performance

The following parameters shall be taken in consideration:

(a) maximum train current (4.2.4.1);

(b) power factor of trains and the mean useful voltage (4.2.4.2).
3.5.1 The TSI requires the energy subsystem to be designed to achieve a specified performance. The maximum train current limit applies to the whole train (inclusive of train auxiliaries), not a single unit. Requirements for the GB mainline railway are set out in GLRT1210.

3.5.2 The power limit refers to the maximum power taken from the current collection system for a complete train (for example, all pantographs in a multiple pantograph train).

3.5.3 Current or power limitation devices fitted to trains restrict the amount of power taken by the trains to keep the overall power demand within the limitations of the system. To avoid unnecessary rolling stock costs, the energy subsystem will allow trains (a combination of rolling stock coupled together) up to 2 MW to operate without power or current limitations.

3.5.4 The characteristics of power or current limitation devices fitted to the rolling stock is defined in clause 7.3 of EN 50388:2012 and the characteristics for automatic voltage regulation is defined in clause 7.2 of EN 50388:2012.

3.5.5 A range of documentation and design / modelling may be used to specify the train currents including a breakdown / summary of rolling stock used for simulation purposes and to allow an assessment to be carried out.

3.6 Mean useful voltage

The calculated mean useful voltage ‘at the pantograph’ shall comply with EN 50388:2012, clause 8 (except clause 8.3 that is replaced by point C.1 of Appendix C). Simulation shall take into account values of the real power factor of trains. Point C.2 of Appendix C provides additional information to clause 8.2 of the EN 50388:2012.

(1) The assessment shall be demonstrated in accordance with EN 50388:2012, clause 15.4.
(2) The assessment shall be demonstrated only in the case of newly build or upgraded sub-systems.
(referred to as the ‘dimensioning train’). A detailed description of the process of calculation is set out in EN 50388:2012, Annex B.

3.6.2 Appendix C of the ENE TSI gives requirements in terms of compliance and clarifies the line speed differentials in EN 50388:2012, because the EN refers to terminology from the former conventional rail TSIs.

3.6.3 Modelling may be used to demonstrate mean useful voltage during normal operating conditions to allow an assessment to be carried out. When calculating the power supply quality, it is important to note that the objective is a power supply system that in normal operation can supply every train with the power required in order to meet the timetable.

3.6.4 The energy subsystem design is to 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 will also take account of their power factors.

3.6.5 The assessment aspect of mean useful voltage requirement is only required to be demonstrated for a new or upgraded energy subsystem and not for renewal.

3.7 Current capacity, DC systems, trains at standstill

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.5. Current capacity, DC systems, trains at standstill</td>
</tr>
<tr>
<td>(1) The OCL of DC systems shall be designed to sustain 300 A (for a 1.5 kV supply system) and 200 A (for a 3 kV supply system), per pantograph when the train is at standstill.</td>
</tr>
<tr>
<td>(2) The current capacity at standstill shall be achieved for the test value of static contact force given in table 4 of clause 7.2 of EN 50367:2012.</td>
</tr>
<tr>
<td>(3) The OCL shall be designed taking into account the temperature limits in accordance with EN 50119:2009, clause 5.1.2.</td>
</tr>
</tbody>
</table>

3.7.1 These clauses have no relevance to the GB mainline railway.

3.8 Regenerative braking

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.6. Regenerative braking</td>
</tr>
<tr>
<td>(1) AC power supply systems shall be designed to allow the use of regenerative braking able to exchange power seamlessly either with other trains or by any other means.</td>
</tr>
<tr>
<td>(2) DC power supply systems shall be designed to permit the use of regenerative braking at least by exchanging power with other trains.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.2.4. Particular assessment procedures for energy subsystem</td>
</tr>
<tr>
<td>6.2.4.2. Assessment of regenerative braking</td>
</tr>
</tbody>
</table>
ENETSI

(1) The assessment for AC power supply fixed installations shall be demonstrated according to EN 50388:2012, clause 15.7.2.

(2) The assessment for DC power supply shall be demonstrated by a design review.

LOC & PAS TSI

4.2.8.2.3 Regenerative brake with energy to the overhead contact line

(1) Electric units which return electrical energy to the overhead contact line in regenerative braking mode shall comply with the specification referenced in Appendix J-1, index 42 [EN 50388:2012].12.1.1

(2) It shall be possible to control the use of the regenerative brake.

3.8.1 Facilities to permit the use of regenerative braking are provided for economic and environmental reasons. Regenerative braking for AC systems is widely available in modern rolling stock. Existing technologies allow energy in AC systems to be regenerated with low harmonic content, which would otherwise affect the quality of energy delivered by the supplier to other consumers.

3.8.2 The statement in the LOC & PAS TSI that “It shall be possible to control the use of regenerative braking” is specified to enable regenerative braking to be disabled, should the energy system not be capable of receiving regenerative braking energy. In some designs of the rolling stock, a small reverse current is exported to the line even when using the rheostatic brake. Further information on this is set out in GMRT2111.

3.8.3 Assessment is done through analysis of the system design for both control and protection at infrastructure level to ensure that feedback of energy is accepted into the system and/or the National Grid without affecting the protection of the system as a whole, or for AC systems, by a combined system test as set out in clause 15.7.2 of EN 50388:2012.

3.8.4 A range of documentation such as control and protection device configuration and data sheets, including distribution designs, may be used to demonstrate regenerative braking and allow an assessment to be carried out.

3.9 Electrical protection coordination arrangements

ENETSI

4.2.7 Electrical protection coordination arrangements

Electrical protection coordination design of the energy subsystem shall comply with the requirements detailed in EN 50388:2012, clause 11.

LOC & PAS TSI

4.2.8.2.10 Electrical protection of the train

(1) Electric units shall be protected against internal short-circuits (from inside the unit).
(2) The location of the main circuit breaker shall be such as to protect the on-board high voltage circuits, including any high voltage connections between vehicles. The pantograph, the main circuit breaker, and the high voltage connection between them shall be located on the same vehicle.

(3) Electric units shall protect themselves against short overvoltage, temporary overvoltage and maximum fault current. To meet this requirement, electrical protection coordination design of the unit shall comply with the requirements defined in the specification referenced in Appendix J-1, index 53 [EN 50388:2012, clause 11].

3.10 Harmonics and dynamic effects for AC traction power supply systems

(1) The interaction of traction power supply system and rolling stock can lead to electrical instabilities in the system.
(2) In order to achieve electrical system compatibility, harmonic overvoltage shall be limited below critical values according to EN 50388:2012, clause 10.4.

6.2.4. Particular assessment procedures for energy subsystem

6.2.4.4. Assessment harmonics and dynamic effects for AC traction power supply systems

(1) A compatibility study shall be carried out according to EN 50388:2012, clause 10.3.

(2) This study shall be carried out only in the case of introducing converters with active semi-conductors in the power supply system.

(3) The notified body shall assess if criteria of EN 50388:2012, clause 10.4 are fulfilled.

4.2.8.2.7 System Energy Disturbances for ac systems

(1) An Electric unit shall not cause unacceptable overvoltage and other phenomena described in the specification referenced in Appendix J-1, index 45, clause 10.1 (harmonics and dynamic effects) on the overhead contact line.

(2) A compatibility study shall be done in accordance with the methodology defined in the specification referenced in Appendix J-1, index 45, [EN 50388:2012] clause 10.3. The steps and hypothesis described in Table 5 of the same specification have to be defined by the applicant (column 3 ‘Concerned party’ not applicable), with input data presented as in Annex D of the same specification; the acceptance criteria shall be as defined in clause 10.4 the same specification.

(3) All hypothesis and data considered for this compatibility study shall be recorded in the technical documentation (see clause 4.2.12.2).

3.10.1 These unacceptable overvoltage and other phenomena are related to the harmonic and dynamic characteristics of power supply fixed installations and rolling stock, which can create overvoltage and other instability phenomena in the power supply system.

3.10.2 A compatibility study is required only when introducing converters with active semi-conductors to the energy subsystem (see EN 50388:2012 clause 10.2 (Acceptance procedure for new elements)). The TSI requires the compatibility study to be carried out in this case, to assess any consequences resulting from the introduction of the new active element into the system. The compatibility study is explained in detail in EN 50388:2012 clause 10.3.

3.10.3 The role of the notified body on this issue is only to check if the criteria of EN 50388:2012 clause 10.4 (Methodology and acceptance criteria) are fulfilled in the study. In a 25 kV 50 Hz AC system, the criterion is that no peak voltage is to exceed 50 kV at any point, as long as the duration of the peak does not exceed the limits specified in EN 50163, where system voltage exceeding \( U_{\text{max}} \) is defined.

3.10.4 The total harmonics voltage distortion is not defined in the ENE TSI and EN 50388. With the harmonics voltage compatibility assessment experienced in the GB mainline railway, a 45 kV peak (90 kV peak to peak) voltage has been used as an achievable safe criterion on Network Rail’s infrastructure.
3.10.5 A range of documentation such as a compatibility study / case may be used to demonstrate harmonics and dynamic effects and allow a design assessment to be carried out, only if converters with active semi-conductors are being introduced into the system.

3.11 Geometry of the overhead contact line

**ENE TSI**

4.2.9. Geometry of the overhead contact line

(1) The overhead contact line shall be designed for pantographs with the head geometry specified in the LOC & PAS TSI, point 4.2.8.2.9.2 taking into account the rules set out in point 7.2.3 of this TSI.

(2) The contact wire height and the lateral deviation of the contact wire under the action of a cross-wind are factors which govern the interoperability of the rail network.

**LOC & PAS TSI**

4.2.8.2.9.2 Pantograph Head Geometry (IC Level)

(1) For electric units designed to be operated on other track gauge systems than 1 520 mm system, at least one of the pantograph(s) to be installed shall have a head geometry type compliant with one of the two specifications given in the clauses 4.2.8.2.9.2.1 and 2 below.

(2) For electric units designed to be operated solely on the 1 520 mm system, at least one of the pantograph(s) to be installed shall have a head geometry type compliant with one of the three specifications given in the clauses 4.2.8.9.2.1, 2 and 3 below.

(3) The type(s) of pantograph head geometry that an Electric unit is equipped with shall be recorded in the technical documentation defined in clause 4.2.12.2 of this TSI.

(4) The width of pantograph head shall not exceed 0.65 metres.

(5) Pantograph heads fitted with contact strips having independent suspensions shall be compliant with the specification referenced in Appendix J-1, index 47 [EN 50367:2012, clause 5.3.2.2].

(6) Contact between contact wire and pantograph head is permitted outside the contact strips and within the whole conducting range over limited line sections under adverse conditions, e.g. coincidence of vehicle swaying and high winds. Conducting range and the minimum length of contact strip are specified below as part of the pantograph head geometry.

4.2.8.2.9.2.1 Pantograph Head Geometry Type 1600 mm

(1) The pantograph head geometry shall be as depicted in the specification referenced in Appendix J-1, index 48 [EN 50367:2012, Annex A.2 Figure A.6].

(2) Text not replicated [1950mm Pantograph]

(3) Text not replicated [2000 / 2260mm Pantograph]
7.3.2.14 Pantograph head geometry (4.2.8.2.9.)

For operation on the existing network, it is allowed to equip electric units with a pantograph having a head geometry of length 1 600 mm as depicted in EN 50367:2012, Annex B.2 figure B.6 (as alternative to requirement in clause 4.2.8.2.9.2).

3.11.1 To ensure compatibility with existing energy subsystems in GB, a specific case is included in the LOC & PAS TSI (7.3.2.14) for the fitting of the pantograph designed for existing GB infrastructure, with metallic horns (EN 50367:2012, Annex B.2 Figure B.6) and limits to the along track dimension as set out in EN 50367:2012, clause 5.3 (defined as ‘width’ in the ENE TSI) to ensure compatibility with the existing designs of ‘short’ neutral section insulators. Single carbon-strip pantographs are not compatible with some designs of existing section insulators.

3.11.2 The ENE TSI UK national implementation plan states that for all future new electrification, the UK plans to construct an energy subsystem compatible with a pantograph head profile compliant with EN 50367:2012, Figure B.6 and Figure A.6. The lateral deviation will be compliant with clause 4.2.9.2 of the ENE TSI.

3.11.3 A range of documentation such as an IC ISV, designs and calculations may be used to demonstrate the geometry of the overhead contact line and allow a design assessment to be carried out.

3.11.4 A range of documentation such as design verification may be used to demonstrate the geometry of the overhead contact line and allow a production assessment to be carried out if a dynamic test is not required.

3.12 Contact wire height

<table>
<thead>
<tr>
<th>Description</th>
<th>v ≥ 250 [km/h]</th>
<th>v &lt; 250 [km/h]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal contact wire height [mm]</td>
<td>Between 5 080 and 5 300</td>
<td>Between 5 000 and 5 750</td>
</tr>
<tr>
<td>Minimum design contact wire height [mm]</td>
<td>5 080</td>
<td>In accordance with EN 50119:2009, clause 5.10.5 depending on the chosen gauge</td>
</tr>
<tr>
<td>Maximum design contact wire height [mm]</td>
<td>5 300</td>
<td>6 200 (1)</td>
</tr>
</tbody>
</table>

(1) Taking into account tolerances and uplift in accordance with EN 50119:2009 figure 1, the maximum contact wire height shall not be greater than 6 500 mm.

(2) For the relation between the contact wire heights and pantograph working heights see EN 50119:2009 figure 1.
(3) At level crossings the contact wire height shall be specified by national rules or in the absence of national rules, according to EN 50122-1:2011, clauses 5.2.4 and 5.2.5.

(4) For the track gauge system 1 520 and 1 524 mm the values for contact wire height are as follows:

(a) Nominal contact wire height: between 6 000 mm and 6 300 mm;
(b) Minimum design contact wire height: 5 550 mm;
(c) Maximum design contact wire height: 6 800 mm.

ENE TSI Specific Case (GB)

7.4.2.9.2. Contact wire height (4.2.9.1) (P case)

Specific case United Kingdom (Great Britain) (‘P’)

For technical compatibility with existing lines, the installation of a pantograph on an electric unit shall allow mechanical contact of the contact wires at the extended range of wire heights in accordance with the national technical rules notified for this purpose.

LOC & PAS TSI Specific Case (GB)

7.3.2.13. Height of interaction with contact wires (RST level) (4.2.8.2.9.1.1)

Specific case United Kingdom (Great Britain) (‘P’)

For technical compatibility with existing lines, the installation of a pantograph on an electric unit shall allow mechanical contact of the contact wires at the extended range of wire heights in accordance with the national technical rules notified for this purpose.

3.12.1 Table 4.2.9.1 of the TSI, defines the contact wire height, including the nominal contact wire height, the minimum design contact wire height and the maximum design contact wire height.

3.12.2 The nominal contact wire height is a design value only and can be chosen between 5.0 m and 5.75 m. The nominal contact wire height value is included in the TSI so that pantograph adjustments can be made to optimise the current collection from the overhead contact line (OCL). The nominal contact wire height in ENE TSI terms refers to the most common or most usually found contact wire height or range of heights.

3.12.3 For GB infrastructure, there is a specific case, 7.4.2.9.2, because of the historic gauge constraints and need to achieve compatibility with existing rolling stock. The NTRs associated with this specific case are set out in GLRT1210, clause 3.1, ‘Overhead contact line geometry and gauging’.

3.12.4 The minimum and maximum design contact wire heights are chosen to ensure that the minimum and maximum values achieved in use are never exceeded. The maximum and minimum contact wire heights are chosen to be compatible with the working limits of the pantograph, as illustrated in EN 50119:2009 Figure 1. At locations where there is a standing surface, for example a station platform, the minimum contact wire height may need to be greater than this minimum value, to meet the protected provisions against electrical shock (see 3.22). However, as a guide in the first instance, heights should be chosen to maximise clearance requirements.

3.12.5 The national rules relating to contact wire height over level crossings, are set out in GLRT1210, Part 3.
3.12.6 The specific case in the LOC & PAS TSI clause 7.3.2.13, increases the working range of the pantograph to reflect the permissible contact wire heights required for GB infrastructure, and rolling stock, as set out in GMRT2111.

3.12.7 A range of documentation such as an IC ISV, designs and calculations may be used to demonstrate the contact wire height and allow a design assessment to be carried out.

3.13 Maximum lateral deviation

<table>
<thead>
<tr>
<th>ENE TSI</th>
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</table>

4.2.9.2. Maximum lateral deviation
(1) The maximum lateral deviation of the contact wire in relation to the track centre line under action of a cross wind shall be in accordance to table 4.2.9.2.

<table>
<thead>
<tr>
<th>Table 4.2.9.2</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Maximum lateral deviation depending on the pantograph length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pantograph length [mm]</td>
</tr>
<tr>
<td>1 600</td>
</tr>
<tr>
<td>1 950</td>
</tr>
</tbody>
</table>

(1) The values shall be adjusted taking into account the movement of the pantograph and track tolerances according to Appendix D.1.4.

(2) In the case of the multi-rail track, the requirement for lateral deviation shall be fulfilled for each pair of rails (designed, to be operated as a separated track) that is intended to be assessed against TSI.

(3) Track gauge system 1 520 mm: For Member States applying the pantograph profile according to LOC&PAS TSI, point 4.2.8.2.9.2.3 the maximum lateral deviation of the contact wire in relation to the pantograph centre under action of a cross wind shall be 500 mm.

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
</table>

Appendix D.1.4 Calculation of maximum lateral deviation of contact wire
The maximum lateral deviation of the contact wire shall be calculated by taking into consideration the total movement of the pantograph with respect to the nominal track position and the conducting range (or working length, for pantographs without horns made from a conducting material) as follows:

\[ D_1 = b_{w,c} + b_{w} + b_{h,mec} \]

**bw,c** — defined in points 4.2.8.2.9.1 and 4.2.8.2.9.2 of LOC&PAS TSI

<table>
<thead>
<tr>
<th>ENE TSI Specific case</th>
</tr>
</thead>
</table>

7.4.2.9.3. Maximum lateral deviation (4.2.9.2) and pantograph gauge (4.2.10) (P case)
3.13.1 The maximum lateral deviation of the contact wire of 400 mm, set out in clause 4.2.9.2, provides compatibility with 1600 mm pantographs (EN 50367:2012, Figures A.6 and B.6), and with 1950 mm pantographs (EN 50367:2012, Figure A.7) although this latter option is currently not adopted on the GB mainline railway.

3.13.2 GLRT1210 section 3, and GMRT2173 clause 3.4 and Appendix E, support the specific case 7.4.2.9.3 relating to the maximum lateral deviation and provide a more refined approach to achieving compatibility between the extreme contact wire positions and the pantograph head.

3.13.3 A range of documentation such as an IC ISV, designs and calculations may be used to demonstrate the maximum lateral deviation and allow a design assessment to be carried out.

3.14 Pantograph gauge

**ENE TSI Specific case**

For new, upgrade or renewal of the energy subsystem on existing infrastructure it is allowed to calculate the adjustment to the maximum lateral deviation, the verification heights, and pantograph gauge in accordance with the national technical rules notified for this purpose.

Specific case for the United Kingdom of Great Britain and Northern Ireland, applying only to the mainline network in Great Britain

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**ENE TSI**

4.2.10. Pantograph gauge

(1) No part of the energy sub-system shall enter the mechanical kinematic pantograph gauge (see Appendix D figure D.2) except for the contact wire and steady arm.

(2) The mechanical kinematic pantograph gauge for interoperable lines is specified using the method shown in Appendix D.1.2 and the pantograph profiles defined in LOC&PAS TSI, points 4.2.8.2.9.2.1 and 4.2.8.2.9.2.2

(3) This gauge shall be calculated using a kinematic method, with values:

(a) for the pantograph sway $e_{pu}$ of 0,110 m at the lower verification height $h_u' = 5,0$ m and

(b) for the pantograph sway $e_{po}$ of 0,170 m at the upper verification height $h_o' = 6,5$ m, in accordance with point D.1.2.1.4 of Appendix D and other values in accordance with point D.1.3 of Appendix D.

(4) Track gauge system 1 520 mm:

For Member States applying the pantograph profile according to LOC&PAS TSI, point 4.2.8.2.9.2.3 the static gauge available for pantograph is defined in point D.2 of Appendix D.

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**ENE TSI Specific case**

7.4.2.9.3. Maximum lateral deviation (4.2.9.2) and pantograph gauge (4.2.10) (P case)

For new, upgrade or renewal of the energy subsystem on existing infrastructure it is allowed to calculate the adjustment to the maximum lateral deviation, the verification heights, and pantograph gauge in accordance with the national technical rules notified for this purpose.
3.14.1 The ENE TSI specifies how the pantograph gauge is calculated using the methodology stated in Appendix D of the TSI for both the 1600 mm and 1950 mm pantographs. Appendix D relates to reference gauge approach that is commonly used in mainland Europe. It is not used for the existing GB mainline railway.

3.14.2 GB has a specific case for the pantograph gauge in order to ensure compatibility with existing infrastructure. The sway of the pantograph, which defines the pantograph gauge, is determined using the methodology identified within the NTR for this purpose set out in GMRT2173 clause 3.4 and Appendix E.

3.14.3 A range of documentation such as an IC ISV and cross-sectional designs may be used to demonstrate the pantograph gauge and allow a design assessment to be carried out.

3.15 Mean contact force

4.2.11. Mean contact force

(1) The mean contact force $F_m$ is the statistical mean value of the contact force. $F_m$ is formed by the static, dynamic and aerodynamic components of the pantograph contact force.

(2) The ranges of $F_m$ for each of the power supply systems are defined in EN 50367:2012 Table 6.

(3) The overhead contact lines shall be designed to be capable to sustain the upper design limit of $F_m$ given in EN 50367:2012 Table 6.

(4) The curves apply to speed up to 320 km/h. For speeds above 320 km/h procedures set out in point 6.1.3 shall apply.

3.15.1 The upper and lower limits of statistical mean force, $F_m$, are specified in accordance with the limits in Table 6 of EN 50367:2012.

3.15.2 The limits of speeds for which the curves are valid are up to and including 200 km/h and then greater than 200 km/h but up to 320 km/h. For speeds beyond 320 km/h, clause 6.1.3 of the ENE TSI applies the innovation requirements.

3.15.3 The mean contact forces for both speed limits are shown in Figure A8 of EN 50367:2012. The mean contact forces in this context are a design parameter only, and the most onerous case needs to be assumed, as the OCL accommodates a range of pantograph types. In practice, the values measured during testing of a pantograph will lie between upper and lower limit curves.

3.15.4 A range of documentation such as an IC ISV and simulation may be used to demonstrate the mean contact force of the overhead contact line and allow a design assessment to be carried out.
3.16 Dynamic behaviour and quality of current collection

**Table 4.2.12**

<table>
<thead>
<tr>
<th>Requirement</th>
<th>( v \geq 250 \text{ [km/h]} )</th>
<th>( 250 &gt; v &gt; 160 \text{ [km/h]} )</th>
<th>( v \leq 160 \text{ [km/h]} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space for steady arm uplift ( S_0 )</td>
<td>( 2S_0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean contact force ( F_m )</td>
<td>( \leq 0.2 )</td>
<td>( \leq 0.1 ) for AC systems</td>
<td>( \leq 0.2 ) for DC systems</td>
</tr>
<tr>
<td>Percentage of arcing at maximum line speed, ( \sigma_{\text{max}} ) (minimum duration of arc 5 ms)</td>
<td>( 0.3F_m )</td>
<td>( \leq 0.1 )</td>
<td>( \leq 0.1 )</td>
</tr>
</tbody>
</table>

(2) \( S_0 \) is the calculated, simulated or measured uplift of the contact wire at a steady arm, generated in normal operating conditions with one or more pantographs with the upper limit of \( F_m \) at the maximum line speed. When the uplift of the steady arm is physically limited due to the overhead contact line design, it is permissible for the necessary space to be reduced to \( 1.5S_0 \) (refer to EN 50119:2009, clause 5.10.2).

(3) Maximum force (\( F_{\text{max}} \)) is usually within the range of \( F_m \) plus three standard deviations \( \sigma_{\text{max}} \); higher values may occur at particular locations and are given in EN 50119:2009, table 4, clause 5.2.5.2. For rigid components such as section insulators in overhead contact line systems, the contact force can increase up to a maximum of 350 N.

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**ENETSI**

6.2.4. Particular assessment procedures for energy subsystem

6.2.4.5. Assessment of dynamic behaviour and quality of current collection (integration into a subsystem)

(1) The main goal of this test is to identify allocation design and construction errors but not to assess the basic design in principle.

(2) Measurements of the interaction parameters shall be carried out in accordance with EN 50317:2012.

(3) These measurements shall be carried out with an interoperability constituent pantograph, exhibiting the mean contact force characteristics as required by point 4.2.11 of this TSI for the design speed of the line considering aspects related to minimum speed and siding tracks.
3.16.1  The dynamic behaviour is a crucial parameter, which describes the relationship between the overhead contact line and the pantograph in order to achieve a good quality of current collection. Table 4.2.12 of the TSI specifies requirements for three speed ranges, but as it has not been practice in GB to use the arcing method as an assessment method, the requirements are the same over the whole speed range.

3.16.2  The ENE TSI calls for a number of parameters to be met, as set out in EN 50367:2012 which allows for either the method using standard deviation, $\sigma_{\text{max}}$, or the method using percentage of arcing at maximum line speed, $NQ [\%]$. It is not required to use both methods. It has not been past GB practice to use the percentage of arcing method.

3.16.3  The overhead contact line is an Interoperability Constituent (IC) and is assessed initially in accordance with clause 6.1.4.1 of the TSI. The assessment criteria are based upon running an IC pantograph on the overhead contact line being assessed. Simulations are done using a simulation tool verified in accordance with EN 50318:2002, and measurements are done as set out in EN 50317:2012. The acceptance criteria from the measurement tests are set out in table 4.2.12 of the TSI. Further information on the assessment process is set out in the draft revision prEN 50318:2016 Annex C.

3.16.4  The range of documentation such as an IC ISV and simulation may be used to demonstrate the mean contact force of the overhead contact line and allow a design assessment to be carried out.

<table>
<thead>
<tr>
<th>ENE TSI Specific Case</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7.4.2.9.5. Conformity assessment of OCL as component (P case)</strong></td>
</tr>
<tr>
<td>The national rules may define the procedure for conformity related to points 7.4.2.9.2 and 7.4.2.9.3 and associated certificates.</td>
</tr>
<tr>
<td>The procedure may include the conformity assessment of parts which are not subject to a specific case.</td>
</tr>
</tbody>
</table>

3.16.5  Within GB, due to gauge constraints, specific cases have been included to permit the use of NTRs. Where a specific case for the UK has been incorporated in an element that is defined in the ENE TSI as an IC, the regulations do not permit IC certification to be issued, where the NTR makes the IC more restrictive. Specific case 7.4.2.9.5 permits the use of an alternative approach. This is set out in GLRT1210 clause 3.9 which is equivalent to ‘A national procedure for the assessment and certification of components, which relate to Interoperability Constituents and UK/GB Specific Cases’ (see references). See Part 5 for further guidance.

3.16.6  Where IC certification would usually have been issued, this procedure permits the use of an ISV certificate. An element that has an ISV issued under this procedure can be treated as an IC for the purposes of assessment.

3.16.7  To avoid the need for expensive dynamic testing, the TSI permits that for speeds up to 120 km/h (for AC systems) an alternative method can be proposed to identify construction errors. The TSI does not
prescribe any particular methodology, and one such test could be standard commissioning tests measuring heights and staggers.

3.16.8 Although these tests are defined for a single pantograph, all pantographs on the train are to meet the value of \( F_{m} \) as set out in LOC & PAS TSI 4.2.8.2.9.7. Arrangement of Pantographs (RST Level). The design, set out in clause 4.2.13, is made taking into account the pantograph configurations that will be permitted to operate on the route.

3.16.9 A range of documentation such as an IC ISV and dynamic testing may be used to demonstrate the dynamic behaviour of the overhead contact line and allow a production assessment to be carried out.

### 3.17 Pantograph spacing for overhead contact line design

#### ENE TSI

**4.2.13. Pantograph spacing for overhead contact line design**

The overhead contact line shall be designed for a minimum of two pantographs operating adjacently, in such a way that minimum spacing centre line to centre line of adjacent pantographs heads is equal or lower than values set out in one column ‘A’, ‘B’, or ‘C’ selected from Table 4.2.13:

<table>
<thead>
<tr>
<th>Design speed [km/h]</th>
<th>AC Minimum distance [m]</th>
<th>3 kV DC Minimum distance [m]</th>
<th>1.5 kV DC Minimum distance [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>( v \geq 250 )</td>
<td>200</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>( 160 &lt; v &lt; 250 )</td>
<td>200</td>
<td>85</td>
<td>35</td>
</tr>
<tr>
<td>( 120 &lt; v \leq 160 )</td>
<td>85</td>
<td>85</td>
<td>35</td>
</tr>
<tr>
<td>( 80 &lt; v \leq 120 )</td>
<td>20</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>( v \leq 80 )</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

#### LOC & PAS TSI

**4.2.8.2.9.7. Arrangement of Pantographs (RST Level)**

(1) It is permissible for more than one pantograph to be simultaneously in contact with the overhead contact line equipment.

(2) The number of pantographs and their spacing shall be designed taking into consideration the requirements of current collection performance, as defined in clause 4.2.8.2.9.6 above.

(3) Where the spacing of 2 consecutive pantographs in fixed or predefined formations of the assessed unit is less than the spacing shown in clause 4.2.13 of the TSI Energy for the selected OCL design distance type, or where more than 2 pantographs are simultaneously in contact with the overhead contact line equipment, it shall be demonstrated by testing that the current collection quality as defined in clause...
4.2.8.2.9.6 above is met for the poorest performing pantograph (identified by simulations to be performed prior to that test).

(4) The OCL design distance type (A, B or C as defined in the clause 4.2.13 of the TSI Energy) selected (and therefore used for the test) shall be recorded in the technical documentation (see clause 4.2.12.2).

3.17.1 The requirements set out in Table 4.2.13 of the TSI may not be sufficient for the requirements of traffic expected to operate on the route. If there is an operational need, then the overhead contact line can be designed for a shorter distance between pantographs in relation to speed and/or more than two pantographs in operation. GLRT1210 sets out additional GB requirements in order to ensure compatibility with existing rolling stock.

3.17.2 Where trains operate with more than one pantograph, there may be limitations on the configuration and separation of pantographs. The maximum number of raised pantographs, the minimum spacing in the case of two or more pantographs, and the permitted speeds for each combination are recorded in the RINF.

3.17.3 The LOC & PAS TSI gives adequate flexibility in terms of the arrangement and numbers of pantographs, referring back to the minimum requirement identified in section 4.2.13 of the ENE TSI. The LOC & PAS TSI also states the need for the current collection criteria, as defined in 4.2.12 of ENE TSI, to be met for the poorest performing pantograph on the train.

3.17.4 A range of documentation such as an IC ISV and simulation may be used to demonstrate the pantograph spacing for overhead contact line and allow a design assessment to be carried out.

3.18 Contact wire material

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.14. Contact wire material</td>
</tr>
<tr>
<td>(1) The combination of contact wire material and contact strip material has a strong impact on the wear of contact strips and contact wire.</td>
</tr>
<tr>
<td>(2) Permissible contact strip materials are defined in point 4.2.8.2.9.4.2 of LOC&amp;PAS TSI.</td>
</tr>
<tr>
<td>(3) Permissible materials for contact wires are copper and copper-alloy. The contact wire shall comply with the requirements of EN 50149:2012, clauses 4.2, (excluding the reference to annex B of the standard) 4.3 and 4.6 to 4.8.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LOC&amp;PAS TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.8.2.9.4.2 Contact strip material</td>
</tr>
<tr>
<td>(1) The combination of contact wire material and contact strip material has a strong impact on the wear of contact strips and contact wire.</td>
</tr>
<tr>
<td>(2) Permissible contact strip materials are defined in point 4.2.8.2.9.4.2 of LOC&amp;PAS TSI.</td>
</tr>
<tr>
<td>(3) Permissible materials for contact wires are copper and copper-alloy. The contact wire shall comply with the requirements of EN 50149:2012, clauses 4.2, (excluding the reference to annex B of the standard) 4.3 and 4.6 to 4.8.</td>
</tr>
</tbody>
</table>
3.18.1 The TSI requires the overhead contact line material to allow the operation of pantographs fitted with contact strips as defined within clause 4.2.8.2.9.4.2 of the LOC & PAS TSI. Trains in GB currently operate with metal impregnated contact strips with a metal content of approximately 35%. Any new overhead contact line is designed to allow both plain carbon and metal impregnated carbon types of contact strips to operate.

3.18.2 The UIC undertook a project, COSTRIM (RSSB Project T876 - Testing of overhead line contact wire and collector strip wear) which looked at wear characteristics of different types of contact strip material. The project concluded that, although impregnating the carbon strips with copper increases the current collection capacity and weight, no difference in wear between the two types of contact strips was observed up to a metal content of 35% in mass (the highest level fully tested).

3.18.3 A range of documentation such as an IC ISV and suppliers’ delivery notes may be used to demonstrate the contact wire material and allow a design assessment to be carried out.

3.19 Phase separation sections

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.2.15. Phase separation sections</strong></td>
</tr>
<tr>
<td><strong>4.2.15.1. General</strong></td>
</tr>
<tr>
<td>(1) The design of phase separation sections shall ensure that trains can move from one section to an adjacent one without bridging the two phases. Power consumption of the train (traction, auxiliaries and no-load current of the transformer) shall be brought to zero before entering the phase separation section. Adequate means (except for the short separation section) shall be provided to allow a train that is stopped within the phase separation section to be restarted.</td>
</tr>
<tr>
<td>(2) The overall length D of neutral sections is defined in EN 50367:2012, clause 4. For the calculation of D clearances in accordance to EN 50119:2009, clause 5.1.3 and an uplift of S0 shall be taken into account.</td>
</tr>
<tr>
<td><strong>4.2.15.2. Lines with speed v ≥ 250 km/h</strong></td>
</tr>
<tr>
<td>Two types of designs of phase separation sections may be adopted, either:</td>
</tr>
<tr>
<td>(a) a phase separation design where all the pantographs of the longest TSI compliant trains are within the neutral section. The overall length of the neutral section shall be at least 402 m. For detailed requirements see EN 50367:2012, Annex A.1.2, or</td>
</tr>
<tr>
<td>(b) a shorter phase separation with three insulated overlaps as shown in EN 50367:2012, Annex A.1.4. The overall length of the neutral section is less than 142 m including clearances and tolerances.</td>
</tr>
<tr>
<td><strong>4.2.15.3. Lines with speed v &lt; 250 km/h</strong></td>
</tr>
<tr>
<td>The design of separation sections shall normally adopt solutions as described in EN 50367:2012, Annex A.1. Where an alternative solution is proposed, it shall be demonstrated that the alternative is at least as reliable.</td>
</tr>
</tbody>
</table>

3.19.1 In GB, a phase separation section is what has traditionally been called a neutral section and compliant to EN 50367:2012 Figure A.3 – Short neutral section. These provide a cost-effective solution in the space-constrained railway but are not suitable for all line speeds. Phase separation sections are not compatible with pantograph widths (along track) greater than 650 mm. GMRT2111 sets out the requirements for pantograph widths.

3.19.2 The TSI permits the use of other designs of phase separation sections. These designs are based upon multiple adjacent overlaps in the overhead contact line. Two designs are specified in the TSI – the first
4.2.15 2(a) specifies a design where the whole of the longest train is within the phase separation section and the spacing of the pantographs is not critical; however, unless a sophisticated control strategy is adopted, the whole train will lose power while traversing the phase separation section. The second type specified in 4.2.15 2(b) utilising at least three insulated overlaps relies for its operation on only some of the insulated overlaps being bridged simultaneously during the passage of an electric train. Where trains operate with more than one pantograph, there may be limitations on the configuration and separation of pantographs.

3.19.3 In GB, automatic control of power is required as phase and system separation sections are not designed to be traversed with the train drawing any current. See GLRT1210 for the requirements for compatibility between receivers on existing rolling stock and inductors (magnets) on trackside energy subsystem. A very small load of a voltage transformer on the train can remain connected to the line when traversing a phase separation section.

3.19.4 At present, automatic power control is implemented using the existing design of trackside magnets until ERTMS becomes more widely available, when it could be implemented using standard ERTMS elements. The ENE TSI clause 4.3.4 (3) mandates the use of ERTMS for control of power functions on the train. The CCS TSI states that use of these functions is optional. The ERA is aware of this inconsistency. The current practise is to utilise the APC system (receiver / inductor) as set out in GLRT1210, until a consistent solution can be found for a system controlled through ERTMS.

3.19.5 A range of documentation such as an IC ISV and designs may be used to demonstrate the phase separation sections of the overhead contact line and allow a design assessment to be carried out.

3.20 System separation sections

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.2.16. System separation sections</strong></td>
</tr>
<tr>
<td><strong>4.2.16.1. General</strong></td>
</tr>
<tr>
<td>(1) The design of system separation sections shall ensure that trains can move from one power supply system to an adjacent different power supply system without bridging the two systems. There are two methods for traversing system separation sections:</td>
</tr>
<tr>
<td>(a) with pantograph raised and touching the contact wire;</td>
</tr>
<tr>
<td>(b) with pantograph lowered and not touching the contact wire.</td>
</tr>
<tr>
<td>(2) The neighbouring Infrastructure Managers shall agree either (a) or (b) according to the prevailing circumstances.</td>
</tr>
<tr>
<td>(3) The overall length D of neutral sections is defined in EN 50367:2012, clause 4. For the calculation of D clearances in accordance to EN 50119:2009, clause 5.1.3 and an uplift of S0 shall be taken into account.</td>
</tr>
<tr>
<td><strong>4.2.16.2. Pantographs raised</strong></td>
</tr>
<tr>
<td>(1) Power consumption of the train (traction, auxiliaries and no-load current of the transformer) shall be brought to zero before entering the system separation section.</td>
</tr>
<tr>
<td>(2) If system separation sections are traversed with pantographs raised to the contact wire, their functional design is specified as follows:</td>
</tr>
<tr>
<td>(a) the geometry of different elements of the overhead contact line shall prevent pantographs short-circuiting or bridging both power systems;</td>
</tr>
</tbody>
</table>
(b) provision shall be made in the energy subsystem to avoid bridging of both adjacent power supply systems should the opening of the on-board circuit breaker(s) fail;

(c) variation in contact wire height along the entire separation section shall fulfil requirements set in EN 50119:2009, clause 5.10.3.

4.2.16.3. Pantographs lowered

(1) This option shall be chosen if the conditions of operation with pantographs raised cannot be met.

(2) If a system separation section is traversed with pantographs lowered, it shall be designed so as to avoid the electrical connection of the two power supply systems by an unintentionally raised pantograph.

3.20.1 The purpose of the system separation sections is to ensure that a vehicle passing through does not bridge two adjacent systems. In GB, there will be few system separation sections. If the systems are of the same type, then the requirements are similar to those set out for phase separation sections. This clause of the TSI does not deal with 25 kV AC to 600/750 V DC conductor rail interfaces. Any interface requirements in this respect are addressed by the relevant NTRs, GLRT1210 for AC systems and GLRT1212 for DC systems.

3.21 On-ground energy data collecting system

4.2.17. On-ground energy data collecting system

(1) Point 4.2.8.2.8 of LOC & PAS TSI contains the requirements for on-board Energy Measuring Systems (EMS) intended to produce and transmit the Compiled Energy Billing Data (CEBD) to an on-ground energy data collecting system.

(2) The on-ground energy data collecting system (DCS) shall receive, store and export CEBD without corrupting it.

(3) The specification related to interface protocols between EMS and DCS and transferred data format are an open point, which, in any case, shall be closed within 2 years after the entry into force of this Regulation.

4.2.8.2.8. On-board Energy Measurement System

(1) The on-board energy measurement system is the system for measurement of electric energy taken from or returned (during regenerative braking) to the overhead contact line (OCL) by the electric unit.

(2) On-board energy measurement systems shall comply with requirements of the Appendix D of this TSI.

(3) This system is suitable for billing purposes; the data provided by it shall be accepted for billing in all Member States.

(4) The fitment of an on-board energy measurement system, and of its on-board location function shall be recorded in the technical documentation described in clause 4.2.12.2 of this TSI; the description of on-board to ground communication shall be part of the documentation.
The maintenance documentation described in clause 4.2.12.3 of this TSI shall include any periodic verification procedure, in order to ensure the required accuracy level of the on-board energy measurement system during its lifetime.

3.21.1 The traction current measuring system in the merged TSIs has been split into two parts:
   a) On-ground energy data collecting system (DCS), set out in the ENE TSI.
   b) On-board energy measurement system (EMS) set out in the LOC & PAS TSI.

3.21.2 The ENE TSI requirements cross-reference to the on board (EMS) requirements within LOC & PAS TSI. The EMS’s output, the Compiled Energy Billing Data (CEBD), is to be transferred without corruption from the on-board EMS to an on-ground DCS. This data can be utilised for consumption based billing.

3.21.3 The protocol which enables the CEBD to be transferred between EMS and DCS is currently an open point.

3.21.4 This open point relates to the on-board to ground communication protocol and the structure and format of the data (for example, XML). The Regulation implementing the ENE TSI states that this open point is to be closed two years after the entry into force of this Regulation – the ENE TSI. The earliest date by which the open point will be closed is January 2017.

3.21.5 The EN 50463 series is currently in revision and will provide an interoperable protocol to support closure of this open point. This standard is now expected to be published during 2017, and as a result closure of the open point may be later than specified in the ENE TSI.

3.21.6 GMRT2132 sets out requirements for the EMS of vehicles operating over the GB mainline railway which are similar to those set out in the previously published CR LOC & PAS TSI. Pending closure of the open point in the TSIs, the UK has notified specific clauses of GMRT2132.

3.21.7 The ENE TSI does not require the on-ground energy data collecting system to be assessed by the notified body.

3.21.8 In addition, the Regulation implementing the TSI requires, in Article 9 point 4, that the Member State is to ensure that an on-ground settlement system capable to receive data from a DCS and accept it for billing, is implemented two years after the closing of the open points mentioned in point 4.2.17 of the Annex. The on-ground settlement system is to be able to exchange compiled energy billing data (CEBD) with other settlement systems, validate the CEBD and allocate the consumption data to the correct parties. This is to be done by taking into account the relevant legislation concerning the energy market.

### 3.22 Protective provisions against electric shock

**ENE TSI**

4.2.18. Protective provisions against electric shock

Electrical safety of the overhead contact line system and protection against electric shock shall be achieved by compliance with EN 50122-1:2011+A1:2011, clauses 5.2.1 (only for public areas), 5.3.1, 5.3.2, 6.1, 6.2 (excluding requirements for connections for track circuits) and regarding AC voltage limits for the safety of persons by compliance with 9.2.2.1 and 9.2.2.2 of the standard and regarding DC voltage limits by compliance with 9.3.2.1 and 9.3.2.2 of the standard.
6.2.4. Particular assessment procedures for energy subsystem

6.2.4.6. Assessment of the protective provisions against electric shock

1) For each installation it shall be demonstrated that the basic design of protective provisions against electric shock is in accordance with point 4.2.18.
2) In addition the existence of rules and procedures which ensure that the installation is installed as designed shall be checked.

ENE TSI Specific Case

7.4.2.9.4. Protective provisions against electric shock (4.2.18) (P case)

For upgrade or renewal of the existing energy subsystem or the construction of new energy subsystems on existing infrastructure, in place of the reference to EN50122-1:2011+A1:2011 clause 5.2.1, it is allowed to design the protective provisions against electric shock in accordance with the national technical rules notified for this purpose. Specific case for the United Kingdom of Great Britain and Northern Ireland, applying only to the mainline network in Great Britain.

LOC & PAS TSI

4.2.8.4. Protection against electrical hazards

1) Rolling stock and its electrically live components shall be designed such that direct or indirect contact with train staff and passenger is prevented, both in normal cases and in cases of equipment failure. Provisions described in the specification referenced in Appendix J-1, index 54 [EN 50153:2002] shall be applied in order to meet this requirement.

3.22.1 The requirement addresses one aspect of electrical safety. This aspect of electrical safety is also a requirement under Health and Safety legislation.

3.22.2 The TSI requires compliance with a number of clauses within EN 50122 1:2011. The special national condition for GB associated with EN 50122-1:2011 clause 5.2.1 is not to be used without a full risk assessment as indicated in the national forward to BS EN 50122-1:2011+A2:2016.

3.22.3 A relaxation of the requirements of EN 50122-1:2011 clause 5.2.1 is possible using the specific case 7.4.2.9.4, but this relaxation will need to demonstrate compliance with the requirements of the Electricity at Work Regulations.

3.22.4 Assessments are required to be undertaken at the design and development phase to ensure that the designs are in accordance with the requirements set out in 4.2.18 of the ENE TSI. Additionally, the existence of rules and procedures needs to be checked to ensure that the installations are constructed in accordance with the agreed design. No assessment is necessary at the production phase, provided the designs have been checked by an independent body, in accordance with Appendix B of the ENE TSI.

3.22.5 Any project including platforms will also need to consider the adequacy of the electrical clearances from the platform standing surface, to address the risk of direct contact electric shock from live parts of the OCL equipment and live parts mounted on the train roof. Information on these clearances can be found in GLRT1210 and GMRT2111 and their respective guidance notes.

3.22.6 For overbridges on lines with an OCL, there is a need to comply with the protective provisions for electrical safety to prevent direct contact electric shock from live parts of the OCL and pantograph. These provisions are set out in the Energy TSI and associated standard EN 50122 1:2011. Dependent upon the...
design, the bridge deck and parapet can be used to provide these protective provisions if they meet the relevant requirements set out in EN 50122-1:2011.

3.22.7 GB has specific cases defined within the INF TSI for both gauge and platform height (see section 4.3.3 of the ENE TSI) and this in turn makes compliance section 4.2.18 of the ENE TSI more complicated in areas of restrictive clearances.

3.22.8 A range of documentation such as system modelling reports, earthing and bonding system designs, electrical clearance designs, bridge designs etc may be used to demonstrate the protective provisions against electric shock and allow a design assessment to be carried out.

3.23 Interfaces with safety in rail tunnel TSI

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.2.2. Interfaces of this TSI with the Safety in railway tunnels TSI</td>
</tr>
<tr>
<td>TSI Requirements relating to the energy subsystem for safety in railway tunnels are set out in the TSI relating to Safety in railway tunnels.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SRT TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.2. Subsystem Energy</td>
</tr>
<tr>
<td>4.2.2.1. Segmentation of overhead line or conductor rails</td>
</tr>
<tr>
<td>This specification applies to tunnels of more than 5 km in length.</td>
</tr>
<tr>
<td>a) The traction energy supply system in tunnels shall be divided into sections, each not exceeding 5 km. This specification applies only if the signalling system permits the presence of more than one train in the tunnel on each track simultaneously.</td>
</tr>
<tr>
<td>b) Remote control and switching of each ‘switching section’ shall be provided.</td>
</tr>
<tr>
<td>c) A means of communication and lighting shall be provided at the switching location to enable safe manual operation and maintenance of the switching equipment.</td>
</tr>
<tr>
<td>4.2.2.2. Overhead line or conductor rail earthing</td>
</tr>
<tr>
<td>This specification applies to all tunnels of more than 1 km length.</td>
</tr>
<tr>
<td>(a) Earthing devices shall be provided at tunnel access points and, if the earthing procedures allow the earthing of a single section, close to the separation points between sections. These shall be either portable devices or manually or remotely controlled fixed installations.</td>
</tr>
<tr>
<td>(b) Communication and lighting means necessary for earthing operations shall be provided.</td>
</tr>
<tr>
<td>(c) Procedures and responsibilities for earthing shall be defined between the Infrastructure Manager and the emergency response services, based on the emergency scenarios considered within the emergency plan.</td>
</tr>
<tr>
<td>4.2.2.3. Electricity supply</td>
</tr>
<tr>
<td>This specification applies to all tunnels of more than 1 km length.</td>
</tr>
<tr>
<td>The electricity power distribution system in the tunnel shall be suitable for the emergency response services equipment in accordance with the emergency plan for the tunnel. Some national emergency response services groups may be self-sufficient in relation to power supply. In this case, the option of not</td>
</tr>
</tbody>
</table>
providing power supply facilities for the use of such groups may be appropriate. Such a decision, however, must be described in the emergency plan.

4.2.2.4. Requirements for electrical cables in tunnels
This specification applies to all tunnels of more than 1 km length.

In case of fire, exposed cables shall have the characteristics of low flammability, low fire spread, low toxicity and low smoke density. These requirements are fulfilled when the cables fulfil as a minimum the requirements of classification B2CA, s1a, a1, as per Commission Decision 2006/751/EC.

4.2.2.5. Reliability of electrical installations
This specification applies to all tunnels of more than 1 km length.

(a) Electrical installations relevant for safety (Fire detection, emergency lighting, emergency communication and any other system identified by the Infrastructure Manager or contracting entity as vital to the safety of passengers in the tunnel) shall be protected against damage arising from mechanical impact, heat or fire.

(b) The distribution system shall be designed to enable the system to tolerate unavoidable damage by (for example) energizing alternative links.

(c) Autonomy and reliability: an alternative power supply shall be available for an appropriate period of time after failure of the main power supply. The time required shall be consistent with the evacuation scenarios considered and included in the emergency plan.

3.23.1 This section applies to the infrastructure part of the subsystem energy, which has been placed in the SRT TSI.

3.23.2 The design of the energy subsystem is integrated into the tunnel design and supports the tunnel emergency design requirements.

3.23.3 The SRT TSI requires the use of low flammability, low fire spread, low toxicity and low smoke density cables in a tunnel environment.

3.23.4 For further guidance, see GI/GN7619 Guidance on the Safety in Railway Tunnels Technical Specification for Interoperability.

3.24 Functional and technical specifications of the interface

3.24.1 General requirements

From the standpoint of technical compatibility, the interfaces are listed in subsystem order as follows: rolling stock, infrastructure, control — command and signalling, and operation and traffic management.

3.24.1.1 This section of the TSI is a series of tables dealing with the inter-relations between the TSIs.
### 3.24.2 Interface with rolling stock subsystem

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference in the ENE TSI</th>
<th>Parameter</th>
<th>Reference in the LOC &amp; PAS TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage and frequency</td>
<td>4.2.3</td>
<td>Operation within range of voltages and frequencies</td>
<td>4.2.8.2.2</td>
</tr>
<tr>
<td>Parameters relating to supply system performance: — max train current — power factor of trains and the mean useful voltage</td>
<td>4.2.4</td>
<td>Max current from OCL</td>
<td>4.2.8.2.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Power factor</td>
<td>4.2.8.2.6</td>
</tr>
<tr>
<td>Current capacity, DC systems, trains at standstill</td>
<td>4.2.5</td>
<td>Maximum current at standstill</td>
<td>4.2.8.2.5</td>
</tr>
<tr>
<td>Regenerative braking</td>
<td>4.2.6</td>
<td>Regenerative brake with energy to OCL</td>
<td>4.2.8.2.3</td>
</tr>
<tr>
<td>Electrical protection coordination arrangements</td>
<td>4.2.7</td>
<td>Electrical protection of the train</td>
<td>4.2.8.2.10</td>
</tr>
<tr>
<td>Harmonics and dynamic effects for AC traction power supply systems</td>
<td>4.2.8</td>
<td>System energy disturbances for AC systems</td>
<td>4.2.8.2.7</td>
</tr>
<tr>
<td>Geometry of the overhead contact line</td>
<td>4.2.9</td>
<td>Working range in height of pantograph</td>
<td>4.2.8.2.9.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pantograph head geometry</td>
<td>4.2.8.2.9.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gauging</td>
<td>4.2.3.1</td>
</tr>
<tr>
<td>Mean contact force</td>
<td>4.2.10 Appendix D</td>
<td>Pantograph static contact force</td>
<td>4.2.8.2.9.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pantograph contact force and dynamic behaviour</td>
<td>4.2.8.2.9.6</td>
</tr>
<tr>
<td>Dynamic behaviour and quality of current collection</td>
<td>4.2.12</td>
<td>Pantograph contact force and dynamic behaviour</td>
<td>4.2.8.2.9.6</td>
</tr>
</tbody>
</table>
4.3.2 Interface with Rolling Stock subsystem.

<table>
<thead>
<tr>
<th>Reference in the ENE TSI</th>
<th>Reference in the LOC &amp; PAS TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pantograph spacing for overhead contact line design</td>
<td>4.2.13</td>
</tr>
<tr>
<td>Contact wire material</td>
<td>4.2.14</td>
</tr>
<tr>
<td>Separation sections: phase system</td>
<td>4.2.15 4.2.16</td>
</tr>
<tr>
<td>On-ground energy data collecting system</td>
<td>4.2.17</td>
</tr>
</tbody>
</table>

3.24.2.1 The table above has identified a number of clauses within the ENE TSI and the corresponding clauses within the LOC & PAS TSI, which relate to it.

4.3.3 Interface with Infrastructure subsystem.

<table>
<thead>
<tr>
<th>Reference in the ENE TSI</th>
<th>Reference in the INF TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pantographs gauge</td>
<td>4.2.10</td>
</tr>
</tbody>
</table>

3.24.3.1 The table above has identified a clause within the ENE TSI and the corresponding clause within the INF TSI, which relate to it.

3.24.3.2 The Infrastructure TSI has also a specific case for the GB mainline railway associated with platform heights, allowing GB to utilise an NTR instead. The platform height also impacts electrical clearances to be achieved at stations.

3.24.3.3 Although the ENE TSI does not specifically mention an interface with the PRM TSI, there may be indirect interfaces that need to be considered in electrification design such as the placement of overhead masts and other equipment on station platforms so as to facilitate compliance with the requirements set out in the PRM TSI.

4.3.4 Interface with control command and signalling subsystems

(1) The interface for power control is an interface between the energy and the rolling stock subsystems.

(2) However, the information is transmitted via the control-command and signalling subsystems and consequently the transmission interface is specified in the CCS TSI and the LOC & PAS TSI.
EAE TSI

(3) The relevant information to perform the switching of the circuit breaker, change of maximum train current, change of the power supply system and pantograph management shall be transmitted via ERTMS when the line is equipped with ERTMS.

(4) Harmonic currents affecting control-command and signalling subsystems are set out in the CCS TSI.

3.24.4.1 There is a presumption that the control of traction power and pantographs at a neutral section is part of the ERTMS signalling system. This has not been the case to-date in GB. ERTMS does include some functionality (sometimes called ‘post box functions’) that could be used for this application if it were chosen to do so in the future. These functions do not pass through information in all operational states.

3.24.4.2 The use of a bespoke Packet 44 protocol for control of traction power is considered to be compliant with the CCS TSI rather than the use of the specific functions in Packet 66. However, rather than having several bespoke systems, a single Packet 44 system could be utilised for the energy ‘post box functions’ and this can be nationally adopted within GB, once it has been agreed by others.

3.24.4.3 As noted under the phase separation system guidance, while the ENE TSI mandates the requirement for control through the ERTMS system, the CCS TSI states that it is an optional requirement. ERA are aware of this inconsistency. See guidance on phase separation section.

3.24.4.4 Existing practice is for an APC system to be utilised on the GB mainline railway to provide technical compatibility with existing rolling stock when passing through neutral sections. GLRT1210 sets out the requirements associated with the APC system.

3.24.4.5 In terms of harmonics, the difficult issue of compatibility between rolling stock and signalling, connected by the power supply arrangements, is assumed to be addressed in the CCS TSI. However, the CCS TSI does not address the issue of harmonic interaction with the energy subsystem, which is dealt with by clause 4.2.8. of the ENE TSI (see guidance on harmonics and dynamic effects for AC traction power supply systems).

3.24.5 Interface with operation and traffic management subsystem

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Reference in the ENE TSI</th>
<th>Reference in the OPE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum train</td>
<td>4.2.4.1</td>
<td>4.2.2.5</td>
</tr>
<tr>
<td>Separation sections System</td>
<td>4.2.15</td>
<td>4.2.2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.2.1.2.2.1</td>
</tr>
<tr>
<td>Train composition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation of the Route Book</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preparation of the Route Book</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.24.5.1 This requirement is addressed through documentation following agreement between the IM and train operators.

3.24.5.2 There is a relationship with normal and perturbed timetable running and maximum peak current. The traffic management system will need to work within the limitations of the energy system as defined.
within the RINF. In all service conditions, the IM is required to operate the energy subsystem within its authorised design capabilities.

### 3.24.6 Operating rules

**ENE TSI**

4.4. Operating rules

(1) Operating rules are developed within the procedures described in the infrastructure manager safety management system. These rules take into account the documentation related to operation, which forms a part of the technical file, as required in Article 18(3) and as set out in Annex VI of Directive 2008/57/EC.

(2) In certain situations involving pre-planned works, it may be necessary to temporarily derogate from the specifications of the energy subsystem and its interoperability constituents defined in Sections 4 and 5 of the TSI.

3.24.6.1 This requirement is addressed through documentation and forms part of the IM’s safety management system.

### 3.24.7 Maintenance rules

**ENE TSI**

4.5. Maintenance rules

(1) Maintenance rules are developed within the procedures described in the infrastructure manager safety management system.

(2) The maintenance file for ICs and subsystem elements shall be prepared before placing a subsystem into service as the part of the technical file accompanying the declaration of verification.

(3) The maintenance plan shall be drawn up for the subsystem to ensure that the requirements set out in this TSI are maintained during its lifetime.

6.2.4. Particular assessment procedures for energy subsystem

6.2.4.7. Assessment of maintenance plan

(1) The assessment shall be carried out by verifying the existence of the maintenance plan.

(2) The notified body is not responsible for assessing the suitability of the detailed requirements set out in the plan.

3.24.7.1 The IM is required to prepare a maintenance plan, which is based on the technical file, to ensure that the system is maintained so that it remains compliant with the TSI specification at authorisation during its service life.

3.24.7.2 The ENE TSI specifies that the NoBo does not audit the maintenance plan but only verifies that it exists.
3.24.8 Professional qualifications

The professional qualifications of staff required for the operation and maintenance of the energy subsystem are covered by the procedures described in the infrastructure manager safety management system and are not set out in this TSI.

3.24.8.1 No further guidance is provided.

3.24.9 Health and safety conditions

(1) The health and safety conditions of staff required for the operation and maintenance of the energy subsystem shall be compliant with the relevant European and national legislation.

(2) This issue is also covered by the procedures described in the infrastructure manager safety management system

3.24.9.1 No further guidance is provided.
### Part 4 Guidance on ENE TSI Chapter 5 - Interoperability Constituents (IC)

#### 4.1 List of constituents

4.1.1 General

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5 Interoperability Constituents</strong></td>
</tr>
<tr>
<td><strong>5.1 List of constituents</strong></td>
</tr>
<tr>
<td>1) The interoperability constituents are covered by the relevant provisions of Directive 2008/57/EC and they are listed here below for the energy subsystem.</td>
</tr>
<tr>
<td>(2) Overhead contact line:</td>
</tr>
<tr>
<td>(a) The interoperability constituent overhead contact line consists of the components listed below to be installed within an energy subsystem and the associated design and configuration rules.</td>
</tr>
<tr>
<td>(b) The components of an overhead contact line are an arrangement of wire(s) suspended over the railway line for supplying electricity to electric trains, together with associated fittings, in-line insulators and other attachments including feeders and jumpers. It is placed above the upper limit of the vehicle gauge, supplying vehicles with electrical energy through pantographs.</td>
</tr>
<tr>
<td>(c) The supporting components such as cantilevers, masts and foundations, return conductors, auto-transformer feeders, switches and other insulators are not part of the interoperability constituent overhead contact line. They are covered by subsystem requirements so far as interoperability is concerned.</td>
</tr>
<tr>
<td>(3) The conformity assessment shall cover the phases and characteristics as indicated in point 6.1.4 and by X in the Table A.1 of Appendix A to this TSI.</td>
</tr>
</tbody>
</table>

4.1.1.1 This chapter introduces the main aspect of the Interoperability Directive 2008/57/EC, to ensure free movement of vehicles and goods across EU borders. The energy subsystem only has one interoperable constituent, overhead contact line.

4.1.1.2 Overhead contact line, clause 5.1 (2) (b) of the ENE TSI, can be summarised as being all wires, associated equipment and the design rules, which would have an impact on the dynamic movement of a pantograph(s) collecting power from it. Conversely, clause 5.1 (2) (c) lists items of the overhead contact line system that can be excluded from the IC assessment.

4.1.1.3 The requirements for the conformity assessment are defined within 6.1.4 and by Table A.1 (denoted with X). Further guidance regarding how this is applied within GB has been provided under the relevant sections below.

4.1.2 Constituents’ performances and specifications

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5 Interoperability Constituents</strong></td>
</tr>
<tr>
<td><strong>5.2 Constituents’ performances and specifications</strong></td>
</tr>
<tr>
<td><strong>5.2.1. Overhead contact line</strong></td>
</tr>
</tbody>
</table>
5.2.1.1 Geometry of the OCL
The design of the overhead contact line shall comply with point 4.2.9.

5.2.1.2 Mean contact force
The overhead contact line shall be designed by using the mean contact force Fm stipulated in point 4.2.11.

5.2.1.3 Dynamic behaviour
Requirements for dynamic behaviour of the overhead contact line are set out in point 4.2.12.

5.2.1.4 Space for steady arm uplift
The overhead contact line shall be designed providing the required space for uplift as set out in point 4.2.12.

5.2.1.5 Pantograph spacing for overhead contact line design
The overhead contact line shall be designed for pantograph spacing as specified in point 4.2.13.

5.2.1.6 Current at standstill
For DC systems, the overhead contact line shall be designed for the requirements set out in point 4.2.5.

5.2.1.7 Contact wire material
The contact wire material shall comply with the requirements set out in point 4.2.14.

4.1.2.1 This repeats the requirements in Part 4 in relation to the interoperability constituent OCL, which can be assessed independently of a particular application. These are the criteria that determine the certificate of conformity for an IC. The pantograph is also an IC in the LOC & PAS TSI.

4.1.2.2 In order to obtain IC status, the OCL has to meet certain performance and specification requirements. Clause 5.2 defines these performance and specification requirements and points back to the relevant technical requirements within section 4 of the TSI. The key parameters are as follows:

a) Geometry of the OCL.
b) Mean contact force.
c) Dynamic behaviour.
d) Space for steady state arm uplift.
e) Pantograph spacing for OCL.
f) Current at standstill (DC systems).
g) Contact wire material.

4.1.2.3 Within GB, due to gauge constraints, specific cases have been granted to permit the use of NTRs. Where a specific case for the UK has been incorporated in an element that is defined in the TSI as an IC, the regulations do not permit IC certification to be issued, where the NTR makes the IC more restrictive. Specific case 7.4.2.9.5 permits the use of an alternative approach. This is set out in GLRT1210 clause 3.9, which is equivalent to the more general process set out in ‘A national procedure for the assessment and certification of components, which relate to Interoperability Constituents and UK/GB Specific Cases’ (see references).

4.1.2.4 Where IC certification would usually have been issued, this procedure permits the use of an Intermediate Statement of Verification (ISV) certificate. An element that has an ISV issued under this procedure can be treated as an IC for the purposes of assessment.
5.1 Interoperability constituents

5.1.1 Conformity assessment procedures

<table>
<thead>
<tr>
<th>ENE TSI</th>
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<tbody>
<tr>
<td>6 Assessment of conformity of the interoperability constituents and EC verification of the subsystems</td>
</tr>
<tr>
<td>6.1 Interoperability constituents</td>
</tr>
<tr>
<td>6.1.1. Conformity assessment procedures</td>
</tr>
<tr>
<td>(1) The conformity assessment procedures of interoperability constituents as defined in Section 5 of this TSI shall be carried out by application of relevant modules.</td>
</tr>
<tr>
<td>(2) Assessment procedures for particular requirements for interoperability constituent are set out in point 6.1.4.</td>
</tr>
</tbody>
</table>

5.1.1.1 For some projects seeking an authorisation, potential difficulties have been encountered in the conformity assessment process regarding interoperability constituents. The ENE TSI contains specific cases for the requirements of the interoperability constituent (either described in the TSI itself or in a national rule). Notified bodies have identified issues in certifying interoperability constituents where they are built according to the specific case. The two main issues/questions that were identified are:

a) Whether the constituent, if built to the requirements of a specific case not necessarily fully compliant with the main part of the TSI (chapters 4 and 5), may be considered as an interoperability constituent, as the latter is meant to have an EU-wide application, and not only in one Member State.

b) How the assessment and authorisation might be carried out in the case where the specific case requirements are fully described in the TSI, or where the specific case in the TSI refers to the NTRs.

5.1.1.2 The UK requested the ERA to issue a technical opinion on how interoperability constituents are certified when they need to meet the requirements resulting from a specific case. The response from the ERA and the process to follow are described in a ‘National procedure for the assessment and certification of components which relate to Interoperability Constituents and UK/GB Specific Cases’ which has been developed to address the problem and gives projects a way of dealing with this issue (see references).

5.1.1.3 Refer to *dynamic behaviour and quality of current collection* for further information on assessment.

5.1.1.4 Typically, IC ISV OLE will only require reassessment when any change in component in the OLE would result in a change of the performance of the OLE.

5.1.2 Application of modules

<table>
<thead>
<tr>
<th>ENE TSI</th>
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<tbody>
<tr>
<td>6 Assessment of conformity of the interoperability constituents and EC verification of the subsystems</td>
</tr>
<tr>
<td>6.1 Interoperability constituents</td>
</tr>
<tr>
<td>6.1.2. Application of modules</td>
</tr>
</tbody>
</table>
ENIE TSI

(1) The following modules for conformity assessment of interoperability constituents are used:
(a) CA Internal production control
(b) CB EC type examination
(c) CC Conformity to type based on internal production control
(d) CH Conformity based on full quality management system
(e) CH1 Conformity based on full quality management system plus design examination

Table 6.1.2 Modules for conformity assessment to be applied for ICs

<table>
<thead>
<tr>
<th>Procedures</th>
<th>Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placed on the EU market before entry in force of this TSI</td>
<td>CA or CH</td>
</tr>
<tr>
<td>Placed on the EU market after entry in force of this TSI</td>
<td>CB + CC or CH1</td>
</tr>
</tbody>
</table>

(2) The modules for conformity assessment of interoperability constituents shall be chosen from those shown in Table 6.1.2.

(3) In the case of products placed on the market before the publication of relevant TSIs, the type is considered to have been approved and therefore EC type examination (module CB) is not necessary, provided that the manufacturer demonstrates that tests and verification of interoperability constituents have been considered successful for previous applications under comparable conditions and are in conformity with the requirements of this TSI. In this case these assessments shall remain valid in the new application. If it is not possible to demonstrate that the solution is positively proven in the past, the procedure for ICs placed on the EU market after publication of this TSI applies.

5.1.2.1 Module CB has been used previously within GB mainline railway.

5.1.2.2 No further guidance is provided.

5.1.3 Innovative solutions for interoperability constituents

5.1.3.1 In order to keep pace with technological progress and encourage modernisation, innovative solutions for an IC may be permitted or promoted and their implementation, under certain conditions, allowed.

5.1.3.2 Where an innovative solution is proposed, the manufacturer or their authorised representative is required to state how it deviates from or how it complements the relevant section of the TSI. Guidance from the Member State (DfT for GB) may be sought before submitting an innovative solution proposal.
5.1.3.3 The innovative solution is assessed by the Commission, and the Commission may request the opinion of the ERA on the proposed innovative solution. If this assessment is positive, the ERA is required to devise the functional and interface specifications of the innovative solution and develop the relevant assessment methods. These will need to be included in future versions of the TSI in order to allow the use of the innovative solution.

5.1.4 Particular assessment procedure for the interoperability constituent — overhead contact line

**ENE TSI**

### 6.1.4. Particular assessment procedure for the interoperability constituent — overhead contact line

#### 6.1.4.1. Assessment of dynamic behaviour and quality of current collection

**Methodology:**

(a) The assessment of the dynamic behaviour and the quality of the current collection involves the overhead contact line (energy subsystem) and the pantograph (rolling stock subsystem).

(b) Compliance with the requirements on dynamic behaviour shall be verified by assessment of:

- Contact wire uplift - and either:
  - Mean contact force $F_m$ and standard deviation $\sigma_{max}$
  - Percentage of arcing

(c) The Contracting Entity shall declare the method to be used for verification.

(d) The design of overhead contact line shall be assessed with a simulation tool validated according with EN 50318:2002 and by measurement according to EN 50317:2012.

(e) If an existing OCL design has been in operation for at least 20 years, then the requirement for simulation defined in the point (2) is optional. The measurement as defined in point (3) shall be carried out for the worst case arrangements of the pantographs regarding the interaction performance of this particular OCL design.

(f) The measurement can be conducted on a specially constructed test section or on a line where the overhead contact line is under construction.

**Simulation:**

(a) For the purposes of simulation and analysis of the results, representative features (for example tunnels, crossovers, neutral sections etc.) shall be taken into account.

(b) The simulations shall be made using at least two different TSI compliant types of pantograph for the appropriate speed (1) and supply system, up to the design speed of the proposed interoperability constituent overhead contact line.

(c) It is allowed to perform the simulation using types of pantograph that are under the process of IC certification, provided that they fulfil the other requirements of LOC&PAS TSI.

(d) The simulation shall be performed for single pantograph and multiple pantographs with spacing according to the requirements set in point 4.2.13.

(e) In order to be acceptable, the simulated current collection quality shall be in accordance with point 4.2.12 for uplift, mean contact force and standard deviation for each of the pantographs. (1) i.e. the speed of the two types of pantograph shall be at least equal to the design speed of the simulated overhead contact line.

**Measurement:**
(a) If the simulation results are acceptable, a site dynamic test with a representative section of the new overhead contact line shall be undertaken.

(b) This measurement can be done before putting into service or under full operation conditions.

(c) For the above mentioned site test, one of the two types of the pantograph chosen for the simulation shall be installed on a rolling stock that allows the appropriate speed on the representative section.

(d) The tests shall be performed at least for the worst case arrangements of the pantographs regarding the interaction performance derived from the simulations. If it is not possible to test using spacing between pantographs of 8 m, then it is permissible, for tests at speeds of up to 80 km/h, to increase the spacing between two consecutive pantographs to up to 15 m.

(e) The mean contact force of each pantograph shall fulfil the requirements of the point 4.2.11 up to envisaged design speed of the OCL under test.

(f) In order to be acceptable, the measured current collection quality shall be in accordance with point 4.2.12, for uplift, and either the mean contact force and standard deviation or percentage of arcing.

(g) If all the above assessments are passed successfully, the tested overhead contact line design shall be considered to be compliant and may be used on lines where the characteristics of the design are compatible.

(h) Assessment of dynamic behaviour and quality of current collection for interoperability constituent pantograph is set out in the point 6.1.3.7 of the LOC & PAS TSI.

6.1.4.2. Assessment of current at standstill.

The conformity assessment shall be carried out in accordance with EN 50367:2012, Annex A.3 for the static force defined in point 4.2.5.

5.1.4.1 Dynamic behaviour and quality of current collection is a key criterion for the pantograph OCL interface. It determines whether the train is collecting adequate current and able to operate within its normal envelope, and determines the wear on both the pantograph and OCL’s contact wire.

5.1.4.2 The assessment of the OCL as an IC or, where a specific case is used, an ISV, is carried out at both the design and development phases. Firstly, a review of the design through simulation and dynamic assessment and then through measurement during testing on a representative section of the route. Construction testing is to identify any shortcomings during installation; however, dynamic testing could be undertaken alongside if deemed appropriate. Further information on the assessment process is set out in the draft revision prEN 50318:2016 Annex C.

5.1.4.3 Simulation is undertaken on a representative section of the route, including features, utilising models of two different types of TSI compliant pantographs which are either ICs, in the process of getting IC status or, where a specific case is used, an ISV status in place of an IC.

5.1.4.4 Simulations need to be undertaken for single and multiple pantograph configuration, as in 4.2.13 of the ENE TSI, at appropriate speeds; however, for the GB mainline railway, the spacing has been modified as set out in GLRT1210 to allow for technical compatibility with other types of rolling stock used in GB that are not covered in the minimum TSI specifications. The simulation acceptance criteria are defined in 6.1.4.1 clause 2(e) and clause 3(f).

5.1.4.5 Once the simulation results are satisfactory, then measurement tests are undertaken as per 6.1.4.1 clause 1(b), utilising one of the simulated pantographs. The measurements are to validate the modelled output, and if they agree it supports that the use of the simulated values for generic application.

Measurement tests are done for the worse case situation identified by the simulation. The tests are to be done on a representative section of a track (dedicated or where a new line is being electrified / constructed).
5.1.4.6 The ERA has indicated during discussions on minor changes to IC OLE that it would expect that the IC would only require to be reassessed if that change would result in a change to the performance of the IC. The same procedure could be applied to an ISV being used in place of the IC process.

5.1.5 EC declaration of conformity of interoperability constituent OCL

ENETSI

6.1 Interoperability constituents

6.1.5. EC declaration of conformity of interoperability constituent OCL

According to Annex IV, Section 3 of Directive 2008/57/EC, the EC declaration of conformity shall be accompanied by statement setting out the condition of use:

(a) maximum design speed;
(b) nominal voltage and frequency;
(c) nominal current rating;
(d) accepted pantograph profile.

5.1.5.1 The requirements stated are applicable to the situation of an ISV used for an IC that uses a specific case.

5.1.6 General provisions

ENETSI

6.2 Energy subsystem

6.2.1. General provisions

(1) At the request of the applicant, the notified body carries out EC verification in accordance with Article 18 of Directive 2008/57/EC and in accordance with the provisions of the relevant modules.

(2) If the applicant demonstrates that tests or verifications of an energy subsystem have been successful for previous applications of a design in similar circumstances, the notified body shall take these tests and verifications into account for the EC verification.

(3) Assessment procedures for particular requirements for subsystem are set out in point 6.2.4.

(4) The applicant shall draw up the EC declaration of verification for the energy subsystem in accordance with Article 18(1) of and Annex V to Directive 2008/57/EC.

5.1.6.1 As part of the 4th railway package, Directive 2008/57/EC has been recast into 2016/797, the references are now to Article 15 (1) and Annex IV with respect to (4) above.

5.1.7 Application of modules

ENETSI

6.2.2. Application of modules

For the EC verification procedure of the energy subsystem, the applicant or its authorised representative established within the Community may choose either:
(a) Module SG: EC verification based on unit verification, or
(b) Module SH1: EC verification based on full quality management system plus design examination.

6.2.2.1. Application of module SG In case of module SG, the notified body may take into account evidence of examinations, checking or tests that have been successfully performed under comparable conditions by other bodies or by (or on behalf of) the applicant.

6.2.2.2. Application of module SH1 The module SH1 may be chosen only where the activities contributing to the proposed subsystem to be verified (design, manufacturing, assembling, installation) are subject to a quality management system for design, production, final product inspection and testing, approved and surveyed by a notified body.

5.1.7.1 The conformity assessment procedures are set out in the 2008/57/EC Directive (as modified) Annexes IV, V, and VI.

5.1.7.2 The conformity assessment modules are described separately and are generic in their application to the different subsystems; Commission Decision 2010/713/EU describes the requirements within each of the modules.

5.1.8 Innovative solutions

5.1.8.1 In order to keep pace with technological progress and encourage modernisation, innovative solutions may be permitted or promoted and their implementation, under certain conditions, allowed.

5.1.8.2 Innovative solutions may relate to the subsystem, its parts and its interoperability constituents.

5.1.8.3 Where an innovative solution is proposed, the manufacturer or their authorised representative is required to state how it deviates from or complements the relevant section of the TSI. Guidance from the Member State (DfT for GB) may be sought before submitting an innovative solution proposal.

5.1.8.4 The innovative solution is assessed by the Commission, and the Commission may request the opinion of the ERA on the proposed innovative solution. If this assessment is positive, the ERA is required to devise the functional and interface specifications of the innovative solution and develop the relevant assessment methods. These will need to be included in future versions of the TSI in order to allow the use of the innovative solution.

5.1.9 Particular assessment procedures

5.1.9.1 Guidance has been provided on assessment procedures in Part 3.
5.1.10 Subsystem containing interoperability constituents not holding an EC declaration

ENE TSI

6.3 Sub-system containing interoperability constituents not holding an EC declaration

6.3.1. Conditions

(1) Until 31 May 2021, a notified body is allowed to issue an EC certificate of verification for a subsystem, even if some of the interoperability constituents incorporated within the subsystem are not covered by the relevant EC declarations of conformity and/or suitability for use according to this TSI, if the following criteria are complied with:

(a) the conformity of the subsystem has been checked against the requirements of Section 4 and in relation to points 6.2 and 6.3 and Section 7, except point 7.4, of this TSI by the notified body. Furthermore the conformity of the ICs to Section 5 and point 6.1 does not apply, and

(b) the interoperability constituents, which are not covered by the relevant EC declaration of conformity and/or suitability for use, have been used in a subsystem already approved and put in service in at least one of the Member State before the entry in force of this TSI.

(2) EC Declarations of conformity and/or suitability for use shall not be drawn up for the interoperability constituents assessed in this manner.

ENE TSI

6.3.2. Documentation

(1) The EC certificate of verification of the subsystem shall indicate clearly which interoperability constituents have been assessed by the notified body as part of the subsystem verification.

(2) The EC declaration of verification of the subsystem shall indicate clearly:

(a) which interoperability constituents have been assessed as part of the subsystem,

(b) confirmation that the subsystem contains the interoperability constituents identical to those verified as part of the subsystem,

(c) for those interoperability constituents, the reason(s) why the manufacturer did not provide an EC declaration of conformity and/or suitability for use before its incorporation into the subsystem, including the application of national rules notified under Article 17 of Directive 2008/57/EC.

5.1.10.1 The requirement stated above are equally applicable to an ISV used in place of an IC that uses a specific case.

5.1.11 Maintenance of the subsystems certified according to 6.3.1

ENE TSI

6.3.3. Maintenance of the subsystems certified according to 6.3.1

(1) During and after the transition period and until the subsystem is upgraded or renewed (taking into account the decision of Member State on application of TSIs), the interoperability constituents which do not hold an EC declaration of conformity and/or suitability for use and are of the same type are allowed to be used as maintenance related replacements (spare parts) for the subsystem, under the responsibility of the body responsible for maintenance.
(2) In any case the body responsible for maintenance must ensure that the components for maintenance related replacements are suitable for their applications, are used within their area of use, and enable interoperability to be achieved within the rail system while at the same time meeting the essential requirements. Such components must be traceable and certified in accordance with any national or international rule, or any code of practice widely acknowledged in the railway domain.

5.1.11.1 While the system is being upgraded and / or renewed and, subject to authorisation by the Member State, non-certified maintenance related spares can be utilised so long as they are compatible with the originally installed system.

5.1.11.2 As set out in 6.3.3.(2), the TSI requires that the IM has a plan to ensure that any components used to maintain the system are both suitable for use and ensure that the system remains in the ‘authorised state’ maintaining interoperability within the rail system and meeting the essential requirements.
Part 6 Guidance on ENE TSI Chapter 7 - Implementation of the Energy TSI

6.1 Implementation of the Energy TSI

6.1.1 Implementation plan

<table>
<thead>
<tr>
<th>ENETSI</th>
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</thead>
<tbody>
<tr>
<td><strong>7 Implementation of the Energy TSI</strong></td>
</tr>
<tr>
<td>Member States shall develop a national plan for the implementation of this TSI, considering the coherence of the entire rail system of the European Union. This plan shall include all new, renewed and upgraded lines, in line with the details mentioned in points 7.1 to 7.4 here below.</td>
</tr>
</tbody>
</table>

| **7.1. Application of this TSI to railway lines** |
| Sections 4 to 6 and any specific provisions in points 7.2 to 7.3 here below apply in full to the lines within the geographical scope of this TSI, which will be placed in service as interoperable lines after this TSI enters into force. |

| **7.2 Application of this TSI to new, renewed or upgraded railway lines** |
| **7.2.1. Introduction** |
| (1) For the purpose of this section, a ‘new line’ means a line that creates a route where none currently exists. |
| (2) The following situations may be considered as an upgrade or renewal of existing lines: |
| (a) the realignment of part of an existing route; |
| (b) the creation of a bypass; |
| (c) the addition of one or more tracks on an existing route, regardless of the distance between the original tracks and the additional tracks. |
| (3) In accordance with the conditions laid down in Article 20(1) of Directive 2008/57/EC, the implementation plan indicates the way existing fixed installations defined in point 2.1 shall be adapted when it is economically justified to do so. |

| **7.2.2. Implementation plan for voltage and frequency** |
| (1) The choice of power supply system is a Member State’s competence. The decision should be taken on economic and technical grounds, taking into account at least the following elements: |
| (a) the existing power supply system in the Member State; |
| (b) any connection to railway line in neighbouring countries with an existing electrical power supply; |
| (c) power demand. |
| (2) new lines with speed greater than 250 km/h shall be supplied with one of the AC systems as defined in point 4.2.3. |

| **7.2.3. Implementation plan for OCL geometry** |
7.2.3.1. Scope of the implementation plan Member States’ implementation plan shall take into account the following elements:
(a) closing gaps between different OCL geometries;
(b) any connection to the existing OCL geometries in neighbouring areas;
(c) existing certified ICs OCL.

7.2.3.2. Implementation rules for 1 435 mm track gauge system The OCL shall be designed taking into account the following rules:
(a) New lines with speed greater than 250 km/h shall accommodate both pantographs as specified in the LOC & PAS TSI points 4.2.8.2.9.2.1 (1 600 mm) and 4.2.8.2.9.2.2 (1 950 mm). If this is not possible, the OCL shall be designed for use by at least a pantograph with the head geometry specified in the LOC & PAS TSI point 4.2.8.2.9.2.1 (1 600 mm).
(b) Renewed or upgraded lines with speed equal or greater than 250 km/h shall accommodate at least a pantograph with the head geometry specified in the LOC & PAS TSI point 4.2.8.2.9.2.1 (1 600 mm).
(c) Other cases: the OCL shall be designed for use by at least one of the pantographs with the head geometry specified in the LOC & PAS TSI points 4.2.8.2.9.2.1 (1 600 mm) or 4.2.8.2.9.2.2 (1 950 mm).

7.2.3.3. Track gauge systems different than 1 435mm The OCL shall be designed for use by at least one of the pantographs with the head geometry specified in the LOC & PAS TSI point 4.2.8.2.9.2.1.

6.1.1.1 The Member State has published the UK National Implementation Plan through the DfT website. The implementation plan provides the information required by the TSI in respect of currently authorised schemes.

6.1.2. Implementation of the on-ground energy data collecting system

Within 2 years after the ‘open point’ mentioned in point 4.2.17 is closed, Member States shall ensure that an on-ground energy data collecting system capable to exchange compiled energy billing data will be implemented.

6.1.2.1 The Member State’s UK National Implementation Plan is silent on this issue. Alternative arrangements are currently in place for the use of metered data for energy billing.

6.1.2.2 The process of implementation of the on-ground energy data collecting system is complex and involves actors outside the railway sector. It is to be undertaken with close cooperation of the energy and railway market regulators. It also refers not only to the adaptation of technical solutions but also influences the current national legal framework related to implementation of energy market directives, railway directives and other national legislations (such as fiscal). It is also important to define the role and responsibilities of railway entities (infrastructure managers and railway undertakings) in the energy market. The TSI requires that Member States shall ensure that an on-ground energy data collecting system capable of exchanging compiled energy billing data will be implemented within two years of closing the ‘open point’, as defined in 4.2.17 of the ENE TSI. The open point will be closed in 2017, and therefore the Member State has until about 2019 to have an on-ground energy data collecting system in place.
6.1.3 Application of this TSI to existing lines

7.3 Application of this TSI to existing lines

7.3.1. Introduction

In case this TSI shall apply to existing lines and without prejudice to point 7.4 (specific cases), the following elements shall be considered:

(a) Where Article 20(2) of Directive 2008/57/EC applies, Member States shall decide which requirements of the TSI shall apply, taking into account the implementation plan.

(b) Where Article 20(2) of Directive 2008/57/EC does not apply, compliance with this TSI is recommended. Where compliance is not possible, the contracting entity informs the Member State of the reason thereof.

(c) When a Member State requires a new authorisation for placing into service, the Contracting Entity shall define the practical measures and different phases of the project which are necessary to achieve the required levels of performance. These project phases may include transition periods for placing equipment into service with reduced levels of performance.

(d) An existing subsystem may allow the circulation of TSI-compliant vehicles whilst meeting the essential requirements of Directive 2008/57/EC. The procedure to be used for the demonstration of the level of compliance with the basic parameters of the TSI shall be in accordance with Commission Recommendation 2011/622/EU (1).

(1) Commission Recommendation 2011/622/EU of 20 September 2011 on the procedure demonstrating the level of compliance of existing railway lines with the basic parameters of the technical specifications for interoperability (OJ L 243, 21.9.2011, p. 23)

7.3.2. Upgrading/renewal of the OCL and/or the power supply

(1) It is possible to gradually modify all or part of the OCL and/or the power supply system — element by element — over an extended period of time to achieve compliance with this TSI.

(2) However, compliance of the entire subsystem can only be declared when all elements are compliant with the TSI over a complete section of route.

(3) The process of upgrading/renewal should take into consideration the need of maintaining compatibility with the existing energy subsystem and other subsystems. For a project including elements not being TSI compliant, the procedures for the assessment of conformity and EC verification to be applied should be agreed with the Member State.

6.1.3.1 The Member State has published the UK National Implementation Plan through the DfT website.

6.1.3.2 Projects are categorised as either ‘Upgrade’ or ‘Renewal’ based on an objective assessment normally undertaken by the Member State of whether the ‘overall performance of the subsystem’ is improved. With the energy subsystem, it is possible to gradually modify the OCL or the power supply system element by element, over an extended period of time. The expectation of the ERA and the Commission expressed in this clause is that, as the opportunity arises, new elements will be installed in such a way as to move towards the achievement of compliance with the ENE TSI and other TSIs over a period of time.

6.1.4 Parameters related to maintenance

7.3.3. Parameters related to maintenance
While maintaining the energy subsystem, formal verifications and authorisations for placing into service are not required. However, maintenance replacements may be undertaken, as far as reasonably practicable, in accordance with the requirements of this TSI contributing to the development of interoperability.

6.1.4.1 This primarily applies to the existing infrastructure that has not been upgraded or renewed. There is a requirement to ensure that maintenance replacements, as far as reasonably practicable, do not impede the ongoing convergence to TSI compliance.

6.1.5 Existing subsystem that are not subject to a renewal or upgrading project

7.3.4. Existing subsystem that are not subject to a renewal or upgrading project

The procedure to be used for the demonstration of the level of compliance of existing lines with the basic parameters of this TSI shall be in accordance with Commission Recommendation 2011/622/EU.

6.1.5.1 The commission recommendation 2011/622/EU has been repealed and replaced by 2014/881/EU (Commission Recommendation on the procedure demonstrating the level of compliance of existing railway lines with the basic parameters of the technical specifications for interoperability).

6.1.5.2 Commission recommendation 2014/881/EU describes arrangements for undertaking, on a voluntary basis, the assessment of existing lines for compliance with the ENE TSI parameters by an independent assessor and populating the RINF accordingly.

6.2 Specific cases

6.2.1 General

7.4. Specific cases

7.4.1. General

(1) The specific cases, as listed in point 7.4.2, describe special provisions that are needed and authorised on particular networks of each Member State.

(2) These specific cases are classified as:

— ‘P’ cases: ‘permanent’ cases,
— ‘T’ cases: ‘temporary’ cases, where it is planned that the target system is reached in the future.

7.4.2. List of specific cases

7.4.2.9. Particular features on the UK network for Great Britain

Text not reproduced – included with the relevant clause in part 4.
6.2.1.1 Specific cases are identified for each Member State separately. Guidance on those affecting the GB mainline railway specific cases have been provided alongside the clauses of Chapter 4 of the ENE TSI to which the specific case applies.

6.2.1.2 A specific case is any part of the rail system which needs special provisions in the TSIs, either temporary or definitive, because of geographical, topographical or urban environmental constraints or those affecting compatibility with the existing system. This may include, in particular, railway lines and networks isolated from the rest of the community, the loading gauge, the track gauge or space between the tracks and vehicles strictly intended for local, regional or historical use, as well as vehicles originating from or destined for third countries. (Article 2 (l) of Directive 2008/57/EC.). It is expected that a MS will notify a NTR to support a specific case, even though in some cases, the alternative arrangements are described in this section of the TSI.
### Guidance on ENE TSI Annexes

**7.1 Appendix A - Conformity assessment of interoperability constituents**

#### ENE TSI

**Appendix A - Conformity assessment of interoperability constituents**

**A.1 Scope**

This Appendix indicates the conformity assessment of interoperability constituent (overhead contact line) of the energy subsystem. For existing interoperability constituents, the process described in point 6.1.2. shall be followed.

**A.2 Characteristics**

The characteristics of the interoperability constituent to be assessed applying modules CB or CH1 are marked by an X in Table A.1. The production phase shall be assessed within the subsystem.

<table>
<thead>
<tr>
<th>Characteristic — point</th>
<th>Design review</th>
<th>Manufacturing process review</th>
<th>Test ((^2))</th>
<th>Product quality (series production)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geometry of the OCL — 5.2.1.1</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Mean contact force — 5.2.1.2 (1)</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Dynamic behaviour — 5.2.1.3</td>
<td>X</td>
<td>N/A</td>
<td>X</td>
<td>N/A</td>
</tr>
<tr>
<td>Space for steady arm uplift — 5.2.1.4</td>
<td>X</td>
<td>N/A</td>
<td>X</td>
<td>N/A</td>
</tr>
<tr>
<td>Pantograph spacing for overhead contact line design — 5.2.1.5</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Current at standstill — 5.2.1.6</td>
<td>X</td>
<td>N/A</td>
<td>X</td>
<td>N/A</td>
</tr>
<tr>
<td>Contact wire material — 5.2.1.7</td>
<td>X</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

N/A: not applicable
7.1.1 Appendix A of the ENE TSI provides a set of requirements related to assessment of the various stages of the development of the interoperability constituent: overhead contact line, and needs to be read in conjunction with the applicable assessment modules. It indicates when an assessment of each stage is required: at design review, manufacturing process review, test phase in production and when each individual element is required to be assessed. It also indicates where a specific assessment requirement is set out in Chapter 5 of the ENE TSI.

7.1.2 Where a specific case is used, the information in Appendix A of the ENE TSI is to be read in conjunction with GLRT1210, clause 3.9 and guidance provided under section 7.4.2.9.5 of the ENE TSI.

7.1.3 The ‘National procedure for the assessment and certification of components which relate to Interoperability Constituentsand UK/GB Specific Cases’ (see references) can be applied here.

7.2 Appendix B - EC verification of the energy subsystem

<table>
<thead>
<tr>
<th>Basic parameters</th>
<th>Assessment phase</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Design develop. phase</td>
</tr>
<tr>
<td></td>
<td>Design review</td>
</tr>
<tr>
<td>Voltage and frequency — 4.2.3</td>
<td>X</td>
</tr>
<tr>
<td>Parameters relating to supply system performance — 4.2.4</td>
<td>X</td>
</tr>
<tr>
<td>Current capacity, DC systems, trains — (1)</td>
<td>X (1)</td>
</tr>
</tbody>
</table>
Appendix B - EC verification of the energy subsystem

B.1 Scope

This Appendix indicates the EC verification of the energy subsystem.

B.2 Characteristics

The characteristics of the subsystem to be assessed in the different phases of design, installation and operation are marked by X in Table B.1.

<table>
<thead>
<tr>
<th>Table B.1</th>
<th>EC verification of the energy subsystem</th>
</tr>
</thead>
<tbody>
<tr>
<td>at standstill — 4.2.5</td>
<td></td>
</tr>
<tr>
<td>Regenerative braking — 4.2.6</td>
<td>X</td>
</tr>
<tr>
<td>Electrical protection coordination arrangements — 4.2.7</td>
<td>X</td>
</tr>
<tr>
<td>Harmonics and dynamic effects for AC traction power supply systems — 4.2.8</td>
<td>X</td>
</tr>
<tr>
<td>Geometry of the overhead contact line — 4.2.9</td>
<td>X (1)</td>
</tr>
<tr>
<td>Pantograph gauge — 4.2.10</td>
<td>X</td>
</tr>
<tr>
<td>Mean contact force — 4.2.11</td>
<td>X (1)</td>
</tr>
<tr>
<td>Dynamic behaviour and quality of current collection — 4.2.12</td>
<td>X (1)</td>
</tr>
<tr>
<td>Pantograph spacing for overhead contact line design — 4.2.13</td>
<td>X (1)</td>
</tr>
<tr>
<td>Contact wire material — 4.2.14</td>
<td>X (1)</td>
</tr>
<tr>
<td>Phase separation sections — 4.2.15</td>
<td>X</td>
</tr>
</tbody>
</table>
Appendix B - EC verification of the energy subsystem

B.1 Scope

This Appendix indicates the EC verification of the energy subsystem.

B.2 Characteristics

The characteristics of the subsystem to be assessed in the different phases of design, installation and operation are marked by X in Table B.1.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>X</th>
<th>N/A</th>
<th>N/A</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>System separation sections — 4.2.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-ground energy data collecting system — 4.2.17</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Protective provisions against electric shock — 4.2.18</td>
<td></td>
<td>X</td>
<td>X</td>
<td>N/A</td>
</tr>
<tr>
<td>Maintenance rules — 4.5</td>
<td>N/A</td>
<td>N/A</td>
<td>X</td>
<td>N/A</td>
</tr>
</tbody>
</table>

N/A: not applicable

(1) Only to be carried out if the overhead contact line has not been assessed as interoperability constituent.

(2) Validation under full operating conditions shall only be done when the validation in the phase ‘Assembly before putting into service’ is not possible.

(3) To be carried out as an alternative assessment method in case the dynamic behaviour of the OCL integrated into subsystem is not measured (see point 6.2.4.5)

(4) To be carried out in case the check is not done by another independent body.

7.2.1 Appendix B of the ENE TSI provides a set of requirements related to assessment of the various stages of the development of the energy subsystem and needs to be read in conjunction with the applicable assessment modules. It indicates when an assessment of each stage is required: at design review, construction, assembly, mounting, assembled, before putting into service, validation under full operating conditions and when each individual element is required to be assessed. It also indicates where a specific assessment requirement is set out in the ENE TSI Chapter 6.

7.2.2 Where a specific case set out in clause 7.4.2.9.5 of the ENE TSI is used and the assessment information given in Appendix B of the ENE TSI is to be read in conjunction with GLRT1210 clause 3.9 and guidance provided under section 7.4.2.9.5 of the ENE TSI, the assessment will be undertaken by a DeBo as it is against the requirements of a NTR.

7.2.3 For the correct interpretation of Table B.1 of the ENE TSI, the indication N/A is that the assessment is generally not performed by NoBo except in the situations set out below:
a) Geometry of the overhead contact line (4.2.9), in the column ‘Assembled before putting into service’, when an alternative assessment method is used as foreseen in point 6.2.4.5. (Assessment of dynamic behaviour and quality of current collection (integration into a subsystem)) of the ENE TSI; and

b) Dynamic behaviour and quality of current collection (4.2.12), in the column Validation under full operating conditions, when the validation in the phase ‘Assembly before putting into service’ is not possible due to limitation of operational speed on test track or unavailability of suitable rolling stock or infrastructure.

7.2.4 Guidance for point 6.2.4.5 of the ENE TSI is covered in Part 3 of this guidance note.

### 7.3 Appendix C - Mean useful voltage

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
</table>

#### Appendix C - Mean useful voltage

The minimum values for mean useful voltage at the pantograph under normal operating conditions shall be as given in Table C.1.

#### Table C.1

<table>
<thead>
<tr>
<th>Minimum $U_{\text{mean useful}}$ at pantograph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply system</td>
</tr>
<tr>
<td>Zone and train</td>
</tr>
<tr>
<td>AC 25 kV 50 Hz</td>
</tr>
<tr>
<td>AC 15 kV 16,7 Hz</td>
</tr>
<tr>
<td>DC 3 kV</td>
</tr>
<tr>
<td>DC 1,5 kV</td>
</tr>
</tbody>
</table>

#### C.2 Simulation Rules

- **Zone used for simulation to calculate $U_{\text{mean useful}}$**
  - Simulations shall be carried out on a zone which represents a significant part of a line or a part of the network, such as the relevant feeding section(s) in the network for the object to be designed and assessed.

- **Time period used for simulation to calculate $U_{\text{mean useful}}$**
  - For simulation of $U_{\text{mean useful}}$ (train) and $U_{\text{mean useful}}$ (zone) only trains that are part of the simulation during a relevant time, such as the time needed to go through a complete feeding section, have to be considered.

7.3.1 This table and the associated simulation rules are provided here because the values quoted in EN 50388:2012 do not align with the wording of this TSI. A revision to EN 50388:2012 is in progress to bring the standard into alignment with the TSI. The table set out in the ENE TSI takes precedence over the table in EN 50388:2012.
7.4 Appendix D - Specification of the pantograph gauge

### D.1 Specification of the mechanical kinematic pantograph gauge

#### D.1.1 General

**D.1.1.1 Space to be cleared for electrified lines**

In the case of lines electrified by an overhead contact line, an additional space should be cleared:

— to accommodate the OCL equipment,
— to allow the free passage of the pantograph.

This Appendix deals with the free passage of the pantograph (pantograph gauge). The electrical clearance is considered by the Infrastructure Manager.

#### D.1.1.2 Particularities

The pantograph gauge differs in some aspects from the obstacle gauge:

— The pantograph is (partly) live and, for this reason, an electrical clearance is to be complied with, according to the nature of the obstacle (insulated or not),
— The presence of insulating horns should be taken into account, where necessary. Therefore a double reference contour has to be defined to take account of the mechanical and electrical interference simultaneously,
— In collecting condition, the pantograph is in permanent contact with the contact wire and, for this reason, its height is variable. So is the height of the pantograph gauge.

The remainder of the text not reproduced

7.4.1 This calculation method is not used for the GB mainline railway because of the restricted gauge envelope. Calculation of gauge is the subject of the specific cases in the INF TSI (7.7.17. Particular features on the UK network for Great Britain and Appendix Q); the LOC & PAS TSI (7.3.2.2. Gauging Specific case the United Kingdom (Great Britain)) and ENE TSI Specific case (7.4.2.9.3. Maximum lateral deviation and pantograph gauge). The calculation method for the pantograph gauge that is used in GB is set out in GMRT2173 clause 3.4 and Appendix E. See also guidance G.3.14 Pantograph gauge on clause 4.2.10 of the ENE TSI.

7.5 Appendix E - List of referenced standards

<table>
<thead>
<tr>
<th>Index No.</th>
<th>Reference</th>
<th>Document name</th>
<th>Version</th>
<th>BP(s) concerned</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EN 50119</td>
<td>Railway applications —</td>
<td>2009</td>
<td>Current capacity, DC systems, trains</td>
</tr>
</tbody>
</table>
# Appendix E - List of referenced standards

## Table E.1 List of referenced standards

<table>
<thead>
<tr>
<th>Index No.</th>
<th>Reference</th>
<th>Document name</th>
<th>Version</th>
<th>BP(s) concerned</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>EN 50122-1:2011+A1:2011</td>
<td><strong>Railway applications —</strong> Fixed installations — Electric traction overhead contact lines</td>
<td>2011</td>
<td>Geometry of the overhead contact line (4.2.9) and Protective provisions against electric shock (4.2.18)</td>
</tr>
<tr>
<td>3</td>
<td>EN 50149</td>
<td><strong>Railway applications —</strong> Fixed installations — Electric traction — Copper and copper alloy grooved contact wires</td>
<td>2012</td>
<td>Contact wire material (4.2.14)</td>
</tr>
<tr>
<td>4</td>
<td>EN 50163</td>
<td><strong>Railway applications —</strong> Supply voltages of traction systems</td>
<td>2004</td>
<td>Voltage and frequency (4.2.3)</td>
</tr>
<tr>
<td>5</td>
<td>EN 50367</td>
<td><strong>Railway applications —</strong> Current collection systems — Technical criteria for the interaction between pantograph and overhead line (to 2012)</td>
<td>2012</td>
<td>Current capacity, DC systems, trains at standstill (4.2.5), Mean contact force (4.2.11), Phase separation sections (4.2.15) and System separation sections (4.2.16)</td>
</tr>
</tbody>
</table>
## Appendix E - List of referenced standards

### Table E.1 List of referenced standards

<table>
<thead>
<tr>
<th>Index No.</th>
<th>Reference</th>
<th>Document name</th>
<th>Version</th>
<th>BP(s) concerned</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>EN 50388</td>
<td>Railway applications — Power supply and rolling stock — Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability</td>
<td>2012</td>
<td>Parameters relating to supply system performance (4.2.4), Electrical protection coordination arrangements (4.2.7), Harmonics and dynamic effects for AC systems (4.2.8)</td>
</tr>
<tr>
<td>7</td>
<td>EN 50317</td>
<td>Railway applications — Current collection systems — Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line</td>
<td>2012</td>
<td>Assessment of dynamic behaviour and quality of current collection (6.1.4.1 and 6.2.4.5)</td>
</tr>
<tr>
<td>8</td>
<td>EN 50318</td>
<td>Railway applications — Current collection systems — Validation of simulation of the dynamic interaction between pantograph and overhead contact line</td>
<td>2002</td>
<td>Assessment of dynamic behaviour and quality of current collection (6.1.4.1)</td>
</tr>
</tbody>
</table>
### Appendix J - List of referenced standards

The following is the list of referenced ENs (from the LOC & PAS TSI, Appendix J) associated with Energy Subsystem and mentioned in this document.

<table>
<thead>
<tr>
<th>Index No.</th>
<th>Reference</th>
<th>Document name</th>
<th>Version</th>
<th>BP(s) concerned</th>
</tr>
</thead>
<tbody>
<tr>
<td>47</td>
<td>EN 50367</td>
<td>Railway applications — Current collection systems — Technical criteria for the interaction between pantograph and overhead line (to achieve free access)</td>
<td>2012</td>
<td>Pantograph head geometry (4.2.8.2.9.2.) Clause 5.3.2.2</td>
</tr>
<tr>
<td>48</td>
<td>EN 50367</td>
<td>Railway applications — Current collection systems — Technical criteria for the interaction between pantograph and overhead line (to achieve free access)</td>
<td>2012</td>
<td>Pantograph head geometry type 1600mm (4.2.8.2.9.2.1) Clause Annex A.2, figure A.6</td>
</tr>
<tr>
<td>53</td>
<td>EN 50388</td>
<td>Railway applications — Power supply and rolling stock — Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability</td>
<td>2012</td>
<td>Electrical protection of train – protection co-ordination (4.2.8.2.9.10), clause 11</td>
</tr>
</tbody>
</table>

7.5.1 A number of these standards have been updated from the issue mentioned within the ENE TSI. However, as these standards are dated references within the ENE TSI, assessment is against the version referenced.

7.5.2 No further guidance is provided.
7.6 Appendix F- List of open points

7.6.1 List of open points

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appendix F List of open points</strong></td>
</tr>
<tr>
<td>1) Specification related to interface protocols between energy measuring system (EMS) and data collecting system (DCS) (4.2.17).</td>
</tr>
</tbody>
</table>

7.6.1.1 Appendix F of the ENE TSI sets out the only open point in this TSI. Work is in hand at European level to close this open point by 2018.

7.6.2 Areas not covered by this TSI

7.6.2.1 The TSI is not a design guide and there is a need to capture other design and construction requirements from other sources. The TSIs only specify the requirements to the extent necessary to meet the objectives of the interoperability directive.

7.6.2.2 The following areas are identified as areas that are not covered by the TSI but may have interface implications and are typically considered when designing, constructing and maintaining the energy subsystem:

a) Short circuit fault levels.
b) Loss of line voltage and re-closure procedure.
c) Electrical insulation co-ordination.
d) Safety warning signs.
e) Electrical and mechanical clearances.

7.6.2.3 Requirements in these areas are set out in GLRT1210 for the GB mainline railway.

7.7 Appendix G - Glossary

7.7.1 Glossary

<table>
<thead>
<tr>
<th>ENE TSI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appendix G – Glossary</strong></td>
</tr>
<tr>
<td>Text not reproduced</td>
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</tbody>
</table>

7.7.1.1 See definitions section.
Appendices

Appendix A  Table of correspondence with national rules

Appendix A.1  The table below provides a cross reference between the requirements of the ENE TSI and the related national rules.

<table>
<thead>
<tr>
<th>Reference in the ENE TSI</th>
<th>Reference in GLRT1210 (specific case, open points, technical compatibility)</th>
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<tr>
<td>Voltage and frequency (and specific case 7.4.2.9.1)</td>
<td>4.2.3</td>
</tr>
<tr>
<td>Parameters relating to supply system performance:</td>
<td>4.2.4</td>
</tr>
<tr>
<td>a) max train current power factor of trains; and</td>
<td></td>
</tr>
<tr>
<td>b) the mean useful voltage</td>
<td></td>
</tr>
<tr>
<td>Current capacity, DC systems, trains at standstill</td>
<td>4.2.5</td>
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<tr>
<td>Regenerative braking</td>
<td>4.2.6</td>
</tr>
<tr>
<td>Electrical protection co-ordination arrangements</td>
<td>4.2.7</td>
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<tr>
<td>Harmonics and dynamic effects for AC traction power supply systems</td>
<td>4.2.8</td>
</tr>
<tr>
<td>Geometry of the overhead contact line - 4.2.9.1 Contact wire height (and specific case 7.4.2.9.2) and 4.2.9.2 maximum lateral deviation (and specific case 7.4.2.9.3)</td>
<td>4.2.9 (4.2.9.1 and 4.2.9.2)</td>
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<td></td>
</tr>
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<td></td>
<td>4.2.10</td>
</tr>
<tr>
<td>Pantograph gauge (and specific case 7.4.2.9.3)</td>
<td>Appendix D</td>
</tr>
<tr>
<td>Reference in the ENE TSI</td>
<td>Reference in GLRT1210 (specific case, open points, technical compatibility)</td>
</tr>
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<td>-------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Mean contact force</td>
<td>Quality of current collection</td>
</tr>
<tr>
<td>Dynamic behaviour and quality of current collection</td>
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</tr>
<tr>
<td>Paragraph spacing for overhead contact line design</td>
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<tr>
<td>Contact wire material</td>
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<td>Separation sections: Phase</td>
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<tr>
<td>Separation sections: System</td>
<td>Separation sections and section insulators</td>
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<tr>
<td>On-ground energy data collecting system</td>
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<tr>
<td>Protective provisions against electric shock (and specific case 7.4.2.9.4)</td>
<td>Contact line and current collector zones (and protective provisions against direct contact for 7.4.2.9.4)</td>
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</tbody>
</table>

3.2 (and 2.2.2)
**Definitions**

The terms set out below, include those used in the ERA Application Guide and Annex G – Glossary of the TSI. Many of these terms are defined in other documents; in these cases, the source of the definition is indicated.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Parameter</td>
<td>Any regulatory, technical or operational condition which is critical to interoperability and is specified in the relevant TSIs.</td>
</tr>
<tr>
<td>Compiled energy billing data</td>
<td>Dataset compiled by the Data Handling System (DHS) suitable for energy billing (ENE TSI).</td>
</tr>
<tr>
<td>Conformity</td>
<td>Compliance with applicable requirements of a product, process, service, system, person or body.</td>
</tr>
<tr>
<td>Conformity assessment</td>
<td>The process demonstrating whether specified requirements relating to a product, process, service, system, person or body have been fulfilled. Article R1(12), Annex 1 of Decision 768/2008/EC. Article 3, Definitions (13), of Decision 2010/713/EU.</td>
</tr>
<tr>
<td>Contact force</td>
<td>Vertical force applied by the pantograph to the OCL. BS EN 50367:2006.</td>
</tr>
<tr>
<td>Contact Line System</td>
<td>The system that distributes the electrical energy to the trains running on the route and transmits it to the trains by means of current collectors. ENE TSI.</td>
</tr>
<tr>
<td>Contact wire uplift</td>
<td>Vertical upward movement of the contact wire due to the force produced from the pantograph EN 50119:2009+A1:2013, ENE TSI.</td>
</tr>
<tr>
<td>Contracting Entity</td>
<td>Any entity, whether public or private, which orders the design and / or construction or the renewal or upgrading of a subsystem. This entity may be a railway undertaking, an infrastructure manager or a keeper, or the concession holder responsible for carrying out a project. Article 2 (r) of Directive 2008/57/EC.</td>
</tr>
<tr>
<td>Current Collector</td>
<td>Equipment fitted to the vehicle and intended to collect current from a contact wire or conductor rail IEC 60050-811, definition 811-32-01.</td>
</tr>
<tr>
<td>Designated Body(DeBo)</td>
<td>Designated Bodies are independent third parties appointed by the Secretary of State to assess and verify conformity of projects with Notified National Technical Rules (NNTRs) in the United Kingdom. They operate in tandem with Notified Bodies (NoBos) which assess and verify conformity with Technical Specifications for Interoperability (TSIs). DfT Interoperability Glossary.</td>
</tr>
<tr>
<td>Gauge</td>
<td>Set of rules, including a reference contour and its associated calculation rules allowing defining the</td>
</tr>
</tbody>
</table>
outer dimensions of the vehicle and the space to be cleared by the infrastructure. *ENE TSI.*

**Note:** According to the calculation method implemented, the gauge will be a static, kinematic or dynamic.

**GB mainline railway**

Mainline railway has the meaning given to it in the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (as amended) and the associated exclusions. GB Mainline Railway is the mainline railway network excluding any railway in Northern Ireland; the Channel Tunnel; the dedicated high speed railway between London St Pancras International Station and the Channel Tunnel; and any other exclusions determined by the member state.

**Infrastructure Manager (IM)**

Any ‘body’ or undertaking that is responsible in particular for establishing and maintaining railway infrastructure, or part thereof, as defined in article 3 of Directive 91/440/EEC, which may also include the management of infrastructure control and safety systems. The functions of the infrastructure manager on a network or part of a network may be allocated to different bodies or undertakings. *Article 3 (b) of Directive 2004/49/EC.*

**Interoperability constituents**

An elementary component, group of components, subassembly or complete assembly of equipment incorporated or intended to be incorporated into a subsystem. Interoperability constituents are placed on the market with an intended area of use and are assessed for conformity independently of the subsystem.

**Interoperability Constituent Intermediate Statement of Verification**

An Interoperability Constituent that requires the use of a specific case certified using an Intermediate Statement of Verification.

**Lateral deviation**

Deviation of the contact wire from the track centre line under action of a crosswind. *EN 50367:2012. ENE TSI.*

**Level crossing**

An intersection at the same elevation of a road, footpath or bridleway and one or more rail tracks. *IEV ref 821-07-01 – modified.*

**Line speed**

Maximum speed measured in kilometres per hour for which a line has been designed. *ENE TSI.*

**Maintenance plan**

A series of documents setting out the infrastructure maintenance procedures adopted by an infrastructure manager. *ENE TSI.*
Maximum contact wire height

Maximum possible contact wire height, which the pantograph is required to reach, in all conditions. EN 50119:2009+A1:2013.

Mean contact force

Statistical mean value of the contact force. BS EN 50367:2006.

Mean useful voltage train

Voltage identifying the dimensioning train and enables the effect on its performance to be quantified. ENE TSI.

Mean useful voltage zone

Voltage giving an indication of the quality of the power supply in a geographic zone during the peak traffic period in the timetable. ENE TSI.

Member State

The role of the government of a Member State of the European Union, typically the DfT for rail in Great Britain.

Minimum contact wire height

A minimum value of the contact wire height in the span in order to avoid the arcing between one or more contact wires and vehicles in all conditions. EN 50119:2009+A1:2013, ENE TSI.

Minimum design contact wire height

Theoretical contact wire height, including tolerances, designed to ensure that the minimum contact wire height is always achieved. EN 50119:2009+A1:2013.

National Technical Rule (NTR)

A technical rule used for implementing the essential requirements in the circumstances listed in Article 17(3) of the Railway Interoperability Directive 2008/57/EC.

Neutral section insulator

An assembly inserted in a continuous run of contact line for isolating two electrical sections from each other that maintains continuous current collection during pantograph passage. ENE TSI – incorrect definition.

Note: This definition is inaccurate but will be removed in a future revision as it is not used in the TSI.

Nominal contact wire height

A nominal value of the contact wire height at a support in the normal conditions. EN 50119:2009+A1:2013, ENE TSI.

Nominal voltage

Value of the voltage by which the electrical installation or part of the electrical installation is designated and identified. IEV-826-11-01

Normal service

Planned timetable service. ENE TSI.
Notified body: The bodies responsible for assessing the conformity or suitability for use of the interoperability constituents or for appraising the EC procedure for verification of the subsystems. Article 2 (j) of Directive 2008/57/EC.

On-ground energy data collecting system (data collecting service): On-ground service collecting the CEBD from an Energy Measurement System. ENE TSI.

Open Point: Parameters that have been formally identified as in scope of a TSI or Railway Group Standard for which no common requirement has been agreed.

ORR: Office of Rail and Road.

Project Entity: As defined in the Railways (Interoperability) Regulations 2011 (as amended): ‘project entity’ means, in relation to a project, a contracting entity or manufacturer or the authorised representative established in the EU of a contracting entity or manufacturer.’ Article 3 (a) of Directive 2004/49/EC.

Reference contour: A contour, associated to each gauge, showing the shape of a cross-section and used as a basis to work out the sizing rules of the infrastructure, on the one hand, and of the vehicle, on the other hand.

Register of Infrastructure (RINF): A register that shall be maintained for each TSI-certified line that describes the main features and requirements of each subsystem and their correlation with the relevant TSI.

Renewal: Any major substitution work on a subsystem or part subsystem, which does not change the overall performance of the subsystem. Article 2 (n) of Directive 2008/57/EC.

Return circuit: All conductors which form the intended path for the traction return current and the current under fault conditions. EN 50122-1:2011+A1:2011. All conductors which form the intended path for the traction return current. ENE TSI.

Return conductor: Conductor paralleling the track return system and connected to the running rails at periodic intervals. EN 50122-1:2011+A1:2011

Specific case: Any part of the rail system which needs special provisions in the TSIs, either temporary or definitive, because of geographical, topographical or urban
environment constraints or those affecting compatibility with the existing system. This may include, in particular, railway lines and networks isolated from the rest of the European Community, the loading gauge, the track gauge or space between the tracks and vehicles strictly intended for local, regional or historical use, as well as vehicles originating from or destined for third countries. Article 2 (l) of Directive 2008/57/EC.

**Static contact force**
Mean vertical force exerted upwards by the pantograph head on the OCL, and caused by the pantograph-raising device, while the pantograph is raised and the vehicle is at a standstill. BS EN 50367:2006.

**Substitution in the framework of maintenance**
Any replacement of components by parts of identical function and performance in the framework of preventive or corrective maintenance. Article 2 (p) of Directive 2008/57/EC.

**Train**
A ‘train’ is an operational formation consisting of one or more units. A Unit may be composed of several ‘vehicles’. Directive 2008/57/EC, Article 2(c). LOC&PAS TSI 2.2.1

**Note:** In GB application, an operational formation may consist of locomotives, wagons, coaches, multiple units or a single fixed formation unit and any combination thereof.

**Upgrade**
Any major modification work on a subsystem or part subsystem, which improves the overall performance of the subsystem. Article 2 (m) of Directive 2008/57/EC.

**Abbreviations**
Including selected abbreviations used in the ERA Application Guide.

- **AC** Alternating Current.
- **ADD** Auto Dropping Device.
- **APC** Automatic Power Control.
- **CCS** Control, Command and Signalling.
- **CEBD** Compiled Energy Billing Data.
- **DC** Direct Current.
- **DCS** On-ground energy data collecting system (data collecting service).
- **DeBo** Designated Body.
- **DFT** Department for Transport.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMC</td>
<td>Electromagnetic Compatibility.</td>
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<tr>
<td>EN</td>
<td>European Standards</td>
</tr>
<tr>
<td>ENE</td>
<td>Energy Subsystem.</td>
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<tr>
<td>ERTMS</td>
<td>European Rail Traffic Management System.</td>
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<tr>
<td>ETCS</td>
<td>European Train Control System.</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>EUAR</td>
<td>European Union Agency for Railways, formerly known as European Rail Agency.</td>
</tr>
<tr>
<td>GB</td>
<td>Great Britain.</td>
</tr>
<tr>
<td>IC</td>
<td>Interoperability Constituent.</td>
</tr>
<tr>
<td>IM</td>
<td>Infrastructure Manager.</td>
</tr>
<tr>
<td>INF</td>
<td>Infrastructure Subsystem.</td>
</tr>
<tr>
<td>ISV</td>
<td>Intermediate Statement of Verification.</td>
</tr>
<tr>
<td>IC ISV</td>
<td>Interoperability Constituent certified using an Intermediate Statement of Verification.</td>
</tr>
<tr>
<td>LOC &amp; PAS</td>
<td>Locomotives &amp; Passenger Carriages. Part of the RST subsystem.</td>
</tr>
<tr>
<td>MS</td>
<td>EU or EEA Member State.</td>
</tr>
<tr>
<td>NNTR</td>
<td>Notified National Technical Rules.</td>
</tr>
<tr>
<td>NoBo</td>
<td>Notified Body.</td>
</tr>
<tr>
<td>NTR</td>
<td>National Technical Rule.</td>
</tr>
<tr>
<td>OCL</td>
<td>Overhead Contact Line.</td>
</tr>
<tr>
<td>OPS</td>
<td>Operations &amp; Traffic Management functional subsystem.</td>
</tr>
<tr>
<td>RINF</td>
<td>Register of Infrastructure.</td>
</tr>
<tr>
<td>RIR</td>
<td>Railways (Interoperability) Regulations 2011.</td>
</tr>
<tr>
<td>SRT</td>
<td>Safety in Rail Tunnels.</td>
</tr>
<tr>
<td>UK</td>
<td>United Kingdom.</td>
</tr>
</tbody>
</table>
References

The Catalogue of Railway Group Standards gives the current issue number and status of documents published by RSSB. This information is also available from [http://www.rssb.co.uk/railway-group-standards.co.uk](http://www.rssb.co.uk/railway-group-standards.co.uk).

- RGSC 01: Railway Group Standards Code
- RGSC 02: Standards Manual

Documents referenced in the text

### Railway Group Standards

- **GERT8270**: Assessment of Route Compatibility of Vehicles and Infrastructure.
- **GLRT1210**: AC Energy Subsystem and Interfaces to Rolling Stock Subsystem.
- **GLRT1212**: DC Conductor Rail Energy Subsystem and Interfaces to Rolling Stock Subsystem.
- **GMRT2111**: Rolling Stock Subsystem and Interfaces to AC Energy Subsystem.
- **GMRT2132**: On-board Energy Metering for Billing Purposes.
- **GMRT2173**: Requirements for the Size of Vehicles and Position of Equipment.

### RSSB Documents

- **GEGN8600**: Guidance on the Conventional Rail Energy TSI.
- **GLGN1610**: Guidance on AC Energy Subsystem and Interfaces to Rolling Stock Subsystem.
- **GMGN2611**: Guidance on Rolling Stock Subsystem and Interfaces to AC Energy Subsystem.
- **T876**: RSSB Research project - T876 Testing of overhead line contact wire and collector strip wear - UIC project CoSTRIM.

### Other References

DfT Geographical Scope of the ENE TSI

EN 50119:2009
Railway applications — Fixed installations — Electric traction overhead contact lines.

Railway applications — Fixed installations — Electrical safety, earthing and the return circuit — Part 1: Protective provisions against electric shock.

EN 50149:2012
Railway applications — Fixed installations — Electric traction — Copper and copper alloy grooved contact wires.

EN 50163:2004
Railway applications — Supply voltages of traction systems.

EN 50317:2012
Railway applications — Current collection systems — Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line.

EN 50318:2002
Railway applications — Current collection systems — Validation of simulation of the dynamic interaction between pantograph and overhead contact line.

prEN 50318:2016
Railway applications — Current collection systems — Validation of simulation of the dynamic interaction between pantograph and overhead contact line. (Revision issued as a draft for public comment dated Nov 2016).

EN 50367:2012
Railway applications — Current collection systems — Technical criteria for the interaction between power supply (substation) and rolling stock to achieve interoperability.

EN 50388:2012
Railway applications — Power supply and rolling stock — Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability.

European Rail Agency Application Guide to the ENE TSI

List of NNTRs

National Implementation Plan

ORR Policy on Third Rail Electrification
Technical Specifications for Interoperability and Associated Documents

Details of the current TSIs and Application Guides are available at http://www.rssb.co.uk/Library/standards-and-the-rail-industry/2015-01-list-of-tsis.pdf

01/16 DV-EN09:2004

2004/49/EC

2008/57/EC

2010/713/EU
Commission Decision on the Modules for the procedures for assessment of conformity, suitability for use and EC verification to be used in the technical specifications for interoperability, (OJ L319, 4.12.2010, p1).

2011/665/EU

2014/881/EU
Commission Recommendation on the procedure demonstrating the level of compliance of existing railway lines with the basic parameters of the technical specifications for interoperability. http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014H0881&from=EN

2014/897/EU

2016/797

91/440/EEC

CCS TSI
Control, Command and Signalling TSI, Decision 2012/88/EU (OJ L51/1, 25.01.2012, p1).

LOC & PAS TSI
Guidance on the Energy TSI


Other relevant documents

Railway Group Standards

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

RSSB Documents

GLGN1612  Guidance on DC Conductor Rail Energy Subsystem and Interfaces to Rolling Stock Subsystem.

GMGN2613  Guidance on Rolling Stock Subsystem and Interfaces to DC Conductor Rail Energy Subsystem.