

BS EN 15528:2015



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Railway applications — Line categories for managing the interface between load limits of vehicles and infrastructure

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

The UK participation in its preparation was entrusted by Technical Committee RAE/1, Railway Applications, to Subcommittee RAE/1/-/8, Railway Applications - Vehicle/Track Interaction.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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English Version

**Railway applications - Line categories for managing the
interface between load limits of vehicles and
infrastructure**

Applications ferroviaires - Catégories de ligne pour la
gestion des interfaces entre limites de charges des
véhicules et de l'infrastructure

Bahnanwendungen - Streckenklassen zur Behandlung
der Schnittstelle zwischen Lastgrenzen der Fahrzeuge
und Infrastruktur

This European Standard was approved by CEN on 22 August 2015.

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European foreword

This document (EN 15528:2015) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2016, and conflicting national standards shall be withdrawn at the latest by April 2016.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 15528:2008+A1:2012.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2008/57/EC.

For relationship with EU Directive 2008/57/EC, see informative Annex ZA, which is an integral part of this document.

Significant technical changes between this European Standard and the previous edition are:

- Extension of the range of Line Categories
 - new Line Categories a10, a12 and a14 to cover light passenger vehicles (Urban Rail);
 - new Line Categories D5 and E6 to optimize the payload for freight wagons.
- Providing information and guidance for additional dynamic checks, for higher speeds and certain vehicle types.
- Implementation of MU-classes alternative to individual train checks.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

The existing European railway infrastructure consists of elements designed for varying historical requirements. Most civil engineering railway infrastructure was built before the introduction of the Technical Specifications for Interoperability (TSIs) and the Eurocodes for the design of structures.

This European Standard defines a line classification system for infrastructure managers and railway undertakings to manage the interface between the load limits for railway vehicles and the payload limits for freight wagons and the vertical load carrying capacity of a line.

The line classification system takes into account parameters such as:

- axle load (P);
- geometrical aspects relating to the spacing of axles;
- mass per unit length (p);
- speed;

and provides a transparent method for determining whether the vertical loading characteristics of vehicles are compatible with the load carrying capacity of lines on the network.

The line classification system utilizes a suite of line categories with each line category defined in this standard by a load model.

1 Scope

This European Standard describes methods of classification of existing and new railway lines and the categorization of vehicles. The standard specifies the technical requirements for ensuring the compatibility of the interface between a vehicle and infrastructure with respect to the vertical load carrying capacity of a line. The standard is suitable for use on freight, passenger and mixed traffic lines with standard track gauge and wider than standard track gauge. It contains requirements relevant to:

- classification of the vertical load carrying capacity of railway infrastructure;
- design of railway vehicles;
- determination of payload limits of freight wagons.

A summary of the classification of infrastructure and the categorization of vehicles is given in Annex B.

The assessment of the vertical load carrying capacity of civil engineering structures, track, sub-grade and earthworks by the use of the load models defined in Annex A permits the classification of infrastructure into line categories.

This European Standard identifies on which lines vehicles are compatible to the infrastructure for regular traffic regarding vertical load effects.

Line categories are provided for:

- all traffic types;
- heavy freight traffic;
- locomotives;
- multiple units;
- lightweight passenger traffic.

Portable trolleys as defined by EN 13977 are outside the scope of this European Standard as well as the working mode of maintenance vehicles (e.g. rail mounted plant, cranes).

This European Standard does not cover the system used in Great Britain, where all lines and vehicles are classified in accordance with the RA (Route Availability) System. A guide to the equivalent categories in accordance with this European Standard is given in Annex Q.

This European Standard does not cover requirements relating to the maximum total mass or maximum length of a train.

The requirements of this European Standard do not replace any regulations related to running behaviour of vehicles described by the assessment quantities for running safety, track loading and ride characteristics (see EN 14363).

This Standard does not impose any requirements to vehicles or infrastructure, but gives guidance to a simplified management of the interface between vehicles and infrastructure.

Publication of line categories is outside the scope of this European Standard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1991-2:2003, *Eurocode 1: Actions on structures — Part 2: Traffic loads on bridges*

EN 15663:2009¹⁾, *Railway applications — Definition of vehicle reference masses*

EN 15877-1, *Railway applications — Marking on railway vehicles — Part 1: Freight wagons*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

associated maximum speed

local maximum speed for which the line category is valid

3.1.2

axle load

P

sum of the static vertical wheel forces exerted on the track through a wheelset or a pair of independent wheels divided by g

Note 1 to entry: In this standard “load” and “force” are described with units of “mass” (kg or t).

3.1.3

axle load

P_i

axle load P of the axle i

3.1.4

axle spacing

design values of the distances between the centres of adjacent axles

3.1.5

bending moment

designation of an internal force of a beam as used in structural design

3.1.6

categorization of vehicles

statement of the vertical loading characteristics of a railway vehicle, according to the combination of axle loads and axle spacing, by allocation of a line category

1) This document is currently impacted by the corrigendum EN 15663:2009/AC:2010.

3.1.7

classification of infrastructure

statement of the load carrying capacity of infrastructure on a line by allocation of a line category and related speed information

3.1.8

compatibility

demonstration of the satisfactory interface between the load effects of the vehicles and the load capacity of the infrastructure

3.1.9

design mass under normal payload

mass of vehicle equipped with all the consumables and occupied by all staff, which it requires in order to fulfil its function plus the normal payload defined in EN 15663 as implemented by Annex D

3.1.10

design mass under exceptional payload

mass of vehicle equipped with all the consumables and occupied by all staff, which it requires in order to fulfil its function plus the exceptional payload defined in EN 15663 as implemented by Annex D

3.1.11

length over buffers

L

length over buffers or between coupling planes in case of no buffers

3.1.12

line category

designation of the specific load model based on reference wagons

3.1.13

line speed

general maximum speed of traffic on a route

3.1.14

load limit

maximum allowable payload for a wagon related to each line category

3.1.15

load model

defined by a specific formation of reference wagons

3.1.16

locomotive

traction vehicle that is not intended to carry a payload

Note 1 to entry: In this standard, power heads are considered as locomotives.

3.1.17

locomotive class

reference vehicle with representative locomotive parameters

3.1.18

mass per unit length

p

mass of a vehicle or unit divided by length over buffers

3.1.19

maximum passenger traffic speed/maximum freight traffic speed

additional information provided by the infrastructure manager giving the general limit to the maximum traffic speed on a line according to the type of traffic

3.1.20

reference wagon

virtual vehicle used as a module of loading for a load model defined by axle load, axle spacing and mass per unit length

3.1.21

multiple unit

MU

fixed formation or railcar that can operate as a train not intended to be reconfigured, except within a workshop environment

3.1.22

MU-group

group of MU-trains determined according to the predominant running gear within the unit (conventional bogie, articulated bogie, single axle)

3.1.23

MU-class

defined by the train parameters, axle spacing pattern and axle load within a MU-group

3.1.24

passenger carriages

vehicles without traction: coaches, restaurant cars, sleeping cars, couchettes cars, vans, driving trailers, car carriers and similar vehicles, intended to be integrated in a variable formation as passenger train

3.1.25

series of locomotives

locomotives designed to be equal (the same axle spacing and the same nominal values for mass m_{nom} and, axle loads $P_{i,\text{nom}}$)

3.1.26

shear force

designation of an internal force of a beam as used in structural design

3.1.27

special vehicles

vehicles which are designed for maintenance, inspection or renewal of infrastructure elements or for special transport purposes where the fleet is operated with a low mileage compared to normal railway vehicles including:

a) maintenance vehicles including:

1) cranes and matching wagons;

- 2) on-Track Machines (see EN 14033 (all parts));
- 3) road rail machines (see EN 15746 (all parts));
- 4) demountable machines (see EN 15955 (all parts));
- 5) trailers (see EN 15954 (all parts));
- b) monitoring and inspection vehicles, including:
 - 1) track inspection vehicles;
 - 2) catenary inspection vehicles;
- c) special transport vehicles, including:
 - 1) transformer transporter;
 - 2) crucible transporters;
 - 3) loaded wagons with more than 8 axles (UIC 502-1)

3.1.28 wheel load

Q
static vertical wheel/rail contact forces divided by g

Note 1 to entry: The terminology in this standard for “load” and “force” is used with the meaning and units of “mass” (kg or t).

3.1.29 wheel load

Q_i
wheel load Q of the axle i

3.2 Symbols and abbreviated terms

$1 + \varphi'$	Dynamic factor	—
$1 + \varphi'_{\text{UIC}}$	Limit value of the dynamic factor as defined in UIC 776-1	—
$2a^*$	Bogie spacing between pivot centres within a vehicle	m
$2a^*_{\text{adopted}}$	Adopted value of $2a^*$ used in Annex U	m
$2a^*_{\text{table}}$	$2a^*$ value in tables of Annex U	m
$2a^*_{\text{unit}}$	$2a^*$ value of a MU unit used in Annex U	m
$2a^+$	Axle spacing in a bogie	m
$2a^+_{\text{table}}$	$2a^+$ value in tables of Annex U	m
$2a^+_{\text{unit}}$	$2a^+$ value of a MU unit used in Annex U	m
AB	Articulated bogie	Unit
a	Distance between axles	m

b	Distance from end axle to the end of the nearest coupling plane	m
c	Distance between two inside axles	m
CB	Conventional bogie	—
ETCS	Electronic Train Control System	—
HSLM	High Speed Load Model	—
d_n	Distance between axle n and axle $(n-1)$	m
g	acceleration due to gravity	9,81 m/s ²
L	Length over buffers	mm
L_{Coa}	Coach length	m
m	Mass	t
m_{nom}	Nominal values for mass	t
$m_{\text{nom,excess}}$	Modified nominal value for mass due to excess of tolerances	t
MU	Multiple unit	—
No_{Coa}	Number of coaches within a unit	—
No_{Units}	Number of units within a train	—
n	Axle number	—
n_0	Natural frequency	Hz
p	Mass per unit length	t/m
P	Axle load	t
P_i	Axle load of axle i	t
$P_{i,\text{nom}}$	Nominal value for axle load of axle i	t
$P_{\text{LineCategory}}$	Maximum axle load for a Line Category	t
P_{MUclass}	Maximum axle load for a MU-class	t
$P_{\text{nom,excess}}$	Modified nominal value for axle load due to excess of tolerances	t
P_{red}	Reduced value of axle load	t
P_{unit}	Maximum axle load within the unit	t
Q	Wheel load	t
Q_i	Wheel load of axle i	t
$Q_{i\text{r}}/Q_{i\text{l}}$	Wheel load of axle i right or left	t
RA	Route Availability	—
SA	Single axle	—
s_n	Distance between axle n and axle 1	m
$u1+u2$	Bogie spacing between pivot centres of adjacent vehicles	m
$u3$	Overhang of end coaches	m
u_{unit}	Overhang value of a MU unit used in Annex U	m
u_{table}	Overhang value in tables of Annex U	m

UIC	International Union of Railways	—
V	Speed	km/h

4 Classification system

4.1 Definition of line categories

The use of a classification system using line categories permits easy understanding of the load-related compatibility of vehicles and infrastructure.

The line category resulting from the classification process for infrastructure represents the ability of the infrastructure (track, track substructures, earthworks, civil engineering structures) to withstand the vertical loads imposed by vehicles on the line or section of line for regular service.

Each line category (a10, a12, a14, A, B1, B2, C2, C3, C4, D2, D3, D4, D5, D4xL and also E4 and E5, E6) is defined by a load model based on reference wagons defined by the characteristics given in Annex A:

- axle load;
- geometrical characteristics of the spacing of axles;
- length of the vehicle.

The value “mass per unit length” of the reference wagon is determined from the above parameters.

4.2 Correlation to types of vehicles

The load effects of different vehicle types are compared to the load models defining the different line categories.

All types of vehicles and freight wagons with their corresponding payload are covered by the line categories A, B1, B2, C2, C3, C4, D2, D3, D4.

Line categories D5, E4, E5 and E6 are defined exclusively for heavy freight wagons.

Locomotives can be covered by:

- line categories B1, B2, C2, C3, C4, D2, D3, D4 and D4xL (plus optional detailed specification for axle spacing ranges);
- locomotive classes L4 and L6.

Passenger carriages and Multiple Units can be covered by:

- line categories a10, a12, a14, B1, C2, D2 (plus optional detailed specification for axle spacing and vehicle lengths). Line categories a10, a12 and a14 have been specially developed for light rail vehicles with up to 14 t axle loads.
- MU-groups and MU-classes, which are provided to assist additional compatibility checks between infrastructure and vehicles where there is a risk of excessive dynamic effects in bridges.

For rail vehicles or wagons with payload limits categorized above D4 or D4xL it is recommended that the infrastructure manager and railway undertaking consider the use of static and dynamic wheel load measuring devices attached to the track and/or fitted to vehicles to assist with ensuring compliance with the requirements of this European Standard.

4.3 Correlation between line category and speed

4.3.1 Introduction

The classification of infrastructure applies to all types of railway vehicles, which can have different maximum speeds (e.g. freight and passenger traffic). Additional information defining the maximum speed corresponding to the line category shall be stated.

As a result of the classification of infrastructure, additional information specifying the line classification can be given to cover two or more combinations (e.g. different maximum speeds and associated line categories for passenger and freight trains).

NOTE Examples illustrating information about line classification and relationship with speed are given in Annex H.

The combinations used for publication should be in accordance with legal, technical and operational requirements (e.g. ETCS ²⁾ speed levels).

The local line speed shall be taken into account for the classification of engineering structures (see 5.1) and other relevant infrastructure elements (see 5.2).

The line category and associated maximum speed shall be considered as a single combined quantity.

4.3.2 Freight traffic

When classifying infrastructure lines into line categories, the line category at maximum freight traffic speed (maximum 120 km/h) shall be determined.

120 km/h corresponds to the maximum speed for conventional freight traffic and is the limit of validity for freight traffic using line categories. In excess of 120 km/h individual checks shall be carried out.

Optionally, an additional higher line category at an associated lower speed (less than the maximum freight traffic speed) may be determined.

NOTE In some situations it may be desirable to determine the line category at a lower speed to maximize the line category.

In addition, for D5, E4, E5 or E6 lines, an associated maximum speed for such traffic shall be stated together with the associated maximum speed for conventional line traffic of line category D4.

4.3.3 Mixed traffic and passenger traffic

On mixed traffic lines with passenger traffic, the line category at maximum freight traffic speed in 4.3.2 is generally sufficient and appropriate for the optimization of freight traffic.

For vehicles and locomotives, categorized into the same or lesser line category as the line, and which run faster than the maximum freight traffic speed, additional checks starting on the basis of the maximum freight traffic speed shall be taken into account for the classification of engineering structures (see 5.1) and other relevant infrastructure elements (see 5.2).

For speeds over 120 km/h and up to the maximum line speed, the different combinations of line categories-with speed shall be in accordance with general technical and operational requirements or restrictions.

NOTE Line Categories as classification information for speeds over 120 km/h may be related to vehicle types or types of traffic. Additional compatibility checks at different speed levels for different vehicle types may be required to demonstrate compatibility (see 5.1.2 and Annex F).

2) European Train Control System.

5 Classification of infrastructure

5.1 Civil engineering structures

5.1.1 Classification

When classifying a railway line into line categories, the load carrying capacity of structures supporting the track on the line shall be determined and expressed using the load models of Annex A taking speed into account. The speed(s) and where relevant traffic types shall be in accordance with 4.2 and 4.3.

The method used to determine the load carrying capacity of structures (bridges and other structures supporting the track) shall take account of the condition of the existing structures and be in accordance with national requirements.

NOTE Examples of typical methods used to determine the load carrying capacity of structures are given in Annex G.

The assessment of the load capacity of structures shall take the following into account:

- load models and combination of vehicles shall be applied to produce the most onerous load effects (e.g. on continuous beams parts of the load model which produce a relieving effect shall be neglected);
- dynamic load effects (e.g. using the dynamic factor for real trains in EN 1991-2:2003, Annex C);
- partial safety factors for railway loading due to mass tolerances and potential overloading (see 6.2);
- existing operating and other restrictions relating e.g. to different types of traffic.

When determining the line classification and maximum operating speed for locomotives, account may be taken of the reduced likelihood of overloading and cargo displacements (in comparison with other traffic types). Any reduction in partial safety factors for railway loads should be in accordance with national requirements.

The load models defined in Annex A are for the classification of lines and are not to be used for the design of new structures. For the design of new structures the rail traffic loading given in EN 1991-2 shall be used.

The resulting output of the classification process of each structure on a line shall satisfy the requirements of Clause 4.

5.1.2 Dynamic checks

To address the potential risk of adverse bridge dynamic effects, resulting from resonance and other excessive dynamic effects in the structure, the need to carry out additional dynamic checks shall be considered according to the risk arising from the combination of vehicle type and speed.

NOTE 1 Annex F provides guidance on combinations of vehicle type and speed which do not require dynamic compatibility checks on existing bridges.

Where it is identified that dynamic checks are required:

- the maximum bridge deck accelerations under the track shall be assessed;
- allowances for the dynamic increase in load effects in the structure shall be checked (e.g. the adequacy of the dynamic factor for real trains in EN 1991-2:2003, Annex C applied to the static loading).

When investigating the dynamic response of bridges, the following parameters shall be taken into account:

- bridge parameters such as structural type, span, mass, natural frequencies, damping and stiffness, for example;
- train data such as formation of vehicles, coach lengths, axle load as specified in Annex D, and axle spacing, for example;
- speed range.

Guidance on carrying out dynamic calculations on a range of bridges is given in Annex P.

To reduce the effort of carrying out dynamic checks, a proposed train can be compared to trains or load models (MU-classes or HSLM ³⁾) for which compatibility with bridges on the line has been previously demonstrated using methods which allow for dynamic effects.

Load models of MU-classes covering the dynamic excitation of different families of real individual MU's are defined in Annex E. Dynamic calculations made with these load models cover the evaluation of the effects of these families.

The results of the dynamic analysis can be used to assist the decision on the compatibility of either individual trains or MU-classes with the infrastructure.

If a proposed train is within the scope of a MU-class that has previously been demonstrated to be compatible with the infrastructure, then no further checks are needed to demonstrate compatibility (see 6.5 and Annex C). Otherwise, the normal procedure for an individual train check is required.

If infrastructure compatibility for an MU-class is not demonstrated or achieved, individual train checks can be performed to check compatibility.

NOTE 2 Annex S provides information on typical loco hauled passenger trains that may be used for dynamic checks.

5.2 Track construction, track substructure and earthworks

The load carrying capacity of the track, track substructure and earthworks shall be determined in accordance with national requirements. Typically such methods take account of the type of rail and track components, sleeper spacing, track geometry, track quality, annual tonnage of traffic, inspection and maintenance regimes and other national requirements, etc.

The limit values for cant deficiency for lines with track gauges wider than nominal track gauge may be modified according to EN 13803-1.

For E4 and E5 traffic, a maximum service speed of 100 km/h and a maximum cant deficiency of 100 mm are recommended. For E6 traffic a maximum speed of 80 km/h is recommended.

In order to establish an appropriate maximum speed for wagons with axle loads greater than 22,5 t for proposed speeds > 100 km/h, special studies should be undertaken to check the dynamic effects on the track.

The infrastructure manager shall determine the correspondence between the local track classification system and the line classification system defined in this European Standard. Annex O shows an example of the correspondence.

The results shall be used to determine the line classification in accordance with this European Standard with respect to the load carrying capacity of the track, track substructure and earthworks.

3) High speed load model defined in EN 1991-2.

5.3 Infrastructures classification results

The classification of a line or a section shall be taken as the lesser of:

- the line classification of civil engineering structures determined in accordance with 5.1;
- the line classification of track, track substructures and earthworks determined in accordance with 5.2;
- relevant associated requirements relating to speed in accordance with 5.1.2;
- other general requirements including requirements relating to maximum permitted speeds for different types of traffic and operating restrictions;
- additional qualifications relating to the validity of the line classification.

The result of infrastructure classification shall include the permissible line category(ies) and their associated maximum speed(s) of each line or section of line. If necessary, additional speed regulations and operating requirements relating to locomotives (e.g. locomotive classes and associated maximum speed) or traffic types (e.g. maximum speed of freight traffic or passenger traffic) shall be considered.

For publication and implementation, the result of the infrastructure classification due to this standard should be adjusted according to international and national requirements including legal, technical and operational requirements.

Where the line classification related to associated speed is D4xL, D5, E4, E5 or E6, the maximum speed for line category D4 shall also be stated.

NOTE Examples of line classification result are given in Annex H.

6 Categorization of railway vehicles

6.1 General rules

The categorization of a vehicle by line category or the determination of payload limits for a freight wagon defined by line category represents the static vertical load effects produced by the vehicle or freight wagon.

A vehicle is appropriate to a line category, when the static vertical load effects produced by the vehicle to be investigated are equal to or do not exceed the static load effects produced by the reference wagon (see Annex A) of this line category. The axle loads, the number of axles, the axle spacing and the length of the vehicle are required for comparison with the static load effects produced by the reference wagons.

The line category of a vehicle or the permissible payload of vehicles shall be determined such that the maximum bending moments and maximum shear forces on a single beam of any span length, and throughout the span, for any position of load across the span due to the vehicle being categorized, do not exceed the values calculated for the load models defined in Annex A. In the calculations, the vehicle being categorized shall be represented by an unlimited number of the vehicles formed into a train, unless specified differently (e.g. see 6.6).

For non-symmetric vehicles (e.g. where the end overhang at each end of the vehicle is different or the axle loads vary along the length of the vehicle) the most onerous orientation of the vehicle (or fixed formation) shall be used.

Where the vehicle(s) operate in a predefined or fixed formation, the formation (single or required number of coupled formations) shall be compared with the load models of line categories defined in Annex A (e.g. for multiple units or cranes). Two cases shall be considered: a train comprising the most

onerous arrangement of the fixed formations and the fixed formation incorporated into a train of the reference wagons.

Simply supported spans from 1,0 m to 100,0 m shall be checked. The maximum span increments shall not exceed the values in Table 1.

Table 1 — Maximum span increments depending on span length

span range [m]	maximum span increment [m]
1,0 to 10,0	0,2
10,0 to 20,0	1,0
20,0 to 60,0	2,0
60,0 to 100,0	5,0

NOTE 1 An example of the application of the method is given in Annex I.

NOTE 2 The determination of maximum bending moments and maximum shear forces can be undertaken using influence lines or multilevel approximation methods.

Annexes J, K, L, T and U provide tables to determine the corresponding line category without any calculation, if the specified conditions are fulfilled.

The axle load distribution of each vehicle shall be determined by measurement for the load condition design mass in working order according to EN 15663 (for freight wagons, this load condition is equal to tare condition). For locomotives and passenger carrying vehicles single wheel loads shall be measured.

If any of the items (e.g. staff masses, parts of the fuel and consumables, wear of wheels) are not included in the measured weights, adjustments shall be made by calculation.

Based on the measured weight results, any missing payload components (e.g. passenger mass) up to the relevant mass condition (see Table 2 and Annex D) shall be completed by calculation.

Within a series of vehicles of the same type, the nominal values of mass m_{nom} and axle loads $P_{i,nom}$ shall be considered the same.

To determine the line category (or the locomotive class) of a vehicle type, the nominal axle loads in the load cases specified in column B of Table 2 shall be used. If all individual vehicles within the same type are within the tolerances given in columns C to D of Table 2 their compliance with the vehicle type is demonstrated.

If the tolerances used for a vehicle type exceed these acceptable tolerances, the excess load shall be added to the nominal axle load and nominal masses used for the determination of the line category for the vehicle type.

If some values of a single vehicle are outside this acceptable tolerance, the excess load shall be added to the nominal axle load and nominal masses. These new values shall be used for the determination of the line category for this single vehicle.

If a single vehicle or vehicle type is modified leading to loads outside the acceptable tolerance field, the excess load shall be added to the nominal axle load and nominal masses. These new values shall be used for the determination of the line category for the single vehicle or the vehicle type.

NOTE 3 In some of these cases an adjustment of the nominal values m_{nom} and $P_{i,nom}$ may be adequate to allow all values to satisfy the tolerances in Table 2.

NOTE 4 For freight wagons a change of tare or change of axle distribution requires a check of the payload values in the wagon load table.

Table 2 — Tolerances specified for categorization of vehicles into line categories

A	B	C	D	E
Vehicle Type	Load case for determination of nominal values used for categorization of vehicles	Acceptable tolerances and deviations for the use of nominal values for categorization of vehicles		
		Mass m	Axle load P_i	Wheel load Q_{ir} or Q_{il}
Wagons	Design mass under normal payload (max payloads specified in the load table of the vehicle) according to EN 15663	a	≤ 100 kg on each individual axle load a	b
Locomotives ^c	Design mass in working order according to EN 15663	≤ 3 %	≤ 3 %	≤ 5 % of the mean wheel load of each individual axle
Passenger Carriages Multiple Units	Design mass with payload according to Annex D	≤ 3 %	≤ 3 %	≤ 5 % ^d
Special vehicles	Self-propelled special vehicles shall be treated as locomotives, the others as a wagon. For predefined or fixed formations made up of various types of vehicles, the approach used for each vehicle in the formation shall correspond to the type of vehicle.			

^a The tare weight of the wagon (corresponding to design mass in working order) plus the payload of the relevant line category (marked on the wagon load table), taking into account the UIC Loading Guidelines [9], generate the maximum mass and maximum axle load. The payloads of the load table shall be revised, if changes in axle load of more than 100 kg, whether as a result of technical alterations or as a change of the axle load distribution, occur.

^b The ratio of the two wheel loads on each axle shall not exceed $10/8 = 1,25$ in any loaded condition. Additionally, the sum of both wheel loads shall not exceed the axle load relevant for line category (UIC Loading Guidelines [9]).

^c See Annex R for an example of a weight note used to assist with determining the axle loads used for categorizing locomotives.

^d Each individual wheel load according to load condition design mass with payload according to Annex D shall not exceed 5 % of half of the maximum axle load corresponding to the relevant line category. This shall be checked taking into account the measured wheel load distribution in tare condition with a calculated allowance for payload including any eccentricity of the centre of gravity of the payload.

If the nominal values of mass or axle load or the axle arrangement of a vehicle type are changed (e.g. due to any modification in design or later), a re-categorization (or re-calculation of payload limits in the case of freight wagons) shall be undertaken. In that case compliance with tolerances for the new nominal weight and axle load shall be demonstrated by new measurements of wheel and/or axle load.

6.2 Freight wagons

6.2.1 Specific rules for freight wagons

The compatibility of freight wagons and their loads with the load capacity of lines is determined by their geometrical and load characteristics, i.e. axle spacing, axle loads and the resulting mass per unit length.

The payload limit according to line category shall be determined according to 6.1.

The maximum permissible payload and axle load for each type of wagon corresponding to each line category can be calculated as shown in Annex I. Alternatively, permissible axle loads for 4- and 6-axle wagons are given in Annex J and Annex K, which can be used to determine the maximum permitted payloads.

The above payload limits are only valid if the permissible payload is evenly distributed over the length of the wagon. In the case of longitudinally displaced or unevenly distributed loading, the payload shall be reduced, so that the value of the permissible axle load is not exceeded.

As an exception 20 t axle loads may be exceeded by up to 0,5 t on category C lines for:

- 2-axle wagons with 20 t axle loads and $14,10 \text{ m} < \text{length over buffers} < 15,50 \text{ m}$ to bring their payload up to 25 t;
- wagons designed for 22,5 t axle loads to offset the extra tare incurred in making them suitable for such axle loads;
- the maximum permissible wheel load shall be 11,1 t.

6.2.2 Resulting load limits for freight wagons

The results of the calculation of the maximum payload of a wagon for each line category determined according to 6.1 and 6.2.1 is shown in Annex I and shall be marked in the wagon load table according to EN 15877-1.

Where lower load limits are required by specific regulations (e.g. speed restrictions, braking) these lower values shall be used.

The tare of a wagon shall be rounded up to the nearest tenth of a tonne.

Groups of wagons with the same equipment shall be identified within each major manufacturing series (e.g. wagons with air brakes, wagons with air brakes and gangway fitted with a screw brake). For each group of wagons, a nominal tare value shall be determined and used in the calculations, if the tare of each wagon of this group is within the tolerances for wagons given in columns C to D of Table 2. Alternatively, the measured weight of an individual wagon can be used to determine the payload limit for the corresponding wagon.

The corresponding payload marked on the wagon load table shall be rounded down to the nearest tenth of a tonne.

6.3 Locomotives

6.3.1 General

Locomotives shall be categorized into line categories.

6.3.2 4-axle locomotives

Generally, the relevant parameters for categorization of 4-axle locomotives are axle load P (18 t to 22,5 t) and the bogie axle spacing (2,2 m to 3,4 m).

Typically the mass per unit length is less than 6,4 t/m and the distance from the end axle to the end of the nearest coupling plane is greater than 1,9 m.

Subject to satisfying the above criteria the maximum axle load determines the line category:

- line category D2: $20\text{ t} < \text{maximum axle load } P \leq 22,5\text{ t}$;
- line category C2: $18\text{ t} < \text{maximum axle load } P \leq 20\text{ t}$;
- line category B2: $16\text{ t} < \text{maximum axle load } P \leq 18\text{ t}$.

NOTE Additional L4 locomotive classes are defined in Annex M to provide greater graduation (e.g. to facilitate providing additional information indicating that a 21,0 t 4-axle locomotive is compatible with a C2 line).

6.3.3 6-axle locomotives

Generally, the relevant parameters for categorization of 6-axle locomotives are:

- the maximum axle load P (18 t to 22 t) in combination with;
- the distance between axles within a bogie (1,80 m to 2,25 m).

Typically, the mass per unit length (p) is less than 6,4 t/m and the distance from end axle to the end of the nearest coupling plane (a) is greater than 2,1 m.

Line categories of 6-axle locomotives according to P and a are given in Annex L.

NOTE To assist with optimizing line categories for most 6-axle locomotives, locomotive classes L6₁₉, L6₂₀, L6₂₁ and L6₂₂ are defined in Annex N.

6.4 Passenger carriages

Passenger carriages shall be categorized into line categories. Alternatively, if the vehicle parameters of the carriage satisfy the requirements given in Table 3, Table 4 can be used to identify the line category.

Table 3 — Requirements for the application of Table 4

Parameter	Parameter range
Axle spacing in bogie	$1,8\text{ m} \leq 2a^+ \leq 3,0\text{ m}$
Bogie spacing between pivot centres	$2a^* \geq 15,6\text{ m}$
Overhang (distance pivot centre to coupling plane)	$u \geq 3,0\text{ m}$

Table 4 — Corresponding line category (in combination with Table 3)

Max axle load	Line category
≤ 10,0 t	a10
≤ 12,0 t	a12
≤ 14,0 t	a14
≤ 16,0 t	A
≤ 18,0 t	B1
≤ 20,0 t	C2
≤ 22,5 t	D2

Mass condition and passenger payload for determining the line category and for checking dynamic compatibility are given in Annex D.

6.5 Multiple units

Multiple units shall be categorized into line categories. The procedure described in 6.1 can be replaced by the simple parameter check given in Annex T (especially see T.5). Typical formations of light rail MUs and the minimum values of axle geometrics are given in Annex U to provide guidance for categorization.

Mass condition and passenger payload for determining the line category and for checking dynamic compatibility are given in Annex D.

Multiple units with a maximum design speed in excess of the values in Annex F shall be checked against the train parameters covered by each MU-class in accordance with Annex C. When the multiple unit satisfies the parameters it shall be allocated to the relevant MU-class.

6.6 Special vehicles

Special vehicles shall be categorized into line categories. When determining the line category, two different cases shall be taken into account:

Case 1: a train of an unlimited number of fixed formation vehicles (or single vehicles) as appropriate;

Case 2: one single fixed formation or single vehicle as appropriate conveyed in a train of reference wagons (except reference wagons xL-a and xL-b) defined in Annex A corresponding to the line category determined from Case 1.

The categorization shall be taken as the most onerous of Case 1 and Case 2.

The line category for road-rail machines, demountable machines and trailers shall be documented in the technical documentation.

6.7 Vehicle categorization results

The result of the categorization process is shown in Table 5.

Table 5 — Categorization results

Type of vehicles	Result
Freight wagons	Payload limits
Locomotives	Line category and, where available, locomotive class
Passenger carriages	Line category
Multiple units	Line category and, if applicable MU-class ($\max P_{\text{MUclass}}$ and $\max v$)
Special vehicles	Line category or payload limits

If vehicles or wagons and payloads cannot be categorized, being outside of the scope of the line categories defined in 6.1 in this standard, these vehicles shall be treated as individual vehicles.

The following information, being part of the technical documents of the vehicle, should be made available as it is necessary for carrying out individual checks for demonstrating the compatibility between a vehicle and infrastructure and should be recorded in the demonstration of compatibility:

- total vehicle mass (for each vehicle) and mass per axle (for each axle) for the load conditions design mass in working order and according to Annex D;
- the position of the axles along the vehicle (or fixed formation of vehicles) – axle spacing and the distance from the coupling planes to the adjacent axles;
- the length of the vehicle (or fixed formation of vehicles);
- maximum design speed of the vehicle (or fixed formation of vehicles).

7 Compatibility of the interface between vehicle and infrastructure

If the category of a vehicle (or the payload limit of a wagon) is less than or equal to the classification of the line, compatibility has been demonstrated. Requirements related to speed also form part of this validation.

The line categories of Table A.2, representing the basic line categories for all vehicles, are defined by capital letter $A < B < C < D$ and number $1 < 2 < 3 < 4$ (Exception: Line Category A has no number and is covered by all other Line Categories of Table A.2). A ranking is only possible, if both letter and number shall be less than or equal (e.g. $D4 > C3$, $C2 > B2$, $C4 > B2$; a ranking is not possible between some combinations for example $C3 \neq D2$ or $D3 \neq C4$), because the relativity of load effect varies according to span length. Rankings of other Line Categories are shown within the notes of the Tables A.3 and A.4 of Annex A.

When considering a train, the ruling case for the train shall be the vehicle with the most onerous categorization with the maximum speed of the train limited to the most restrictive speed requirement.

Freight traffic is compatible with the line if the line category corresponding to the payload of all wagons and line categories of the locomotive(s) do not exceed the line category of the line taking into account the maximum freight speed (see 4.3.2).

Passenger traffic is compatible with the line if the line categories of locomotives and coaches do not exceed the line category of the line taking into account the associated maximum speed. If necessary, additional requirements (e.g. locomotive classes, conditions for compatibility for single approvals from individual line checks) shall be taken into account.

Where compatibility using line categories cannot be demonstrated, an individual line check, taking local procedures into account, shall be performed to demonstrate compatibility.

An individual line check is necessary:

- for individual vehicles (see 5.1 and 6.7);
- if the line category of a vehicle or payload limit of a wagon exceeds the line category of the line;
- if the operating speed exceeds the associated maximum speed of the line category;
- for exceptional consignments ⁴⁾ (e.g. loaded wagons with more than 8 axles);
- for freight traffic not complying with the requirements of this European Standard.

In most cases, individual line checks require additional specific evaluations or calculations.

Where a new or different vehicle or payload is proposed that will require an individual line check, early consultation should be carried out with the infrastructure manager during the first stages of design of the vehicle and or the planning of operation to facilitate optimization of the compatibility process.

Possible results of individual line checks are:

- compatibility demonstrated;
- compatibility demonstrated subject to additional restrictions on operating speeds or loading, limitations on train formation, the use of e.g. protection wagons;
- compatibility not demonstrated, vehicle or train operation refused.

If the static approach on which the line categories are based for characterizing the interaction between vehicle formation and infrastructure is not sufficient, depending on speed, the need to carry out additional dynamic checks shall be considered to demonstrate compatibility (see 5.1.2).

4) Exceptional consignments are defined in UIC 502-1.

Annex A (normative)

Reference wagons and load models representing the line categories

Table A.1 — Reference wagons

Reference wagon	Axle load P (t)	Geometrical characteristics	Mass per unit length p (t/m) ^a
a10	10,0		2,0
a12	12,0		2,4
a14	14,0		2,8
A	16,0		5,0
B1	18,0		5,0
B2	18,0		6,4

Reference wagon	Axle load P (t)	Geometrical characteristics	Mass per unit length p (t/m) ^a
C2	20,0		6,4
C3	20,0		7,2
C4	20,0		8,0
D2	22,5		6,4
D3	22,5		7,2
D4	22,5		8,0
D5	22,5		8,8
xL-a	20,0		8,0

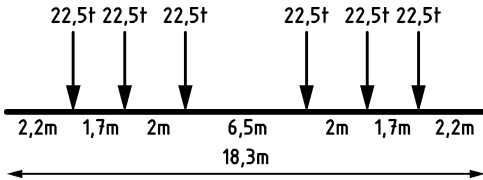
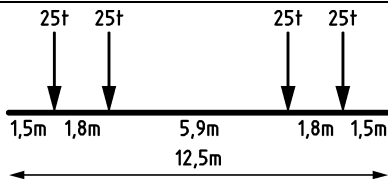
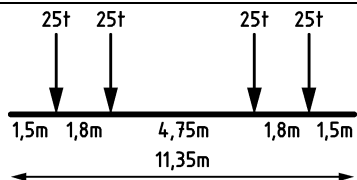
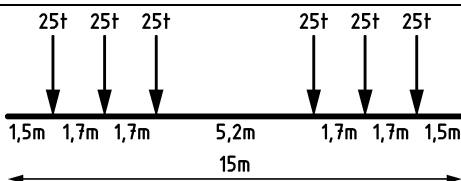
Reference wagon	Axle load P (t)	Geometrical characteristics	Mass per unit length p (t/m) ^a
xL-b	22,5		7,4
E4	25,0		8,0
E5	25,0		8,8
E6	25,0		10,0
Additional reference wagons may be used to manage special traffic on specific lines (e.g. reference wagon F with axle load P equal to 27,5 t or G with axle load P equal to 30,0 t).			
^a The value for " p " results from the relationship: (number of axles) $\times P$ /(length of reference wagon). The reference wagon is defined by " P " and the geometrical characteristics.			

Table A.2 — Load models representing the line categories for all vehicles

Line category	Arrangement of reference wagons n unlimited number
A	$n \times A$...  ...
B1	$n \times B1$...  ...
B2	$n \times B2$...  ...
C2	$n \times C2$...  ...
C3	$n \times C3$...  ...
C4	$n \times C4$...  ...
D2	$n \times D2$...  ...
D3	$n \times D3$...  ...
D4	$n \times D4$...  ...
NOTE 1 The first character, a letter, characterizes the limits for axle load and the second character, a number, characterizes the limits for mass per unit length of the corresponding reference wagon of the load model. The line categories are ranked by letter $A < B < C < D$ and number $1 < 2 < 3 < 4$. NOTE 2 $D2 < D3$ and $C2 < D3$, but $D2 \neq C3$.	

Table A.3 — Load models representing the line categories for light rail vehicles

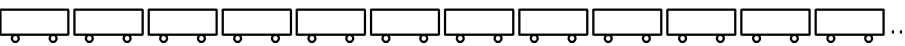
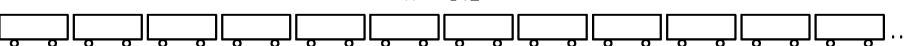
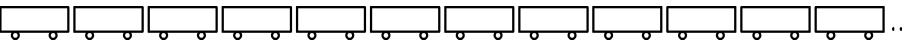
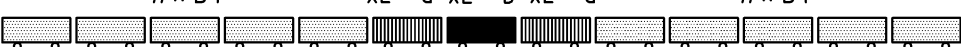
Line category	Arrangement of reference wagons n ...unlimited number
a10	$n \times a10$...  ...
a12	$n \times a12$...  ...
a14	$n \times a14$...  ...
NOTE Ranking: $a10 < a12 < a14$; A of Table A.2 $> a10, 12$, and $a14$.	

Table A.4 — Load models representing the line categories for specific types of vehicles

Line category	Arrangement of reference wagons n ...unlimited number
D4xL ^a	$n \times D4$ $xL - a$ $xL - b$ $xL - a$ $n \times D4$...  ...
D5 ^b	$n \times D5$...  ...
E4 ^b	$n \times E4$...  ...
E5 ^b	$n \times E5$...  ...
E6 ^b	$n \times E6$...  ...
D4xL may be used for other types of vehicles. Special traffic may be categorized according to deviating regulations or to different line categories (e.g. line category F – 27,5 t or G – 30,0 t).	
^a D4xL was developed for locomotives. ^b D5, E4, E5 and E6 only valid for freight wagons.	
NOTE Ranking: $E4 < E5 < E6$; $D5 < E5 < E6$; but not comparable $E4 \neq D5$; D4xL is not comparable to all others; all members of Table A.4 $> D4$ of Table A.2.	

Annex B (informative)

Flow chart: Classification of infrastructure and categorization of vehicles

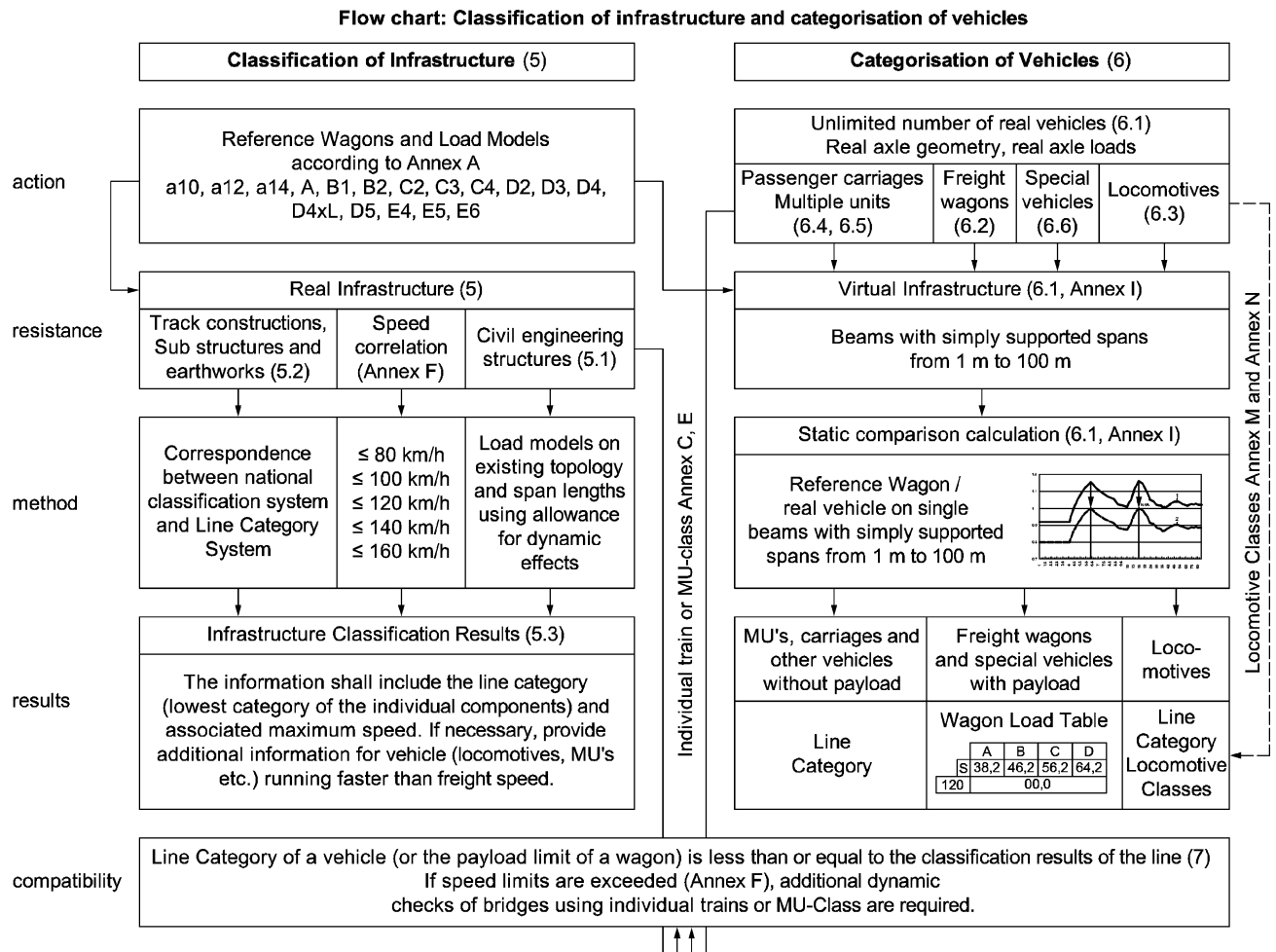


Figure B.1 — Flow chart for the classification of infrastructure and categorization of vehicles