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work better for society.

## Guide for the application of the LOC&PAS TSI (*Commission Regulation (EU) No 1302/2014 of 18 November 2014 and amended by the Commission Implementing Regulation (EU) 2019/776*)

*In accordance with Article 19(3) of Regulation (EU) 2016/796 of the European Parliament and of the Council of 11 May 2016*

### Document History

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## 1. SCOPE OF THIS GUIDE

### 1.1. Content of the guide

#### 1.1.1. Scope

This document is an Annex to the “Guide for the Application of TSIs”. It provides information on the application of Technical Specification for Interoperability for the “rolling stock subsystem - Locomotives and passenger rolling stock” adopted by the Commission Regulation (Commission Regulation (EU) No 1302/2014 of 18 November 2014 and amended by the Commission Implementing Regulations (EU) 2016/919, 2018/868, 2019/776, and 2020/387) (from now on referred as TSI LOC&PAS).

The guide needs to be read and used only in conjunction with the TSI LOC&PAS. It is intended to facilitate its application but it does not substitute for it. The general part of the “Guide for the Application of TSIs” has also to be considered.

#### 1.1.2. Content of the guide

In chapter 2 of this document, extracts of the original text of the TSI LOC&PAS are provided, shown in a shaded text box and these are followed by a text that gives guidance.

Guidance is not provided for every clause where the original TSI LOC&PAS requires no further explanation.

Guidance is of voluntary application. It does not mandate any requirement in addition to those set out in the TSI LOC&PAS.

Guidance is given by means of further explanatory text and where relevant by reference to standards that are means of demonstrating compliance with the TSI LOC&PAS; relevant standards are listed in the chapter 4 of this document, and their purpose is indicated in the column “purpose” of the table.

### 1.2. Document reference/s

*Table 1: Document reference/s*

<i>DOCUMENT REFERENCE</i>	<i>TITLE</i>	<i>LAST ISSUE</i>
[1] (EU) 2016/796	Regulation (EU) 2016/796 of the European Parliament and of the Council of 11 May 2016 on the European Union Agency for Railways and repealing Regulation (EC) No 881/2004	L 138, 26.5.2016, p. 1-43
[2] (EU) 2016/797	Directive (EU) 2016/797 of the European Parliament and of the Council of 11 May 2016 on the interoperability of the rail system within the European Union	L 138, 26.5.2016, p. 44-101
[3] (EU) 2016/798	Directive (EU) 2016/798 of the European Parliament and of the Council of 11 May 2016 on railway safety	L 138, 26.5.2016, p. 102-149
[4] 2012/34/EU	Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 establishing a single European railway area	L 343, 14.12.2012, p. 32-77

Table 1: Document reference/s

DOCUMENT REFERENCE	TITLE	LAST ISSUE
[5] 2010/713/EU	Commission Decision 2010/713/EU of 9 November 2010 on modules for the procedures for assessment of conformity, suitability for use and EC verification to be used in the technical specifications for interoperability adopted under Directive 2008/57/EC of the European Parliament and of the Council	L 319, 4.12.2010, p. 1-52
[6] 768/2008/EC	Decision 768/2008/EC of the European Parliament and of the Council of 9 July 2008 on a common framework for the marketing of products, and repealing Council Decision 93/465/EEC	L 218, 13.8.2008, p. 82-128
[7] (EC)765/2008	Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation and market surveillance relating to the marketing of products and repealing Regulation (EEC) No 339/93	L 218, 13.8.2008, p. 30-47
[8] (EU)2018/545	Commission Implementing Regulation (EU) 2018/545 of 4 April 2018 establishing practical arrangements for the railway vehicle authorisation and railway vehicle type authorisation process pursuant to Directive (EU) 2016/797 of the European Parliament and of the Council	L 90, 6.4.2018, p. 66–104

### 1.3. Definitions and abbreviations

Table 1: Definitions

TERM	DEFINITION/ SOURCE
Acts issued by the Agency	Are those listed in Article 4 of Regulation (EU) 2016/796 of the European Parliament and of the Council (Agency Regulation)
Basic parameter	Any regulatory, technical or operational condition which is critical to interoperability and is specified in the relevant TSIs (Article 2(12) of Directive (EU) 2016/797)
Basic design characteristics	parameters that are used to identify the vehicle type as specified in the issued vehicle type authorisation and recorded in the European Register of Authorised Types of Vehicles ('ERATV') (Article 2(2) of Regulation (EU) 2018/545)
Conformity assessment	Process demonstrating whether specified requirements relating to a product, process, service, subsystem, person or body have been fulfilled (Article 2(41) of Directive (EU) 2016/797)
Conformity assessment body	Body that has been notified or designated to be responsible for conformity assessment activities, including calibration, testing, certification and inspection; a conformity assessment body is classified as a 'notified body' following notification by a Member State; a conformity assessment body is classified as a 'designated body' following designation by a Member State (Article 2(42) of Directive (EU) 2016/797)

Table 1: Definitions

<i>TERM</i>	<i>DEFINITION/ SOURCE</i>
Contracting entity	Public or private entity which orders the design and/or construction or the renewal or upgrading of a subsystem (Article 2(20) of Directive (EU) 2016/797)
European Register of Authorised Types of Vehicles (ERATV)	Register of types of vehicles authorised by the Member States for placing in service. It contains the technical characteristics of vehicles' types as defined in the relevant TSIs, the manufacturer's name, dates, references and Member States granting authorisations, restrictions and withdrawals (Article 48 of Directive (EU) 2016/797)
Existing rail system	Infrastructure composed of lines and fixed installations of the existing, rail network as well as the vehicles of all categories and origin travelling on that infrastructure (Article 2(16) of Directive (EU) 2016/797)
Harmonised standard	European standard adopted on the basis of a request made by the Commission for the application of Union harmonising legislation (Article 2(1)(c) of Regulation (EU) No 1025/2012)
Infrastructure Manager	Any body or firm responsible for the operation, maintenance and renewal of railway infrastructure on a network, as well as responsible for participating in its development as determined by the Member State within the framework of its general policy on development and financing of infrastructure (Article 3(2) of Directive 2012/34/EU amended by Directive (EU) 2016/2370)
Non-application of a TSI	Certain circumstance, by which projects can be exempted from having to comply with all or part of a TSI or TSIs (Article 7 of Directive (EU) 2016/797)
Open point	Certain technical aspect corresponding to the essential requirements, which cannot be explicitly covered in a TSI (Article 4(6) of Directive (EU) 2016/797)
Placing in service	All the operations by which a subsystem is put into its operational service (Article 2(19) of Directive (EU) 2016/797)
Placing on the market	First making available on the Union's market of an interoperability constituent, subsystem or vehicle ready to function in its design operating state (Article 2(35) of Directive (EU) 2016/797)
Project at an advanced stage of development	Any project the planning or construction stage of which has reached a point where a change in the technical specifications may compromise the viability of the project as planned (Article 2(23) of Directive (EU) 2016/797)
Railway Undertaking	Railway undertaking as defined in point (1) of Article 3 of Directive 2012/34/EU, and any other public or private undertaking, the activity of which is to provide transport of goods and/or passengers by rail on the basis that the undertaking is to ensure traction; this also includes undertakings which provide traction only (Article 2(45) of Directive (EU) 2016/797)
Register of infrastructure (RINF)	Register of infrastructure indicates the main features of fixed installations, covered by the subsystems: infrastructure, energy and parts of control-command and signalling. It publishes performance and technical characteristics mainly related to interfaces with rolling stock and operation (Article 49 of Directive (EU) 2016/797)

Table 1: Definitions

<i>TERM</i>	<i>DEFINITION/ SOURCE</i>
Renewal	Any major substitution work on a subsystem or part of it, which does not change the overall performance of the subsystem. (Article 2(15) of Directive (EU) 2016/797)
Specific case	Any part of the rail system which needs special provisions in the TSIs, either temporary or permanent, because of geographical, topographical or urban environment constraints or those affecting compatibility with the existing system, in particular railway lines and networks isolated from the rest of the Union, the loading gauge, the track gauge or space between the tracks and vehicles strictly intended for local, regional or historical use, as well as vehicles originating from or destined for third countries (Article 2(13) of Directive (EU) 2016/797)
Substitution in the framework of maintenance	Any replacement of components by parts of identical function and performance in the framework of preventive or corrective maintenance (Article 2(17) of Directive (EU) 2016/797)
Upgrading	Any major modification work on a subsystem or part of it which results in a change in the technical file accompanying the 'EC' declaration of verification, if that technical file exists, and which improves the overall performance of the subsystem (Article 2(14) of Directive (EU) 2016/797)

Table 2: Abbreviations

<i>ABBREVIATION</i>	<i>FULL TEXT</i>
AC	Alternating Current
CCS	Command Control and Signalling
CEN	European Committee for Standardisation
CR	Conventional Rail
DC	Direct Current
EC	European Commission
EMC	Electro Magnetic Compatibility
EN	European standard
ENE	Energy
ERA	European Union Agency for Railways also called "the Agency"
ERADIS	Interoperability and Safety database managed by the European Union Agency for railways
ERATV	European Register of Authorised Types of Vehicles
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
EU	European Union



<i>ABBREVIATION</i>	<i>FULL TEXT</i>
IC	Interoperability Constituent
IM	Infrastructure Manager
INF	Infrastructure
ISO	International Organisation for Standardisation
ISV	Intermediate Statement of Verification
MS	EU or EEA Member State
NoBo	Notified Body
NB-Rail	Coordination group of notified bodies for railway products and systems
NOI	Noise
NSA	National Safety Authority
NSR	National Safety Rule
NR	National Rule
OJ	Official Journal of the European Union
PRM	Person with Disabilities or Person with Reduced Mobility
RFU	Recommendation for Use
RINF	Register of Infrastructure
RR	Revision Request
RRA	Revision Request Author
RS	Rolling Stock
RU	Railway Undertaking
SRT	Safety in Railway Tunnels
SS	Subsystem
TR	Technical Report
TS	Technical Specification
TSI	Technical Specification for Interoperability
UIC	International Union of Railways (Union Internationale des Chemins de Fer)
WG	Working Group
WP	Working Party

## 2. GUIDANCE ON THE APPLICATION OF THE LOC&PAS TSI

### 2.1. Introduction

The structure of this chapter of the application guide follows the structure of the TSI and contains the following sections:

- Scope of the TSI.
- Content of the TSI.
- Characterisation of the rolling stock subsystem.
- Interoperability constituents.
- Assessment of conformity.
- Implementation.
- Some practical cases.

The LOC&PAS TSI is not a standalone regulation; Additional legal provisions apply for the placing in the market of structural subsystems as set out in the Regulation (EU) 2018/545. This document does not provide any guidance related to Regulation (EU) 2018/545.

## 2.2. Scope and definition of the subsystem

### 2.2.1. Clauses 2.2.2(A) and 2.3:1(C) Rolling stock in the scope of this TSI

#### *‘2.2.2. Rolling stock:*

*Definitions below are classified in three groups as defined in the section 2 of Annex I to Directive (EU) 2016/797.*

*(A) Locomotives and passenger rolling stock, including thermal or electric traction units, self-propelling thermal or electric passenger trains, and passenger coaches;:*

*(1) Thermal or electric traction units*

*[...]*

*Traction in a train can also be provided by a powered vehicle with or without driving cab, which is not intended to be uncoupled during normal operation. Such a vehicle is called a Power Unit (or power car) in general or a Power Head when located at one end of the trainset and fitted with a driving cab.*

The concept of thermal unit as defined in TSI could be applied to units fitted with a thermal engine other than a diesel engine, such as gas propelled units. In this case, the innovative solution principle should be applied at least to the clauses specifically aimed at diesel units (e.g, clause 4.2.10.3.3)

#### *Clause 2.3.1(C) Special vehicles, such as on-track machines*

*This type of rolling stock is in the scope of the TSI only when:*

*(1) It is running on its own rail wheels and*

*(2) It is designed and intended to be detected by a track based train detection system for traffic management and*

*(3) In case of OTMs, it is in transport (running) configuration, self-propelled or hauled.*

#### **Exclusion from the scope of this TSI:**

*In case of OTMs, working configuration is outside the scope of this TSI.*

For vehicles with different sets of wheels, the case of transport on (road) wheels with tyres (condition 1) is not in the scope of the TSI.

For movements on a closed track, there is no need to be detected by a track based train detection system (condition 2), therefore this case is not in the scope of the TSI.

In case of OTM in transport configuration (condition 3), if the Applicant chooses to apply the TSI (see clause 7.1.1.3 of the LOC&PAS TSI), he can apply the WAG TSI (only when hauled) or the LOC&PAS TSI (self-propelled

or hauled) for conformity assessment; a vehicle may be assessed under either the TSIs depending on the characteristics and the intended use of the vehicle in question in comparison with the technical scope of the respective TSIs. In case the Applicant chooses not to apply the TSIs, the Applicant still needs to apply the procedure for authorisation set out in Regulation 2018/545.

Note 1: For OTMs, in the standard EN 14033-1, ‘transport mode’ is called ‘running mode’.

Note 2: In the context of this TSI, road-rail machines (in the scope of EN 15746) are considered as OTMs. Only road-rail machines of cat. 8 and 9 (in the scope of EN 15746) can fall in category D), once only these are designed and intended to be detected by a track based train system for traffic management.

Regarding ‘infrastructure inspection vehicles’, these should be treated as conventional rolling stock and not as OTMs; however the decision to apply the TSI is also left to the Applicant (see clause 7.1.1.3 of the LOC&PAS TSI).

Note: for inspection vehicles, the definition in section 2.2 states that there is no distinction between working mode and transport mode.

## 2.3. Content of the TSI

### 2.3.1. Clause 1.3 (c) and (e): Technical specification and conformity assessment

*“In accordance with Article 4(3) of Directive (EU) 2016/ 797, this TSI:*  
 (c) *establishes the functional and technical specifications to be met by the subsystem and its interfaces vis-à-vis other subsystems (Chapter 4);*  
 (...)  
 (e) *states, in each case under consideration, which procedures are to be used in order to assess the conformity or the suitability for use of the interoperability constituents, on the one hand, or the “EC” verification of the subsystems, on the other hand (Chapter 6);”*

Where it has not been possible to specify separately the technical requirement and its conformity assessment requirement, a combined requirement is specified in Chapter 4. Chapter 6 contains particular assessment procedures, where they are specified separately; Chapter 6 should therefore be considered in conjunction with Chapter 4.

Guidance related to the particular assessment procedure is given where necessary together with guidance on the corresponding clause of Chapter 4 in this application guide.

See also clauses 6.1.1 and 6.2.1.

### 2.3.2. Clause 3.1 Essential requirements

#### *3.1 Elements of the rolling stock subsystem corresponding to the essential requirements*

*The following table indicates the essential requirements, as set out and numbered in Annex III of Directive (EU) 2016/ 797, taken into account by the specifications set out in Chapter 4 of this TSI.*

The TSI does not repeat requirements specified in other applicable EU directives.

### 2.3.3. Section 4.3: Functional and technical specification of the interfaces.

Interfaces with other subsystems are identified in this section. There is no verification to be performed in relation to TSIs covering other subsystems which are listed in this section during the conformity assessment against this TSI.

## 2.4. Characterisation of the subsystem

### 2.4.1. Clause 4.1.2: Description of the rolling stock subject to the application of this TSI

*(1) Rolling stock subject to the application of this TSI (designated as a unit in the context of this TSI) shall be described in the certificate of ‘EC’ verification, using one of the following characteristics:*

- *Trainset in fixed formation, and when required, predefined formation(s) of several trainsets of the type under assessment for multiple operation.*
- *Single vehicle or fixed rakes of vehicles intended for predefined formation(s)*
- *Single vehicle or fixed rakes of vehicles intended for general operation and when required, predefined formation(s) of several vehicles (locomotives) of the type under assessment for multiple operation.*

*Note: Multiple operation of the unit under assessment with other types of rolling stock is not in the scope of this TSI.”*

Predefined formation of several trainsets or vehicles of the type under assessment for multiple operation can be covered by the EC verification if required by the Applicant.

As examples, for an electric and/or diesel multiple unit, multiple operation may include several predefined formations (2 trainsets, 3 trainsets...), for locomotives, multiple operation may cover the case of 2 locomotives coupled in a train.

In the case of articulated trainsets with several predefined formation(s), the predefined formation can be described using vehicles (‘running on its own wheels’), rakes of vehicles or vehicles without or with partial running gear (e.g. on one end).

The ‘other types of rolling stock’ referred to in the note may already be authorised to be placed in service. They are not subject to conformity assessment against this TSI at the same time as the unit under assessment. Therefore, they are not considered in the EC verification related to that unit.

Multiple operation of the unit under assessment with other types of rolling stock is managed by the RU according to the OPE TSI, clause 4.2.2.5”.

For vehicles intended to be used in general operation see also clause 6.2.7 of the TSI.

### 2.4.2. Clause 4.1.3: Main categorisation of the rolling stock for application of TSI requirements

*“(3) The technical categories of rolling stock are the following:*

*(...)*

*— Unit fitted with traction equipment*

*— Electric unit, defined as a unit supplied with electric energy by electrification system(s) specified in the Energy TSI.*

*— Thermal traction unit*

*(...) A unit is characterised by one or several of the categories above.*

*(4) Unless stated otherwise in the clauses of Section 4.2, requirements specified in this TSI apply to all technical categories of rolling stock defined above.*

*(6) The maximum design speed of the unit (...)”*

The categories have been designed with the objective to attribute requirements to each unit under assessment.

For example, a passenger coach with a cab falls into the following categories: “Unit designed to carry passengers” and “Unit fitted with a cab”.

If it is equipped with a pantograph, it falls in the category “electric unit” too, because it is supplied with electric energy in accordance with the ENE TSI.

Units fitted with traction equipment such as hydrogen cells or batteries are neither thermal nor electric traction units. However, they are traction units and there are clauses in the LOC&PAS TSI which apply to them

(e.g. 4.2.4.2.2(2)). In this case, the innovative solution principle should be applied at least to the clauses specifically aimed at electric units not related to energy supply in accordance with ENE TSI (e.g. clause 4.2.8.2.10).

Regarding maximum design speed and speed criteria the LOC & PAS TSI uses km/h in a number of clauses to differentiate between requirements. Strict mathematical conversion of these figures to mph would lead to inappropriate requirements for the UK and Ireland railway. For example ‘speeds greater than 200 km/h’ would include 125 mph which is not the intention. Table in Annex 2 provides agreed values that should be used to convert from km/h to mph where the figures are used to differentiate requirements.

#### 2.4.3. Clause 4.2.1.3 Safety aspects

*(4) Electronic devices and software, which are used to fulfil functions essential to safety shall be developed and assessed according to a methodology adequate for safety related electronic devices and software.*

The standards listed in Annex 1 of the Application Guide remain of voluntary application; the column ‘purpose of the voluntary reference’ has also to be taken into account to ensure that the related standards are applied according to their scope.

However, the standards listed in Annex 1 should be considered as reference by the Notified Body (like harmonised standards), meaning that the methodology proposed by the Applicant should give results equivalents to those obtained by application of the listed standards.

#### 2.4.4. Clause 4.2.2.2.4: Rescue coupling

*“...Lateral location of brake pipes and cocks according to the specification referenced in Appendix J-1, index 5”*

While the standard referenced in Appendix J-1, index 5 is the UIC 648:2001, the lateral location can be found in chapter 7 of EN 16839:2017.

*“(3) ...This is achieved either by means of a permanently installed compatible coupling system or through a rescue coupler (also called rescue adaptor). In the latter case, the unit assessed against this TSI shall be designed so that it is possible to carry the rescue coupler on board.”*

The LOC & PAS TSI does not mandate the provision of a rescue coupler on each unit and therefore, the decision not to install a rescue coupler on-board should be made by the railway undertaking in conjunction with the infrastructure manager who, typically, has responsibility for clearing the line. In determining the provision of rescue couplers, account should be taken of the time and need to make it available.

EN15020:2006+A1:2010 ‘Railway applications — Rescue coupler — Performance requirements, specific interface geometry and test methods’ provides a presumption of conformity for vehicles equipped with Type 10 automatic coupling and a rescue vehicle equipped with UIC pattern of buffers and draw gear. This standard is mandatory according to the TSI (therefore, this reference is not repeated in annex 1 of this Application Guide).

#### 2.4.5. Clause 4.2.2.3: Gangways

*“(1) Where a gangway is provided as a means for passengers to circulate from one coach or one trainset to another, it shall accommodate all relative movements of vehicles in normal operation without exposing passengers to undue risk.*

(2) Where operation with the gangway not being connected is foreseen, it shall be possible to prevent access by passengers to the gangway.  
 (3) Requirements related to the gangway door when the gangway is not in use are specified in clause 4.2.5.7 “Passenger related items – Inter-unit doors”.  
 (4) Additional requirements are expressed in the TSI PRM.  
 (5) These requirements of this clause do not apply to the end of vehicles where this area is not intended for regular use by passengers.”

Compliance with clauses 7.4, 7.9, 9.2 and 9.3 of the EN 16286-1:2013 gives presumption of conformity.

Additionally to the LOC&PAS TSI, the following clauses of the PRM TSI apply:

- 4.2.2.6, 4.2.2.9 (7) for all gangways and
- 4.2.2.8 for gangways with height changes

#### 2.4.6. Clause 4.2.2.4: Strength of vehicle structure

“(2) For OTMs, alternative requirements to those expressed in this clause for static load, category and acceleration are set out in Appendix C, clause C.1.”

The strength of the OTM structure can be assessed by an alternative arrangement set out in Appendix C, clause C.1 of the TSI.

Therefore it is possible according to clause 4.2.2.4 of the TSI to demonstrate compliance with the requirements either by calculation or by tests. It is also made possible by clause 4.2.2.4 of the TSI and Appendix C, clause C.1 to classify the OTM either as PI, PII, FI or FII for the load definitions that are taken into account in the demonstration.

“(8) Joining techniques are covered by the above requirements. A verification procedure shall exist to ensure at the production phase that defects that may decrease the mechanical characteristics of the structure are controlled.”

Verification of joining techniques used are part of the complete design and manufacturing assessment process as set out in Commission Decision 2010/713/EC (decision on assessment modules) and should be part of the quality management system of the manufacturers taking into account risks associated to the techniques used (assembly by screws or rivets, welding, gluing...).

For welding of metallic parts, Annex 1 lists the applicable relevant standards.

Note: Verification of joining techniques may apply as well to joints of the bogie frame covered by clause 4.2.3.5.1 (see EN standard index 20 of the Annex J-1, clause 7 applicable on a voluntary basis)

#### 2.4.7. Clause 4.2.2.5 Passive safety

“(5) Passive safety is aimed at complementing active safety when all other measures have failed...”

Passive safety is more commonly known as vehicle structural crashworthiness and should not be confused with ‘Interior Passive Safety’. ‘Interior Passive Safety’ is a separate topic to further support the objective of minimising the risk of injury to passengers on board due to secondary impact (see 7.5.2.1 of the TSI); there is no verification mandated in this TSI regarding ‘interior passive safety’.

#### 2.4.8. Clause 4.2.2.6 Lifting and jacking

“(3) It shall be possible to safely lift or jack each vehicle composing the unit, for recovery purposes (following derailment or other accident or incident), and for maintenance purposes. To this purpose, suitable vehicle body interfaces (lifting/jacking points) shall be provided, which permit the application of vertical or quasi-vertical forces. The vehicle shall be designed for complete lifting or jacking, including the running gear (e.g. by securing/attaching the bogies to the vehicle

*body). It shall also be possible to lift or jack any end of the vehicle (including its running gear) with the other end resting on the remaining running gear(s)."*

All relevant topics of the EN 16404 covering structural requirements were taken into account in an amendment to the EN 12663-1:2010+A1:2014.

Note: To take into account the particular conditions at the re-railing of low floor vehicles a relevant CEN working group has been set up to reconsider the EN 16404:2014. The working group results led to the revised EN 16404:2016.

#### 2.4.9. Clause 4.2.2.9: Mechanical characteristics of glass (other than windscreens)

*"(1) Where glass is used in glazing (including mirrors), it shall be either laminated or toughened glass which is in accordance with one of the relevant publicly available standard suitable for railway application with regard to the quality and area of use, thereby minimising the risk to passenger and staff being injured by breaking glass."*

Some of the relevant standards are listed in Annex 1 of this Application Guide. Other relevant standard should be accepted as a basis for conformity assessment, provided that its relevance is proven by the Applicant to the NoBo.

#### 2.4.10. Clause 4.2.2.10: Load conditions and weighted mass

*"(3) For OTMs, different load conditions (minimum mass, maximum mass) may be used, in order to take into account optional on-board equipment"*

An OTM may be operated in different configurations, for example equipped with different tools for different tasks or functions. This optional on-board equipment might, for each configuration, affect the mass of the vehicle. Therefore, the different masses depending on the configuration may be considered when defining the load conditions according to the TSI.

#### 2.4.11. Clause 4.2.3.1: Gauging

*"(2) The applicant shall select the intended reference profile including the reference profile for the lower parts. This reference profile shall be recorded in the technical documentation defined in clause 4.2.12 of this TSI."*

The Applicant (who signs the EC declaration of verification) selects freely the reference profile used to design the rolling stock (chosen profile). The outer boundaries of the rolling stock are subsequently assessed against this chosen profile and the result is recorded in the technical documentation.

Furthermore, the EN 15273-2 contains requirements on the minimum vertical convex / concave curve radius capability which have to be registered in ERATV as these are a basic design characteristic and part of the route compatibility check.

The intended assessed profile may present deviations to a 'known' reference profile (e.g. national gauges given in Annexes of EN 15273-2); in that case, deviations should be recorded in the technical documentation.

*"(4) In case the unit is declared as compliant with one or several of the reference contours G1, GA, GB, GC or DE3, including those related to the lower part GI1, GI2 or GI3, as set out in the specification referenced in Appendix J-1, index 14, compliance shall be established by the kinematic method as set out in the specification referenced in Appendix J-1, index 14.*

*The compliance to those reference contour(s) shall be recorded in the technical documentation defined in clause 4.2.12 of this TSI."*

The Applicant is furthermore required to state if the rolling stock is compatible with (one of) the reference profile(s) (i.e. reference profile according to EN 15273) of the categories of line as per the INF TSI. These

reference profile(s) the rolling stock complies with (if any) are to be recorded in the technical documentation; they provide a reference for interoperability purpose.

Regarding the possibility to widening the rolling stock as a function of the possibilities offered by the infrastructure due to tolerances (Annex I of EN 15273-1:2013) it is permitted to design the rolling stock using this extra widening option. But then it is not anymore considered compliant with the original reference profile and will not be recorded as such in the register of authorised types ERATV.

The intended profile recorded in the technical documentation has to mention the original reference profile and the limitations/reverses linked to the application of Annex I of EN 15273-1:2013.

This possibility offered by the infrastructure and corresponding limitations should also be recorded in the register of the infrastructure.

Annex R.3 of EN 15273-2:2013+A1:2016 lists documents that can be taken into account to verify the conformity of a gauge.

*” (5) For electric units, the pantograph gauge shall be verified by calculation according to the specification referenced in Appendix J-1, index 14, clause A.3.12 to ensure that the pantograph envelope complies with the mechanical kinematic pantograph gauge which in itself is determined according to Annex D of TSI ENE, and depends on the choice made for the pantograph head geometry: the two permitted possibilities are defined in clause 4.2.8.2.9.2 of this TSI.  
The voltage of the power supply is considered in the infrastructure gauge in order to ensure the proper insulation distances between the pantograph and fixed installations.”*

The pantograph envelope has interfaces with the three TSIs INF, ENE and LOC&PAS:

- It is based on the pantograph head geometry defined in clause 4.2.8.2.9.2 of LOC&PAS TSI, used as a reference for the overhead line contact position.
- The mechanical kinematic pantograph gauge calculation method is described in the Annex D of ENE TSI.
- This is complemented by the electrical clearance, which has to be considered for the structure gauge defined in the clause 4.2.3.1 of the INF TSI.

The necessary electrical clearance between the pantograph and fixed installations depends on the supply voltage (i.e 25 kV AC, 15 kV AC, 1.5 kV DC, 3 kV DC) and on local conditions for the insulation and creepage distances calculations (which are known by the IM); they are needed for defining the structure gauge. Note: this aspect is covered when defining the structure gauge; it is not in the scope of the LOC&PAS TSI; the IM has to consider electrical clearances between the conductive parts of the pantograph or catenary and the structure, in addition to the requirements of the INF TSI.

*” (6) The pantograph sway as specified in clause 4.2.10 of TSI ENE and used for the mechanical kinematic gauge calculation shall be justified by calculations or measurements as set out in the specification referenced in Appendix J-1, index 14.”*

For verifying the sway coefficient (or the flexibility coefficient) of the pantograph, which is considered in the mechanical part of the equation, it is permitted to use simulations, or input from past designs, or finally a ‘type’ test may acknowledge the sway coefficient.

#### 2.4.12. Clause 4.2.3.2.1: Axle load parameter

*“(1) (...) The axle load is a performance parameter of the infrastructure specified in clause 4.2.1 of the INF TSI and depends on the traffic code of the line. It has to be considered in combination with the axle spacing, with the train length and with the maximum allowed speed for the unit on the considered line.”*



The load carrying capacity of the infrastructure defines the limiting value that the rolling stock axle load is required not to exceed in operation. The compatibility between INF and vehicle is not part of conformity assessment against this TSI.

*“(3) Use of this information at operational level for compatibility check between rolling stock and infrastructure (outside the scope of this TSI):  
The axle load of each individual axle of the unit to be used as interface parameter to the infrastructure has to be defined by the railway undertaking as required in clause 4.2.2.5 of the TSI OPE, considering the expected load for the intended service (not defined when the unit is assessed).”*

The axle load in combination with the axle spacing of a rolling stock is one of the parameters used for the technical compatibility of the rolling stock to the infrastructure (as described in EN 15528:2008). The TSI does not set out the maximum axle load which has to be taken into account for this technical compatibility assessment as this approach would be too restrictive. Instead, reference is made to clause 4.2.2.5 of the OPE TSI which states that these parameters have been checked through the authorisation process and the RU is responsible for the train composition and the route compatibility and is required to ensure that “the weight of the train must be within the maximum permissible for the section of route. Axle load limitations must be respected”. In this way the RU should control by operating rules the payload of its rolling stock in order to be compatible with the route.

#### 2.4.13. Clause 4.2.3.3.1: Rolling Stock characteristics for the compatibility with train detection systems

*“(2) The set of characteristics the rolling stock is compatible with shall be recorded in the technical documentation described in clause 4.2.12 of this TSI”*

The set of parameters in order to be compatible with train detection systems, such as track circuits, axle counters and loop systems, have been identified in the TSI with references to the CCS TSI for each parameter and type of train detection system.

The TSI requirement for rolling stock regarding compatibility with CCS TSI is that the train detection system(s) which the rolling stock has been assessed as being compatible with is (are) declared and recorded in the technical documentation.

Rolling stock are permitted to be non-compatible with any TSI specification relating to this clause.

In the current situation, there are several open points declared in the relevant TSIs (e.g. electromagnetic compatibility).

In case the compatibility with the existing train detection systems is not covered by the TSI requirements above, this should be checked at MS level according to the notified national rules by a designated body appointed by the MS. This verification is not in the scope of the TSIs, but is part of the authorisation for placing on the market; its result will be indicated in the ERATV.

#### 2.4.14. Clause 4.2.3.4.2: Running dynamic behaviour

*“(3) The unit shall run safely and produce an acceptable level of track loading when operated within the limits defined by the combination(s) of speed and cant deficiency under the conditions set out in the specification referenced in Appendix J-I, index 16.”*

Note 1: Although the EN 14363:2016 defines the process for assessment of the running characteristics of railway vehicles on standard track gauge only (1435 mm), the standard can be applied for the assessment of the running characteristics in other track gauges by analogy. E.g. the test procedures described in EN 14363:2016 can be applied to vehicles operated on networks with other track gauges too.

Note 2: Even if some sub-clauses (4.2.3.4.2.x) of the LOC&PAS TSI refer to specific chapters of the EN 14363:2016, this does not mean that other chapters can be fully disregarded.

There are general principles and some relationships between chapters that may be relevant, even if they are not directly mentioned as mandatory in the Appendix J–1.

The rolling stock may have to be tested for several combinations of admissible speed and cant deficiency (combinations to be selected by the Applicant) for their running dynamic behaviour in accordance with EN 14363:2016. This technical specification covers tilting systems too.

The specified limit values (running safety, track loading) are to be met under the conditions of use of the rolling stock (operational parameters/restrictions), such as the combination of speed and cant deficiency.

It means that neither the TSI nor the standards limit the possible combinations; the Applicant is free to define these values. The only requirement being that the limit values are met under those conditions chosen by the Applicant.

Note 3: In EN 14363:2016 (1 Scope): "(...) The document contains acceptance criteria for all types of vehicles with nominal static vertical wheelset forces up to 225 kN (of the highest loaded wheelset of the vehicle in the assessed load configuration specified in 5.3.2). In addition for freight vehicles with nominal static vertical wheelset forces up to 250 kN the acceptance criteria are defined. (...)"

The infrastructure where the rolling stock will be operated should be taken into account by the Applicant to define the necessary combinations to be tested.

For speed >300 km/h, the EN 14363:2016 does not specify specific limits for the track quality due to a lack of return of experience. This case is covered by the following sentence in Annex M.4 of EN 14363:2016: "*For speed above 300 km/h, the target test conditions shall correspond to better track quality than the track quality specified for the speed 300 km/h*". This is justified by the following considerations:

- on these sections of track, operation at 300 km/h is possible, therefore the required track quality shall be as good as for 300 km/h.
- an open point on such subject is not satisfactory because there is no sufficient return of experience for defining national rule(s).

It is expected in such case that the concerned manufacturer, railway undertaking and infrastructure manager will cooperate in order to ensure the feasibility of the railway project (operation from 300 km/h up to 350 km/h).

In any case, the values met on the test track shall be reported as required in Annex M.5 of the EN 14363:2016; corresponding operating limitations shall be reported too. The process for innovative solution may be used by the stakeholders in order to take into account the values met on the test track for complementing TSI and EN 14363:2016.

For other track gauges than 1435 mm, test conditions and limit values may be defined for particular application/operating conditions, notwithstanding any specific case defined in the TSI. The geometrical track qualities and conditions the rolling stock was tested for will define the limiting operating conditions of the rolling stock.

#### 2.4.15. Clause 4.2.3.4.3.2: In-service values of wheelset equivalent conicity

*"(1) The combined equivalent conicities the vehicle is designed for, as verified by the demonstration of conformity of the running dynamic behaviour specified in clause 6.2.3.4 of this TSI, shall be specified for in-service conditions in the maintenance documentation as set out in point 4.2.12.3.2, taking into account the contributions of wheel and rail profiles."*

The following elements regarding maintenance limits of wheels and wheelsets, and how local conditions of the network may be considered, are given to the attention of RUs (Railway Undertakings) and ECMs (Entities in Charge of Maintenance):

The maintenance plan should set out the RU's (or ECM's) procedures for maintaining wheelsets and wheel profiles. The procedures should take account of the conicity ranges for which the vehicle is designed (see

clause 4.2.3.4.2 of this TSI). During operation, these limits are to be kept within the limit values considering the local conditions of the infrastructure where the rolling stock is operated.

Wheelsets should be maintained to ensure (directly or indirectly) that the wheelset conicity remains within the approved limits for the vehicle when the wheelset is modelled passing over those of the representative samples of track test conditions (simulated by calculation) specified in tables 11-16 of this TSI which are relevant considering local conditions of the network.

For a novel bogie / vehicle design, or for operation of a known vehicle on a route with relevant different characteristics, the development of wear of a wheel profile, and therefore the change in wheelset conicity, is usually not known. For this situation a provisional maintenance plan should be proposed. The validity of the plan should be confirmed following monitoring of the wheel profile and equivalent conicity in service. The monitoring should consider a representative number of wheelsets and should take into account the variation between wheelsets in different positions in the vehicle and between different vehicle types in the trainset.

In case the running dynamic test required in the clause 4.2.3.4.2 of the TSI has been performed with a representative wheel profile (naturally worn in service or theoretically worn) on test track sections as defined in Table 2 of EN 14363:2016, the maintenance plan may be based on the monitoring of the geometrical dimensions of the wheels, with a wheel profile limit extrapolated from the test conditions (and compliant to the clause 4.2.3.5.2.2 of this TSI). The in-service value of equivalent conicity is then indirectly controlled, with the assumption that the test track sections are representative of the actual network on which the vehicle is operated.

*“(2) If ride instability is reported, the railway undertaking and the Infrastructure Manager shall localise the section of the line in a joint investigation.*

*“(3) The railway undertaking shall measure the wheel profiles and the front-to-front distance (distance of active faces) of the wheelsets in question. The equivalent conicity shall be calculated using the calculation scenarios provided in clause 6.2.3.6 in order to check if compliance with the maximum equivalent conicity the vehicle was designed and tested for is met. If it is not the case, the wheel profiles have to be corrected.”*

These points (2) and (3) are to be applied during operation; they are not part of the conformity assessment against the TSI and are not assessed by the notified body.

During operation, for any problem met, it is recommended to make sure that an inspection of the train and track, according to the usual maintenance procedures (including periodicity) of RU and IM, respectively, has been conducted. This may include reviewing wheels, yaw dampers, suspension components, etc. for the RU and track geometric defects, etc. for the IM. If it is not the case, this lack of maintenance has to be corrected.

Despite of the application of usual maintenance procedures, if ride instability is reported, the RU should model the measured wheel profiles and distances between active faces of the wheels over the representative sample of track test conditions specified in relevant tables 11-16 of the chapter 6 of the TSI to calculate the equivalent conicity and check its compliance with the maximum equivalent conicity at which the vehicle is designed and certified to be stable.

As examples:

- For the 1435mm track gauge the following scenarios are considered representative for the check of the equivalent conicity:
  - for speeds up to 200 km/h, the cases 1,2,7 and 8 under test conditions in table 12 of clause 6.2.3.6 are representative,
  - for higher speeds only the cases 1 and 2 are representative.

- For the 1668 mm track gauge, the following scenarios are considered representative for the check of the equivalent conicity:
  - for speeds up to 200 km/h, the cases 1 and 3, rail sections 54 E1 and 60 E1,
  - for higher speeds only the case 1 is representative, rail section 60 E1.

If the wheelset parameters do not comply with the maximum equivalent conicity at which the vehicle is designed and certified to be stable the maintenance strategy of the wheel profiles are to be modified to avoid unstable behaviour.

If the wheelsets comply with the maximum equivalent conicity at which the vehicle is designed and certified to be stable, the INF TSI requires the IM to check the track for compliance with the requirements set out in the INF TSI.

If both vehicle and track comply with the requirements of the relevant TSIs, a joint investigation by the RU and the IM should be undertaken to determine the reason for the instability.

*2.4.16. Clause 4.2.3.5.2.1 Mechanical and geometric characteristics of wheelsets / Conformity assessment clause 6.2.3.7: Axles*

*“(2) The demonstration of compliance for mechanical resistance and fatigue characteristics of the axle shall be in accordance with the specification referenced in Appendix J-1, index 88, clauses 4, 5 and 6 for non-powered axles, or the specification referenced in Appendix J-1, index 89, clauses 4, 5 and 6 for powered axles.*

*The decision criteria for the permissible stress is specified in the specification referenced in Appendix J-1, index 88, clause 7 for nonpowered axles, or the specification referenced in Appendix J-1, index 89, clause 7 for powered axles.*

The verification of the axle is intended to be done by calculation as set out in EN 13103 and 13104 which defines:

- the load cases to be considered;
- the specific calculation methods for the design of the axle and the decision criteria;
- the permissible stress:
  - for steel grade EA1N and
  - the methodology to determine the permissible stress with other materials.

*“(4) A verification procedure shall exist to ensure at the production phase that no defects may detrimentally affect safety due to any change in the mechanical characteristics of the axles.*

*(5) The tensile strength of the material in the axle, the resistance to impact, the surface integrity, the material characteristics and the material cleanliness shall be verified. The verification procedure shall specify the batch sampling used for each characteristic to be verified.”*

The axle is considered a safety relevant component which needs to be checked and controlled, not only for the design criteria, but also for ensuring end quality of the product. EN 13261:2009+A1:2010 sets out the verification procedure to be followed for the parameters stated in the TSI; the number of samples to be checked in production, the procedures to follow for any significant changes in the design of the axle or changes of manufacturer of the material of the axle, etc.

This may be part of the assessment of the quality management system of the manufacturer: sampling, batch size and similar issues may be based on the EN 13261:2009+A1:2010 Annex I.

**2.4.17. Clause 4.2.3.5.2.2: Mechanical and geometrical characteristics of wheels / Conformity assessment clause 6.1.3.1**

*“(1) The mechanical characteristics of the wheel shall be proven by mechanical strength calculations, taking into account three load cases: straight track (centred wheelset), curve (flange pressed against the rail), and negotiating of points and crossings (inside surface of flange applied to the rail), as specified in the specification referenced in Appendix J-1, index 71, clauses 7.2.1 and 7.2.2.”*

The wheel is required to be designed following the methodology set out in EN 13979-1:2003+A2:2011 clause 7 which requires calculations to be performed and subsequent tests if design criteria are not met.

*“(6) A verification procedure shall exist to ensure at the production phase that no defects may detrimentally affect safety due to any change in the mechanical characteristics of the wheels.” (...)*

The wheel is considered to be a safety relevant component which needs to be checked and controlled, not only for the design criteria, but also for ensuring end quality of the product. EN 13262:2004+A2:2012 sets out the verification procedure to be followed for the parameters stated in the TSI; this verification covers the material characteristics and the number of samples to be checked in production, the procedures to follow for any changes in the design of the wheel or changes of manufacturer of the material of the wheel, etc.

In particular, the verification of the fatigue characteristics of the wheel material is intended to be performed if there is a change of supplier of the raw material for the production of the wheel, or there are any significant changes to the manufacturing process, or the design of the wheel is appreciably changed in diameter and web shape.

This may be part of the assessment of the quality management system of the manufacturer; sampling, batch size and similar issues may be based on the EN 13262:2004+A2:2012 Annex E.

**2.4.18. Clause 4.2.3.5.3: Automatic variable gauge systems / Conformity assessment clause 6.1.3.1a**

*Clause 4.2.3.5.3:*

*“(1) This requirement is applicable to units equipped with an automatic variable gauge system with changeover mechanism of the axial position of the wheels allowing the unit to be compatible with 1435 mm track gauge and other track gauge(s) within the scope of this TSI by means of passage through a track gauge changeover facility.”*

Section 4.2.3.5.3 applies without prejudice to sections 4.2.3.5.1 and 4.2.3.5.2.

*Clause 4.2.3.5.3:*

*“(5) The failure of the locking of the position of the wheels and braking equipment (if relevant) during operation has typical credible potential to lead directly to a catastrophic accident (resulting in multiple fatalities); considering this severity of the failure consequence, it shall be demonstrated that the risk is controlled to an acceptable level.*

*(6) The automatic variable gauge system is defined as an interoperable constituent (clause 5.3.4b). The conformity assessment procedure is specified in clause 6.1.3.1a (IC level), in clause 6.2.3.5 (safety requirement) and in clause 6.2.3.7b (subsystem level) of this TSI.”*

The latest revision of the common safety method for risk evaluation and assessment (Commission Implementing Regulation (EU) 402/2013) clarifies in point 2.5.6 of its Annex I that the harmonised design

targets needed to apply the ‘explicit risk estimation and evaluation’ cannot be used neither for purely mechanical systems nor for purely mechanical part of mixed systems.

Taking into account that the safety target is fixed in the TSI for the locking of the position of the wheels and braking equipment in the variable gauge system, as long as this system is:

- purely mechanical or
- composed of both a purely mechanical part and an electrical, electronic and programmable electronic part

a safety demonstration referred to in clauses 4.2.3.5.3, 6.1.3.1 and 6.2.3.7b of the TSI should use as risk acceptance principles “codes of practice” or “similar reference systems”. This means that the manufacturer will have to compare the proposed solution to similar existing ones (e.g. mechanical systems subject to similar forces); a risk analysis based on “explicit risk estimation and evaluation” should not be acceptable for the purely mechanical part.

The existing codes of practice for the validation of these systems are:

- EN 17069-1:2019, clause 6.3.2 “Railway applications - Systems and procedures for change of track gauge”
- National rules (e.g. Annex G of ETH de Material Rodante Ferroviario. Unidades Autopropulsadas, DGF-MFOM, 2009)
- UIC 510-4, v.2, 2002

Existing systems already in service can be referred to as reference systems.

*Clause 6.1.3.1b:*

*“The automatic variable gauge system may be subject to an assessment of suitability for use (module CV; see also clause 6.1.6)”*

The manufacturer has the ultimate responsibility of meeting all the essential requirements applicable to automatic variable gauge system. The LOC&PAS TSI specifies the need to perform validation tests (both on gauge changeover facilities and on-track) representative of in-service conditions. For these ‘representative of in-service condition tests’, the Applicant can choose whether to perform them on dedicated lines open to the traffic or in dedicated railway test-rings / facilities; the application of module CV is purely voluntary.

According to Decision 2010/713/EU it is the manufacturer who defines the programme for validation of a variable gauge system by in-service experience using module CV. The on-track tests described in prEN “Railway applications - Systems and procedures for change of track gauge” may be taken as reference. The provisions of this draft standard may be altered by the manufacturer taken into account the area of use of the automatic variable gauge system and the level of experience that the manufacturer possesses with similar designs of this equipment. The objective of in-service testing is to perform the tests under real conditions and tailored to match the area of use of the automatic variable gauge system.

*2.4.19. Clause 4.2.4: Braking*

*2.4.20. Clause 4.2.4.2.1: Functional requirements*

*“(6) [...] The temperature reached around the brake components shall also be considered in the design of the rolling stock.”*

The TSI mandates that the components in the vicinity of brake components be designed with consideration of the temperature reached around these components, and maintain their functionality at that temperature. This applies in particular to wheels with built-in brake discs; the applicant responsible for the design and the selection of the wheel (as IC) should take into account the attachment of the disc, the effective temperature

reached and the heat transfer when brakes are used in order to prevent thermo-mechanical problems (thermal fatigue) in the wheel web.

The Applicant has to take into account other fire risks (e.g. sparks) independently of conformity assessment to TSIs.

*“(14) A brake application command, whatever its control mode, shall take control of the brake system, even in case of active brake release command; this requirement is permitted not to apply when intentional suppression of the brake application command is given by the driver (e.g. passenger alarm override, uncoupling...)”*

Intentional suppression (combined with other functions) of the brake application by the driver is permitted by the TSI in those specific situations described in the documented procedures for train operation.

*“(15) [...]For speeds higher than 5 km/h, the maximum jerk due to the use of brakes shall be lower than 4 m/s<sup>3</sup>. The jerk behaviour may be derived from the calculation and from the evaluation of the deceleration behaviour as measured during the brake tests (as described in the clauses 6.2.3.8 and 6.2.3.9).”*

The jerk rate of 4 m/s<sup>3</sup> is generally associated with rapid changes to the brake demand for the safety of standing passengers.

#### 2.4.21. Clause 4.2.4.4.1: Emergency braking command

*“(2) At least two independent emergency brake command devices shall be available, allowing the activation of the emergency brake by a simple and single action from the driver in his normal driving position, using one hand.*

*The sequential activation of these two devices may be considered in the demonstration of compliance to the safety requirement N°1 of table 3 of clause 4.2.4.2.2.*

*One of these devices shall be a red punch button (mushroom push button).*

*The emergency brake position of these two devices when activated shall be self locking by a mechanical device; unlocking this position shall be possible only by an intentional action.*

*(4) Unless the command is cancelled, the emergency brake activation shall lead permanently, automatically to the following actions:*

- transmission of an emergency brake command along the train by the brake control line.*
- cut-off of all tractive effort in less than 2 second; this cut-off shall not be able to be reset until the traction command is cancelled by the driver.*
- a inhibition of all ‘release brake’ commands or actions.”*

Activation of the emergency brake leads to the described actions; these actions may only be cancelled by the intentional actions of the driver. In the case where the signal which has led to the emergency braking activation disappears for other reasons than intentional cancellation (for example in case of command failure), this is not considered as a cancellation, and the TSI mandates the described actions that continue to be applied.

#### 2.4.22. Clause 4.2.4.4.2: Service braking command

*“(2) The service brake function shall allow the driver to adjust (by application or release) the brake force between a minimum and a maximum value in a range of at least 7 steps (including brake release and maximum brake force), in order to control the speed of the train.”*

The TSI does not mandate mechanical notches on the brake lever corresponding to the steps; the brake lever may be of any type (continuous, with pulses, time dependant...); the objective is to have a sufficient precision of the service brake command.

#### 2.4.23. Clause 4.2.4.4.5: Parking braking command

*“(2) The parking braking command shall lead to the application of a defined brake force for an unlimited period of time, during which a lack of any energy on board may occur.”*

“Unlimited period of time” means that the parking brake force should not rely on stored energy on-board (e.g. compressed air, electric); this may be validated by design review because a test can only be performed during a limited period of time. According to Clause 4.2.4.5.5 of this TSI the parking brake performance (force) shall be verified by calculation.

#### 2.4.24. Clause 4.2.4.5.1: Braking performance – General requirements

*“(2) The friction coefficients used by friction brake equipment and considered in the calculation shall be justified (see the specification referenced in Appendix J-1, index 24).”*

The friction coefficients considered in the calculation should be chosen from data (obtained from calculations or test results) provided by the supplier, taking into account their environmental conditions as described in the standard EN 14531-1 (which depend on general environmental conditions specified in clause 4.2.6.1 of the TSI, and on effects internal to the rolling stock due to the braking system). They should correspond to the value met during tests (possible correction after tests).

As mentioned in the standard above, the friction coefficients of composite blocks and pads could be reduced by humidity. Operation during severe climatic conditions could be addressed by additional operational rules and the use of speed restrictions too (see clause 4.2.6.1 of the TSI).

*“(5) The maximum average deceleration developed with all brakes in use, including the brake independent of wheel/rail adhesion, shall be lower than 2,5 m/s<sup>2</sup>; this requirement is linked to the longitudinal resistance of the track.”*

The maximum average deceleration to be evaluated should correspond to the longitudinal deceleration ‘transmitted’ to the track; it may be obtained by filtering the signal ‘deceleration = f(time)’ with a filter 1 second.

#### 2.4.25. Clause 4.2.4.5.2: Emergency braking

*“(5) The emergency braking performance calculation shall be performed with a brake system in two different modes, and considering degraded conditions:*

- [...]
  - *Degraded mode: corresponding to the failures considered in clause 4.2.4.2.2, hazard no. 3, and nominal value of the friction coefficients used by friction brake equipment. Degraded mode shall consider possible single failures; to that end, the emergency braking performance shall be determined for the case of single point(s) failure(s) leading to the longest stopping distance, and the associated single failure shall be clearly identified (component involved and failure mode, failure rate if available).*
- [...]

The TSI mandates to identify single point failures and to evaluate their impact on the braking performance.

*“(6) The emergency braking performance calculation shall be performed for the three following load conditions:*

- *minimum load: “design mass in working order” (as described in clause 4.2.2.10)*
- *normal load: “design mass under normal payload” (as described in clause 4.2.2.10)*
- *maximum braking load: load condition lower or equal to “design mass under exceptional payload” (as described in clause 4.2.2.10)*



*In case this load condition is lower than “design mass under exceptional payload”, it shall be justified and documented in the general documentation described in clause 4.2.12.2.”*

Maximum braking load should be evaluated taking into account the realistic worst case likely to be encountered in service (including applicable speed limitations depending on load if any).

#### 2.4.26. Clause 4.2.4.5.3: Service braking

*“Maximum service braking performance:*

*(3) When the service braking has higher design performance capability than the emergency braking, it shall be possible to limit the maximum service braking performance (by design of the braking control system, or as a maintenance activity) at a level lower than the emergency braking performance.*

*Note:*

*A Member State may ask the emergency braking performance to be at a higher level than the maximum service braking performance for safety reasons, but in any case it cannot prevent the access to a railway undertaking using a higher maximum service braking performance, unless that Member State is able to demonstrate that the national safety level is endangered.”*

The TSI permits the design of RST with the service braking having a higher performance capability than the emergency braking.

The limitation of the service braking performance (when required as stated above) may be obtained by an intervention at maintenance workshop (for example change of software, or change of settings of components of the braking system).

The NSA is permitted to limit the maximum service braking performance, but in cases where a RU does not agree and has adequate operating rules, the TSI mandates that the NSA demonstrates that such a limitation is necessary to maintain the national level of safety.

#### 2.4.27. Clause 4.2.4.5.4: Calculations related to thermal capacity

*“(2) For OTMs, it is allowed to verify this requirement by temperature measurements on wheels and brake equipment.”*

For OTMs it is not mandatory to provide thermal capacity calculation, this can be replaced by temperature measurements.

#### 2.4.28. Clause 4.2.4.6.1: Limit of wheel rail adhesion profile

*“(1) The braking system of a unit shall be designed so that emergency brake performance (dynamic brake included if it contributes to the performance) and the service brake performance (without dynamic brake) do not assume a calculated wheel/rail adhesion for each wheelset in the speed range > 30 km/h and < 250 km/h higher than 0,15 with the following exceptions:*

- for units assessed in fixed or pre-defined formation(s) having 7 axles or less, the calculated wheel/rail adhesion shall not be higher than 0,13.*
- for units assessed in fixed or pre-defined formation(s) having 20 axles or more the calculated wheel/rail adhesion for the load case “minimum load” is permitted to be higher than 0,15, but shall not be higher than 0,17.*

*Note: for the load case “normal load”, there is no exception; the limit value of 0,15 applies. This minimum number of axles may be reduced to 16 axles if the test required in Section 4.2.4.6.2 related to the efficiency of the WSP system is performed for the load case “minimum load”, and provides positive result.*

*In the speed range > 250 km/h and < = 350 km/h, the three limit values above shall decline linearly in order to be reduced by 0,05 at 350 km/h.”*

The wheel rail adhesion limits specified are considered as realistic values on the basis that the wheel rail contact should not rely on higher adhesion coefficients.

These limits do not prevent the unit being subject to the test to verify the efficiency of the WSP system (test required in clause 4.2.4.6.2).

During emergency brake, 0.15 is the usual limit for units operated in general operation (train formation not known at design stage); for these units, the WSP test is performed with a representative train configuration (as the future train formations are not known).

For short trainsets, a lower limit is specified because it is known that they are more sensitive to degraded adhesion conditions; the opposite applies for long trainsets. For all trainsets, the check of the efficiency of the WSP is performed with the real train configuration, therefore validating the real behaviour of the train in degraded adhesion conditions.

#### 2.4.29. Clause 4.2.4.6.2: Wheel slide protection system

*“(6) The wheel slide protection system shall be designed according to the specification referenced in Appendix J-1, index 30, clause 4; the conformity assessment procedure is specified in clause 6.1.3.2.*

The WSP is required to be designed according to EN 15595:2009+A1:2011 clauses 4, 5 and 6. The content of the test report to be provided is described in EN 15595:2009+A1:2011 point 7.

The clause 6.2.1 of the standard is specific to coaches, but cannot be referred to in the TSI for 2 reasons: this clause assumes a certain stopping distance performance which is not specified in the TSI, and the definition of a coach is not given in this TSI. Clause 6.2.3 is more general, and can apply to all types of RST.

Where a coach has a stopping distance consistent with the clause 6.2.1, the Applicant may comply on a voluntary basis to clause 6.2.1 in addition to clause 6.2.3.

*“(7) Requirements on performance at unit level:  
If a unit is equipped with a WSP, a test shall be done to verify the efficiency of the WSP system (maximum extension of stopping distance compared to the stopping distance on dry rail) when integrated in the unit; the conformity assessment procedure is specified in clause 6.2.3.10.*

The clause 6.2.3.10 requires a test in low adhesion conditions according to EN 15595:2009+A1:2011 point 6.4.

The test in low adhesion conditions is specified in point 6.4.2.2. The content of the test report to be provided is described in EN 15595:2009+A1:2011 point 7.

In case a test in very low adhesion conditions as specified in point 6.4.2.3 is performed too, it should be documented in the test report too.

The conditions and limitations of use of the WSP are defined by the conformity assessment tests that are performed; these conditions and limitations should be included in the documentation (part of the technical file).

#### 2.4.30. Clause 4.2.4.7: Dynamic brake - Braking system linked to traction system

*“Where the braking performance of the dynamic brake or of braking system linked to the traction system is included in the performance of the emergency braking in normal mode defined in clause 4.2.4.5.2, the dynamic brake or the braking system linked to traction:*

*(1) Shall be commanded by the main brake system control line (see clause 4.2.4.2.1).*

*(2) Shall be subject to a safety analysis covering the hazard “after activation of an emergency command, complete loss of the dynamic brake force”.*  
*This safety analysis shall be considered in the safety analysis required by the safety requirement N°3 set out in clause 4.2.4.2.2 for the emergency brake function.*  
*For electric units, in case the presence on-board the unit of the voltage delivered by the external power supply is a condition for the dynamic brake application, the safety analysis shall cover failures leading to absence on-board the unit of that voltage.*  
*In case the hazard above is not controlled at the level of the rolling stock (failure of the external power supply system), the braking performance of the dynamic brake or of braking system linked to the traction system shall not be included in the performance of the emergency braking in normal mode defined in clause 4.2.4.5.2.”*

Where the dynamic brake is included in the emergency braking performance, the TSI mandates evaluation of the global reliability of this dynamic brake; this is needed to assess the safety requirement, No. 3 of the TSI clause 4.2.4.2.2, considering the possible compensation by pneumatic brake too. If relevant, the on-board parts of the power supply have to be considered too (pantograph, inverter...), and an assumption has to be taken regarding the availability of the external power supply.

#### 2.4.31. Clause 4.2.4.8.2: Magnetic track brake

*“(2) A magnetic track brake is allowed to be used as an emergency brake, as mentioned in the TSI INF, clause 4.2.6.2.2.”*

This clause addresses only emergency brake.

It does not prohibit the use of braking systems independent of wheel-rail adhesion for service brake; this use may be subject of restrictions, which are described in the Infrastructure register.

Clause 4.2.6.2.2 of the INF TSI states:

*“(1) The track, including switches and crossings, shall be designed to be compatible with the use of magnetic braking systems for emergency braking.*

*[...]*

*(3) For the 1600 mm track gauge system it shall be permitted not to apply paragraph (1).”*

Electro-magnetic compatibility aspects for interface to axle counters are covered in clause 4.2.3.3.1.2.

#### 2.4.32. Clause 4.2.4.8.3: Eddy current track brake

*“(4) The maximum distance between the eddy current track brake and the track corresponding to ‘brake released’ position will be recorded in the technical documentation described in clause 4.2.12 of this TSI.”*

The maximum distance has to be determined in order to ensure the compatibility with the gauge. It may be useful for the electromagnetic compatibility (currently an open point).

*“(7) The Register of Infrastructure indicates per track section if their use is allowed, and provides in such case their conditions for use.*

- *The maximum distance between the eddy current track brake and the track corresponding to ‘brake released’ referred to in point (4),*
- *Fixed speed threshold referred to in point (5),*
- *Vertical force as a function of the train speed, for the case of full application of eddy current track brake (emergency braking) and limited application of eddy current brake (service braking),*

- *Braking force as a function of the train speed, for the case of full application of eddy current track brake (emergency braking) and limited application of eddy current brake (service braking),”*

The findings of the ECUC project (Eddy Current brake Compatibility) may be used to determine the thermal effect to the infrastructure when performing the verification of compatibility of the unit with a network or route.

#### 2.4.33. Clause 4.2.4.9: Brake state and fault indication

*“(1) Information available to train staff shall allow the identification of degraded conditions concerning the rolling stock (brake performance lower than the performance required), for which specific operating rules apply. To that end, it shall be possible at certain phases during operation for the train staff to identify the status (applied or released or isolated) of the main (emergency and service) and parking brake systems, and the status of each part (including one or several actuators) of these systems that can be controlled and/or isolated independently.”*

The control of the status of the braking system is directly dependent on the design of the system; the choice of the parts to be controlled independently is made by the Applicant. It has a direct impact on degraded operating conditions, which have to be described in the documentation required by clause 4.2.12.4.

*“(2) If the parking brake always depends directly on the state of main brake system, it is not required to have an additional and specific indication for the parking brake system.”*

This point (2) applies to certain brake architectures (e.g. units fitted with automatic parking brake), in which the parking brake depends directly on the state of the main brake system.

#### **Applicability to units intended for general operation:**

*“(7) Only functionalities that are relevant to the design characteristics of the unit (e.g. presence of a cab,...) shall be considered.  
The signals transmission required (if any) between the unit and the other coupled unit(s) in a train for the information regarding the brake system to be available at train level shall be documented, taking into account functional aspects.  
This TSI does not impose any technical solution regarding physical interfaces between units”*

For example, in case of assessment of a passenger carriage for general operation with no cab, it is not possible to check the information the driver will receive in the cab; it is only possible to check local indications (for example external brake indicators), and electric or numeric information that is to be transmitted to a cab when the carriage is integrated in a train.

#### 2.4.34. Clause 4.2.5: Passenger-related items

*“For information purposes only, the following non exhaustive list gives an overview of the basic parameters covered by the TSI PRM, which are applicable to units which are intended to carry passengers.”*

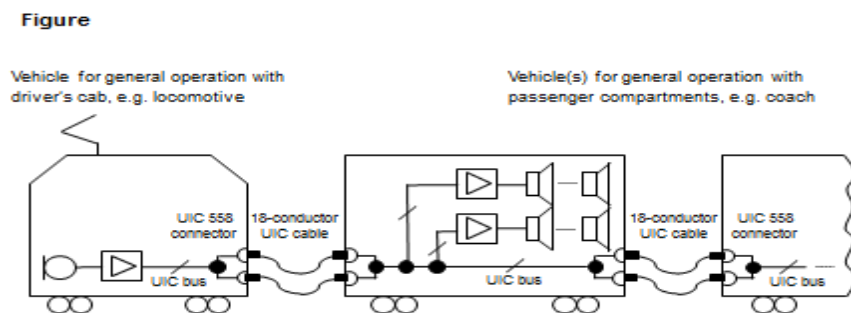
The PRM TSI is in force and applies independently of the LOC&PAS TSI to the RST that is designed to carry passengers and that is in the scope of the LOC&PAS TSI.

## 2.4.35. Clause 4.2.5.2: Audible communication system

“(3) The equipment shall be able to remain on standby independently of the main energy source for at least three hours. During the standby time the equipment shall be able to actually function at random intervals and periods during an accumulated time of 30 minutes.  
 (4) The communication system shall be designed in such a manner that it continues to operate at least half (distributed throughout the train) of its loudspeakers in the event of a failure in one of its transmission elements or, as an alternative, another means shall be available to inform the passengers in the event of a failure.”

In case of units fitting a UIC 558 or similar bus for audible communication via loudspeakers, the first alternative of requirement (4) is deemed to be fulfilled under following conditions:

- Passenger areas are equipped with two independent lines for amplifiers and loudspeakers using one transmission path of the UIC 558 bus (see figure below)
- Driver cabs are equipped with one microphone and one amplifier connected to the transmission path of the UIC 558 bus.



## 2.4.36. Clause 4.2.5.3.1: Passenger alarm

“(1) This clause is applicable to all units designed to carry passengers and units designed to haul passenger trains.  
 (2) The passenger alarm function gives to anyone in the train [...]”

This clause is applicable at train level in the conditions set out in clause 4.2.5.3.3 only. Shunting mode may be excluded from the scope of this clause as far as the shunting operations are not carried out under such conditions.

## 2.4.37. Clause 4.2.5.3.2: Passenger alarm: Requirements for information interfaces

“(4) A device in the cab shall allow the driver to acknowledge his awareness of the alarm. The driver's acknowledgement shall be perceivable at the place where the passenger alarm was triggered and shall stop the acoustic signal in the cab.”

When a passenger alarm is initiated, this results in a visual and an acoustic signs in the cab. In the case of no acknowledgement of the alarm by the driver, a brake will be initiated after 10 seconds, which will be perceived by passengers as a confirmation of the alarm..

In the case where the passenger alarm is acknowledged by the driver, the clause above applies. There will be no automatic application of the brake, but passengers should be informed that the driver is aware of the alarm; the means to inform passengers is not specified in the TSI, but it is required as being a direct consequence of the acknowledgement by the driver; it is not mandatory to have this information generated immediately, but it should be given within the 10 seconds of the passenger alarm being initiated.

For example, the means to inform passengers could be an acoustic signal in the unit, or it could be a visual sign (light at the position where the alarm was initiated).

#### 2.4.38. Clause 4.2.5.3.4: Passenger alarm: Criteria for a train departing from a platform

*“(1) A train is deemed to be departing from a platform during the period of time elapsing between the moment when door status is changed from ‘released’ to ‘closed and locked’ and the moment when the train has partly left the platform.  
(2) This moment shall be detected on-board (function allowing physical detection of the platform or based on speed or distance criteria, or any alternative criteria).”*

The following ways to detect that the train has partly left the platform are (among others) permitted:

- Physical detection of the platform (marker on the tracks)
- The speed of the train reaches the speed criteria specified in clause 6.5 of EN 16334:2014.
- The distance covered is 100 (+/- 20) m.
- The time elapsed since the train starts to move after the door status is changed from ‘released’ to ‘closed and locked’ is more than 10 s.

The Applicant may implement a similar technical solution using a distance higher than 100 m, or a higher speed criteria providing that he demonstrates that the criterion “train departing from a platform” as defined in the TSI clause above will cease to apply.

#### 2.4.39. Clause 4.2.5.3.5: Passenger alarm: Safety requirements

*(...) considering that the functional failure has typical credible potential to lead directly to “single fatality and/or severe injury”.*

Pending the publication of the harmonized risk acceptance criteria in the foreseen amendment to the CSM on risk assessment regulation, clause 9 of EN 16334:2014 specifies a failure rate that may be used for demonstration of conformity to the requirements of clause 4.2.5.3.5.

#### 2.4.40. Clause 4.2.5.3.6: Passenger alarm: Degraded modes

*“(1) Units fitted with a driver's cab shall be fitted with a device which allows authorised staff to isolate the passenger alarm system.  
(2) If the passenger alarm system is not functioning, either after intentional isolation by staff, due to a technical failure, or by coupling the unit with a non-compatible unit, this shall be permanently indicated to the driver in the active driver's cab, and application of the passenger alarm shall result in a direct application of brakes.”*

The application of brakes when the passenger alarm is degraded as explained in 4.2.5.3.6(2) should not prevent the driver from overriding the brake application.

#### 2.4.41. Clause 4.2.5.3.7: Passenger alarm: Applicability to units intended for general operation

*“(1) Only functionalities that are relevant to the design characteristics of the unit (e.g. presence of a cab, of a crew interface system,...) shall be considered.  
(2) The signals transmission required between the unit and the other coupled unit(s) in a train for the passenger alarm system to be available at train level shall be implemented and documented, taking into account functional aspects described above in this clause.”*

When the unit under assessment has to be coupled to other units to be operated as a train, and the train composition is not defined, it is not usually possible to verify all functionalities; only information available on the unit under assessment needs to be verified.

Note: this is also applicable to clause 4.2.5.4 ‘Communication devices for passengers’ and to clause 4.2.5.5 ‘Exterior doors’.

#### 2.4.42. Clause 4.2.5.4: Communication devices for passengers

The device allowing the communication function described in this clause may use the device of the communication function described in the point (5) of clause 4.2.5.3.2 (passenger alarm).

However, the initiative of establishing the communication link is specific to each function (passenger’s initiative for communication device, driver’s initiative following the activation of a passenger alarm). The TSI contains no requirements regarding the reliability of the communication device. On a voluntary basis, the user may specify such requirements and ask the Notified Body to assess them.

EN 16683:2015, clause 5 and annex D provides additional guidance on the communication device for passengers design.

#### 2.4.43. Clause 4.2.5.8: Internal air quality

*“(2) The CO<sub>2</sub> level shall not exceed 5000 ppm in all operating conditions, excepted in the 2 cases below:  
- In case of interruption of the ventilation, due to an interruption of the main power supply or to a breakdown of the system, an emergency provision shall ensure the supply of outside air into all passenger and staff areas.  
If this emergency provision is ensured through battery supplied forced ventilation, the duration in which the CO<sub>2</sub> level will remain below 10000 ppm shall be defined assuming a passenger load derived from the load condition “design mass under normal payload  
The conformity assessment procedure is defined in clause 6.2.3.12.  
This duration shall not be less than 30 minutes.  
[...].”*

The maximum CO<sub>2</sub> level is specified for all operating conditions, i.e. at any speed up to the maximum speed of the unit, and also at stop.

If the emergency provision is ensured through battery supplied forced ventilation, this functionality is limited in time due to the autonomy of the battery; therefore, it is required to evaluate the expected duration during which the functionality will be met.

Alternatively, the requirement can be met by provision of passive facilities such as openable windows or flaps (providing external air into the train). Since the airflow through such passive devices will vary with the ambient conditions, and therefore cannot be directly assessed, there is no assessment procedure required, and there is no minimum area of opening specified. Operational rules (outside of scope of the LOC&PAS TSI) are needed for the effective use of such facilities.

*“- In case of switch off or closing of all means of external ventilation, or switch off of air conditioning system, in order to prevent passengers being exposed to environmental fumes that may be present, especially in tunnels, and in the event of a fire, as described in clause 4.2.10.4.2.”*

The means to be used by the train staff (manual closing, closing by remote control) are not specified; any means is acceptable.

#### 2.4.44. Clause 4.2.6.1: Environmental conditions - general

*“(4)...For the functions identified in the clauses below, design and/or testing provisions taken to ensure that the rolling stock is meeting the TSI requirements in this range shall be described in the technical documentation.”*

The applicant defines the range of environmental conditions in terms of temperature, snow ice and hail conditions (and the combination of the conditions) the rolling stock is intended to be operated under.

In section 7.4 ‘Specific environmental conditions’ of the TSI, Member States have identified the specific conditions that shall be taken into account for rolling stock to operate without any restrictions on their network. The applicant can choose to apply these conditions in order to avoid restrictions at operating level (e.g. under winter conditions), but this is not mandatory for a vehicle to get an ‘authorisation for placing in service’ in the concerned Member State.

All the provisions taken by the applicant to ensure that the vehicle is capable of operating under the chosen conditions (e.g. temperature zone) are to be documented in the technical documentation. This should allow the user of the vehicle to define and take additional provisions where necessary, depending on real operating conditions.

**Note:** Clause 5 and 6 of CEN/TR16251 defines design guidance and criteria for validation of the rolling stock and its constituents under specific (severe) environmental conditions to which this rolling stock may be subject.

#### 2.4.45. Clause 4.2.6.1.2: Snow, ice and hail

*“(3) Where more severe “snow, ice and hail“ conditions are selected, rolling stock and the parts of the subsystem shall then be designed to meet TSI requirements considering the following scenarios:*

- *Snowdrift (light snow with low water equivalent content), covering the track up to 80 cm continuously above top rail level.*
- *Powder snow, snowfall of large quantities of light snow with low water equivalent content.*
- *Temperature gradient, temperature and humidity variation during one single run causing ice build-ups on the rolling stock.*
- *Combined effect with low temperature according to the temperature zone chosen as defined in clause 4.2.6.1.1.*

*(...)*

Following is a more detailed description of the conditions/scenarios related to snow that may be considered by the applicant when defined design and/or testing provisions. The applicant may choose other conditions/scenarios depending on the area and conditions of use of the rolling stock:

These conditions/scenarios are based on a return of experience gathered by Nordic countries; they are not expressed in terms of design criteria directly applicable to vehicles.

Weather conditions resulting in whirling snow in the air along the train in the temperature area of  $-10^{\circ}\text{C} < T < 0^{\circ}\text{C}$ :

Conditions with whirling snow are frequently occurring during winter time in Finland, Norway and Sweden. They are caused by loose snow whirled by the wind and the train's speed and may result in clogging of air intakes; build-ups of snow and ice, causing e.g. derailment, brake hose breakage, or obstruction of sight from the driver's position.

The braking power may be considerably decreased if suitable measures are not ensured. On disc braked rolling stock the snow tends to build up a layer of snow/ice between the brake pads and the brake disc. The same phenomenon is found on blocks braked rolling stock. A prolonged stopping distance has to be avoided. Composite brake pads and composite brake blocks proven suitable for winter conditions are necessary to avoid operational restrictions. Extensive testing therefore has been carried through during the last three decades to find acceptable composite friction elements.

Operational rules, such as routine brake testing/braking during such conditions are frequently utilised in order to minimise the risk of any adverse loss of brake capacity under these conditions.



Routine brake testing before starting the operation and also during the run (heat braking to be sure that the braking power is maintained, and test braking for instance before signals, stations and especially long and steep gradients) is also utilised.

Very low temperatures are mainly found in the inland of Finland and Sweden, but also in Norway (the further north, the colder).

Low ambient temperature and rapid variation of temperature combined with humidity may require measures to limit condensation and/or proper drainage (i.e. for structures that are closed and may collect humidity).

Light snow on the line in heights up to 800 mm above top of the rails:

In the Nordic area, severe snow falls are mainly found in Sweden and Norway. In Sweden un-ploughed lines with up to 800 mm light snow may be found resulting from 24 hours of snowfall; in such a case, the Infrastructure Manager acting as the Traffic Manager or at the request of the Traffic Manager may have to apply particular procedures.

This is not common in Norway where the fallen snow tends to be heavier (higher density), and the heaviest snow falls not so intensive. In Finland the height of snow is low.

Heavier snow on the line with varying heights above top of the rail, and where the top of the snow might be laterally level or inclining:

Avalanches, snow drifts, ice-slides etc. on the line are almost solely found on Norwegian lines, and mostly on the mountainous lines. Snow drifts may also occur more sporadic at conditions with heavy snowfall and strong wind. Laterally inclining top of a snow drift or an avalanche will cause strong lateral forces when running into it and challenge the resistance to derailment. A snow plough with a shape securing downwards forces is necessary (see point on obstacle deflector in the TSI).

Consistency of the snow as everything from very loose and light to ice- or concrete-like, from dry to near soak-wet snow with any density from 100-400 kg/m<sup>3</sup>:

Heavy snow causes high resistance when running into it. Appropriate strength of primarily the snow plough and its fastenings and the front of the rolling stock is necessary (see point on obstacle deflector in the TSI).

In addition openly mounted under-floor equipment needs enforced protection to avoid harm from e.g. ice lumps.

Sudden changes when running through long tunnels:

Despite low outside air temperature the air inside long tunnels always will show some degrees above zero and the relative air humidity will be near 100 %. Where the line has many long tunnels and the outside air temperature is low snow and ice tends to build up especially on the vehicle ends, on the under-floor equipment and on/in the running gear.

The rolling stock will instantly gather condense on the outside. Repeated cycles builds up ice that i.e. may obstruct free movements increasing the risk for derailment. Accumulated snow/ice results in increased weight and forces.

The high relative humidity in cooling air may cause breakdown of electronics.

2.4.46. Clause 4.2.6.2: Aerodynamic effects

*”(1) The requirements of this clause apply to all rolling stock. For rolling stock operated on the 1520 mm and 1600 mm track gauge system, in case of maximum speed higher than the limits specified in the clauses 4.2.6.2.1 to 4.2.6.2.5 the procedure for innovative solution shall apply.”*

For vehicles intended to operate in several track gauges, compliance with requirements of clauses 4.2.6.2.1, 4.2.6.2.2 and 4.2.6.2.4 should be demonstrated for all track gauges the vehicle is intended to be compatible with.

The compliance may be demonstrated either by assessing the vehicle in both track gauges or by assessing the vehicle in one track gauge and demonstrating that such track gauge is the worst case scenario.

#### 2.4.47. Clause 4.2.6.2.3: Maximum pressure variations in tunnels

*” (1) Units of maximum design speed higher than or equal to 200 km/h shall be aerodynamically designed so that for a given combination (reference case) of train speed and tunnel cross section in case of a solo run in a simple, non-inclined tube-like tunnel (without any shafts etc.) a requirement for the characteristic pressure variation shall be met. The requirements are given in the Table 5.”*

A vehicle may be exempted of demonstrating compliance with this requirement if its operation will be restricted to networks without tunnels or a network where the maximum speed in the tunnels is lower than 200 km/h. The authorisation granted to such vehicle may include this restriction in accordance with Article 21(10) of the Directive(EU) 2016/797.

#### 2.4.48. Clause 4.2.6.2.4: Cross wind

*” (3) For units of maximum design speed equal to or higher than 250 km/h the crosswind effects shall be according to one of the following methods :*  
*(a) determined and complying with the specification of the HS RST TSI 2008 clause 4.2.6.3, or.*  
*(b) determined by the assessment method of the specification referenced in Appendix J-1, index 37. The resulting characteristic wind curve of the most sensitive vehicle of the unit under assessment shall be recorded in the technical documentation as per clause 4.2.12.*

The applicant chooses between the two methods given: assessment in accordance with the EN standard (using the same method as for units of lower maximum speed), or assessment specified in the HS RST TSI (in force since 2008, in the meantime the CEN WG has complemented the standard for HS).

The EN standard offers a set of methodologies for the determination of the characteristic wind curves for vehicles circulating on 1435 mm track gauge. The standard may be applied to other track gauges by adjusting some of the methodologies described; The reference characteristic wind curves defined in HS RST TSI 2008 are only valid for 1435 mm track gauge.

NOTE: Article 11 (2) of the Commission Regulation indicates that HS RST TSI 2008 remains applicable for this particular subject; see also clause 7.1.1.7 of the LOC&PAS TSI.

#### **Additional information for defining relevant operating rules:**

The resulting characteristic wind curves recorded in the technical documentation should be taken into account for the railway undertaking to define relevant operating rules also considering available information provided by the Infrastructure Manager on wind conditions for a given line (in particular, where these wind conditions are considered as critical).

*‘(1) This requirement applies to units of maximum design speed higher than 250 km/h.*  
*(2) The requirement on the aerodynamic effect of trains on ballasted tracks, in order to limit risks induced by the projection of ballast (ballast pick up), is an open point.*

#### 2.4.49. Clause 4.2.7.1: External lights

External lights are interoperability constituents, and their colour and luminous intensity are required to be tested at an IC level. The test may include particular conditions of integration of the lights (e.g. additional glazing); such condition is part of the area of use of the component.

In case of uncertainty regarding the area of use, the applicant may undertake additional verifications at vehicle level, and submit the results to the Notified Body.

#### 2.4.50. Clause 4.2.7.1.1: Head lights

*“(2) Two white headlamps shall be provided at the front end of the train in order to give visibility for the train driver.”*

*[...]*

*(7) Additional head lamps may be provided (e.g. upper head lamps). [...]*

The TSI specifies minimum requirements regarding head lights that are sufficient to operate on the EU network.

The use by RUs of additional headlamps is not prohibited by TSI; the use of these additional headlamps may be subject to restrictions on certain networks; however, their presence cannot be a condition for access to a network. The standard EN 15153-1 provides guidance on the location of these additional headlamps.

#### 2.4.51. Clause 4.2.7.1.4: Lamp controls

*“(2) It shall be possible for the driver to control:*

- the head, marker lamps of the unit from the normal driving position;*
- the tail lamps of the unit from the cab.*

*This control may use independent command or combination of commands.*

*Note: where it is intended to use lights to inform of an emergency situation (operating rule, see TSI OPE), this should be done only by means of head lamps in flashing/blinking mode.”*

The TSI specifies the lamp controls at the level of the unit; there is no specification at the level of the train.

The use by RUs of lights to display an emergency situation is not prohibited by the TSI; it may be subject to restrictions on certain networks; however, this functionality cannot be a condition for access to a network.

#### 2.4.52. Clause 4.2.8.2.2: Operation within range of voltages and frequencies

*“(1) Electric units shall be able to operate within the range of at least one of the systems “voltage and frequency” defined in the TSI Energy, clause 4.2.3.”*

The design of RST for other additional systems “voltage and frequency” not described in the ENE TSI is not prohibited by the TSI.

If such additional system is the subject of a specific case in the ENE TSI, it is by consequence subject of a specific case in the LOC&PAS TSI (listed in section 7.3, with applicable rules described or to be notified).

If it only applies to the networks not in the scope of the TSIs, it should be covered by national rules.

#### 2.4.53. Clause 4.2.8.2.7: System energy disturbances for AC systems

*“(2) A compatibility study shall be done in accordance with the methodology defined in the specification referenced in Appendix J-1, index 45, clause 10.3. The steps and hypothesis described in table 5 of the same specification have to be defined by the applicant (column 3 “Concerned party” not applicable), with input data presented as in Annex D of the same*

*specification; the acceptance criteria shall be as defined in clause 10.4 of the same specification.  
(3) All hypothesis and data considered for this compatibility study shall be recorded in the technical documentation (see clause 4.2.12.2).”*

See part of the Application guide covering the ENE TSI, and in particular its clause 4.2.8.

#### 2.4.54. Clause 4.2.8.2.8: On-board energy measurement system

##### 2.4.55. Clause 4.2.8.2.8.1: General

“

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

*(2) The EMS shall include at least the following functions: Energy measurement function (EMF) as set out in clause 4.2.8.2.8.2, data handling system (DHS) as set out in clause 4.2.8.2.8.3.*

*(3) A suitable communication system will send the measured data to an on-ground data collecting system (DCS). The interface protocols and transferred data format between EMS and DCS shall fulfil the requirements set out in point 4.2.8.2.8.4.*

*(4) This system is suitable for billing purposes; the data defined in point 4.2.8.2.8.3 (4) provided by this system shall be accepted for billing in all Member States*

*(5) The EMS rated current and voltage shall be matched to the electric unit rated current and voltage; it shall continue to function correctly when changing between several traction energy supply systems.*

*(6) Data stored in the EMS shall be protected against loss of the power supply and the EMS shall be protected from non-authorized access.*

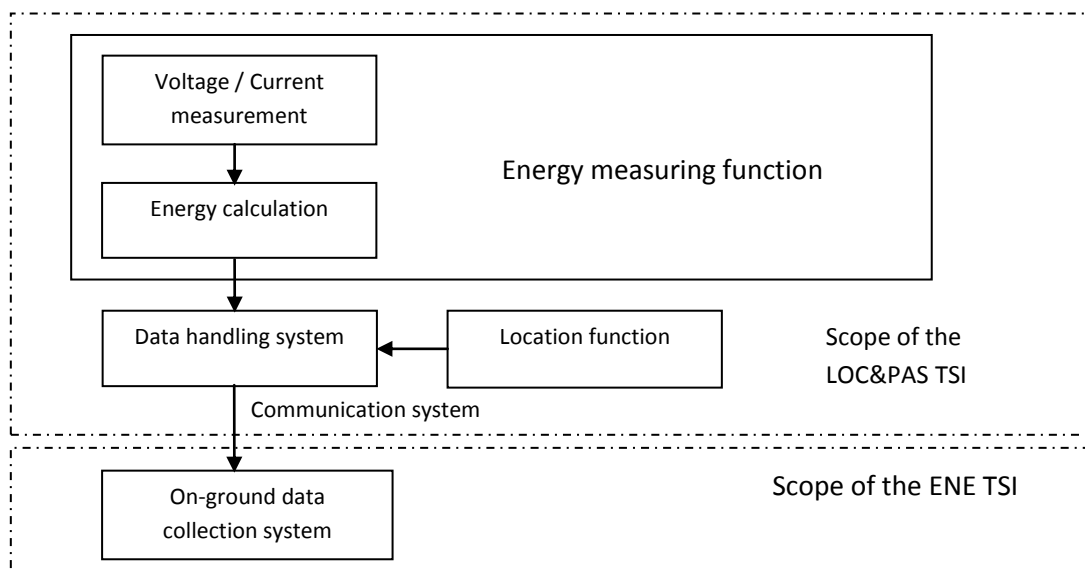
*(7) An on-board location function providing location data originated from an external source to the DHS shall be provided in networks where such function is necessary for billing purposes only. In any case, the EMS system shall be able to accommodate a compatible location function. If the location function is provided, it shall fulfil the requirements set out in clause 4.4 of EN 50463-3:2016.*

*(8) The fitment of an EMS, its on-board location function, the description of on-board to ground communication and the metrological control including the accuracy class of the EMF shall be recorded in the technical documentation described in clause 4.2.12.2 of this TSI.*

*(9) The maintenance documentation described in clause 4.2.12.3 of this TSI shall include any periodic verification procedure to ensure the required accuracy level of the EMS during its lifetime.”*

The aim of the requirements set out in this TSI and in the ENE TSI is to ensure that all Data Collecting Systems (DCS) shall be able to collect data from all on-board energy measurement systems (EMS).

The functions of the on-board energy measurement system and their data flow diagram are illustrated in the picture below. These functions can be performed by individual devices or may be combined in one or more integrated assemblies.



It is permissible to access the data in the EMS for other purposes (e.g. feedback to the driver regarding the efficient operation of the train) provided that it can be demonstrated that the integrity of EMS functions and data are not compromised by this arrangement.

#### 2.4.56. Clause 4.2.8.2.9.2: Pantograph head geometry (IC level)

*“(1) For electric units designed to be operated on other track gauge systems than 1520 mm or 1600 mm system, at least one of the pantograph(s) to be installed shall have a head geometry type compliant with one of the two specifications given in the clauses 4.2.8.2.9.2.1 and 2 below.”*

The installation of other additional pantograph of different head geometry is not prohibited by the TSI. If such an additional pantograph is needed, specific cases on pantograph head geometry set out in section 7.3 of the LOC&PAS TSI cover both:

- OCL designs which are the subject of a Specific case in the ENE TSI and
- Non ENE TSI compliant OCL designs in existing lines

**Note:** networks outside of scope of TSIs, and Rolling Stock operated on these networks only are covered by national rules (e.g. networks with a power supply system of 600 VDC or 750 VDC).

#### 2.4.57. Clause 4.2.8.2.9.4.2: Contact strip material

*“(1) Material used for the contact strips shall be mechanically and electrically compatible with the contact wire material (as specified in clause 4.2.14 of the ENE TSI), in order to ensure proper current collection and to avoid excessive abrasion of the surface of the contact wires, thereby minimising wear of both contact wires and contact strips.”*

See also clause 5.3.11 of the TSI defining the area of use of the IC contact strips. See also clause 6.1.3.8 specifying the conformity assessment procedure to be used; this clauses give the possibility to the manufacturer to make an assessment of suitability for use.

The following EN standards are covering this subject:

- EN 50367:2012/AC:2013: this standard deals with the interaction between contact line and pantograph; it indicates usual material for overhead contact lines and for contact strips; however, regarding contact strip material, the TSI gives more possibilities.
- EN 50405:2015 : this standard deals with the assessment of contact strips.

Aspects defining the contact strips area of use (clause 5.3.11 of the TSI) should be considered in the assessment procedure.

*“(2) Plain carbon or impregnated carbon with additive material shall be permitted. Where a metallic additive material is used, the metallic content of the carbon contact strips shall be copper or copper alloy and shall not exceed a content of 35 % by weight where used on AC lines and of 40% where used on DC lines. Pantographs assessed against this TSI shall be fitted with contact strips of a material mentioned above.  
(3) Additionally, contact strips of other material or higher percentage of metallic contents or impregnated carbon with clad copper are allowed (if permitted in the infrastructure register) provided that:...”*

Contact strips covered by an EC declaration of conformity according to point (2) are allowed for applications corresponding to their area of use on the whole EU network, without any additional test of compatibility with a particular line. An infrastructure manager cannot refuse such contact strip and cannot impose to the railway undertaking to use a particular material.

Point (3) gives the possibility to use contact strips of other material, subject to agreement of the infrastructure management (via information in the infrastructure register).

Percentage of metallic content is calculated on the total weight of the contact strip.

Regarding the pantograph contact force and dynamic behaviour, the weight and size (thickness) of the pantograph head may have an impact on the test results; therefore, in case of use of different contact strips than those initially validated, it should be checked that the weight and size variations are not significant; the manufacturer of the pantograph should cover this aspect in the technical documents provided with the pantograph EC declaration of conformity.

#### 2.4.58. Clause 4.2.8.2.9.6: Pantograph contact force and dynamic behaviour

*“(4) The verification at interoperability constituent level shall validate the dynamic behaviour of the pantograph itself, and its capability to collect current from a TSI compliant overhead contact line; the conformity assessment procedure is specified in clause 6.1.3.7.  
(5) The verification at rolling stock subsystem level (integration in a particular vehicle) shall allow to adjust the contact force, taking into account aerodynamic effects due to the rolling stock and the position of the pantograph in the unit or train fixed or predefined formation(s); the conformity assessment procedure is specified in clause 6.2.3.20.”*

The pantograph is the component that ensures the current collection from the overhead contact line (OCL). The quality of the current collection depends on characteristics of the OCL, of the pantograph and of the rolling stock (including interaction between multiple pantographs simultaneously raised in a train); these 3 elements have a certain dynamic behaviour that has an impact on the final performance.

When a pantograph is designed, a set of characteristics regarding the OCL are taken into account, including the maximum operating speed of the rolling stock (which depends on the OCL and on the rolling stock); in addition, the design allows for the adjustment of the contact forces (static and dynamic), by different means (pressure, springs, deflector...).

A pantograph is not designed for a particular rolling stock, but for an OCL geometry ensuring compatibility with the pantograph head geometry and a maximum speed; the definition of the pantograph as an interoperability constituent (IC) is in line with this principle.

Tests performed for the assessment of the pantograph as IC aim at validating characteristics of the pantograph itself, for OCLs compliant to the ENE TSI, and for a certain maximum speed (area of use of the IC

defined in the clause 5.3.10 of the LOC&PAS TSI). The concept of IC allows the designer or manufacturer of the pantograph to issue an EC declaration of conformity independently of a particular use of the pantograph.

When this pantograph is integrated in a particular rolling stock, the Applicant for this rolling stock has to make the necessary adjustments in order to get a mean contact force in the range specified in the TSI (e.g. adjusting aerodynamical components of the pantograph to a specific position).

See also part of the Application guide covering the ENE TSI, and in particular its clause related to “*Assessment of Dynamic behaviour and quality of current collection*”.

*“(6) ...For the speed range above 320 km/h up to the maximum speed (if higher than 320 km/h), the procedure for innovative solution described in article 10 and Chapter 6 of this TSI shall apply.”*

The same procedure is specified in the ENE TSI for overhead contact lines designed for speed above 320 km/h; this procedure for innovative solution will allow complementing the Energy and LOC&PAS TSIs as soon as an application in that speed range will be planned. This procedure is preferred to the application of a national rule (as in case of open point in TSIs) because it avoids the risk of divergences in different Member States.

#### 2.4.59. Clause 4.2.8.2.9.7: Arrangement of pantographs (RST level)

*“(2) The number of pantographs and their spacing shall be designed taking into consideration the requirements of current collection performance, as defined in clause 4.2.8.2.9.6.  
(3) Where the spacing of 2 consecutive pantographs in fixed or pre-defined formations of the assessed unit is less than the spacing shown in clause 4.2.13 of the TSI Energy for the selected OCL design distance type, or where more than 2 pantographs are simultaneously in contact with the overhead contact line equipment, it shall be demonstrated by testing that the current collection quality as defined in clause 4.2.8.2.9.6 above is met for the poorest performing pantograph (identified by simulations to be performed prior to that test).  
(4) The OCL design distance type (A, B or C as defined in the clause 4.2.13 of TSI Energy) selected (and therefore used for the test) shall be recorded in the technical documentation (see clause 4.2.12.2).”*

See part of the Application guide covering the ENE TSI and in particular ENE TSI clause 4.2.13.

The train formation(s) subject to the application of the TSI (as described in clause 4.1.2 and defined by the applicant) should be considered.

The simulations made in order to identify the poorest performing pantograph should be documented and justified; they may refer to specific rules for the network where the vehicle is intended to be operated.

#### 2.4.60. Clause 4.2.8.2.9.8: Running through phase or system separation sections (RST level)

*“(3) When running through phase or system separation sections, it shall be possible to bring the power consumption of the unit to zero. The infrastructure register gives information on the permitted pantographs position: lowered or raised (with permitted pantograph arrangements) when running through systems or phase separation sections.”*

See part of the Application guide covering the ENE TSI, and in particular its clause 4.2.15 & 4.2.16.

The operational conditions for running through phase/system separation sections are set in ENE TSI with further information given in EN 50367:2012/AC:2013 and EN 50388:2012/AC:2013. Additionally the Register of Infrastructure gives details relating to the particular separation section.

The message about required operation (to be done on-board while passing through separation sections) is delivered to a vehicle through the signalling system. It can be a lineside signal informing a driver to perform specified actions manually or CCS system sends the message and automatically triggers the required action

by vehicle equipment, without driver's intervention. The last solution is compulsory on the HS lines as defined in the Annex 1 of Directive (EU) 2016/797.

*“(4) Electric units of maximum design speed higher than or equal to 250 km/h shall be fitted with an on-board TCMS (train control and monitoring system) able to receive from the ground the information related to the location of the separation section, and the subsequent commands to the control of the pantograph and main circuit breaker shall be triggered automatically by the TCMS of the unit, without intervention of the driver.*

*“(5) Units intended to operate on lines that are fitted with the ETCS track side system for control command and signalling shall be fitted with an on-board TCMS (train control and monitoring system) able to receive from the ETCS system the information related to the location of the separation section as described in Annex A, Index 7 of TSI CCS; for units of maximum design speed lower than 250 km/h, the subsequent commands are not required to be automatic, but information on section separation provided by ETCS shall be displayed on-board for the intervention of the driver.”*

For all kinds of trains (both HS and non-HS), the transmission path depicted in the case (5), i.e. from ETCS trackside installation (balises and/or radio link with RBC) to the vehicle and to ETCS onboard (TCMS or whatever onboard module), is the only one required for interoperability.

For HS trains ( $V > 250$  Km/h), the handling of neutral sections must be operated automatically by the onboard TCMS on the base of info received from ETCS onboard system. It allows the driver to interrupt the automatic sequence in whichever moment, and then to let the automatic sequence to continue if the driver removes the stop. This add-on helps to cope with degradations not manageable by the automatic procedure.

For non-HS trains, the automatic handling of neutral sections is not mandatory. But all the related information provided by ETCS trackside installation must be sent anyway to the vehicle via the ETCS onboard-Train Interface if fitted with, and also provided to the driver in the ETCS DMI according to CCS-TSI provisions. So, even if not mandatory, it allows any degree of partial automation and anyhow eases the manual handling and/or the supervision by the driver.

#### 2.4.61. Clause 4.2.8.2.9.10: Pantograph lowering (RST level)

*“(4) Electric units of maximum design speed higher than 160 km/h shall be equipped with an ADD.*

*“(5) Electric units that require more than one pantograph raised in operation and of maximum design speed higher than 120 km/h shall be equipped with an ADD.*

*“(6) Other electric units are permitted to be equipped with an ADD.”*

The automatic dropping device (ADD) functionality is specified in the TSI. The specified ADD is therefore accepted on all networks.

For electric units having a maximum speed lower or equal than 160 km/h, or lower or equal than 120 km/h in case of unit requiring more than 1 pantograph raised in operation, the option is with the Applicant to equip or not the RST with the ADD functionality.

A train with 2 locomotives is not considered as an 'electric unit' in the context of this TSI, therefore requirement (5) does not apply to locomotives.



#### 2.4.62. Clause 4.2.8.3: Diesel and other thermal traction system

An example of ‘other thermal traction systems’ are trains propelled by liquefied natural gas. Additional guidance on these trains is provided in point 2.2.1 of this document.

#### 2.4.63. Clause 4.2.9.1.1: Driver’s cab - General

*“(1) The driver’s cabs shall be designed to permit operation by a single driver.”*

The TSI requires that the design permits operation by a single driver. The design for operation by more than one driver is outside of scope of this TSI (however this is not prohibited).

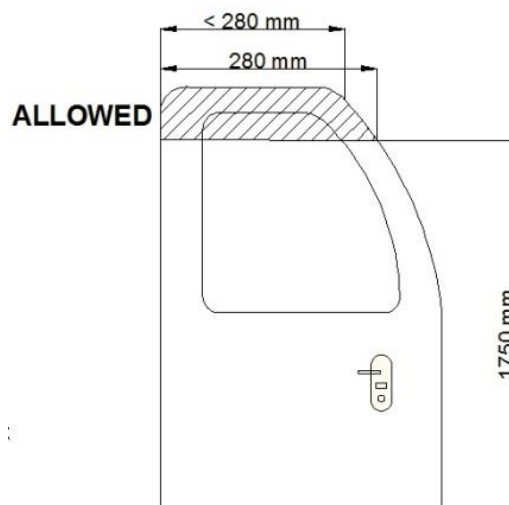
#### 2.4.64. Clause 4.2.9.1.2.1: Access and egress in operating conditions

*“(1) The driver’s cab shall be accessible from both sides of the train from 200 mm below top of rail.  
(2) It is permissible for this access to be either directly from the exterior, using a cab external door, or through the area at the rear of the cab...”  
(3) The means for the train crew to access in and to egress out of the cab...”*

For access points (1) and (3), clauses 7.1, 7.2, and 7.3 of EN 16116-1:2013 may be used for conformity assessment. The ‘area at the rear of the cab’ may include a passenger compartment, a technical compartment, a vestibule, and/or a gangway.

*“(8) For both driver’s cab external doors and internal doors, in case they are positioned perpendicular to and against the side of the vehicle, it is allowed to have the clearance width in the upper part reduced (angle on the top-outer side) due to the gauge of the vehicle; this reduction shall be strictly limited to the gauge constraint in the upper part and shall not lead to a clearance width on top side of the door lower than 280 mm.*

This requirements allow for a doorwidth lower than 280 mm for doors with a vertical clearance higher than 1750 mm as far as a minimum width of 280 mm is respected between the lower part of the door and a height of 1750 mm. (see picture below)



#### 2.4.65. Clause 4.2.9.1.3.1: Front visibility

*“(3) For locomotives with central cab and for OTMs, in order to ensure the visibility of low signals, it is permitted that the driver moves to several different positions in the cab in order to meet the above requirement; it is not required to meet the requirement from the seated driving position.”*

For locomotives with central cab, due to the nose structure in front of the cab, and for OTMs, due to the layout of the cab, the visibility of low signals at both sides of the track is not always possible from the seated driving position.

For locomotives with central cab and OTMs: If movements from the driver are required to enable him to see low signals then these movements within the cab are not to be hindered by equipment inside the cab.

For locomotives with central cab, the visibility of the low signals from the seated driving position is only required for the track side corresponding to the cab side from which the driver is operating the locomotive.

For OTMs, the requirements set out in clause 14.6 of EN 14033-1 are an acceptable mean of compliance.

#### 2.4.66. Clause 4.2.9.1.5: Driver’s seat

*“Requirements at component level:*

*(1) The driver’s seat shall be designed in such a way that it allows him to undertake all normal driving functions in a seated position, taking into account the anthropometric measurements of the driver as set out in the Appendix E. It shall allow for correct posture of the driver from the physiological point of view.*

*(2) It shall be possible for the driver to adjust the seat position in order to meet the reference position of eyes for external visibility, as defined in clause 4.2.9.1.3.1.*

*(3) Ergonomics and health aspects shall be considered in the design of the seat, and its use by the driver.*

*Requirements for integration in the driver’s cab:*

*(4) The mounting of the seat in the cab shall allow to meet external visibility requirements as specified in clause 4.2.9.1.3.1 above by using the range of adjustment provided by the seat (at component level); it shall not alter ergonomics and health aspects and the use of the seat by the driver.*

*(5) The seat shall not constitute an obstacle for the driver to escape in case of emergency.*

*(6) The mounting of the driver’s seat in locomotives, and in driving coaches in case these coaches are intended to also be operated by a driver in standing position shall allow adjustment to get the necessary free space needed for the standing driving position.”*

The UIC 651 of July 2002, clause 5.1 (except clause 5.1.4) provides detailed guidance on the driver’s seat design.

#### 2.4.67. Clause 4.2.9.1.7: Climate control and air quality

*“(2) At the seated driving position (as defined in the clause 4.2.9.1.3) of the driver’s head and shoulders, there shall be no air flows caused by the ventilation system having an air velocity exceeding the limit value recognised to ensure a proper working environment.”*

An acceptable limit value for the air velocity is set out in EN14813-1:2006+A1:2010, clause 9.5; the measurement procedure of air velocity is specified in EN14813-2:2006+A1:2010, clause 6.2. It is permitted to provide to the driver a means to adjust the air velocity and/or to direct the air flow for his own comfort; in that case, the acceptable limit should be reached for at least one position of the adjustment system.

There is no requirement in the TSI regarding the temperature in the cab, excepted when the applicant covers severe climatic conditions as described in clause 4.2.6.1. In any case, real operating and working conditions

should be taken into account by the railway undertaking (user of the vehicle) and are outside of scope of this TSI.

#### 2.4.68. Clause 4.2.9.3.1: Driver's activity control function

*“(2) ...The system shall allow for the adjustment (at workshop, as a maintenance activity) of the time X within the range of 5 seconds to 60 seconds.”*

*“(5) Notes:*

- It is allowed to have the function described in this clause fulfilled by the CCS Subsystem.*
- The value of the time X has to be defined and justified by the railway undertaking (application of TSI OPE and CSM, and consideration of its current code of practice or means of compliance; outside of scope of the present TSI).*
- As a transitional measure, it is also allowed to install a system of a fix time X (no adjustment possible) provided that the time X is within the range of 5 seconds to 60 seconds and that the railway undertaking can justify this fix time (as described above).*
- A Member State may impose to the railway undertakings operating on its territory to adjust their rolling stock with a maximum limit for time X, if the Member state can demonstrate that this is needed to preserve the national safety level. In all other cases, Member States cannot prevent the access of a railway undertaking that is using a higher time Z (within the range specified).”*

There is not a unique response time specified, but only a range, because this function has interfaces with operating rules and human factors; therefore, the RU may have its own code of practice regarding this response time.

For newly designed systems (most of the time software based), the requirement mandating the functionality of adjustment of the response time is part of the TSI specification; this does not represent any difficulty, and allows the use of the same system by different RUs; this functionality of adjustment has to be assessed by the notified body.

At operating level (not part of conformity assessment against this TSI), the RU should define and justify the response time X being used.

In the meantime the newly designed systems are available, a note allowing the use of systems of existing design without the functionality of adjustment of the response time (which continue to satisfy the operational need in the current situation) has been inserted in the TSI.

In case of a train running in different MSs having a differing requirement of the maximum value of the time X for safety reasons, the RU has to select a value accepted by the different MS(s) (for example, the minimum one, which will be accepted because the MS can only ask for a maximum value); in case the MS(s) have no particular requirement, the RU may use a time X within the range specified in the TSI according to its own operating rules. It should be noted that the “roll away protection” is in the scope of the CCS TSI, and is not covered by the LOC&PAS TSI (even if the “driver's activity control” function is used for that purpose in existing applications).

#### 2.4.69. Clause 4.2.9.3.3: Driver display unit and screens

*“(2) For functions in the scope of this TSI, the information or commands to be used by the driver to control and command the train, and given by means of display units or screens, shall be designed to allow proper use and reaction from the driver.”*

This functional requirement is applicable to control and commands, whatever the technology used (cable, network, optical fibre, wireless...).

#### 2.4.70. Clause 4.2.9.3.4: Controls and indicators

*“(1) Functional requirements are specified with other requirements applicable to specific function, in the clause describing that function.”*

The TSI does not impose any specific technology for the train control system (wired, IT solution, remote control). The technology used should be taken into account for compliance to TSI requirements (e.g. functional and safety requirements).

*“(4) In order to prevent any dangerous confusion with outside operational signalling, no green lights or green illumination are permitted in a driver’s cab, except for existing class B cab signalling system (according TSI CCS).”*

Green lights not visible (inside closed cubicles) are allowed.

*“(5) Audible information generated by on-board equipment inside the cab for the driver shall be at least 6 dB(A) above the noise level in the cab (this noise level taken as reference being measured under conditions specified in the TSI Noise).”*

The 'audible information generated by on board equipment' is evaluated by a measurement of 'the median received noise level' at the level of the driver’s ear when audible information is generated by on board equipment. This measurement may be performed at different speeds in case the audible information generated is speed dependant.

An adaptive audible device may be used to fulfil the requirement above.

The assessment process of the interior cab noise and the test conditions are defined in the revised TSI noise, which refers to EN 15892:2011.

The simplified evaluation method set out in point 6.2.3 of the NOI TSI also applies to the assessment process of the interior cab noise and may be applied to assess the requirement above.

#### 2.4.71. Clause 4.2.9.3.5: Labelling

*“(2) Harmonised pictograms shall be used to mark controls and indicators in the cab.”*

Until it is agreed to refer to the relevant EN 16186-2:2017 and EN 16186-3:2016 in the TSI, this clause may be partially covered by UIC 612-0 Appendix H, UIC 612-01 Appendix A and UIC 612-03 clause 3.2.

ISO 3864-1 is also applicable as it provides general guidance on safety colours and safety signs.

#### 2.4.72. Clause 4.2.9.4: On-board tools and portable equipment

This clause requires the availability of space in or near the driver’s cab for the tools and portable equipment required by the TSIs plus relevant national rules; the presence of the tools themselves is not required.

Exceptions: fire extinguishers (requested in clause 4.2.10.3.1 of the TSI) and self-rescue device in manned traction units of freight trains (requested in clause 4.7.1 of the SRT TSI).

#### 2.4.73. Clause 4.2.10.2: Measures to prevent fire

The requirements of this clause corresponding to diesel traction systems could be generalised to other thermal traction systems, such as liquefied natural gas. If this is not possible, e.g. due to lack of information in the relevant standards, the requirement should be covered via the 'innovative solution' described in article 10 of the enacting part of the TSI.

#### 2.4.74. Clause 4.2.10.2.1:Material requirements

*“(3) In order to ensure constant product characteristics and manufacturing process, it is required that:*

- the certificate to prove compliance of a material with the standard, which shall be issued immediately after testing of this material, shall be reviewed every 5 years.*
- in case there is no change in the product characteristics and manufacturing process, and no change in the requirements (TSI), it is not required to perform new testing of this material; the certificate needs only to be updated regarding its date of issue.”*

Certificates referring to a test report older than 5 years could be accepted if TSI requirements have not changed and it is demonstrated that the product manufacturing process and material characteristics remain unchanged. This demonstration should cover the complete supply chain involved in the product manufacturing process and consists in:

- checking the certification of the quality management system of original equipment manufacturers involved in the supply chain (e.g, via its certification against Standards such as ISO 9001, ISO/TS 22163, IRIS, etc)
- sampling of additional evidences provided by the applicant (e.g, product configuration management, quality control, audits, etc)

In any case, the demonstration above needs to be performed every 5 years.

UNIFE manufacturer declaration on fire behaviour of supplied products (template available on the UNIFE webpage) provides an acceptable mean of compliance with the requirement above.

#### 2.4.75. Clause 4.2.10.2.2:Specific measures for flammable liquids

*“(1) Railway vehicles shall be provided with measures preventing a fire from occurring and spreading due to leakage of flammable liquids or gases.  
[...].”*

Compliance with EN 45545-7:2013 gives presumption of conformity.

Liquified gas used in some traction systems is not currently within the scope of EN 45545-7:2013. Where this is used it should be assessed under CSM against applicable codes of practice such as UNECE Regulation 110.

#### 2.4.76. Clause 4.2.10.3.1: Portable fire extinguishers

*“(1) This clause is applicable to units designed to carry passengers and/or staff.  
(2) The unit shall be equipped with adequate and sufficient portable fire extinguishers, in passenger and/or staff areas.  
(3) Water plus additive type fire extinguishers are deemed to be adequate for on-board rolling stock purposes.”*

This clause also applies to freight locomotives and self-propelling units designed to carry payloads other than passengers/staff.

Fire extinguishers compliant to clause 6.3 of EN 45545-6:2013 have presumption of conformity.

#### 2.4.77. Clause 4.2.10.3.2: Fire detection systems

*“(1) The equipment and the areas on rolling stock that intrinsically impose a fire risk shall be equipped with a system that will detect fire at an early stage.  
(2) Upon fire detection the driver shall be notified and appropriate automatic actions shall be initiated to minimize the subsequent risk to passengers and train staff.  
[...].”*

Compliance with EN 45545-6:2013, clause 5.2 and Table 1 gives presumption of conformity with point (1) above.

Compliance with EN 45545-6:2013, clause 5.3, 5.4 (except 5.4.5) gives presumption of conformity with point (2) above.

#### 2.4.78. Clause 4.2.10.3.3: Fire automatic fighting system for freight diesel units

*“(1) This clause is applicable to diesel powered freight locomotives and diesel powered freight self-propelling units.  
(2) These units shall be equipped with an automatic system capable of detecting a diesel fuel fire and of shutting down all relevant equipment and cutting off the fuel supply.”*

This system is intended to mitigate the effects of a diesel fuel fire, not to fight nor extinguish it.

Compliance with EN 45545-6:2013, Table 1, clauses 5.2 and 5.3 gives presumption of conformity for the detection system coupled with the automatic fire fighting system.

Compliance with EN 45545-6:2013, clause 5.4.2.2 and Table 2 gives presumption of conformity for the shutting down of equipment and cutting of fuel supply functions.

#### 2.4.79. Clause 4.2.10.3.4: Fire containment and control systems for passenger rolling stock

*“(4) If other FCCS are used instead of full cross section partitions within passenger/ staff areas, the following requirements shall apply:*

- They shall be installed in each vehicle of the unit, which is intended to carry passengers and/or staff,*
- They shall ensure that fire and smoke will not extend in dangerous concentrations over a length of more than 30m within the passenger/ staff areas inside the unit, for at least 15 minutes after the start of a fire.*

*The assessment of this parameter is an open point.”*

Fire Containment and Control Systems (FCCS) are intended to contain a fire and the resulting smoke inside a limited space for 15 minutes.

Until a European standard is available, national rules notified to cover this open point used to assess FCCS which are not based on full cross section partitions (e.g. water mist systems) may define the assessment method with pass/fail criteria.

This assessment method should be based on the results of a real test with a suitable fire load and it should be possible to test the FCCS regardless the train it will be fitted on.

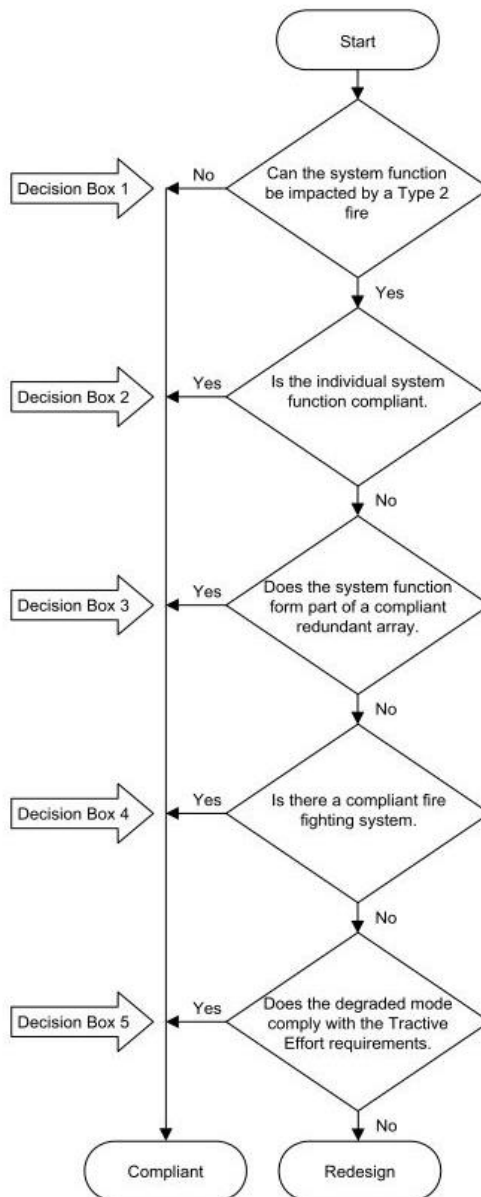
If the system is activated automatically, the assessment method may cover the fire/smoke detection system coupled with the alternative FCCS system.

#### 2.4.80. Clause 4.2.10.4.4: Running capability

*(1) This clause is applicable to category A and category B passenger rolling stock (including passenger locomotives).  
(2) The unit shall be designed so that, in the event of fire on-board, the running capability of the train will enable it to run to a suitable firefighting point.  
(3) Compliance shall be demonstrated by application of the specification referenced in Annex J-1, index 63, in which the system functions impacted by a ‘type 2’ fire shall be:*

- braking for rolling stock of fire safety category A: this function shall be assessed for a duration of 4 minutes.*
- braking and traction for rolling stock of fire safety category B: these functions shall be assessed for a duration of 15 minutes at a minimum speed of 80 km/h.*

The running capability both for traction and braking does not imply full redundancy. Several methods are defined in EN 50553:2012 and EN 50553:2012/AC:2013 to achieve running capability according to flowchart:



Furthermore, The SRT TSI defines in its chapter 2.2 the three risk scenarios covered: hot incidents, cold incidents and prolonged stop. In case of ‘hot’ incident:

*“[...]For rolling stock of category B, the passengers in the affected area will move to a non-affected area of the train where they are protected from fire and fumes*

*Whenever possible the train leaves the tunnel. Passengers are evacuated, directed by the train crew, or by self-rescue, to a safe area in the open air.*

*If appropriate, the train may stop at a fire fighting point inside the tunnel. Passengers are evacuated, directed by the train crew, or by self-rescue, to a safe area.*

*If a fire extinguishing system can extinguish the fire, the incident will become a ‘cold’ incident.[...]”*

This is consistent with the requirements of the EN 50553, which clarifies in its introductory part that compliance with running capability requirements for any relevant system function is derived from one or more of the following:

- Absence of relevant fire
- Assuring system function under fire
- Assuring system function of a redundant array under fire
- Extinguishing the fire
- Assuring sufficient remaining tractive effort under the fire.

Therefore, for diesel locomotives, if it is proven that in case of fire in the diesel engine, the fuel supply is cut off and the extinguishing system can extinguish the fire according to the test defined in EN 50553, clause 6.5.3.2, the TSI does not impose a running capability of 15 minutes and allows for trains hauled by a single diesel locomotive to be classified as “category B”.

According to EN 50553, the systems that are relevant for running capability are as follows:

- Control & Communication
- Auxiliary equipment
- Fire detection and fighting
- Transformer and inductances
- Diesel fuel and other combustible fluids
- Pantograph and related equipment
- Luggage storage
- Cables
- Technical cabinets
- Vehicle body accessories
- Pneumatic and hydraulic equipment
- Driver protection

This clause is also applicable to passenger trains hauled by a locomotive (diesel or electric).

#### 2.4.81. Clause 4.2.10.5.1: Passenger emergency exits

*(1) This section is applicable to units designed to carry passengers.*

##### **Definitions and clarifications**

*“(2) Through route: route through the train which can be entered and exited from different ends and which permits the movement of passengers and staff, along the longitudinal axis of the train without obstruction. Interior doors on the through route which are intended to be used by passengers in normal service and which can also be opened in case of power failure are considered not to obstruct the movement of passengers and staff.”[...]*

##### **Requirements**

*“(6) Emergency exits shall be provided in sufficient quantity along through route(s) on both sides of the unit; they shall be indicated. They shall be accessible and sufficient in size to allow the release of persons.*

*(7) An emergency exit shall be able to be opened by a passenger from inside the train.*

*(8) All external passenger doors shall be equipped with emergency opening devices allowing them to be used as emergency exits (see clause 4.2.5.5.9).*

*(9) Each vehicle designed to contain up to 40 passengers shall have at least two emergency exits.*

*(10) Each vehicle designed to contain more than 40 passengers shall have at least three emergency exits.*

*(11) Each vehicle intended to carry passengers shall have at least one emergency exit on each vehicle side.”[...]*

Conformity with clause 4.3 (with the exception of 4.3.1.2 and 4.3.4) of EN 45545-4:2013 gives presumption of conformity with points 6 to 11 above.



[...]

*“(12) The number of the doors and their dimensions shall allow the complete evacuation within three minutes by passengers without their baggage. It is permitted to consider that passengers with reduced mobility are to be assisted by other passengers or staff, and that wheelchair users are evacuated without their wheelchair.*

*Verification of this requirement shall be made by a physical test under normal operating conditions.”[...]*

Normal operating conditions means that the physical test shall be carried out in front of an obstacle-free platform for which the vehicle is designed for (height of platform). This physical test shall determine the time to evacuate the train.

The test exercise should be at a sufficient scale to ensure that all equipment and procedures are fully evaluated. A real test of a 'part train' or 'part load' may be sufficient to validate assumptions about detrainment times and the effectiveness of emergency equipment, provided the results can be extrapolated by modelling or analogy to the full train situation.

The number of passengers to be evacuated corresponds at least to the load case 'design mass under normal payload' as defined in clause 4.2.2.10 of the TSI.

The physical test does not provide the total evacuation time needed to evacuate all passengers from the train to area place of final safety. The total evacuation time is divided into the following steps:

1. Detection time: delay required to detect the fire, either by an automatic device or by people
2. Alarm time: delay for the alarm process to be launched and completed
3. Response time: delay for the people to understand the alarm signal, understand its importance, decide to leave their current activity and begin to evacuate
4. Moving of people from the train to the walkway (corresponding to the physical test mentioned above).
5. Travel time: Moving of people from platform to a place of final safety.

The 3 minutes requirement only covers step 4 above. Moreover, in many emergency situations there will be no platform available or the platform height may not be suited to the height of the vehicle doors, thus increasing the time needed in step 4 well above the 3 minutes limit.

#### 2.4.82. Clause 4.2.10.5.2: Driver's cab emergency exits

*“Requirements are specified in clause 4.2.9.1.2.2 of the present TSI.”*

Conformity with clause 4.3.1.2 of EN 45545-4:2013 gives presumption of conformity to the clause above.

#### 2.4.83. Clause 4.2.11.2.2: Exterior cleaning through a washing plant

*“(2) It shall be possible to control the speed of trains that are intended to be cleaned externally through a washing plant on level track at a value between 2 km/h and 5 km/h. This requirement is aimed at ensuring compatibility with washing plants.”*

A fixed speed value is to be selected as a setpoint by the applicant in the range of 2 to 5 km/h. When verifying the speed control, the applicant should define the tolerance to be applied. In order to grant compatibility with the existing washing plants (not compliant with INF TSI), the user of the vehicle or the applicant may adopt a design allowing several speed setpoints.

The speed setpoint(s) should be recorded in the technical documentation.

#### 2.4.84. Clause 4.2.12: Documentation for operation and maintenance

The TSI does not impose the format (paper, electronic file...) of the documentation to be provided.

#### 2.4.85. Clause 4.2.12.1: General

*“(1) This clause 4.2.12 of the TSI describes the documentation requested in clause 2.4(a) of Annex IV of Directive (EU) 2016/797 (clause titled “Technical file”): “technical characteristics linked to the design including general and detailed drawings with respect to execution, electrical and hydraulic diagrams, control-circuit diagrams, description of data-processing and automatic systems, documentation on operation and maintenance, etc., relevant for the subsystem concerned.”*

*“(2) This documentation, being part of the technical file, is compiled by applicant and has to accompany the EC declaration of verification. It is kept by the applicant throughout the service life of the subsystem.”*

This clause covers the following set of documents:

- Technical documents describing the Rolling Stock and its area of use
- Technical documentation to allow the maintenance of the vehicle
- Technical documentation to allow the operation of the vehicle

#### 2.4.86. Clause 4.2.12.3: Documentation related to Maintenance

*“The following information necessary to undertake maintenance activities on rolling stock shall be provided:*

*(2) The maintenance design justification file: explains how maintenance activities are defined and designed in order to ensure that the rolling stock characteristics will be kept within acceptable limits of use during its lifetime.*

*The maintenance design justification file shall give input data in order to determine the criteria for inspection and the periodicity of maintenance activities.*

*(3) The maintenance description file: explains how maintenance activities are recommended to be performed.”*

The documentation to be provided by the Applicant for the EC declaration of verification should contain the technical elements that are listed in this clause 4.2.12.3 of the TSI.

The Applicant is responsible for gathering this documentation in the technical file (including those that may be defined and provided by its subcontractors).

Note: this documentation is assessed by the NoBo according to the clause 6.2.4 of the TSI: compilation; technical content not assessed.

This documentation is in principle not related to a particular use of the rolling stock (the common use of the RST being defined by its category according to clause 4.1.3 of the TSI, and by its technical characteristics), but it may include hypothesis regarding its use.

This documentation is not required to be the final documentation to be used by the Entity in Charge of Maintenance (ECM), who has to take into account real operating and maintenance conditions in order to issue maintenance procedures or manuals that are directly applied by workers in charge of maintenance. The language to be used for the final documentation should be defined by the user (not in the scope of this TSI). In case the ECM deviates from the technical elements provided, it is under its own responsibility.

#### 2.4.87. Clause 4.2.12.4, 5 and 6: Operating documentation, Lifting diagram and instructions and Rescue related descriptions

This documentation is not required to be the final documentation to be used by the driver, which has to take into account real operating conditions in order to issue operating procedures or manuals that are directly

applied by the driver. The language to be used for the final documentation should be defined by the user (not in the scope of this TSI).

## 2.5. Interoperability constituent(s)

### 2.5.1. Clause 5.3.5: WSP (wheel slide protection system)

*“(1) A brake system of pneumatic type.  
Note: the WSP is not considered as an IC for other types of brake system such as hydraulic, dynamic and mixed braking systems, and this clause does not apply in that case.”*

The concept of Interoperability Constituent (IC) for the WSP system is limited to WSP functions to be used only with a pneumatic brake system, and using dump valves to control the amount of air within the brake cylinder (definition given in EN15595). In other cases (WSP system controlling different braking systems), this concept has not been retained due to the complexity of the functional interfaces between the RST and the WSP system.

### 2.5.2. Clause 5.3.9: Horns

*“(2) A horn shall comply with the requirements concerning the soundings of signals defined in clause 4.2.7.2.1. These requirements shall be assessed at IC level.”*

The sounding of signals (frequencies) do not depend on the integration of the horn on the rolling stock; they are checked only at the level of the IC; the assessment procedure is specified in the clause 6.1.3.6 of the TSI, and includes the verification of both parameters simultaneously (frequencies and sound pressure level) by reference to the clause 6 of EN 15153-2; for the sound pressure level measurement, the horn should be installed on a reference vehicle.

The sound pressure level defined in clause 4.2.7.2.2 has also to be checked at rolling stock level for each application of the IC according to the assessment procedure specified in clause 6.2.3.17, because the integration of the horn may lead to attenuations; however, they should be covered by the allowed range (8 dB).

### 2.5.3. Clause 5.3.10: Pantograph

*“(4) The maximum current at standstill per contact wire of the overhead contact line for DC systems.  
Note: the maximum current at standstill, as defined in clause 4.2.8.2.5, shall be compatible with the value above, considering the characteristics of the overhead contact line (1 or 2 contact wires).”*

The assessment of the maximum current at standstill at the level of the pantograph (considered as IC) is made with 1 contact wire.

The note explains that when the pantograph is integrated in a RST, due to the required current at standstill, the pantograph may limit the area of use of the RST in terms of characteristics of the OCL; for example, the current needed at standstill by the RST may be compatible only with OCLs made of 2 wires in case the pantograph has a “maximum current at standstill per contact wire” lower than the maximum current at standstill draws from the OCL by the RST, but higher when weighted with a factor (between 1 and 2) applied for compatibility with an OCL made of 2 wires.

## 2.6. Conformity assessment and EC verification

### 2.6.1. Clauses 6.1.4 and 6.2.4: Project phases where assessment is required (Appendix H)

*“(1) It is detailed in Appendix H of this TSI in which phases of the project an assessment shall be done:*

- *Design and development phase:*
  - *Design review and/or design examination.*
  - *Type test: test to verify the design, if and as defined in the Section 4.2.*
- *Production phase: routine test to verify the conformity of production. The entity in charge of the assessment of the routine tests is determined according to the assessment module chosen.”*

The table given in Annex H gives an overview of the assessment to be performed in the different phases of development and production, both for interoperability constituents and rolling stock subsystem in the scope of this TSI. This table is not to be used as a stand-alone document; it is intended to be used with consideration of the requirements expressed in the section 4.2 and chapter 6 of the TSI, which sometimes specify different requirements for different types of RST.

For example, the following is not repeated in Annex H, but is applicable:

- requirements of the clause 4.2.8.2 “Power supply” apply only to electric units,
- requirements of the clause 4.2.9 “Driver’s cab” do not apply if the RST is not fitted with a driver’s cab,
- section 4.2 allows for exemption of tests in particular cases (for “strength of vehicle structure”, “rolling stock dynamic behaviour” ...),
- certain types of RST are exempted of some of the requirements (for example OTMs are exempted of “passive safety” requirements).

Regarding the routine tests, their detailed content is not defined in the TSI; the Annex H mentions only the clauses where a routine test is to be performed, without prejudice to the conformity assessment procedures (modules) chosen by the Applicant; for modules based on quality management system of the production process, the Applicant is responsible for the definition of routine tests.

### 2.6.2. Clause 6.2.3.5: Conformity assessment for safety requirements

*“(3) (...)*

**1.** *Application of a harmonized risk acceptance criterion associated to the severity level specified in the clause 4.2 (e.g. “fatalities” for emergency braking)*

*The applicant may choose to use this method, provided that there is an available harmonized risk acceptance criterion defined in the CSM on Risk Assessment and its amendments (Commission Implementing Regulation (EU) No 402/2013)<sup>(1)</sup>.*

*The applicant shall demonstrate compliance with the harmonised criterion by applying Annex I-3 of the CSM on RA. The following principles (and their combinations) may be used for the demonstration: similarity with reference system(s); application of codes of practice; application of an explicit risk estimation (e.g. probabilistic approach).*

*The applicant shall designate the body for the assessment of the demonstration he will provide: the notified body selected for the RST sub-system or an assessment body as defined in the CSM on RA.*

*The demonstration shall be recognized in all Member States; or.*

*“*

The standard EN 50126-1 provides a methodology for safety studies.

The methodology to be used in order to demonstrate the compliance to the safety requirements expressed in the TSI may be the following:

- perform a safety analysis at the highest level of the system, with the use of adequate tools such as fault tree analysis, failure mode effects and criticality analysis, in order to identify critical parts or components of the system.
- identify the parts or components of the system for which the notion of 'reference system' or 'code of practice' is adequate to justify their reliability and safety performance.
- demonstrate for other parts or components of the system (if any) that their reliability and safety performance allow fulfilling the TSI requirement at system level.

As an example for the braking system, based on the return of experience available among manufacturers of braking systems and of RST, among RUs and among NSAs, some elements of the braking system which have been widely used may be considered as 'reference system', and some standards as 'code of practice' within the limit of their scope.

The national rules used before the entry into application of this TSI may also be considered as code of practice (provided that they satisfy the requirements of the CSM).

Reliability data related to components used in the braking system may also be determined from this return of experience.

In case of rolling stock fitted with braking systems based on the UIC technology, the integration of these brake systems may require some changes in the way they are controlled and commanded; this aspect has to be evaluated carefully not to hinder the safety performance of the complete brake system.

### 2.6.3. Clause 6.2.7: Assessment of units intended to be used in general operation

*“(1) Where a new, upgraded or renewed unit to be used in general operation is subject to assessment against this TSI (in accordance with clause 4.1.2), some of the TSI requirements require a reference train for their assessment. This is mentioned in the relevant provisions of Section 4.2. Similarly, some of the TSI requirements at train level cannot be assessed at unit level; such cases are described for the relevant requirements in Section 4.2 of this TSI.  
(2) The area of use in terms of type of RST which, coupled with the unit to be assessed, ensures that the train is compliant with the TSI is not verified by the Notified Body.  
(3) After such a unit has received the authorisation to be placed in service, its use in a train formation (whether TSI compliant or not) shall be dealt with under the responsibility of the Railway Undertaking, according to the rules defined in clause 4.2.2.5 of the OPE TSI (train composition)”*

A unit intended for 'General operation' is defined in point 2.2.1 (h) of this TSI as “a unit [...] intended to be coupled with other unit(s) in a train formation which is not defined at design stage.”.

As the train formation is not defined when the unit for general operation is being authorised, some TSI requirements are either not fully assessed, or assessed for a 'reference train'.

The use of such unit in a train formation (composed by TSI compliant units or not) is under the responsibility of the railway undertaking, according to the following clause of the OPE TSI:

#### *“4.2.2.5. Train composition*

*The railway undertaking must define the rules and procedures to be followed by his staff so as to ensure that the train is in compliance with the allocated path.*

*Train composition requirements must take into account the following elements:*

*[...]*

(c) the train

— the combination of vehicles forming a train must comply with the technical constraints of the route concerned and be within the maximum length permissible for forwarding and receiving terminals;

(d) the railway undertaking is responsible for ensuring that the train is technically fit for the journey to be undertaken and remains so throughout the journey;

[...].”

For example, the ‘door-traction interlock’ requirements are set out in clause 4.2.5.5.7 of the LOC&PAS TSI for all RST. On top of these requirements, clause 4.2.5.5.10 applies for units intended for general operation:

“(1) Only functionalities that are relevant to the design characteristics of the unit (e.g. presence of a cab, of a crew interface system for door control, etc.) shall be considered.

(2) The signals transmission required between the unit and the other coupled unit(s) in a train for the door system to be available at train level shall be implemented and documented, taking into account functional aspects.

(3) This TSI does not impose any technical solution regarding physical interfaces between units.”

Therefore, if the passenger locomotive or a passenger coach is operated in a train where all the units have compatible signal transmission, the door-traction interlock system works. Otherwise, it is up to the railway undertaking to define how to manage the situation in accordance with clause 4.2.2.5 of the OPE TSI and its safety management system.

#### 2.6.4. 6.2.7a Additional optional requirements for units intended to be used in general operation

“Compliance with these provisions does not assure full interchangeability of units and does not exempt the railway undertaking of its responsibilities regarding the use of these units in a train formation as defined in clause 6.2.7. If the applicant selects this option, a notified body has to assess the compliance within the EC verification procedure. This shall be reported in the certificate and in the technical documentation.”

The general provisions set out in clause 6.2.7 also applies for vehicles fulfilling the optional clause 6.2.7a and the guidance provided in clause 2.6.3 above is also applicable.

Examples of further requirements to fulfil the clause 4.2.2.5 of OPE TSI not covered by clause 6.2.7a are the signal transmissions for:

- passenger alarm (including emergency brake overriding system)
- opening/closure of passenger doors
- passenger information system.

## 2.7. Implementation

### 2.7.1. Clause 7.1.1.2.1: Application of the TSI during transition phase

*“(3) The application of this TSI to rolling stock which falls under one of the three cases above is not mandatory if one of the following conditions is met:*

- *In case the rolling stock is in the scope of the HS RST TSI 2008 or of the CR LOC&PAS TSI 2011, the relevant TSI(s), including implementation rules and period of validity of the “type or design examination certificate” (7 years) are applied. This provision shall not apply to vehicles that are not conform to the HS RST TSI 2008 or to the CR LOC&PAS TSI 2011 and that are placed on the market after 31 May 2017*
- *In case the rolling stock is in the scope of neither the HS RST TSI 2008 nor the CR LOC&PAS TSI 2011: the authorisation for placing in service is delivered during a transition period ending on 31 December 2020.*

*(4) During the transition phase, if the applicant chooses not to apply this TSI, it is reminded that the other TSIs and/or notified national rules apply according to their respective scopes and implementation rules for the authorization to place on the market in accordance with Article 21 of Directive (EU) 2016/797’*

*In particular, TSIs to be repealed by this TSI continue to apply, under the conditions stated in Article 11.”*

The transition phase is only applicable to the present TSI; it is not relevant for other TSIs (Commission decisions or regulations) which are in force; these other TSIs shall apply according to their own implementation rules.

The transition phase for this revised merged TSI is a continuation of the transition phases already defined and agreed in the previous TSIs.

Rolling stock is in the scope of the previous TSIs when these TSIs would be applicable to it; this does not mean that the previous TSI was effectively applied.

In case the rolling stock is in the scope of the previous RST TSIs at the date of application of this TSI, it is allowed to assess it by reference to a valid type examination certificate; see also article 9 of the regulation TSI LOC&PAS. When the type examination certificate has to be reviewed, the latest TSI in force (i.e. the present one) shall apply.

A table explaining the transition periods is given below:

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Timeline	01/06/2011	01/01/2015	01/06/2017	31/05/2018	16/06/2019	31/12/2020	31/12/2021	31/12/2028
Applicability of L&P 2011	EIF L&P 2011		End of transition					
Applicability of L&P 2014			EIF L&P 2014		End of transition (off-TEN only)			
Applicability of L&P 2014 rev 2019					EIF L&P 2014 rev 2019			
<i>RST characteristics</i>	<i>Applicable legislation depending on RST characteristics and date of placing on the market</i>							
Rolling Stock operated on the TEN network and not compliant to TSIs (Case 2 in L&P TSI)	NRs Non-application of L&P 2014 and L&P 2011 - until end of transition L&P 2011 (L&P 2014, Section 7.1.1.2.1 (3) + L&P 2011, Art. 2(2) and section 7.1.1.2)			<b>NOT AUTHORISED or</b> <i>Apply art 7 of IOD 2016/297</i>				
Rolling Stock operated exclusively on the off-TEN network (Case 3 in L&P TSI)	NRs Out of scope of L&P 2011 or HS 2008, non-application of L&P 2014 - until EIF L&P 2014 + 6 years (L&P 2014, Section 7.1.1.2.1 (3) <sup>2nd§</sup> )			<b>NOT AUTHORISED or</b> <i>Apply art 7 of IOD 2016/297</i>				
Rolling Stock operated on the TEN and/or HS network and compliant to HS TSI 2008 and/or L&P TSI 2011 (Case 1 in L&P TSI)				<i>Theoretical range of time for the end of validity of type certificates</i>  <i>Earliest: Phase B starting 01/06/2011</i> <i>Latest: Phase B starting 01/01/2022 (1/1/2015 + 7 years)</i>				<b>NOT AUTHORISED or</b> <i>Apply art 7 of IOD 2016/297</i>
	L&P 2011 or HS 2008		Non-application of L&P2014 - until max. 7 years phase A + 7 years phase B (L&P 2014, Section 7.1.1.2.1 (3)) <b>EXCEPT</b> specific requirements' transition periods defined in Sections 7.1.1.3 to 7.1.1.7 of L&P 2014					
Rolling Stock compliant to L&P TSI 2014				<i>Theoretical range of time for the end of validity of certificates</i>  <i>Earliest: Phase B starting 01/01/2015</i> <i>Latest: Phase B starting 16/06/2026</i>				<b>NOT AUTHORISED or</b> <i>Apply art 7 of IOD 2016/297</i>
			L&P 2014		Non-application of rev 2019 - until max. 7 years phase A + 7 years phase B + limitation to 31/12/2028 (Art. 11(3) L&P 2014 rev 2019) <b>EXCEPT</b> specific requirements' transition periods defined in Sections 7.1.1.4 to 7.1.1.8 of L&P 2014 rev 2019			
Rolling Stock compliant to L&P TSI 2014 rev 2019					L&P 2014 rev 2019			



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work better for society.

#### 2.7.2. Clause 7.1.1.2.4: Definition of Rolling Stock of an existing design

*“(3) For modifications to an existing design, the following rules apply until 31 May 2017:*

- In case of design modifications strictly limited to those necessary to ensure the technical compatibility of the rolling stock with fixed installations (corresponding to interfaces with infrastructure, energy, or control-command and signalling subsystems), the application of this TSI is not mandatory.*
- In case of other design modifications, the present clause related to “existing design” does not apply.”*

This clause is intended to allow for modifications within a type family that represent improvements which increase interoperability, e.g. to make a locomotive of an existing design compatible with an additional power supply system, or with an additional signalling system. The ending date corresponds to the end of the transition period of the CR LOC&PAS TSI, in which there is a similar clause.

#### 2.7.3. Clause 7.1.1.3: Application to special vehicles, such as on-track machines

*“(1) The application of this TSI to mobile railway infrastructure construction and maintenance equipment (as defined in Sections 2.2 and 2.3) is not mandatory.”*

This clause applies to vehicles listed in section 2.2: OTMs and Infrastructure inspection vehicles. When the TSI is applied, OTMs are subject to requirements specific to them (e.g. annex C of the TSI), and infrastructure inspection vehicles are subject to the same requirement as any vehicle in the scope of the TSI.

#### 2.7.4. Clause 7.1.2 Changes to an existing rolling stock or rolling stock type, clause 7.1.2.1 Introduction

*“(2) [...] The holder of the vehicle type authorisation shall provide, under reasonable conditions, the information necessary for assessing the changes to the entity managing the change.*

Each entity managing the change needs to ensure, that all relevant information for the intended changes are available before changing any existing rolling stock. If the holder of the type authorisation is not the same as the entity managing the change, the entity managing the change should request the holder of type authorisation all necessary information to perform the change. Contractual arrangements may be needed between the holder of the vehicle type and entity managing the change to facilitate the information needed.

Other possibilities (e.g. that the holder of type authorisation performs the change) are analysed in the guidance to Article 15 of Implementing regulation (EU) 2018/545.

Implementing regulation (EU) 2018/545 requires in case of changes of authorised vehicles that the changes shall be categorised according to its Article 15 (1). Even for the small changes it has to be checked if there is a “deviation from the technical files accompanying the EC declarations for verification for the subsystems”, see Article 15(1)(a) and (b). Therefore, each entity managing the change needs this technical file or all documents related to the change.

‘(12) In any case, the entity managing the change shall ensure that the technical documentation which is relating to the EC type or design examination certificate is updated accordingly.

Further explanation is provided in the Guidance for the application of Regulation 2018/545.

#### 2.7.5 Clause 7.1.2.2 Rules to manage changes in both rolling stock and rolling stock type

*‘(8) The safety judgement mandated in Article 21(12)(b) of Directive (EU) 2016/797 shall cover changes concerning basic parameters of the table of section 3.1, related to all the essential requirements, in particular the requirements “Safety” and “Technical compatibility”.’*

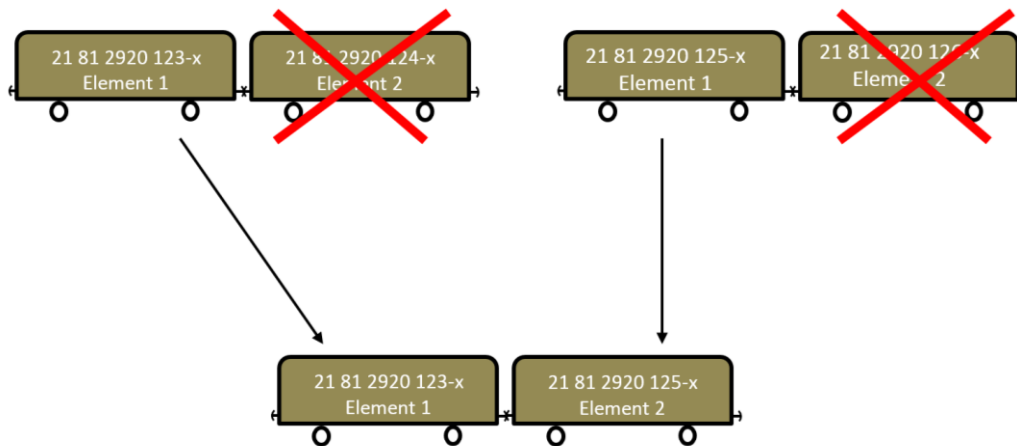
The general safety judgement mandated in Article 21(12)(b) of Directive (EU) 2016/797 should cover all aspects related to the change. Article 13 of the Commission Implementing Regulation (EU) 2018/545 further explains how the essential requirements ‘safety’ and ‘technical compatibility’ impacted by the change are to be dealt with.

*‘(10) The replacement of a whole unit or (a) vehicle(s) within a unit (e.g. a replacement after a severe damage; see also clause 6.2.9) does not require a conformity assessment against this TSI, as long as the unit or the vehicle(s) are identical to the ones they replace. Such units must be traceable and certified in accordance with any national or international rule, or any code of practice widely acknowledged in the railway domain.’*

An example of the paragraph above may be two units each consisting of two vehicles which need to be reconfigured, e.g. due to an accident (see figure below).

In this case, it may be possible to form a new unit from two vehicles of the different units and retain the vehicles’ European Vehicle Numbers (EVNs) without requiring new authorisation.

The maintenance schedule of the resulting unit should be redefined.



### 3. APPLICABLE SPECIFICATIONS AND STANDARDS

#### 3.1. Explanation of the use of the specifications and standards

Standards of voluntary use which have been identified during the drafting process of the TSI are listed in the Annex 1, column “Voluntary ref to clause(s) of Standard N°”; as far as possible, the clause of the standard which is relevant for the conformity assessment of the TSI requirement should be identified. In addition, the column “Voluntary ref – Purpose” should give a written explanation regarding the purpose of the reference to the standard.

Where relevant, an additional explanation is given in the chapter 2 above.

The Annex 1 is to be completed after review with Standardisation Bodies, and on a regular basis, in order to take into account new or revised harmonised standards.

For consistency, the Annex 1 should be read with consideration of the Appendix J-1 of the TSI, titled “Standards or normative documents referred to in this TSI”, which lists “Mandatory ref to clause(s) of Standard”; both annexes have the same structure. Standards listed in the Appendix J-1 of the TSI are not always repeated in the Annex 1 of this application guide, even if additional clauses to those identified as mandatory may be used on a voluntary basis.

## Annex 1 List of standards

TSI		Standard		
Characteristics to be assessed		Voluntary ref to clause(s) of Standard N°	Purpose of the Voluntary ref	To be drafted
Element of the Rolling Stock sub-system	Clause			
Safety aspects	4.2.1.3	EN 50126-1:2017, EN 50128:2011, relevant clauses,  EN 50657:2017 (relevant clauses)		
Structure and mechanical parts	4.2.2			
Inner coupling		EN15566:2016, relevant clauses	Draw gear and screw coupling - Product definition and verification	
	4.2.2.2.2	EN15551:2017, relevant clauses	Buffers - Product definition and verification	
Gangways	4.2.2.3	EN 16286-1:2013 cl. 7.4, 7.9, 9.2 and 9.3		
Strength of vehicle structure	4.2.2.4	EN15085-5:2007 table 1	For verification of metallic joints.	
Passive safety	4.2.2.5		For heavy haul locomotives with centre coupler	RFS 042

TSI		Standard		To be drafted
Characteristics to be assessed		Voluntary ref to clause(s) of Standard N°	Purpose of the Voluntary ref	
Element of the Rolling Stock sub-system	Clause			
Mechanical characteristics of glass (other than windscreens)	4.2.2.9	E-ECE 324/Rev.1/Add. 42/Rev.3, of August 2012 Regulation 43. Emergency glasses: Annex A3 (clauses 9.2 and 9.3) and Annex A5 (clauses 2 and 3.1).  Non-emergency glasses: Annex A3 (clauses 9.2 and 9.3), Annex A5 (clauses 2 and 3.1), Annex A6 (clause 4.2) and Annex K.  EN ISO 12543:2011 Parts 1 – 6.  EN 12150-Parts 1 & 2 :2015/2004		
<b>Track interaction and gauging</b>	<b>4.2.3</b>			
Gauging	4.2.3.1	EN 15273-2:2013	For definition of “intermediate gauges”.  For tilting trains running with $l_p > l_c$ , the pantograph gauge verification. (clause A.3.13)	
		EN 15273 - 1 :2013, Annex I	For widening the rolling stock as a function of the possibilities offered by the infrastructure due to tolerances.	
Axle load parameter	4.2.3.2.1	EN 15528:2008	For categorisation of RST according to line category.	RFS 033

TSI		Standard		To be drafted
Characteristics to be assessed		Voluntary ref to clause(s) of Standard N°	Purpose of the Voluntary ref	
Element of the Rolling Stock sub-system	Clause			
Wheel load	4.2.3.2.2			
Axle bearing condition monitoring	4.2.3.3.2	EN 15437-1:2009 EN 15437-2:2012	Track side system On-board system (open point)	
Safety against derailment running on twisted track	4.2.3.4.1			
Running dynamic behaviour	4.2.3.4.2			
Equivalent conicity	4.2.3.4.3			
Design values for new wheel profiles	4.2.3.4.3.1			
In-service values of wheelset equivalent conicity	4.2.3.4.3.2			

TSI		Standard		To be drafted
Characteristics to be assessed		Voluntary ref to clause(s) of Standard N°	Purpose of the Voluntary ref	
Element of the Rolling Stock sub-system	Clause			
Mechanical and geometrical characteristics of wheelsets - axles  - assembly	4.2.3.5.2.1	EN 13261:2009+A1:2010	Relevant clauses for product verification	
		EN 12080:2007+A1:2010 EN 12081:2007+A1:2010 EN 12082:2007+A1:2010 EN15313:2010	Relevant clauses for in service wheelset parameters	
		EN 13103:2009+A1:2010+A2:2012	Relevant clauses for calculation for verification (Non-powered axles)	
		EN 13104:2009+A1:2010	Relevant clauses for calculation for verification (Powered axles)	
Mechanical and geometrical characteristics of wheels	4.2.3.5.2.2	EN 13262:2004+A2:2012	Product design verification	

TSI		Standard		To be drafted
Characteristics to be assessed		Voluntary ref to clause(s) of Standard N°	Purpose of the Voluntary ref	
Element of the Rolling Stock sub-system	Clause			
Automatic variable gauge systems	4.2.3.5.2.3 6.1.3.1b	EN 15827:2011  EN 17069-1:2019	The methodology for the validation of bogie and running gear can be used for some aspects of the validation of the variable gauge systems.  The validation plan defined in the EN 17069-1:2019 could be used as a “code of practice” in order to perform the safety analysis resulting in the definition of the validation plan. The area and conditions of use of this validation plan should be taken into account.	
Minimum curve radius	4.2.3.6			
Life guards	4.2.3.7			
<b>Braking</b>	<b>4.2.4</b>			
Functional requirements	4.2.4.2.1			
Safety requirements	4.2.4.2.2	EN 50126-1:2017	Demonstration of safety requirements	
Type of brake system	4.2.4.3	EN 14198:2004 EN 15179:2007	Design principle of brake system	
		EN15355:2008 EN15611:2008 EN 15612:2008 EN 15625:2008	Definition and verification of brake component of UIC brake system	
Emergency braking	4.2.4.4.1			
Service braking	4.2.4.4.2			
Direct braking command	4.2.4.4.3			
Dynamic braking command	4.2.4.4.4			
Parking braking command	4.2.4.4.5			
Braking performance	4.2.4.5.1			



TSI		Standard		To be drafted
Characteristics to be assessed		Voluntary ref to clause(s) of Standard N°	Purpose of the Voluntary ref	
Element of the Rolling Stock sub-system	Clause			
Calculation		UIC 544-1:Oct 2004	Additional guidance to EN 14531-1 & 6	
Braking test		UIC 544-1:Oct 2004	Test methodology	RFS 002
Emergency braking	4.2.4.5.2			
Service braking	4.2.4.5.3			
Calculations related to thermal capacity	4.2.4.5.4			
Parking brake	4.2.4.5.5			
Limit of wheel rail adhesion profile	4.2.4.6.1			
Wheel slide protection system	4.2.4.6.2	EN 15595:2009	Specific clause applicable to coaches.	
Dynamic brake - Braking systems linked to traction system	4.2.4.7			
Braking system independant of adhesion conditions	4.2.4.8			
General	4.2.4.8.1			
Magnetic track brake	4.2.4.8.2.			
Eddy current track brake	4.2.4.8.3			
Brake state and fault indication	4.2.4.9	EN 15220-1:2008	Product verification for brake indicators.	
Brake requirements for rescue purposes	4.2.4.10	EN 15807:2011	Half coupling definition and verification	
<b>Passenger related items</b>	<b>4.2.5</b>			
Passenger alarm: functional requirements	4.2.5.3	EN 16334:2014, relevant clauses	Requirement for standard to CEN covering last developments, and interface with braking/braking override	
Passenger alarm: criteria for a train departing from a platform	4.2.5.3.4	EN 16334:2014, clause 6.5	Criteria to detect that a train has left the platform	

TSI		Standard		
Characteristics to be assessed		Voluntary ref to clause(s) of Standard N°	Purpose of the Voluntary ref	To be drafted
Element of the Rolling Stock sub-system	Clause			
Passenger alarm: safety requirements	4.2.5.3.5	EN 16334:2014, clause 8		
Communication devices for passengers	4.2.5.4	EN 16683:2015, clause 5		
Exterior doors: access to and egress from Rolling Stock	4.2.5.5	EN 14752:2015	Design of doors	
Exterior door system construction	4.2.5.6	EN 14752:2015	Design of doors	
Internal air quality	4.2.5.8	EN 13129-1:2002, cl. 6.7.1, Annex F	Fresh air volume providing presumption of conformity to TSI.	
		EN 13129-2:2004 cl 5.1.2 and 9.5	Measurement method of fresh air volume	
<b>Environmental conditions and aerodynamic effects</b>	<b>4.2.6</b>			
Environmental conditions	4.2.6.1	EN 50125-1:2014  clause 4 and 5 of CEN/TR 16251:2016	Guidance for environmental parameters not specified in the TSI  Design and test of RST for severe conditions	RFS 007
Cross wind	4.2.6.2.4	EN14067-6:2009	Guidance for aspects not specified in the TSI	
<b>Traction and electrical equipment</b>	<b>4.2.8</b>			
Contact strip material	4.2.8.2.9.4.2	EN 50405:2006	For material of contact strips	RFS 024
Insulation of pantograph from the vehicle	4.2.8.2.9.9	EN 50163:2004 EN 50124-1:2001	Design rules	
<b>Cab and operation</b>	<b>4.2.9</b>			

TSI		Standard		
Characteristics to be assessed		Voluntary ref to clause(s) of Standard N°	Purpose of the Voluntary ref	To be drafted
Element of the Rolling Stock sub-system	Clause			
Access and egress in operating conditions	4.2.9.1.2.1 (1) and (3)	EN 16116-1:2013  Clause 7.1, 7.2 and 7.3		
Driver's cab emergency exit	4.2.9.1.2.2	EN15227:2008, cl. 6.3	TSI requirement verification	
Front visibility	4.2.9.1.3.1	EN 16186-1:2014  cl. 5.2.2.  EN 14033-1:2011  cl. 14.6		RFS 006
Interior layout	4.2.9.1.4			RFS 006
Driver's seat	4.2.9.1.5	UIC 651 of July 2002, clause 5.1 (except clause 5.1.4)	This UIC leaflet provide detailed guidance on the driver's seat design	
Climate control and air quality	4.2.9.1.7	EN 14813-1:2006+A1:2010 cl9.5 EN 14813-2:2006+A1:2010 cl6.2 UIC 651 cl 2.9.3	Air velocity (around head of driver)	
Internal lighting	4.2.9.1.8	EN 13272:2012 cl 6	Measurement of luminosity	
Driver display unit and screens	4.2.9.3.3	UIC 612 family	Relevant sections for design rules	RFS 023 RFS 022
Controls and indicators	4.2.9.3.4	UIC 612 family	Relevant sections for design rules	RFS 022
Labelling	4.2.9.3.5	UIC 612-0 Appendix H, UIC 612-01 Appendix A, UIC 612-03 clause 3.2  ISO 3864-1:2011	The UIC leaflets provide detailed requirements for marking controls and indicators in the cab  The ISO 3864-1 provides general guidance on safety colours and safety signs.	

TSI		Standard		
Characteristics to be assessed		Voluntary ref to clause(s) of Standard N°	Purpose of the Voluntary ref	To be drafted
Element of the Rolling Stock sub-system	Clause			
Remote control function	4.2.9.3.6	EN 50239:1999/AC :2012	Design and assessment, including safety aspects	
<b>Fire safety and evacuation</b>	<b>4.2.10</b>			
Specific measures for flammable liquids	4.2.10.2.2	EN 45545-7:2013	Only prevention of leakage of flammable liquids	
Portable fire extinguishers	4.2.10.3.1	EN 45545-6:2013 cl 6.3	Portable fire extinguisher requirements and situation in the vehicle	
Fire detection systems	4.2.10.3.2	EN 45545-6:2013 Table 1 and 2, cl. 5.2, 5.3 and 5.4 (excluding 5.4.5)	Requirements for Fire detection systems and automatic actions.	
Automatic fire fighting system for freight diesel units	4.2.10.3.3	EN 45545-6:2013 Table 1, and 2, cl. 5.2, 5.3 and 5.4.2.2	Requirements for diesel fire detection system and cutting of fuel supply + shutting down equipment actions.	
Fire containment and control systems for passenger rolling stock	4.2.10.3.4			RFS 045
Passenger emergency exits	4.2.10.5.1	EN 45545-4:2013 cl. 4.3 (excluding 4.3.1.2 and 4.3.4)	Requirements for passenger emergency exits	
Driver's cab emergency exits	4.2.10.5.2	EN 45545-4:2013 cl. 4.3.1.2	Requirements for driver's cab emergency exits	
<b>Servicing</b>	<b>4.2.11</b>			
Cleaning of driver's cab windscreen	4.2.11.2.1			
Exterior cleaning through a washing plant	4.2.11.2.2			
Connection to toilet discharge system	4.2.11.3			
Water refilling equipment	4.2.11.4			RFS 014
Interface for water refilling	4.2.11.5			RFS 014

TSI		Standard		To be drafted
Characteristics to be assessed		Voluntary ref to clause(s) of Standard N°	Purpose of the Voluntary ref	
Element of the Rolling Stock sub-system	Clause			
Special requirements for stabling of trains	4.2.11.6			
Refuelling equipment	4.2.11.7	EN 16507:2014	Guidance to interface	
<b>Documentation for operation and maintenance</b>	<b>4.2.12</b>			
General	4.2.12.1			
General documentation	4.2.12.2			
Documentation related to maintenance	4.2.12.3			
Operating documentation	4.2.12.4			
Lifting diagram and instructions	4.2.12.5			
Rescue related descriptions	4.2.12.6			

## Annex 2: Table of speed conversions for UK and Ireland

<b>INS, RST and ENE speed conversions</b>	
<b>km/h</b>	<b>Mph</b>
2	1
3	1
5	3
10	5
15	10
20	10
30	20
40	25
50	30
60	40
80	50
100	60
120	75
140	90
150	95
160	100
170	105
180	110
190	120
200	125
220	135
225	140
230	145
250	155
280	175
300	190
320	200
350	220
360	225