



BSI Standards Publication

Railway applications — Gauges

Part 2: Rolling stock

National foreword

This British Standard is the UK implementation of EN 15273-2:2025. It supersedes BS EN 15273-2:2013+A1:2016, which is withdrawn.

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European foreword

This document (EN 15273-2:2025) 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of an identical text or by endorsement, at the latest by April 2026, and conflicting national standards shall be withdrawn at the latest by April 2026.

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

This document is one of the series EN 15273, *Railway applications — Gauges* as listed below:

- EN 15273-1:2025, *General — Common rules for rolling stock and infrastructure* gives the general explanations of gauging and defines the sharing of the space between rolling stock and infrastructure;
- EN 15273-2:2025, *Rolling stock* gives the rules for dimensioning vehicles;
- EN 15273-3:2025, *Infrastructure* gives the rules for positioning the infrastructure;
- EN 15273-4:2025, *Catalogue of defined gauges* includes a non-exhaustive list of reference profiles and parameters to be used by infrastructure and rolling stock;
- CEN/TR 15273-5:2025, *Background, explanation and worked examples*.

This document supersedes EN 15273-2:2013+A1:2016.

In comparison with the previous edition, the following technical modifications have been made:

- the series was fully restructured, from three parts to five parts;
- Clause 3 and Clause 4 now refer to EN 15273-1:2025 where all terms and symbols are defined;
- modification of the whole Clause 5;
- reordering of all specific rules of defined kinematic gauge inside the Annex A to Annex P by moving to the normative Annex A;
- addition of new rules in Annex A about the wheel-zone;
- restructured A.3.13 and A.3.16 into two Annexes, normative Annex B for passive tilting vehicle and informative Annex C for active tilting vehicle;
- addition of a new normative Annex D about the graphical method use for defined kinematic gauge;
- for defined kinematic gauge, removal of all reference profile inside the EN 15273-2:2025 replace in normative Annex E by tables with the links with EN 15273-4:2025 to define the reference profile, basic data and lateral projections;
- for defined static gauge, removal of all reference profile inside the EN 15273-2:2025 replace in normative Annex G by tables with the links with EN 15273-4:2025 to define the reference profile, basic data and lateral projections;

- regrouping all particular rules for German, Belgian and pantograph gauges in normative Annex E;
- reordering all specific rules of defined static gauge inside the Annex A to Annex P by moving to the normative Annex F;
- for all defined gauges (static, kinematic and dynamic), removal of all formulae for calculating specific lateral reductions and replacement by generic formulae in each normative Annexes A, Annex F and Annex K;
- removal of specific Annex K defined static gauges OSJD;
- removal of normative Annex Q Vehicle widening depending on the available spaces of the infrastructure;
- content of normative Annex R Static and kinematic gauges: list of documents for a vehicle gauge conformance certification moved to normative Annex N list of documents for rolling stock gauge assessment applicable for defined kinematic, static and dynamic gauges;
- addition of absolute gauging process and comparative process in normative Annex M.

This document has been prepared under a standardization request addressed to CEN by the European Commission. The Standing Committee of the EFTA States subsequently approves these requests for its Member States.

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

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

Introduction

The aim of this series EN 15273 is to define the rules for the calculation and verification of the dimensions of rolling stock and infrastructure from a gauging perspective.

This series EN 15273 sets out gauging processes taking into account the relative movements between rolling stock and infrastructure as well as the necessary margins or clearances.

EN 15273-2:2025 covers rolling stock gauges and is used in conjunction with the following parts:

- *Part 1: General — Common rules for rolling stock and infrastructure;*
- *Part 3: Infrastructure;*
- *Part 4: Catalogue of defined gauges;*
- *Part 5: Background, explanation and worked examples.*

1 Scope

This document is applicable to new vehicle designs, to modifications to existing vehicles and for checking existing vehicles to be used on another route or network.

This document contains:

- the rules for rolling stock for all defined gauges;
- the swept envelope calculation process used for defined dynamic gauges, absolute and comparative process;
- the list of documents required to assess vehicle conformity to this standard.

This document is applicable to heavy rail vehicles using various track gauges. Other vehicles and networks are outside the scope of this document, but the rules may be applied to them with some adjustments and agreement of the share of responsibility between rolling stock and infrastructure.

This document is not applicable to the gauges “S” and “T” for track gauge 1 520 mm.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 14363:2016+A2:2022, *Railway applications — Testing and Simulation for the acceptance of running characteristics of railway vehicles — Running Behaviour and stationary tests*

EN 15273-1:2025, *Railway applications — Gauges — Part 1: General — Common rules for rolling stock and infrastructure*

EN 15273-3:2025, *Railway applications — Gauges — Part 3: Infrastructure*

EN 15273-4:2025, *Railway Applications — Gauges — Part 4: Catalogue of defined gauges*

EN 15663:2017+A2:2024, *Railway applications — Vehicle reference masses*

EN 50119:2020, *Railway applications — Fixed installations — Electric traction overhead contact lines*

EN 50215:2009, *Railway applications — Rolling stock — Testing of rolling stock on completion of construction and before entry into service*

EN 50367:2020, *Railway applications — Fixed installations and rolling stock — Criteria to achieve technical compatibility between pantographs and overhead contact line¹*

¹ Document impacted by A1:2022 and A2:2025.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 15273-1:2025 apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp/>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Symbols and abbreviations

For the purposes of this document, the symbols and abbreviations given in EN 15273-1:2025 apply.

5 Gauges and gauging processes

5.1 General principles for all defined gauges

- a) For each gauge, it is mandatory to respect the combination of the specified profile and associated rules.
- b) The defined gauge calculation shall be based upon the assumption that all the vehicle characteristics that influence the gauge are maintained throughout the operational life of the vehicle. These characteristics shall be stated in the maintenance documentation, including the factors influencing displacements and their limiting or maximum values (e.g. limits of wear on suspension components).
- c) Wear limits of all parts, equipment and systems influencing movements of the vehicle shall be included in the documents provided by the rolling stock domain for approving the use of the vehicle.
- d) For consistency, the maximum construction gauge shall be drawn with the vehicle in loading condition “dead mass” as defined by EN 15663:2017+A2:2024, nevertheless calculations are made taking into account all loading conditions.
- e) If the vehicle does not fully meet the requirements of the defined gauge, in exceptional cases it may be approved for operation with deviation. It is not then compatible with the infrastructure cleared for the gauge considered.

5.2 Defined static and kinematic gauges

The calculation methods applied for the defined gauges are based on a reference profile and their associated rules.

The static and kinematic gauges take into account the maximum value of each displacement.

The static method can be used up to a limit value of the flexibility coefficient (s_{lim}).

The kinematic method can be used regardless of the value of the flexibility coefficient.

5.3 Dynamic methods

5.3.1 General principles

The vehicle simulation model shall be validated by calculations, by comparisons with other vehicles, by testing or by other appropriate means commensurate with the level of risk, complexity and innovation in the vehicle design. The method of validation depends on the process being followed.

5.3.2 Dynamic method based on defined gauges

The vehicle shall not exceed a certain reference profile including the curve radii dependent projections added under specified conditions. Multiple vehicle swept envelopes shall be calculated by defining the maximum vehicle space to be occupied under normal service and certain failure conditions for each curve radius. The dynamic movement may be calculated either by use of formulae or by simulations. This envelope shall remain within the dynamic reference profile including the adding of curve radii dependent projections on routes where the vehicle is required to operate.

5.3.3 Absolute gauging process

The absolute gauging process requires calculation of clearance between the swept envelope of the vehicle and the infrastructure at every location along a route. The local conditions (e. g track curvature, installed cant, line speed and track fixity) are used to determine the swept envelope of the vehicle on the effective track position. Acceptable clearances between the vehicle swept envelope on the effective track position and all infrastructure on a route are required to achieve gauging compatibility.

5.3.4 Comparative gauging process

The comparative gauging process relies on existing vehicles known as comparator vehicles operating safely on a route. Where all swept envelopes of the candidate vehicle are within the swept envelopes of a comparator vehicle, or vehicles, having been assessed as having gauging compatibility with the section of track, then gauging compatibility shall be deemed to be achieved. The swept envelopes of both comparator and candidate vehicles are calculated on a virtual route by use of simulations.

Annex A (normative)

Defined kinematic gauges — common rules

A.1 General rules

A.1.1 Requirements for use of defined kinematic gauges

The following requirements and considerations apply to defined kinematic gauges:

- a) The formulae specified for each defined kinematic gauge shall be applied by introducing all the “worst case” parameters, i.e. with their maximum values (e.g. clearances, lateral and vertical displacements, etc.) while taking realistic combinations of the parameters into account.
- b) If, as a deviation from the above point, a vehicle is designed using one or several parameters with their optimized value (a calculated value, or one encountered during operation), the gauge documents shall be submitted to the body responsible for conformity assessment in the form of simulation analysis reports, test reports, risk analyses, etc. In this case, the whole range of situations (e.g. maximum operating speed, maximum cant deficiency, dynamic displacements, load states etc.) shall be taken into account. It should be noted that this procedure could result in a vehicle being specified that would not be compatible with all infrastructure even if it fits the gauge of the same designation.
- c) Defined kinematic gauges apply also to open wagons and their loads. In this case, the flexibility coefficient of the load itself shall be taken into account, adding it to the flexibility coefficient of the suspension of the wagon itself.

In these conditions, the whole set “wagon+load” can be regarded as a current type of wagon. Wagons loaded with containers and swap bodies (transported on carrier wagons equipped with load fixing devices) and semi-trailers (transported on pocket wagons) are examples of the above application.

- d) Before new vehicles enter service the flexibility coefficient shall be verified by measurement according to EN 14363:2016+A2:2022 (method 1 or method 2). For cases, in which either the spatial distribution of the payload or the payload itself cannot be reproduced correctly in test conditions (e.g. centres of gravity of seated and standing passengers), the assessment of the flexibility coefficient s via computer simulations based on a validated vehicle model shall be considered sufficient
- e) The calculation and the measurement of the flexibility coefficient s can result in different values (e.g. because of different wagon loadings). In any case, the choice of the value of s retained for gauge calculation according to EN 15273-2:2025 shall be clearly justified in the technical documents accompanying the vehicle (see Annex N).
- f) Defined kinematic gauges can be used to size tilting vehicles, which is set out in Annex B.

Annex B is considered normative since passive tilting is based on the basic principle of having the rotation centre above the centre of gravity, regardless of the technology used in the vehicle. Therefore, the formulae developed in Annex B are not expected to be influenced by different technologies used in different passive tilting vehicles.

However, active tilting is dependent on the technology used to force the rotation, and therefore, formulae developed in Annex C may need to be adapted. Therefore, the general formulae in Annex C, based on a general principle used in the industry for this kind of vehicle (actuators located between the bogie frame and the carbody), can only be considered informative.

The compatibility of passive and active tilting trains with the corresponding infrastructure shall be subject to a specific procedure for permission to operate by the Infrastructure Managers concerned.

- g) Concerning the verification of pantographs mounted on the tilting vehicles or subject to $I = I_p > I_c$, three cases are dealt with in this standard:

— pantographs that are not part of the tilting mechanism.

These can include pantographs mounted on non-tilting elements of the tilting body (for example bogies) or pantographs mounted on non-tilting bodies but subject to $I = I_p > I_c$. This is included in Annex B because it is related to a non-active system;

— pantographs that are attached to the tilting body with a counter rotation system.

These are pantographs mounted on tilting vehicles equipped with a counter rotational device. This is included in Annex C;

— pantographs with an in-built re-centring system.

There are pantographs equipped with a re-centring device mounted on non-tilting vehicles but subject to $I = I_p > I_c$. This is included in Annex C;

- h) Instead of using the algebraic calculations given in this Annex to define a maximum construction gauge, it is possible to use the graphical method in Annex D.

A.1.2 Dimensional tolerances on vehicles

A.1.2.1 General principles

The dimensions of a finished vehicle in loading condition “dead mass” as defined by EN 15663:2017+A2:2024 shall remain within the maximum construction gauge. On the finished vehicle, an exceedance of the maximum construction gauge due to the manufacturing process can be accepted, up to:

- a) 0,0025 m for any semi-width b_{veh} of body, bogie or running gear taken separately;
- b) for any height h_{veh} of the finished vehicle:
 - 0,010 m on the heights of upper parts of the gauge for the vehicle profile (see Figure A.10);
 - 0,005 m per suspension stage on the heights of lower parts of the gauge (see Figure A.3), if vertical suspension displacements correspond to a bottoming displacement.
- c) a dissymmetry smaller than $\eta_{0,r}$.

The above values cannot be adopted to increase the nominal dimensions of the vehicles systematically.

A.1.2.2 Guidance on finished vehicle dimensional checking

— Lateral measurements:

It is considered that the semi-widths b_{veh} with respect to the track centreline cannot be measured accurately in practice on the finished vehicle. This is caused by residual lateral displacement in the suspension (hysteresis) or wheel to rail clearance. For such cases it should be necessary for a completed vehicle profile to comply with the requirement on the dissymmetry angle given in item c) of A.1.2.1 when set on the running gear.

Item a) of A.1.2.1 is related to the semi-width b_{veh} of each part of the vehicle, i. e. body, bogie or running gear, measured separately after manufacturing and completion, but before the body is put on the running gear.

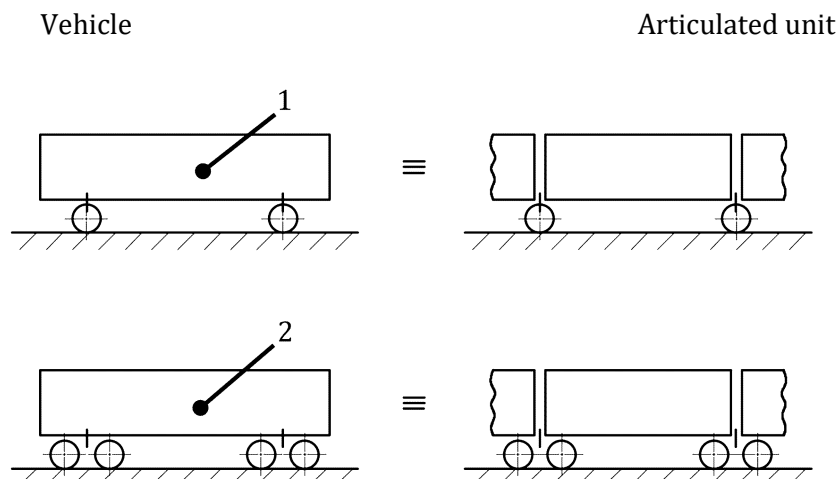
— Vertical measurements:

Item b) of A.1.2.1 is related to the finished vehicle, when the body is set on the running gear and the vehicle is at a standstill on a level track.

A.1.3 Applicability of this annex

The formulae given in this annex are generally applicable to vehicle configurations shown below (see Figure A.1):

- a) vehicles not fitted with bogies with the body directly sprung on two wheelsets (one suspension level). In the case of vehicles with bodies sprung on a different number of wheelsets or with two stages of suspension, it will be necessary to adapt the formulae to the actual geometric conditions;
- b) bogie vehicles with the body sprung on two bogies with two wheelsets. In the case of vehicles with more than two bogies or fitted with bogies with more than two wheelsets or fitted with one bogie and one wheelset, it will be necessary to adapt the formulae to the actual geometric conditions;
- c) articulated unit: calculation corresponding to vehicles with single wheelsets or with bogies if they are symmetrical articulated units, see Figure A.1.

**Key**

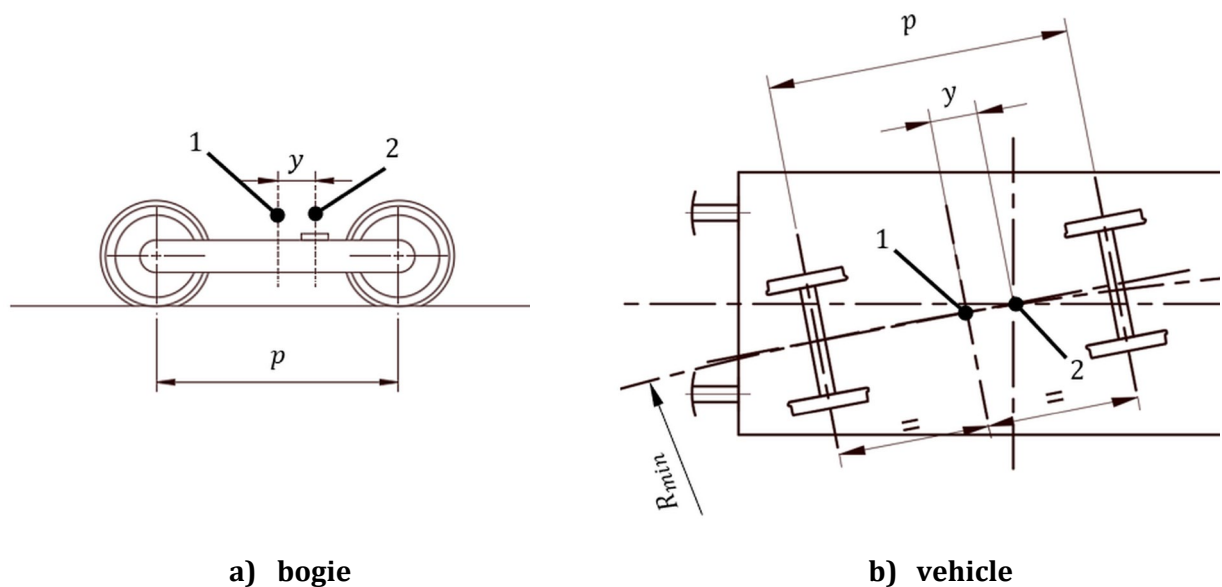
- 1 2 independent wheelsets
- 2 2-bogies

Figure A.1 — Correspondence between separate vehicles and articulated units

- d) for non-conventional vehicles, a new process according to geometric configurations shall be determined to prove that the vehicle complies with the gauge. It is also possible to use the graphical method described in Annex D.

A.1.4 Vehicles with non-coincident bogie centre and rotation point

In the case of vehicles with bogies where the axis of rotation is not in the centre of the bogie as shown in Figure A.2, in order to determine the a and n values, the cross point of the bogie longitudinal centreline with that of the vehicle body will be considered as a theoretical centre, determined graphically, when the vehicle is on a radius curve R_{min} , with the wheelsets centred on the track and without lateral suspension displacements. If y is the distance from this theoretical centre to the geometrical centre of the bogie (at an equivalent distance from the two outermost wheelsets), $\frac{p_A^2}{4}$ shall be replaced by $\left(\frac{p_A^2}{4} - y^2\right)$, and $\frac{p_B^2}{4}$ by $\left(\frac{p_B^2}{4} - y^2\right)$ in the formulae.

**Key**

- 1 bogie centre
- 2 rotation point

Figure A.2 — Vehicles with non-coincident bogie centre and rotation point

A.1.5 Bogie classes

For the purposes of this standard, bogies are classified as follows:

- motor bogie: a bogie with wheelsets which are considered as powered if the adhesion coefficient $\mu \geq 0,19$;
- trailing bogie: a bogie with wheelsets which are trailing or considered as non-powered if the adhesion coefficient $\mu < 0,19$;
- mixed bogie: a bogie with powered and trailing wheelsets. if the powered wheelset adhesion coefficient is greater than or equal to 0,19, the mixed bogie is considered as a motor bogie.

The adhesion coefficient is calculated with the Formula (A.1):

$$\mu = \frac{F_w}{g \cdot M_e} \quad (\text{A.1})$$

The maximum value for μ shall be considered in relation to the worst combination of traction force (failure mode excluded) and wheelset load.

The maximum value for μ shall be determined taking into account the worst combination of traction force F_w (failure mode excluded) and axle load M_e .

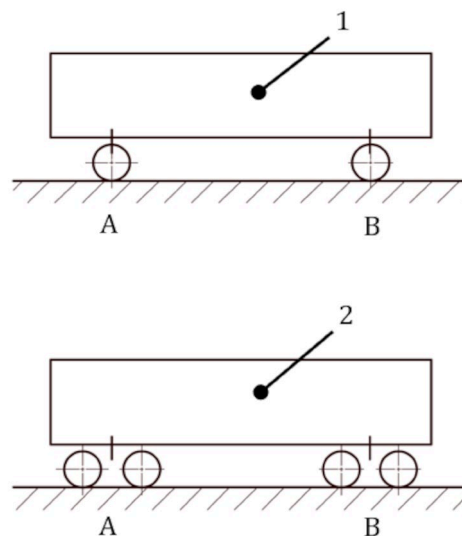
A.1.6 Designation of running gear

In this document, both independent wheelsets and both bogies of a vehicle are designated A or B, as shown in Figure A.3.

For vehicles with one motor bogie and one trailing bogie, A corresponds to the motor one and B to the trailing one.

For all other cases A is selected indifferently.

For the sections located between the end wheelsets or the bogie pivots, $n_{i,A}$ is always related to the same wheelset or bogie pivot – A.



Key

- 1 vehicle fitted with independent wheelsets
- 2 vehicle fitted with bogies

Figure A.3 — Designation of running gear

A.2 Determination of the vehicle heights

A.2.1 General

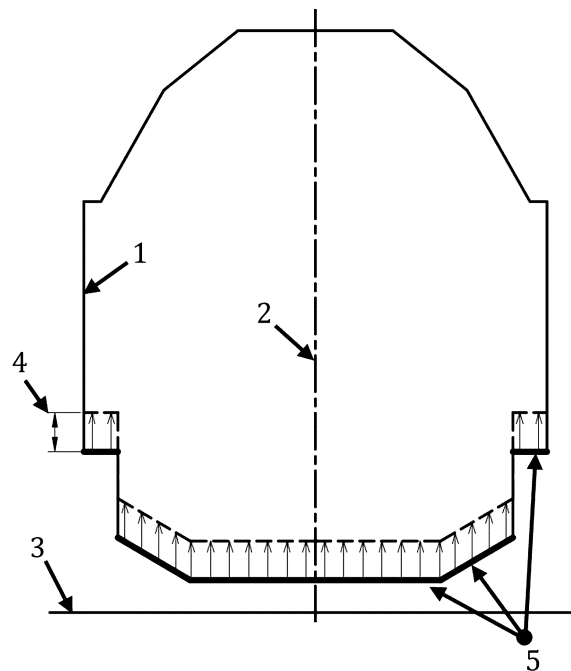
The minimum heights are determined for the lower part of the vehicle (lower parts of the gauge) and intermediate non-vertical lines on the reference profile.

The maximum heights are determined for the upper part of the vehicles (upper parts of the gauge).

A.2.2 Determination of the minimum heights above running plane

A.2.2.1 General

The minimum heights above running plane of a vehicle in loading condition “dead mass” as defined by EN 15663:2017+A2:2024 and its components located close to the lower part of a gauge as shown in Figure A.4, shall be determined taking into account the vertical displacements and vertical reductions described in the following subclauses.



Key

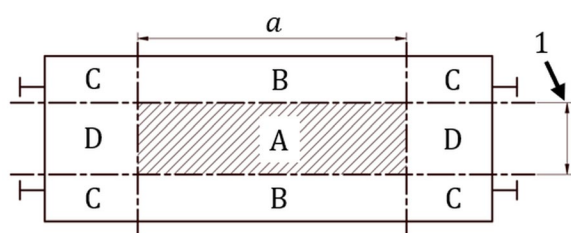
- 1 reference profile
- 2 centreline of reference profile
- 3 running plane
- 4 vertical reductions $E_{v,u,i}$, $E_{v,u,a}$
- 5 considered parts of the reference profile

Figure A.4 — Determination of the minimum heights

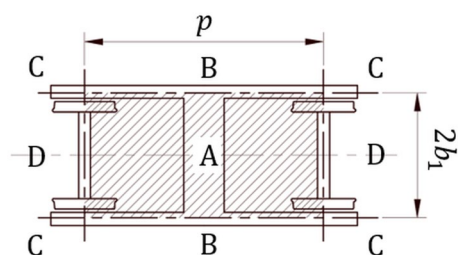
A.2.2.2 Overall reductions to be taken into account to determine the minimum heights above running plane

A.2.2.2.1 General principles

As shown in Figure A.5, in order to calculate the vertical reductions, the carbody and bogie are split into separate zones based on the suspension design.



a) vehicle



b) bogie

Key

1 $2 \cdot b_2$ or $2 \cdot b_1$

NOTE a is to be considered as the distance between the secondary suspension centrelines for bogies with non-coincident secondary suspension centreline and pivot centreline.

Figure A.5 — support polygon zones

The Table A.1 sums up for each zone A, B, C, D the elements to take into account in order to determine the vertical displacement values. These values are to be adapted according to the studied vehicle.

Table A.1 — Vertical reduction values

Zone	Element	Usage case	Locomotives, coaches, multiple units, railcars	Wagons (single suspension level)	Running gear or bogie (single suspension level or primary suspension only) See NOTE 6
ZONE A	Suspension displacements	(a)	Aff	Aff	Aff See NOTE 5
	Clearances to the side bearers		$J \frac{b}{b_g}$ See NOTE 3	$J \frac{b}{b_g}$ See NOTE 3	–
	Wheel wear		U_{sr}	U_{sr}	U_{sr}
	Body camber		0	Flc	–
	Vertical curve		$e_{u,i}$	$e_{u,i}$	$e_{u,i}$
	Rules for bottom lines of gauge	(b)	$e_{i,mh}, e_{i,1}, e_{i,2}, e_{i,3}, e_{i,4} ore_{i,f,b}$	$e_{i,mh}, e_{i,1}, e_{i,2}, e_{i,3}, e_{i,4} ore_{i,f,b}$	$e_{i,mh}, e_{i,1}, e_{i,2}, e_{i,3}, e_{i,4} ore_{i,f,b}$
ZONE B	Suspension displacements	(a)	$Aff + 0,1 \cdot s \cdot (b - b_2)$ See Figure A.7b, NOTE 1 and NOTE 2	$Aff + \Delta Aff \frac{(b - b_1)}{2 \cdot b_1}$ See Figure A.7a	Aff See NOTE 5
	Clearances to the side bearers		$J \frac{b}{b_g}$ See NOTE 3	$J \frac{b}{b_g}$ See NOTE 3	–
	Wheel wear		U_{sr}	U_{sr}	U_{sr}
	Body camber		0	Flc	0
	Vertical curve		$e_{u,i}$	$e_{u,i}$	$e_{u,i}$
	Rules for bottom lines of gauge	(b)	$e_{i,mh}, e_{i,1}, e_{i,2}, e_{i,3}, e_{i,4} ore_{i,f,b}$	$e_{i,mh}, e_{i,1}, e_{i,2}, e_{i,3}, e_{i,4} ore_{i,f,b}$	$e_{i,mh}, e_{i,1}, e_{i,2}, e_{i,3}, e_{i,4} ore_{i,f,b}$

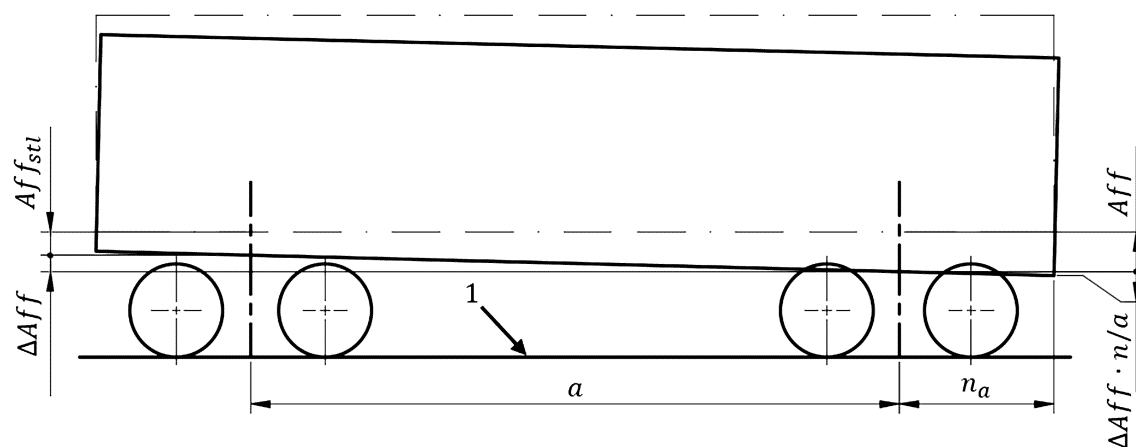
Zone	Element	Usage case	Locomotives, coaches, multiple units, railcars	Wagons (single suspension level)	Running gear or bogie (single suspension level or primary suspension only) See NOTE 6
ZONE C	Suspension displacements	(a)	$\text{Max} \left(\begin{array}{l} Aff + \Delta Aff \cdot \frac{n_a}{a} \\ Aff + 0,1 \cdot s \cdot (b - b_2) \end{array} \right)$ See NOTE 2	$Aff + \Delta Aff \frac{\sqrt{n_a^2 + (b - b_1)^2}}{\sqrt{a^2 + 4 \cdot b_1^2}}$	$Aff + \Delta Aff \cdot \frac{n_a}{p}$ See NOTE 5
	Clearances to the side bearers		$J \frac{b}{b_G} \text{ See NOTE 3}$	$J \frac{b}{b_G} \text{ See NOTE 3}$	–
	Wheel wear		$Usr + \Delta Usr \cdot \frac{n_a}{a}$	$Usr + \Delta Usr \cdot \frac{n_a}{a}$	$Usr + \Delta Usr \cdot \frac{n_a}{p}$
	Body camber		0	Flc	0
	Vertical curve		$e_{u,a}$	$e_{u,a}$	$e_{u,a}$
	Rules for bottom lines of gauge	(b)	$e_{a,mh}, \text{ or } e_{a,fb}$	$e_{a,mh}, \text{ or } e_{a,fb}$	$e_{a,mh}, \text{ or } e_{a,fb}$

Zone	Element	Usage case	Locomotives, coaches, vans, multiple units (See NOTE 7), special wagons, railcars, special vehicles	Wagons, special vehicles (single suspension level)	Running gear or bogie (single suspension level or primary suspension only) See NOTE 6
ZONE D	Suspension displacements	(a)	$Aff + \Delta Aff \cdot \frac{n_a}{a}$ See Figure A.6	$Aff + \Delta Aff \cdot \frac{n_a}{a}$ See Figure A.6	$Aff + \Delta Aff \cdot \frac{n_a}{p}$ See Figure A.6
	Clearances to the side bearers		$J \frac{b}{b_G}$ See NOTE 3	$J \frac{b}{b_G}$ See NOTE 3	–
	Wheel wear		$Usr + \Delta Usr \cdot \frac{n_a}{a}$	$Usr + \Delta Usr \cdot \frac{n_a}{a}$	$Usr + \Delta Usr \cdot \frac{n_a}{p}$
	Body camber		0	Flc	0
	Vertical curve		$e_{u,a}$	$e_{u,a}$	$e_{u,a}$
	Rules for bottom lines of gauge	(b)	$e_{a,mh}, \text{ or } e_{a,fb}$	$e_{a,mh}, \text{ or } e_{a,fb}$	$e_{a,mh}, \text{ or } e_{a,fb}$
	NOTE 1 The flexibility coefficient value s covers the remaining suspension displacement possibilities. The s value for vertical displacements can be different to the s value used for lateral quasi-static displacement z_{cin}. For example, if Aff is equal to bottoming displacement for zone A, then s can be regarded as zero for zone B and zone C. NOTE 2 Depending on the suspension architecture, parameter b_1 can be replaced by b_2 in the formulae above. NOTE 3 Clearances to the side bearers are used if existing. NOTE 4 It is possible to replace b by b_{CR}. NOTE 5 Secondary suspended components of a bogie shall be calculated according to the specifications in the column for locomotives, coaches, vans, motor vehicle with one motor bogie and one trailer bogie, special wagons, railcars, locomotives, coaches, multiple units. NOTE 6 For the running gear, depending on the suspension architecture, an additional vertical displacement due to rolling shall be taken into account. Therefore, the flexibility coefficient value s can be adjusted for the primary suspension level. NOTE 7 For the purposes of this document, multiple unit (MU) trains considered contain motor vehicle(s) with one motor bogie and one trailer bogie.				

Usage case (a):	These elements shall be accumulated for each vehicle type to obtain $E_{v,u,i}$, $E_{v,u,a}$				
Usage case (b):	This element shall be added if relevant for the vehicle type under consideration. For the bottom lines of the gauge, the effect of vertical curve according to A.2.2.2.5 shall be replaced by A.2.2.2.6.				
<i>Aff</i>	Suspension displacement value, including spring tolerance as specified in A.2.2.2.4.				
ΔAff	Difference in suspension displacement, applicable for zone C and zone D in the longitudinal direction and for zone B and zone C for lateral direction.				
ΔUsr	Maximum difference allowed by the maintenance rules between the mean wheel radius of the two bogies (bogie vehicle) or between the wheelset radius (non-bogie vehicle).				

In the longitudinal direction, the difference in vertical displacement as shown in Figure A.6, the particular suspension types shall be considered as follows:

- suspensions with steel or rubber springs, a difference in the vertical displacements ΔAff of the two bogies shall be taken into account, considering Aff in one bogie and the suspension displacement due to the maximum static load Aff_{stl} in the other.
- suspensions with air springs, when a pneumatic link does not exist between the suspensions of the two bogies, a difference in the downward displacements shall be taken into account. In this case, a suspension displacement Aff is considered for one of the bogies and suspension displacement due to the maximum static load Aff_{stl} with an air spring inflated is considered for the second bogie. When a pneumatic link exists between the suspensions of the two bogies, the air spring of the second bogie is considered deflated.

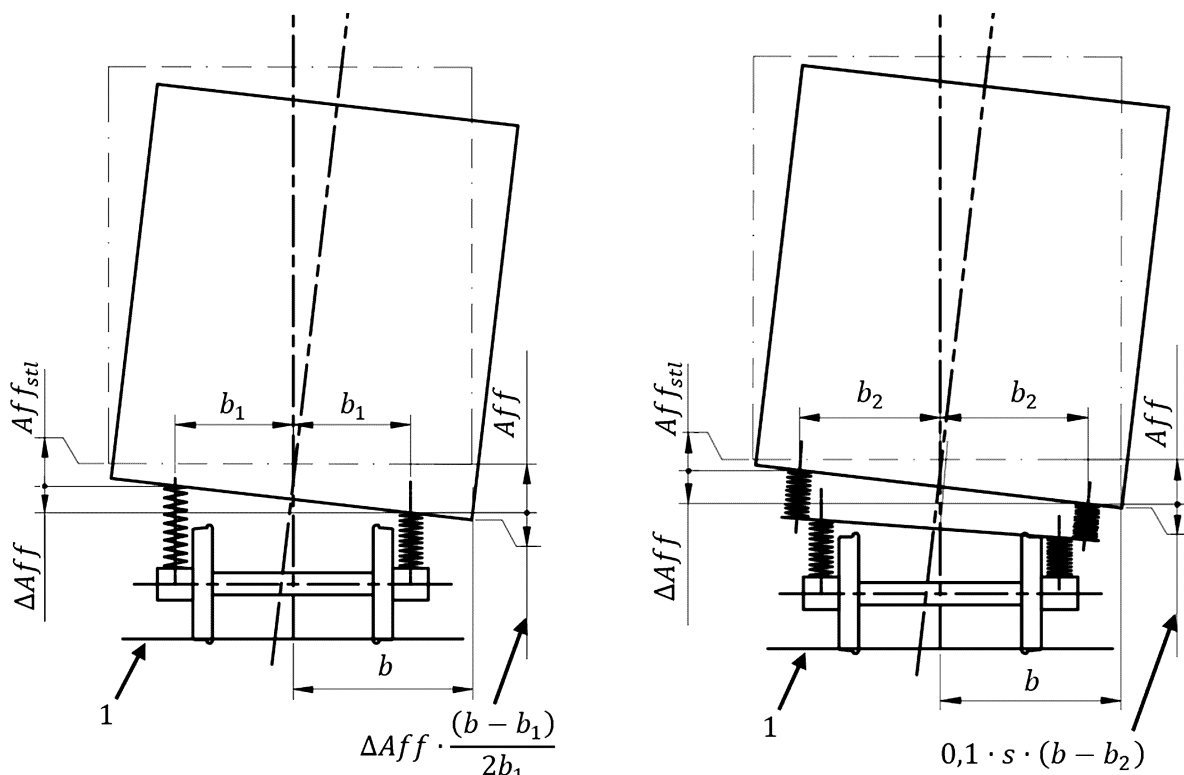


Key

1 running plane

Figure A.6 — Pitch due to different vertical suspension displacements

In the lateral direction, the difference in the vertical displacements of the springs between left and right suspension datum, as shown in Figure A.7a and Figure A.7b, is obtained considering the deflection under maximum static load Aff_{stl} for the first one and the deflection Aff defined in Table A.2 for the second one.



a) Vehicle with one level of suspension

b) Vehicle with two levels of suspension

Key

1 running plane

Figure A.7 — Roll due to different vertical suspension displacements

A.2.2.2.2 Wear displacements – *Usr*

These displacements concern the following parts:

- wheels: maximum wear for all types of vehicle or wear allowed between adjustments (if compensatory adjustments are planned during maintenance);
- miscellaneous parts: maximum wear – examples: side-bearers, brake rigging, etc., for all vehicles and for each special assembly;
- axle boxes: wear ignored.

A.2.2.2.3 Structure deformation displacement – *Flc*

The effect of the following elements on the structure deformation displacement *Flc* can be ignored:

- a) for wheelsets and bogie frame: sag;
- b) for carbody:
 - 1) twist
 - 2) lateral bending

3) sag: ignored for all vehicles except for wagons or special vehicles

for which the sag along the carbody has to be taken into account under the effect of an exceptional payload as defined in EN 15663:2017+A2:2024 increased by 30 % to take into account dynamic deformations.

A.2.2.2.4 Suspension displacement – *Aff*

The following displacements of the primary and secondary suspension are to be taken into account:

a) steel spring and rubber spring:

Table A.2 — Suspension displacement for different types of rolling stock

Type of rolling stock	Suspension displacement
Locomotives	Deflection under static load with an overload of 30 % of the sprung mass in load condition “design mass in working order” as defined in EN 15663:2017+A2:2024 or total displacement (bottoming)
Wagons	Total displacement (bottoming)
Coaches and vans, special wagons, motor vehicle with one motor bogie and one trailer bogie, railcars, running gear, special vehicles (see EN 17343:2023, 3.1.7.8)	Deflection under static load with an overload of 30 % of the sprung mass in load condition “design exceptional mass” as defined in EN 15663:2017+A2:2024 or total displacement (bottoming)

Where the displacements are not calculated under a total displacement (bottoming), the effect of tolerances of the stiffness of the springs has to be taken into account;

NOTE Special wagons: wagons whose loading surface height above the running plane is reduced to allow maximum loading capacities in the vertical direction. This category includes what are sometimes called low floor wagons: pocket wagons, “rolling-road” wagons and similar wagons.

b) air spring:

total deflection with air springs deflated. If there are back-up steel or rubber suspensions, the rules described in a) shall be applied.

A.2.2.2.5 Vertical reduction formulae for vertical curves

All vehicles shall be able to pass over convex or concave vertical curves of radius $R_{v,min}$. The heights of the vehicle gauge relative to the running plane shall be increased by the value $e_{u,i}$ or $e_{u,a}$:

— Formula (A.2) is applicable for the sections located between the end wheelsets or the bogie pivots:

$$e_{u,i} = \left[\frac{a \cdot n_{i,A} - n_{i,A}^2 + \frac{a - n_{i,A}}{4} \cdot \frac{p_A^2}{a} + \frac{n_{i,A}}{4} \cdot \frac{p_B^2}{a}}{2 \cdot R_{v,min}} - S_{v,u} \right]_{>0} \quad (A.2)$$

— for the sections located beyond the end wheelsets or the bogie pivots:

— Formula (A.3) is applicable for the sections beyond A:

$$e_{u,a} = \left[\frac{a \cdot n_a + n_a^2 + \frac{n_a + a}{4} \frac{p_A^2}{a} + \frac{n_a + a}{4} \frac{p_B^2}{a}}{2 \cdot R_{v,min}} - S_{v,u} \right]_{>0} \quad (A.3)$$

— Formula (A.4) is applicable for the sections beyond B:

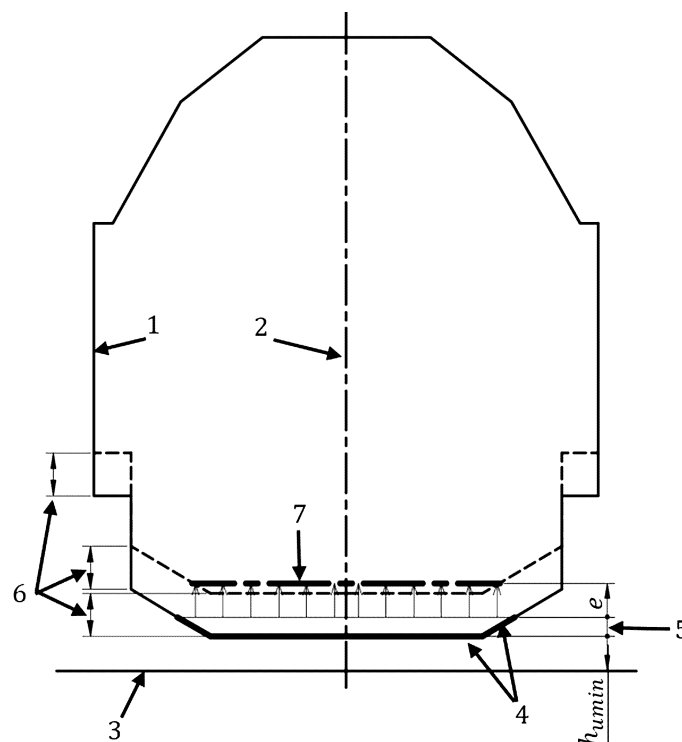
$$e_{u,a} = \left[\frac{a \cdot n_a + n_a^2 + \frac{n_a}{4} \frac{p_A^2}{a} + \frac{n_a + a}{4} \frac{p_B^2}{a}}{2 \cdot R_{v,min}} - S_{v,u} \right]_{>0} \quad (A.4)$$

For designation of A and B, see A.1.6, for basic data see Annex E.

A.2.2.2.6 Rules for bottom lines of gauge – marshalling hump and embarkation onto ferries

A.2.2.2.6.1 General

The Figure A.8 illustrates the rules applicable for bottom lines of gauge.



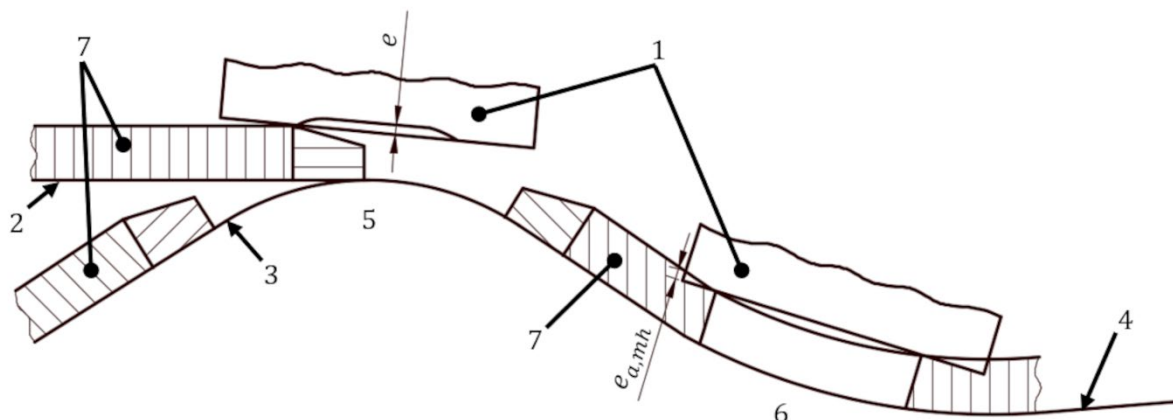
Key

- 1 reference profile
- 2 centreline of reference profile
- 3 running plane
- 4 bottom lines
- 5 effect of suspension displacements, clearances to the side bearers, wheel wear and body sag
- 6 $E_{v,u,i}$, $E_{v,u,a}$ – see Table A.1, footnote a
- 7 maximum construction gauge
- 8 vertical reduction applied, see Table A.1, usage case (b)

Figure A.8 — Bottom lines of gauge

A.2.2.2.6.2 Vertical reduction formulae for passing over marshalling humps

Figure A.9 shows the vertical reductions to be taken into account for vehicles passing over the marshalling hump.



Key

- 1 vehicle
- 2 shunting ramp
- 3 classic hump
- 4 running plane
- 5 convex
- 6 concave
- 7 track brake suppressed
- $e \quad \max(e_{i,mh}, e_{i,1}, e_{i,2}, e_{i,3}, e_{i,4})$

Figure A.9 — Passing over marshalling hump

NOTE Associated lateral rules are given in A.3.3.1.

a – Sections located between the end wheelsets or between the bogie pivots

The minimum height of vehicles, taking into account vertical displacements as defined in Table A.1 except for $e_{u,i}$ (see Table A.1, usage case (b)), shall be at least equal to $h_{u min}$ increased by the maximum value of, $e_{i,mh}$, $e_{i,1}$, $e_{i,2}$, $e_{i,3}$, and $e_{i,4}$ calculated with the Formulae (A.5) to (A.11):

a1 – Convex curve

Vehicles shall be able to pass over convex curves $R_{v,cnv}$, without any part other than the wheel flange dropping below the running plane.

$$e_{i,mh} = \left[\frac{a \cdot n_{i,A} - n_{i,A}^2 + \frac{a - n_{i,A}}{4} \cdot \frac{p_A^2}{4} + \frac{n_{i,A}}{4} \cdot \frac{p_B^2}{4}}{2 \cdot R_{v,cnv}} - h_{u min} \right]_{>0} \quad (A.5)$$

a2 – Track brakes

Vehicles shall be capable of passing over track brakes in an active or non-active position located on non-vertically curved track and reaching to $h_{u min}$ above the running plane.

$$e_{i,1} = \frac{n_i}{a} \cdot \frac{(a - n_i - X)^2}{2 \cdot R_{v,cnv}}, \text{ when } a \leq 17,80 \text{ m and } n_i < \left(\frac{a-3}{3}\right) \quad (A.6)$$

$$e_{i,2} = \frac{2 \cdot (a-X)^3}{27 \cdot a \cdot R_{v,cnv}}, \text{ when } a \leq 17,80 \text{ m and } n_i \geq \left(\frac{a-3}{3}\right) \quad (\text{A.7})$$

$$e_{i,3} = \left(\frac{27}{4} \cdot \frac{n_i}{a-X}\right) \cdot \left(1 - \frac{n_i}{a-X}\right)^2 \cdot \left(\frac{2 \cdot a^2}{27 \cdot R_{v,cnv}} - e_v\right), \text{ when } a > 17,80 \text{ m and } n_i < \left(\frac{a-3}{3}\right) \quad (\text{A.8})$$

$$e_{i,4} = \frac{2 \cdot a^2}{27 \cdot R_{v,cnv}} - e_v, \text{ when } a > 17,80 \text{ m and } n_i \geq \left(\frac{a-3}{3}\right) \quad (\text{A.9})$$

b – Sections located beyond the end wheelsets or beyond the bogie pivots

Vehicles shall be capable of passing over track brakes in an active or non-active position located on vertically curved track $R_{v,cnc}$ and reaching to h_{umin} above the running plane.

The minimum height of vehicles, taking into account vertical displacements as defined in Table A.1 except for $e_{u,a}$ (see Table A.1, usage case (b)), shall be at least equal to h_{umin} increased by $e_{a,mh}$:

— Formula (A.10) is applicable for the sections beyond A:

$$e_{a,mh} = \frac{a \cdot n_a + n_a^2 - \frac{n_a + a}{a} \cdot \frac{p_A^2}{4} + \frac{n_a}{a} \cdot \frac{p_B^2}{4}}{2 \cdot R_{v,cnc}} \quad (\text{A.10})$$

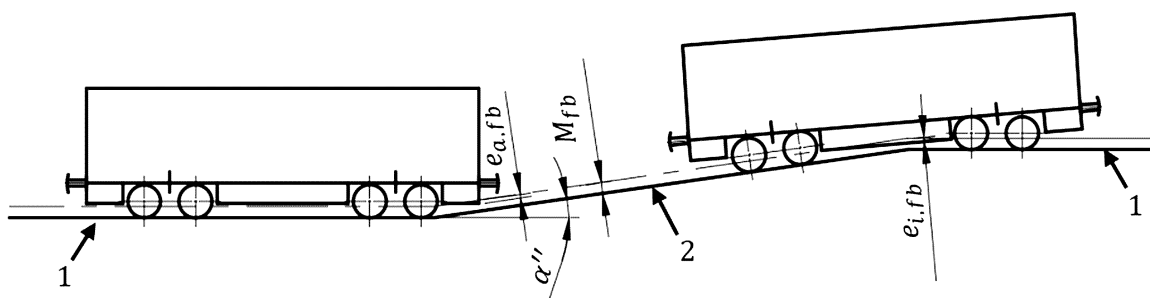
— Formula (A.11) is applicable for the sections beyond B:

$$e_{a,mh} = \frac{a \cdot n_a + n_a^2 + \frac{n_a}{a} \cdot \frac{p_A^2}{4} - \frac{n_a + a}{a} \cdot \frac{p_B^2}{4}}{2 \cdot R_{v,cnc}} \quad (\text{A.11})$$

For designation of A and B, see A.1.6

A.2.2.2.6.3 Conditions for embarkation onto ferries

Vehicles shall be capable of passing over vertical transitions made by a loading ramp between ferry and quay. Figure A.10 shows the vertical reductions.



Key

- 1 running plane of ferry or quay
- 2 running plane of loading ramp

Figure A.10 — Embarkation onto ferry

The minimum height of vehicles, taking into account vertical static displacements as defined below, shall be at least equal to $M_{f,b}$ increased by the value of $e_{i,fb}$ or $e_{a,fb}$ calculated with the following formulae:

- Formula (A.12) is applicable for the sections located between the end wheelsets or the bogie pivots:

$$e_{i,fb} = \frac{n_i \cdot (a - n_i)}{a} \cdot \tan(\alpha'') \quad (\text{A.12})$$

- Formula (A.13) is applicable for the sections located beyond the end wheelsets or the bogie pivots:

$$e_{a,fb} = n_a \cdot \tan(\alpha'') \quad (\text{A.13})$$

For the fixed allowance $M_{f,b}$ and the angle made by the link span α'' - see EN 15273-4:2025.

Vertical static displacement to take into account:

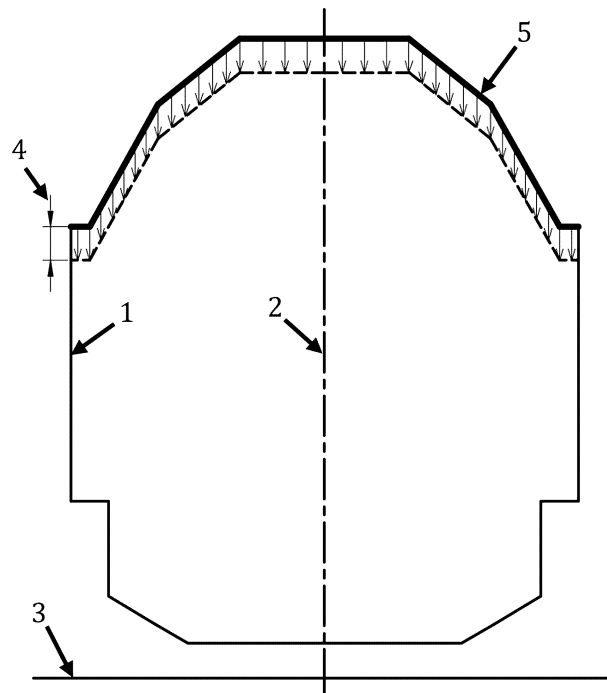
- maximum allowed wheel wear U_{sr} , see A.2.2.2.2;
- structure deformation of the carbody due to the static loading Flc , see A.2.2.2.3;
- downward suspension displacement value Aff_{stl} including spring tolerances in static loading under maximum or exceptional payload as defined in EN 15663:2017+A2:2024.

Vertical suspension displacements Aff_{stl} are taken into account according to A.2.2.2.4 with the following exception: for steel and rubber springs (see A.2.2.2.4, a)) and for any vehicle type the static deflection only shall be considered. The dynamic deflection and pitch due to suspension movements is covered by the allowance $M_{f,b}$.

A.2.3 Determination of maximum heights above running plane

A.2.3.1 General

The maximum heights above running plane of a vehicle in loading condition “dead mass” as defined by EN 15663:2017+A2:2024, and its components located close to the upper part of the gauge as shown in Figure A.11 shall be determined taking into account the sum of the vertical displacements (see A.2.3.2 and A.2.3.3) and vertical reductions (see A.2.3.4) corresponding to $E_{v,o,i}$ or $E_{v,o,a}$.

**Key**

- 1 reference profile
- 2 centreline of reference profile
- 3 running plane
- 4 vertical reductions $E_{v,o,i}$, $E_{v,o,a}$
- 5 considered parts of the reference profile

Figure A.11 — Determination of maximum heights**A.2.3.2 Bending effect of structures**

Except for wagons the longitudinal sag may be disregarded for the carbody.

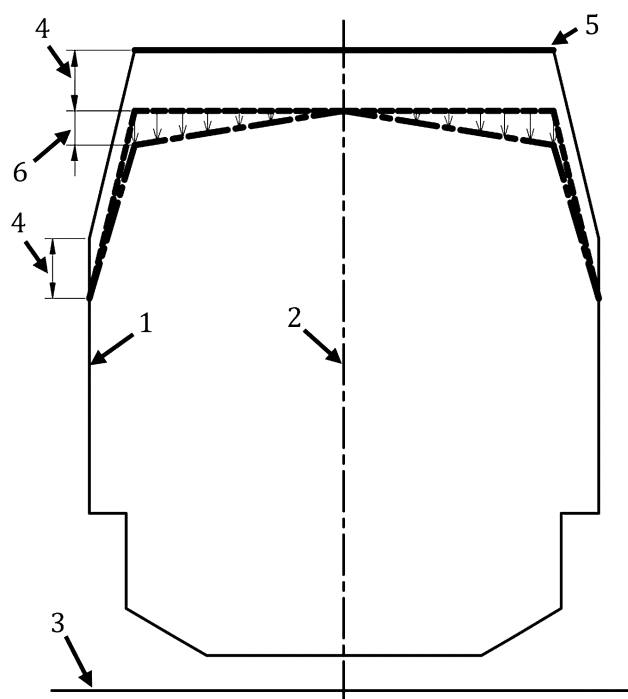
A.2.3.3 Suspension displacement

The upward displacement of the suspension is taken into account by considering a 0,010 m increase for each level of suspension.

The roll due to the dissymmetry and the pitch due to suspension movements are ignored.

If the upper horizontal line of a gauge, as illustrated in Figure A.12, has a half-width greater than one metre, the vertical component $z_{cin,v}$ of the roll displacement shall be added to $E_{v,o,i}$ or $E_{v,o,a}$.

NOTE 1 For example $z_{cin,v}$ is applicable for the top of gauges GC, GB2, BE4, SEC, PTc, GEC16.

**Key**

- 1 reference profile
- 2 centreline of reference profile
- 3 running plane
- 4 vertical reductions $E_{v,o,i}$, $E_{v,o,a}$
- 5 upper horizontal line of gauge
- 6 vertical quasi static displacements $z_{cin,v}$

Figure A.12 — Upper line of gauge

If $b > 1$ m, Formula (A.14) or Formula (A.15) are to be applied:

$$z_{cin,v} = s \cdot b \cdot \frac{D_0}{L} + (s - s_0)_{>0} \cdot b \cdot \frac{(D_{max} - D_0)}{L} \quad (A.14)$$

or

$$z_{cin,v} = s \cdot b \cdot \frac{I_0}{L} + (s - s_0)_{>0} \cdot b \cdot \frac{(I_{max} - I_0)}{L} \quad (A.15)$$

Otherwise $z_{cin,v}$ is not taken into account.

NOTE 2 $z_{cin,v}$ is only applied on the horizontal upper line of the reference profile.

A.2.3.4 Vertical curves

The heights of the rolling stock relative to the running plane taking into account vertical displacements as defined in A.2.3.2 and A.2.3.3 shall be reduced:

- Formula (A.16) is applicable for the sections located between the end wheelsets or the bogie pivots:

$$e_{o,i} = \left[\frac{a \cdot n_{i,A} - n_{i,A}^2 + \frac{a - n_{i,A}}{a} \cdot \frac{p_A^2}{4} + \frac{n_{i,A}}{a} \cdot \frac{p_B^2}{4}}{2 \cdot R_{v,min}} - S_{v,o} \right]_{>0} \quad (\text{A.16})$$

- for the sections located beyond the end wheelsets or the bogie pivots:

- Formula (A.17) is applicable for the sections beyond A:

$$e_{o,a} = \left[\frac{a \cdot n_a + n_a^2 - \frac{n_a + a}{a} \cdot \frac{p_A^2}{4} + \frac{n_a}{a} \cdot \frac{p_B^2}{4}}{2 \cdot R_{v,min}} - S_{v,o} \right]_{>0} \quad (\text{A.17})$$

- Formula (A.18) is applicable for the sections beyond B:

$$e_{o,a} = \left[\frac{a \cdot n_a + n_a^2 + \frac{n_a}{a} \cdot \frac{p_A^2}{4} - \frac{n_a + a}{a} \cdot \frac{p_B^2}{4}}{2 \cdot R_{v,min}} - S_{v,o} \right]_{>0} \quad (\text{A.18})$$

For designation of A and B, see A.1.6.

A.3 Determination of the vehicle semi-widths

A.3.1 General

Taking into account the lateral displacements of vehicles (specified in the associated rules for each gauge), the semi-widths of the vehicles considered shall not exceed the corresponding semi-width of the reference profile of the gauge, reduced by the maximum values E_i or E_a .

For each section along the vehicle, reductions E_i for $n_{i,A}$ or E_a for n_a are calculated by applying the formulae given in the following points with basic data for each kinematic gauge from EN 15273-4:2025. The value of R , with $\infty \geq R \geq R_{min}$, to be considered is that one which gives the highest value for E_i or E_a .

These displacements are the sum of the following displacements:

- quasi-static displacements resulting from the roll of the vehicle on its suspension and its dissymmetry (when this is greater than $\eta_{0,r}$);
- lateral displacements resulting from the vehicle operating along curves and straight track (overthrows, clearances, etc.), where the vehicle vertical centreline is considered to be perpendicular to the running plane;
- lateral bending of the vehicle body is generally disregarded except for special types of wagon or heavily loaded wagons for which these values exceed 10 mm.

A.3.2 Quasi-static displacements

A.3.2.1 General

The quasi-static displacements result from the inclination of the suspended parts under the influence of gravity (canted track) and/or centrifugal acceleration (curved track).

The flexibility coefficient value s can vary according to the loading, the cant value or cant deficiency value.

Load cases between “design mass in working order” (MVD) or “dead mass” (if the gauge calculation considers the empty vehicle) and “design exceptional mass” (MXD) as defined in EN 15663:2017+A2:2024 may be considered to obtain the worst flexibility coefficient.

The value s is determined by vehicle designers according to the technology and characteristics of the vehicle.

The value s is checked on a finished vehicle by test following EN 14363:2016+A2:2022 (method 1 or method 2; see also A.1.1 d).

The values of the flexibility coefficient s should be adapted according to the test result.

Depending on the point considered, the results of the calculation for the two s values at MVD and MXD load cases can be combined in order to obtain the critical case (e.g. for a given profile using s_{MVD} for P and higher, and s_{MXD} for point lower than P). If a combined analysis using multiple flexibility coefficients is carried out it shall be demonstrated that the most critical case is taken into account.

NOTE For the following two calculation steps can be used:

1. Calculation of the vehicle in the nominal position (load case MVD) with flexibility coefficient s_{MVD}
2. Calculation of the vehicle in the lowered position by static deflection $A_{ff_{stl}}$ (load case MXD) with flexibility coefficient s_{MXD}

The vehicle shall meet the construction gauge for both calculations. Value h_c can be taken into account with regard to the height of the vehicle bump stops, the height of the vehicle secondary suspension, or another height, according to the technology and characteristics of the vehicle. For more detail see CEN/TR 15273-5:2025, 7.1.1.5.2.

A.3.2.2 General cases

For sprung parts of height h , the quasi-static displacement z_{cin} is calculated with Formula (A.19a) or Formula (A.19b):

$$z_{cin} = \frac{s \cdot D_0}{L} \cdot (h - h_c)_{>0} + \left\{ \tan[\eta_0 - \eta_{0,r}]_{>0} \right\} \cdot |h - h_c| + \left[\frac{s \cdot (D_{max} - D_0)}{L} \cdot (h - h_c)_{>0} - \frac{s_0 \cdot (D_{max} - D_0)}{L} \cdot (h - h_{c0})_{>0} \right]_{>0} \quad (A.19a)$$

or

$$z_{cin} = \frac{s \cdot I_0}{L} \cdot (h - h_c)_{>0} + \left\{ \tan[\eta_0 - \eta_{0,r}]_{>0} \right\} \cdot |h - h_c| + \left[\frac{s \cdot (I_{max} - I_0)}{L} \cdot (h - h_c)_{>0} - \frac{s_0 \cdot (I_{max} - I_0)}{L} \cdot (h - h_{c0})_{>0} \right]_{>0} \quad (A.19b)$$

For conventional vehicles, Formula (A.19a) shall be used for sections located between the end wheelsets or the bogie pivots and Formula (A.19b) shall be used for sections located beyond the end wheelsets or the bogie pivots. For other cases, like active tilting trains, the worst case should be used according to the technology.

These formulae apply if the roll centre is below the centre of gravity. Otherwise, formulae for passive tilting vehicles apply – see Clause B.3.

NOTE In order to simplify the calculation, it is possible to replace h by h_{CR} for points above the roll centre at which the width b_{CR} decreases with the height, as well as for points below the roll centre at which the width b_{CR} increases with the height (see examples in CEN/TR 15273-5:2025).

If the roll centre height and the flexibility coefficient of different bogies on a vehicle vary, the Formula (A.19a) or Formula (A.19b) for z_{cin} should be adapted or the most conservative value should be used.

A.3.2.3 Effect of side bearer clearances

For sprung parts of height h , where bogies equipped with side bearers, the quasi-static displacement z_{cin} is calculated with Formula (A.20a) or Formula (A.20b):

$$z_{cin} = \frac{s \cdot D_0}{L} \cdot (h - h_c)_{>0} + \left\{ \tan \left[\eta'_0 + \left(\arctan \frac{(J - 0,005)_{>0}}{b_G} \right) \cdot (1 + s) - \eta_{0,r} \right]_{>0} \right\} \cdot |h - h_c| + \left[\frac{s \cdot (D_{max} - D_0)}{L} \cdot (h - h_c)_{>0} - \frac{s_0 \cdot (D_{max} - D_0)}{L} \cdot (h - h_{c0})_{>0} \right]_{>0} \quad (\text{A.20a})$$

or

$$z_{cin} = \frac{s \cdot I_0}{L} \cdot (h - h_c)_{>0} + \left\{ \tan \left[\eta'_0 + \left(\arctan \frac{(J - 0,005)_{>0}}{b_G} \right) \cdot (1 + s) - \eta_{0,r} \right]_{>0} \right\} \cdot |h - h_c| + \left[\frac{s \cdot (I_{max} - I_0)}{L} \cdot (h - h_c)_{>0} - \frac{s_0 \cdot (I_{max} - I_0)}{L} \cdot (h - h_{c0})_{>0} \right]_{>0} \quad (\text{A.20b})$$

Where:

η'_0 is the dissymmetry corresponding to a side bearer clearance j of 5 mm.

Formula (A.20a) shall be used for sections located between the end wheelsets or the bogie pivots and formula (A.20b) shall be used for sections located beyond the end wheelsets or the bogie pivots.

NOTE In order to simplify the calculation, it is possible to replace h by h_{CR} for points above the roll centre at which the width b_{CR} decreases with the height, as well as for points below the roll centre at which the width b_{CR} increases with the height (see examples in CEN/TR 15273-5:2025).

A.3.2.4 Particular case for the lower parts

In Formula (A.19) and Formula (A.20), the parts of z_{cin} in relation to cant and cant deficiency take into account the higher parts for which $(h - h_c)_{>0}$, as $q + w$ is generally considered greater than z_{cin} in the lower part of the reference profile. Nevertheless, in the particular case when $s > s_0$ it is necessary to check if the lower part remains inside the reference profile including lateral projection in the opposite side of the displacement $q + w$ for D_{max} and I_{max} (see explanation in CEN/TR 15273-5:2025, 7.1.1.6).

This can be checked by formulae, graphical method or simulation.

A.3.3 Lateral reductions – general formulae

A.3.3.1 General

The various operating positions of a vehicle on the track depend on the lateral clearances of the different parts connecting the body of the vehicles to the track and the design of the vehicle running gear (independent wheelsets, motor bogies, trailing bogies, etc.).

The different positions the vehicle can assume on the track should be studied in order to take account of any angular displacement coefficient A_n to be applied to certain terms to be used for the calculation of the inside reductions E_i and outside reductions E_a :

- for cases of wheelset configuration not shown in the Table A.3 to Table A.6, the track position conditions to be taken into account shall be the most unfavourable;
- for articulated vehicles according to Figure A.1, it is recommended that the operating position indicated for the standard 2-bogie vehicles be taken;
- the vehicles track operation position below is given for vehicles fitted with non-steerable wheelsets. For vehicles with other wheelset types (for example independent wheels) an adapted displacement factor can be used with an appropriate explanation and demonstration. If not demonstrated, the worst case of displacement factor given in Table A.3 to Table A.6 shall be considered;
- when the value of A_2 is zero, the bogie is considered tangential to the centreline of the track to define the values of play $w_{(R)}$ between bogie and body.

Defined kinematic gauges take into account a minimum curve radius R_{min} – see value in EN 15273-4:2025 even if the vehicle under study can pass over even smaller curve radii.

In the following formulae:

- $A_{n,A}$ is associated with the bogie A, $A_{n,B}$ is associated with the bogie B;
- $S_l = \frac{l-l_{nom}}{2}$ ($l = l_{max}$ for the rolling stock see EN 15273-4:2025).

A.3.3.2 Sections located between the end wheelsets or between the bogie pivots

A.3.3.2.1 General

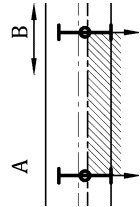
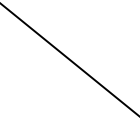
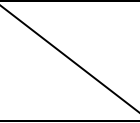
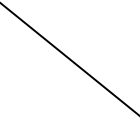
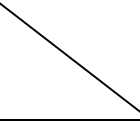
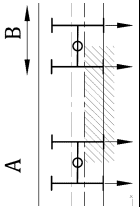
The lateral reduction for the sections located between the end wheelsets or between the bogie pivots shall be calculated with Formula (A.21).

$$E_i = \frac{a \cdot n_{i,A} - n_{i,A}^2 + A_{1,A} \cdot \frac{p_A^2}{4} + A_{1,B} \cdot \frac{p_B^2}{4}}{2 \cdot R} + A_{2,A} \cdot \frac{l_{max} - d_A}{2} + A_{2,B} \cdot \frac{l_{max} - d_B}{2} + A_{3,A} \cdot w_{i,(R),A} + A_{3,B} \cdot w_{i,(R),B} + A_{5,A} \cdot q_A + A_{5,B} \cdot q_B + z_{cin} - S_{R,i} - A_6 \cdot S_l \quad (A.21)$$

A.3.3.2.2 Straight track

Table A.3 shows the displacement factors for straight track.

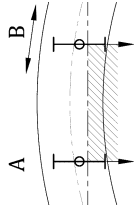
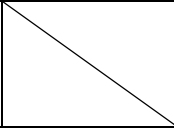
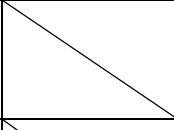
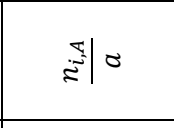
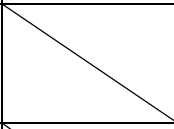
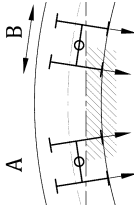
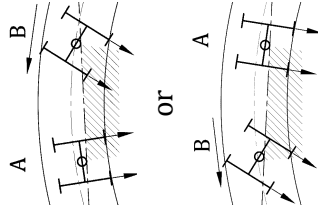
Table A.3 — Displacement factors for straight track

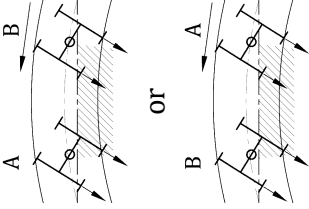
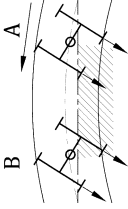
Vehicles	Position of vehicles in track	Case number	$A_{1,A}$	$A_{1,B}$	$A_{2,A}$	$A_{2,B}$	$A_{3,A}$	$A_{3,B}$	$A_{5,A}$	$A_{5,B}$	A_6
Vehicles with two wheelsets, and the bogies themselves		(1)			$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$			$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	1
Vehicles with bogies		(2)	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	1

A.3.3.2.3 Curved track

Table A.4 shows the displacement factors for curves.

Table A.4 — Displacement factors for curves

Vehicles	Position of vehicles in track	Case number	$A_{1,A}$	$A_{1,B}$	$A_{2,A}$	$A_{2,B}$	$A_{3,A}$	$A_{3,B}$	$A_{5,A}$	$A_{5,B}$	A_6
Vehicles with two wheelsets, and the bogies themselves		(3)			$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$			$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	1
Vehicles with 2 motor bogies or designated as “motor” bogies		(4)	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	1
Vehicles with 1 bogie designated as a “motor” bogie and 1 trailing bogie or regarded as a “trailing” bogie		(5)	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	$\frac{a - n_{i,A}}{a}$	0	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	$\frac{a - n_{i,A}}{a}$

Vehicles	Position of vehicles in track	Case number	$A_{1,A}$	$A_{1,B}$	$A_{2,A}$	$A_{2,B}$	$A_{3,A}$	$A_{3,B}$	$A_{5,A}$	$A_{5,B}$	A_6
Vehicles with 2 trailing bogies or regarded as “trailing” bogies	 or 	(6)	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	0	0	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	$\frac{a - n_{i,A}}{a}$	$\frac{n_{i,A}}{a}$	0

A.3.3.3 Sections located beyond the end wheelsets or beyond the bogie pivots

A.3.3.3.1 General

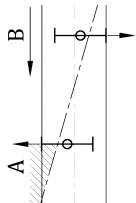
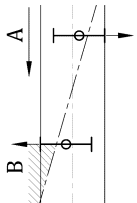
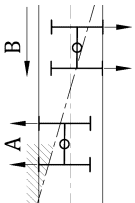
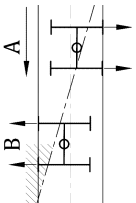
The lateral reduction for the sections located beyond the end wheelsets or beyond the bogie pivots shall be calculated with Formula (A.22).

$$E_a = \frac{a \cdot n_a + n_a^2 - A_{1,A} \cdot \frac{p_A^2}{4} + A_{1,B} \cdot \frac{p_B^2}{4}}{2 \cdot R} + A_{2,A} \cdot \frac{l_{max} - d_A}{2} + A_{2,B} \cdot \frac{l_{max} - d_B}{2} + A_{3,A} \cdot W_{i,(R),A} + A_{3,B} \cdot W_{i,(R),B} + A_{4,A} \cdot W_{a,(R),A} + A_{4,B} \cdot W_{a,(R),B} + A_{5,A} \cdot q_A + A_{5,B} \cdot q_B + Z_{cin} - S_{R,a} - S_l \quad (A.22)$$

A.3.3.3.2 Straight track

Table A.5 shows the displacement factors for straight track.

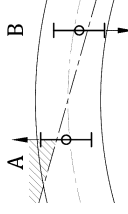
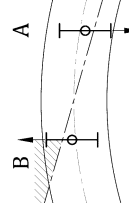
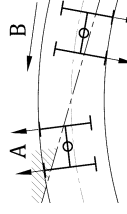
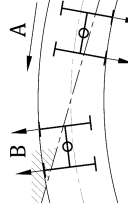
Table A.5 — Displacement factors for straight track

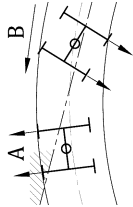
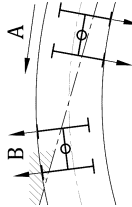
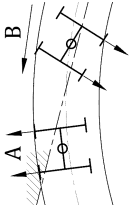
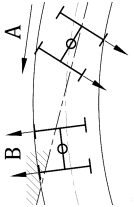
Vehicles	Position of vehicles in track	Case number	$A_{1,A}$	$A_{1,B}$	$A_{2,A}$	$A_{2,B}$	$A_{3,A}$	$A_{3,B}$	$A_{4,A}$	$A_{4,B}$	$A_{5,A}$	$A_{5,B}$
Vehicles with independent wheelsets, and the bogies themselves		(7)			$\frac{n_a + a}{a}$	$\frac{n_a}{a}$					$\frac{n_a + a}{a}$	$\frac{n_a}{a}$
		(8)			$\frac{n_a}{a}$	$\frac{n_a + a}{a}$					$\frac{n_a}{a}$	$\frac{n_a + a}{a}$
Vehicles with bogies		(9)	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	0	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$	0	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$
		(10)	$-\frac{n_a}{a}$	$-\frac{n_a + a}{a}$	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	0	0	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$

A.3.3.3 Curved track

Table A.6 shows the displacement factors for curved track.

Table A.6 — Displacement factors for curves

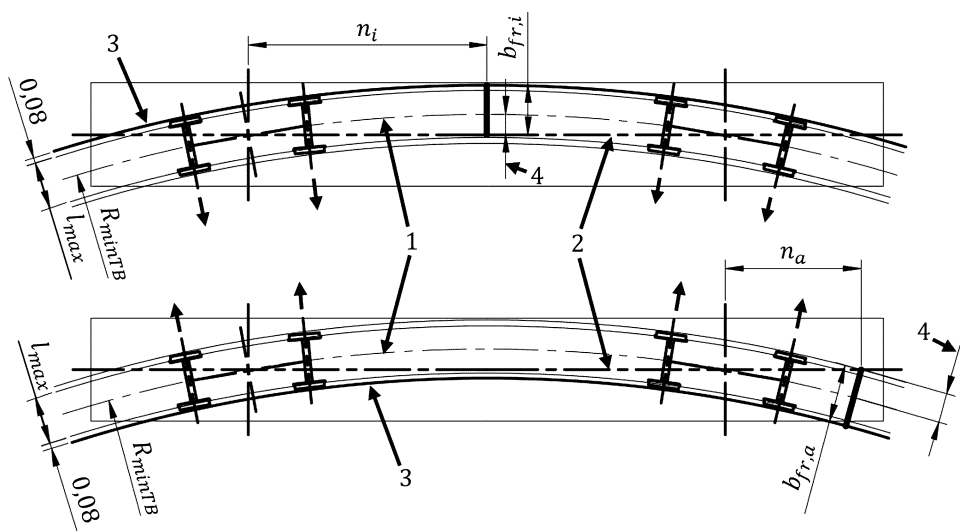
Vehicles	Position of vehicles in track	Case number	$A_{1,A}$	$A_{1,B}$	$A_{2,A}$	$A_{2,B}$	$A_{3,A}$	$A_{3,B}$	$A_{4,A}$	$A_{4,B}$	$A_{5,A}$	$A_{5,B}$
Vehicles with independent wheelsets, and the bogies themselves		(11)			$\frac{n_a + a}{a}$	$\frac{n_a}{a}$					$\frac{n_a + a}{a}$	$\frac{n_a}{a}$
		(12)			$\frac{n_a}{a}$	$\frac{n_a + a}{a}$					$\frac{n_a}{a}$	$\frac{n_a + a}{a}$
Vehicles with 2 motor bogies or designated as “motor” bogies		(13)	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	0	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$	0	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$
		(14)	$-\frac{n_a}{a}$	$-\frac{n_a + a}{a}$	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	0	0	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$

Vehicles	Position of vehicles in track	Case number	$A_{1,A}$	$A_{1,B}$	$A_{2,A}$	$A_{2,B}$	$A_{3,A}$	$A_{3,B}$	$A_{4,A}$	$A_{4,B}$	$A_{5,A}$	$A_{5,B}$
Vehicles with 1 bogie designated as a “motor” bogie and 1 trailing bogie or regarded as a “trailing” bogie		(15)	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$	0	0	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$	0	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$
		(16)	$-\frac{n_a}{a}$	$-\frac{n_a + a}{a}$	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	0	0	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$
Vehicles with 2 trailing bogies or regarded as “trailing” bogies		(17)	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$	0	0	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$	0	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$
		(18)	$-\frac{n_a}{a}$	$-\frac{n_a + a}{a}$	0	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	0	0	$\frac{n_a + a}{a}$	$\frac{n_a}{a}$	$\frac{n_a + a}{a}$

A.3.4 Rules for bottom lines of gauge – shunting devices and contact ramps

A.3.4.1 Use of shunting devices on curved tracks

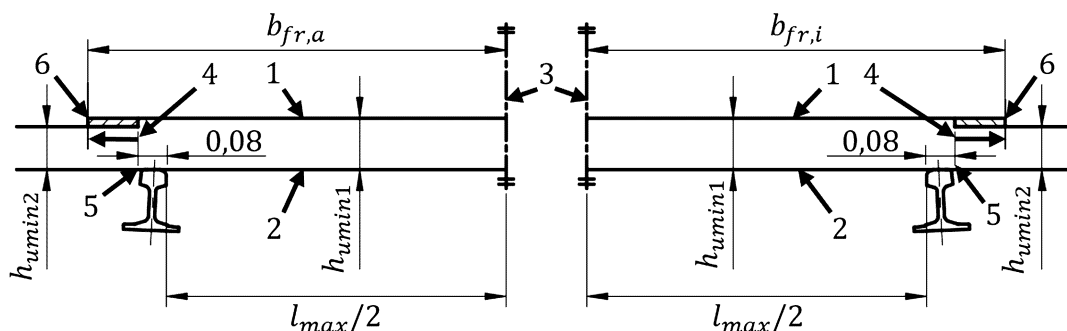
Track brakes, when in an active position, and stopping devices, in particular the shunting device, can reach the height h_{umin1} or h_{umin2} (see Figure A.14) and may be installed on curves of radius R_{minTB} (see Figure A.13).



Key

- 1 track centreline
- 2 centreline of vehicle
- 3 limit for drag shoes (or scotches)
- 4 increase (geometric overthrow + lateral displacement due to clearance between wheelsets and track)

Figure A.13 — Distances $b_{fr,i}$ and $b_{fr,a}$ (top view)

**Key**

- 1 reference profile
- 2 running plane
- 3 centreline of reference profile
- 4 increase (geometric overthrow + lateral displacement due to clearance between wheelsets and track)
- 5 limit for drag shoes (or scotches)
- 6 maximum construction gauge

Figure A.14 — Distances $b_{fr,i}$ and $b_{fr,a}$ Cross section

It follows that the application limit for the h_{umin1} or h_{umin2} dimensions at a constant distance from the inner edge of the rail (0,080 m) is a variable distance $b_{fr,i}$ or $b_{fr,a}$ from the centreline of the vehicle, as shown in Figure A.13.

The formulae are:

- Formula (A.23) is applicable for the sections located between the end wheelsets or the bogie pivots:

$$b_{fr,i} = \frac{a \cdot n_{i,A} - n_{i,A}^2 + A_{1,A} \cdot \frac{p_A^2}{4} + A_{1,B} \cdot \frac{p_B^2}{4}}{2 \cdot R_{minTB}} + A_{2,A} \cdot \frac{l_{max} - d_A}{2} + A_{2,B} \cdot \frac{l_{max} - d_B}{2} + 0,080 + \frac{l_{max}}{2} \quad (A.23)$$

- Formula (A.24) is applicable for the sections located beyond the end wheelsets or the bogie pivots:

$$b_{fr,a} = \frac{a \cdot n_a + n_a^2 - A_{1,A} \cdot \frac{p_A^2}{4} + A_{1,B} \cdot \frac{p_B^2}{4}}{2 \cdot R_{minTB}} + A_{2,A} \cdot \frac{l_{max} - d_A}{2} + A_{2,B} \cdot \frac{l_{max} - d_B}{2} + 0,080 + \frac{l_{max}}{2} \quad (A.24)$$

NOTE 1 In the particular case involving the use of shunting devices, the influence of clearances $q + w$ can be considered as negligible.

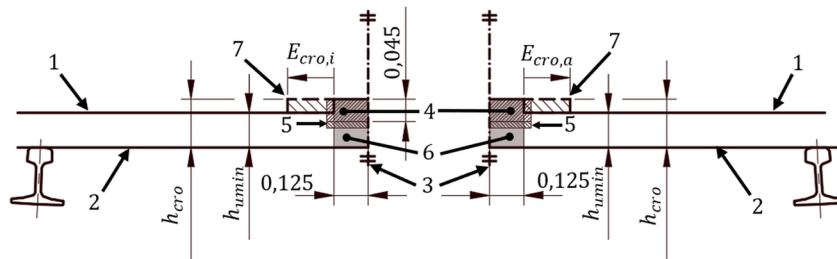
NOTE 2 Associated vertical rules are given in A.2.2.2.6.2.

NOTE 3 Values of coefficients “ A_n ” are given in Table A.3 to Table A.6.

A.3.4.2 Contact ramps

For vehicles intended to operate on networks fitted with contact ramps “crocodile” (see CEN/TR 15273-5:2025, 7.1.1.7), a free space shall be provided in the lower horizontal part of the reference profile at a height h_{cro} .

This free space shall contain only the brushes that shall come into contact with the ramps.



Key

- 1 reference profile
- 2 running plane
- 3 centreline of reference profile
- 4 zone for contact brushes when the vehicle is at a standstill
- 5 zone for contact brushes when the vehicle is running
- 6 zone reserved for contact ramps
- 7 zone to be cleared for contact ramps due to the lateral vehicle displacement

Figure A.15 — Contact ramp zone

When the vehicle is at a standstill at design mass in working order for locomotives or design exceptional mass for other vehicles, as defined in EN 15663:2017+A2:2024, the contact brush may descend to a level 0,045 m down into the zone intended for installation of the contact ramps. Taking into account the flexible and deformable character of the contact brush, it is permitted for the contact brush to drop below this level only for the dynamic complementary displacement of the primary suspension.

The longitudinal position of the contact brush shall comply with the following rules:

1) brush mounted on bogie frame:

- a) sections located between wheelsets: no specific rule;
- b) Formula (A.25) is applicable for the sections located beyond wheelsets:

$$\frac{p \cdot n_a + n_a^2}{2 \cdot R_{cro}} + \frac{2 \cdot n_a + p}{p} \cdot \left(\frac{l_{max-d}}{2} + q \right) \leq 0,065 \quad (A.25)$$

2) brush mounted under body frame of vehicle with independent wheelsets:

- a) Formula (A.26) is applicable for the sections located between wheelsets:

$$\frac{a \cdot n_i - n_i^2}{2 \cdot R_{cro}} + \frac{l_{max-d}}{2} + q \leq 0,065 \quad (A.26)$$

- b) sections located beyond wheelsets: installation of brush is forbidden.

NOTE 1 Explanations about 0,065 m are given in CEN/TR 15273-5:2025.

Vehicle parts likely to descend to less than h_{cro} from the running plane on track without vertical curvature with vertical displacements as defined in A.2.2, shall not be located less than 0,125 m from the track centreline when the vehicle is installed on a curved track of radius R_{cro} and track width l_{max} .

For parts under the bogies, the semi-width to be cleared in the contact ramp zone is fixed at 0,150 m.

The semi-width of the space for contact ramps below the vehicles considered shall exceed the corresponding semi-width of this space on the reference profile of the gauge, increased by the values $E_{cro,i}$ or $E_{cro,a}$.

The formulae are:

- Formula (A.27) is applicable for the sections located between the end wheelsets or the bogie pivots:

$$E_{cro,i} = \frac{a \cdot n_{i,A} - n_{i,A}^2 + A_{1,A} \cdot \frac{p_A^2}{4} + A_{1,B} \cdot \frac{p_B^2}{4}}{2 \cdot R} + A_{2,A} \cdot \frac{l_{max} - d_A}{2} + A_{2,B} \cdot \frac{l_{max} - d_B}{2} + A_{3,A} \cdot w_{i,(R_{cro}),A} + A_{3,B} \cdot w_{i,(R_{cro}),B} + A_{5,A} \cdot q_A + A_{5,B} \cdot q_B \quad (A.27)$$

- Formula (A.28) is applicable for the sections located beyond the end wheelsets or the bogie pivots:

$$E_{cro,a} = \frac{a \cdot n_a + n_a^2 - A_{1,A} \cdot \frac{p_A^2}{4} + A_{1,B} \cdot \frac{p_B^2}{4}}{2 \cdot R} + A_{2,A} \cdot \frac{l_{max} - d_A}{2} + A_{2,B} \cdot \frac{l_{max} - d_B}{2} + A_{3,A} \cdot w_{i,(R_{cro}),A} + A_{3,B} \cdot w_{i,(R_{cro}),B} + A_{4,A} \cdot w_{a,(R_{cro}),A} + A_{4,B} \cdot w_{a,(R_{cro}),B} + A_{5,A} \cdot q_A + A_{5,B} \cdot q_B \quad (A.28)$$

NOTE 2 Values of coefficients “ A_n ” are given in Table A.3 to Table A.6.

The longitudinal position of the contact brush should also comply with the local regulation.

A.4 Pantograph gauge verification and non-insulated devices on the vehicle's roof

A.4.1 Pantograph gauge verification

A.4.1.1 General principles

For the pantograph reference profile, basic data and horizontal projections see EN 15273-4:2025, Clause 8.

The verification calculation shall show that the pantograph movements to be verified are no greater than those agreed as standard for the rolling stock; the result is that the values of $P'_{o,i}$ and $P'_{o,a}$ (pantographs raised to h'_o above running plane) and $P'_{u,i}$ and $P'_{u,a}$ (pantographs raised to h'_u above running plane) shall be negative or zero applying the formulae given in A.4.1.2 and A.4.1.3.

- a) Vehicles where the lateral clearances vary linearly according to $1/R$.

Two cases shall be analysed: the position of a vehicle operating on a curve of minimum radius R_{min} and the position on a straight track, $R = \infty$.

- b) Vehicles where the lateral clearances vary nonlinearly according to $1/R$.

In addition to operation along a straight track and on a curve radius R_{min} , the verification is carried out on the curve radius R for which the variation of the clearance w relative to $1/R$ presents a discontinuity (or more than one), e.g. a value of R from which the variable bump stops begin to work.

If the lateral clearances vary according to the operational radius, in the following formulae, the value $w_{i,(R)}$, which is related to the radius R under consideration, at pivot level (real or theoretical) shall be taken for $P'_{o,i}$ and $P'_{u,i}$, and for $P'_{o,a}$ and $P'_{u,a}$ the value $w_{a,(R)}$ and the corresponding value $w_{i,(R)}$.

Pantographs are usually very close to the bogie centre, the following formulae only take into account parameters p , q , d of the closest bogie to the pantograph. The values of coefficients “A” are given by Table A.3 to Table A.6.

A.4.1.2 Formulae for a pantograph located between the end wheelsets or the bogie pivots (verification with the vehicle at a standstill on canted track)

Formula (A.29) and Formula (A.30) are applicable for the sections located between the end wheelsets or the bogie pivots:

$$P'_{o,i} = \frac{a \cdot n_{i,A} - n_{i,A}^2 + \frac{p^2}{4}}{2 \cdot R} + q + A_{3,A} \cdot w_{i,(R),A} + A_{3,B} \cdot w_{i,(R),B} + \frac{s \cdot D'_0}{L} \cdot (h'_o - h_c) + \sqrt{t^2 + \tau^2 + [\theta \cdot (h'_o - h_c)]^2} + \left[\frac{s \cdot (D'_{max} - D'_0)}{L} \cdot (h'_o - h_c) - \frac{s'_0 \cdot (D'_{max} - D'_0)}{L} \cdot (h'_o - h_{c0}) \right]_{>0} - (e_{p,o} + Abt_o) - S'_R \quad (A.29)$$

If $P'_{o,i} \leq 0$ the pantograph remains inside the gauge at its upper collecting point.

$$P'_{u,i} = \frac{a \cdot n_{i,A} - n_{i,A}^2 + \frac{p^2}{4}}{2 \cdot R} + q + A_{3,A} \cdot w_{i,(R),A} + A_{3,B} \cdot w_{i,(R),B} + \frac{s \cdot D'_0}{L} \cdot (h'_u - h_c) + \sqrt{\left(t \cdot \frac{h'_u - h_t}{h'_o - h_t} \right)^2 + \tau^2 + [\theta \cdot (h'_u - h_c)]^2} + \left[\frac{s \cdot (D'_{max} - D'_0)}{L} \cdot (h'_u - h_c) - \frac{s'_0 \cdot (D'_{max} - D'_0)}{L} \cdot (h'_u - h_{c0}) \right]_{>0} - (e_{p,u} + Abt_u) - S'_R \quad (A.30)$$

If $P'_{u,i} \leq 0$ the pantograph remains inside the gauge at its lower collecting point.

A.4.1.3 Formulae for a pantograph located beyond the end wheelsets or bogie pivots (verification of vehicle in running conditions on track with cant deficiency)

Formula (A.31) and Formula (A.32) are applicable for the sections located beyond the end wheelsets or bogie pivots:

$$P'_{o,a} = \frac{a \cdot n_a + n_a^2 - \frac{p^2}{4}}{2 \cdot R} + \frac{l_{max} - d}{2} \cdot \frac{2n_a}{a} + q \cdot \frac{2n_a + a}{a} + A_{3,A} \cdot w_{i,(R),A} + A_{3,B} \cdot w_{i,(R),B} + A_{4,A} \cdot w_{a,(R),A} + A_{4,B} \cdot w_{a,(R),B} + \frac{s \cdot I'_0}{L} \cdot (h'_o - h_c) + \sqrt{t^2 + \tau^2 + [\theta \cdot (h'_o - h_c)]^2} + \left[\frac{s \cdot (I'_{max} - I'_0)}{L} \cdot (h'_o - h_c) - \frac{s'_0 \cdot (I'_{max} - I'_0)}{L} \cdot (h'_o - h_{c0}) \right]_{>0} - (e_{p,o} + Abt_o) - S'_R \quad (A.31)$$

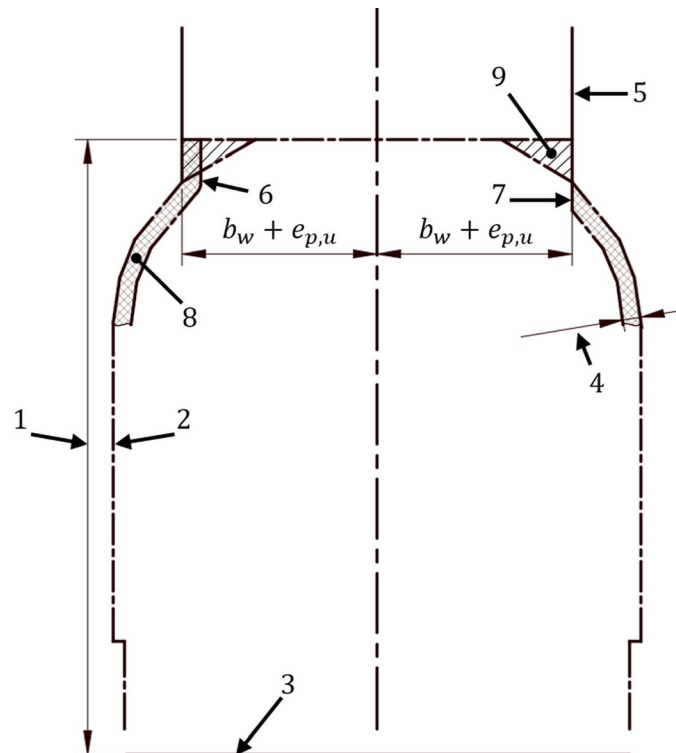
If $P'_{o,a} \leq 0$ the pantograph remains inside the gauge at its upper collecting point.

$$P'_{u,a} = \frac{a \cdot n_a + n_a^2 - \frac{p^2}{4}}{2 \cdot R} + \frac{l_{max} - d}{2} \cdot \frac{2n_a}{a} + q \cdot \frac{2n_a + a}{a} + A_{3,A} \cdot w_{i,(R),A} + A_{3,B} \cdot w_{i,(R),B} + A_{4,A} \cdot w_{a,(R),A} + A_{4,B} \cdot w_{a,(R),B} + \frac{s \cdot I'_0}{L} \cdot (h'_u - h_c) + \sqrt{\left(t \cdot \frac{h'_u - h_t}{h'_o - h_t} \right)^2 + \tau^2 + [\theta \cdot (h'_u - h_c)]^2} + \left[\frac{s \cdot (I'_{max} - I'_0)}{L} \cdot (h'_u - h_c) - \frac{s'_0 \cdot (I'_{max} - I'_0)}{L} \cdot (h'_u - h_{c0}) \right]_{>0} - (e_{p,u} + Abt_u) - S'_R \quad (A.32)$$

If $P'_{u,a} \leq 0$ the pantograph remains inside the gauge at its lower collecting point.

A.4.2 Pantographs in the lowered position and non-insulated live parts on vehicle's roof

A.4.2.1 Pantographs in the lowered position and non-insulated live parts on vehicle's roof reference profile



Key

- 1 height of the kinematic reference profile
- 2 kinematic reference profile
- 3 running plane
- 4 electrical clearance according to voltage of power supply system c_{elec} – see Table A.7
- 5 pantograph reference profile
- 6 limit for pantograph with insulated horns the electrical clearance corresponding to the width of insulated horns c_w is taken into account by the rolling stock domain
- 7 limit for pantograph without insulated horns – In this case, the electrical clearance is taken into account by the Infrastructure domain
- 8 zones into which the non-insulated parts likely to remain live shall not penetrate
- 9 “special zones” – see A.4.2.3

Figure A.16 — Pantographs in the lowered position and non-insulated live parts on vehicle roof reference profile

For electrical clearance values see the Table A.7.

Table A.7 — Values for the electrical clearance c_{elec}

Voltage of the power supply system V	Electrical clearance m
25 000 (AC)	0,170
15 000 (AC)	0,150
3 000 (DC)	0,100
1 500 (DC)	0,100
750 (DC)	0,100

A.4.2.2 Rules for non-insulated devices on the vehicle roof outside the pantograph reference profile

For all non-insulated devices on the vehicle roof outside the pantograph reference profile, the dimension of the maximum construction gauge shall be reduced by the electrical clearance given in Table A.7.

A.4.2.3 Rules for devices on the vehicle roof and pantograph in the lowered position inside pantograph reference profile

On electrified lines, “special zones” (see Figure A.16) are defined by the width of the pantograph reference profile and the upper line of the defined kinematic reference profile. These zones may be used for non-live parts of pantograph heads in the lowered position and for other vehicle parts.

To maintain gauge interoperability, the width of these zones shall take into account the width of the narrowest pantograph head and therefore their semi-width is limited to the value b_w of the smallest pantograph head – see EN 50367:2020.

Greater values may be used, but in this case the vehicle may not be compatible with all infrastructure of the required gauge.

On non-electrified lines, specific studies shall be done on the railway networks to use “special zones”.

All devices on the vehicle roof and the pantograph in the stowed position shall be arranged to comply both with the maximum construction gauge and the pantograph reference profile, reduced by the values E_i or E_a as defined following Clause A.3 with specific lateral projection S'_R and basic data ($I'_0, D'_0, I'_{max}, D'_{max}, s'_0, h_{c0}$) used for pantograph gauge verification, except for z_{cin} calculated with Formula (A.33) and Formula (A.34).

$$z_{cin} = \left[\frac{s \cdot D'_0}{L} + \theta \right] (h - h_c) + \left[\frac{s \cdot (D'_{max} - D'_0)}{L} \cdot (h - h_c) - \frac{s'_{0'} \cdot (D'_{max} - D'_0)}{L} \cdot (h - h_{c0}) \right]_{>0} \quad (A.33)$$

or

$$z_{cin} = \left[\frac{s \cdot I'_0}{L} + \theta \right] (h - h_c) + \left[\frac{s \cdot (I'_{max} - I'_0)}{L} \cdot (h - h_c) - \frac{s'_{0'} \cdot (I'_{max} - I'_0)}{L} \cdot (h - h_{c0}) \right]_{>0} \quad (A.34)$$

If the collecting pantograph head has insulated horns, allowances shall be taken into account also for non-insulated parts likely to remain live, including another pantograph in the lowered position, if any (see CEN/TR 15273-5:2025, 7.1.1.9.2). Otherwise, insulating allowances will not be taken into account – see Figure A.16.