

Energy National Technical Specification Notice

ENE NTSN – Technical Annex

Draft for preliminary consultation based on the [NTSN published on 1st January 2021](#) with the [ERA proposals for the TSI 2022 package \(Digital Rail and Green Freight\)](#) shown as changes to this. The markup reflects the proposed TSI text, except where this has been amended for applicability to GB, such as substituting 'NTSN' for 'TSI'. Please note, this draft may still include TSI proposals which need to be further amended where text is not applicable to GB.

This is provided to elicit views on the TSI proposals to inform the development of the industry recommendation for similar NTSN changes. It does not reflect RSSB or industry proposals for NTSN changes. These will be provided with a supporting business case for change for consultation in early 2023.

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1. INTRODUCTION

1.1. TECHNICAL SCOPE

This NTSN concerns the energy subsystem and part of the maintenance subsystem of the GB rail system.

The energy and the maintenance subsystems are defined respectively in paragraphs 2.2 and 2.8 of Schedule 3 to the Railways (Interoperability) Regulations 2011.

The technical scope of this NTSN is further defined in Article 2 of this NTSN.

1.2. GEOGRAPHICAL SCOPE

The geographical scope of this NTSN is defined in Article 2(4) of this NTSN.

1.3. *This provision has been left intentionally blank*

2. DESCRIPTION OF THE ENERGY SUBSYSTEM

2.1. DEFINITION

- (1) This NTSN covers all fixed installations necessary to achieve interoperability that are required to supply traction energy to a train.
- (2) The energy subsystem consists of:
 - (a) substations: connected on the primary side to the high-voltage grid, with transformation of the high-voltage to a voltage and/or conversion to a [traction](#) power supply system suitable for the trains. On the secondary side, substations are connected to the railway contact line system;
 - (b) sectioning locations: electrical equipment located at intermediate locations between substations to supply and parallel contact lines and to provide protection, isolation and auxiliary supplies;
 - (c) separation sections: equipment required to provide the transition between electrically different systems or between different phases of the same electrical system;

- (d) contact line system: a system that distributes the electrical energy to the trains running on the route and transmits it to the trains by means of current collectors. The contact line system is also equipped with manually or remotely controlled disconnectors which are required to isolate sections or groups of the contact line system according to operational necessity. Feeder lines are also part of the contact line system;
 - (e) return circuit: all conductors which form the intended path for the traction return current. Therefore, so far as this aspect is concerned, the return circuit is part of the energy subsystem and has an interface with the infrastructure subsystem.
- (3) In accordance with paragraph 2.2 of Schedule 3 to the Railways (Interoperability) Regulations 2011, the trackside of the electricity consumption measuring system, referred to in this NTSN as on-ground energy data collection system, is set out in ~~point~~ [clause](#) 4.2.17 of this NTSN.

2.1.1. [Traction](#) ~~P~~power supply

- (1) The objective of the [traction](#) power supply system is to supply every train with power in order to meet the planned timetable.
- (2) Basic parameters for [traction](#) power supply system are defined in ~~point~~ [section](#) 4.2.

2.1.2. Geometry of the overhead contact line (OCL) and quality of current collection

- (1) The objective is to ensure reliable and continuous power transfer from the [traction](#) power supply system to the rolling stock. The interaction between the overhead contact line and the pantograph is an important aspect of interoperability.
- (2) Basic parameters referring to the geometry of the OCL and quality of current collection are set out in [section](#) point 4.2.

2.2. INTERFACES WITH OTHER SUBSYSTEMS

2.2.1. Introduction

- (1) The energy subsystem interfaces with other subsystems of the GB rail system in order to achieve the envisaged performance. These subsystems are listed below:

- (a) Rolling stock;
- (b) Infrastructure;
- (c) Trackside control command and signalling;
- (d) On-board control command and signalling;
- (e) Operation and traffic management.

- (2) ~~Point-Section~~ [Section 4.3](#) of this NTSN sets out the functional and technical specification of these interfaces.

2.2.2. Interfaces of this NTSN with the Safety in railway tunnels NTSN

Requirements relating to the energy subsystem for safety in railway tunnels are set out in the NTSN relating to Safety in railway tunnels.

3. ESSENTIAL REQUIREMENTS

The following table indicates basic parameters of this NTSN and their correspondence to the essential requirements as set out and numbered in Schedule 2 to the Railways (Interoperability) Regulations 2011.

NTSN point clause	Title of NTSN point clause	Safety	R&A	Health	Environmental protection	Technical Compatibility	Accessibility
4.2.3	Voltage and frequency	—	—	—	—	1.5 2.2.3	—
4.2.4	Parameters relating to Traction power supply system -performance	—	—	—	—	1.5 2.2.3	—
4.2.5	Current- capacity, DC systems, trains at standstill	—	—	—	—	1.5 2.2.3	—
4.2.6	Regenerative braking	—	—	—	1.4.1 1.4.3	1.5 2.2.3	—
4.2.7	Electrical protection coordination arrangements	2.2.1	—	—	—	1.5	—

NTSN point clause	Title of NTSN point clause	Safety	R&A	Health	Environmental protection	Technical Compatibility	Accessibility
4.2.8	Harmonics and dynamic effects for AC traction power supply systems	—	—	—	1.4.1 1.4.3	1.5	—
4.2.9	Geometry of the overhead contact line	—	—	—	—	1.5 2.2.3	—
4.2.10	Pantograph gauge	—	—	—	—	1.5 2.2.3	—
4.2.11	Mean contact force	—	—	—	—	1.5 2.2.3	—
4.2.12	Dynamic behaviour and quality of current collection	—	—	—	1.4.1 2.2.2	1.5 2.2.3	—
4.2.13	Pantograph spacing for overhead contact line design	—	—	—	—	1.5 2.2.3	—
4.2.14	Contact wire material	—	—	1.3.1 1.3.2	1.4.1	1.5 2.2.3	—
4.2.15	Phase separation sections	2.2.1	—	—	1.4.1 1.4.3	1.5 2.2.3	—
4.2.16	System separation sections	2.2.1	—	—	1.4.1 1.4.3	1.5 2.2.3	—
4.2.17	On-ground energy data collecting system	—	—	—	—	1.5	—
4.2.18	Protective provisions against electric shock	1.1.1 1.1.3 2.2.1	—	—	1.4.1 1.4.3 2.2.2	1.5	—
4.4	Operating rules	2.2.1	—	—	—	1.5	—
4.5	Maintenance rules	1.1.1 2.2.1	1.2	—	—	1.5 2.2.3	—

NTSN point clause	Title of NTSN point clause	Safety	R&A	Health	Environmental protection	Technical Compatibility	Accessibility
4.6	Professional qualifications	2.2.1	—	—	—	—	—
4.7	Health and safety conditions	1.1.1 1.1.3 2.2.1	—	—	1.4.1 1.4.3 2.2.2	—	—

4. CHARACTERISATION OF THE SUBSYSTEM

4.1. INTRODUCTION

- (1) The GB rail system, 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 sections](#) 4.2 and 4.3, do not impose the use of specific technologies or technical solutions, except where this is strictly necessary for the safe and uninterrupted movement of trains which accomplish the required levels of performance for those lines.
- (2) Innovative solutions for interoperability, which do not fulfil requirements specified in this NTSN and are not assessable as stated in this NTSN, require new specifications and/or new assessment methods. The process for obtaining an exemption for innovative solutions is described in [points clauses](#) 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 sections](#) 4.2 to 4.7.
- (4) Procedures for the UK verification of the energy subsystem are indicated in [point clause](#) 6.2.4 and Appendix B, Table B.1, of this NTSN.
- (5) For UK specific cases, see [point section](#) 7.4.

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

4.2. FUNCTIONAL AND TECHNICAL SPECIFICATIONS OF THE SUBSYSTEM

4.2.1. ~~Not Used~~ **General provisions**

~~The performance to be achieved by the energy subsystem is specified at least by the required performance of the GB rail system with respect to:~~

- ~~(a) — maximum line speed;~~
- ~~(b) — type(s) of train;~~
- ~~(c) — train service requirements;~~
- ~~(d) — power demand of the trains at the pantographs.~~

4.2.2. **Basic parameters characterising the energy subsystem**

The basic parameters characterising the energy subsystem are:

4.2.2.1. **Traction ~~P~~power supply:**

- (a) Voltage and frequency (4.2.3);
- (b) Parameters relating to traction power 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)

4.2.3. Voltage and frequency

- (1) The nominal voltage and nominal frequency of the energy subsystem traction power supply system 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;
 - (d) DC 1,5 kV.

For new lines with speed greater than 250 km/h, implementation rules are specified in clause 7.1.1 of this NTSN.

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

4.2.4. ~~Parameters relating to supply system~~ Traction power supply performance

- (1) For newly built subsystems, or in the case the traction power supply system is changed (e.g. migration from DC to AC), the quality index for the subsystem shall be according to the specification referenced in Appendix E, index [1] that enables every trainset to meet the design timetable.

~~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).~~

~~4.2.4.1. Maximum train current~~

~~The energy subsystem design shall ensure the ability of the power supply to achieve the specified performance and allow the operation of trains with a power less than 2 MW without power or current limitation.~~

~~4.2.4.2. 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.~~

4.2.5. Current at standstill ~~(DC systems only)~~

- (1) [The OCL shall be designed to sustain as a minimum at least the values of current at standstill per pantograph, in accordance with the specification referenced in Appendix E, index \[2\].](#) ~~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.~~
- ~~(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.~~
- ~~(3) The OCL shall be designed taking into account the temperature limits in accordance with EN 50119:2009, clause 5.1.2.~~

4.2.6. Regenerative braking

- (1) AC [traction](#) 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.
- (2) DC [traction](#) power supply systems shall be designed to permit the use of regenerative braking at least by exchanging power with other trains.

4.2.7. Electrical protection coordination arrangements

Electrical protection coordination design of the energy subsystem shall comply with the requirements detailed in [the specification referenced in Appendix E, index \[1a\]](#) ~~EN 50388:2012, clause 11.~~

4.2.8. 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 overvoltages shall be limited below critical values according to [the specification referenced in Appendix E, index \[1\]](#) ~~EN 50388:2012, clause 10.4.~~

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 NTSN, ~~point clause~~ 4.2.8.2.9.2 taking into account the rules set out in [clause 7.1.2](#) ~~point 7.2.3~~ of this NTSN.
- (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.

4.2.9.1. Contact wire height

- (1) The permissible data for contact wire height is given in Table 4.2.9.1.

Table 4.2.9.1

Contact wire height

Description	v ≥ 250 [km/h]	v < 250 [km/h]
Nominal contact wire height [mm]	Between 5 080 and 5 300	Between 5 000 and 5 750
Minimum design contact wire height [mm]	5 080	In accordance with the specification referenced in Appendix E, index [3] EN 50119:2009, clause 5.10.5 depending on the chosen gauge
Maximum design contact wire height [mm]	5 300	6 200 ⁽¹⁾
(1) Taking into account tolerances and uplift in accordance with the specification referenced in Appendix E, index [3] 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 [the specification referenced in Appendix E, index \[3\]](#) ~~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 technical rules, according to [the specification referenced in Appendix E, index \[4\]](#) ~~EN 50122-1:2011, clauses 5.2.4 and 5.2.5.~~

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 [with the specification referenced in Appendix E index \[2\]](#) ~~to table 4.2.9.2.~~

Table 4.2.9.2

Maximum lateral deviation depending on the pantograph length

Pantograph length [mm]	Maximum lateral deviation [mm]
1-600	400 ([±])
1-950	550 ([±])
(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 NTSN.

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 ~~shall be is~~ specified using the method ~~shown in Appendix D.1.2~~ [given in the specification referenced in Appendix E, index \[2\]](#) and the pantograph profiles defined in LOC&PAS NTSN, ~~points~~ [clauses](#) 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 σ_{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.~~

4.2.11. 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 [traction](#) power supply systems are defined in [the specification referenced in Appendix E, index \[2\]](#) ~~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 [the specification referenced in Appendix E, index \[2\]](#) ~~EN 50367:2012 Table 6.~~
- (4) The curves apply to speed up to 360km/h. For speeds above 360 km/h procedures set out in ~~point~~ [clause](#) 6.1.3 shall apply.

4.2.12. Dynamic behaviour and quality of current collection

- (1) Depending on the assessment method, the overhead contact line shall achieve the values of dynamic performance and contact wire uplift (at the design speed) set out in Table 4.2.12.

Table 4.2.12

Requirements for dynamic behaviour and current collection quality

Requirement	$v \geq 250$ [km/h]	$250 > v > 160$ [km/h]	$v \leq 160$ [km/h]
Space for steady arm uplift	2S ₀		
Mean contact force F_m	See 4.2.11		
Standard deviation at maximum line speed σ_{max} [N]	0,3 F_m		
Percentage of arcing at maximum line speed, NQ [%] (minimum duration of arc 5 ms)	$\leq 0,2$	$\leq 0,1$ for AC systems $\leq 0,2$ for DC systems	$\leq 0,1$

- (2) S_0 is the ~~calculated~~, simulated or measured uplift of the contact wire at a steady arm, ~~generated in normal operating conditions~~ with a minimum of two~~one or more~~ pantographs operating simultaneously with the upper limit of F_m at the ~~maximum line~~ OCL design 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 1,5 S_0 (refer to the specification referenced in Appendix E, index [3]~~EN 50119:2009, clause 5.10.2~~).
- (3) Maximum force (F_{max}) is usually within the range of F_m plus three standard deviations σ_{max} ; higher values may occur at particular locations and are given in the specification referenced in Appendix E, index [3]~~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.

4.2.13. Pantograph spacing for overhead contact line design

The overhead contact line shall be designed for trains with two pantographs operating simultaneously~~a minimum of two pantographs operating adjacently~~. The design spacing of the two ~~adjacent~~ pantograph heads, centre line to centre line, shall be equal or lower values set out in the specification referenced in Appendix E, index [2]~~one column 'A', 'B', or 'C' selected from Table 4.2.13:~~

Table 4.2.13

Pantograph spacing for OCL design

Design speed {km/h}	AC distance {m}			3-kV-DC distance {m}			1,5-kV-DC distance {m}		
	A	B	C	A	B	C	A	B	C
$v \geq 250$	200			200			200	200	35
$160 < v < 250$	200	85	35	200	115	35	200	85	35
$120 < v \leq 160$	85	85	35	20	20	20	85	35	20
$80 < v \leq 120$	20	15	15	20	15	15	35	20	15
$v \leq 80$	8	8	8	8	8	8	20	8	8

4.2.14. Contact wire material

- (1) The combination of contact wire material and contact strip material has a strong impact on the wear of contact strips and contact wire.
- (2) Permissible contact strip materials are defined in ~~point~~ [clause 4.2.8.2.9.4.2](#) of LOC&PAS NTSN.
- (3) Permissible materials for contact wires are copper and copper-alloy. The contact wire shall comply with the requirements of [the specification referenced in Appendix E, index \[5\]](#) ~~EN 50149:2012, clauses 4.2, (excluding the reference to annex B of the standard) 4.3 and 4.6 to 4.8.~~

4.2.15. Phase separation sections

4.2.15.1. General

- (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)~~ [exchange between the OCL and the unit](#) shall be brought to zero, [by switching off the circuit breaker or other equivalent means](#), 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.
- (2) The overall length D of neutral sections is defined in [the specification referenced in Appendix E, index \[2\]](#) ~~EN 50367:2012, clause 4.~~ For the calculation of D clearances in accordance to [the specification referenced in Appendix E, index \[3\]](#) ~~EN 50119:2009, clause 5.1.3~~ and an uplift of S0 shall be taken into account.

4.2.15.2. Lines with speed $v \geq 250$ km/h

Two types of designs of phase separation sections may be adopted, either:

- (a) a phase separation design where all the pantographs of the longest NTSN compliant trains are within the neutral section. The overall length of the neutral section shall be at least 402 m.

For detailed requirements see [the specification referenced in Appendix E, index \[2\]](#) ~~EN 50367:2012, Annex A.1.2~~, or

- (b) a shorter phase separation with three insulated overlaps as shown in [the specification referenced in Appendix E, index \[2\]](#) ~~EN 50367:2012, Annex A.1.4.~~

The overall length of the neutral section is less than 142 m including clearances and tolerances.

4.2.15.3. Lines with speed $v < 250$ km/h

The design of separation sections shall normally adopt solutions as described in [the specification referenced in Appendix E, index \[2\]](#) ~~EN 50367:2012, Annex A.1~~. Where an alternative solution is proposed, it shall be demonstrated that the alternative is at least as reliable.

4.2.16. System separation sections

4.2.16.1. General

(1) The design of system separation sections shall ensure that trains can move from one [traction](#) power supply system to an adjacent different [traction](#) power supply system without bridging the two systems. There are two methods for traversing system separation sections:

- (a) with pantograph raised and touching the contact wire;
- (b) with pantograph lowered and not touching the contact wire.

(2) The neighbouring Infrastructure Managers shall agree either (a) or (b) according to the prevailing circumstances.

(3) The overall length D of neutral sections is defined in [the specification referenced in Appendix E, index \[2\]](#) ~~EN 50367:2012, clause 4~~. For the calculation of D clearances in accordance to [the specification referenced in Appendix E, index \[3\]](#) ~~EN 50119:2009, clause 5.1.3~~ and an uplift of S_0 shall be taken into account.

4.2.16.2. Pantographs raised

(1) Power [exchange between the OCL and the unit](#) ~~consumption of the train (traction, auxiliaries and no-load current of the transformer)~~ shall be brought to zero [by switching off the circuit breaker or other equivalent means](#) before entering the system separation section.

(2) If system separation sections are traversed with pantographs raised to the contact wire, their functional design is specified as follows:

- (a) the geometry of different elements of the overhead contact line shall prevent pantographs short-circuiting or bridging both power systems;

- (b) provision shall be made in the energy subsystem to avoid bridging of both adjacent [traction](#) 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 [the specification referenced in Appendix E, index \[3\]](#) ~~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 [traction](#) power supply systems by an unintentionally raised pantograph.

4.2.17. On-ground energy data collecting system

- (1) ~~Point-Clause~~ [4.2.8.2.8](#) of LOC & PAS NTSN 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, in accordance with the [specification referenced in Appendix E, index \[6\]](#) ~~requirements quoted in clause 4.12 of EN 504463-3:2017.~~
- (3) The on-ground energy DCS shall support all the data exchange requirements as defined in ~~point-clause~~ [4.2.8.2.8.4](#) of the LOC&PAS NTSN and requirements set out in [the specification referenced in Appendix E, index \[7\]](#) ~~clauses 4.3.6 and 4.3.7 of EN 50463-4:2017.~~

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 [the specification referenced in Appendix E, index \[4\]](#) ~~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 [the specification referenced in Appendix E, index \[4\]](#) ~~9.3.2.1 and 9.3.2.2 of the standard.~~

4.3. FUNCTIONAL AND TECHNICAL SPECIFICATIONS OF THE INTERFACES

4.3.1. 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.

4.3.2. Interface with Rolling Stock subsystem.

Reference in the ENE NTSN		Reference in the LOC & PAS NTSN	
Parameter	Point Clause	Parameter	Point Clause
Voltage and frequency	4.2.3	Operation within range of voltages and frequencies	4.2.8.2.2
Parameters relating to supply system <u>Traction power supply</u> performance: <ul style="list-style-type: none"> — max train current — power factor of trains and the mean useful voltage 	4.2.4	Max current from OCL Power factor	4.2.8.2.4 4.2.8.2.6
Current capacity, DC systems, trains at standstill	4.2.5	Maximum current at standstill	4.2.8.2.5
Regenerative braking	4.2.6	Regenerative brake with energy to OCL	4.2.8.2.3
Electrical protection coordination arrangements	4.2.7	Electrical protection of the train	4.2.8.2.10
Harmonics and dynamic effects for AC traction power supply systems	4.2.8	<u>Harmonics and dynamic effects</u> System energy disturbances for AC systems	4.2.8.2.7
Geometry of the overhead contact line	4.2.9	Working range in height of pantograph	4.2.8.2.9.1 4.2.8.2.9.2

Reference in the ENE NTSN		Reference in the LOC & PAS NTSN	
Parameter	Point Clause	Parameter	Point Clause
		Pantograph head geometry	
Pantograph gauge	4.2.10 Appendix D	Pantograph head geometry Gauging	4.2.8.2.9.2 4.2.3.1
Mean contact force	4.2.11	Pantograph static contact force	4.2.8.2.9.5
		Pantograph contact force and dynamic behaviour	4.2.8.2.9.6
Dynamic behaviour and quality of current collection	4.2.12	Pantograph contact force and dynamic behaviour	4.2.8.2.9.6
Pantograph spacing for overhead contact line design	4.2.13	Arrangements of pantographs	4.2.8.2.9.7
Contact wire material	4.2.14	Contact strip material	4.2.8.2.9.4
Separation sections: phase system	4.2.15	Running through phase or system separation section	4.2.8.2.9.8
	4.2.16		
On-ground energy data collecting system	4.2.17	On-board Energy measurement system	4.2.8.2.8

4.3.3. Interface with Infrastructure subsystem

Reference in the ENE NTSN		Reference in the INF NTSN	
Parameter	Point Clause	Parameter	Point Clause
Pantographs gauge	4.2.10	Structure gauge	4.2.3.1

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 [between the ETCS trackside and the ETCS on-board sub-systems as well as between the ETCS on-board and the vehicle power system.](#) ~~via the control command and signalling subsystems and e~~ Consequently the transmission interface is specified in the CCS NTSN and the LOC & PAS NTSN.
- (3) The relevant information to perform the switching of the circuit breaker, [the](#) change of maximum train current, [the](#) change of the [traction](#) power supply system and [the](#) pantograph management shall be transmitted via ~~ERTMS~~ [ETCS](#) when the line is equipped with ~~ERTMS~~ [ETCS and these trackside functionalities are implemented.](#)
- (4) Harmonic currents affecting control-command and signalling subsystems are set out in the CCS NTSN.

4.3.5. Interface with Operation and traffic management subsystem

Reference in the ENE NTSN		Reference in the OPE NTSN	
Parameter	Point Clause	Parameter	Point Clause
Traction power supply performance Maximum train current	4.2.4. 1	Train composition Preparation of the Route Book	4.2.2.5 4.2.1.2.2.1
Separation sections: Phase System	4.2.15 4.2.16	Train composition Preparation of the Route Book	4.2.2.5 4.2.1.2.2.1

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 and as set out in regulation 17(2)(a) of and Schedule 4 to the Railways (Interoperability) Regulations 2011.
- (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~~[chapters](#) 4 and 5 of ~~this~~[the](#) NTSN.

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 NTSN are maintained during its lifetime.

4.6. 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 NTSN.

4.7. 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 national legislation.
- (2) This issue is also covered by the procedures described in the infrastructure manager safety management system.

5. INTEROPERABILITY CONSTITUENTS

5.1. LIST OF CONSTITUENTS

- (1) The interoperability constituents are covered by the relevant provisions of Part 3 of the Railways (Interoperability) Regulations 2011 and these constituents are listed here below for the energy subsystem.
- (2) Overhead contact line:

- (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.
 - (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.
 - (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.
- (3) The conformity assessment shall cover the phases and characteristics as indicated in [point-clause 6.1.4](#) and by X in the Table A.1 of Appendix A to this NTSN.

Note: there are UK specific cases relevant to this IC (see points 7.4.2.9.1, 7.4.2.9.2, 7.4.2.9.3 and 7.4.2.9.4).

5.2. CONSTITUENTS' PERFORMANCES AND SPECIFICATIONS

5.2.1. Overhead contact line

5.2.1.1. *Geometry of the OCL*

The design of the overhead contact line shall comply with [point-clause 4.2.9](#).

5.2.1.2. *Mean contact force*

The overhead contact line shall be designed by using the mean contact force F_m stipulated in [point-clause 4.2.11](#).

5.2.1.3. *Dynamic behaviour*

Requirements for dynamic behaviour of the overhead contact line are set out in [point-clause 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~~[clause](#) 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~~[clause](#) 4.2.13.

5.2.1.6. Current at standstill ~~(DC systems only)~~

~~For DC systems, t~~he overhead contact line shall be designed for the requirements set out in ~~point~~[clause](#) 4.2.5.

5.2.1.7. Contact wire material

The contact wire material shall comply with the requirements set out in ~~point~~[clause](#) 4.2.14.

6. ASSESSMENT OF CONFORMITY OF THE INTEROPERABILITY CONSTITUENTS AND UK VERIFICATION OF THE SUBSYSTEMS

Modules for the procedures for assessment of conformity, suitability for use and EC verification modules are described in the Modules NTSN.

6.1. INTEROPERABILITY CONSTITUENTS

6.1.1. Conformity assessment procedures

- (1) The conformity assessment procedures of interoperability constituents as defined in ~~Section~~[chapter](#) 5 of this NTSN shall be carried out by application of relevant modules.
- (2) Assessment procedures for particular requirements for interoperability constituent are set out in ~~point~~[clause](#) 6.1.4.

6.1.2. Application of modules as set out in the Modules NTSN

- (1) The following modules for conformity assessment of interoperability constituents are used:

CA Internal production control

CB	UK type examination
CC	Conformity to type based on internal production control
CH	Conformity based on full quality management system
CH1	Conformity based on full quality management system plus design examination

Table 6.1.2

Modules for conformity assessment to be applied for ICs

Procedures	Modules
Placed on the UK market	CB + CC or CH1

- (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 UK market before the 12 December 2014, the type is considered to have been approved and therefore UK 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 the ENE TSI 1301/2014/EU. 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 UK market after publication of this NTSN applies.

6.1.3. Innovative solutions for interoperability constituents

- (1) If an innovative solution is proposed for an interoperability constituent, the procedure described in Article 10 of this NTSN shall apply.

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

- (1) 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 σ_{max}

or

— 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 to the specification referenced in Appendix E, index [8]~~with EN 50318:2002~~ and by measurement according to the specification referenced in Appendix E, index [9]~~EN 50317:2012~~.

For OCL with a design speed up to and including 100 km/h, simulation and measurement of the dynamic behaviour are not required.

~~(d)~~(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.

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

(2) 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 NTSN 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.

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.

- (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 NTSN.
 - (d) The simulation shall be performed for single pantograph and multiple pantographs with spacing according to the requirements set in ~~point~~[clause](#) 4.2.13.
 - (e) In order to be acceptable, the simulated current collection quality shall be in accordance with ~~point~~[clause](#) 4.2.12 for uplift, mean contact force and standard deviation for each of the pantographs.
- (3) 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~~[clause](#) 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~~[clause](#) 4.2.12, for uplift, and either the mean contact force and standard deviation or percentage of arcing. [The uplift of at least two steady arms shall be measured.](#)
 - (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~~[clause](#) 6.1.3.7 of the LOC & PAS NTSN.

6.1.4.2. Assessment of current at standstill (DC systems only)

The conformity assessment [for DC systems](#) shall be carried out in accordance with [the specification referenced in Appendix E, index \[2\]](#) ~~EN 50367: 2012, Annex A.3 for the static force defined in point 4.2.5.~~

6.1.5. UK declaration of conformity of interoperability constituent OCL

The UK declaration of conformity shall be accompanied by statement setting out the condition of use:

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

6.2. ENERGY SUBSYSTEM

6.2.1. General provisions

- (1) At the request of the applicant, the approved body carries out UK verification in accordance with Schedule 4 to the Railways (Interoperability) Regulations 2011 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 approved body shall take these tests and verifications into account for the UK verification.
- (3) Assessment procedures for particular requirements for subsystem are set out in ~~point~~[clause](#) 6.2.4.
- (4) The applicant shall draw up the UK declaration of verification for the energy subsystem in accordance with regulation 16 and 17 and Schedule 5 to the Railways (Interoperability) Regulations 2011.

6.2.2. Application of modules

For the UK verification procedure of the energy subsystem, the applicant or its authorised representative may choose either:

- (a) Module SG: UK verification based on unit verification, or
- (b) Module SH1: UK verification based on full quality management system plus design examination.

6.2.2.1. Application of module SG

In case of module SG, the approved 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 an approved body.

6.2.3. Innovative solutions

If an innovative solution is proposed for the energy subsystem, the procedure described in Article 10 of this NTSN shall apply.

6.2.4. Particular assessment procedures for energy subsystem

6.2.4.1. Assessment of ~~mean-useful-voltage~~ and frequency

(1) The applicant shall declare in the technical file which nominal voltage is chosen for the traction power supply only in the following cases:

- a new energy subsystem is built, or
- the traction power supply system is changed (e.g. migration from DC to AC).

~~(1) The assessment shall be demonstrated in accordance with EN 50388:2012, clause 15.4.~~

(2) The selected traction power supply system shall be assessed by a document review in the design phase. An assessment is required only in the following cases:

- a new sub-systems is built, or
- the traction power supply system is changed (e.g. migration from DC to AC).

~~(2) The assessment shall be demonstrated only in the case of newly build or upgraded sub-systems.~~

6.2.4.1 a. Assessment of traction power supply performance

(1) The applicant shall declare:

- (a) a quality index as defined in the clause 4.2.4 for the subsystem
- (b) that the output of the design study complies with the specification referenced in Appendix E, index [1].

(2) The assessment shall be carried out by verifying only the existence of the declaration.

6.2.4.2. Assessment of regenerative braking

- (1) The assessment for AC traction power supply fixed installations shall be demonstrated according to the specification referenced in Appendix E, index [1a]~~EN 50388:2012, clause 15.7.2.~~
- (2) The assessment for DC traction power supply shall be demonstrated by a design review.

6.2.4.3. Assessment of electrical protection coordination arrangements

The assessment shall be demonstrated for design and operation of substations in accordance with the specification referenced in Appendix E, index [1a]~~EN 50388:2012, clause 15.6.~~

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

- (1) A compatibility study shall be carried out according to the specification referenced in Appendix E, index [1a]~~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 traction power supply system.
- (3) The approved body shall assess if criteria of the specification referenced in Appendix E, index [1a]~~EN 50388:2012, clause 10.4~~ are fulfilled.

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 [the specification referenced in Appendix E, index \[9\]](#) ~~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~~ [clause](#) 4.2.11 of this NTSN for the design speed of the line considering aspects related to minimum speed and siding tracks.
- (4) The installed overhead contact line shall be accepted if the measurement results comply with the requirements in ~~point~~ [clause](#) 4.2.12.
- (5) For operational speeds up to 120 km/h (AC systems) and up to 160 km/h (DC systems), measurement of the dynamic behaviour is not mandatory. In this case alternative methods of identifying construction errors shall be used, such as measurement of OCL geometry according to ~~point~~ [clause](#) 4.2.9.
- (6) Assessment of dynamic behaviour and quality of current collection for integration of the pantograph into rolling stock subsystem are set out in point 6.2.3.20 of LOC & PAS NTSN.

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.

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 approved body is not responsible for assessing the suitability of the detailed requirements set out in the plan.

6.3. SUB-SYSTEM CONTAINING INTEROPERABILITY CONSTITUENTS NOT HOLDING AN EC OR UK DECLARATION

The circumstances in which it is permissible to rely on an EC declaration of conformity rather than a UK declaration of conformity to place an interoperability constituent on the UK market and any relevant additional assessment requirements are set out in Part 3 and regulation 47A of the Railways (Interoperability) Regulations 2011 and in the NTSN concerning the further assessment of interoperability constituents which hold an EC declaration of conformity or suitability for use.

6.3.1. Conditions

- (1) Subject to 6.3 above, until 31 May 2021, an approved body is allowed to issue a UK certificate of verification for a subsystem, even if some of the interoperability constituents incorporated within the subsystem are not covered by the relevant EC or UK declarations of conformity and/or suitability for use according to this NTSN (or relevant TSIs), if the following criteria are complied with:
 - (a) the conformity of the subsystem has been checked against the requirements of [chapter Section 4](#) and in relation to [sections points 6.2](#) and [6.3](#) and [chapter Section 7](#), except [point section 7.4](#), of this NTSN by the approved body. Furthermore, the conformity of the ICs to [chapter Section 5](#) and [point section 6.1](#) does not apply, and
 - (b) the interoperability constituents, which are not covered by the relevant UK 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 States of the EU or the UK before the 1 January 2015.
- (2) UK Declarations of conformity and/or suitability for use shall not be drawn up for the interoperability constituents assessed in this manner.

6.3.2. Documentation

- (1) The UK certificate of verification of the subsystem shall indicate clearly which interoperability constituents have been assessed by the notified body or the approved body as part of the subsystem verification.
- (2) The UK 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 or UK declaration of conformity and/or suitability for use before its incorporation into the subsystem, including the application of national technical rules.

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 the Competent Authority on application of NTSNs), the interoperability constituents which do not hold an EC or UK 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.

7. IMPLEMENTATION OF THE ENERGY NTSN

~~As referred to in Article 9, the UK has published an implementation plan.~~

7.1. NATIONAL IMPLEMENTATION PLAN

- (1) ~~Member States~~ The UK shall develop a national plan for the implementation of this NTSN, ~~considering the coherence of the entire rail system of the European Union~~. This plan shall include all projects regarding new, renewal and upgrading of energy subsystem and shall ensure a gradual migration within a reasonable timescale onwards an interoperable target energy subsystem fully compliant with this NTSN.
- (2) By 1 January 2022, ~~Member States~~ the UK shall ensure that an on-ground energy data collecting system capable to exchange compiled energy billing data in accordance with clause 4.2.17 of this NTSN is implemented.

7.1.1. Implementation rules for voltage and frequency

New lines with speed greater than 250 km/h shall be supplied with one of the AC systems as defined in clause 4.2.3.

7.1.2. Implementation rules for OCL geometry

7.1.2.1. Implementation rules for 1435 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 NTSN clauses 4.2.8.2.9.2.1 (1600 mm) and 4.2.8.2.9.2.2 (1950 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 NTSN clause 4.2.8.2.9.2.1 (1600 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 NTSN clause 4.2.8.2.9.2.1 (1600 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 NTSN clauses 4.2.8.2.9.2.1 (1600 mm) or 4.2.8.2.9.2.2 (1950 mm).

7.1.2.2. This provision has been left intentionally blank ~~Track gauge systems different than 1435mm~~

~~The OCL shall be designed for use by at least one of the pantographs with the head geometry specified in the LOC & PAS TSI clause 4.2.8.2.9.2.~~

7.2. APPLICATION OF THIS NTSN TO A NEW ENERGY SUBSYSTEM

(1) For a new energy subsystem, the application of this NTSN shall be compulsory.

(2) For the purpose of this NTSN a 'new energy subsystem' means an energy subsystem placed into service after this NTSN enters into force, which is or will be created where no traction power supply and OCL previously existed.

Any other energy subsystem shall be considered as an 'existing energy subsystem'.

- (3) The following situations at least, but not restricted to, are not a “new” line (new energy subsystem), but “upgrading”:
- (a) 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.

7.3. APPLICATION OF THIS NTSN TO AN EXISTING ENERGY SUBSYSTEM

7.3.1. Performance criteria of the subsystem

“Upgrading” is a major modification work of an existing energy subsystem resulting in an increase of the line speed of more than 30km/h or fall in the cases that are included in 7.2 (3).

7.3.2. Application of the NTSN

- (1) The conformity with this NTSN is mandatory for a subsystem or part(s) of it which are upgraded or renewed. However, this NTSN recognizes that due to the characteristics of the inherited railway system, compliance of existing energy subsystem with this NTSN may be achieved through a gradual improvement of interoperability, as below.
- (2) For the upgraded energy subsystem, the application of this NTSN shall be compulsory, and applied fully to the upgraded subsystem within the geographical coverage of the upgrading. The geographical coverage of the upgrading shall be defined based on locations and shall result in the compliance of all basic parameters of the energy subsystem associated with the tracks that are subject to the upgrading.
- (3) In the event of a change other than an upgrading of the energy subsystem, the application of this NTSN for each of the basic parameters (established in clause 4.2.2) affected by a change shall be compulsory when the change requires carry out a new ‘EC’ verification procedure. Provisions defined in the Articles 6 and 7 of the Commission Implementing Regulation 2019/250 shall be applied.

In the abovementioned event and for those basic parameters not affected by a change, or when the change does not require carry out a new ‘EC’ verification procedure, the demonstration of the level of compliance with this NTSN is voluntary.

- (4) For substitution in the framework of maintenance the formal verification in accordance with this NTSN, is not required. However, maintenance replacements should be, as far as it is reasonably practicable, undertaken in accordance with the requirements of this NTSN.
- (5) ‘Renewal’ differs from a substitution undertaken in the framework of maintenance, since it gives the opportunity to achieve a NTSN compliant subsystem. For this purpose, ‘major substitution’ in the framework of ‘renewal’ should be interpreted as a project undertaken to systematically replace elements on a subsystem or part of it.
- (6) ‘Substitution in the framework of maintenance’ means any replacement of components by parts of identical function and performance in the framework of maintenance.
- (7) For the existing energy subsystem, in any event other than an upgrading, for the maximum lateral deviation of the OCL, it is permitted to deviate from the requirement given in clause 4.2.9.2. as long as it has been proven that any NTSN compliant rolling stock with an NTSN compliant pantograph (as described in clause 7.1.2.1 of this NTSN) has already operated under the same OCL design installed in the network without occurring any incident.

~~7.1. APPLICATION OF THIS NTSN 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 NTSN, which will be placed in service as interoperable lines after this NTSN is published.~~

~~7.2. APPLICATION OF THIS NTSN 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.~~~~

~~7.2.2. Implementation plan for voltage and frequency~~

- ~~(1) Any decisions about power supply systems should be taken on economic and technical grounds, taking into account at least the following elements:
 - ~~(a) the existing power supply system;~~
 - ~~(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~~

~~The 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 NTSN 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 NTSN 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 NTSN 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 NTSN 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 1435mm~~

~~The OCL shall be designed for use by at least one of the pantographs with the head geometry specified in the LOC & PAS NTSN point 4.2.8.2.9.2.~~

~~7.2.4. Implementation of the on-ground energy data collecting system~~

~~By 1 January 2022, the Competent Authority shall ensure that an on-ground energy data-collecting system capable to exchange compiled energy billing data in accordance with point 4.2.17 of this NTSN is implemented.~~

~~7.3. APPLICATION OF THIS NTSN TO EXISTING LINES~~

~~7.3.1. Introduction~~

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

- ~~(a) The scope of the upgrading or renewal of the energy subsystem may cover the entire subsystem on a given line or only certain parts of the subsystem. In accordance with regulation 13 of the Railways (Interoperability) Regulations 2011 the Competent Authority shall examine the project and decide whether a new authorisation for placing in service is needed.~~
- ~~(b) Where a new authorisation is required, parts of the energy subsystem falling under the scope of the upgrading or renewal shall comply with this NTSN and shall be subject to the procedure established in regulation 16 and 17 of the Railways (Interoperability) Regulations 2011, unless a permission for non-application of the NTSN is granted according to regulation 14 of the Railways (Interoperability) Regulations 2011.~~
- ~~(c) Where a new authorisation for placing in service is required, the Project 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) Where a new authorisation for placing in service is not required, compliance with this NTSN is recommended. Where compliance is not possible, the project entity shall inform the Competent Authority of the reasons thereof.~~

~~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 NTSN.~~

~~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 NTSN contributing to the development of interoperability.~~

~~7.3.4.~~ 7.3.3. Existing subsystem lines that are not subject to a renewal or upgrading project

The demonstration of the level of compliance of existing lines with the basic parameters of the NTSN is voluntary. The procedure to be used for the demonstration of the level of compliance of existing lines with the basic parameters of this NTSN shall be in accordance with Recommendation 2014/881/EU.

~~7.3.5.~~ 7.3.4. *This provision has been left intentionally blank*

7.4. UK SPECIFIC CASES

7.4.1. General

- (1) The UK specific cases, as listed in point clause 7.4.2, describe special provisions that are needed and authorised on particular networks.
- (2) These UK specific cases are classified as:
 - “P” cases: “permanent” cases,
 - “T” cases: “temporary” cases (note there are no T cases for the UK).

7.4.2. List of UK specific cases

7.4.2.1. *This provision has been left intentionally blank*

7.4.2.2. *This provision has been left intentionally blank*

7.4.2.3. *This provision has been left intentionally blank*

7.4.2.4. *This provision has been left intentionally blank*

7.4.2.5. *This provision has been left intentionally blank*

7.4.2.6. *This provision has been left intentionally blank*

7.4.2.7. *This provision has been left intentionally blank*

7.4.2.8. *This provision has been left intentionally blank*

7.4.2.9. Particular features on the network for Great Britain

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.

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

7.4.2.9.2. Contact wire height (4.2.9.1)

P case

For new, upgrade or renewal of the energy subsystem on existing infrastructure it is allowed to design the overhead contact line wire height in accordance with the national technical rules.

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

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.

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

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.

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

7.4.2.9.5. Conformity assessment of OCL as component

P case

The national technical rules may define the procedure for conformity related to points 7.4.2.9.2 and 7.4.2.9.3 and associated certificates.

The procedure may include the conformity assessment of parts which are not subject to a UK specific case.

7.4.2.10. *Particular features on the Eurotunnel network*

7.4.2.10.1. Contact wire height (4.2.9.1)

P case

For, upgrade or renewal of the existing energy subsystem it is allowed for the overhead contact line wire height to be designed in accordance with the national technical rules.

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~~-[clause](#) 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 A.1

Assessment of the interoperability constituent: overhead contact line

	Assessment in the following phase			
	Design and development phase			Production phase
Characteristic – point	Design review	Manufacturing process review	Test ⁽²¹⁾	Product quality (series production)
Geometry of the OCL – 5.2.1.1	X	N/A	N/A	N/A
Mean contact force – 5.2.1.2 ⁽²¹⁾	X	N/A	N/A	N/A
Dynamic behaviour – 5.2.1.3	X	N/A	X	N/A
Space for steady arm uplift – 5.2.1.4	X	N/A	X	N/A
Pantograph spacing for overhead contact line design – 5.2.1.5	X	N/A	N/A	N/A
Current at standstill – 5.2.1.6	X	N/A	X (only for DC systems)	N/A

Contact wire material – 5.2.1.7	X	N/A	N/A	N/A
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N/A: not applicable

(1) [Test as defined in clause 6.1.4. about “Particular assessment procedure for the interoperability constituent — overhead contact line”.](#)

(2) The measurement of the contact force is integrated with the process of assessment of dynamic behaviour and quality of current collection.

~~(2) Test as defined in Section 6.1.4. on particular assessment procedure for the interoperability constituent — overhead contact line.~~

Appendix B UK verification of the energy subsystem

B.1 SCOPE

This Appendix indicates the UK 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 B.1

UK verification of the energy subsystem

Basic parameters	Assessment phase			
	Design develop phase	Production phase		
	Design review	Construction, assembly, mounting	Assembled, before putting into service	Validation under full operating conditions
Voltage and frequency – 4.2.3	X	N/A	N/A	N/A
Parameters relating to supply system Traction power supply performance – 4.2.4	X	N/A	N/A	N/A
DC systems only : Current capacity, DC systems, trains at standstill – 4.2.5	X ⁽¹⁾	N/A	N/A	N/A

Regenerative braking – 4.2.6	X	N/A	N/A	N/A
Electrical protection coordination arrangements – 4.2.7	X	N/A	X	N/A
Harmonics and dynamic effects for AC traction power supply systems – 4.2.8	X	N/A	N/A	N/A
Geometry of the overhead contact line – 4.2.9	X ⁽¹⁾	N/A	N/A ⁽³⁾	N/A
Pantograph gauge – 4.2.10	X	N/A	N/A	N/A
Mean contact force – 4.2.11	X ⁽¹⁾	N/A	N/A	N/A
Dynamic behaviour and quality of current collection – 4.2.12	X ⁽¹⁾	N/A	X ⁽²⁾ ⁽³⁾	N/A ⁽²⁾
Pantograph spacing for overhead contact line design – 4.2.13	X ⁽¹⁾	N/A	N/A	N/A
Contact wire material – 4.2.14	X ⁽¹⁾	N/A	N/A	N/A
Phase separation sections – 4.2.15	X	N/A	N/A	N/A
System separation sections – 4.2.16	X	N/A	N/A	N/A
On-ground energy data collecting system – 4.2.17	N/A	N/A	N/A	N/A
Protective provisions against electric shock – 4.2.18	X	X ⁽⁴⁾	X ⁽⁴⁾	N/A
Maintenance rules – 4.5	N/A	N/A	X	N/A

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.

Appendix C Mean useful voltage

C.1 VALUES FOR U MEAN USEFUL AT THE PANTOGRAPH

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

Minimum U mean useful at pantograph

Traction power supply system	V	
	Line speed $v > 200$ [km/h]	Line speed $v \leq 200$ [km/h]
	Zone and train	Zone and train
AC 25 kV 50 Hz	22 500	22 000
AC 15 kV 16,7 Hz	14 200	13 500
DC 3 kV	2 800	2 700
DC 1,5 kV	1 300	1 300

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.

Appendix D ~~Intentionally deleted~~ 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.~~

~~D.1.1.3 Symbols and abbreviations~~

Symbol	Designation	Unit
b_w	Half length of the pantograph bow	m
$b_{w,\epsilon}$	Half length of the pantograph bow conducting length (with insulating horns) or working length (with conducting horns)	m
$b'_{o,mec}$	Width of mechanical kinematic pantograph gauge at upper verification point	m

Symbol	Designation	Unit
$b'_{u,mec}$	Width of mechanical kinematic pantograph gauge at lower verification point	m
$b'_{h,mec}$	Width of mechanical kinematic pantograph gauge at intermediate height, h	m
d_t	Lateral deviation of contact wire	m
D'_0	Reference cant taken into account by the vehicle for the pantograph gauge	m
e_p	Pantograph sway due to the vehicle characteristics	m
e_{p0}	Pantograph sway at the upper verification point	m
e_{pu}	Pantograph sway at the lower verification point	m
f_s	Margin to take account of the raising of the contact wire	m
f_{wa}	Margin to take account of the wear of the pantograph contact strip	m
f_{ws}	Margin to take account of the bow trespassing the contact wire due to the pantograph sway	m
h	Height in relation to the running surface	m
h'_{c0}	Reference roll centre height for the pantograph gauge	m
h'	Reference height in the calculation of the pantograph gauge	m
h'_e	Maximum verification height of the pantograph gauge in a collecting position	m
h'_u	Minimum verification height of the pantograph gauge in a collecting position	m
h_{eff}	Effective height of the raised pantograph	m
h_{ec}	Static height of the contact wire	m
l'_0	Reference cant deficiency taken into account by the vehicle for the pantograph gauging	m
L	Distance between rail centres of a track	m
l	Track gauge, distance between the rail running edges	m

Symbol	Designation	Unit
q	Transverse play between axle and bogie frame or, for vehicles not fitted with bogies, between axle and vehicle body	m
qs'	Quasi-static movement	m
R	Horizontal curve radius	m
s'_e	Flexibility coefficient taken into account by agreement between the vehicle and the infrastructure for the pantograph gauging	-
$S'_{i/a}$	Allowed additional overthrow on the inside/outside of the curve for pantographs	m
w	Transverse play between bogie and body	m
Σ_j	Sum of the (horizontal) safety margins covering some random phenomena ($j = 1, 2$ or 3) for the pantograph gauge	m

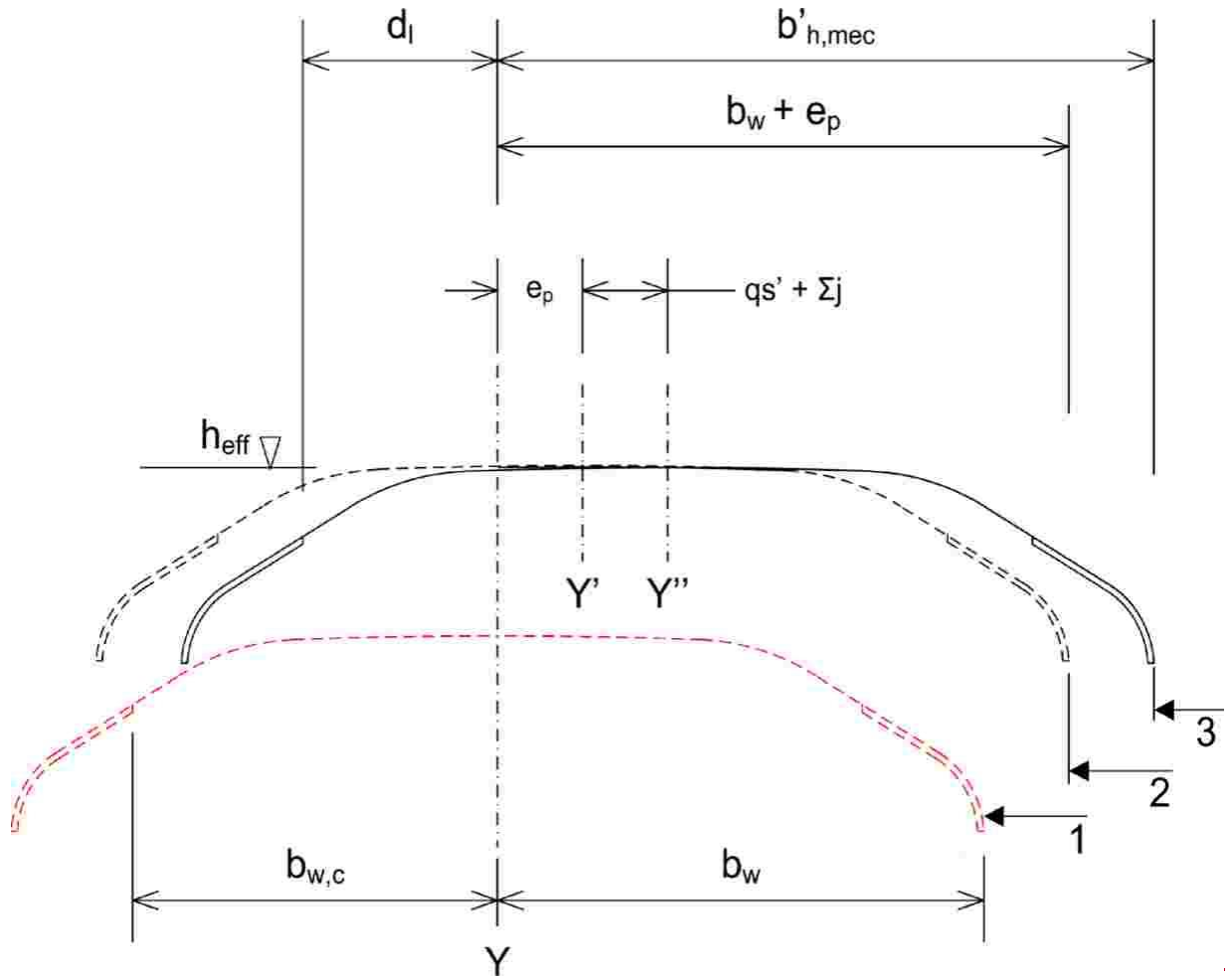
Subscript a: refers to the outside of the curve

Subscript i: refers to the inside of the curve

D.1.1.4 Basic principles

Figure D.1

Pantograph-mechanical gauges



Caption:

Y : Centre line of the track

Y' : Centre line of the pantograph — for deriving the free passage reference profile

Y'' : Centre line of the pantograph — for deriving the mechanical kinematic pantograph gauge

1: Pantograph profile

2: Free passage reference profile

3: Mechanical kinematic gauge

The pantograph gauge is only met if the mechanical and electrical gauges are complied with simultaneously:

- The free passage reference profile includes the pantograph collector head length and the pantograph sway e_p , which applies up to the reference cant or cant deficiency,
- Live and insulated obstacles shall remain outside the mechanical gauge,
- Non insulated obstacles (earthed or at a potential different from the OCL) shall remain outside the mechanical and electrical gauges.

D.1.2 – Specification of the mechanical kinematic pantograph gauge

D.1.2.1 – Specification of the width of the mechanical gauge

D.1.2.1.1 – Scope

The width of the pantograph gauge is mainly specified by the length and displacements of the pantograph under consideration. Beyond specific phenomena, phenomena similar to those of the obstacle gauge are found in the transverse displacements.

The pantograph gauge shall be considered at the following heights:

- The upper verification height h'_o
- The lower verification height h'_u

Between those two heights, it can be considered that gauge width varies in a linear way.

The various parameters are shown in figure D.2.

D.1.2.1.2 – Calculation methodology

The pantograph gauge width shall be specified by the sum of the parameters defined below. In the case of a line run by various pantographs, the maximum width should be considered.

For the lower verification point with $h = h'_u$:

$$b'_{u(i/a),mec} = \left(b_w + e_{pu} + S'_{i/a} + qS'_{i/a} + \sum_j \right)_{\max}$$

For the upper verification point with $h = h'_o$:

$$b'_{o(i/a),mec} = \left(b_w + e_{po} + S'_{i/a} + qS'_{i/a} + \sum_j \right)_{\max}$$

Note i/a = inside/outside curve.

For any intermediate height h , width is specified by means of an interpolation:

$$b'_{h,mec} = b'_{u,mec} + \frac{h - h'_u}{h'_o - h'_u} \times (b'_{o,mec} - b'_{u,mec})$$

~~D.1.2.1.3 Half length bw of the pantograph bow~~

The half length b_w of the pantograph bow depends on the type of pantograph used. The pantograph profile(s) to be considered are defined in LOC&PAS NTSN, point 4.2.8.2.9.2.

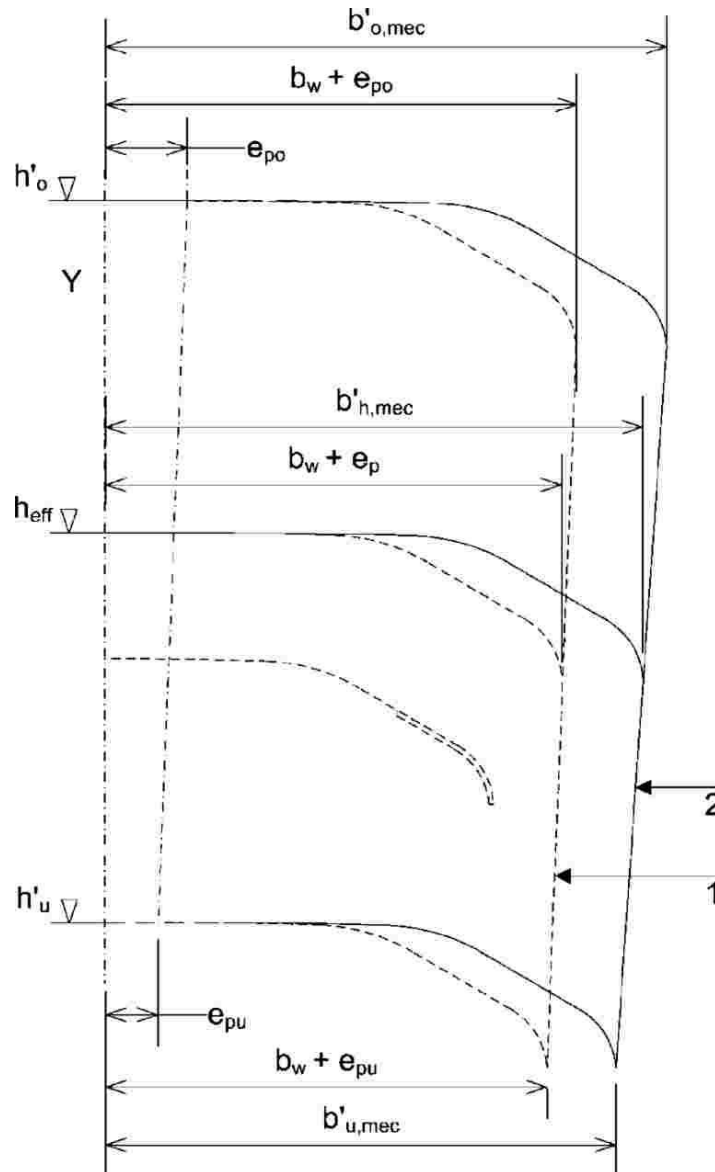
~~D.1.2.1.4 Pantograph sway ep~~

The sway mainly depends on the following phenomena:

- Play $q + w$ in the axle boxes and between bogie and body.
- The amount of body inclination taken into account by the vehicle (depending on the specific flexibility s'_o , the reference cant D'_o and the reference cant deficiency l'_o).
- The mounting tolerance of the pantograph on the roof.
- The transverse flexibility of the mounting device on the roof.
- The height under consideration h' .

Figure D.2

Specification of the width of the mechanical kinematic gauge of the pantograph at different heights



Caption:

Y: Centre of the track

1: Free passage reference profile

2: Mechanical kinematic pantograph gauge

D.1.2.1.5 Additional overthrows

The pantograph gauge has a specific additional overthrows. In case of standard track gauge the following formula applies:

$$S'_{i/a} = \frac{2,5}{R} + \frac{\ell - 1,435}{2}$$

~~For other track gauges the national technical rules apply.~~

~~D.1.2.1.6 Quasi-static effect~~

~~Since the pantograph is installed on the roof, the quasi-static effect plays an important role in the calculation of the pantograph gauge. That effect is calculated from the specific flexibility s'_0 , reference cant D'_0 and reference cant deficiency I'_0 :~~

$$qs'_i = \frac{S'_0}{L} [D - D'_0]_{>0} (h - h'_{c0})$$

$$qs'_a = \frac{S'_0}{L} [I - I'_0]_{>0} (h - h'_{c0})$$

~~Note: Pantographs are normally mounted on the roof of a power unit, whose reference flexibility s'_0 is generally smaller than that of the obstacle gauge s_0 .~~

~~D.1.2.1.7 Allowances~~

~~According to gauge definition, the following phenomena should be considered:~~

- ~~—— Loading dissymmetry;~~
- ~~—— The transverse displacement of the track between two successive maintenance actions;~~
- ~~—— The cant variation occurring between two successive maintenance actions;~~
- ~~—— Oscillations generated by track unevenness.~~

~~The sum of the abovementioned allowances is covered by Σ_j .~~

~~D.1.2.2 Specification of the height of the mechanical gauge~~

~~Gauge height shall be specified on the basis of the static height h_{cc} , of the contact wire at the local point under consideration. The following parameters should be considered:~~

- ~~—— The raising f_s of the contact wire generated by the pantograph contact force. The value of f_s depends on the OCL type and so shall be specified by the Infrastructure Manager in accordance with point 4.2.12.~~
- ~~—— The raising of the pantograph head due to the pantograph head skew generated by the staggered contact point and the wear of the collector strip $f_{ws} + f_{wg}$. The permissible value of f_{ws} is shown in LOC & PAS NTSN and f_{wg} depends on maintenance requirements.~~

The height of the mechanical gauge is given by the following formula:

$$h_{\text{eff}} = h_{\text{cc}} + f_s + f_{\text{ws}} + f_{\text{wa}}$$

D.1.3 Reference parameters

Parameters for the kinematic mechanical pantograph gauge and for Specification of the maximum lateral deviation of the contact wire shall be as follows:

— l — according to track gauge

— $s'_g = 0,225$

— $h'_{eg} = 0,5 \text{ m}$

— $l'_g = 0,066 \text{ m}$ and $D'_g = 0,066 \text{ m}$

— $h'_e = 6,500 \text{ m}$ and $h'_u = 5,000 \text{ m}$

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:

$$d_t = b_{w,c} + b_w - b'_{h,mec}$$

$b_{w,c}$ — defined in points 4.2.8.2.9.1 and 4.2.8.2.9.2 of LOC&PAS NTSN

Appendix E List of referenced standards

Table E.1

List of referenced standards

Index	Parameter	NTSN Clause	Standard Clause
[1]	Railway Applications - Fixed installations and rolling stock - Technical criteria for the coordination between electric traction power supply systems and rolling stock to achieve interoperability - Part 1: General	EN 50388-1	2022
[1.1]	Traction power supply performance	4.2.4	8.2

Index	Parameter	NTSN Clause	Standard Clause
[1.2]	Harmonics and dynamic effects for AC traction power supply systems	4.2.8 (2)	10.2 – Table 6
[1.3]	Assessment of traction power supply performance	6.2.4.1a	8.4
[1a]	Railway Applications – Power supply and rolling stock - Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability	EN 50388	2012
[1a.1]	Electrical protection coordination arrangements	4.2.7	11
[1a.2]	Assessment of regenerative braking	6.2.4.2 (1)	15.7.2
[1a.3]	Assessment of electrical protection coordination arrangements	6.2.4.3	15.6
[1a.4]	Assessment of harmonics and dynamic effects for AC traction power supply systems	6.2.4.4 (1)	10.3
[1a.5]	Assessment of harmonics and dynamic effects for AC traction power supply systems	6.2.4.4 (3)	10.4
[2]	Railway Applications - Fixed installations and rolling stock - Criteria to achieve technical compatibility between pantographs and overhead contact line	EN 50367	2020
[2.1]	Current at standstill	4.2.5	7.2, table 5
[2.2]	Maximum lateral deviation	4.2.9.2 (1)	5.2.5
[2.3]	Mechanical kinematic pantograph gauge	4.2.10 (2)	5.2.2
[2.4]	Mean contact force	4.2.11 (2) and (3)	Table 6
[2.5]	Pantograph spacing for overhead contact line design	4.2.13	Table 9
[2.6]	Phase separation sections - General - length D of neutral section	4.2.15.1 (2)	4
[2.7]	Lines with speed $v \geq 250$ km/h	4.2.15.2 (a)	Annex A.1.2

Index	Parameter	NTSN Clause	Standard Clause
[2.8]	Lines with speed $v \geq 250$ km/h	4.2.15.2 (b)	Annex A.1.4
[2.9]	Lines with speed $v < 250$ km/h	4.2.15.3	Annex A.1
[2.10]	System separation sections - General - length D of neutral section	4.2.16.1 (3)	4
[2.11]	Assessment of current at standstill (DC systems only)	6.1.4.2	Annex A.3
[3]	Railway Applications - Fixed installations – Electric traction overhead contact lines	EN 50119	2020
[3.1]	Minimum design contact wire height	4.2.9.1 (1)	5.10.4
[3.2]	Maximum design contact wire height	4.2.9.1 (1) Note (1)	figure 3
[3.3]	Relation with pantograph working height	4.2.9.1 (2)	figure 3
[3.4]	Dynamic behaviour and quality of current collection	4.2.12 (2)	5.10.2
[3.5]	Dynamic behaviour and quality of current collection	4.2.12 (3)	5.2.5.2, table 4
[3.6]	Phase separation sections - calculation of D, clearances	4.2.15.1 (2)	5.1.3
[3.7]	System separation sections – General - calculation of D, clearances	4.2.16.1 (3)	5.1.3
[3.8]	System separation sections - pantographs raised	4.2.16.2 (2)	5.10.3
[4]	Railway Applications - Fixed installations – Electrical safety, earthing and the return circuit – Part 1: Protective provisions against electric shock	EN 50122-1	2011+A1:2011 +AC:2012+A2:2016+A3:2016+A4:2017
[4.1]	Contact wire height	4.2.9.1 (3)	5.2.4 and 5.2.5
[4.2]	Protective provisions against electric shock	4.2.18	5.2.1 (only for public areas), 5.3.1, 5.3.2, 6.1, 6.2 (excluding requirements for

Index	Parameter	NTSN Clause	Standard Clause
			connections for track circuits)
[4.3]	AC voltage limits	4.2.18	9.2.2.1 and 9.2.2.2
[4.4]	DC voltage limits	4.2.18	9.3.2.1 and 9.3.2.2
[5]	Railway Applications - Fixed installations – Electric traction – Copper and copper alloy grooved contact wire	EN 50149	2012
[5.1]	Contact wire material	4.2.14 (3)	4.2 (excluding the reference to annex B of the standard), 4.3 and 4.6 to 4.8
[6]	Railway Applications – Energy measurement on board trains – Part 3: Data handling	EN 50463-3	2017
[6.1]	On-ground energy data collecting system	4.2.17 (2)	4.12
[7]	Railway Applications – Energy measurement on board trains – Part 4: Communication	EN 50463-4	2017
[7.1]	On-ground energy data collecting system	4.2.17 (3)	4.3.6 and 4.3.7
[8]	Railway Applications – current collection systems – Validation of simulation of the dynamic interaction between pantograph and overhead contact line	EN 50318	2018+A1:2022
[8.1]	Assessment of dynamic behaviour and quality of current collection – Simulation tool	6.1.4.1 (1)	
[9]	Railway Applications – current collection systems – Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line	EN 50317	2012
[9.1]	Assessment of dynamic behaviour and quality of current collection - Measurement	6.1.4.1 (1)	

Index	Parameter	NTSN Clause	Standard Clause
[9.2]	Assessment of dynamic behaviour and quality of current collection (integration into a subsystem)	6.2.4.5 (2)	

Index No.	Reference	Document name	Version	BP(s) concerned
1	EN 50119	Railway applications— Fixed installations— Electric traction overhead contact lines	2009	Current capacity, DC systems, trains at standstill (4.2.5), Geometry of overhead contact line (4.2.9), Dynamic behaviour and quality of current collection (4.2.12), Phase separation sections (4.2.15) and System separation sections (4.2.16)
2	EN 50122-1:2011+A1:2011	Railway applications— Fixed installations— Electrical safety, earthing and the return circuit—Part 1: Protective provisions against electric shock	2011	Geometry of the overhead contact line (4.2.9) and Protective provisions against electric shock (4.2.18)
3	EN 50149	Railway applications— Fixed installations— Electric traction— Copper and copper alloy grooved contact wires	2012	Contact wire material (4.2.14)
4	EN 50163	Railway applications— Supply voltages of traction systems	2004	Voltage and frequency (4.2.3)
5	EN 50367	Railway applications— Current collection systems—Technical	2012	Current capacity, DC systems, trains at standstill (4.2.5), Mean contact force

Index No.	Reference	Document name	Version	BP(s) concerned
		criteria for the interaction between pantograph and overhead line (to achieve free access)		<i>(4.2.11), Phase separation sections (4.2.15) and System separation sections (4.2.16)</i>
5a	EN 50367	Railway applications — Fixed installation and rolling stock — Criteria to achieve technical compatibility between pantographs and overhead contact line	2020	Current at standstill (4.2.5)
6	EN 50388	Railway applications — Power supply and rolling stock — Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability	2012	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)
7	EN 50317	Railway applications — Current collection systems — Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line	2012	Assessment of dynamic behaviour and quality of current collection (6.1.4.1 and 6.2.4.5)
8	EN 50318	Railway applications — Current collection systems — Validation of simulation of the dynamic interaction between pantograph	2002	Assessment of dynamic behaviour and quality of current collection (6.1.4.1)

Index No.	Reference	Document name	Version	BP(s) concerned
		and overhead contact line		
9	EN 50463-3	Railway application – Energy measurement on board trains – Part 3: Data handling	2017	On-ground energy data collecting system (4.2.17)
10	EN 50463-4	Railway application – Energy measurement on board trains – Part 4: Communication	2017	On-ground energy data collecting system (4.2.17)

Appendix F *Intentionally deleted*

Appendix G **Glossary**

Table G.1

Glossary

Defined term	Abbr.	Definition
AC		Alternative current
DC		Direct current
Compiled energy billing data	CEBD	Dataset compiled by the Data Handling System (DHS) suitable for energy billing
Contact line system		System that distributes the electrical energy to the trains running on the route and transmits it to the trains by means of current collectors
Contact force		Vertical force applied by the pantograph to the OCL
Contact wire uplift		Vertical upward movement of the contact wire due to the force produced from the pantograph

Defined term	Abbr.	Definition
Current collector		Equipment fitted to the vehicle and intended to collect current from a contact wire or conductor rail
Gauge		Set of rules including a reference contour and its associated calculation rules allowing defining the outer dimensions of the vehicle and the space to be cleared by the infrastructure. NOTE: According to the calculation method implemented, the gauge will be a static, kinematic or dynamic
Lateral deviation		Lateral stagger of contact wire in maximum crosswind.
Level crossing		An intersection at the same elevation of a road and one or more rail tracks
Line speed		Maximum speed measured in kilometres per hour for which a line has been designed
Maintenance plan		A series of documents setting out the infrastructure maintenance procedures adopted by an infrastructure manager
Mean contact force		Statistical mean value of the contact force
Mean useful voltage train		Voltage identifying the dimensioning train and enables the effect on its performance to be quantified
Mean useful voltage zone		Voltage giving an indication of the quality of the traction power supply in a geographic zone during the peak traffic period in the timetable
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
Nominal contact wire height		A nominal value of the contact wire height at a support in the normal conditions
Nominal voltage		Voltage by which an installation or part of an installation is designated
Normal service		Planned timetable service
On-ground energy data collecting	DCS	On-ground service collecting the CEBD from an Energy Measurement System

Defined term	Abbr.	Definition
system (data collecting service)		
Overhead contact line	OCL	Contact line placed above (or beside) the upper limit of the vehicle gauge and supplying vehicles with electric energy through roof-mounted current collection equipment
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
Return circuit		All conductors which form the intended path for the traction return current
Static contact force		Mean vertical force exerted upwards by the pantograph head on the OCL, and caused by the pantograph-raising device, whilst the pantograph is raised and the vehicle is standstill