

Moving Europe towards a sustainable and safe railway system without frontiers.

Guide for the application of the INF TSI

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

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This guide does not contain any legally binding advice. It may serve as a clarification tool without however dictating in any manner compulsory procedures to be followed and without establishing any legally binding practice. The guide provides explanations on the provisions contained in the TSIs and should be helpful for understanding the approaches and rules described therein. However, it does not substitute for them.

The guide is publicly available and it will be regularly updated to reflect progress with European standards and changes to the TSIs.

The reader should refer to the website of the European Union Agency for Railways for information about its latest available edition.

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1. SCOPE OF THIS GUIDE

1.1. Scope

This document is an annex to the Guide for the application of TSIs. It provides information on the application of the Technical Specification for Interoperability for the 'Infrastructure' subsystem adopted by Commission Regulation EU/1299/2014 of 18 November 2014 and amended by the Commission Implementing Regulations (EU) 2019/776 and (EU) 2023/1694 of 10 August 2023 (from now on referred as INF TSI).

The guide should be read and used only in conjunction with the INF TSI. It is intended to facilitate its application but does not replace it.

The general part of the 'Guide for the application of TSIs' should also be considered.

1.2. Content of the guide

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

Guidance is not provided for sections in which the original INF TSI requires no further explanation.

The guidance is for voluntary application. It does not mandate any requirement in addition to those set out in the INF TSI.

Guidance is given by means of further explanatory text and, where relevant, by reference to standards that demonstrate compliance with the INF TSI.

A list of standards referred to in this Application Guide is enclosed in Appendix 1.

1.3. Reference documents

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

1.4. Definitions, abbreviations and acronyms

Definitions and abbreviations are given in the general part of the 'Guide for the application of TSIs'. Here below is a list of acronyms used in this document:

CEN	European Committee for Standardization
EU	European Union
HS RST TSI	High Speed Rolling Stock TSI
HSLM	High Speed Load Model
IAL	Immediate Action Limits
IC	Interoperability Constituents
IM	Infrastructure Manager

INF TSI	Infrastructure TSI
MS	Member State
NoBo	Notified Body
PRM TSI	Person with Reduced Mobility TSI
QC	Quality Control
RU	Railway Undertaking
SRT TSI	Safety in Railway Tunnel TSI
TEN	Trans European Network
TSI	Technical Specification for Interoperability

2. CLARIFICATIONS ON THE INF TSI

General remarks

For all the requirements laid down for new lines, it is understood that these requirements are optional when upgrading or renewing existing lines. It is expected that, while preparing the project for the upgrade/renewal of an existing line, the fulfilment of such requirements will be considered when technically and economically possible.

2.1. Introduction (Section 1)

2.1.1. Geographical scope (Point 1.2)

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

Article 2(4) of the (INF TSI) quotes:

The TSI shall apply to the network of the Union rail system as described in Annex I of Directive (EU) 2016/797 with the exclusion of cases referred to in Article 1(3) and (4) of Directive (EU) 2016/797.

2.1.2. Content of this TSI (Point 1.3)

(2) Requirements in this TSI are valid for all track gauge systems within the scope of this TSI, unless a paragraph refers to specific track gauge systems or to specific nominal track gauges.

The concept of track gauge system has been set out in order to give rise to technical harmonization within rail systems with the same nominal track gauge (i.e.: 1668 mm, which is shared between Spain and Portugal; 1600 mm, shared between Ireland and United Kingdom; 1524 mm, shared among Finland, Sweden and

Estonia; 1520 mm, shared among Estonia, Latvia, Lithuania, Poland and Slovakia; together with 1435 mm, which is regarded as the European standard nominal track gauge).

Requirements stated in the TSI have to be applied according to the following priority order:

1. General requirements in section 4 of INF TSI to be fulfilled unless covered by a specific requirement of the track gauge system concerned (section 4 of INF TSI), or a specific case of the MS concerned (point 7.7 of INF TSI). For most of the parameters listed in the INF TSI, in general, requirements are valid for all track gauge systems.
2. Specific requirements for the relevant track gauge system (section 4) to be fulfilled unless covered by a specific case of the MS concerned (point 7.7).

All specific requirements referring to a specific track gauge system or a specific nominal track gauge commence with the following wording: "for the XXXX track gauge system...", "*instead of point (x), for the XXXX track gauge system*" and "*instead of point (x), for the nominal track gauge of XXX...*".

An example for a Basic Parameter valid for all track gauge systems is "Track resistance to vertical loads" (Point 4.2.6.1): there is no paragraph within the Point referring to specific track gauge systems.

An example for a Basic Parameter that has different requirements for different track gauge systems is "Structure Gauge" (Point 4.2.3.1): paragraphs (4) and (5) of the Point replace, for the 1520 mm and 1600 track gauge system, respectively, the requirements set by paragraphs (1) to (3) of the same basic parameter.

2.2. Definition and scope of subsystem (Section 2)

2.3 Interfaces of this TSI with the Persons with Reduced Mobility TSI

All requirements relating to the infrastructure subsystem for the access of persons with reduced mobility to the railway system are set out in the Persons with Reduced Mobility TSI.

2.4 Interfaces of this TSI with the Safety in Railway Tunnels TSI

All requirements relating to the infrastructure subsystem for safety in railway tunnels are set out in the Safety in Railway Tunnels TSI.

PRM and SRT TSIs bring additional requirements to the Infrastructure subsystem in addition to those given by the INF TSI itself. Therefore, the verification of the subsystem against INF TSI does not include requirements of those TSIs.

The Infrastructure subsystem has to be assessed against the PRM and/or SRT TSIs when relevant.

2.6. Relation to the codification of Combined Transport

(1) The provisions for structure gauge are laid down in point 4.2.3.1.

(2) The codification system used for the conveyance of intermodal loading units in combined transport shall be in accordance with the specification referenced in Appendix T, index [A]. It can be based on:

- (a) the characteristics of the line and the exact position of the obstacles;*
- (b) the reference profile of the structure gauge of that line;*
- (c) a combination of the methods referred to in points (a) and (b).*

For further guidance on this point, refer to the technical document ERA/TD/2023-01/CCT on codification for combined transport, and to specific application guide.

2.3. Essential requirements (Section3)

The Directive (EU) 2016/797 states essential requirements related to health, safety, reliability, availability, environmental protection, technical compatibility and accessibility. Table 1 of the INF TSI lists the basic parameters of the infrastructure subsystem which are considered to correspond to these requirements.

2.4. Description of the Infrastructure subsystem (Section 4)

2.4.1. Introduction (Point 4.1)

(2) The limiting values set out in this TSI are not intended to be imposed as usual design values. However the design values must be within the limits set out in this TSI.

The TSI defines the basic parameters and the minimum levels to be respected in order to meet the essential requirements. The purpose of the INF TSI is not to be considered as a design guide.

Design and construction of a railway infrastructure should be based on standards, good practices values, etc.

These values shall be within the limits of TSI requirements.

(5) Where reference is made to EN standards, any variations called ‘national deviations’ in the EN do not apply, unless otherwise specified in this TSI.

It is not permitted to apply “national deviations” to an EN standard unless it is specified in TSI. The concept of “National Deviation” means any modification, addition to or deletion from the content of an EN, made in a national standard within the same scope as the EN.

The concept of “National Annex” is different from that of National Deviations: a National Annex may contain only allowed choices for defined “Nationally Determined Parameters (NDP)” and information provided for easier implementation (“Non contradictory Complementary Information (NCCI)”). A National Annex shall not alter any provision of the European Standard except the allowed choices for the “Nationally Determined Parameters (NDP)”.

2.4.2. TSI Categories of Line (Point 4.2.1)

(2) The TSI category of line shall be a combination of traffic codes. For lines where only one type of traffic is carried (for example a freight only line), a single code may be used to describe the performances; where mixed traffic runs the category will be described by one or more codes for passenger and freight. The combined traffic codes describe the envelope within which the desired mix of traffic can be accommodated.

When building the concept of the INF TSI categories of line, the following rules have been applied:

- no differentiation between High Speed and Conventional Railway lines;
- no distinction between lines of TEN and Off-TEN network;
- classification now includes the type of traffic and the value of performance parameter (e.g., ‘P4’);
- no distinction between “new”, “upgraded” and renewed lines;

After analysis of typical traffic modes in Europe, several types of traffic codes were selected, both for Passenger traffic and for Freight traffic. Each TSI category of line can be created using multiple traffic codes given in Table 2 and 3 of the INF TSI, in any combination. This provides a flexible categorization to reflect actual traffic needs.

Example to categorize a line into traffic codes and TSI category of line

If a new line is intended to be operated by passenger trains with a speed of 250 km/h, local trains with a speed of 120 km/h, and heavy freight trains operating at night, then the best combination of traffic codes would be P2, P5 and F1.

Consequently, the TSI category of line for this case would simply be P2-P5-F1.

The line shall be designed in order to fulfil the envelope of performance parameters for this category:

- Structure gauge: GC (from F1),
- Axle load: 22,5 t (from F1),
- Line speed: max. 200 - 250 km/h (from P2),
- Usable length of platform: 200 – 400 m (from P2) and 50 – 200 m (from P5; where only local trains are allowed to stop),
- Train length: 740 – 1050 m (from F1).

The example above was also selected to demonstrate that a combination of traffic codes can be assigned to a line even if the characteristics of such line are not continuously applicable, fulfilling (in all its length) the conditions of the three traffic codes (P2-P5-F1). It is to be noted that in such situation the different type of operations must be restricted to the specific conditions within the line (as for example a specific train station designed for P5 where the P2 type of passenger traffic is not permitted to stop).

Further information and application of the above example to the loading capability requirements for structures according to Traffic Code are described in Appendix 3 of this application guide.

(4) Lines shall be classified based on the type of traffic (traffic code) characterised by the following performance parameters:

- *structure gauge,*
- *axle load,*
- *line speed,*
- *train length*
- *usable length of platform.*

The values in the columns for ‘structure gauge’ and ‘axle load’, which directly affect train running, shall be mandatory minimum levels as per traffic code targeted. Notwithstanding TEN-T requirements, the range of values indicated in the columns for ‘line speed’, ‘usable length of platform’ and ‘train length’ shall be applied, as long as reasonably practicable.

(7) The performance levels for types of traffic are set out in Table 2 and Table 3.

Table 2				
Infrastructure performance parameters for passenger traffic (route compatibility checks are subject to point 4.2.2.5 and Appendix D1 of the OPE TSI)				
Traffic code	Structure gauge	Axle load [t]	Line speed [km/h]	Usable length of platform [m]
P1	GC	17 ⁽¹⁾ / 21.5 ⁽²⁾	250-350	400
P2	GB	20 ⁽¹⁾ / 22.5 ⁽²⁾	200-250	200-400
P3	DE3	22,5 ⁽³⁾	120-200	200-400
P4	GB	22,5 ⁽³⁾	120-200	200-400
P5	GA	20 ⁽³⁾	80-120	50-200
P6	G1	12 ⁽³⁾	n.a.	n.a.
P1520	S	22,5 ⁽³⁾	80-160	35-400
P1600	IRL1	22,5 ⁽³⁾	80-160	75-240

(1) Minimum required values of axle load to be used for checks of bridges using a dynamic appraisal, based on design mass in working order for power heads and locomotives and operational mass under normal payload for vehicles capable of carrying a payload of passengers or luggage (mass definitions in accordance with the specification referenced in Appendix T Index [1]).

(2) Minimum required values of axle load to be used for checks of infrastructure using a static loading, based on design mass under exceptional payload for vehicles capable of carrying a payload of passengers or luggage (mass definitions in accordance with the specification referenced in Appendix T Index [1] with regard of the specification referenced in Appendix T Index [2]). This axle load may be linked to limited speed.

(3) To be used for checks of infrastructure used for static loading, based on design mass in working order for power heads and locomotives and design mass under exceptional payload for other vehicles (mass definitions in accordance with the specification referenced in Appendix T Index [1] with regard of the specification referenced in Appendix T Index [2]). This axle load may be linked to limited speed.

Table 3				
Infrastructure performance parameters for freight traffic (route compatibility checks are subject to point 4.2.2.5 and Appendix D1 of the OPE TSI)				
Traffic code	Structure gauge	Axle load [t]	Line speed [km/h]	Train length [m]
F1	GC	22,5 ⁽¹⁾	100-120	740-1050

F2	GB	22,5 ⁽¹⁾	100-120	600-1050
F3	GA	20 ⁽¹⁾	60-100	500-1050
F4	G1	18 ⁽¹⁾	n.a.	n.a.
F1520	S	25 ⁽¹⁾	50-120	1050
F1600	IRL1	22,5 ⁽¹⁾	50-100	150-450

(1) To be used for static checks of infrastructure, based on design mass in working order for power heads and locomotives and design mass under normal payload for other vehicles (mass definitions in accordance with the specification referenced in Appendix T Index [1]). This axle load may be linked to limited speed.

Note: Tables 2 and 3 are not to be used for compatibility checks between rolling stock and infrastructure

The performance parameters “structure gauge” and “axle load” are considered as “Hard” parameters; it means that it is mandatory to provide at least their precise value. This is the reason why in Table 2 and 3 they are specified as single values.

The performance parameters “line speed”, “usable length of platform” and “train length” are considered as “Soft” parameters; that means that values of these parameters for specific line may be selected from the range/value given in Table 2 and 3. This selection should be made at the beginning of the project.

Some considerations on note (1) of Table 2:

For dynamic checks, the composition of the train is relevant. Trains with axle loads according to the definition under note (1) and complying to the validity limits of HSLM in Annex E of Appendix T index [10] are covered by HSLM defined in 4.2.7.1.2 (2). Load model HSLM is used for dynamic checks of new and existing bridges (Appendix E). The mass definition "operational mass under normal payload" covers the former mass definition for “Class 1” trains, according to the HS RST TSI (Decision 2008/232/CE) in this case.

With this, the dynamic effects of trains being within the limits of validity of HSLM (Annex E of Appendix T index [10]) are covered in the design of new bridges and the assessment of existing bridges with HSLM according to 4.2.7.1.2 (2) and Appendix E.

If trains:

- have a maximum axle load higher than the value as in note (1) of table 2, or
- are outside the limits of validity of HSLM (Annex E of Appendix T index [10])

these “Real Trains” or appropriate dynamic load models are to be used for dynamic calculations according to 4.2.7.1.2 (3) and Appendix E of the INF TSI. In this case, the maximum axle loads of the “Real Train” are determined using the mass definition “design mass under normal payload” according to Appendix K of INF TSI for passenger carrying vehicles.

The dynamic load model HSLM is currently under revision.

Some considerations on notes (1), (2) and (3) of Table 2:

The axle loads according to the definition under notes (2) and (3) of Table 2 of INF TSI indicate the maximum axle load considering full loading due to standing passengers and other payloads. As this is the highest possible axle load, it is also used for the categorisation of a vehicle into a Line Category, for the vehicle reference mass as set out in Appendix T index [1] of INF TSI with as set out in the specification referenced in Appendix T index [2] of INF TSI. The Line Category which in turn is used for assessing the

static loads effects of trains composed of individual vehicles on infrastructure. Axle load in according with the mass definition in the notes (2) and (3) may be linked to a limited speed, see also 4.2.1 (12) of INF TSI.

The axle load values for wagons in Table 3 represent the values according to design mass under normal payload according to Appendix T index [1], which is the maximum payload for freight. The reference mass conditions are also set out according to the type of vehicle in Appendix T index [2]. Axle load in accordance with the mass definition in note (1) may be linked to a limited speed, see also 4.2.1 (12).

Codes P1 to P5 and F1 to F2 are generally intended to be applied to TEN lines. P6 and F4 are intended to be the minimum requirements for Off TEN lines: this does not exclude the possibility to apply any other traffic code for Off TEN Lines.

P1520 and F1520 are specifically for on 1520 mm track gauge systems. P1600 and F1600 are specifically for on 1600 mm track gauge systems.

The performance parameter 'usable length of platform' applies to passenger traffic because this is the main interface between passenger rolling stock and infrastructure (e.g., at a platform): the real train length might be longer or shorter than platform length, the parameter describes only the length to be provided for access of passengers from the platform to the train.

The performance parameter 'train length' applies to freight traffic because the train length determines the minimum length of a siding to be provided.

(8) For structures, axle load by itself is not sufficient to set out the requirements for infrastructure. Requirements are specified as follows:

- for new structures in points 4.2.7.1 and 4.2.7.2,*
- for existing structures in point 4.2.7.4,*
- for track in point 4.2.6.”;*

The technical interface between structures (that carry the vertical loading of trains) and trains is complex. The parameter axle load on its own is not sufficient to define the interface requirements.

For example, the interface is a function of the static loading characteristics of the train and the speed of the train. The static loading characteristics of the train are a function of:

- the maximum axle load for the heaviest axle in the train;
- the maximum axle load of each axle in the train and how this varies throughout the length of the train; and
- the spacing of axles along the length of the train and how this spacing varies along the length of the train.

Depending upon these characteristics, the critical case defining the train/structure interface is for example (and not limited to these examples):

- the maximum axle load for the heaviest axle load in the train for structures or parts of a structure (especially bridges) with very short loaded lengths and/or where local loading effects are critical;
- load effects generated by the axles in a bogie of a vehicle, from the axles in adjacent bogies for structures or parts of a structure (especially bridges) with intermediate loaded lengths;
- load effects that tend towards average values of loading per meter for structures with extremely long loaded lengths; and
- for structures that comprise of parts with different loaded lengths (especially some bridges), a mix of the above are relevant. For example, a truss bridge could have loaded lengths ranging from potentially very short loaded lengths for parts of the floor of the bridge, to intermediate

loaded lengths for cross girders spanning between the main trusses and supporting the floor, to longer intermediate loaded lengths for some of the diagonal members in the truss, to finally loaded lengths equal to the span of the truss for some parts of the truss.

For the design of new bridges this complexity is addressed by setting the vertical loading requirements in terms of Load Model 71 (and additionally Load Model SW/0 for continuous bridge decks and continuous bridge elements). Load Model 71 and Load Model SW/0 are defined by reference to EN1991-2:2003/AC:2010. See the guidance on 4.2.7.

The loading requirements in the TSI INF for structures correspond to the level of the interface between the structural subsystems infrastructure and rolling stock, which is at the top of rail level. For the design of new geotechnical structures including earthworks, EN 1991-2:2003 identifies that the equivalent vertical loading is applied as a distributed load at a level specified below the running surface of the track. EN 1991-2:2003 identifies that the loading can be distributed over the width of a track. [Additional information: It is good practice for the selected calculation model used in the design of new geotechnical structures to consider the nature of the geotechnical structure, its behavior, and the resultant appropriate load distribution onto the geotechnical structure].

For existing structures, this complexity is addressed by setting the vertical loading requirements for existing structures (especially bridges) generally in terms of the EN Line Categories defined in EN15528:2021. See the guidance on 4.2.7.4 and Appendix E.

Where the above vertical loading enhanced by normal (common practice) dynamic factors is not sufficient on its own to define the technical interface between trains and bridges, additional dynamic loading requirements apply. See the guidance on 4.2.7.1.2(2) and Appendix E.

Further guidance may be found in EN15528:2021.

(9) Passenger hubs, freight hubs and connecting lines are included in the above traffic codes, as appropriate.

The requirements of a selected Traffic Code for a line are also valid for the running tracks passing through passenger hubs, freight hubs and connecting lines. Running tracks are those tracks used for the operation of trains.

(12) It is permissible for specific locations on the line to be designed for any or all of the performance parameters line speed, usable length of platform and train length less than those set out in Table 2 and Table 3, where duly justified to meet geographical, urban or environmental constraints.

Geographical, urban or environmental constraints can for example restrict the alignment of a line and the resultant alignment of a line can for example restrict the maximum speed.

The design speed for a line also affects the alignment of main tracks through a station. Any other station track does not need to meet this requirement. If main tracks through a station need to be designed for lower speeds, then this is normally justified by geographical or urban constraints.

Reduced speed in tunnels, aside platforms or bridges are not due to design speed but due to specific operational conditions, and does not necessarily concern all trains in all cases. For example, speed on bridges depends on the EN line category of the vehicles and thus may be different.

The track in main direction of a turnout is normally designed for line speed; the diverging track of switches does not need to comply with this speed. Side modifiers, gauge changeover facilities and other installations of this type may require reduced speed. It should be regarded as a local permanent speed restriction rather than a lower design speed.

2.4.3. Requirements for Basic Parameters (Point 4.2.2.2)

(4) In case of multi-rail track, requirements of this TSI are to be applied separately to each pair of rails designed to be operated as separate track.

The three-rail system is a particular case of a multi-rail track, in which one rail is common for two track gauges.

The assessment need not be applied to both tracks at the same time, and the EC declaration of verification may be issued separately for each track.

This would allow for example in a three-rail system one pair of rails to be assessed as one track with the option to assess the track formed using the third rail at some time in the future (or not subject it to assessment at all).

(6) A short section of track with devices to allow transition between different nominal track gauges is allowed.

Devices mentioned in this Point include equipment for:

- Gauge changeover facilities.
- Equipment for exchange of wheelsets.
- Equipment for exchange of bogies.
- Any other systems allowing transition.

2.4.4. Structure gauge (Point 4.2.3.1)

(1) The upper part of the structure gauge shall be set on the basis of the gauges selected in accordance with point 4.2.1, which are set out in the specification referenced in Appendix T Index [3].

The target is to use the Installation Nominal Gauge in new lines, upgrading and in general, wherever it is possible.

For the design and construction of a new line, if the local situation is such that the installation nominal gauge cannot be cleared (for example because of geographical, urban or environmental constraints), an installation limit gauge may be defined and cleared. In this case, it is necessary to justify the use of the Installation Limit Gauge.

For other cases, such as existing lines, renewals, local improvements, new elements, etc., it is possible either to use the Installation Nominal or the Limit Gauge, although it is advisable to use the Installation Nominal Gauge.

The use of a uniform gauge may permit efficient design and maintenance by IM, and also EC verification by the NoBo, thus avoiding a very time-consuming calculation for any location and any potential obstacle.

The structure gauge used on a certain project is generally the same for other projects. Therefore, it would be useful to have the calculations verified once. These verifications can be performed based on EN 15273-3:2013+A1:2016. The conditions of use, such as the applied gauge (GA, GB, GC and others, e.g., national gauges), minimum radius, maximum cant and cant deficiency, track quality, etc., are to be mentioned in the calculation note. The resulting structure gauge profile that will be used for the verification of the obstacles should clearly mention these points, too.

2.4.5. Distance between track centres (Point 4.2.3.2)

(3) The distance between track centres shall at least satisfy the requirements for the limit installation distance between track centres, defined in accordance with the specification referenced in Appendix T Index [3].

There are exceptional cases for which the limit installation distance between track centres, calculated according to point 9 of EN 15273-3:2013+A1:2016, is greater than the minimum nominal distance between track centres defined in Table 4 and 6 in INF TSI.

Therefore, when deciding the distance between track centres in a double-track railway line, the minimum requirements of Table 4 and 6 shall be fulfilled, as well as the requirements for the limit installation distance between track centres defined in paragraph (3).

For example, in the case of two tracks with a radius of 1900 m, speed equal to 200 km/h and cants of 180 mm and 90 mm, the value of the limit installation distance between track centres obtained for GB structure gauge is 3825 mm, which is higher than the distance between track centres of 3800 mm defined in table 4.

2.4.6. Minimum radius of horizontal curve (Point 4.2.3.4)

(2) Reverse curves, except in marshalling yards where wagons are shunted individually, with small radii for new lines shall be designed to prevent buffer locking.

For straight intermediate track elements between the curves, the specification referenced in Appendix T, index [4] shall apply, whose values are based on the reference vehicles defined in the same specification. To prevent buffer locking for existing vehicles that do not fulfil the assumptions of the reference vehicles, infrastructure manager may specify longer lengths of the straight intermediate element.

For non-straight intermediate track elements, a detailed calculation shall be made in order to check the magnitude of the end throw differences.

When a non-straight intermediate element is used between two curves with opposite curvature, the geometry and length of this element should be defined in such a way that the magnitude of the end-throw difference still prevents buffer locking.

For the case of existing vehicles that do not fulfil the assumptions of the reference vehicles to prevent buffer locking, the infrastructure manager may specify longer lengths of the straight intermediate element. For example, the generic lower limits defined in Table N1 of EN 13803:2017 can be required as lower limits for dedicated freight lines.

2.4.7. Cant deficiency (Point 4.2.4.3)

(1) The maximum values for cant deficiency are set out in Table 8.

Table 8
Maximum cant deficiency [mm]

Design speed [km/h]	$v \leq 160$	$160 < v \leq 300$	$v > 300$
For Operation of rolling stock conforming to the Locomotives and Passenger TSI	153		100
For operation of rolling stock conforming to the Freight Wagons TSI	130	-	-

In the INF TSI, only maximum values of cant deficiency are given. So, for the verification of stability of vehicles on the track using the parameter of uncompensated acceleration, recalculations have to be done in order to be able to compare applied values of uncompensated acceleration with the cant deficiency limits expressed in mm.

The maximum values of cant deficiency set in Table 8 of INF TSI (and in Table 9 of INF TSI for the 1668 mm track gauge system) must be respected in the design/construction of a railway infrastructure line, taking as reference which TSI compliant Rolling Stock is intended to be operated on that specific line.

Rules and requirements for compliance of rolling stocks against TSIs are described in the relevant TSI (LOC&PAS and/or Freight).

(2) It is permissible for trains specifically designed to travel with higher cant deficiency (for example multiple units with axle loads lower than set out in table 2; vehicles with special equipment for the negotiation of curves) to run with higher cant deficiency values, subject to a demonstration that this can be achieved safely.

Rules for the demonstration of safe running of vehicles, relating to running dynamics, are described in the LOC&PAS TSI.

Other verifications may be needed in order to guarantee that the operation of the referred types of rolling stock at speeds above the design speed is safe, such as those regarding structure gauge, distance between track centres, structures resistance to traffic loads, maximum pressure variations in tunnels, crosswinds, ballast pick up, immediate action limits on track geometry defects due to the higher speed attained, etc.

2.4.8. Equivalent concity (Point 4.2.4.5)

(3) Design track gauge, rail head profile and rail inclination for plain line shall be selected to ensure that the equivalent concity limits set out in Table 10 are not exceeded.

The design track gauge to be taken into account when assessing the requirement of "Equivalent Concity" are the values of "design track gauge" as defined in Appendix S "Glossary" of INF TSI.

2.4.9. Rail inclination (Point 4.2.4.7)**4.2.4.7.1 Plain line**

(2) For tracks intended to be operated at speeds greater than 60 km/h, the rail inclination for a given route shall be selected from the range 1/20 to 1/40.

For tracks intended to be operated at speeds up to 60 km/h, the rail inclination could be either vertical or inclined.

(3) For sections of not more than 100 m between switches and crossings without inclination where the running speed is no more than 200 km/h, the laying of rails without inclination is allowed.

4.2.4.7.2 Requirements for switches and crossings

(1) The rail shall be designed to be either vertical or inclined.

(2) If the rail is inclined, the designed inclination shall be selected from the range 1/20 to 1/40.

(3) The inclination can be given by the shape of the active part of the rail head profile

(4) Within switches and crossings where the running speed is more than 200 km/h and no more than 250 km/h, the laying of rails without inclination is allowed provided that it is limited to sections not exceeding 50 m.

(5) For speeds of more than 250 km/h the rails shall be inclined.

The inclination of the rail, either in plain line or in Switches & Crossings, can be chosen within the range from 1/20 to 1/40.

The table below summarizes the different situations for rail inclination as set out in points 4.2.4.7.1 and 4.2.4.7.2.

Rail inclination for plain line and switches and crossings

	Plain line	Switches and Crossings
v ≤ 200 km/h	<i>Inclined*</i> <small>* For sections of not more than 100 m between switches and crossings without inclination where the running speed is no more than 200 km/h, the laying of rails without inclination is allowed.</small>	<i>Vertical or Inclined</i>
200 <v ≤ 250	<i>Inclined</i>	<i>Inclined*</i> <small>* Within switches and crossings where the running speed is more than 200 km/h and no more than 250 km/h, the laying of rails without inclination is allowed provided that it is limited to sections not exceeding 50 m.</small>
v > 250	<i>Inclined</i>	<i>Inclined</i>

2.4.10. Track resistance to applied loads (Point 4.2.6)

4.2.6.1. Track resistance to vertical loads

The track design, including switches and crossings, shall take into account at least the following forces:

- (a) the axle load selected according to point 4.2.1;
- (b) maximum vertical wheel forces. Maximum wheel forces for defined test conditions are set out in the specification referenced in Appendix T, index [9].
- (c) vertical quasi-static wheel forces. Maximum quasi-static wheel forces for defined test conditions are set out in the specification referenced in Appendix T, index [9].

4.2.6.2. Longitudinal track resistance

4.2.6.2.1 Design forces

The track, including switches and crossings, shall be designed to withstand longitudinal forces equivalent to the force arising from braking of 2.5 m/s² for the performance parameters chosen in accordance with point 4.2.1.

4.2.6.2.2 Compatibility with braking systems

- (1) The track, including switches and crossings, shall be designed to be compatible with the use of magnetic braking systems for emergency braking.
- (2) Provisions for the use of eddy current braking systems on track shall be defined at operational level by the infrastructure manager on the basis of the specific characteristics of the track, including switches and crossings. The conditions of use of this braking system are registered in accordance with Commission Implementing Regulation (EU) 2019/777 (RINF).
- (3) For the 1600 mm track gauge system it shall be allowed not to apply point (1).

4.2.6.3. Lateral track resistance

The track design, including switches and crossings, shall take into account at least the following forces:

- (a) lateral forces; Maximum lateral forces exerted by a wheel set on the track for defined test conditions are set out in the specification referenced in Appendix T, index [9];
- (b) quasi-static guiding forces; Maximum quasi-static guiding forces Y_{qst} for defined radii and test conditions are set out in the specification referenced in Appendix T, index [9].

Point 4.2.6 gives guidance to Infrastructure Managers on the loads that the track must be able to withstand. The load values used for calculation of track components and/or track assemblies shall be consistent with point 4.2.6. The reference “at least” in the TSI reflects the fact that the maximum loads to be taken into account while designing the track may depend on planned operation and general strategy of each IM (running of special trains, running of maintenance vehicles, etc.).

2.4.11. Structures resistance to traffic loads (Point 4.2.7)

General guidance related to structures

For requirements related to the load carrying capability of structures, the TSI INF permits choice according to the Traffic Code(s) used to define the TSI Category of Line for a line. Accordingly, the design requirements for the vertical loading capability of new structures and the structures requirements for structures on existing lines ('the future target system') are set out according to Traffic Code.

The Traffic Code is a line parameter. A combination of Traffic Codes defines the TSI Category of Line (see TSI INF point 4.2.1 (2)).

General guidance relating to speed

When the requirements for the design of a new structure (4.2.7.1.2(2), 4.2.7.1.3 and 4.2.7.3) and for existing structures (4.2.7.4 and Appendix E) are a function of speed, then the speed to be taken into account may consider point 4.2.1(12), note (2) and note (3) to Table 2, note (1) to Table 3, and the local allowed speed. The local allowed speed is a function of many elements, including, for example, track geometry and the load carrying capacity of structures.

For the design of new bridges the allowance for the dynamic effects of vertical loads set out in 4.2.7.1.2(1), by reference to the formula for dynamic factor ϕ set out in EN1991-2:2003/AC:2010, is not a function of the speed of rail traffic at a bridge. The formula for the dynamic factor ϕ set out in EN1991-2:2003/AC:2010 utilises a simple format for the design of new bridges.

[Background: in the derivation of the normal formula for the dynamic factor ϕ account was taken of heavy trains (freight), travelling at up to lower maximum speeds, and lighter trains (passenger), travelling at up to higher maximum speeds].

For situations in which EN1991-2:2003/AC:2010 requires additional checks for the design of new bridges on the adequacy of:

- load multiplication factor α x dynamic factor ϕ x Load Model LM71 (and SW/0 where applicable)

the TSI INF sets out an additional dynamic loading (load model HSLM) to be taken into account and the requirement for a dynamic analysis by reference to EN1991-2:2003/AC:2010 requirements.

2.4.11.1. Vertical loads (Point 4.2.7.1.1)

Bridges shall be designed to support vertical loads in accordance with the following load models, set out in the specification referenced in Appendix T, Index [10]:

- (a) Load Model 71, as set out in the specification referenced in Appendix T, Index [10];*
- (b) in addition, for continuous bridges, Load Model SW/0, as set out in the specification referenced in Appendix T, Index [10].*
- (2) The load models shall be multiplied by the factor alpha (α) as set out in the specification referenced in Appendix T, Index [10].*
- (3) The value of factor alpha (α) shall be equal to or greater than the values set out in Table 11.*

Table 11	
Factor alpha (α) for the design of new bridges	
Type of traffic	Minimum factor alpha (α)
P1, P2, P3, P4	1,0
P5	0,91
P6	0,83
P1520	1
P1600	1,1
F1, F2, F3	1,0
F4	0,91
F1520	1,46
F1600	1,1

The vertical loading requirement for the design of new bridges is set out by reference to Load Model 71, which is defined in EN1991-2:2003/AC:2010.

For continuous bridge decks and continuous structural elements there is an additional vertical loading requirement set out by reference to the Load Model SW/0, which is also defined in EN1991-2:2003/AC:2010.

To allow for the different load capability requirements according to Traffic Code Load Model 71 (and where appropriate Load Model SW/0), the load model is multiplied by the load multiplication factor alpha (α) set out in EN1991-2:2003/AC:2010.

Table 11 sets out the minimum required values of alpha (α) according to Traffic Code.

The resultant vertical loading requirements for new bridges are a little more conservative or equal to the requirements for existing bridges set out in Appendix E. This is especially applicable for Traffic Code P6, where vertical loading capability is also provided in the requirements for new bridges for some self-propelled infrastructure maintenance vehicles. See also the guidance on Appendix E.

2.4.11.2. Allowance for dynamic effects of vertical loads (Point 4.2.7.1.2)

(1) The load effects from the Load Model 71 and Load Model SW/0 shall be enhanced by the dynamic factor phi (Φ) as set out in the specification referenced in Appendix T, Index [10].

(2) For bridges for speeds over 200 km/h where the specification referenced in Appendix T, Index [10] requires a dynamic analysis to be carried out, the bridge shall additionally be designed for HSLM defined in the specification referenced in Appendix T, Index [10].

(3) It is permissible to design new bridges such that they will also accommodate an individual passenger train with higher axle loads than covered by HSLM. The dynamic analysis shall be undertaken using the characteristic value of the loading from the individual train taken as the design mass under normal payload in accordance with Appendix K with an allowance for passengers in standing areas in accordance with Note 1 of Appendix K.

These requirements set out:

- the general requirements for all bridges in point 4.2.7.1.2(1); and
- the additional dynamic analysis design loading requirements in point 4.2.7.1.2(2).

The additional dynamic loading requirements set out in point 4.2.7.1.2(2) apply when both the following criteria apply:

- the local allowed speed at the bridge exceeds 200km/h, and
- EN1991-2:2003/AC:2010 requires a dynamic analysis.

The additional dynamic analysis loading requirements in point 4.2.7.1.2(2) are set out using load model HSLM defined in EN1991-2:2003/AC:2010.

For bridges for speeds exceeding 200km/h, point 4.2.7.1.2(2) sets out the requirements for when, in addition, a bridge must be designed for load model HSLM for the situations set out in the referenced clause in EN1991-2: 2003.

Point 4.2.7.1.2(3) identifies that some individual passenger trains have a greater dynamic bridge loading than HSLM. For these cases, point 4.2.7.1.2(3) sets out the reference mass conditions for determining the maximum axle loads of the train used in the design in a dynamic analysis.

Load model HSLM was developed to cover high speed trains with a vehicle design speed exceeding 200km/h. Some studies indicate that the dynamic loading effects generated in some bridges by some high speed trains exceed the corresponding effects from load model HSLM. To address this risk, EN1991-2:2003/AC:2010 (for when a dynamic analysis is required) also requires the design of the bridge to take into account each real permitted and envisaged passenger train. The real trains used for the design may be a set of existing real trains selected by the Applicant to cover the permitted and envisaged trains. It is suggested that it is good practice to follow the principles for existing bridges in Appendix E Note 9 and the associated reference to the OPE TSI: the dynamic loading details of the trains to be used (individual axle loads and position along the train) should be referenced in the information set out in accordance with the TSI OPE Appendix D.1 regarding RINF 1.1.1.1.2.4.4, and identified as a requirement for the design of new bridges.

2.4.11.3. *Equivalent vertical loading for new geotechnical structures, earthworks and earth pressure effects (Point 4.2.7.2)*

(1) Geotechnical structures and earthworks shall be designed and earth pressure effects shall be specified taking into account the vertical loads produced by the Load Model 71, as set out in the specification referenced in Appendix T, Index [10].

The loading requirements in the TSI INF for structures correspond to the level of the interface between the structural subsystems infrastructure and rolling stock, that is at the top of rail level. To avoid unnecessary conservatism in the design of geotechnical structures, it can, in some situations, be advantageous to take into account the distribution of Load Model LM71 by the track and track formation, and the overall behaviour of the geotechnical structure when determining the loading. This is a consequence of the distribution of the loading from Load Model 71 that is applied to the geotechnical structure (typically at a lower level than the top of rail level and corresponding to the top of the geotechnical structure).

In addition to the design loading case based on a continuous length of Load Model 71 applied to a track, for some exceptional geotechnical design situations where typical cross sectional analysis techniques are insufficient, the critical design situation results from sections of the track with no loading and other adjacent sections of the track loaded by the maximum loading from Load Model 71.

[Background: it is expected that the planned revision to EN 1991-2/ AC:2010 will provide enhanced guidance on the application of Load Model 71 to the design of geotechnical structures. It is also expected that the planned revision to EN 1997 will provide additional guidance on the determination of load effects from rail traffic actions in geotechnical structures. It is expected that the updates will provide recommendations

relating to the application of rail traffic loading for checking the overall global stability of geotechnical structures and for checking local load effects. For some geotechnical structures a differential loading case comprising of adjacent loaded and unloaded lengths of the same track can be a critical loading case].

2.4.11.4. *Resistance of existing structures (bridges and geotechnical structures including earthworks) to traffic loads (Point 4.2.7.4)*

(2) The minimum capability requirements for structures for each traffic code are given in Appendix E and must be met for the line to be declared interoperable.

Generally, the requirements for existing bridges are set out in Appendix E by a combined quantity of an EN Line Category and an associated speed requirement. For the upgrade of existing geotechnical structures, including earthworks, the requirements are set out in Appendix E by an EN Line Category. EN Line Categories are defined in EN15528:2021.

See also the guidance on Appendix E.

The requirements set out for the structures also apply when required by the TSI INF point 7.3.1 and 7.3.2.

NOTE: the requirements also apply on a voluntary basis to existing structures where the Applicant chooses to declare that the bridges and or geotechnical structures, including earthworks, on a line meet the interoperability requirements according to the Traffic Codes defining the TSI Category of Line for the line. See TSI INF points 4.2.7.4(3)(b) and 7.3.3.

2.4.12. Immediate action limits on track geometry defects (Point 4.2.8)

4.2.8.1. *The immediate action limit for alignment*

- (1) *The immediate action limits for isolated defects in alignment are set out in the specification referenced in Appendix T, index [12]. Isolated defects shall not exceed the limits of wavelength range D1.*
- (2) *The immediate action limits for isolated defects in alignment for speeds of more than 300 km/h are an open point.*

4.2.8.2. *The immediate action limit for longitudinal level*

- (1) *The immediate action limits for isolated defects in longitudinal level are set out in the specification referenced in Appendix T, index [12]. Isolated defects shall not exceed the limits of wavelength range D1.*
- (2) *The immediate action limits for isolated defects in longitudinal level for speeds of more than 300 km/h are an open point.*

For alignment and for longitudinal level these points refer to the IAL of EN 13848-5: 2017.

For alignment and longitudinal level, the maintenance regimes of several European countries already use stricter IAL than the ones in the EN 13848-5:2017: this means that the compliance with what is required by the INF TSI is guaranteed.

Decision of IMs of a possible “relaxation” (but still within the limits of the INF TSI) of the IAL for their network should never come from the application of the INF TSI itself: the Safety Management System of each Infrastructure Manager has to justify that the “new” IAL defined in their respective network can still guarantee the safe running of trains.

2.4.13. Platforms (Point 4.2.9)

(2) For the requirements of this point it is permissible to design platforms required for the current service requirement provided provision is made for the reasonably foreseeable future service requirements. When specifying the interfaces with trains intended to stop at the platform, consideration shall be given to both the current service requirements and the reasonably foreseeable service requirements at least 10 years following the bringing into service of the platform.

The current service requirements should be established by taking into account what is needed to give support to operation at the moment when the platform is being designed, plus a provision as defined in the Glossary of the TSI (Passive provision).

Foreseeable service requirements should be based on the information that is available at the moment when the platform is being designed.

Paragraph (2) allows new platforms to be designed to satisfy current service needs (e.g., non-TSI compliant trains stop) provided that provision is included in the design to enable “reasonably foreseeable” future service requirements to be accommodated (e.g., compliant TSI trains will stop at the station).

2.4.13.1. Platform height (Point 4.2.9.2)

(1) The nominal platform height shall be 550 mm or 760 mm above the running surface for radii of 300 m or more

For the assessment of the platform height in the “after assembly - before putting into service” phase, it is expected that the tolerances and specific assessment procedures usually defined by the applicant will be considered.

2.4.13.2. Platform offset (Point 4.2.9.3)

(1) The distance between the track centre and the platform edge parallel to the running plane (b_q), as defined in the specification referenced in Appendix T, index [3] shall be set on the basis of the installation limit gauge ($b_{q\text{lim}}$). The installation limit gauge shall be calculated on the basis of the gauge G1.

For structure gauges with equal width of reference profiles and associated rules at the height of the platform edge, the same value will be obtained for the installation limit gauge ($b_{q\text{lim}}$). Therefore, the calculations made for any of them will be valid for the rest.

For example, the calculations made on the basis of a gauge other than G1 (i.e., GA, GB, GC or DE3) will fulfil the requirements of this point.

2.4.14. Maximum pressure variations in tunnels (Point 4.2.10.1)

(1) Any new tunnel or underground structure falling in the categories described in the specification referenced in appendix T, index [14] has to provide that maximum pressure variation, caused by the passage of a train running at the maximum allowed speed in the tunnel, do not exceed 10 kPa during the time taken for the train to pass through the tunnel.

The design of the cross section of a tunnel involves several other requirements, in addition to that of the “Maximum pressure variation”, in order to give room to, for example:

- The verification of the structure gauge.
- The installation of the energy and signalling systems.
- Walkways for the evacuation passengers in case of emergency.

Additionally, it is recommended to take into account the effects on energy consumption of the aerodynamic resistance to the motion of trains, which depends on the clearance between trains and tunnels.

“The maximum allowed speed in the tunnel” to be considered is the maximum speed which is attainable when the most restrictive conditions for all the relevant subsystems are taken into account.

This speed will be used for the verification of the requirement at design review.

The definition of a tunnel in the EN 14067-5:2021/AC:2023 applies here. The definition of tunnel in the TSI SRT doesn't apply in this case.

2.4.15. Equivalent concity in service (Point 4.2.11.2)

(1) *If ride instability is reported, the railway undertaking and the infrastructure manager shall localise the section of the line in a joint investigation according paragraphs (2) and (3) hereafter.*

Note: This joint investigation is also specified in point 4.2.3.4.3.2 of TSI LOC & PAS for action on rolling stock.

(2) *The infrastructure manager shall measure the track gauge and the railhead profiles at the site in question at a distance of approximate 10 m. The mean equivalent concity over 100 m shall be calculated by modelling with the wheelsets (a) – (d) mentioned in paragraph 4.2.4.5(4) of this TSI in order to check for compliance, for the purpose of the joint investigation, with the limit equivalent concity for the track specified in Table 14.*

Table 14

Equivalent concity in service limit values for the track, (for the purpose of joint investigation)

<i>Speed range [km/h]</i>	<i>Maximum value of mean equivalent concity over 100 m</i>
<i>$v \leq 60$</i>	<i>assessment not required</i>
<i>$60 < v \leq 120$</i>	<i>0,40</i>
<i>$120 < v \leq 160$</i>	<i>0,35</i>
<i>$160 < v \leq 230$</i>	<i>0,30</i>
<i>$v > 230$</i>	<i>0,25</i>

(3) *If the mean equivalent concity over 100 m complies with the limit values in Table 14,*

a joint investigation by the railway undertaking and the infrastructure manager shall be undertaken to specify the reason for the instability.

Ride instability is influenced by several factors, one of which being the in service equivalent conicity mentioned in the TSI. It is advisable that when ride instability problems are encountered, all these factors are taken into consideration while conducting the joint investigation.

Defects in running gear or other issues from the vehicle may create unstable running. On the track side, some geometric defects may also result in unstable running even when respecting the equivalent conicity values. These defects may even result from unstable running of other previous trains that have previously passed over the line.

During the investigation, it is recommended to start with an inspection of the train and track, according to the usual maintenance procedures of RU and IM, respectively. This may include reviewing wheels, yaw dampers, suspension components, etc. for the RU and track geometric defects, etc. for the IM.

For evaluating the in-service value of equivalent conicity, in the process of the joint investigation by the Infrastructure Manager (IM) and the Railway Undertaking (RU), the first step is to identify the location where ride instability is being experienced (4.2.11.2(1) of INF TSI).

The IM then calculates the track mean equivalent conicity over 100m following the process described in 4.2.11.2 (2) and compares the values against those given in Table 14.

At the same time, the RU calculates the wheelset equivalent conicity following the process described in point 4.2.3.4.3.2 (3) of the TSI LOC&PAS and compares the values against the maximum equivalent conicity the vehicle was designed and tested for.

There are several outcomes following these calculations:

- Both the results obtained from the calculations by the IM and RU fulfil the requirements set in their respective TSIs so no prescribed actions have to be undertaken.
In this situation, the IM and RU shall continue their joint investigation in order to find out the reason of the instability.
- The results obtained from the IM's calculation exceed the limiting values. Actions shall be taken on the infrastructure to return the mean equivalent conicity to acceptable levels.
- The results obtained from the RU's calculation exceed the limiting values. Actions shall be taken to return the wheel sets to the correct profile.
- Both the results obtained from the calculations by the IM and RU exceed the requirements set in their respective TSIs. Actions shall be put in place on both the infrastructure and the wheel sets in order to restore the limiting values.

In order to return the track into the limits of equivalent conicity, different actions may be taken, depending on the cause. Rail grinding may be practical in case of wear problems or even narrow track gauge. For the case of narrow gauge this may be resolved by changing or adapting the fastenings or replacing sleepers.

After corrective actions have been taken, the joint investigation should continue in order to effectively verify whether the problem of instability has been resolved.

The joint investigation above described should be conducted regardless of the TSI compliance of rolling stock.

2.4.16. Fixed installation for servicing trains (Point 4.2.12)

4.2.12.1. General

This point 4.2.12 sets out the infrastructure elements of the maintenance subsystem required for servicing trains

Provision of fixed installations for servicing trains is optional. The Member State decides which elements belong to the interoperable network according to point 6.2.4.14.

2.4.17. Operating rules (Point 4.4)

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

Temporary suspension of the requirements of the TSI is permitted for pre-planned works.

An example would be at the site of a new underpass where provisional arrangements, non-compliant with the TSI, will be in place during the construction period.

2.5. Interoperability Constituents (Section 5)

Paragraphs (1) and (2) of Point 5.1 and paragraphs (1) and (3) of Point 5.2 define precisely which elements of the track are understood as Interoperability Constituents of the Infrastructure subsystem.

According to Points 5.1 and 5.2, the following goods, other than those mentioned in 5.2(3), are not considered to be Interoperability Constituents:

- a) steel sleepers (or made of any material which is not concrete or wood);
- b) specific fastenings such as low restraint fastenings, high resilient fastenings, noise and vibration mitigators, etc.;
- c) any element specifically used only on non-ballasted track (slab track, track on bridges, track with embedded rail, etc.).

These elements are not classified as ICs in this TSI for one or more of the following reasons:

- there are no harmonized specifications for these elements;
- the elements are not commonly used or are only used in specific locations and conditions;
- the small volume of production does not bring benefits to the opening market;
- several technical solutions exist for these types of elements.

Components which function like ICs, but which are excluded from the list of ICs, shall be assessed at subsystem level (together with the subsystem).

The existing ICs which have been in use prior to publication of the TSI can be reused according to the conditions set out in Point 6.6. of the TSI.

2.5.1. The rail fastening system (Point 5.3.2)

(2) The rail fastening system shall comply in laboratory test conditions with the following requirements:

(a) the longitudinal force required to cause the rail to begin to slip (i.e. move in an inelastic way)

through a single rail fastening assembly shall be at least 7kN and for speeds of more than 250 km/h shall be at least 9kN,

(b) the rail fastening shall resist application of 3 000 000 cycles of the typical load applied in a sharp curve, such that the change in performance of the fastening system shall not exceed:

- 20 % in terms of clamping force,*
- 25 % in terms of vertical stiffness,*
- a reduction of more than 20 % in terms of longitudinal restraint.*

The typical load shall be appropriate to:

- the maximum axle load the rail fastening system is designed to accommodate,*
- the combination of rail, rail inclination, rail pad and type of sleepers with which the fastening system may be used.'*

Tests on rail fastenings

When a module CH (see point 6.1.2) is selected for assessing the conformity of the IC “Rail fastening system”, quality control tests to confirm the performance of rail fastenings must be appropriate for the rail fastening design.

It is the responsibility of the organization signing the declaration of conformity to be able to demonstrate that Quality Control (QC) procedures are in place to ensure that fastenings supplied have a performance consistent with the requirements set out in Point 5.3.2. These are requirements that, by their nature, can only be demonstrated directly in type approval tests.

It must be possible to demonstrate that these QC checks ensure that the rail fastenings supplied are the same as the fastenings subjected to the type approval test.

In this respect, QC checks of every component of the rail fastening system, performed during manufacturing, should include regular measurements of:

- geometric features defining the clamping force (e.g., geometry of any spring steel rail clip, position of anchoring devices in the sleeper and thickness of rail pads and insulators);
- the critical shapes and dimensions;
- the key mechanical and material properties.

This may also include subjecting samples of some components, such as spring steel clips, to routine fatigue testing. Nevertheless, it is recognized that repeated load testing of complete rail fastening assemblies can only be carried out at the type approval stage.

Longitudinal restraint (5.3.2(2)(a))

For the purposes of using the TSI and in association with ENs, the longitudinal rail restraint is defined as the minimum axial force, applied to a rail secured to a sleeper by a fastening assembly, causing non-elastic slip of the rail through the fastening system.

For general applications in plain line, this value shall be at least:

- 7 kN, for speed equal or lower than 250km/h;
- 9 kN, for speed higher than 250 kmh.

A method for determining if the fastening system meets these requirements at the type approval testing stage is given in EN 13146-1:2019.

Some alternative methods exist, which are based on the force required to cause gross slip (instead of beginning of slip) on the rail. This force may be substantially higher than the force defined in these

European Standards, but fastening systems compliant with methods based on gross slip may not be compliant with the method based on beginning of slip. For example, some rail fastening assemblies which comply with the typical North American requirement for 10.7kN 'creep resistance' (based on gross slip) may fail the European requirement for 7kN (based on the beginning of slip).

For some applications, other values of longitudinal restraint may be appropriate: on some structures, it may be desirable to allow controlled slip of the rail in the vicinity of structural movement joints, and so, special fastenings with reduced, or zero, longitudinal restraint may be required.

These special fastening systems are covered by paragraph 5.2(3) and are not considered ICs as they do not fulfil the requirements for longitudinal rail restraint.

Resistance to cyclic loads (5.3.2(2)(b))

The resistance to cyclic loads is demonstrated in a type approval test, in which a complete rail fastening assembly is subjected to a combination of cyclic loads applied through a piece of rail, appropriate to its intended use. An acceptable test method is set out in EN 13146-4:2020. This method is consistent with the requirement for 20% permitted change in clamping force and longitudinal restraint, and 25% change in vertical static stiffness (up to a vertical static stiffness of 300 MN/m).

2.5.2. Track sleepers (Point 5.3.3)

(1) Track sleepers shall be designed such that when they are used with a specified rail and rail fastening system they will have properties that are consistent with the requirements of point 4.2.4.1 for 'Nominal track gauge', point 4.2.4.7 for 'Rail inclination' and point 4.2.6 for 'Track resistance to applied loads'.

According to Point 6.1.4.4, the EC declaration of conformity for track sleepers must include, among others, the statement setting out the combinations of rail, rail inclination and type of rail fastening system with which the sleeper may be used. No separate EC declarations of conformity are needed for sleepers that may be used with more than one combination.

The applicant has to show, and the NoBo has to verify, that the construction and geometry of the sleeper allow the declared elements to be used in those combinations.

Additionally, the sleeper has to fulfil the requirements referred to in Point 5.3.3:

- a) in reference to Point 4.2.4.1: that the sleeper is designed for the nominal track gauge;
- b) in reference to Point 4.2.4.7: that the sleeper construction allows for keeping the rail inclination within the permitted range.

The conformity assessment in relation to the requirements of Point 4.2.6 'Track resistance to applied loads' shall also be carried out for the scope of application declared by the manufacturer. This means that, normally, manufacturers declare the maximum axle load which may be applied to the sleeper, or the design bending moment assumed in the sleeper (as the result of the maximum vertical axle load permitted). The resistance to longitudinal and transversal forces relates to the types of fastenings which are assumed to be installed on the sleepers: manufacturers have to guarantee resistance to actions exerted by fastenings.

(2) For the nominal track gauge system of 1 435 mm, the design track gauge for track sleepers in straight alignments and in horizontal curves with radius greater than 300 m shall be 1 437 mm.

From the nominal track gauge of the project, a design value of the track gauge shall be used to design the track.

The track design starts with the choice of rail profiles to be used and the rail inclination to be applied. The further design concerns basically the design of the sleepers together with its fastening system to be used with the sleeper.

For drawing the assembly of components within the sleepers, the following steps are common practise:

the rails are put at the 'design track gauge';

fastening systems are added on the drawing of the sleeper, where it is verified that the different components fit together.

This is done at the nominal dimensions of all components.

Limited lateral gaps are provided between the rail foot and the fastening systems in order to allow for tolerances of the different components. The full verification of the compatibility of all tolerances with the design is out of the scope of the TSI.

If different rail profiles are used, separate drawings shall be produced for different rail profiles.

The actual values for gauge in track will depend on the chosen design values for all components, the production tolerances and the assembly in track, eventually influenced by train loads and maintenance operations. The choice of the gaps between rail foot and fastening may be considered to influence the actual values in track. Gaps are not necessarily to be put equally distributed between left and right from the rail foot.

For the turnouts, a similar approach is applied. As changing the track gauge has an impact in the theoretical diagram of the turnout, it is good practice to choose the design value for the turnout equal to the nominal track gauge. The position of the gaps between rail foot can be chosen in such way to have an actual and mean track gauge in track somewhat wider than if gaps were distributed evenly left and right of rail.

2.6. Assessment of Conformity of Interoperability Constituents and EC Verification of the Subsystems (Section 6)

2.6.1. Assessment of sleepers (Point 6.1.5.2)

(2) For polyvalent gauge and multiple gauge track sleepers it is allowed not to assess the design track gauge for the nominal track gauge of 1 435 mm.

Polyvalent gauge track sleeper: a track sleeper designed to fit the rail in more than one position in order to allow for a different track gauge on each position.

Multiple gauge track sleeper: a track sleeper designed to include more than one track gauge within the respective pairs of rails.

2.6.2. Assessment of structure gauge (6.2.4.1)

(3) After assembly before putting into service clearances shall be verified at locations where the designed installation limit gauge is approached by less than 100 mm or the installation nominal gauge or uniform gauge is approached by less than 50 mm.

For the assessment of the structure gauge after assembly before putting into service, it is expected that the specific assessment procedures usually defined by the applicant will be considered.

2.6.3. Assessment of distance between track centres (6.2.4.2)

2) After assembly before putting into service, distance between track centres shall be verified at critical locations where the limit installation distance between track centres as defined in accordance with the specification referenced in appendix T, index [3] is approached by less than 50 mm.

For the assessment of the distance between track centres after assembly before putting into service, it is expected that the specific assessment procedures, usually defined by the applicant, will be considered.

2.6.4. Assessment of track layout (Point 6.2.4.4)

(1) At design review the curvature, cant, cant deficiency and abrupt change of cant deficiency shall be assessed against the local design speed.

When assessing the values of “cant” and “minimum radius of horizontal curve” in the “Assembly before putting into service” phase (as required in Table 37), tolerances and specific assessment procedures, usually defined by IMs in their rules for acceptance of works, should be taken into account.

(3) At assembly before putting into service, for the review of the minimum horizontal curve the measurement values provided by the applicant or infrastructure manager shall be assessed. Rules for acceptance of works defined by the infrastructure manager shall be taken into account.

The assessment of the minimum horizontal curve procedure can be done according to EN 13231-1:2013 “Railway applications - Track - Acceptance of works - Part 1: Works on ballasted track - Plain line, switches and crossings”.

For the assessment of track layout at assembly before putting into service, the specific assessment procedures usually defined by the applicant or infrastructure manager shall be taken into account.

2.6.5. Assessment of cant deficiency for trains designed to travel with higher cant deficiency (Point 6.2.4.5)

Point 4.2.4.3(2) states that ‘It is permissible for trains specifically designed to travel with higher cant deficiency (for example multiple units with lower axle loads; vehicles with special equipment for the negotiation of curves) to run with higher cant deficiency values, subject to a demonstration that this can be achieved safely’. This demonstration is outside the scope of this TSI and thus not subject to a notified body verification of the infrastructure subsystem. The demonstration shall be undertaken by the RU, if necessary in cooperation with the IM.

For trains running at higher cant deficiency, demonstration of safe running has to be performed according to EN14363:2016+A2:2022.

For gauging, verification has to be performed according to section 14 of EN 15273- 3:2013+A1:2016

Operation at speeds above design speed may also have an impact on other requirements to be accomplished, such as those regarding distance between track centres, structures resistance to traffic loads, maximum pressure variations in tunnels, crosswinds, ballast pick up, immediate action limits on track geometry defects due to the higher speed attained.

2.6.6. Assessment of design values for equivalent conicity (Point 6.2.4.6)

Assessment of design values for equivalent conicity shall be done using the results of calculations made by the infrastructure manager or the contracting entity on the basis of the specification referenced in appendix T, index [5].

When assessing the design value of the parameter “Equivalent Conicity”, calculations have to be performed according to the procedure defined in point 4.2.4.5 of INF TSI, having chosen the following elements of the track configuration:

- design track gauge;
- rail head profile;
- rail inclination.

Appendix 2 to this Guide provides several track configurations that are deemed to fulfil the requirement of design equivalent conicity.

For projects in which serviceable rails are used, for the assessment of design value of equivalent conicity, the theoretical railhead profile may be taken into account.

2.6.7. Assessment procedure of existing structures (Point 6.2.4.10)

(1) Assessment of existing structures against the requirements of point 4.2.7.4(3) (b) and (c) shall be done by one of the following methods:

- (a) A check that the values of EN line categories, in combination with the allowed speed published, or intended to be published, for the lines containing the structures, are in line with the requirements of Appendix E:*
- (b) A check that the values of EN line categories, in combination with the allowed speed specified for the bridges or for the design, or alternative requirements specified with LM71 and factor alpha (α) for P1 and P2, are in line with the requirements of Appendix E:*
- (c) A check that the traffic loads specified for the structures or for the design against the minimum requirements of points 4.2.7.1.1, 4.2.7.1.2. and 4.2.7.2. When reviewing the value of factor alpha (α) in accordance with points 4.2.7.1.1 and 4.2.7.2, it is only necessary to check that the value of factor alpha (α) is in line with the value of factor alpha (α) mentioned in Table 11.*
- (d) Where the requirement for an existing bridge is specified by reference to the design load model HSLM in Appendix E the assessment of the existing bridge shall be done by either of the following methods:*
 - checking the specification of the design of the existing bridge or*
 - checking the specification of the dynamic appraisal or*
 - checking the published load carrying capacity of the existing bridge in the register of*

infrastructure (RINF) for the parameter 1.1.1.1.2.4.2 (Compliance of structures with the High Speed Load Model (HSLM))

- (e) *Where the requirement for an existing bridge is specified by reference to alternative dynamic loading requirements (Appendix E note 8), the assessment of the existing bridge shall be done by checking the specification of the dynamic appraisal for these alternative loading requirements against the requirements in Appendix E note 8.*

General

It is only necessary for the Notified Body to check that the requirements relating to existing structures (according to the type of structure) were used. For example, by reviewing information provided by the Applicant to check this information, it is demonstrated that the requirements for the upgrade of structures set out in the TSI INF were specified for the upgrade of an existing structure on an existing line.

The Notified Body is not required to carry out any calculations.

The Notified Body is not required to review any calculations.

The choice of method for the assessment procedure for existing structures is made by the Applicant.

It is acceptable for a different method to be chosen for each structure on a line or for different parts of a structure. For example, an existing structure may have the vertical load carrying capacity described in terms of EN Line Category, and the design of a replaced part described in terms of Load Model 71. For example, the information could describe the vertical load carrying capacity of a replacement bridge deck floor (in terms of Load Model 71 specified for the design of the replacement floor) and information on the vertical load carrying capacity of the retained main girders supplied (in terms of an EN Line Category at an associated speed).

The principle in 6.2.4.9 may also be applied so that the Notified Body is not required to review any calculations of existing structures and is not required to carry out any calculations.

Point (a)

The requirements set out in 6.2.4.10.1(a) are satisfied when the EN Line Category, as published by the IM, satisfies the requirements for the intended Traffic Codes.

When published information is checked, the source of the published information is not limited to the RINF. For example, other sources of information include information published to support the TSI OPE point 4.2.2.5, and, in particular, to support the application of the OPE TSI Appendix D.1 for the Route Compatibility Check 'Traffic loads and load carrying capacity of infrastructure'. The published information may, for example, provide guidance and information as well as data on infrastructure vertical load carrying capacity.

When checking whether the published values of EN Line Categories (EN15528:2021) and speed comply with the requirements in Appendix E, using the methods set out in 6.2.4.10(a) and 6.2.4.10(b), it is important to check the speed at which the published values of an EN Line Category apply. For example, in some cases a published value of D2 may be for freight traffic with a maximum speed of 120km/h: this vertical load carrying capacity would not satisfy an EN Line Category loading requirement of D2 at a local allowed speed of 160km/h. In such cases, the Applicant would need to provide additional information demonstrating that the INF TSI requirements for existing structures have been satisfied.

Similarly, an EN Line Category of D4 in the RINF, and a local allowed speed of 250km/h, does not indicate a vertical load carrying capacity for existing structures of D4 at 250km/h, and further information should be provided by the Applicant. The additional information could, for example, set

out the relationship between the EN Line Category published in the RINF and speed. For example, information published in accordance with the requirements of EN15528:2021 and OPE TSI Appendix D.1 for the Route Compatibility Check 'Traffic loads and load carrying capacity of infrastructure'. EN15528:2021 section 4.3 provides further guidance on this subject.

Examples of checks on published information against the requirements for existing bridges specified in terms of an EN Line Category and associated speed

Example	TSI INF Requirement	Published information or information intended to be published [point 6.2.4.10(1)(a)]	Check
1	D2-100	D4-100	1) First, check if published information covers required speed: Published information at same or greater speed than the TSI INF speed requirement - Ok. 2) Next, check if TSI INF EN Line Category requirements are satisfied: D4 equals or is greater* than D2 - Ok. Result: published information satisfies INF TSI requirements for existing bridges.
2	D2-160	D4 at freight speeds (max 100km/hr)	1) First, check if published information covers required speed: Published EN Line category is for a speed range that does not satisfy the INF TSI speed requirement. Result: more information is needed from Applicant to demonstrate bridge meets INF TSI requirements for bridges.
3	D2-160	D4 at freight speeds (max 100km/hr) Local allowed speed at site of bridge 100km/hr	1) First, check published information covers required speed: Published EN Line category is for a speed that does not satisfy the general INF TSI speed requirement. However, taking into account the local allowed speed in accordance with Table 38A note 1, the published information for EN Line Category covers the INF TSI speed requirement - Ok. 2) Next, check INF TSI EN Line Category requirements are satisfied: D4 equals or is greater* than D2 - Ok. Result: published information satisfies INF TSI requirements for existing bridges.
4	D2-100	D4 at freight speeds up to 100km/hr	1) First, check published information covers required speed: Published information at same speed or greater speed than the INF TSI speed requirement - Ok. 2) Next, check INF TSI EN Line Category requirements satisfied: D4 equals or is greater* than D2 - Ok. Result: published information satisfies INF TSI requirements for existing bridges.
5	D2 -120	C3-120	1) First, check published information covers required speed:

Example	TSI INF Requirement	Published information or information intended to be published [point 6.2.4.10(1)(a)]	Check
			<p>Published information at same or greater speed than the INF TSI speed requirement - Ok.</p> <p>2) Next, check INF TSI EN Line Category requirements satisfied:</p> <p>C3 is not greater than or equal* to D2 for all spans.</p> <p>Result: more information needed from Applicant to demonstrate bridge meets TSI INF requirements for existing bridges.</p>

* For the check, it is necessary for both the published (or intended to be published) letter of the EN Line Category to be greater than (or equal) to the INF TSI requirement, and the published (or intended to be published) EN Line Category number to be greater than (or equal) to the TSI INF requirement. For example:

- $D \geq D$ and $D > C$ plus $2 \geq 2$ and $2 > 1$; and
- at the same speed, D2 is generally greater than C2, except for extremely long spans (note same 'number') where D2 tends towards being equal to C2; and
- it should be noted that C3 is not always greater than (or equal) to D2. This is a complex situation in which the result is a function of loaded length and to a varying degree, which is also a function of speed ('3' tends to be greater than '2' for longer spans, but 'D' is greater than 'C' for short spans at the same speed).
- See also EN15528:2021.

Point (b) and (c)

Examples of the assessment procedure for existing structures include:

- a) checks that the original vertical loading design requirements based on Load Model 71 (and if applicable, Load Model SW/0) for a structure satisfy the requirements in point 4.2.7.1.1. For example, to satisfy the required value of $\alpha \times LM71$, and, if applicable, Load Model SW/0; and
- b) checks that the original vertical loading design requirements not based on Load Model 71 satisfy the requirements in Appendix E (or points 4.2.7.1.1 and 4.2.7.1.2(1)).

For point (b) above, where the assessment procedure for existing structure(s) is based on the original design requirements for the structure(s), it is acceptable, for example, to present the results of studies indicating that vertical load models (other than the load models set out in the INF TSI) are equal to or cover the load effects of the required EN Line Categories for existing structures or the load models set out in the INF TSI for the design of new structures (for the range of loaded length(s) of the structures subject to the assessment procedure). To take speed into account, for example, the relevant dynamic factor appropriate to a load model should be applied to the load model when comparing the load effects at speed with the TSI load carrying requirements.

The information provided by the Applicant may be published information and or unpublished information. Examples of unpublished information include:

- the vertical load carrying capacity of individual bridges in terms of Load Model 71 (for example, the percentage of Load Model 71); or
- the vertical load carrying capacity of bridges in terms of national requirements of vertical load carrying capacity, and the results of studies demonstrating that these national requirements of vertical load carrying capacity satisfy the vertical loading requirements for existing structures, as specified in the TSI.

2.6.8. Assessment of platform offset (Point 6.2.4.11)

(1) Assessment of the distance between the track centre and the platform edge as a design review shall be done using the results of calculations made by the Infrastructure Manager or the contracting entity on the basis of the specification referenced in appendix T, index [3].

Methodology to calculate b_{qlim} is set in point 13 of EN 152733:2013+A1:2016.

Definition of b_{qlim} can be found in section H.2.1 of EN 15273-1:2013+A1:2016/AC:2017.2017

2.6.9. Assessment of maximum pressure variations in tunnels (Point 6.2.4.12)

(2) The input parameters to be used during the assessment shall be such that the reference characteristic pressure signature of the trains set out in the LOC&PAS TSI is fulfilled.

In the operation phase, the demonstration can be carried out by the Infrastructure Manager considering real trains, with signatures lower than the reference interoperable train signature as is defined in the LOC&PAS TSI in order to allow higher speeds for these real trains.

2.6.10. Assessment of track resistance for plain line (Point 6.2.5.1)

(1) The demonstration of conformity of the track to the requirements of point 4.2.6 may be done by reference to an existing track design which meets the operating conditions intended for the subsystem concerned.

(2) A track design shall be defined by the technical characteristics as set out in Appendix C.1 to this TSI and by its operating conditions as set out in Appendix D.1 to this TSI.

(3) A track design is considered to be existing, if both of the following conditions are met:

(a) the track design has been in normal operation for at least one year and

(b) the total tonnage over the track was at least 20 million gross tons for the period of normal operation.

(4) The operating conditions for an existing track design refer to conditions which have been applied in normal operation

(5) The assessment to confirm an existing track design shall be performed by checking that the technical characteristics as set out in Appendix C.1 to this TSI and conditions of use as set out in Appendix D.1 to this TSI are specified and that the reference to the previous use of the track design is available.

(6) When a previously assessed existing track design is used in a project, the notified body shall only assess that the conditions of use are respected.

(7) For new track designs that are based on existing track designs, a new assessment can be performed by verifying the differences and evaluating their impact on the track resistance. This assessment may be supported for example by computer simulation or by laboratory or in situ testing.

A track design is considered to be new, if at least one of the technical characteristics set out in Appendix C to this TSI or one of conditions of use set out in Appendix D to this TSI is changed

“Track resistance to applied load” (4.2.6) is a basic parameter for which presumption of conformity at design stage may be used. Point 6.2.5.1 for plain line (and point 6.2.5.2 for switches & crossings) details how the assessment can be performed by referring to an existing track design meeting the operating condition intended for the subsystem concerned.

In that respect, Appendix C and Appendix D are intended to establish respectively the technical characteristics and the conditions of use that define a track design.

Paragraph (3) sets out the conditions under which a track design is considered “existing”.

The track design of the subsystem concerned is presumed to be compliant with the requirements of point 4.2.6 when it is possible to demonstrate that its technical characteristics (as defined in Appendix C) and its conditions of use (as defined in appendix D) are identical to those of an existing track design (which, of course, meets the operating conditions of the subsystem concerned).

The assessment of track resistance to applied loads has to be made by considering the whole set working altogether. Likewise, the consistency of the properties of each track component with the requirements on track resistance for the whole track design, as set out in 4.2.6, has to be evaluated by assessing the whole set containing the referred component. For this reason, Appendix C takes into account the relevant features of every component. Within some track designs, several components of similar characteristics can be used in the same place to allow the use of products from different manufacturers or for other reasons. This circumstance is usually covered by internal classifications of track components, as established in the technical specifications of the IM. The definition of the technical characteristics of a track design may be done by referring to these internal categories of track components, if compatibility with the intended conditions of use as set out in Appendix D is respected.

‘Normal operation’ should be understood as when trains run along the line for their own purposes without any exceptional provision to mitigate their impact on infrastructure.

2.6.11. Subsystems containing Interoperability Constituents not holding an EC declaration (Point 6.5) and Subsystem containing serviceable Interoperability Constituents that are suitable for reuse (Point 6.6)

When assessing subsystems that contain IC not holding an EC declaration or that are reused, the following guide can be used to help identify the procedure to follow:

Table 3: EC verification of the infrastructure subsystem containing serviceable interoperability constituents that are suitable for reuse

Ref.	Features of the subsystem	Reference to INF TSI	Comments
A	General case. Subsystems containing NEW Interoperability Constituents holding an EC declaration	6.2.	The EC verification of the infrastructure <u>subsystem</u> is <u>carried out according to points 6.2 to 6.4.</u>
B	Subsystems containing NEW Interoperability Constituents not holding an EC declaration (procedure valid until the list of interoperability constituents listed in Chapter 5 of INF TSI are revised)	6.5.	If the applicant is developing a new project and intends to use new Interoperability Constituents already manufactured but are not yet covered by an EC declaration, the NoBos are permitted to issue an EC certificate of verification for the subsystem if the following requirements are fulfilled: (a) the conformity of the subsystem has been checked against the requirements of section 4, and points 6.2 to 7 (excluding 7.7) of the TSI (conformity of ICs to section 5 and point 6.1 is not required), and (b) the same type of Interoperability Constituents, have been used in a subsystem already approved and put in service in at least one of the Member State before the entry in force of the TSI.
C	Subsystem containing REUSED serviceable Interoperability Constituents that are suitable for reuse (procedure with no time limit)	6.6.	If the applicant is developing a new project and intends to reuse serviceable Interoperability constituents, the NoBos are permitted to issue an EC certificate of verification for the subsystem if the following two requirements are fulfilled: (a) the conformity at the subsystem level has been checked against the requirements of sections 4, and sections 6.2 to 7 (excluding 7.7) of the TSI (conformity to section 6.1 is not required), and (b) the Interoperability Constituents are not covered by the relevant EC declaration of conformity and/or suitability for use. Usually, the applicant shall ensure that the proposed serviceable constituents are suitable for reuse.

2.7. Technical characteristics of switches and crossings design (Appendix C.2)

Switches and crossings design shall be at least defined by the technical characteristics as follows:

(a) *Rail*

- *Profile(s) & grades (switch rail, stock rail)*
- *Continuous welded rail or length of rails (for jointed track sections)*
- (b) *Fastening system*
 - *Type*
 - *Pad stiffness*
 - *Clamping force*
 - *Longitudinal restraint*
- (c) *Bearer*
 - *Type*
 - *Resistance to vertical loads:*
 - *Concrete: design bending moments*
 - *Wood: compliance to EN 13145:2001*
 - *Steel: moment of inertia of cross section*
 - *Resistance to longitudinal and lateral loads: geometry and weight*
 - *Nominal and design track gauge*
- (d) *Rail inclination*
- (e) *Ballast cross sections (ballast shoulder – ballast thickness)*
- (f) *Ballast type (grading = granulometrie)*
- (g) *Type of crossing (fixed or movable point)*
- (h) *Type of locking (switch panel, movable point of crossing)*
- (i) *Special devices: for example sleeper anchors, third/ fourth rail, ...*
- (j) *Generic switches and crossings drawing indicating*
 - *Geometrical diagram (triangle) describing the length of the turnout and the tangents at the end of the turnout*
 - *Main geometrical characteristics like the main radii in switch, closure and crossing panel, crossing angle*
 - *Sleeper spacing*

In the context of Switches & Crossings (S&C), the elements that support the S&C are commonly known as “bearers”; in that respect, when in Appendix C.2 reference is made to technical characteristic of ‘sleeper’, it has to be intended that the technical characteristics shall refer also to the bearers.

When filling in the data corresponding to the “bearers” nominal and design track gauge, it could be enough to include the nominal track gauge in the list and refer to the drawings of the layout of the Switches & Crossings for the design track gauge of each “bearer”.

“Movable point of crossing” has the same meaning as swing nose crossing.

2.8. Capability requirements for existing structures in accordance with traffic code (Appendix E)

See full Appendix E

General guidance regarding existing structures

The Traffic Code is a line parameter and a combination of Traffic Codes defines the TSI Category of Line.

For setting the requirements for the minimum vertical loading capability of existing structures, the TSI INF permits choice according to the Traffic Code(s) used to define the TSI Category of Line. Accordingly, the minimum vertical loading requirements for existing structures are set out for each Traffic Code.

Appendix E sets out the detailed vertical loading requirements for existing structures.

See also the guidance on point 4.2.7.4.

Appendix E is for Infrastructure Managers and Notified Bodies.

Infrastructure Managers use Appendix E to determine the minimum loading capability requirements for structures on a line, as required by infrastructure TSI.

Appendix E provides an important overview defining the future evolution of the existing infrastructure subsystem regarding the future vertical loading capability of existing structures.

Where the requirements for an existing structure are a function of speed, then the speed to be taken into account may consider point 4.2.1(12), note 2 and note 3 to Table 2 and note 1 to Table 3, and the local allowed speed (see Appendix E note 1). The local allowed speed is a function of many considerations including for example track geometry and the load carrying capacity of structures.

Further to the headings of Table 2 and Table 3, it is important to note that the requirements including values set out in Appendix E are not to be used for checking the compatibility of rolling stock with infrastructure. The requirements for such compatibility checks are set out in the OPE TSI point 4.2.2.5, and, in particular, in the OPE TSI Appendix D.1 for the Route Compatibility Check 'Traffic loads and load carrying capacity of infrastructure'.

General guidance regarding existing bridges

For existing bridges:

In the INF TSI 2019, the requirements were presented in three columns according to the type of vehicle:

- Passenger Carriages (including Coaches, Vans and Car Carriers) and Light Freight Wagons;
- Locomotives and Power Heads;
- Electric or Diesel Multiple Units, Power Units and Railcars.

In the INF TSI 2023, the two first columns referred above have been merged, and the requirements are now presented in two columns according to the following types of traffic:

- Traffic with loco hauled trains: Passenger trains including Carriages (Coaches, Vans and Car Carriers) and Light Freight Wagons and Locomotives and Power Heads;
- Traffic with Electric or Diesel Multiple Units, Power Units and Railcars;

Notes in Table 38A detail relevant differences between passenger carriages and locomotives (and power heads).

For existing bridges, generally, the minimum required loading capability requirements are set out in Table 38A and Table 39A for each Traffic Code using a description of the static loading interface between the rail vehicles and a bridge together with vehicle speed. This vehicle/infrastructure subsystem interface is defined by the combined quantity of an EN Line Category to EN15528:2021 and a corresponding speed. The EN Line Category describes the static loading characteristics of a rail vehicle and is based on the maximum individual axle loads and the geometrical characteristics of the spacing of the axles along the vehicle.

The load carrying requirements include:

- vertical loading requirements based on static loading (for Traffic Codes P1 and P2, two options are set out in Appendix E); and
- the requirement to take the specified speed of rail traffic into account; and
- for some traffic codes, additional dynamic loading requirements apply. Where options are provided for the vertical loading requirements based on static loading, the additional dynamic loading requirements apply to both options.

In addition, alternative requirements for existing bridges are set out in 6.2.4.10(c), which, by cross reference, call up the requirements for the design of new bridges set out in 4.2.7.1.1 and 4.2.7.1.2.

These alternative requirements for existing structures, made by reference to the design requirements for new structures, are thus set out in terms of Load Model 71 (and where appropriate, additionally Load Model SW/0).

Where alternative requirements are set out, the choice of requirement is made by the Applicant. It is acceptable for a different choice to be made for different parts of a structure.

It may be noted that typically the requirements relating to the design of a new structure are not technically equal to the requirements for existing structures. Typically, the requirements for new structures are a little more conservative (onerous) than the requirements for an existing structure for the same Traffic Code. This is to allow some deterioration in a new structure, that is declared as meeting interoperability requirements, before an Infrastructure Manager needs to carry out works to restore the load carrying capacity to the minimum requirements for existing structures. See TSI INF point 4.5(3).

It is the choice of the Infrastructure Manager, as to which requirements apply to an individual existing structure on the line. It is acceptable for a different choice to be made for each structure on the line, or for different parts of a structure.

In the case of Traffic Code P5, the member state is permitted to decide whether the requirements for locomotives and power heads apply. For example, the requirements for locomotives and power heads may be omitted for a line where the passenger traffic business only needs the line for lightweight multiple units. See note 4.

The capability requirements are set out for different types of rail traffic, as indicated by the column headings in the tables. Note 2 sets out where the different types of vehicles in Table 38A are defined. Existing bridges satisfying the requirements for new bridges according to Traffic Code also satisfy the capability requirements for existing bridges for the same Traffic Code (as set out in point 6.2.4.10). The Applicant may make the choice of the approach to be adopted. The approach adopted will often be based on the available published vertical load carrying capacity information for a line, or available data describing the vertical load carrying capacity of existing bridges, or the availability of information describing the design of existing bridges. The vertical load carrying capacity of existing bridges is often described in terms of an EN Line Category (EN15528:2021) or as a percentage of Load Model 71 load carrying capacity. It is acceptable for a different choice to be made for different parts of a structure.

Requirements relating to the speed of rail traffic for existing bridges

Where a speed is stated, this is generally for a speed corresponding to the maximum speed of the speed range for the Traffic Code. This speed value in the table may be reduced in accordance with:

- point 4.2.1(12); and
- the limitation of speed for axle load as set out in note 2 and note 3 to Table 2 and note 1 to Table 3.

Additionally, for an existing bridge it is acceptable to take account of the local allowed speeds as set out in note 1 to Tables 38A and Table 39A.

For Traffic Code P6, no associated speed requirement is stated because there is no speed requirement indicated on Table 2. For P6, it is recommended that the associated speed requirement should be based on note 1 to Table 38A.

Additional requirements when a dynamic analysis is necessary (and associated loading capability requirements)

Dynamic analysis loading requirements

The dynamic analysis loading requirement for existing bridges is set out as load model HSLM for Traffic Codes P1 and P2. If compliance with load model HSLM cannot be shown, then note 8 sets out alternative requirements. See the guidance on Traffic Codes P1 and P2 and note 8 below.

Load model HSLM was developed to cover high speed trains with a vehicle design speed exceeding 200km/h. Some studies indicate that the dynamic loading effects generated in some bridges by some high-speed trains exceed the corresponding effects from load model HSLM. To address this risk, it is recommended that a dynamic check on an existing bridge aligns with the requirement in EN1991-2:2003/AC:2010, to check the bridge for both load model HSLM and each permitted and envisaged passenger real train. The real trains used for the dynamic check may be a set of existing real trains, selected by the infrastructure manager to cover the permitted, and envisaged trains. The dynamic loading details of the trains to be used (individual axle loads and position along the train) should be specified in the information set out, in accordance with the OPE TSI Appendix D.1 regarding RINF 1.1.1.1.2.4.4 and identified as a requirement for existing bridges. When either load model HSLM or these real trains are not satisfied alternative dynamic loading requirements in accordance with note 8 in Appendix E may be adopted and the details should also be recorded in the information set out in accordance with the OPE TSI Appendix D.1 regarding RINF 1.1.1.1.2.4.4. For this case, the train details should be recorded as the load carrying capability of the bridge(s) on the defined line(s).

For Traffic Codes P3a, P3b, P4a and P4b, note 9 sets out that, when dynamic analysis techniques are necessary, the dynamic analysis loading requirements need to be based on real train loading. See the guidance on note 9.

Further to point 6.2.4.10(d) and 6.2.4.10(e), it is only necessary, for the Notified Body, to check the specification of the loading for these checks or the published vertical load carrying capacity (for example load model HSLM).

Speeds requiring a dynamic analysis

The INF TSI does not set out any requirements for existing structures relating to the speeds which require a dynamic analysis. This risk is managed by Appendix E note 9. The requirements relating to when a dynamic analysis is necessary in terms of speed as set out in the requirements for route compatibility checks in the TSI OPE Appendix D.1 regarding RINF 1.1.1.1.2.4.4 should be considered.

It may be noted that the recommendations in EN1991-2:2003/AC:2010 section 6.4.4 relating to whether a dynamic analysis is necessary according to speed and other technical criteria are for the design of new bridges. These recommendations may also be used for existing bridges subject to appropriate modifications being made that allow for the differences in the characteristics of new bridges and the national stock of existing bridges. For existing bridges, recommendations may be provided in the documents setting out the procedures in accordance with Appendix D.1 to the OPE TSI (RINF parameter 1.1.1.1.2.4.4).

Requirements for checking dynamic analysis loading requirements

Dynamic analysis techniques are required to check that the required dynamic analysis loading requirements are met.

When a dynamic analysis is necessary, the methodology used for the dynamic analysis technique is the choice of the Applicant. Examples include, but are not limited to:

- a. a comparison of the dynamic loading characteristics of a required passenger real train(s) with a dynamic analysis load model (including a description of the dynamic loading characteristics of one or more real passenger trains); and/or
- b. a comparison of the dynamic loading characteristics of a required passenger real train(s) with other trains that have been used in previous dynamic analysis checks of bridges on the line; and/or
- c. the dynamic analysis of individual bridges; and/or
- d. parametric dynamic analysis of bridges; and/or
- e. interpretation of previous dynamic studies.

Traffic Code P1 and P2 requirements for existing bridges

For Traffic Codes P1 and P2, the static loading requirements are stated with two options. The static loading requirements are set out either in terms of the combined quantity of an EN Line Category (EN15528:2021) and speed, or in terms of Load Model 71 (Load Model 71 is set out in EN1991-2:2003/AC:2010) with a minimum load multiplication factor alpha (α).

The choice of approach is made by the Applicant: see note 14. The choice may be influenced, for example, by the availability of data describing the vertical load carrying capacity of existing bridges in terms of EN Line Category (EN15528:2021), or design records for the existing bridges. When utilising the alternative criteria, utilising Load Model 71 speed is allowed for by multiplying the loading due to Load Model 71 by the dynamic factor set out in 4.2.7.1.2(1).

It should also be noted that, for Traffic Codes P1 and P2, the minimum loading requirement expressed in terms of EN Line Category (EN15528:2021) is in both cases limited to a maximum of 200km/h (even if the local allowed speed is greater than 200km/h). For local allowable speeds up to 200km/h, the minimum required loading capability is D2 at the local allowable speed, in accordance to note (1).

For Traffic Codes P1 and P2, in addition to defining the static loading interface, it is necessary to define, for existing bridges, an additional dynamic loading requirement. The additional dynamic loading requirement applies to both the options for the static loading set out in Table 38A.

The additional dynamic loading requirement is specified using the dynamic load model HSLM set out in EN1991-2:2003/AC:2010. This additional dynamic loading requirement assists in addressing the risk that excessive load effects due to resonance between a train and a bridge exceeds the normal requirements specified in terms of a static loading interface enhanced by normal industry allowances for the dynamic increment of rail vehicle loading in bridges. Where the requirement for the load model HSLM is not met, alternative requirements in accordance with note 8 may be utilised (for example for bridges built before the introduction of load model HSLM).

Load model HSLM was developed to cover trains with a maximum vehicle design speed of over 200km/h. When a dynamic analysis is necessary for local allowed speeds less than or equal to 200km/h, then the additional dynamic loading requirements for an existing bridge should be in accordance with note 9. For example, the minimum additional dynamic loading requirement may be specified in terms of real passenger trains, with maximum axle loads determined for the reference mass set out in Appendix K. Also see the guidance on Appendix E note 9 in this Application Guide.

Requirements relating to the Load Model SW/0 for existing bridges

When a requirement is expressed as $\alpha \times$ Load Model 71 for continuous decks, and continuous structural elements of bridges the most adverse loading from either $\alpha \times$ Load Model 71 or $\alpha \times$ Load Model SW/0 shall be taken into account as set out in point 4.2.7.1.1(b). Load Model SW/0 is set out in EN1991-2:2003/AC:2010. Again, to allow for the effects of speed, the loading due to Load Model SW/0 is multiplied by the dynamic factor set out in 4.2.7.1.2(1).

Traffic Code P3 and P4 requirements for existing bridges

To maximise the availability of existing bridges for passenger rail traffic and to avoid uneconomic strengthening costs, the minimum vertical load carrying capacity requirements for P3 and P4 are set out by loaded length for passenger traffic (L). This reflects the situation for real passenger trains whereby the EN Line Category (EN15528:2021) of a passenger vehicle is frequently dictated by the loading effects on very short loaded lengths (for example, the load effects generated by a single maximum axle load). As a result the envelope of passenger traffic loading as measured by EN Line Category (EN15528:2021) reduces with increasing loaded lengths. See note 15.

It should also be noted that, for Traffic Codes P3 and P4, the minimum loading requirement expressed in terms of EN Line Category (EN15528:2021) for loaded lengths exceeding 4m is in both cases limited to a maximum speed of 100km/hr (even if the local allowed speed is greater than 100km/h). See * note (15) at the end of the notes to Table 38A and Table 39A.

Guidance on 'loaded length' (L)

The loaded length of a structural member of a bridge is the length of the appropriate influence line for the load effect being considered within which the rail vehicles produce adverse effects. The loaded length is measured along the loaded track(s). For example, for a structural member loaded by a single track for bending load effects, the length of the influence line for the maximum bending moment in the structural member is measured parallel to the track along the centreline of the track.

Guidance on the characteristics and operation of rail traffic covered by Appendix E for existing bridges

To avoid the specification of uneconomic loading requirements for existing bridges, a number of the notes set out limitations according to the type of rail traffic and the vehicle loading characteristics covered by the vertical loading capability requirements in Appendix E. These limitations typically relate to:

- normal operational limitations, for example see notes 3 and 6;
- speed in amplification of note 2 and note 3 to Table 2; and
- this is to reduce (but not eliminate) the number of situations where costly upgrade works and/or costly dynamic analyses could be required for addressing the risk of train/bridge resonant loading. For example, for example see notes 3, 5, 6, 10, 11, 12 and 13.
- whilst not within the scope of the INF TSI, limitations on passenger traffic which are comparable with the basis of the fatigue design requirements for new rail bridges set out in EN1991-2:2003/AC:2010.

Managing the risk of excessive dynamic effects, including resonance, in existing bridges

The risk of excessive dynamic effects, including resonance, in existing bridges is managed by:

- a) for Traffic Codes P1 and P2, by the additional dynamic loading capability requirement specified using the load model HSLM and note 8; and
- b) note 9; and
- c) to a lesser extent, by restrictions on the characteristics and operation of rail vehicles covered as set out in notes 3, 5, 6, 10, 11, 12 and 13.

Note 9

In amplification of (c) above, there is currently no technically available harmonised methodology for defining the loading capability requirements for passenger traffic and/or harmonised bridge parameters for existing bridges for speeds of 200 km/h and below that manages the risk of excessive loading from train/bridge resonant loading. Note 9 sets out the requirements for managing this risk.

Regarding note 9:

- this risk of excessive dynamic effects, including resonance, increases as speeds increase up to 200km/h and above;
- the exact speed at which this risk requires investigation is a complex problem which is a function of the following train parameters:
 - speed;
 - spacing between axles along the train and spacing between groups of axles along the train. Especially repeating regular patterns, or where the spacing between axles in adjacent bogies is a multiple of the bogie axle spacing, or similar considerations regarding the spacing of bogie pivot centres; and
 - maximum axle load;
 - variation in axle loads along the train;
- the exact speed at which this risk requires investigation is a complex problem which is a function of the following bridge parameters:
 - first natural frequency and frequencies of higher modes and associated mode shapes (Eigen forms) along the line of the track (a function of structural configuration, stiffness, mass and structural details dictating whether the structure has line beam, plate, torsional, transverse etc. bending modes);
 - span of the element and slope of the influence line for deflection of the element being considered (at the end of the influence line where a moving axle starts to load the element);
 - the mass of the bridge or of a bridge element; and
 - the damping of the bridge or of a bridge element;
- some further guidance is given in EN15528:2021;
- at the time of writing this Application Guide, the EU Project “HORIZON-ER-JU-2022-ExpIR-02 Bridge Dynamics” had issued a call for research proposals to investigate this topic; and
- currently this risk is managed by note 9 and especially by the requirements relating to dynamic compatibility checks between rail vehicles and bridges set out in Appendix D.1 of the OPE TSI (regarding RINF 1.1.1.1.2.4.4).

General guidance regarding existing geotechnical structures including earthworks

For existing geotechnical structures including earthworks, the minimum required loading capability requirements are set out in Table 38B and Table 39B for each Traffic Code using a description of the static loading interface between the rail vehicle and earthworks. This vehicle/infrastructure subsystem interface is defined by an EN Line Category to EN15528:2021. The EN Line Category describes the static loading characteristics of a rail vehicle and is based on the maximum individual axle loads and the spacing of the axles along the vehicle.

Existing geotechnical structures including earthworks satisfying the requirements for new geotechnical structures including earthworks according to Traffic Code also satisfy the requirements for existing geotechnical structures including earthworks for the same Traffic Code (as set out in point 6.2.4.10 and by cross reference to 4.2.7.2).

The Applicant may make the choice of the approach adopted.

Often the approach adopted will be based on the available published vertical load carrying capacity information for a line, or available data describing the vertical load carrying capacity of existing geotechnical structures, including earthworks. It is acceptable for a different choice to be made for different parts of a geotechnical structure including earthworks.

Requirements relating to the speed of rail traffic for existing geotechnical structures including earthworks

No specific requirements are set out in terms of speed and the required loading capability should be at the local allowed speed in accordance with note 1 to Table 38B and Table 39B. This speed may be reduced in accordance with:

- point 4.2.1(12); and
- the limitation of speed for axle load as set out in note 2 and note 3 to Table 2 and note 1 to Table 3.

2.9. Basis of minimum requirements for structures for passenger coaches and multiple units (Appendix K)

See full Appendix K

Passenger coaches and multiple units

Where a dynamic analysis is necessary (see guidance on 4.2.7.1.2(2) and Appendix E), Appendix K sets out the requirements for determining the maximum axle loads of a real passenger train used in the dynamic analysis. The maximum value of axle load for each axle is determined as well.

The train/bridge vertical loading interface requirements for this dynamic interface can sometimes be sensitive to the variation in maximum axle load along the train or within different parts of the train (the dynamic interface can be more sensitive than for the corresponding static loading interface considerations).

For trains with identical length and axle spacing, it is permissible to assume the highest maximum value of axle load across various train designs (for example, for a train platform), for either an individual axle, or for groups of axles, or for the whole train to cover variations between real trains. This approach can lead to some conservatism in the dynamic loading requirements adopted.

Appendix K sets out the mass conditions for determining the values of maximum axle load for each axle for passenger coaches and multiple units.

For these dynamic analysis checks, the relevant mass condition is the design mass under normal payload, as set out in EN15663:2017+A1:2018. EN15663:2017+A1:2018 permits a choice of payload for passenger payload in standing areas from within the range of values set out in EN15663:2017+A1:2018. Appendix K sets out the passenger payload in standing areas to be used for the purpose of defining the dynamic loading to be used in dynamic analysis checks.

It should be noted that the vehicle mass conditions for dynamic analysis checks are different to the mass condition used for determining the maximum axle loads for determining the EN Line Category of a passenger carrying vehicle. The mass condition used for determining the maximum axle loads for determining the EN Line Category of a passenger carrying vehicle are based on the design mass under exceptional payload.

Locomotives and power heads

Appendix K does not set out the mass conditions to be used for determining the maximum axle loads of a locomotive or power car for a dynamic analysis check.

It is recommended that, for locomotives and power cars which do not carry any passengers and carry no payload, the maximum axle loads used in a dynamic analysis check should be based upon the mass condition design mass in working order.

2.10. Glossary (Appendix S)

<i>Design track gauge / Konstruktionsspurweite / Ecartement de conception de la voie</i>	5.3.3	<i>A single value which is obtained when all the components of the track conform precisely to their design dimensions or their median design dimension when there is a range</i>
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When designing a sleeper, one of the most important goals is to make sure that the track gauge in operation will deviate from its design value as less as possible.

The track gauge, though, is not only affected by the design of the sleeper, but it is also influenced by the dimensions, tolerances and position (within the sleeper) of:

- rails;
- each component of the rail fastening system, with which the sleeper is equipped.

Therefore, when defining the design track gauge of a sleeper, all track components (rails, clips, insulators, etc.) that play a role in the track gauge should be considered with their nominal design dimensions (or median design dimension, when there is a range) and their nominal design position within the sleeper.

In addition to the EC declaration of conformity, the value of the 'design track gauge' should be explicitly stated on all relevant documents (drawings, technical note, etc.) of the sleepers.

The concept of 'design track gauge' is related to the design of the sleepers only. The only basic parameter of the INF TSI that is affected by the 'design track gauge' is the 'equivalent conicity' at design stage. All remaining parameters refer to the nominal value of track gauge.

<i>EN Line Category / EN Streckenklasse / EN Catégorie de ligne</i>	<i>4.2.7.4, Appendix E</i>	<i>The result of the classification process set out in the specification referenced in Appendix T, Index [2] and referred to in that standard as ‘Line Category’. It represents the ability of the infrastructure to withstand the vertical loads imposed by vehicles on the line or section of line for regular (‘normal’) service.</i>
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For the purpose of the INF TSI, “regular service” is equivalent to “normal service”.

<i>Swing nose</i>	<i>4.2.5.2</i>	<i>Within the domain of ‘common crossing with movable point’, the term ‘swing nose’ identifies the part of the crossing which forms the vee and that it is moved to form a continuous running edge for either the main or the branch line.</i>
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According to EN13232-7:2023, within the domain of “common crossing with movable point”, the term “swing nose” identifies the part of the crossing which forms the vee and that it is moved to form a continuous running edge for either the main or the branch line.

<i>Plain line / Freie Strecke / Voie courante</i>	<i>4.2.4.5 4.2.4.6 4.2.4.7</i>	<i>Section of track without switches and crossings.</i>
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In the context of the TSI, the concept of plain line applies both for tracks inside and outside stations.

2.11. Safety assurance over fixed obtuse crossings (Appendix J)

Definitions of “running edge” and “check (face) /” can be found in EN 13232-1:2023 and EN13232-6:2023.

3. APPENDICES

3.1. APPENDIX 1: standards referred to in the TSI and application of standards

The application of some standards listed in Appendix 1, but not referred to in the INF TSI, is not meant to be mandatory. In some cases, harmonised standards that cover the basic parameters of the TSIs provide presumption of conformity with certain clauses of the TSIs. In accordance with the spirit of the new approach to technical harmonisation and standardisation, the application of these standards remains voluntary but their references are published on the Official Journal of the European Union (OJEU). These specifications are listed in the TSI application guide in order to facilitate their use by the industry. These specifications remain complementary to TSIs.

Nevertheless, some standards listed in Table 4 are the same as the ones referred to in the INF TSI: the application of the sections of these standards quoted in the INF TSI is mandatory.

For a general information on Standards please refer to the “Guide for the Application of TSIs”. Table 4 contains the standards referred to in this guide; explanations on the usage of the standards are provided in the core text of the guide.

Table 4: List of standards referenced in this Application Guide

No	Point of INF TSI	Standard
1	4.2.3.1 Structure gauge	EN 15273–3:2013+A1:2016
2	4.2.3.2 Distance Between track centres	EN 15273–3:2013+A1:2016
3	4.2.7.1.2 Allowance for dynamic effects of vertical loads	EN 1991-2:2003/AC:2010
4	4.2.8 Immediate action limits on track geometry defects	EN 13848- 5: 2017
5	4.2.10.1 Maximum pressure variations in tunnels	EN 14067-5:2021/AC:2023
6	5.3.2 Rail fastening system	EN 13146-1:2019 EN 13146-4:2020
7	6.2.4.5 Cant deficiency for trains designed to travel with higher cant deficiency	EN14363: 2016+A2:2022 EN 15273- 3:2013+A1:2016
8	6.2.4.11 Assessment of platform offset	EN 15273-3:2013+A1:2016. EN15273-1:2013+A1:2016/AC:2017
9	Appendix J : Safety assurance over fixed obtuse crossings	EN 13232- 1:20232023 EN13232-6:20232023
10	Appendix S : Glossary : appendix S	EN13232EN 13232-7:2023

3.2. APPENDIX 2: track configurations which fulfil the requirement for the track design against equivalent conicity

Table 5 shows rail profiles in configuration with design track gauges and rail inclinations that fulfil the requirements of the INF TSI against design equivalent conicity. These track configurations are those mostly applied in the EU.

The assumptions and some other details for the calculations are included. Calculations were made for equivalent conicity at $\gamma = 3$ mm.

To assess whether the results of calculations were within the permitted limit, the equivalent conicity limit values listed in Table 10 of the INF TSI were taken.

The fact that a given track configuration fulfils the requirement of design equivalent conicity does not necessarily mean that the same track configuration is valid for any speed and/or axle load: other requirements (e.g., "Track resistance to applied loads", etc.) must be verified in order to determine whether a track configuration can be used on a given line.

Table 5: Track configurations that fulfil the requirement of point 4.2.4.5 "Equivalent Conicity" (Assessed with S1002 & GV 1/40)

Rail head profile	Design Track gauge [mm]	Rail inclinations for 60km/h <V ≤ 200 km/h	Rail inclinations for 200km/h <V ≤ 280 km/h	Rail inclinations for V>280 km/h
46 E1	1435	1:20	1:20	
	1437	1:20	1:20, 1:30, 1:40	1:20
46 E3	1435	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20, 1:30
49 E1	1435	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
49 E3	1435	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
49E5	1435	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20, 1:30, 1:40
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20, 1:30, 1:40
50 E3	1435	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
50 E4	1435	1:20, 1:30, 1:40	1:20	1:20
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
54 E1	1435	1:20, 1:30, 1:40	1:20	1:20
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
	1668	1:20	1:20	1:20

54 E2	1435	1:20, 1:30, 1:40	1:20, 1:40	1:20
	1437	1:20, 1:30, 1:40	1:20, 1:40	1:20
54 E3	1435	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
54 E4	1435	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20,1:30, 1:40
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20, 1:30, 1:40
56 E1	1435	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20, 1:30
60 E1	1435	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20, 1:30
	1668	1:20	1:20	1:20
60 E2	1435	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20, 1:30, 1:40
	1437	1:20, 1:30, 1:40	1:20, 1:30, 1:40	1:20, 1:30, 1:40
BS113a	1435	1:20	1:20	1:20
BS113a ⁱ	1435	1:20		

ⁱ Assessed with S1002, GV 1/40 and EPS.

3.3. APPENDIX 3: example of requirements for structures according to Traffic Code for a TSI category of line P2-P5-F1

This section contains further information and the application of the example in point 2.4.2 for the loading capability requirements for structures according to the combination of Traffic Codes P2, P5 and F1 for the speed range of 200-250 km/h.

For structures the Traffic Code P5 is noncritical in comparison with P2 and F1. For these structures examples P5 is included to demonstrate the principles for identifying the critical loading capability requirements from a combination of Traffic Codes and to demonstrate that the loading capability requirements for P2 and F1 exceed the loading capability requirements for P5.

Also, it is important to note that the requirements including values set out in 4.2.7.4 and Appendix E are not to be used for checking the compatibility of rolling stock with infrastructure. The requirements for such compatibility checks are set out in the OPE TSI point 4.2.2.5 and, in particular, in the OPE TSI Appendix D.1 for the Route Compatibility Check 'Traffic loads and load carrying capacity of infrastructure'. Also see the guidance on Table 2, Table 3 and Annex E.

3.3.1. Structures load carrying requirements for the design of a new line for Traffic Codes P2, P5 and F1

3.3.1.1. For the design of new bridges

General

For the design of new bridges, the load carrying requirements include:

- loading requirements based on static loading; and
- an allowance for the dynamic effect of rail traffic loading; and
- for some traffic codes additional dynamic loading requirements apply.

Load carrying requirements for the design of bridges – Static loading element

For the design of new bridges the load carrying requirements are set out by reference to the relevant load models in EN1991-2:2003/AC:2010, defining the vertical rail traffic actions (including an associated dynamic factor) to be taken into account in the design.

For the design of new bridges, the requirements in point 4.2.7.1 (including vertical loading, centrifugal force, nosing force, traction and braking and track twist requirements) are applicable with, for example, the vertical loading requirements defined in terms of α x Load Model 71 (for continuous decks and continuous structural elements of bridges, the additional load case of α x Load Model SW/0 also applies, as set out in point 4.2.7.1.1(b)) in conjunction with the allowance for the dynamic effects of vertical loads set out in point 4.2.7.1.2(1).

The minimum required value of the load multiplication factor alpha (α) is the smallest value that satisfies the requirements for the required Traffic Codes, which for this example are presented in the following table:

	Minimum value of $\alpha^{(1)}$
Traffic Code P2	1.0
Traffic Code P5	0.91
Traffic Code F1	1.0
Determinant value of α for a TSI Category of Line comprising of Traffic Codes P2, P5 and F1	1.0

Note 1: Minimum value of alpha is set out in Table 11 (4.2.7.1.1)

Load carrying requirements for the design of bridges – Allowance for the dynamic effect of rail traffic loading

To allow for the increase in rail bridge loading due to the speed of rail traffic, the above static loading is multiplied by the dynamic factor set out in point 4.2.7.1.2(1) by reference to the dynamic factor defined in EN1991-2:2003/AC:2010.

Additional dynamic loading requirements

In this example the maximum required speed exceeds 200km/h (see speed range for Traffic Code P2) and for bridges where the local allowed speed is above 200km/h and where EN1991-2:2003/AC:2010 requires a dynamic analysis to be carried out then in addition the bridge is to be designed for the load model HSLM set out in point 4.2.7.1.2(2) by reference to the load model HSLM defined in EN1991-2:2003/AC:2010.

Also see the guidance on load model HSLM in the guidance on TSI INF point 4.2.7.1.2 and in Appendix E.

3.3.1.2. For the design of new geotechnical structures including earthworks

For the design of new geotechnical structures including earthworks, the load carrying requirements are set out by reference to EN1991-2:2003/AC:2010, and define the vertical rail traffic actions to be taken into account in the design.

For the design of new geotechnical structures including earthworks, the requirements in point 4.2.7.2 are applicable with the vertical loading requirements defined in terms of $\alpha \times$ Load Model 71.

The minimum required value of the load multiplication factor alpha (α) is the smallest value that satisfies the requirements for the required Traffic Codes which for this example are presented in the following table:

	Minimum value of $\alpha^{(1)}$
Traffic Code P2	1.0
Traffic Code P5	0.91
Traffic Code F1	1.0
Determinant value of α for a TSI Category of Line comprising of Traffic Codes P2, P5 and F1	1.0

Note 1: Minimum value of alpha is set out in Table 11 (4.2.7.1.1)

3.3.2. Structures load carrying requirements for existing structures on an existing line for Traffic Codes P2, P5 and F1

3.3.2.1. Minimum requirements for existing bridges

General

The load carrying requirements include:

- vertical loading requirements based on static loading (alternative(s) are given); and
- the requirement to take the specified speed of rail traffic into account; and
- for some traffic codes additional dynamic loading requirements apply.

Load carrying requirements for existing bridges - Static loading element

The load carrying requirements applicable to existing bridges on an existing line are generally set out by reference to the relevant EN Line Categories defined in EN15528:2021 and an associated speed to be taken into account.

The requirements in point 4.2.7.4 and Appendix E (particularly Table 38A and Table 39A) are applicable with the requirements specified according to type of rail traffic. A summary of all the static loading elements of the vertical loading requirements for this example is presented in the following table:

	Minimum value of the combined quantity of EN Line Category (EN15528) and speed
Traffic Code P2	D2-200**
Traffic Code P5	C2-120 B1-120
Traffic Code F1	D4-120
Determinant* minimum vertical loading requirements for a TSI Category of Line comprising of Traffic Codes P2, P5 and F1	D2-200* and D4-120

* In this example, the vertical loading requirement for D2 is greater than or equal to C2 at the same speed for all bridge spans. When taking speed into account, D2-200 is also greater than C2-120 for all bridge spans. Similarly, the vertical loading requirement for D4-120 is greater than C2-120 for all spans, and C2-120 is greater than B1-120 for all spans. For very long spans where the dynamic factor for real trains is very close to unity, D4-120 is greater than D2-200. Otherwise, D2-200 is greater than D4-120 for short spans. Hence the requirement for an existing bridge to satisfy both D2-200 and D4-120. Further guidance on the relativity of the vertical loading requirements of the EN Line Categories is set out in EN15528:2021. Where it is not clear which loading criteria is critical, all the relevant loading cases are to be taken into account.

** The alternative vertical loading requirement based on Load Model 71 may be used (for continuous bridge decks and continuous bridge elements, as set out in point 4.2.7.1.1(b), the additional load case of $\alpha \times$ Load Model SW/0 shall be taken into account) with the load multiplication factor alpha (α) = 0.91 (in conjunction with the dynamic factor set out in 4.2.7.1.2(1)).

Load carrying requirements for bridges - Allowance for the dynamic effect of rail traffic loading

To take speed into account, the approach recommended to be adopted should follow industry practice by multiplying the above static loadings defined by an EN Line Category (EN15528:2021) by a dynamic factor for real trains, to allow for the increase in loading due to the maximum local allowed speed. The dynamic factor set out in point 4.2.7.1.2(1) is not valid for use with real trains or an EN Line Category (EN15528:2021). Examples of the dynamic factor that may be used for real trains or EN Line Categories may be found in Annex C of EN1991-2:2003/AC:2010, the UIC leaflet "UIC 776-1R Loads to be considered in railway bridge design, Paris, 2008" and national rail bridge recalculation standards.

Additional dynamic loading requirements

In this example, the maximum required speed range exceeds 200km/h (see speed range for Traffic Code P2) and it is assumed that the local allowed speed is 250km/h. In addition to the above loading requirements based on static loading, the dynamic loading requirements for an existing bridge shall be load model HSLM defined in EN1991-2:2003/AC:2010, with this requirement checked using a method based on a dynamic analysis. If the load model HSLM requirement is not satisfied, then note 8 in Appendix E sets out alternative dynamic loading requirements.

Guidance on when a dynamic analysis is required for local allowed speeds below 200km/h is set out in EN 15528:2021 Annex C.

See also the guidance in Appendix E regarding:

- 'Additional requirements relating to when a dynamic analysis is necessary and the associated loading capability requirements' and
- 'Managing the risk of excessive dynamic effects including resonance in existing bridges'.

Load carrying requirements for existing bridges - Alternative static loading element based on Load Models 71 and SW/0

As an alternative to the above static loading requirements set out in terms of a combined quantity of an EN Line Category (EN15528:2021) and speed, it is permissible for an existing bridge to meet the requirements for the corresponding Traffic Code for the design of new bridges as set out in point 6.2.4.10(c) and point 4.2.7.1. In point 4.2.7.1, the vertical loading requirements are defined in terms of α x Load Model 71 (for continuous decks and continuous structural elements of bridges, the additional load case of α x Load Model SW/0 shall be taken into account, as set out in point 4.2.7.1.1(b) in conjunction with the allowance for the dynamic effects of vertical loads set out in point 4.2.7.1.2(1)).

The minimum required value of the load multiplication factor alpha (α) is the smallest value that satisfies the requirements for the required Traffic Codes which for this example are presented in the following table:

	Minimum value of $\alpha^{(1)}$
Traffic Code P2	1.0
Traffic Code P5	0.91
Traffic Code F1	1.0
Determinant value of α for a TSI Category of Line comprising of Traffic Codes P2, P5 and F1	1.0

Note 1: Minimum value of alpha is set out in Table 11 (4.2.7.1.1)

3.3.2.2. *Minimum requirements for existing geotechnical structures including earthworks*

The minimum requirements for existing geotechnical structures including earthworks are generally set out in Appendix E by reference to the relevant EN Line Categories defined in EN15528:2021.

The load carrying requirements applicable to existing geotechnical structures including earthworks are set out in point 4.2.7.4 and Appendix E (particularly Table 38B and Table 39B), with the requirements specified

according to type of rail vehicle. A summary of all the vertical loading requirements for this example is presented in the following table:

	Minimum value of EN Line Category (EN15528)
Traffic Code P2	D2
Traffic Code P5	C2 B1
Traffic Code F1	D4
Determinant* minimum vertical loading requirements for a TSI Category of Line comprising of Traffic Codes P2, P5 and F1	D4

* The vertical loading of D4 covers D2, C2 and B1. Further guidance on the relativity of the vertical loading requirements of EN Line Categories is set out in EN15528:2021. Where it is not clear which loading criteria is critical, all the relevant loading cases shall be taken into account.

Alternative requirements based on Load Model 71

As an alternative to the above loading requirements set out in terms of an EN Line Category (EN15528:2021), it is permissible for an existing geotechnical structure including an earthwork to be in accordance with point 6.2.4.10(c) which refers to point 4.2.7.2.

In point 4.2.7.2, the vertical loading requirements are defined in terms of $\alpha \times$ Load Model 71. The minimum required value of the load multiplication factor alpha (α) is the smallest value that satisfies the requirements for the required Traffic Codes which for this example are presented in the following table:

	Minimum value of $\alpha^{(1)}$
Traffic Code P2	1.0
Traffic Code P5	0.91
Traffic Code F1	1.0
Determinant value of α for a TSI Category of Line comprising of Traffic Codes P2, P5 and F1	1.0

Note: Minimum value of alpha is set out in Table 11 (4.2.7.1.1)