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 Guide for the application of the CR ENE TSI According to Framework Mandate C(2007)3371 final of 13/07/2007	
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0. DOCUMENT INFORMATION

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Table 1 : Status of the document

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1. SCOPE OF THIS GUIDE

1.1. Scope

1.1.1. This document is an annex to the Guide for the application of TSIs. It provides information on the application of the Technical Specification for Interoperability for the Conventional Rail 'Energy' subsystem adopted by Commission Decision 2011/274/EU of 26 April 2011 ('CR ENE TSI').

1.1.2. The guide should be read and used only in conjunction with the CR ENE TSI. It is intended to facilitate its application, but does not replace it. The general part of the 'Guide for the application of TSIs' should also be considered.

1.2. Content of the guide

1.2.1. In section 2 of this document, extracts of the original text of the CR ENE TSI are provided, in a shaded text box, and these are followed by a text that gives guidance.

1.2.2. Guidance is not provided for clauses where the original CR ENE TSI requires no further explanation.

1.2.3. Guidance is of voluntary application. It does not mandate any requirement in addition to those set out in the CR ENE TSI.

1.2.4. Guidance is given by means of further explanatory text and, where relevant, by reference to standards that demonstrate compliance with the CR ENE TSI; relevant standards are listed in section 3 of this document.

1.2.5. The guide also contains some indications for the implementation strategy.

1.3. Reference documents

Reference documents are listed in the general part of the 'Guide for the application of TSIs'.

1.4. Definitions and abbreviations

Definitions and abbreviations are given in the CR ENE TSI, clause 2.1 and in the general part of the 'Guide for the application of TSIs'.

2. CLARIFICATIONS ON THE CR ENE TSI

2.1. Foreword

This document takes into account the experience gained while drafting the CR ENE TSI and Questions and Requests received from NoBos when introducing the HS ENE TSIs (EC Decisions: 2002/233/EC and 2008/284/EC).

The geographical scope of the CR ENE TSI is the trans-European conventional rail system as described in Annex I (1.1) to Directive 2008/57/EC.

The network of the trans-European conventional rail system is that of the conventional lines of the trans-European transport network identified in Decision 661/2010/EU (which replaced Decision 1692/96/EC).

The scope of the TSI has not yet been extended to the non-TEN lines as provided for in Article 1(4) of Directive 2008/57/EC.

2.2. Essential requirements

The essential requirements cover:

- safety,
- reliability and availability,
- health,
- environmental protection,
- technical compatibility.

and are addressed in chapter 3 of the TSI.

2.3. Characteristics of the subsystem

The following clauses refer to respective clauses of the TSI.

2.3.1. Voltage and frequency (clause 4.2.3)

The values and limits of the voltage and frequency at the terminals of the substation and at the pantograph shall comply with EN50163:2004, clause 4.

The AC 25 kV 50 Hz system is to be the target supply system, for reasons of compatibility with the electrical generation and distribution systems and standardisation of substation equipment.

However, due to the high investment costs needed to migrate from other system voltages to the 25 kV system and the possibility of using multi-system traction units, the use of the following systems for new, upgraded or renewed subsystems is permitted:

- o AC 15 kV 16.7 Hz
- o DC 3 kV, and
- o DC 1.5 kV.

In the case of conventional rail, the wide spread of existing electrification and the fact that multiple traction vehicles are the current state of the art make the migration to one system not economically viable.

Therefore the CR ENE TSI allows the application of AC 1-phase 15 kV 16.7 Hz and DC 1.5 kV and 3 kV systems for new, upgraded or renewed subsystems.

To support interoperability, each of these systems has been standardised according to EN 50163:2004.

For information about implementation, see clause 2.7 of this document.

2.3.2. Parameters relating to supply system performance (clause 4.2.4)

3.3.2.1 Maximum train current

‘The Infrastructure Manager shall declare the maximum train current in the Register of infrastructure (see Annex C).

The energy subsystem design shall ensure the ability of the power supply to achieve the specified performance and permit the operation of trains with a power less than 2 MW without current limitation as described in clause 7.3 of EN50388:2005’.

Though target values for conventional lines with reference to different supply systems are given in EN 50388:2005 (Table 7.1), the parameters that affect the maximum train current are more complex, e.g. type of traffic, type of rolling stock, profile of the line, headway, etc. To put one target value for all conventional lines would lead to oversizing of the supply system and unnecessary costs in fixed installations.

In the TSI it is stressed that the power supply system has to be designed according to real needs, and therefore that the maximum train current shall be indicated in the Register of Infrastructure.

On the other hand, to avoid unnecessary rolling stock costs it was decided that the system should allow trains up to 2 MW without current-limiting devices (see EN50388:2005, clause 7.3) .

3.3.2.2 Power factor

‘The power factor of trains shall be in accordance with requirements in Annex G and EN50388:2005 clause 6.3’.

The power factor is a requirement for the rolling stock, but it is very important for the performance and therefore the design of the Energy subsystem. The values are given in EN 50388:2005.

For trains with power lower than 2 MW, the power factor condition described in the TSI and EN 50388:2005 has to be fulfilled over a complete journey. In order to avoid oversized power supply of marshalling yards and depots, particular requirements for the power factor are given.



3.3.2.3 Mean useful voltage

'The calculated mean useful voltage 'at the pantograph' shall comply with EN50388:2005, clauses 8.3 and 8.4, using the design data for the power factor according to Annex G'.

Mean useful voltage is a quality parameter of the power supply system that shows the ability of the power supply system to deliver to trains the required performance in normal and degraded conditions. The mean useful voltage is a parameter that cannot be directly measured. It is calculated during simulation of the capacity of the supply system for the geographical zone during peak hours of a design timetable and for the train with the lowest voltage (referred to as the 'dimensioning train'). A detailed description of the calculation process is given in EN 50388:2005, Annex B.

2.3.3. Continuity of power supply in case of disturbances in tunnels (clause 4.2.5)

'The power supply and the overhead contact line system shall be designed to enable continuity of operation in case of disturbances in tunnels. This shall be achieved by sectioning overhead contact line in accordance with clause 4.2.3.1 of the SRT TSI'.

The aim of this clause is the link with clause 4.2.3.1 of the SRT TSI and the requirement to assure the continuity of power supply to enable a train to leave an endangered zone. This requirement will apply whenever the ENE TSI applies, whether or not the full SRT TSI applies as well.

2.3.4. Current capacity, DC systems, trains at standstill (clause 4.2.6)

The overhead contact line 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.

This shall be achieved using a static contact force as defined in clause 7.1 of EN50367:2006.

This is an interface issue with rolling stock. The purpose of the requirement is to prevent overheating of the pantograph contact strip / contact wire contact point when the train is at standstill and is drawing power, for example for auxiliary equipment. The issue is complex, and has many influences, for example: ambient temperature, temperature limits of the contact wire (depending on the contact wire material, according to EN 50119:2009), amount of current taken from the overhead contact line (OCL) during the period of time, contact strip material, number of contact strips and contact wires being in touch, static contact force exerted by the pantograph, level of wear of contact strip and contact wire.

These parameters are considered during the design process of the power consumption of the vehicle, the contact strips and the overhead contact line, for the appropriate value of maximum current taken from the OCL. This is a variable (depending on total load of the auxiliary circuit) that is checked and controlled by the RST subsystem.



2.3.5. Regenerative braking (clause 4.2.7)

AC power supply systems shall be designed to permit the use of regenerative braking as a service brake, able to exchange power seamlessly either with other trains or by any other means.

DC power supply systems shall be designed to permit the use of regenerative braking as a service brake at least by exchanging power with other trains.

Regenerative braking for both AC and DC systems is widely used in modern rolling stock.

Current technologies allow energy to be produced for AC and DC systems during regenerative mode with low harmonic content, which impact on the quality of energy delivered by the supplier to other consumers.

For AC systems, the supply system can be designed to feed energy back to the supply grid. It is supposed that any power supplier will accept the feedback of energy.

For DC systems, current technology generally allows exchange between trains, but the use of energy storage systems at the substations or converters to feed back energy to the supply grid is also allowed.

2.3.6. Harmonic and dynamic effects for AC systems (clause 4.2.9)

The CR energy subsystem and rolling stock must be able to work together without interference problems, such as over-voltages and other phenomena described in EN50388:2005 clause 10.

These phenomena are related to the harmonic characteristics of power supply fixed installations and rolling stock, which can create overvoltages and other instability phenomena in the power supply system. Particular attention should be paid when introducing a new element into an existing, stable electric environment. The TSI stresses the need for a compatibility study to be carried out in this case, to assess any consequences resulting from the introduction of the new element into the system. The compatibility study is explained in detail in EN 50388:2005, to which the TSI makes a reference. Technical studies are being undertaken by CENELEC in order to find common compatibility criteria.

2.3.7. Harmonic emissions towards the power utility, External electromagnetic compatibility, Protection of the environment

Similar to HS ENE TSIs, these three parameters have no special requirements relating to the railway energy subsystem. It is considered that the essential requirements referring to environmental protection (see Annex III (1.4) to Directive 2008/57/EC) are fulfilled by the current general European legislation and agreements and national regulations.

2.3.8. Geometry of the overhead contact line (clause 4.2.13)

The nominal contact wire height shall be in the range of 5.00 - 5.75 m. For the relation between the contact wire heights and pantograph working heights see EN50119:2009 figure 1.

The contact wire height may be lower in cases related to gauge (like bridges, tunnels). The minimum contact wire height shall be calculated in accordance with EN50119:2009 clause 5.10.4.

The contact wire may be higher in cases e.g. level crossings, loading areas, etc. In these cases the maximum design contact wire height shall not be greater than 6.20 m.

Taking into account tolerances and uplift in accordance with EN50119:2009 figure 1, the maximum contact wire height shall not be greater than 6.50 m.

Geometry of the overhead contact line is a main interface with the pantograph.

The nominal contact wire height is a design value only and can be between 5.0m and 5.75m. The value is included in the TSI so that pantograph adjustments can be made to optimise the collection of current from the OCL.

The maximum contact wire height takes account of the national road laws and contact wire height over level crossings, which are frequent on conventional railways. In addition, the minimum contact wire height ensures that there is at least the minimum electrical clearance for the appropriate vehicle gauge for the line.

The minimum and maximum design contact wire heights are chosen to ensure that the absolute minimum and maximum values are always achieved.

The difference between the maximum and minimum contact wire heights chosen should also be compatible with the working limits of the pantograph.

At maximum contact wire heights close to 6.50m it is not required that operation can be performed at full design speed of the overhead line. These heights are just included to allow a train to be moved at low speed where such a high contact wire is needed for some special or local reason.

The maximum permissible lateral deviation of the contact wire normal to the design track centre line under the action of cross wind is given in Table 4.2.13.3.

The values shall be adjusted taking into account the movement of the pantograph and track tolerances according to Annex E.

The maximum permissible lateral deviation is strictly related to the target profile of the pantograph head, as defined in the CR LOC&PAS TSI, clause 4.2.8.2.9.2.

The design of the OCL must ensure that in any case the lateral deviation is within the permitted limits set in the CR ENE TSI for at least one of the specified pantograph head profiles.

The reference to EN 50367:2006, as in the HS ENE TSI, was replaced by Annex E, which is based on CEN standard EN 15273:2009 (see also section 2.2.9). The lateral deviation values shall be adapted in accordance with the pantograph movement and track tolerances.

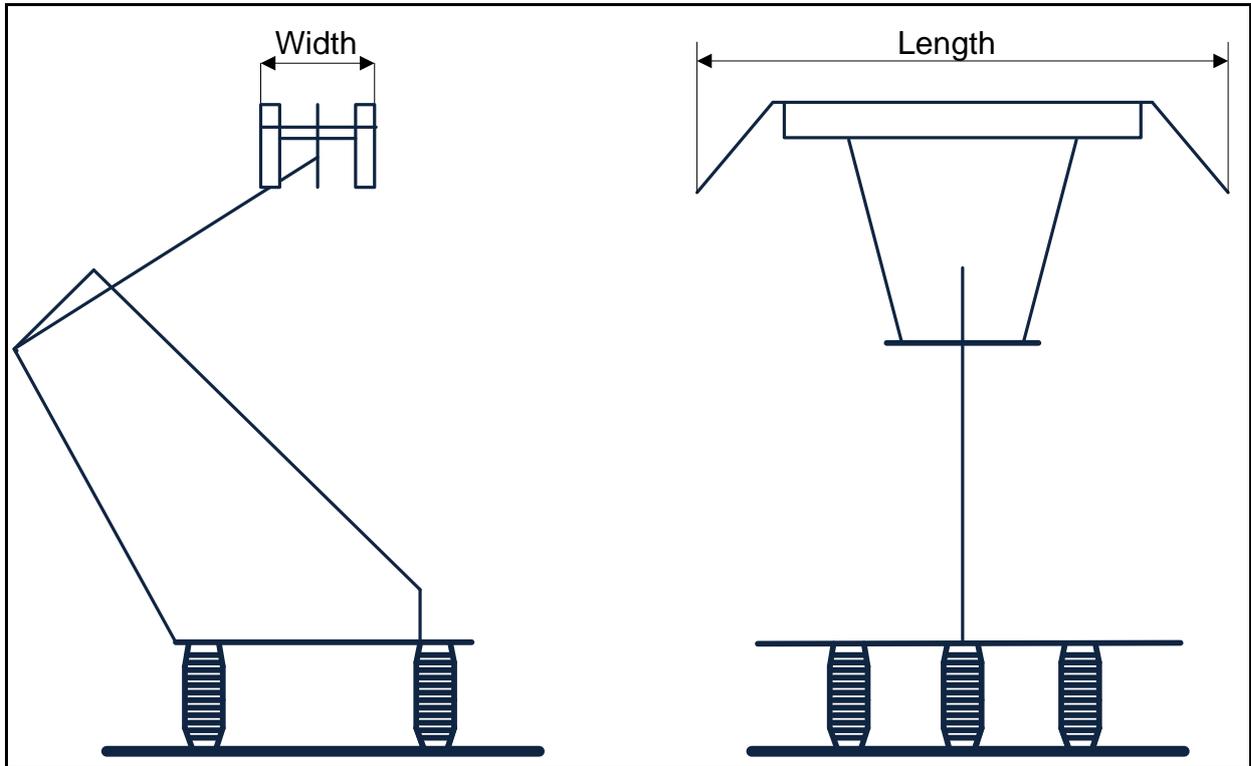


Figure 2.3.8.1 – Pantograph head, width and length (according to Fig. A1 EN50206-1:1998)

2.3.9. Pantograph gauge (clause 4.2.14)

This clause – together with Annex E to the ENE TSI – is based on chapter 11 of CEN standard EN 15273-3:2009 which is part of the EN 15273 series relating to detailed calculation of gauge for infrastructure and vehicles.

Annex E is considered to be more specific to TSI conform rolling stock and pantographs.

Annex E is used to determine the reference profile that is used to calculate the minimum structure gauge necessary for free passage and the maximum lateral deviation of the contact wire.

2.3.10. Mean contact force (clause 4.2.15)

The ranges of F_m for each of the power supply systems are defined in Table 4.2.15.

In accordance to clause 4.2.16, overhead contact lines shall be designed to be capable to sustain this upper limit force curve given in Table 4.2.15.

In comparison to the HS ENE TSI, two major modifications were introduced:



The mean contact force F_m exerted by the pantograph shall be in the range between the minimum static contact force and the force curve given for a particular supply system.

There is a new formula for the force curve for DC 1.5 kV.

In the CR ENE TSI the curve of mean contact force as a function of speed represents the upper limit for the mean contact force. This is different from the HS ENE TSI where the curve is a target curve. Consequently, to meet the CR ENE TSI current collection quality requirements, the conformed OCL must accept a pantograph whose mean contact force curve is within the range defined in the CR ENE TSI.

The above-mentioned changes have the following consequences on the OCL design:

- the OCL should be designed to accept a vehicle with a pantograph exerting a contact force in the range between static force and the force curve
- the OCL should also be designed to sustain the upper limit force curve indicated in Table 4.2.15.

2.3.11. Dynamic behaviour and quality of current collection (clause 4.2.16)

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*

The Contracting Entity shall declare the method to be used for verification. The values to be achieved by the chosen method are set out in Table 4.2.16.

The requirements for this parameter correspond to those in the HS ENE TSI.

Major changes were introduced in the conformity assessment – see clause 2.5.

2.3.12. Pantograph spacing (clause 4.2.17)

The overhead contact line shall be designed for a minimum of two pantographs operating adjacently, having a minimum spacing centre line to centre line of the pantograph head as set out in Table 4.2.17:

The possible solutions for pantograph arrangements – number raised and distances between them – is definitely more variable for CR than HS due to variability of the rolling stock used. This has an impact on OCL design, quality of current collection and design of separation sections. Each OCL should be designed for at least two simultaneously operating pantographs. The distance between two consecutive pantographs is used only for the design of the OCL. For the operational point of view, the information concerning which distance between two consecutive pantographs can be used on a certain line is given in RINF. The distance which is given in RINF is combined with other information such as rules for passing through the separation section.



The idea of defining three types of OCL: A, B and C was due to the following reasons:

- to comply with the requirements of the HS ENE TSI, type A is used;
- to comply with current design rules in the Member States for conventional lines, types B and C are used, depending on the type of the line and variety of operating vehicles.

If necessary, the OCL can be designed for stronger conditions: shorter distance between pantographs in relation to speed and/or more than two pantographs in operation, but this information has to be published in the Register of Infrastructure.

2.3.13. Separation sections (clause 4.2.19 and 4.2.20)

The main goal of the separation section is to ensure that a vehicle passing through this section does not bridge two adjacent phases/systems. Compared to the HS ENE TSI, this TSI gives greater freedom in the design of the separation sections (see sections 4.2.19 and 4.2.20 and Annex F).

Details of the particular separation section relating to: its type, switching off the circuit breaker or lowering the pantograph, accepted arrangements of pantographs when raised are given in the Register of Infrastructure.

Further information is given in EN50367:2006 and EN50388:2005.

2.3.14. Electric energy consumption measuring equipment (clause 4.2.21)

If an electric energy consumption measuring equipment is installed, it shall be compatible with CR LOC&PAS TSI clause 4.2.8.2.8. This equipment can be used for billing purposes and the data provided by it shall be accepted for billing in all Member States.

The problem of splitting the purchased energy among particular consumers arose with the separation of the infrastructure from operators and the opening of the railway market to new players, laid down by Directive 91/440/EEC (and amending acts, relating to allocation of railway infrastructure capacity). It can be done on the basis of carried load and vehicle and line characteristics or by measuring energy consumed on board. The last method requires dedicated meters and a billing system introduced by the traction energy supplier – the IM or an independent company. To limit the range of possible solutions and to comply with Directive 2008/57/EC, the requirements of the on-board part of the equipment were included in the CR LOC&PAS TSI, based on the development of CEN standard prEN50463:2010. The use of this equipment is not mandatory, but if installed it must be compatible with the CR LOC&PAS TSI, section 4.2.8.2.8. The on-board energy measuring equipment is assessed by the NoBo that carries out the EC verification procedure for the rolling stock subsystem.

There is no assessment to be carried out by the NoBo in charge of the energy subsystem.

The equipment can be used for billing, and data provided by this system shall be accepted for this purpose.

2.4. Interfaces

The interfaces between Energy and other subsystems are covered in clause 4.3 of the TSI.

The important interface is with rolling stock. A fundamental issue refers to interaction between the contact wire and the contact strip. The proper interaction between contact wire and contact strips has an impact on the quality of current collection and wear of both elements.

According to the CR ENE TSI, copper and its alloys are indicated as allowable contact wire materials. Though the TSI forbids the use of copper-cadmium alloys in new installations, this material can still be used in case of maintenance replacement of contact wire if the Member State law does not prevent it.

According to CR LOC&PAS TSI, plain carbon is allowed as contact strips material in all cases. Other materials, approved on particular networks, are indicated in the Register of Infrastructure. Studies and tests are currently under way to extend the acceptance of copper impregnated carbon by all EU Member States. The results will be included in the next revision of the TSI.

2.5. Conformity assessment

2.5.1. Assessment of dynamic behaviour and quality of current collection

This is the crucial parameter which describes the relationship between the overhead contact line and pantograph in order to obtain the proper quality of current collection. By comparing the assessment of the parameters (dynamic behaviour and quality of current collection) in the HS and CR ENE TSI, the text was modified and adapted to wider ranges of nominal contact wire height.

The current collection quality is affected by the design and installation quality of both interoperability constituents (overhead contact line and pantograph), and has an impact on their performance and useful life.

In the case of conventional rail, the number and arrangements of the pantographs in simultaneous contact with the overhead contact line have to be taken into account in the assessment (see also the CR ENE TSI, clause 4.2.17).

Additionally, to facilitate and accelerate the process of certification of new interoperability constituents – in the case of new types, the TSI now includes the possibility to perform common tests of both elements (i.e. a new type of OCL and a new type of pantograph). This issue is very important for manufacturers that do not have access to interoperability constituents which were assessed against the HS TSI.

Accordingly, the previous version of the conformity assessment clauses has been adapted and clarified.

2.5.2. Assessment of current at standstill (DC systems)

The conformity assessment for the requirements as in clause 2.3.4 is described in EN 50367:2006 annex A.4.1.

To standardise, the test given in clause A.4.1.1 should be performed with the pantograph in a contact with one contact wire. This is to avoid overheating of the OCL designs with one contact wire.

2.6. Interoperability constituents (ICs)

2.6.1. General

During the process of developing the CR ENE TSI an extensive list of elements creating the Energy subsystem was considered, with a view to identifying possible interoperability constituents. After discussion, the list was limited to three items:

- OCL (as in the HS ENE TSI)

and, additionally:

- section insulator: an assembly inserted in a continuous run of contact line for isolating two electrical sections from each other, that guarantees continuous current collection during pantograph passage.
- neutral section insulator: an assembly inserted in a continuous run of contact line for isolating two electrical sections from each other, that guarantees insulation between the two electrical sections during pantograph passage.

However, the lack of European standardisation relating to requirements and conformity assessment (including the difficulty of assessing them separately from the overhead contact line) led to the conclusion that including insulators in this TSI is premature.

2.6.2. Overhead Contact Line (OCL)

The definition of the Overhead Contact Line in the CR Energy TSI was kept similar to that in the HS.

Because the requirements for the subsystem were simplified compared to the HS, the specifications for the overhead contact line were also reduced accordingly.

The scope of certification of the Interoperability Constituent Overhead Contact Line includes only those elements which are important for the compatibility of the OCL with a TSI-compliant pantograph and train. Other elements need to be considered during the design, installation and commissioning of the OCL, but these are outside the scope of the assessment.

2.6.3. Quality checks of the OCL after integration in the subsystem and before placing in service

When the OCL has been certified as an Interoperability Constituent, it can be used on interoperable lines and integrated into a subsystem. The main aspect of assessment of the dynamic behaviour and quality of current collection of a certified OCL is the identification of installation errors.

Where the maximum operational speed for any track is less than the design speed of the IC OCL (e.g. for layout and/or track and/or signalling constraints), the test should be carried out with the maximum operational speed of the track.

For speeds up to 120 km/h significant installation errors are generally not demonstrated by contact force measurement. In this case, alternative methods of identifying construction errors should be used, such as measurement of the contact wire height, stagger and uplift.

2.7. Implementation

2.7.1. General

As indicated in clauses 7.1 and 7.2.1 of the TSI, the Member State has to specify those parts of the Energy subsystem which are required for interoperable services. The Member State should also develop a migration strategy which indicates the way existing installations should be adapted to fulfil the CR ENE TSI requirements, and the timescale.

In the Energy subsystem, the two most important factors for achieving free access are:

- the power supply system, and
- the overhead contact line design which allows passage of the target pantographs.

2.7.1.1. Power supply system

The issue of the supply system should be considered with flexibility, taking account of local situations and other subsystems such as Control-Command and Signalling (CCS) or Infrastructure as well as progress in multisystem vehicle technologies.

The decision relating to the supply system should be taken at MS level, because it entails not only commitments in the railway sector but also other commitments, such as necessary investments in the MS energy transmission/distribution system, regional development and international agreements.

2.7.1.1. Overhead contact line design

Following the HS ENE TSI requirements, as well as those of the CR ENE TSI, Europantograph 1600mm is considered to be one of the target profiles. On the conventional network, particularly in Central and Eastern Europe, the 1950mm pantograph is widely used. Both are indicated as target profiles for conventional rail in the CR LOC&PAS TSI. As a consequence, to move towards interoperability, the overhead contact line shall be designed for use by at least one of the above-mentioned pantographs.

2.7.2. Application of the TSI to new lines

All of the TSI requirements set out in chapters 4 to 6 and 7.5 are mandatory for new lines when the TSI is in force.

2.7.3. Application of the TSI to upgrading/renewal of lines

It should be considered that upgrading or renewal of an energy subsystem is not done for no reason – it is normally a consequence of plans of general upgrading or renewal of the line. In this case, the scope of the energy subsystem modernisation is defined according to the needs of rail users, i.e. change of speed, timetable or new, more powerful rolling stock. Taking into account the above-mentioned requirements, changes to be made in the energy subsystem should be evaluated during the preliminary design phase. The evaluation has to be made in each case individually, on the basis of the condition of existing installations, business plans and available funds. This evaluation should be a part of the *file describing the project* (Article 20 of the Directive).



The MS shall decide on whether the extent of the works proposed means that a new authorisation for placing in service is needed (Article 20(1) of the Directive). The migration strategy should start to reach compatibility with clauses 4.2.13, 4.2.14 and 4.2.16.



3. APPLICABLE SPECIFICATIONS AND STANDARDS

3.1. Explanation of the use of the specifications and standards

	TSI section	References to EN
1.	4.2.3 Voltage and frequency	EN 50163:2004 – RA – Supply voltages of traction systems clause 4
2.	4.2.4 Parameters relating to supply system performance	EN 50388:2005 – RA – Power supply and rolling stock – Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability clauses 6.3, 7.2, 7.3, 8.3, 8.4, 14.4.1, 14.4.2, 14.4.3
3.	4.2.6 Current capacity, DC systems, trains at standstill	EN 50367:2006, RA – Current collection systems – Technical criteria for the interaction between pantograph and overhead line (to achieve free access) clause 7.1
4.	4.2.7 Regenerative braking	EN 50388:2005 Clauses 12.1.1, 14.7.2.
5.	4.2.8 Electrical protection coordination arrangements	EN 50388:2005 clause 11, except Table 8, clause 14.6
6.	4.2.9 Harmonics and dynamic effects	EN 50388:2005 clause 10.3, 10.4
7.	4.2.13 Geometry of the overhead contact line	EN 50119:2009 – Railway applications – Fixed installations – Electric traction overhead contact lines clauses 5.10.3 and 5.10.4 and Figure 1
8.	4.2.15 Mean contact force	EN 50367:2006 clause 7.1



	TSI section	References to EN
9.	4.2.16 Dynamic behaviour and quality of current collection –	EN 50367:2006 clause 7.2 EN 50119:2009 clause 5.2.5.2, 5.10.2 EN 50317:2002 – RA – Current collection systems – Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line EN 50318:2002 RA – Current collection systems – Validation of simulation of the dynamic interaction between pantograph and overhead contact line
10.	4.2.18 Contact wire material	EN 50149:2001, RA – Fixed installations – Electric traction – Copper and copper alloy grooved contact wires clauses 4.1 to 4.3 and 4.5 to 4.8 (except Table 1)
11.	4.2.19 Phase separation sections	EN 50367:2006 Annex A.1 EN 50388:2005 clause 5.1
12.	4.2.20 System separation sections	EN 50122-2:1998 – RA Fixed Installations – Part 2 Protective provisions against the effects of stray currents caused by DC traction systems clause 6.1.1 EN 50119:2009 clause 5.10.3

3.2. Standards or other documents not referred to in the energy TSI (and therefore voluntary)

	TSI section	Relevant EN or other documents
1	4.2.14 Pantograph gauge Annex E	EN 15273:2009 – RA – Gauges – Part 1, 2, 3
2	4.2.21 Electric energy consumption measuring equipment	UIC leaflet 930 – Exchange of data for cross-border railway energy settlement

