UIC CODE 505-4

4th edition, November 2007

Translation

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Effects of the application of the kinematic gauges defined in the 505 series of leaflets on the positioning of structures in relation to the tracks and of the tracks in relation to each other

Conséquences de l'application des gabarits cinématiques définis par les fiches 505 sur l'implantation des obstacles par rapport aux voies et des voies entre elles

Auswirkungen der Anwendung der kinematischen Begrenzungslinien nach den UIC-Merkblättern Nr. 505 auf den Abstand fester Gegenstände vom Gleis und auf den Gleisabstand

UNION INTERNATIONALE DES CHEMINS DE FER
INTERNATIONALER EISENBAHNVERBAND
INTERNATIONAL UNION OF RAILWAYS

Leaflet to be classified in Volumes:

V - Rolling Stock

VI - Traction
VII - Way and Works

Application:

With effect from 1st November 2007
All members of the International Union of Railways

This leaflet applies to standard gauge lines

Record of updates

1st edition, January 1969	First issue with 1 Amendment
2nd edition, January 1973	with 1 Amendment
3rd edition, January 1977	with 2 Amendments
4th edition, November 2007	Complete overhaul of leaflet in accordance with PTU 1.1.2

The person responsible for this leaflet is named in the UIC Code

Contents

Summary

The aim of this leaflet is to set out the rules enabling infrastructure managers (IM) to determine the clearance which must be provided and maintained so that rolling stock dimensioned according to the gauges set out in *UIC Leaflet 505-1* can safely negotiate structures and pass other rolling stock (distance between track centre lines).

1 - General

In the field of infrastructure, the term "gauge" relates to a reference profile and the rules associated with it which govern the positioning of fixed objects and the distance between track centre lines.

In order to define and apply a gauge or a certain distance between track centre lines, the kinematic reference profile of the chosen gauge and the related rules must be known.

The essential requirements cover safety and compatibility as well as the bi-lateral or multilateral agreements to be taken into consideration.

1.1 - Safety

Compliance with the gauge is critical for safety. The design, construction, maintenance and supervision of infrastructure installations must ensure safe train operations, with no risk of vehicles coming into contact with each other or with fixed objects.

1.2 - Compatibility

To allow interoperability, the characteristics of infrastructure installations must be compatible with those of rolling stock authorised for international traffic.

The safety and compatibility conditions for rolling stock are set out in *UIC Leaflet 505-1* (see Bibliography - page 35).

1.3 - Bi-lateral and multilateral agreements

In the event that the clearance gauge on a given route is not completely in line with that used to build a rolling stock vehicle but the dimensions of the latter are in practice compatible with the infrastructure of the route concerned, bi-lateral or multilateral agreements may be concluded between the RUs and IMs (see List of abbreviations - page 33).

1.4 - Vehicles suitable for running on higher cant deficiencies

In the event that the theoretical cant deficiency I_c, used in the dimensioning of vehicles, is higher than the actual cant deficiency I_c on the running lines, authorisation to operate tilting or conventional stock with a cant deficiency of $I_p > I_c$ must be regulated based on the actual local conventional cant deficiency I_c on the lines to be operated over.

An I_p value and a corresponding maximum speed should be set to ensure compatibility with local infrastructure dimensioned using the conventional method.

As regards train running in degraded mode, any failure modes that may lead to fouling of the gauge must be studied by the manufacturer and approved by the IM.

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2 - Scope of application

2.1 - Gauges used

The gauges used at international level are classified as follows:

- The minimum gauge to be implemented on all lines: **G1**
  This gauge is the international minimum that must be provided on all lines (except in Great Britain, see *UIC Leaflet 503*, see Bibliography - page 35).

- Enlarged gauges provided by some IMs: **G2**
  G2 gauge is a raised gauge used by different IMs (mostly in eastern Europe) based on the basis of bi-lateral or multilateral agreements (see *UIC Leaflet 505-1*).

- Enlarged gauges necessary for certain well defined routes: **GA**, **GB**, **GC**, **GB1** and **GB2** (see *UIC Leaflet 506*, see Bibliography - page 35).

2.2 - Pantographs

The clearance needing to be achieved and maintained to enable pantographs and live roof-mounted equipment to run on electrified lines must comply with the rules in point 9.2 - page 24.

2.3 - Platforms

Platforms must be positioned in accordance with the rules in point 8 - page 16.

3 - Definitions

3.1 - Normal co-ordinates

The expression "normal co-ordinates" is used for orthogonal axes defined in a plane normal to the longitudinal centreline of the rails in nominal position; one of these axes, sometimes called horizontal, is the intersection of the aforementioned plane and the running surface; the other is the perpendicular to this intersection equi-distant from the rails.

For calculation purposes, this centreline and the vehicle centreline must be considered as coincident in order to be able to compare the vehicle construction gauges and the lineside clearance gauges, both calculated on the basis of the kinematic gauge reference profile which is common to both.

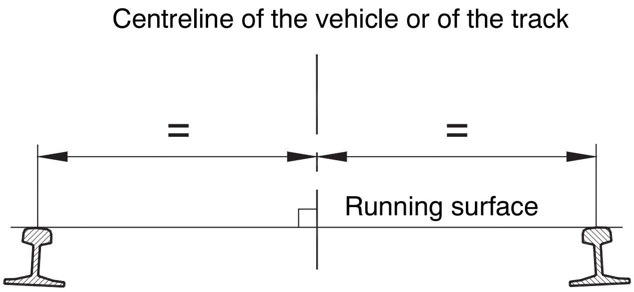

Fig. 1 - Normal coordinates

3.2 - Kinematic reference profile

This profile is related to the normal co-ordinates of the axes and is always associated with rules to determine, in the case of infrastructure, the lineside clearance gauge and the distance between track centre lines.

3.3 - Projection S

This is the permitted projection exceeding the kinematic reference profile when the vehicle runs on a curve and (or) a track with a gauge greater than 1,435 m.

Fig. 2 illustrates the space reserved for projections which must be taken into account when defining the lineside clearance gauge and the distance between track centre lines.

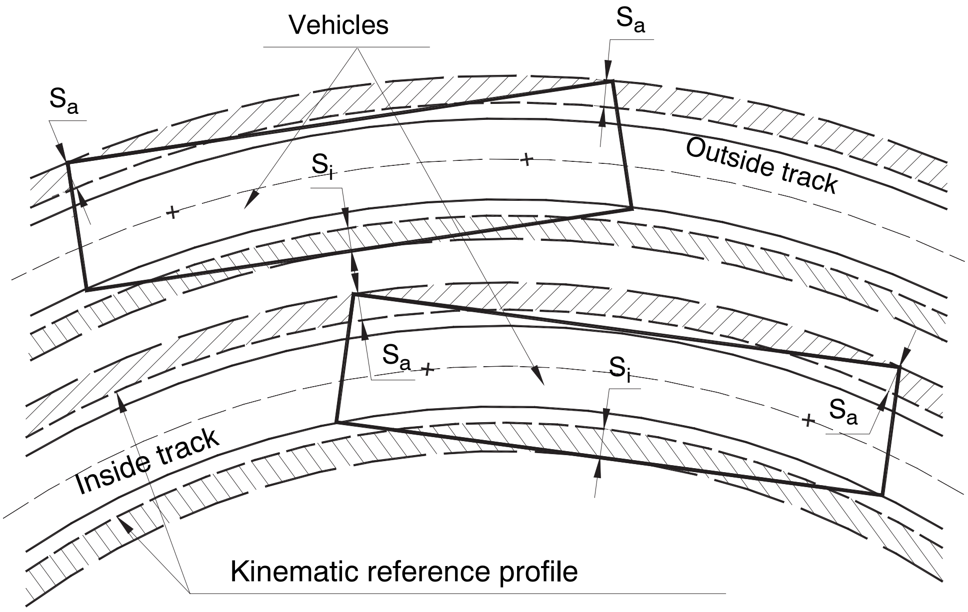

Fig. 2 - Projection S

3.4 - Roll centre C

When the vehicle body is subject to a lateral force parallel to the running surface (gravity component, see Fig. 3 - page 6, or centrifugal force, see Fig. 4 - page 6), it tilts on its suspension.

Should the lateral play of the vehicle and the effect of its dampers reach their limits, the XX' centre line of the vehicle body cross-section takes up a position $X_1X'_1$ in that tilt.

In routine cases of vehicle lateral movement, the position of point C is independent of the lateral force involved.

Point C is known as the "vehicle roll centre" and its distance h_c from the running surface is known as the "roll centre height".

When calculating the lineside clearance gauge and the distance between track centre lines, the value of the height h_c is conventionally taken as 0,5 m.

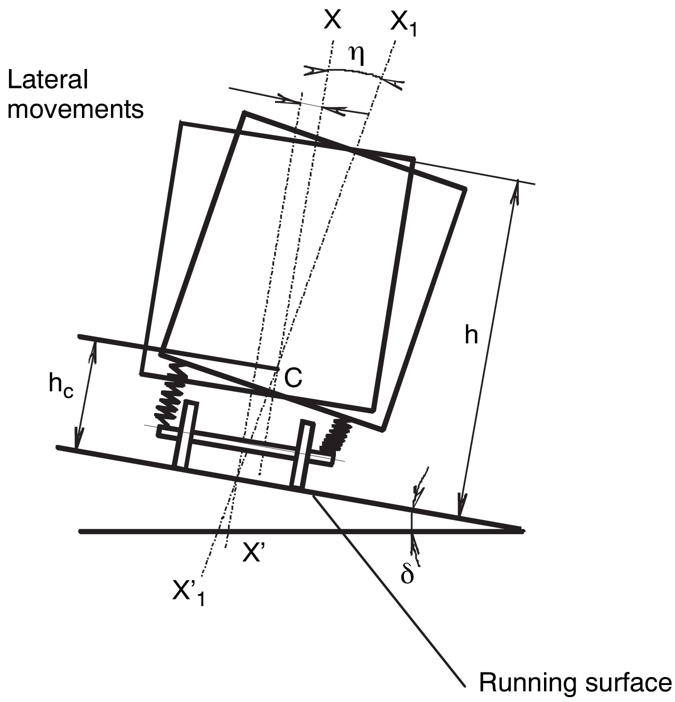

Fig. 3 - Vehicle stationary on canted track

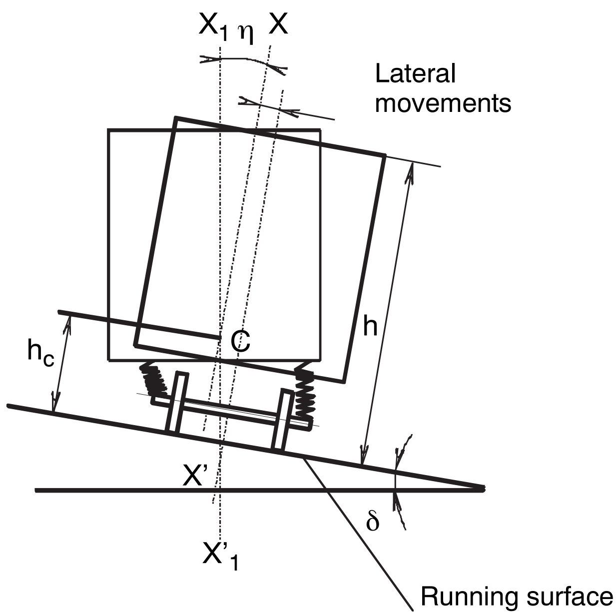

Fig. 4 - Vehicle running on a track with cant deficiency

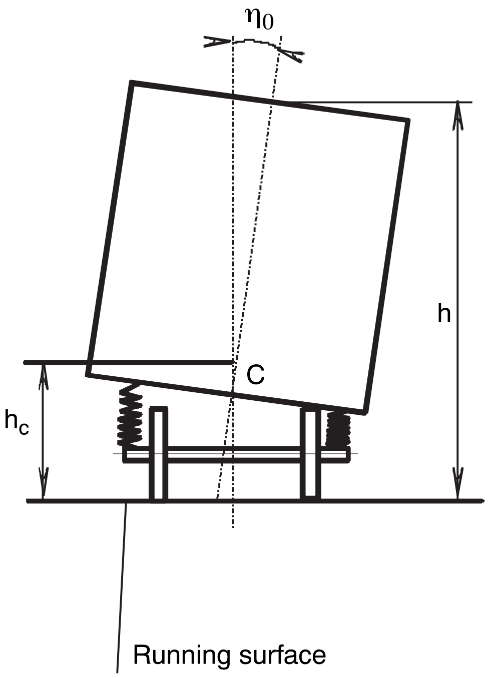

Fig. 5 - Vehicle asymmetry

3.5 - Asymmetry

The asymmetry of a vehicle is defined as the angle η_o that would be formed between the vertical and the centreline of the body of a stationary vehicle on level track in the absence of friction (see Fig. 5). Asymmetry may result from constructional defects, unevenly set up suspension (adjustment, side bearers, pneumatic levelling valves, etc.) and from an off-centre load.

3.6 - Flexibility coefficient s

Whenever a vehicle is stationary on a canted track whose running surface lies at an angle δ to the horizontal, its body leans on its suspensions and forms an angle η with the perpendicular to the running surface (see Fig. 3 - page 6).

The vehicle flexibility coefficient s is defined as: $s = \frac{\eta}{\delta}$

3.7 - Quasi-static movement

This is the lateral movement of a vehicle body resulting from the technology applied and suspension flexibility (s flexibility coefficient) under the effect of centrifugal force not compensated for by cant or excess cant (see Fig. 3 or 4) and under the effect of asymmetry η_o (see Fig. 5). This value depends on the height h of the point in question.

4 - General information on the method of determining the lineside clearance gauge

First of all, a distinction must be drawn between the minimum clearance gauge and the nominal clearance gauge.

A clearance gauge is a theoretical space related to the track, defined to take account of the possible kinematic space requirement of a theoretical piece of rolling stock dimensioned to the reference profile of the chosen gauge. The space requirement may result from the movements of the rolling stock due to various parameters intrinsic to it or to the layout and geometry of the track, the speed of travel, and imperfections/elastic distortion of the track. This clearance must therefore be provided and maintained vis-à-vis lineside objects throughout the route under consideration.

It is important to note that it is necessary to carry out maintenance work periodically on ballasted track to ensure safe train operation and passenger comfort. A consequence of this maintenance work is that tracks shift in relation to their original position over time thereby reducing the clearance from fixed objects. Therefore the IM must take account of factors that may reduce the clearance when planning to apply a chosen clearance gauge. The IM must make allowance for margins for track maintenance work to ensure the chosen gauge remains clear over time. When those margins are used, an absolute minimum space will remain which must not be fouled by any object to prevent critical points arising. That space is referred to as the "minimum lineside clearance gauge".

The dimensions of the nominal lineside clearance gauge are more generous than those of the minimum lineside clearance gauge. It should be applied when constructing new lines, making major changes to installations and where the infrastructure permits it.

When actually positioning objects along tracks, IMs must adopt intermediate dimensions, lying between the minimum clearance gauge and the nominal clearance gauge. These dimensions are set by each IM; they are obtained by increasing the minimum clearance gauge dimensions with the margins set by the IM based on its own operating rules, the track laying method and maintenance method.

4.1 - Minimum clearance gauge

This is the minimum space, related to the normal coordinates of the axes of the track, which should not be fouled by an object and must be provided and maintained to ensure safe running of a given type of rolling stock. In general, the minimum clearance gauge is defined to take account of the maximum, horizontal and vertical space requirements of the most protruding parts of the rolling stock in question.

To determine the envelope horizontally, various parameters covered in the associated rules set out in point 5 - page 12 are added to the horizontal dimensions of the half-width of the kinematic reference profile of the gauge in question. Vertically, the IMs must adjust the dimensions of the kinematic reference profile, of the upper and lower horizontal parts, to take account of transition curves on gradients. Account may also be taken of a margin for track maintenance.

In general, the minimum clearance gauge must be chosen, applied and maintained where special circumstances prevail and at particularly awkward points on old lines (tunnels, road bridges, etc.) in order to limit the scale of engineering work and investment costs.

When applying the minimum clearance gauge at problem points on the infrastructure, the IM must monitor those locations carefully and apply the appropriate rules (for example interconnecting the tracks and the objects). It must also establish controls and checks to ensure that under no circumstances the objects in those zones come over time to foul the minimum clearance gauge.

4.2 - Nominal clearance gauge

This is a larger space than the minimum clearance gauge described above. The safety margins used are greater in comparison with the minimum clearance gauge and reflect the factors peculiar to each IM (running of special traffic, scope for raising speed, strong cross-winds, taking account of aerodynamic effects, etc.).

In general, the nominal clearance gauge must be chosen, applied and maintained when constructing new lines, making major changes to installations and where the infrastructure permits it.

4.3 - Relative positions of various gauges

Fig. 6 - page 10 gives the relative positions of the various gauges, in relation to each another.

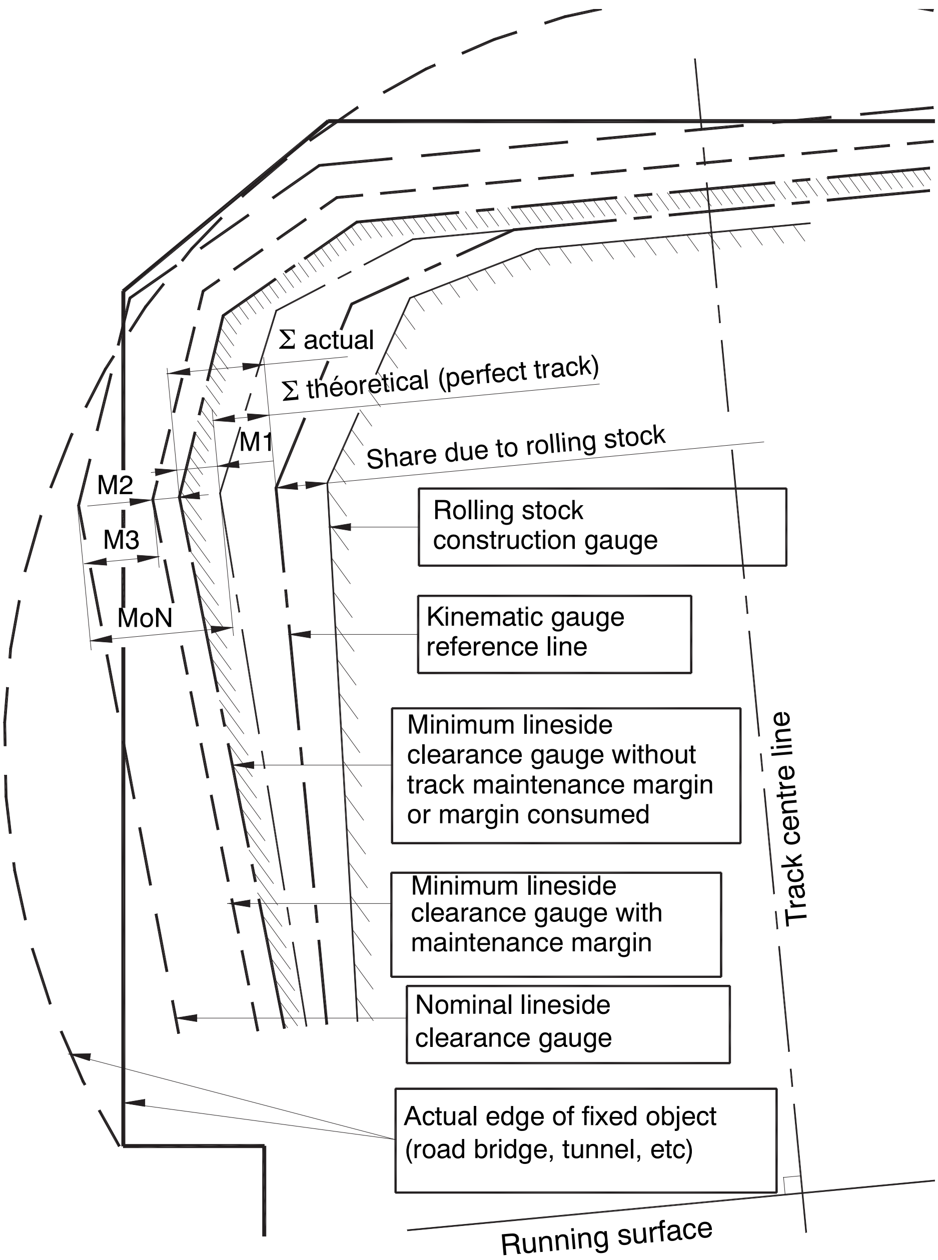

Fig. 6 - Relative positions of various gauges

In the figure:

1. Σ**<u>theoretical</u>** is the share of vehicle movements exceeding the kinematic reference profile for which the IM is responsible, in the case of a perfect vehicle running on a track free of defects and elastic deformation, with no horizontal movement in between overhauls, free of rail wear, etc. taking account of:

   - the projections $\mathbf{S_i}$ and $\mathbf{S_a}$ which are defined in the associated rules specific to individual gauge,
   - the quasi-static movements $\mathbf{q_{si}}$ and $\mathbf{q_{sa}}$ which result from the effect of cant excess or cant deficiency over 50 mm.

2. Σ**<u>actual</u>** as well as Σ**theoretical** include a margin **M1** which covers various phenomena which are considered to be random. Margin **M1** is made up of two components:

   - asymmetry of up to 1° is conventionally taken into account to make partial allowance for vehicle design and suspension adjustment and any unevenly distributed load. This component enables the strict lineside clearance gauge to be specified notwithstanding the oscillations referred to below.
   - rolling stock oscillations generated by interaction between the vehicle and the track, in light of the speed of the line in question and the geometric quality of its tracks (rail wear, elastic deformation of the track under traffic loads, etc.) in particular in the case of track laid on ballast. It is up to the IM to take account of the values for these oscillations.

The position of Σ**actual** determines the minimum lineside clearance gauge excluding a track maintenance margin or margin used.

3. **M2** is the maintenance margin for ballasted track which must be taken on board when planning to apply a chosen gauge given that the margin may be used up by a series of maintenance operations. In the case of slab track or track connected to objects, this margin may be reduced to take account of rail wear and slight track defects. By applying margin **M2** a minimum clearance gauge is defined that allows for a track maintenance margin.

4. **M3** is an additional margin which depends on the features specific to each IM (plans to raise speeds, running of special traffic, strong crosswinds, etc.). Margin **M3** is used to define the nominal lineside clearance gauge.
   It should be noted that to obtain the nominal clearance gauge, margins **M1**, **M2** and **M3** can be covered by an all-encompassing margin **MoN**.

4.4 - Important comments

It is not the intention of this document to oblige IMs to apply certain values or methods to take account of the phenomena covered by margins M1, M2 and M3 or MoN, but rather to simply list the phenomena that are likely to be generated or encountered.

Indeed each IM is free to apply its own margins to cover these phenomena, whether they be pre-defined or calculated using methods devised by the IM based on its experience, operating and maintenance rules, on the level of safety sought and its investment strategy.

In conclusion, the way in which these phenomena are taken into account is the responsibility of the IM.

By way of example, calculation methods are set out in Appendix A - page 28 (for those IMs interested).

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5 - Rules covering the kinematic reference profile to determine the minimum or nominal lineside clearance gauge

As regards the minimum clearance gauge, the rules associated with the kinematic reference profile must take account of the vertical and lateral movements of the rolling stock in question. As regards the nominal gauge, only the safety margins taken into account are greater.

5.1 - Vertical movements

This factor enables the minimum and maximum height above the running surface to be determined for the minimum clearance gauge. The factors to be taken into account are given below.

Determination of the maximum height to be respected above the running surface for low objects.

The maximum height concerns the horizontal lower part of the gauge.

In zones where there are transition curves between different gradients, the effect of the radius of the vertical transition curve ($\mathbf{R_v}$) must be taken into account. To that end the vertical dimensions must be reduced by **50 000/$\mathbf{R_v}$** mm ($\mathbf{R_v}$ in m).

For objects unconnected to the track, a vertical margin **Mv** for track maintenance must be applied under the same conditions as those defined in point 4.4 - page 11.

Specific rules regarding the lower horizontal of the gauge of low parts are covered in point 9.1.1.2 - page 19.

5.2 - Lateral movements

In the case of the minimum clearance gauge, such movements are used to determine a minimum lateral area which must be provided beyond the kinematic reference profile.

On perfect track, the factors which must be taken into account are covered by Σtheoretical which is dealt with in point 4.3 - page 9 and Fig. 6 - page 10, i.e.:

- the projections $\mathbf{S_i}$ or $\mathbf{S_a}$, to be taken into account in relation to the gauge selected,

- the quasi-static movements caused by the effect of excess cant of over 50 mm ($\mathbf{q_{si}}$) or a cant deficiency of over 50 mm ($\mathbf{q_{sa}}$).

As stipulated in point 4.4, to take account of real situations, other factors must, as an obligation, be taken into account and covered by one or more margins for which the individual IM is responsible.

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6 - General information on the method for determining the distance between track centre lines

The distance between the centre lines of two contiguous tracks is determined by taking account of:

- straight tracks:
  - trains running at speed,
- in curves:
  - trains running on the inside track at the maximum authorised speed with quasi-static movement of the vehicle bodies due to cant deficiency,
  - trains at a standstill or moving slowly on the outside track with quasi-static movement of the vehicle bodies due to cant deficiency; these vehicles, at standstill or moving slowly, being considered as objects in relation to the trains running at speed on the inside track.

For the same reasons as specified for the positioning of objects, a distinction needs to be drawn between the minimum and nominal distance between track centre lines.

6.1 - Minimum distance between track centre lines

This is the minimum distance which must be allowed and maintained to ensure that trains running on two contiguous tracks can pass or cross each other without any risk of them coming into contact with each other, given the features of the layout, the speed of travel and the state of repair of the tracks.

In general, the minimum distance between track centre lines is defined to take account of the maximum lateral space requirement of the most protruding parts of the rolling stock types which take up the greatest area.

The minimum distance between track centre lines is determined on the one hand by juxtaposing two half kinematic reference profiles and on the other hand by increasing their half-width by various parameters covered in the associated rules set out in point 7 - page 15.

In general the minimum distance between track centres must be chosen, applied and maintained where particularly awkward circumstances prevail on old lines (tunnels, road bridges, etc.) in order to limit the scale of engineering work and investment costs.

When applying the minimum distance between track centres at problem points on the infrastructure, the IM must monitor those locations carefully and apply the appropriate rules (for example interconnecting the tracks of the infrastructure). It must also establish controls and checks to ensure that with the passage of time under no circumstances the position of the tracks in those zones jeopardises the minimum distance between track centres.

6.2 - Nominal distance between track centres

This is determined in the same way as the minimum distance between track centre lines, although greater safety margins must be defined given the features specific to each IM (working of special traffic, scope for higher speeds, strong cross-winds, account of aerodynamic effects, etc.).

In general the nominal distance between track centre lines should be chosen, applied and maintained in the event of major alteration work on installations, new engineering work or where the infrastructure permits.

6.3 - Illustration of distances between track centre lines

Fig. 7 illustrates the space taken up by vehicles running on each track and the space that must be allowed. It should be noted that the minimum or nominal distance between track centre lines is a theoretical dimension, parallel to the running surface of one of the two tracks.

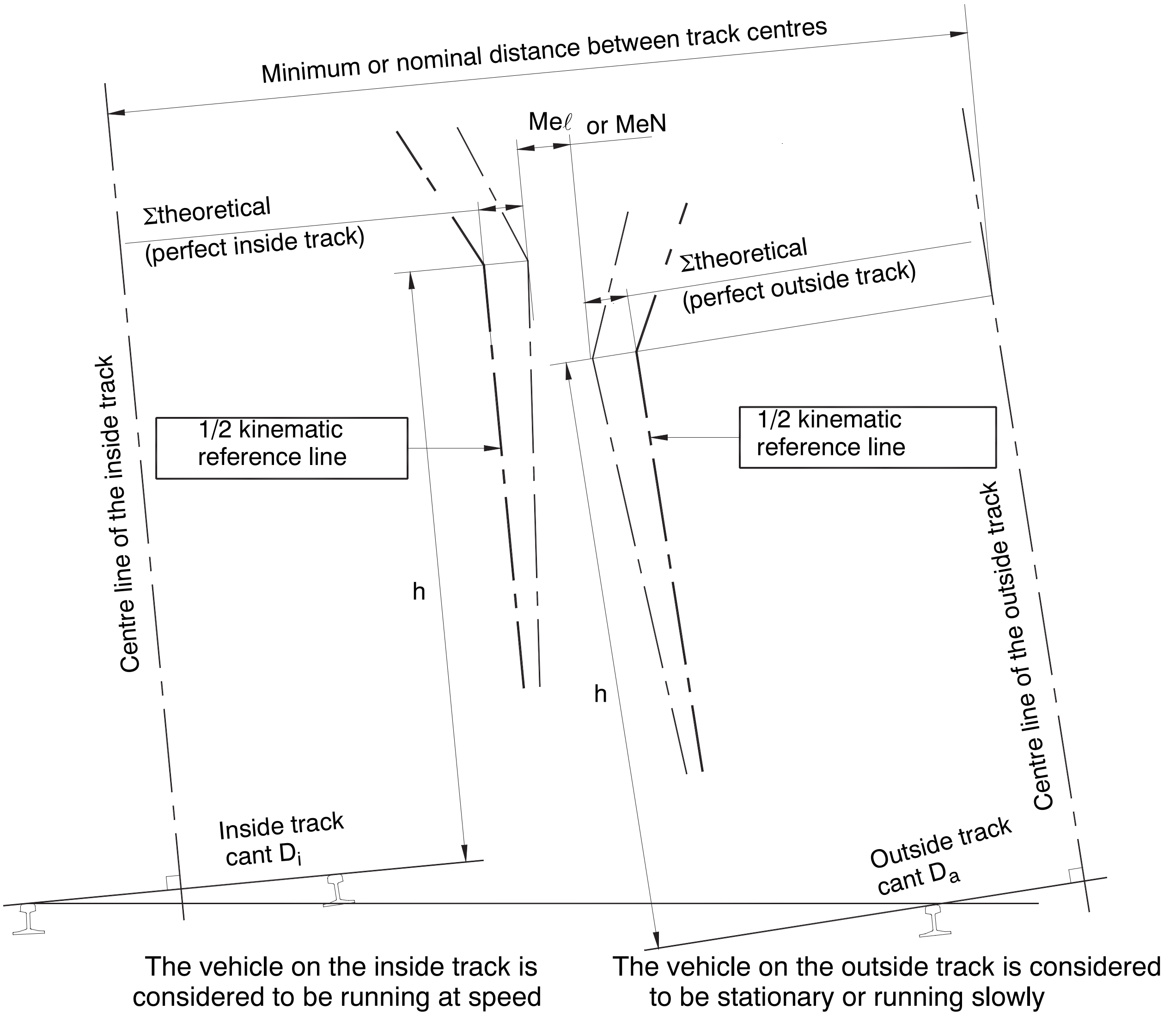

Fig. 7 - Illustration of distances between track centre lines

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7 - Rules covering the kinematic reference profile to determine the minimum and nominal distances between track centres

These rules take account of lateral movement, exceeding each of the half kinematic reference profiles for each of the two contiguous tracks, represented in Fig. 7 - page 14 by Σtheoretical and a margin Meℓ or MeN which is specific to the distance between the track centres, i.e.:

1. the projection on the inside of the curve S_i for the outside track,

2. the projection on the outside of the curve S_a for the inside track,

3. the quasi-static displacement on the inside of the curve q_{si} for the outside track,

4. the quasi-static displacement on the outside of the curve q_{sa} for the inside track,

5. the margin Meℓ or MeN which is specific to the track centre distances, covers phenomena which may be encountered on the two tracks. The margin takes account, for each of the two tracks respectively of the margins dealing with similar phenomena as described in point 4.3 - page 9 under Σactual.

NB: For the same reasons as stated in point 4.4 - page 11, each IM is responsible for taking account of certain phenomena, which are covered by margin Meℓ or MeN as per paragraph 5 above; it is free to apply its own margins to cover these phenomena, whether they be predefined or calculated using methods devised by the IM based on its experience, operating and maintenance rules, on the level of safety sought and its investment strategy.

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8 - Positioning of passenger station platforms

Given the specific needs they must fulfil, the platforms must be located as close as possible to the passenger trains serving them whilst permitting trains not stopping to run through. As a result, the positioning dimension, **Lq**, illustrated in Fig. 8, must be applied in line with the rules on minimum clearance gauges set out in the various sections below.

As an example, *UIC Leaflet 741* (see Bibliography - page 35) sets out regulations for the positioning of platforms 550 mm and 760 mm high.

The IM is responsible for the tolerances for positionning and maintaining platform edges in relation to the associated track.

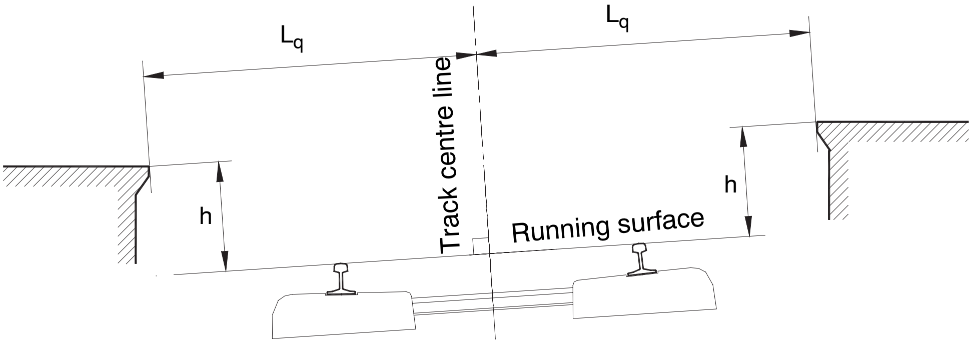


Fig. 8 - Positioning of passenger station platforms

9 - Gauges not governed by bi-lateral or multilateral agreements

9.1 - Gauge G1

The rules for determining the location of objects are given below; they include:

1. a kinematic reference profile for the upper parts (h > 0,400 m),
2. two kinematic reference profiles for the lower parts (h ≤ 0,400 m) in light of the features specific to the infrastructure,
3. the rules associated with these profiles.

9.1.1 - Reference profile for the kinematic gauge

9.1.1.1 - Upper Parts (h > 0,400 m)

Fig. 9 sets out the dimensions of the kinematic reference profile.

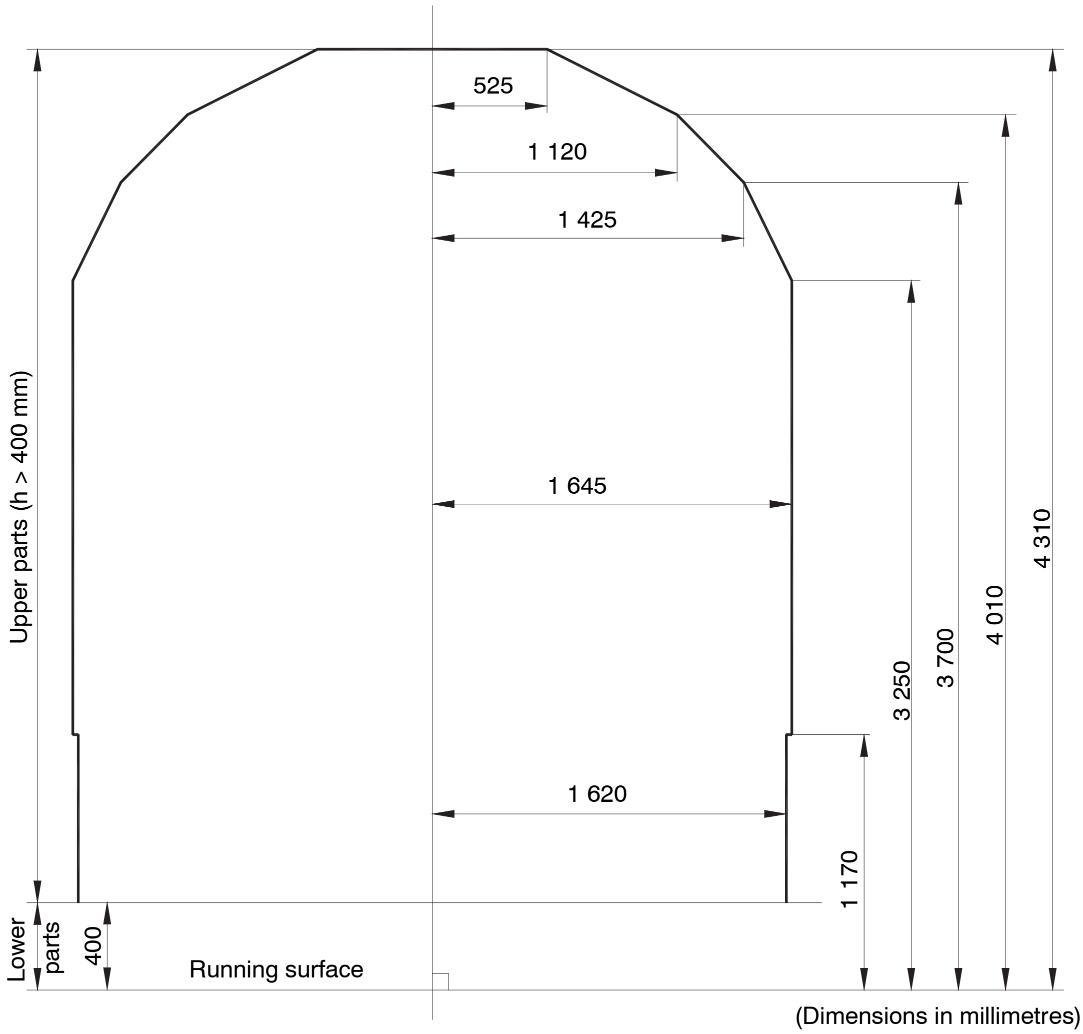


Fig. 9 - Reference profile for the kinematic gauge

Associated rules:

To determine the minimum clearance gauge to be allowed for objects, the IM must add the values resulting from the associated rules defined in point 5 - page 12 to the horizontal dimensions of the half-width of the reference profile of the kinematic gauge, taking account of the special features of paragraph 1. and 2. below:

1. **The projections S_i and S_a** to be taken into consideration are determined as follows:

   - $\infty \geq R \geq 250$ m

   $$\Rightarrow S_i \text{ or } S_a = \frac{3{,}75}{R} + \frac{\ell - 1{,}435}{2} \quad \text{(in m)}$$

   - $250 \geq R \geq 150$m

   $$\Rightarrow S_i = \frac{50}{R} - 0{,}185 + \frac{\ell - 1{,}435}{2} \quad \text{(in m)}$$

   $$\Rightarrow S_a = \frac{60}{R} - 0{,}225 + \frac{\ell - 1{,}435}{2} \quad \text{(in m)}$$

2. **The quasi-static movements q_{si}** and **q_{sa}** are determined as follows:

   a. objects located inside the curve:

   $$\Rightarrow q_{si} = \frac{0{,}4}{1{,}5}[E - 0{,}05]_{>0} \; [h - 0{,}5]_{>0} \quad \text{(in m) (*)}$$

   b. objects located outside the curve:

   $$\Rightarrow q_{sa} = \frac{0{,}4}{1{,}5}[I - 0{,}05]_{>0} \; [h - 0{,}5]_{>0} \quad \text{(in m) (*)}$$

   (*) The sign $[\;]_{>0}$ means that the quantity thus indicated is to be taken at its value if positive and as 0 if it is negative or nil.

3. **Margins**: for the conditions of application see point 4.3 - page 9.

9.1.1.2 - Lower parts (h ≤ 0,400 m)

1. **Kinematic gauge in the area of the rail and track brakes and the area of the track centre line**

Fig. 10 and 11 - page 20 illustrate the various clearances to be allowed.

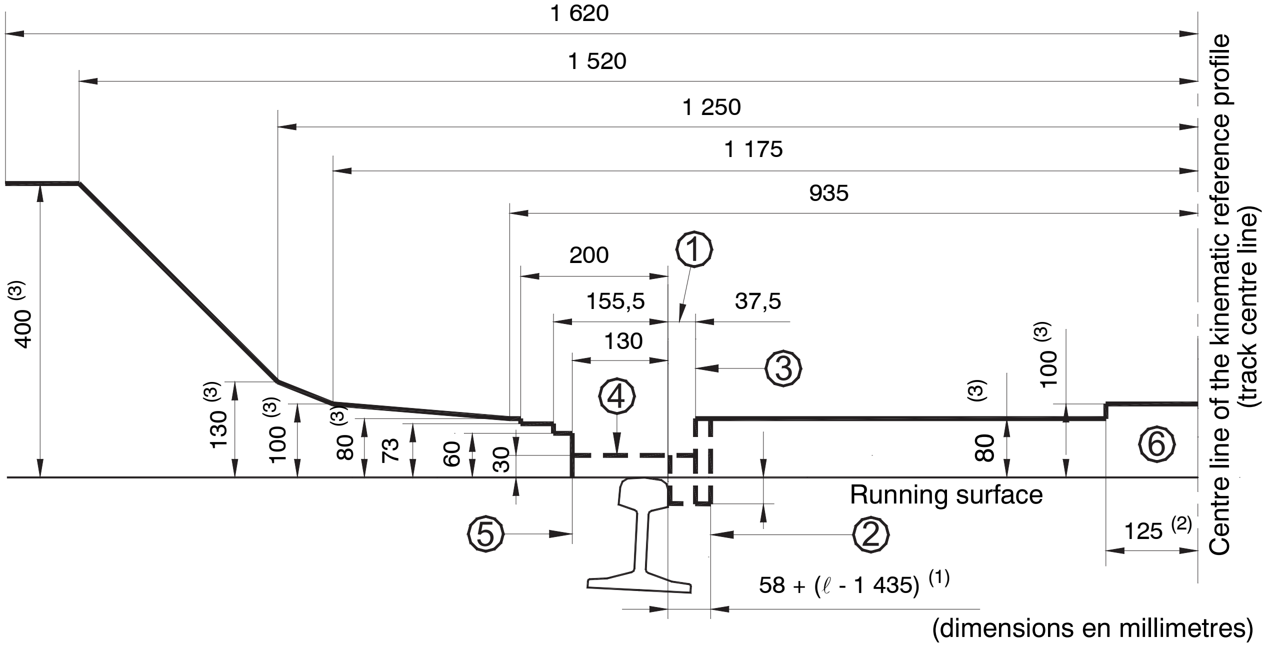


Fig. 10 - Area with track brakes in the released position and other shunting or stopping devices

① maximum theoretical width of the flange profile, taking into account the possible obligue orientation of the axle in the track

② gauge (maximum actual position) for the inside surface of the tyre when the axle is pressed against the opposite rail

③ maximum positioning of check-rails

④ gauge (maximum position) for the parts of the rolling stock adjacent to the wheels

⑤ gauge (maximum position) for the outside surface of the wheel

⑥ area for fixing contact ramps

(1) ℓ = track gauge

(2) irrespective of radius ≥ 250 m and track gauge $\ell \leq$ 1,465 m

(3) these dimensions are valid for level track. They must be reduced by $\frac{50\,000}{R_V}$ mm (R_V in m) for gradient transition curves with a radius of $R_V \geq 500$ m

In the case of objects which are not connected to the track, a vertical track maintenance margin **Mv** must be allowed (see point 5.1 - page 12).

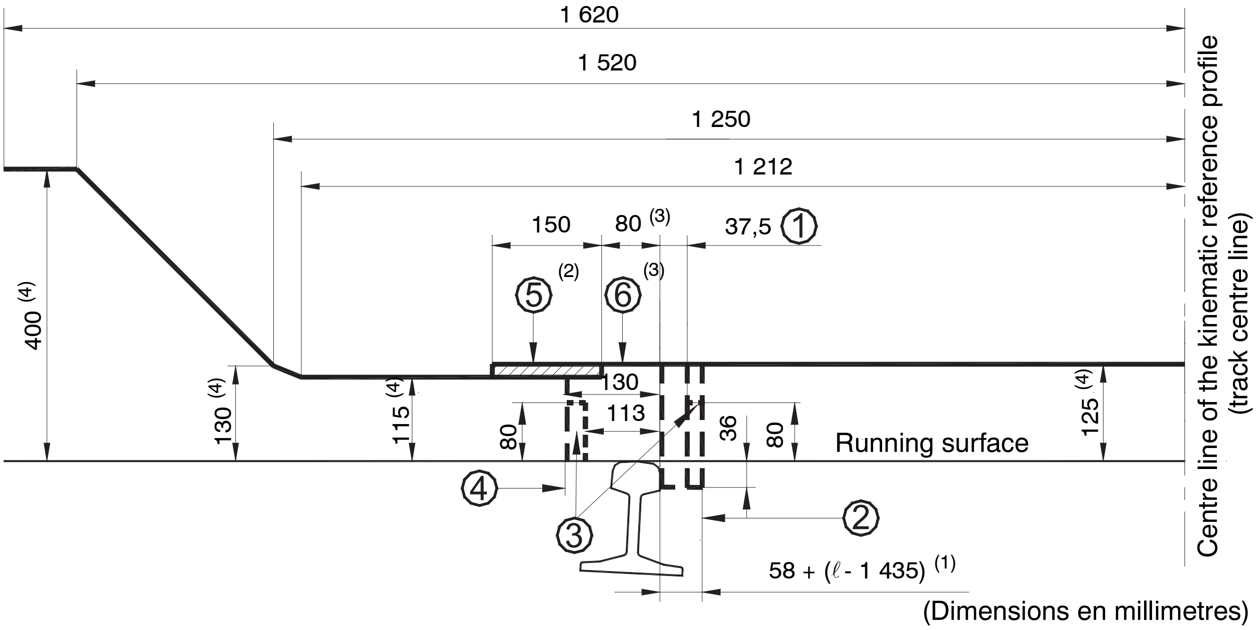


Fig. 11 - Area with track brakes in the applied position and other shunting or stopping devices

① maximum theoretical width of the flange profile taking into account the possible obligue orientation of the wheelset in the track

② gauge (maximum actual position) for the inside surface of the tyre when the axle is pressed against the opposite rail

③ track brakes in the released position

④ gauge (maximum position) for the outside surface of the wheel

⑤ area of ejection of the shoes

⑥ maximum height of the brake shoes

(1) ℓ = track gauge

(2) no fixed track device may penetrate within this area. Only ejectable shoes may penetrate it during ejection

(3) see the rules in **note 2.** (Fig. 10 - page 19)

(4) see the rules in **note 3.** (Fig. 10 - page 19) . Gradient transition curves with a radius of $R_V \geq 500$ m must be reduced by $\frac{50\ 000}{R_V}$ mm (R_V in m)

In the case of objects which are not connected to the track, a vertical track maintenance margin **Mv** must be allowed (see point 5.1).

2. Negotiation of shunting devices in curved track

Track brakes and other shunting or stopping devices which when activated may reach dimensions of 115/125 mm, particularly 125 mm high drag shoes, can be used on curved track with a radius R ≥ 150 m.

3. **Negotiation of braking, shunting or stopping devices on the gradient transition curves of marshalling humps**

The following regulations give two sets of height dimensions applicable to track brakes or to other activated shunting or stopping devices. They have been drafted to take account of the various types of rolling stock likely to go as low as the maximum height for track brakes.

In marshalling yards, the track brakes and other shunting or stopping devices may reach a maximum height of 115/125 mm above the running surface when activated:

- within or close to concave transition curves with a radius $R_v \geq 300$ m,
- in the sections of track that are not concave vertically at least 3 m (5 m) from the starting point of the convex transition curves of radius $R_v \geq 250$ m.

At the extremities of convex transitions of $R_v \geq 250$ m, the dimensions 115/125 mm must be reduced by a value of e_v (in m) equal to:

$$e_{v1} = 0{,}040 \times \frac{250}{R_v} \qquad \left(e_{v2} = 0{,}050 \times \frac{250}{R_v}\right)$$

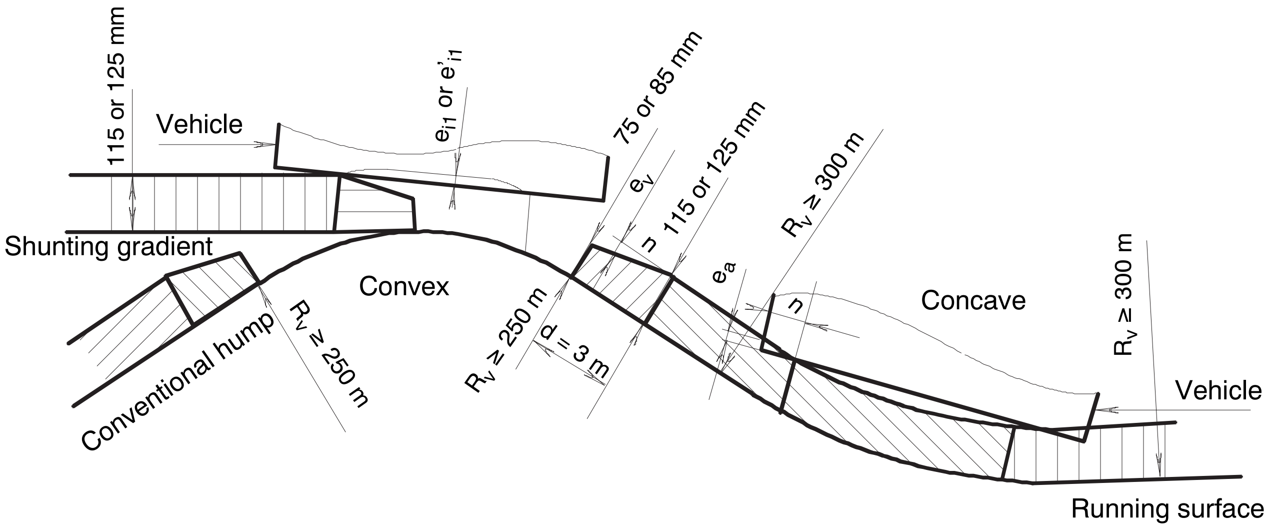


Fig. 12 - Normal values for vertical reductions of the lower parts for passing over vertical transition curves and marshalling yard humps

Between the section from which the dimensions 115/125 (mm) are applicable, namely **3 m** from the starting point of the transition, and the starting point, height reductions must be effected on a linear basis, as follows:

$$e_{v1} = 0{,}040 \times \frac{250}{R_v} \times \frac{3 - d}{3}$$ (see Fig. 13)

"d" being the distance of the section involved in relation to the starting point of the transition.

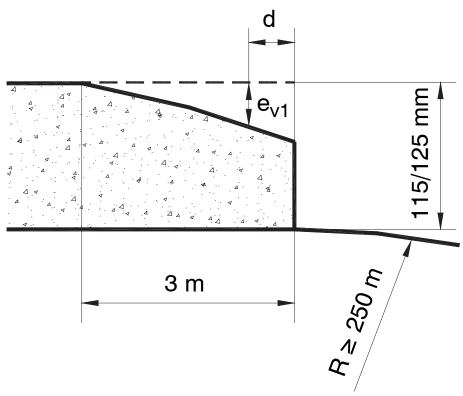


Fig. 13 - Height reductions 3 m from the starting point of the transition

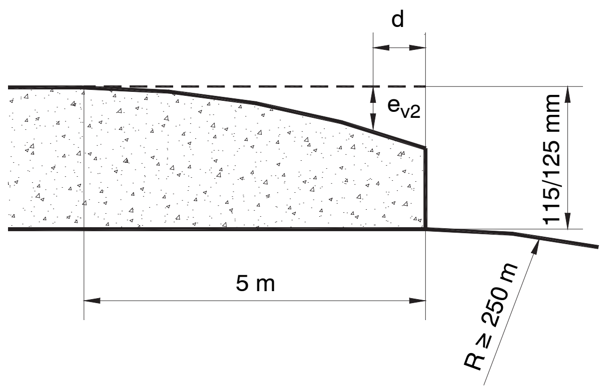


Fig. 14 - Height reductions 5 m from the starting point of the transition

Between the section from which the dimensions 115/125 mm are applicable, namely **5 m** from the starting point of the transition, and the starting point, height reductions must be at least equal to the value of e_{v2} given below:

$$e_{v2} = \left[\frac{15{,}80 - d^3}{53\,325} - 0{,}024\right] \times \frac{250}{R_v}$$ (see Fig. 14)

On marshalling yard sections accessible by hump avoiding lines and likely to be used by mainline locomotives and special wagons not authorised to pass over marshalling yard humps, track brakes or other activated shunting/stopping devices:

- the shunting or stopping devices in the "off" position must clear the gauges illustrated previously in Fig. 10 - page 19 and 11 - page 20,
- the concave and convex gradient transition curves must have a radius of ≥ 500 m.

9.1.2 - Associated rules

To determine the minimum lateral space which must be allowed, IMs must add to the horizontal dimensions of the half-width of the kinematic reference profiles set out in Fig. 10 - page 19 and 11 - page 20:

NB : The horizontal dimensions are measured parallel to the running surface, the centre line of the reference profile being situated perpendicular to that plane and equidistant from both rails.

1. the projections to be taken into account in light of the curve radius, $\mathbf{S_i}$ for objects located inside the curve and $\mathbf{S_a}$ for objects located outside the curve, are calculated as follows:

   - $\infty \geq R \geq 250$

$$\Rightarrow S_i \text{ or } S_a = \frac{2{,}5}{R} + \frac{\ell - 1{,}435}{2} \text{ (in m)}$$

   - $250 \geq R \geq 150$ m

$$\Rightarrow S_i = \frac{50}{R} - 0{,}190 + \frac{\ell - 1{,}435}{2} \text{ (in m)}$$

$$\Rightarrow S_a = \frac{60}{R} - 0{,}230 + \frac{\ell - 1{,}435}{2} \text{ (in m)}$$

2. if necessary, a safety margin covering certain phenomena engendered by rolling stock and the track in service (see point 4.3 - page 9); this margin only concerns the dimensions 1 620, 1 520, 1 250 and 1 175 (see Fig. 10 - page 19) and 1 620, 1 520, 1 250 and 1 212 (see Fig. 11 - page 20).

As regards quasi-static movements, if the value is negative it need not be considered, in line with note (*) in paragraph 2 of point 9.1.1.1 - page 18.

9.2 - Space to be reserved for the pantographs and roof mounted equipment of motive power units running on electrified lines

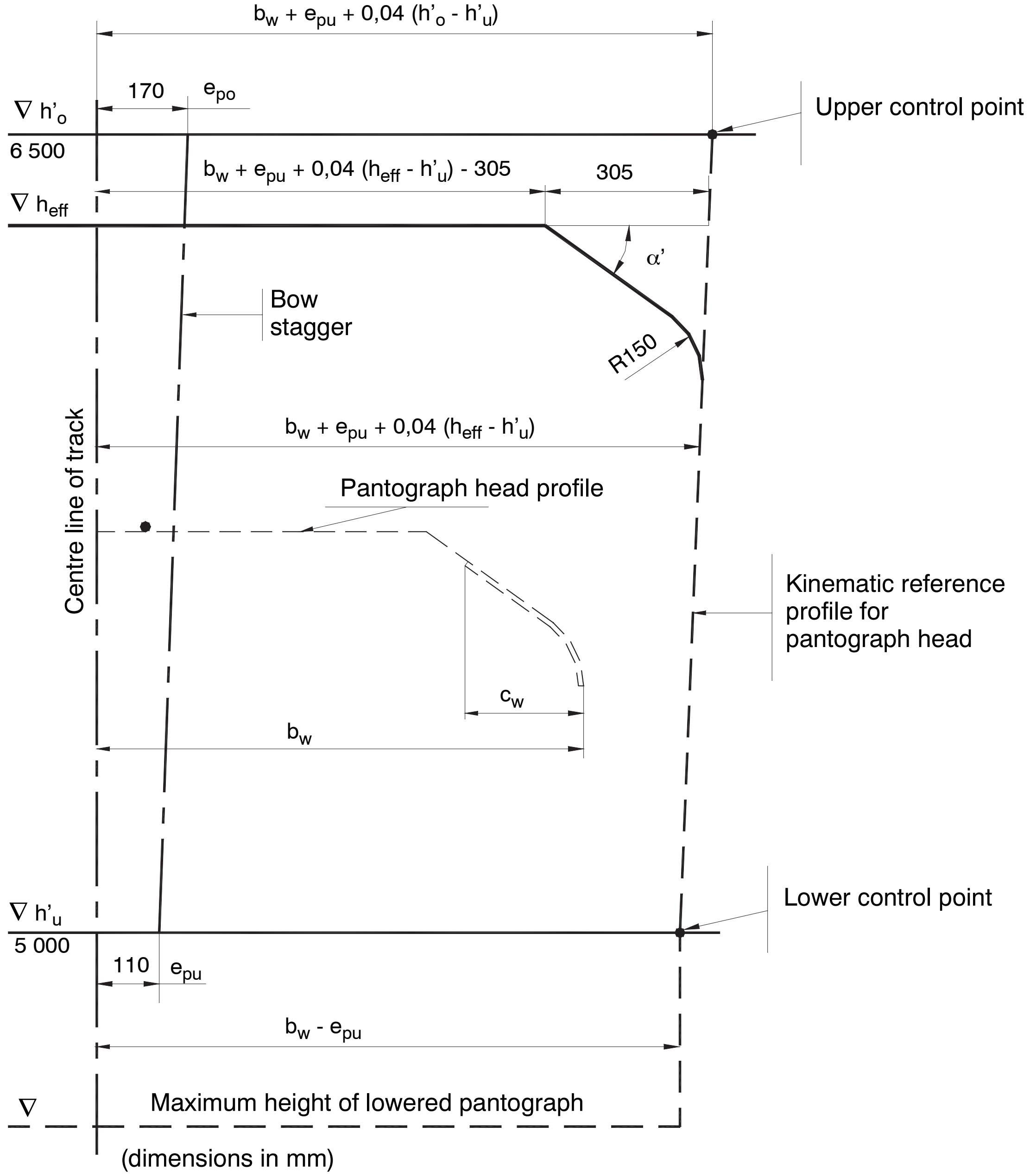


Fig. 15 - Kinematic reference profile of the pantograph gauge

In the figure:

- b_w half-width of pantograph head. The dimensions of the different types of pantograph heads are covered in *prEN 50367* (see Bibliography - page 35)
- c_w horizontal projection of an insulated horn (if applicable)
- h'_o height of upper control point
- h'_u height of lower control point
- h_{eff} height considered
- e_{po} e_p level with upper control point
- e_{pu} e_p level with lower control point
- α' angle of inclined part of the panthograph head in relation to the horizontal plane and ≥ 30° (Exception: 1 600 mm bow ≥ 25° according to *UIC Leaflet 608* - see Bibliography - page 35)

Preliminary comments:

The space to be allowed for pantographs and roof mounted equipment on motive power units must be based on the following two criteria:

1. the kinematic gauge so as to dimension the infrastructure to avoid any risk of collision with the infrastructure,

2. the electrical clearance gauge in order to avoid any risk of flashover (arcing) with dead infrastructure structures.

9.2.1 - Kinematic criteria

To determine the kinematic gauge, IMs must add the following to the horizontal dimensions of the half-width of the kinematic reference profiles set out in Fig. 15 - page 24:

1. the **projection S_i** or **S_a** resulting from the space taken by vehicles negotiating curves and the track gauge. This projection should be considered from both the inside and the outside of the curve. The formula to be applied is:

$$\Rightarrow S_i \text{ or } S_a = \frac{2{,}5}{R} + \frac{\ell - 1{,}435}{2} \text{ (in m)}$$

2. a quasi-static lateral **inclinaison** supplement **q_{si} or q_{sa}** on track sections where the excess cant or cant deficiency exceeds 0,066 m; the effect of the lower values conventionally being included in the reference profile shown in Fig. 15.

   The relation to be applied for objects located inside or outside curves is:

$$\Rightarrow q_{si} \text{ or } q_{sa} = 0{,}15[E \text{ or } I - 0{,}066]_{>0}\,(h - 0{,}5) \text{ (in m)}$$

3. the margins to be applied in line with the requirements of point 4.3 - page 9.

9.2.2 - Criterion for electrical insulation

In addition to the details set out in point 9.2.1, IMs must take account of the following allowance:

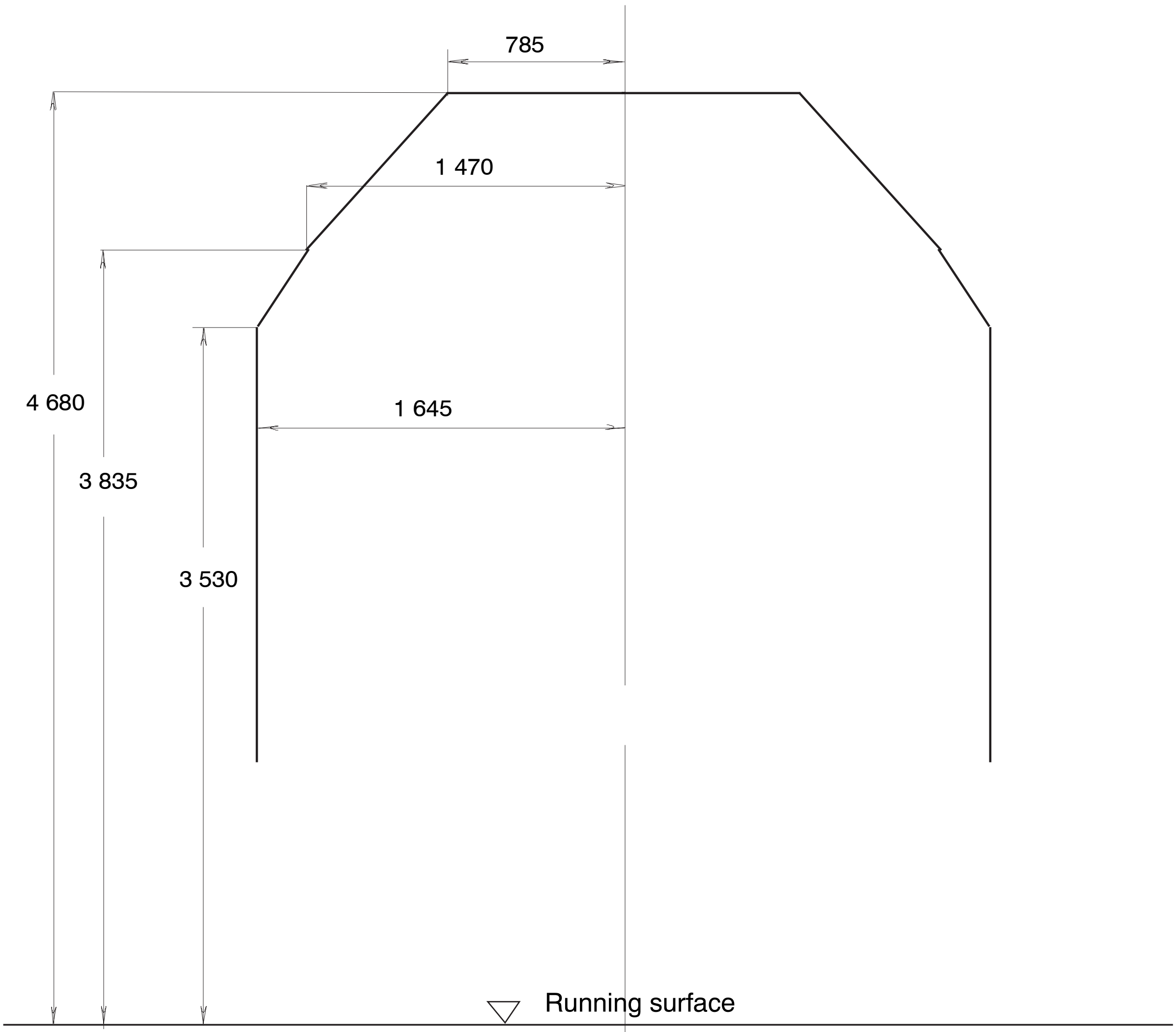
$$[M_i - C_w]_{>0}$$

Whereby:

- M_i is the electric insulation margin defined in *UIC Leaflet 606-1, Annexe 6* (see Bibliography - page 35),

- C_w is the horizontal projection of the insulated horn (if applicable) defined in *UIC Leaflet 608*.

o **10 - Gauges requiring bi-lateral or multilateral agreements with a view to the application of a raised gauge**



(dimensions in millimetres)

Fig. 16 - Kinematic reference profile of G2 gauge

Associated rules:

The associated rules to be applied are those for gauge G1, irrespective of the height h. The same applies for the space to be allowed for the pantographs of motive power units.

11 - Distance between track centres

11.1 - Minimum distance between track centres

As stated in point 7 - page 15, the minimum distance between track centres is obtained by adding the following values to the broadest width of the two half kinematic reference profiles, i.e. 3,29 m:

1. the projections S_i and S_a,

2. the quasi-static movements q_{si} and q_{sa},

3. the margin $Me\ell$ specific to the distances between the track centre lines for which the conditions of application are set out in point 4.3 - page 9.

As a result the minimum distance between track centres, in a typical case, is given by the following general formula:

$E\ell$ (m) = $3{,}29 + S_i + S_a + q_{si} + q_{sa} + [h\ (D_a - D_i)_{>0}] / 1{,}5 + Me\ell$

The projections S_i, S_a and the quasi-static movements q_{si}, q_{sa} to be taken into account depend on the rules specific to the chosen gauges.

The term $[h\ (D_a - D_i)>0] / 1{,}5$ denotes the account being taken of a cant convergence.

It should be noted that the height h above the running surface to be used in the calculation of q_{si}, q_{sa} and in the event of cant convergence depends on the reference profiles of the chosen gauge, i.e.:

- for gauge G1, the height h to be taken into account is 3,25 m,

- for gauge G2, the height h to be taken into account is 3,53 m.

11.2 - Nominal distance between track centres

In the case of the nominal distance between track centres, the rules regarding the minimum distance apply except in the case of the margin MeN, the value of which is greater than in the case of the minimum distance between track centres. The conditions for applying that margin are set out in point 7.

Appendix A - Examples of tolerance calculation methods

A.1 - Introduction

The intention of this Appendix is not to mandate margin values or calculation methods on IMs. Each IM is free to apply its own rules, but for the benefit of interested IMs, examples of some methods that can be applied as they stand or after adaptation are given here.

A.2 - Examples of methods recommended by UIC

The following methods do not preclude IMs from using methods which are based on their own experience and particular circumstances.

In order to establish the values of the margins to be maintained, limit values for track movement and defects, oscillation and load asymmetry and the resulting movements for the track in use must be determined unless other rules are habitually applied and/or other deviations have been defined based on experience. The values recommended by UIC are listed below. These are made up of the elements covered by margin M1.

A.2.1 - Maximum values for track displacement and defects in service (in metres)

1. Lateral movement of the track in relation to its normal position between periodic maintenance operations: 0,025 m,

2. Effect based on the height h, a cant defect in relation to its theoretical value (in the case of curves) or of cross-level (in the case of straight track) of:

   a. ± 0,015 m (v > 80 km/h)

   $$\text{geometric effect} = 0{,}015\frac{h}{1{,}5} = 0{,}01h$$

   $$\text{quasi-static effect} = \frac{s}{1{,}5}[0{,}015][h - 0{,}5]_{>0}$$

   In this equation s stands for the flexibility coefficient. In making this calculation the highest value is to be used, which as a rule is taken as 0,4.

   b. ± 0,020 m (V ≤ 80 km/h)

   $$\text{geometric effect} = 0{,}020\frac{h}{1{,}5} = 0{,}0133h$$

   $$\text{quasi-static effect} = \frac{0{,}4}{1{,}5}[0{,}02][h - 0{,}5]_{>0}$$

A.2.2 - Oscillations caused by vehicle/track dynamic interaction

Oscillations caused by vehicle/track dynamic interaction and related to the maintenance condition of the track (geometric condition, alignment, hunting movement on straight track). When considering this phenomenon, the same importance is attached to track defects and their consequences to the effects of errors in equivalent cant.

For example:

1. the following cant error is given for a line in a particularly good state of repair:

    a. outside curve and on straight track: 0,039 m, i.e. an angle of 0,6°,
    b. inside curve: 0,007 m, i.e. an angle of 0,1°,

2. for other lines:

    a. outside curve and on straight track: 0,065 m, i.e. an angle of 1°,
    b. inside curve: 0,013 m, i.e. an angle of 0.2°.

A.2.3 - Asymmetry

Disparities of up to 1° are generally due to asymmetry owing to unevenly spread vehicle loads and to suspension system adjustment tolerances. The 1° asymmetry and the resulting effect can be equated to a corresponding equivalent cant error.

In the case of a vehicle with a flexibility coefficient of 0,4, a cant error of 0,065 m should be factored in. The 0,065 m value is made up of the following two independent values: 0,050 m for the uneven load spread, corresponding to an angle of 0,77°, and 0,015 m for the suspension system adjustment tolerances, corresponding to an angle of 0,23°.

NB : This phenomenon is independent of the flexibility of the vehicle concerned.

It can also be taken into account using the following equation:

$$t_g\ 1°|h - 0,5|$$

A.3 - Position of fixed installations

A.3.1 - Limit position in the case of ballasted track

Tolerance **M1** for the gauge limit for fixed installations can be derived from the quadratic mean Σ' of various randomly-occurring displacements caused by the phenomena listed in points A.2.1 - page 28, A.2.2 and A.2.3 - page 29.

The result is the following equations, taking account of the estimated geometric quality of the track, the line speeds, and the position of the fixed installations:

1. Line in good state of repair and V > 80 km/h:

   a. inside curves:

$$\Sigma'_i = k\sqrt{0{,}025^2 + \left[0{,}01h + \frac{0{,}4}{1{,}5}(0{,}015)(h-0{,}5)_{>0}\right]^2 + \left(\frac{0{,}4}{1{,}5}\right)^2[0{,}007^2 + 0{,}05^2 + 0{,}015^2][(h-0{,}5)_{>0}]^2}$$

   b. outside curves and on straight track:

$$\Sigma'_a = k\sqrt{0{,}025^2 + \left[0{,}01h + \frac{0{,}4}{1{,}5}(0{,}015)(h-0{,}5)_{>0}\right]^2 + \left(\frac{0{,}4}{1{,}5}\right)^2[0{,}039^2 + 0{,}05^2 + 0{,}015^2][(h-0{,}5)_{>0}]^2}$$

2. Line in good state of repair and V ≤ 80 km/h:

   a. inside curves:

$$\Sigma'_i = k\sqrt{0{,}025^2 + \left[0{,}0133h + \frac{0{,}4}{1{,}5}(0{,}020)(h-0{,}5)_{>0}\right]^2 + \left(\frac{0{,}4}{1{,}5}\right)^2[0{,}007^2 + 0{,}05^2 + 0{,}015^2][(h-0{,}5)_{>0}]^2}$$

   b. outside curves and on straight track:

$$\Sigma'_a = k\sqrt{0{,}025^2 + \left[0{,}0133h + \frac{0{,}4}{1{,}5}(0{,}020)(h-0{,}5)_{>0}\right]^2 + \left(\frac{0{,}4}{1{,}5}\right)^2[0{,}039^2 + 0{,}05^2 + 0{,}015^2][(h-0{,}5)_{>0}]^2}$$

3. Other lines, independent of speed:

   a. inside curves:

$$\Sigma'_i = k\sqrt{0{,}025^2 + \left[0{,}0133h + \frac{0{,}4}{1{,}5}(0{,}020)(h-0{,}5)_{>0}\right]^2 + \left(\frac{0{,}4}{1{,}5}\right)^2[0{,}013^2 + 0{,}05^2 + 0{,}015^2][(h-0{,}5)_{>0}]^2}$$

   b. outside curves and on straight track:

$$\Sigma'_a = k\sqrt{0{,}025^2 + \left[0{,}0133h + \frac{0{,}4}{1{,}5}(0{,}020)(h-0{,}5)_{>0}\right]^2 + \left(\frac{0{,}4}{1{,}5}\right)^2[0{,}065^2 + 0{,}05^2 + 0{,}015^2][(h-0{,}5)_{>0}]^2}$$

where:

k: is a coefficient ≥ 1, to cover the risk that the estimated values for certain phenomena are exceeded.

For example, k = 1,2 where an increased allowance of 20% is used in line with the IM's safety objectives.

and the sum cannot be less than:

$$\Sigma'' = k\sqrt{(0{,}025)^2 + \begin{bmatrix} 0{,}01h \\ 0{,}01h \\ 0{,}0133h \end{bmatrix}^2}$$

A.3.2 - Nominal positioning

UIC suggests that a global tolerance, **MoN**, be used to denote the nominal position, whose value takes account of the phenomena covered by tolerance **M1** which can be derived from the arithmetic sum Σ of the displacements resulting from the phenomena listed in point A.2.1 - page 28, A.2.2 and A.2.3 - page 29.

The result is the following equations for calculating tolerance M1:

1. Line in good state of repair and V > 80 km/h:

   a. inside curves:

$$\Sigma_i = 0{,}025 + 0{,}01h + \frac{0{,}4}{1{,}5}[0{,}015 + 0{,}007 + 0{,}065](h - 0{,}5)_{>0}$$

   b. outside curves and on straight track:

$$\Sigma_a = 0{,}025 + 0{,}01h + \frac{0{,}4}{1{,}5}[0{,}015 + 0{,}039 + 0{,}065](h - 0{,}5)_{>0}$$

2. Line in good state of repair and V ≤ 80 km/h:

   a. inside curves:

$$\Sigma_i = 0{,}025 + 0{,}0133h + \frac{0{,}4}{1{,}5}[0{,}020 + 0{,}013 + 0{,}065](h - 0{,}5)_{>0}$$

   b. outside curves and on straight track:

$$\Sigma_a = 0{,}025 + 0{,}0133h + \frac{0{,}4}{1{,}5}[0{,}020 + 0{,}065 + 0{,}065](h - 0{,}5)_{>0}$$

3. Other lines, irrespective of the speed:

   Formula identical to that in paragraph 2. b. above.

A.4 - Distances between track centres

A.4.1 - Minimum distance between track centrelines

The tolerance to be included to ensure the minimum distance between track centrelines is respected, **Meℓ**, can be derived from the quadratic mean of the various randomly-occurring displacements caused on each of the adjacent tracks by the phenomena listed in point A.2.1 - page 28, A.2.2 and A.2.3 - page 29 and described by the values Σ'_i and Σ'_a .

The equation is therefore:

$$Me\ell = \sqrt{(\Sigma'_i)^2 + (\Sigma'_a)^2}$$

where Σ'_i and Σ'_a are determined in point A.3.1 - page 30.

where the sum cannot be less than:

$$\Sigma'' \sqrt{2}$$

A.4.2 - Nominal distance between track centrelines

The tolerance to be included to ensure the nominal distance between track centrelines is respected, **MeN**, can be derived from the arithmetic sum of the various randomly-occurring displacements on each of the adjacent tracks by the phenomena listed in point A.2.1 - page 28, A.2.2 and A.2.3 - page 29 and described using the values Σ_i and Σ_a.

The equation is therefore:

$$\mathbf{MeN} = \Sigma_i + \Sigma_a$$

or in simplified terms:

$$\mathbf{MeN} = \mathbf{2}\, \Sigma_a$$

A further tolerance can be included to reflect special circumstances for individual IMs (plans to raise speeds, transport of special traffic, high cross-winds, etc.).

List of abbreviations

b_w	half-width of pantograph head
c_w	horizontal projection of an insulated pantograph horn
D	cant deficiency; D_a for the outer track and D_i for the inner track
E	cant excess; in the case of the "gauge" it is the cant of the track in question
E_ℓ	minimum distance between track centre lines
EN	nominal distance between track centre lines
e_p	offset of pantograph owing to vehicle characteristics; e_{po} is the value of e_p at the upper control point and e_{pu} is the value of e_p at the lower control point
h	height of point in question relative to the running surface
h_c	height of roll centre; in the case of the "gauge" this height is conventionally set at 0,50 m above the running surface
h_{eff}	height of point considered for the pantograph clearance
h'o	height of the upper control point for the pantograph clearance
h'u	height of the lower control point for the pantograph clearance
I	cant deficiency; I_p for tilting trains and I_c for conventional trains
IM	infrastructure manager
ℓ	track gauge; distance between the running edges (the "active faces") of the rails of a track
L	distance between the centre lines of the rails of a single track (≈ 1,5 m)
L_q	dimension for lateral positioning of the platform
M1	safety margin, covering certain random phenomena caused by track-vehicle interaction and possible asymmetry of up to 1°, to be taken into account in defining the lineside clearance gauge
M2	margin for track maintenance, depending on the track laying method
M3	additional safety margin, in light of specific circumstances of individual IMs in order to define nominal lineside clearance gauge

Meℓ	margin specific to the minimum distance between track centre lines
MeN	margin specific to the nominal distance between track centre lines
Mi	margin to ensure electrical clearance between the zone reserved for pantographs and live roof-mounted equipment on motive power units with respect to the infrastructure
MoN	margin for nominal lineside clearance gauge
Mv	vertical margin
q_s	quasi-static movement; q_{sa} on the outside of the curve and q_{si} on the inside of the curve
R	level curve radius
RU	railway undertaking
R_v	vertical curve radius in the vicinity of gradient transition curves
s	flexibility coefficient
S	projection; S_a on the outside of the curve S_i on the inside of the curve
α’	angle between the inclined part of pantograph head and the horizontal ≥ 30°

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