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**Železniške naprave - Železniška vozila - Ugotavljanje položaja tirnih vozil med vožnjo po tirnih protikrivinah in izračun prekrivanja odbojnikov**

Railway applications - Railway rolling stock - Investigation of vehicles position on the reserve curve tracks during running and calculation of buffer overlap

Bahnanwendungen - Schienenfahrzeuge - Untersuchung der Fahrzeugstellungen im Gleis bei Durchfahrt von S-Bögen mit Ermittlung der Pufferüberdeckung

Applications ferroviaires - Synthèse des calculs de la largeur des tampons pour appareils de choc et traction

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**ICS:**

45.060.01      Železniška vozila na splošno      Railway rolling stock in  
general

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TECHNICAL REPORT

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September 2019

ICS 45.060.01

English Version

## Railway applications - Railway rolling stock - Investigation of vehicles position on the reverse curve tracks during running and calculation of buffer overlap

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Untersuchung der Fahrzeugstellungen im Gleis bei  
Durchfahrt von S-Bögen mit Ermittlung der  
Pufferüberdeckung

This Technical Report was approved by CEN on 26 May 2019. It has been drawn up by the Technical Committee CEN/TC 256.

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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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## European foreword

This document (CEN/TR 17373:2019) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

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## Introduction

During CEN/TC 256/SC 2/WG 33/SG 2 meetings for the writing of the European Standard EN 15551, SNCF presented its experience about derailments in the space of time from 1976 to 1982 due to insufficient buffer overlap and proposed to modify the formulae written in EN 15551:2009, Annex J to make greater the width of buffer heads sufficient for safety operation service. The formulae SNCF proposed, based on the former assumptions acc. UIC-leaflet from January 1964, simply takes into account the maximal own play of the vehicles, instead of the 5 mm value given in UIC 527-1:2005, 3.2.2 and EN 15551:2009, K.6. Indeed, this 5 mm value is a realistic value for freight wagons but not for other types of vehicles. Regarding the modification of the formulae proposed by SNCF the other members of W 33 pointed out that:

- it is not possible to increase the internal half width of the buffer head over the limits specified by UIC 527-1:2005, Annex A and EN 15551:2009, 6.2.2;
- since 1965 there have been two language versions of UIC 527-1, a French version and a German version, and they have the following discrepancy in the formulae for calculation of the width of buffer head:
  - UIC 527-1 French version: calculates the half width of the buffer head with different formulae for vehicles with running bogies (e.g. coaches, wagons) or with power bogies (e.g. locomotives, power heads and motor vehicles). Thus, the width of the buffer head calculated for vehicles with power bogies will be greater than the width of the buffer head calculated for vehicles with running (non-power) bogies;
  - UIC 527-1 German version: calculates the half width of the buffer head with the same formulae for all types of bogie vehicles, namely: for vehicles with running bogies as well as for vehicles with power bogies.
- No cases of buffer locking due to an insufficient dimensioning of buffer width (with consequently insufficient buffer overlap) were really noticed in Germany, whereas also in German speaking countries the UIC 527-1 formulae in the German version have been used for decades to dimension the buffer heads width.
- The geometry of the outside half width of buffer heads (opposite to vehicle centre line) of SNCF derailed coaches have had a circular shape geometry that reduced the buffing surface in Geometry specified in UIC 527-1:2005, Annex A).

In order to develop a uniform methodology for the calculation of the width of buffer heads, WG 33 decided to create an ad hoc group whose mission was to analyse, by means of realistic simulations, realized with the multi-body Software SIMPACK, if the formulae, written in the standard EN 15551:2009, Annex J, provide the width of buffer head enough for required minimum buffer overlap and what the domain of use of these formulae was.

This document presents the work made by the WG 33 Ad hoc group and the conclusions of this Group.

The investigation is conducted for specified vehicles in different vehicle combinations (train sets) for defined running cases in curves.

The purpose of this investigation is evaluation of following parameters:

- lateral displacement of coupled vehicles on the track;
- lateral displacement of coupled vehicles to each other;

— buffer overlap between two specified coupled vehicles with given buffers.

For this purpose, the types of vehicles defining the train sets and different operational conditions are specified. Position of the vehicles on the track at the moment of maximum lateral displacement to each other (minimum buffer overlap) is recorded.

The worst cases of lateral displacement and buffer overlap between two coupled vehicles as well as relation to UIC 527-1 and EN 15551 formulae are analysed.

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## CEN/TR 17373:2019 (E)

## 1 Scope

The purpose of this document is to analyse the conducted investigation and evaluation of lateral displacement and buffer overlap between each two specified vehicles of different train sets for defined running cases in curves.

For this purpose, the types of vehicles defining the train sets and different operating conditions are specified. Position of the vehicles on the track at the moment of maximum lateral displacement (minimum buffer overlap) is recorded during the calculation.

The worst cases of lateral displacement and buffer overlap between two coupled vehicles as well as relation to formulae in EN 15551:2009 are analysed.

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

No terms and definitions are listed in this document.

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

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

## 4 Symbols and abbreviations

Symbol	Designation	Unit
$a$	Distance between end wheelsets of vehicles not fitted with bogies or between bogie centres	mm
$dg_a$	Geometric overthrow of the vehicle on the outside of the curve	mm
$dg_i$	Geometric overthrow of the vehicle on the inside of the curve	mm
$dy_i$	Distance from the centre line of the buffer to the contact point at the buffer head, index 1, 2 in accordance to the vehicle number	mm
$dy_p$	Distance between the centre lines of the 2 buffers	mm
$F$	Geometric overthrow of the vehicle on the outside of the curve for car body pivots on the track centre line	mm
$F_{BC}$	Compressive force with buffers in contact	kN
$F_{LC}$	Compressive force simulates the forces which occur on the vehicles during braking or pushing operation	kN
$j_1$	Own lateral play (internal lateral displacement) of the vehicle ( $j_1$ ) in secondary suspension	mm
$j_2$	Lateral play in primary suspension	mm
$j_3$	Lateral play of the wheelset in a track	mm

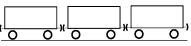
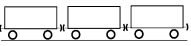


Symbol	Designation	Unit
$k$	Coefficient of lateral displacement of the vehicle on the track	—
$l$	Track gauge, distance between the rail running edges	mm
$l_{\text{nom}}$	Nominal track gauge	mm
$LoB$	Length over buffer	mm or m
$n$	Distance from the section under consideration to the adjacent end wheelset or the closest bogie centre or bogie pivot	mm
$n_a$	Overhang, distance from buffer face to the closest singular wheelset or closest bogie centre	mm
$n_i$	$n$ for the sections between the wheelsets or bogie centres	mm
$p$	Bogie wheelbase	mm
$R$	Horizontal curve radius	mm or m
$R_{LC}$	Horizontal curve radius, left curve	mm or m
$R_{RC}$	Horizontal curve radius, right curve	mm or m
$v$	Vehicle speed	m/s or km/h

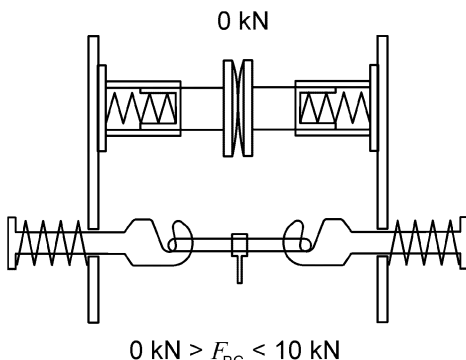
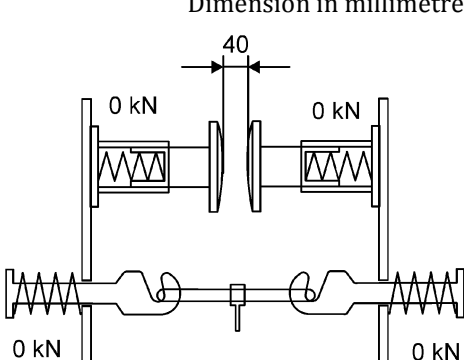
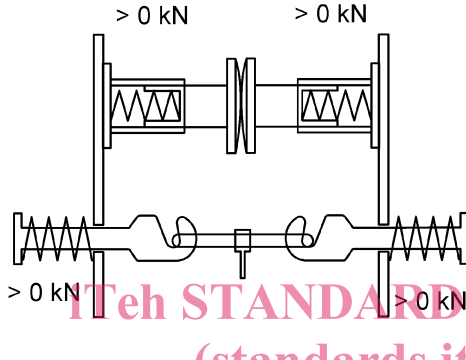
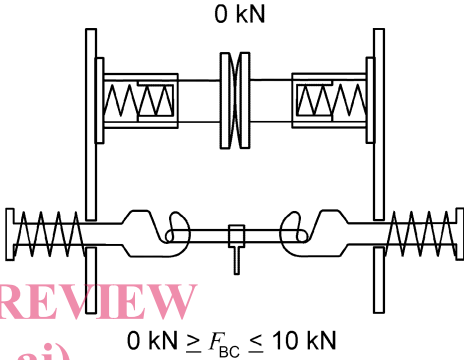
## 5 Boundary conditions (standards.iteh.ai)

The configurations and scenarios studied are described in Table 1 and Table 2.

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**Table 1 — Boundary conditions**

<b>Velocity</b>	$v = 30 \text{ km/h}$	constant	for $R = 150 \text{ m}$
	$v = 40 \text{ km/h}$	constant	for $R = 190 \text{ m}$
<b>Track</b>	$R 150 \text{ m} - 6,79 \text{ m} - R 150 \text{ m}$	gauge	1 470 mm
	$R 190 \text{ m} - 0 \text{ m} - R 190 \text{ m}$	gauge	1 458 mm
<b>Number of vehicles</b>	3		
<b>Vehicle configuration</b>	DB	1 <sup>st</sup> class intercity "Avmz" Avmz - Avmz - Avmz	3 times the same type
	SNCF 1	VTU coaches VTU - VTU - VTU	3 times the same type
	SNCF 2	Loco BB 27000 + 2 freight wagons (FW) (FW, length over buffers, LoB = 18 m, a = 12 m) Loco + Loco + coach	
	Siemens	2 Loco (Vectron) + coach (UIC-type) Loco + Loco + coach	
<b>Compressive force between vehicles<sup>a</sup></b>	$F_{LC} = 0 \text{ kN}$	 = const	
	$F_{LC} = 200 \text{ kN}$	 = const	

## CEN/TR 17373:2019 (E)

Screw coupler tightening	nominal case ( <i>N</i> )	degraded case ( <i>D</i> )
— for locomotives or wagons	<div></div>	<div><p>Dimension in millimetre</p></div>
— for coaches	<div></div>	<div></div>
	Buffers in contact	
	— 2 turns before contact with nuts	
	— Specific rules (SNCF)	
<sup>a</sup>	The compressive force simulates the forces which occur on the vehicles during braking or pushing operation.	

In Table 2, the configurations of the coupled vehicles studied are indicated by the sign “X”. The additional scenarios indicated by a footnote “a” for the “worst case” are the “special” cases where it is assumed that higher requirements might occur and the calculation of the buffer head width in accordance with the specified formulae are not valid for all vehicles.

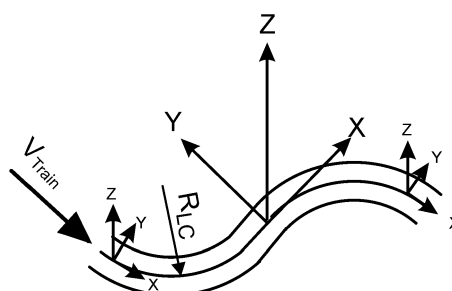
Table 2 — Configuration of coupled vehicles

Operator/ Manufacturer	Vehicle configuration	Screw coupler tightening	0 kN <i>R</i> 150 m <i>v</i> = 30 km/h	0 kN <i>R</i> 190 m <i>v</i> = 40 km/h	200 kN <i>R</i> 150 m <i>v</i> = 30 km/h	200 kN <i>R</i> 190 m <i>v</i> = 40 km/h
DB	3 coaches “Avmz”	<i>N</i>	X	X	X	X
		<i>D</i>			X <sup>a</sup>	
Siemens	2 locomotives + 1 UIC coach Locomotive = Siemens Vectron	<i>N</i>	X		X	
		<i>D</i>			X <sup>a</sup>	
SNCF 1	3 coaches “VTU”	<i>N</i>	X	X	X	X
		<i>D</i>			X <sup>a</sup>	
SNCF 2	1 locomotive + 2 freight wagons locomotive = BB27000	<i>N</i>			X	
		<i>D</i>			X <sup>a</sup>	
<b>Key</b> <i>N</i> = nominal case, see Table 1, Screw coupler tightening <i>D</i> = degraded case, see Table 1, Screw coupler tightening <i>X</i> = configuration to be calculated/simulated						
<sup>a</sup> Classified as "worst case"						

As specified by the previous tables (Table 1 and Table 2), the two following parameters are taken into account, because they are considered as the most influential ones:

- Screw coupler tightening,
- Compressive force (as a reaction to the braking or pushing mode).

In order to compare the results between the calculations from the group members, a uniform coordinate system for the analysis of output data was determined. This coordinate system is defined in accordance with 3-finger rule of the right hand, where "x" follows the track in running direction of the train set, and it is shown in Figure 1.

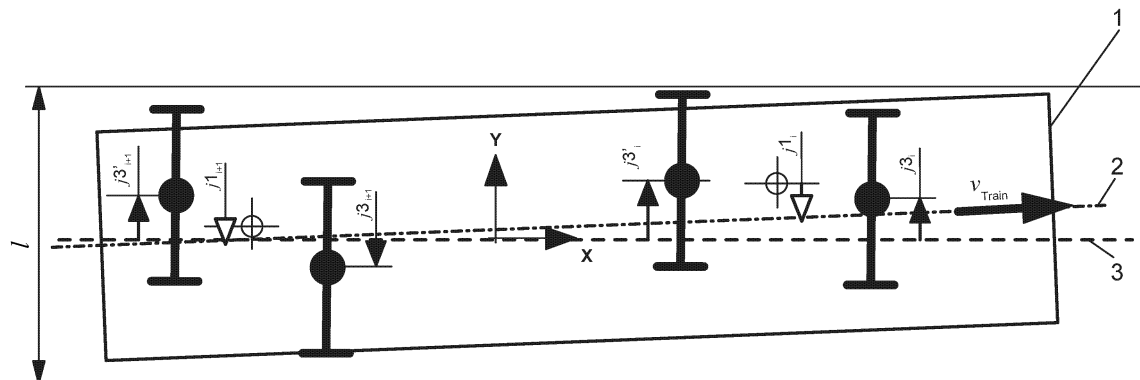


**Key**

- $v_{\text{train}}$  velocity of the train set  
 $R_{\text{LC}}$  radius, left curve

Figure 1 — Coordinate system

It is also necessary to fix of the variables to be registered. The following scheme presents the variable names for vehicle 1 ( $i$  is the position of the bogies:  $i = 1$  is the first bogie entering in the S-curve).



### Key

$v_{\text{train}}$  velocity of the train set

$l$  track gauge: 1 470 mm


1 vehicle body


2 vehicle body centre line

3 track centre line

$x, y$  axis of the coordinate system

 wheelset

 bogie pivot

 own play of the vehicle body on the bogie ( $j1$ ): Example:  $j1_i, j1_{i+1}$

 play of the wheelsets in a track ( $j3$ ): Example:  $j3_i, j3'_i, j3_{i+1}, j3'_{i+1}$

NOTE 1  $i$  is the position of the bogie:  $i = 1$  is the first bogie entering in the S-curve

NOTE 2 ' indicates the second wheelset of the bogie

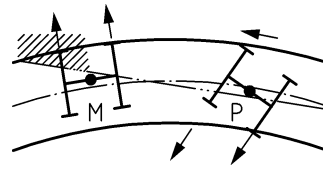
NOTE 3 The play  $j2$  (bogie internal to primary spring) is neglected.

**Figure 2 — Visualization of the names of analysed parameters**

## 6 Vehicle dynamic

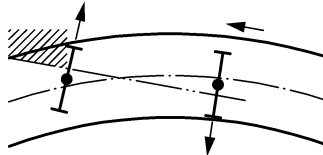
### 6.1 Coefficient of displacement $k$

The lateral displacement of the wheelsets in the track ( $j3$ ) is different for the bogie vehicles and other vehicles. Thus, there are two formulae for the calculation of the coefficient " $k$ " for the position of the wheelsets of the bogies in the curve, see Figure 3.



$$k = \frac{n_a + a}{a} \quad (1)$$

a) Bogie vehicles



$$k = \frac{2 \cdot n_a + a}{a} \quad (2)$$

b) All other vehicles

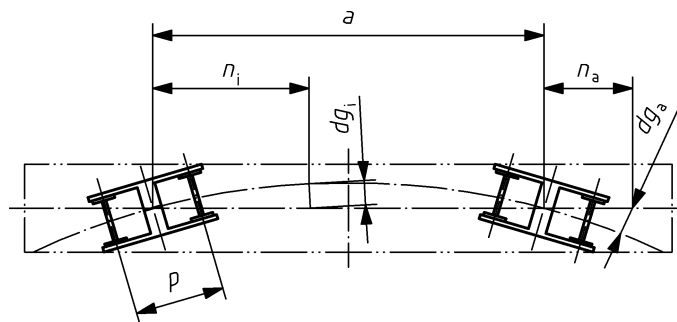
#### Key

- $a$  is the distance, in mm, between end wheelsets or bogie pivots of the vehicle concerned;  
 $n_a$  is the overhang, in mm, of the buffer face in relation to the end wheelsets or bogie pivot;  
 $k$  is the coefficient of displacement of the vehicle in the track.

Figure 3 — Coefficient  $k$  for bogie vehicles and other vehicles

## 6.2 Geometric overthrow $dg$ or $F$

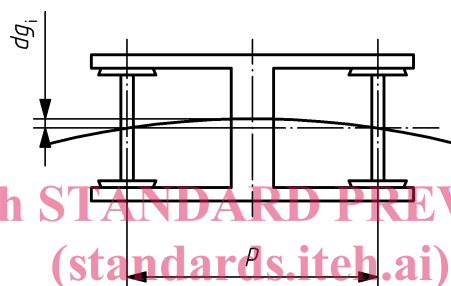
For the definition of the Geometric overthrow ( $dg$ ), see Figure 4.



$$dg_i = \frac{an_i - n_i^2}{2R} \quad (3)$$

$$F \equiv dg_a = \frac{an_a - n_a^2}{2R} \quad (4)$$

a)  $dg$  of the vehicle on a curved track



$$dg_i = \frac{p^2}{8R} \quad (5)$$

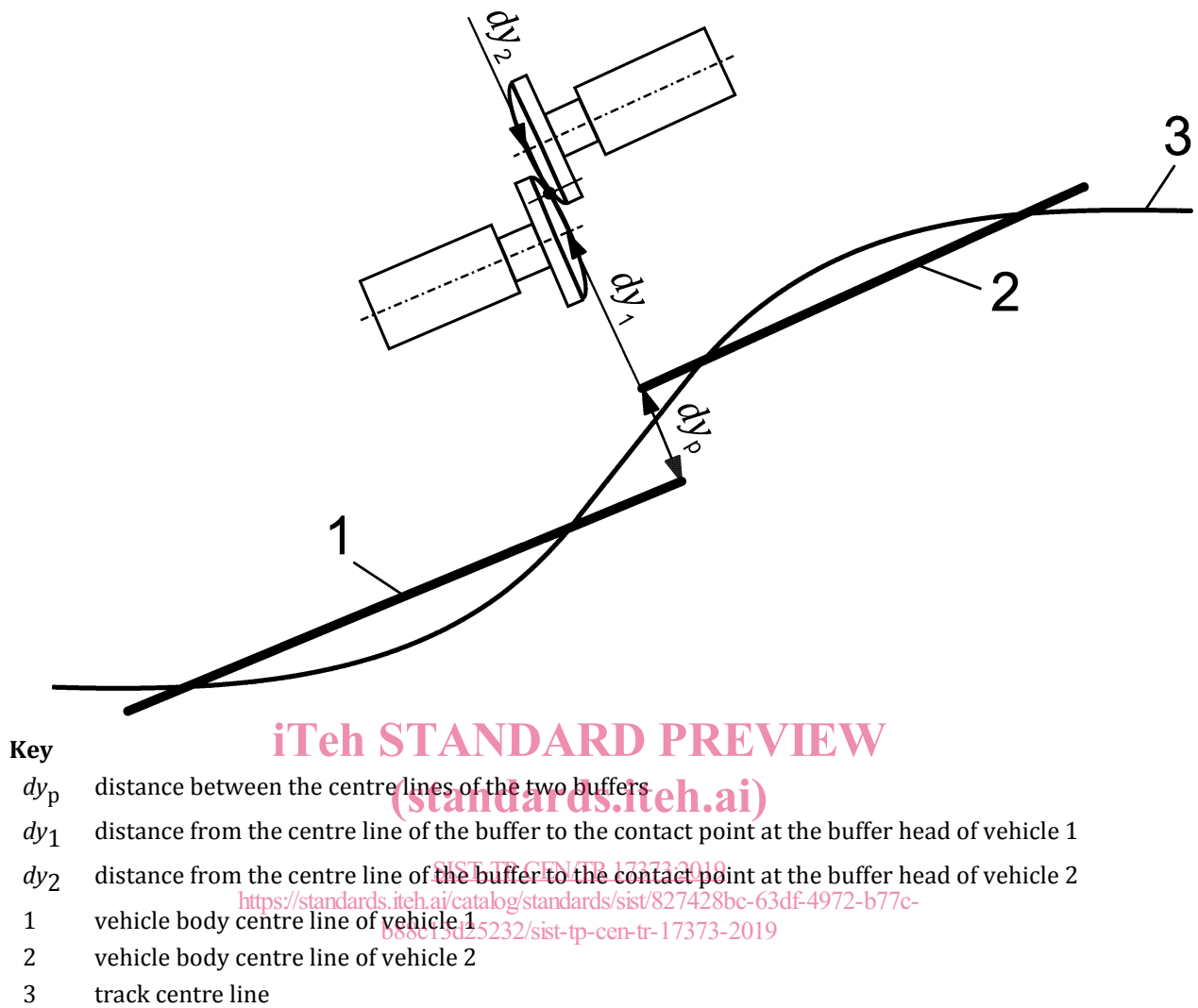
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b)  $dg_i$  of the bogie on a curved track

Figure 4 — Geometric overthrow  $dg$

### 6.3 Location of the vehicle in the track and displacement $dy_p$

The displacement of the centre lines of the two buffers  $dy_p$  to each other is the main parameter to be analysed and it is approximately the shortest distance between the two centre lines (see Figure 5, item 1 and item 2).



**Figure 5 — Scheme of displacement of vehicle body centre line in a S-curve**

## 6.4 Position of the vehicles in the S-curve

### 6.4.1 Bogie vehicles

Figure 6 shows the position of bogie vehicles in S-curve.