REVISION

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1 OBJECT

The object of the present document is to determine the clearance to be kept free for safe operation of the unit proposed by CAF for Tallin Tramway [1].

The clearance is calculated according to BOStrab regulations [2].

Constructional conditions of fixed or movable objects of the track structure can require additions to the clearance presented in the present document. Their determination is not part of the scope of the present document.

The clearances obtained are depending on vehicle dimensions, suspension characteristics, wheel profile and their maintenance and also on track gauge, quality and maintenance. The necessary track input to obtain the gauge clearances in the present document have been obtained from the Technical Specification of the trams [3] and in his absence, from reference values given in [2].

2 GENERAL PRINCIPLES

The definition of the required clearance is based upon:

- Maximum cross sectional dimensions under loads, considering allowances for manufacturing tolerances.
- Maximum possible displacement of the tram in motion
- Dynamics due to the track gauge tolerances, misalignment, cross level error and rail roughness.
- Curve negotiation overthrow and cant excess/deficiency effect.

Lower parts gauging are established with the aim to have a minimum clearance of 80 mm to rail considering:

- Hog and Sag up to 500 m
- Suspension deflections considering up to 8 pax/m2 (70 kg/pax)
- Carbody deflection considering up to 8 pax/ m2 (70 kg/pax)
- Non compensated wheel wear
- Vehicle construction tolerances
- Dynamic pitch

3 SYMBOLS

Sign	Unit	Definitions in the Clearance Regulations
		Technical guidance terms
S	mm	wheelset gauge dimension
Δs	mm	wheel flange wear (per axle) incl. nominal gauge clearance
S	mm	track gauge
ΔS	mm	rail wear incl. gauge widening
ΔS_a	mm	part of ΔS allocated to the outer curve side
ΔS_i	mm	part of ΔS allocated to the inner curve side
$\sigma \approx S - s$	mm	gauge clearance
$\max \sigma \approx \max \Delta s + \max \Delta S$	mm	maximum gauge clearance
α_s	mm/m	deflection of the rail wear
		Technical vehicle terms
a	mm	distance of the carbody guide points/ running gear centres
e	mm	distance between running gear centre and carbody guidance
p	mm	wheel-base
a1	mm	Distance between bogies N car
b	mm	Distance between N bogie and articulation point
a2	mm	Distante between N and C bogie
n1	mm	Cab Section Location
n3	mm	C Rear End Section Location
n4	mm	N Rear End Section Location
i	mm	Gangway length
P		point on the vehicle outline (vehicle point)
x	mm	distance of a vehicle point P from the middle of carbody guidance
ba,i	mm	distance of a vehicle point P from the vehicle midline with mid-position of the vehicle parts
h	mm	level of a vehicle point P, relative to the set position of the draft-technical common running surface tangent
h_C	mm	height of the shake pole C (general)
s	-	Rolling flexibility (souplesse)
$\eta \approx \eta_p + \eta_s$	rad	shake angle
η_p	rad	proportionate shake angle of the primary suspension
η_s	rad	proportionate shake angle of the secondary suspension
η^*	rad	additional shake angle due to shifting of the centre of gravity (suspension basis)
δ	rad	angle of inclination due to deviation of the mutual level of the rails
δ^*	rad	additional angle of inclination due to shifting of the centre of gravity (track basis)
f_F		magnification factor of the angle η (suspension basis)
		Technical track terms
R	m	curve radius
Rv_c	m	Minimum Sag Vertical Radius
Rv_b	m	Minimum Hog Vertical Radius

Sign	Unit	Definitions in the Clearance Regulations
u	mm	track superelevation
Δu	mm	deviation of the mutual level of the rails
Δh	mm	height wear of rail head
m	mm	distance of the taping line levels
α_Q	mm/m	deflection of the transverse displacement of the track
α_V	mm/m	deflection of the vertical displacement of the track
		Speeds, accelerations, forces
v	km/h	permissible running speed
g	m/s^2	gravitational acceleration
a_{nc}	m/s^2	transverse acceleration from centrifugal force excess or slope output
a_s	m/s^2	transverse acceleration from side impact
p_w	N/m^2	wind pressure
A_W	m^2	wind contact surface
F_Q	N	inertial force from centrifugal force excess or slope output (a_q)
F_s	N	inertial force from side impact (a_s)
F_w	N	wind power
Cd	mm	Equivalent Cant due to vehicle interaction to track roughness
		Lateral clearance requirement
y	mm	lateral displacements and shiftings
y_p	mm	lateral clearance requirement of a vehicle point
y_d	mm	clearance requirement between adjacent tracks
y_s	mm	safety margin in the transverse direction
		Additional magnitudes for the determination of the lateral clearance requirement
y_1	mm	transverse displacement of the guide point 1
y_2	mm	transverse displacement of the guide point 2
f_1	mm	magnification/reduction factor of the displacement y_1
f_2	mm	magnification/reduction factor of the displacement y_2
		Curve-geometric projection
b_a	mm	distance of a vehicle point P on the outer curve side from the track centre due to curve-geometric projection incl. half vehicle width
b_i	mm	distance of a vehicle point P on the inner curve side from the track centre due to curve-geometric projection incl. half vehicle width
		Transverse displacement due to the gauge clearance
$y_{\sigma 0}$	mm	transverse displacement of the gauge centre (parallel displacement)
$y_{\sigma 1,2}$	mm	transverse displacement of the running gears 1 and 2
y_{SS}	mm	transverse displacement of the vehicle point due to the gauge clearance
y_{SW}	mm	transverse displacement of the vehicle point due to the deflection of the gauge centre
		Transverse displacement due to technical vehicle factors of influence
y_{TR}	mm	constructional tolerance of wheelset
y_{TA}	mm	constructional tolerance of axle bearing
y_{TD}	mm	constructional tolerance of slewing ring / bogie pivot
y_{TP}	mm	constructional tolerance of primary suspension

Sign	Unit	Definitions in the Clearance Regulations
y_{TW}	mm	constructional tolerance of carbody
y_{SA}	mm	transverse clearance of axle bearing
y_{SD}	mm	transverse clearance of bogie pivot
y_{FR}	mm	wheel banding suspension
y_{FP}	mm	primary suspensión
y_{FS}	mm	secondary suspension, static
y_{DS}	mm	secondary suspension, dynamic
Transverse displacement due to technical track factors of influence		
y_{GV}	mm	track displacement
y_{GW}	mm	change of track displacement
y_{GE}	mm	transverse elasticity between track and rail
Transverse shifting of a vehicle point P due to shaking		
y_W	mm	caused by a lateral force, general
y_{WQ}	mm	caused by the centrifugal force or the slope output
y_{WS}	mm	caused by a side impact
y_{WW}	mm	caused by wind power
Transverse shifting of a vehicle point P due to the angular position of the vehicle		
y_{WB}	mm	caused by the setting tolerance, relative to the vehicle width
y_{WZ}	mm	caused by an asymmetrical additional load
y_{HE}	mm	caused by a deviation of the mutual level of the rails, elastic part
y_{HS}	mm	caused by a deviation of the mutual level of the rails, part remaining due to operation
Vertical clearance requirement Vertical displacements		
z	mm	vertical displacements and shiftings
Ea_v^-	mm	Cab end Sag Overthrow
Ea_v^+	mm	Cab end Hog Overthrow
Ei_v^-	mm	Suspended Car Centre Hog Overthrow
Ei_v^+	mm	Suspended Car Centre Sag Overthrow
z_{TW}	mm	setting tolerance of carbody height (floor level, reference height)
z_{TG}	mm	constructional tolerance of roof (ground) incl. add-on devices to the reference height
z_{VR}	mm	Wheel wear non compensated by adjustement in maintenance
z_{FR}	mm	wheel banding suspension
z_{FP}	mm	static spring excursion of the primary suspension incl. unbalanced spring setting
z_{DP}	mm	dynamic spring excursion of the primary suspension
z_{FS}	mm	static spring excursion of the secondary suspension incl. unbalanced spring setting
z_{DS}	mm	dynamic spring excursion of the secondary suspension
z_{FW}	mm	carbody sagging
z_{GE}	mm	vertical elasticity of the track
z_{GV}	mm	vertical displacement of the track
z_{VS}	mm	vertical rail wear
Vertical shiftings		

Sign	Unit	Definitions in the Clearance Regulations
z_W	mm	shifting caused by a lateral force, general
z_{WQ}	mm	shifting caused by centrifugal force excess or slope output
z_{WS}	mm	shifting caused by side impact
z_{WW}	mm	shifting caused by wind power
z_{HE}	mm	shifting caused by a deviation of the mutual level of the rails, elastic part
z_{HS}	mm	shifting caused by a deviation of the mutual level of the rails, part remaining due to operation
z_{WB}	mm	shifting due to the setting tolerance of the carbody
z_{WZ}	mm	shifting due to an asymmetrical additional load
z_{NG}	mm	shifting due to bouncing movements caused by vertical track displacements
z_S	mm	safety margin in vertical direction

4 TRACK PARAMETERS

The parameters of the fixed installation, its maintenance and even operation of the line used for calculating the gauge clearance to be kept, are shown in Table 4.1.
The values shown in the table have been obtained from the Technical Specification of the trams [3] and in his absence, from reference values given in [2].

m	Track Gauge		1067	mm
	Track Bed: Ballast (b) / Ballastless (h)			
u	Maximum Cant		50	mm
a_{nc}	Maximum Unbalanced Transversal Acceleration		1	m/s2
Rv_c	Minimum Sag Vertical Radius		500	m
Rv_b	Minimum Hog Vertical Radius		500	m
	TRACK BED CHANGES			
yGV	**Track transverse displacement**			
	Ballastless	z	5	mm
	Ballast			
	R>800	z	25	mm
	800>R>40	z	25+1000/R	mm
	R<40	z	50	mm
	Limited by the platform edge			
	R>800	z	3	mm
	R<800	z	5	mm
α_Q	Variation		1,5	mm/m
yGE	**Tranverse elasticity of the track**			
	Straight Track and Curves R>=800 m	nz	1	mm
	Cuves R<800 m			
	towards the outer side	nz	2	mm
	towards the inner side	nz	-1	mm
ΔuHS	**Track Cross Unlevelling**			
	Ballastless	z	10	mm
	Ballast	z	10	mm
ΔuHE	**Vertical elasticity**			
	Ballastless	nz	1	mm
	Ballast	nz	2	mm
	TRACK GAUGE			
ΔS	**Maximum gauge track (rail wear and track displacement included)**		15	mm
	Maximum deviation		1,5	mm/m
ΔSa	Maximum gauge track (rail wear and track displacement included) towards the outer side		15	mm
ΔSi	Maximum gauge track (rail wear and track displacement included) towards the inner side		0	mm
yσ0	Displacement of the track centre		7,5	mm
maxσ	Maximum track clearance		30	mm
	DYNAMIC TRACK INTERACTION			
	Equivalent Cant			
	Ballastless			

	Inner side		7	mm
	Outer side		39	mm
	Ballast			
	Inner side		7	mm
	Outer side		39	mm
	LATERAL FORCES			
as	Transverse acceleration from side impact		0,5	m/s^2
Fw	Wind power force based on 60 km/h		200	N/m^2

Table 4.1. Track Parameters

5 VEHICLE PARAMETERS

Vehicle parameters involved in the gauge calculations, are indicated with their values in Table 5.1.

	VEHICLE DATA			
a1	Distance between bogies N car		5100	mm
b	Distance between N bogie and articulation point		2300	mm
a2	Distante between N and C bogie		9600	mm
n1	Cab Section Location		2200	mm
n3	C Rear End Section Location		6800	mm
n4	N Rear End Section Location		1800	mm
i	Gangway length		1000	mm
p	Wheelset Base		1850	mm
	Carbody width		2300	mm
Aw	C Vehicle Side Wall Area		36	m2
Aw	N Vehicle Side Wall Area		31	m2
hc	C Car Rolling Centre Height		220	mm
hc	N Car Rolling Centre Height		220	mm
s	C Car Souplesse		0,25	
s	N Car Souplesse		0,25	
	LATERAL CONSTRUCTIONAL TOLERANCES, CLEARANCE AND WEAR			
Δs	Maximum wheel flange wear	nz	4	mm
	Nominal wheel flange clearance	nz	3,5	mm
yTR	Constructional tolerance of wheelset	z	1	mm
yTA	Contructional tolerance of axle bearing	z	0,5	mm
yTD	Fitting tolerance of the rotary joint	z	0	mm
yTP	Fitting tolerance of the primary suspension	z	1,5	mm
yTS	Fitting tolerance of the secondary suspension	z	4	mm
yTW	Constructional tolerance of half of the carbody width	z	3	mm
ySA	Axle bearing clearance	nz	0,45	mm
ySD	Slewing ring / bogie pivot clerance	nz	0,6	mm
	Fitting tolerance of devices mounted on the carbody	z	5	mm
	Firring tolerance of the roof-mounted current collection equipment	z	5	mm
	LATERAL SPRING EXCURSIONS			
yFR	Wheel banding suspension (static and dynamic)	nz	1	mm
yFP	Primary Suspension (static and dynamic)	nz	2	mm
	Secondary Suspension (static and dynamic)			
yFS	Static	nz	25	mm

yDS	Dynamic	z	7	mm
	Transverse deflection of the overhrad contact line current collector, relative to the upper roof edge	z	20	mm
	VERTICAL CONSTRUCTIONAL TOLERANCES AND WEAR			
zVR	Wheel wear non compensated by adjustement in maintenance	nz	-10	mm
zTW	Setting tolerance of the car floor height	z	6	mm
		z	-10	mm
zTG	Contructional tolerance of the upper roof elements to floor height	z	10	mm
	Maximum allowed difference between floor height at both sides	z	10	mm
	VERTICAL EXCURSIONS			
zFR	Wheel banding suspension (static and dynamic)	nz	-1	mm
	Primary Suspension			
zFP1	Unbalance setting	nz	0	mm
zFP2	Static spring excursion (between "vehicle empty" and "vehicle full capacity"	nz	-12	mm
zDP	Dynamic	z	10	mm
		z	-8	mm
	Secondary Suspension			
zFS1	Unbalance setting	nz	0	mm
zFS2	Static spring excursion (between "vehicle empty" and "vehicle full capacity"	nz	-31	mm
zDS	Dynamic	z	18	mm
		z	-9	mm
zFW	Carbody maximum deflection	nz	-10	mm
	DISIMETRY			
	Rolling due to asymetrical load distribution		0,45	°
	Rolling due to levelling tolerance		5	mm

Table 5.1. Vehicle Parameters

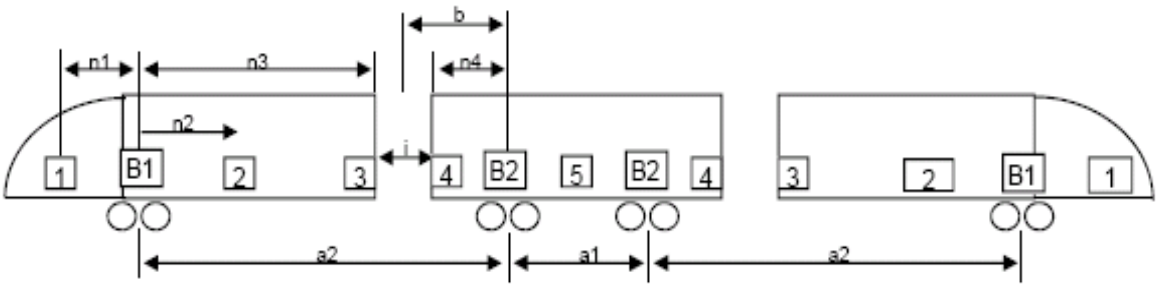


Figure 5.1. Vehicle Principal Dimensions and Sections

6 GAUGE CLERANCE CALCULATION

6.1 PROCEDURE

According to [2] in the first place the curve-geometric projection is to be determined for the vehicle to be examined with the set position of the track and the mid-position of the vehicle on the track.
When the curve-geometric projection has been determined, the vehicle is considered at the most unfavourable positions on the track.

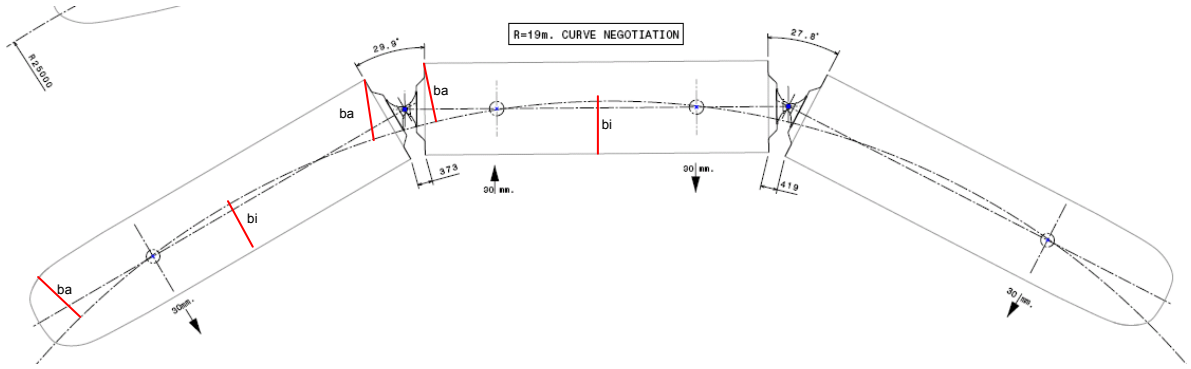


Figure 6.1 Curve-Geometric Projection in Curve

In the extreme positions the effects of the factors of influence are calculated according to Section 4 of [2] for the points of the vehicle with greater geometric projection, separately for each factor of influence.
The factors of influence are classified in non-accidentally occurring (non-accidentally conditioned- *nz*) and accidentally occurring (accidentally conditioned - *z*) factors. The effects of the non-accidentally conditioned factors are added arithmetically. The effects of the accidentally conditioned factors are added quadratically under a joint root according to § 18(3) of BOStrab in consideration of the probability of concurrence of parallel peak values.
The lateral clearance requirement is made up by

- the vehicle width,
- the curve-geometric projection,
- the clearance requirement due to non-accidentally conditioned factors of influence and
- the clearance requirement due to accidentally conditioned factors of influence.

In case of a single track route the clearance requirement is to be assessed to be equally big on both sides.
In the track curve the clearance requirement differs in size for the outside of the curve and for the inside of the curve.
In case of routes with adjacent tracks the clearance requirement in the direction turned away from the adjacent track is calculated as in case of the single track. Towards the adjacent track the probability set-up for both tracks is summed up, i.e. the effects of the accidentally conditioned factors of influence of both sides are added quadratically together under the root so that the clearance requirement between two tracks is usually lower than the double requirement of a single track.
For the determination of the clearance requirement for the ground and roof clearance of the vehicles the clearance requirement also has to be determined in the vertical direction.
Between the clearance requirement and the clearance gauge there shall be a safety margin, which is fixed by the accuracy with which the clearance requirement can be delineated.

6.2 VEHICLE DIMENSIONS

The vehicle points used to calculate the gauge clearance to be kept, are the points with greater geometric curve projection, according to 6.1.

Gauge clearance is calculated for inner side of the curve for:

- Section 2: Door section in C
- Section 5: Door section in N car

In the outer side of the curve, gauge clearance is calculated from:

- Section 1: Cab section in C
- Section 3: Rear End section in C car
- Section 4: Rear End section in N car

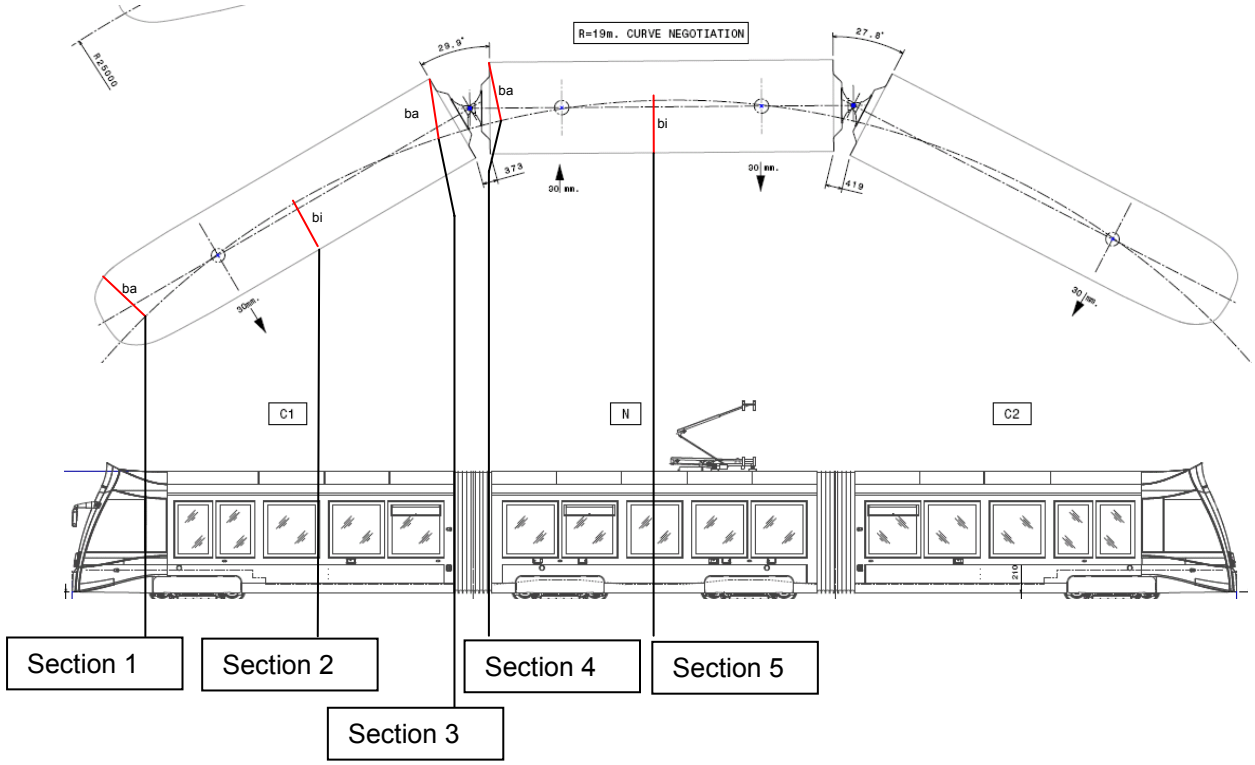


Figure 6.2 Reference Points for Gauge Clearance Analysis

Cross Section width at these sections at different heights are taken into account to obtain the clearance to be kept at any height at both sides of the track. The points considered for the gauge calculations are indicated in Ref [4].

6.3 LATERAL GAUGE CLEARANCE

6.3.1 Single Track

The lateral gauge clearance of the vehicle is calculated at different height h above the running surface, considering:

- the distance of the vehicle point from the track axis in the design (curve-geometric projection including half vehicle width, ba,i),
- the transverse displacement due to the track clearance,
- the transverse displacement and transverse shifting due to non-accidentally conditioned factors of influence and
- the transverse displacement and transverse shifting due to accidentally conditioned factors of influence.

Whilst the curve-geometric projection includes half the vehicle width, the transverse displacement due to track clearance and the non-accidentally conditioned individual requirement are added arithmetically, the probability of coincidence is taken into account for accidentally conditioned variables by adding the values as squares under the root based on the Gaussian law of error propagation:

$$y_p = b_{a,i} + y_{SS} + y_{SA} + y_{SD} + y_{FR} + y_{FP} + y_{FS} + y_{GE} + y_{WQ} + y_{WZ} + y_{HE} + \sqrt{y_{SW}^2 + y_{TR}^2 + y_{TA}^2 + y_{TD}^2 + y_{TP}^2 + y_{TW}^2 + y_{DS}^2 + y_{GW}^2 + y_{GV}^2 + y_{WW}^2 + y_{WS}^2 + y_{WB}^2 + y_{HS}^2}$$

Yp is calculated for section 2 and 5, and maximum value is retained as the clearance to be kept in the inner side of a curve.
Yp is calculated for section 1,3 and 4, maximum value is retained as the clearance to be kept outside of a curve.
As a result, drawing Q.44.00.041 [5] gives the lateral clearance to be kept at both sides of a single track at different heights related to running surface, for straight and different curve radius.

6.3.2 Multiple Track

On multi-track routes a distinction is made between non-adjacent and adjacent tracks.
For non-adjacent tracks, the clearance requirement is determined in the same way as for single tracks.
For adjacent tracks, proceed as follows:

- The influence of the wind is only taken into account for one vehicle.
- The transverse displacement between the tracks is only taken into account for one track.
- The transverse displacement and transverse shifting resulting from accidentally conditioned factors of influence can be combined for both tracks under a single root.

When determining the minimum track clearance to adjacent tracks, the added influence of

- points branching off outwards that are provided for subsequent installation,
- connecting bends
- different cambers

must be taken into account on the clearance requirement.
For adjacent straight tracks on which two vehicles with an identical construction meet in the sideways running position, the following clearance requirement exists as basis for the track clearance for the same vehicle point on both vehicles:

$$y_d = 2 \cdot (b_a + y_{SS} + y_{SA} + y_{SD} + y_{FR} + y_{FP} + y_{FS} + y_{GE} + y_{WQ} + y_{WZ} + y_{HE})$$
$$+ \sqrt{2 \cdot (y_{SW}^2 + y_{TR}^2 + y_{TA}^2 + y_{TD}^2 + y_{TP}^2 + y_{TW}^2 + y_{DS}^2) + y_{GW}^2 + y_{GV}^2 + y_{WW}^2 + 2 \cdot (y_{WS}^2 + y_{WB}^2 + y_{HS}^2)}$$

Minimum track distances, considering no difference in elevation between adjacent tracks are given in Table 6.3.2.1.

Radius (m)	**19**	**20**	**25**	**30**	**40**	**50**	**60**	**80**	**100**
	3665	**3621**	**3451**	**3338**	**3196**	**3111**	**3054**	**2983**	**2940**
Radius (m)	**150**	**200**	**300**	**500**	**600**	**800**	**1000**	**2000**	**STR**
	2883	**2854**	**2826**	**2803**	**2797**	**2788**	**2784**	**2775**	**2672**

Table 6.3.2.1 Minimum track distance

6.3.3 Reduced Gauge Clearance

Reduced gauge clearance at the height of the vehicle is given in Table 6.3.3.1 for different curve radius in the inner and outer side of the curve.

This reduced gauge clearance is applicable to areas where the speed of circulation is low and under control, with no passenger service.

The estimation of this reduced gauge clearance is based on considering rolling and lateral movements reduced taking into account a low speed of circulation.

	19	**20**	**25**	**30**	**40**	**50**	**60**	**80**	**100**
Ea (*)	*1843*	*1819*	*1728*	*1666*	*1589*	*1542*	*1510*	*1471*	*1448*
Ea (**)	*1736*	*1712*	*1621*	*1559*	*1482*	*1435*	*1403*	*1364*	*1341*
Ei	*1609*	*1590*	*1517*	*1469*	*1410*	*1374*	*1351*	*1321*	*1303*
	150	**200**	**300**	**500**	**600**	**800**	**1000**	**2000**	**STR**
Ea (*)	*1416*	*1400*	*1385*	*1372*	*1369*	*1365*	*1363*	*1358*	*1354*
Ea (**)	*1309*	*1293*	*1278*	*1265*	*1262*	*1258*	*1256*	*1251*	*1247*
Ei	*1280*	*1268*	*1256*	*1247*	*1247*	*1247*	*1239*	*1247*	*1247*

(*) Rearview camera included
(**) Rearview camera not included

Table 6.3.3.1. Reduced Gauge Clearance

6.4 VERTICAL GAUGE CLEARANCE

Vehicle lower parts have been designed taken into account that in any running condition a minimum clearance gap of 80 mm is respected, according to point 2.2 of Ref [3].
The condition of maximum approach of the vehicle to the rail is due to the addition of the following factors:

- Non compensated wheel wear (zVR)
- Maximum vertical deflection of the suspension (zFP+zDR+ zFS+ zDS)
- Dynamic pitch of the vehicle: This effect is calculated applying the crossing factor "f" in the dynamic vertical deflection of the suspension stages.
- Constructional tolerances: 10 mm
- Carbody deflection (zFW)
- Vertical curve negotiation: A minimum radius of 500 m has been considered.

As a result of it, Table 6.4.1and 6.4.2 show the vertical gauge clearance to be respected by the different vehicles in nominal position, depending on its position in the vehicle, to be compliant with the minimum gap of 80 mm under any circumstance.

7 CURVE TRANSITIONS

The curve widening has to be spliced rectilinearly towards straight tracks or between adjacent curves.
In curves containing transition curves, the curve widening has to be spliced along the length of the transition curve.
In curves that do not contain transition curves the curve widening has to be spliced as indicated below.

7.1 STRAIGHT AND CURVE

Curve widening in transitions between straight and curve should be done in the way are indicated in Figure 7.1.1.

7.2 S-CURVES

Curves of opposite curvature should be connected by a transition straight track.
In any case following minimums are required for the vehicle:

- S-curves without straight transition can be negotiated for curves of a minimum of 25 m
- S-curves of 20 m can be negotiated with a minimum straight transition of 7,5 m.
- S-curve of 25 m to a 20 m can be negotiated with a minimum straight transition of 5,5 m

Whit no straight transition, curve widening should be done in the way indicated in Figure 7.2.1. and taking into account in the central section (+/-14 m from the transition point), the special lateral gauge clearances indicated in Table 7.2.1.

	25	**30**	**40**	**50**	**60**	**80**	**100**
LGC	*2000*	*1918*	*1815*	*1753*	*1711*	*1656*	*1448*
	150	**200**	**300**	**500**	**600**	**800**	**1000**
LGC	*1586*	*1565*	*1544*	*1527*	*1523*	*1517*	*1514*

Table 7.2.1 Special lateral gauge clearance in S-curves with no transition

8 CONCLUSIONS

Lateral clearances to be kept free for safe operation of vehicles CAF URBOS AXL designed for Tallinn have been calculated according to BOStrab regulations [2].

The results are shown in drawing Q.44.00.041 Ref [5].

Minimum distance between tracks are indicated in Table 6.3.2.1 in multiple tracks.

Additionally, a reduced lateral clearance is given in Table 6.3.3.1 for special locations where vehicles run at low speed (depot).

Lateral clearances in transitions are also indicated in point 7, indicating how to make the transition between straight and curve and between curves of different curvature in terms of gauge widening.

Lower parts of the vehicle have been designed in order to clear a minimum of 85 mm, as required in [3], to the running surface considering different situations that may approach the vehicle to it. The resulting necessary nominal clearances to be respected by the vehicle are indicated in Tables 6.4.1 and 6.4.2.

9 REFERENCES

[1] Q.44.00.001 Trainset Assembly

[2] Preliminary Regulation on the Measurement of the Clearance of Traction Systems in accordance with German Federal Regulations on the Construction and Operation of Light Rail Transit Systems – BOSTRAB Clearance Regulations – December 1996

[3] Technical Specification for Trams. Public Procurement code 41-11 RH. Tallin 2012

[4] Q.44.00.040 Static Gauge

[5] Q.44.00.041 Dynamic Gauge

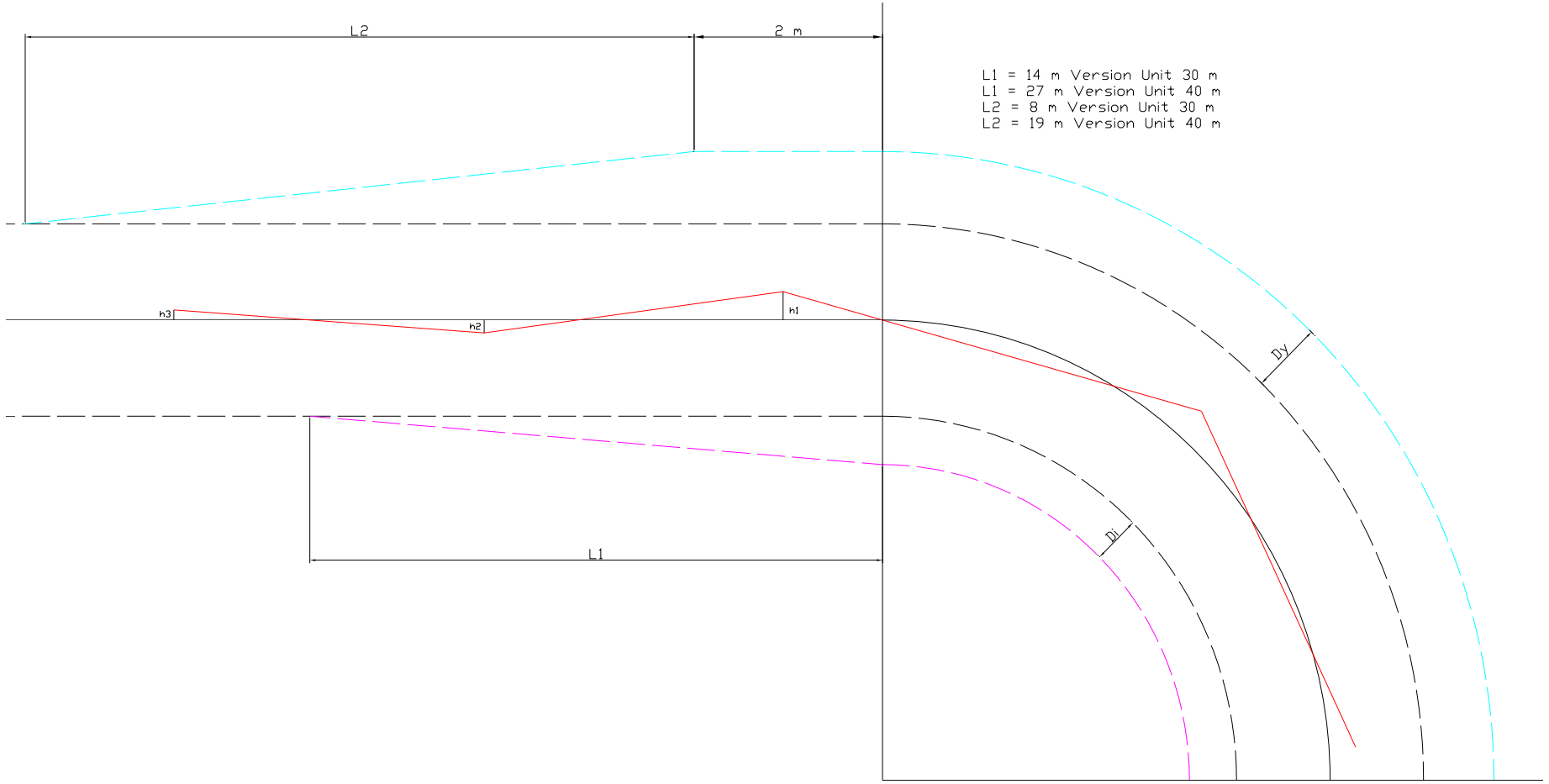


Figure 7.1.1 Splicing between straight and curve

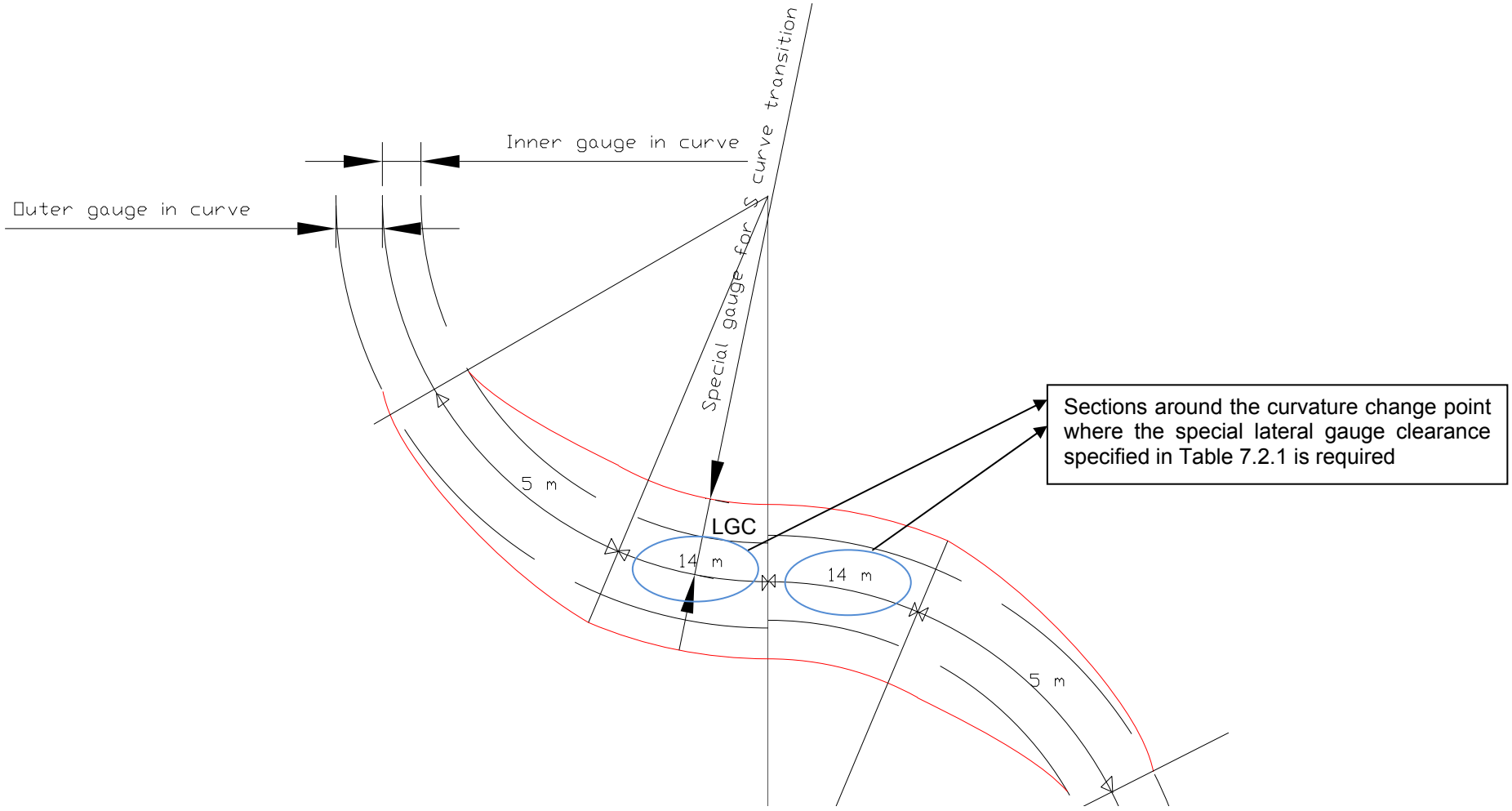


Figure 7.1.2 Splicing in S curves with no transition

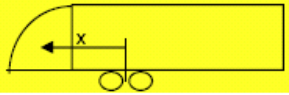
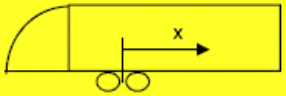
Distancia a bogie "x" (mm)	500	1000	1400	1600	1800	2060	2200	2400	2525	2800	3000	3200	3500	4000	4500	5000	5875	6000	6600	6800
Coche C Extremo cabina																				
Inscripción en curva vertical	-4	-8	-12	-14	-16	-19	-21	-23	-25	-28	-31	-34	-38	-45	-53	-61	-77	-80	-92	-96
Desgaste de ruedas no compensado	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
Descenso de suspensión	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43
Cruce de dinámicos	-20	-24	-26	-28	-29	-31	-32	-33	-34	-36	-37	-39	-41	-44	-47	-51	-57	-58	-62	-63
Tolerancias de caja	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flecha	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Total	**-157**	**-164**	**-170**	**-172**	**-175**	**-178**	**-180**	**-182**	**-184**	**-188**	**-191**	**-194**	**-199**	**-209**	**-220**	**-230**	**-251**	**-253**	**-268**	**-273**
Coche C Extremo trasero																				
Inscripción en curva vertical	-6	-6	-8	-9	-10	-11	-11	-12	-12	-13	-13	-13	-13	-13	-13	-12	-8	-8	-6	-6
Desgaste de ruedas no compensado	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
Descenso de suspensión	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43
Cruce de dinámicos	-18	-19	-20	-20	-21	-21	-22	-22	-22	-23	-23	-24	-24	-25	-26	-28	-29	-30	-31	-31
Tolerancias de caja	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flecha	-0,5	-1	-1,5	-2	-2,5	-3	-3,5	-4	-4,5	-5	-5,5	-6	-6,5	-7	-7,5	-8	-8,5	-9	-9,5	-10
Total	**-158**	**-159**	**-163**	**-164**	**-166**	**-168**	**-169**	**-171**	**-172**	**-173**	**-175**	**-176**	**-177**	**-179**	**-180**	**-180**	**-179**	**-179**	**-180**	**-180**

Table 6.4.1 C Car. Minimum nominal vertical clearance of lower parts of the vehicle to the running surface

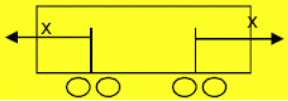
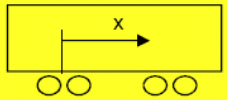
Coche N Extremos																				
Inscripción en curva vertical	-3	-6	-9	-11	-12	-15	-16	-18	-19	-22	-24	-27	-30	-36	-43	-50	-64	-67	-77	-81
Desgaste de ruedas no compensado	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
Descenso de suspensión	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43
Cruce de dinámicos	-20	-24	-26	-28	-29	-31	-32	-33	-34	-36	-37	-38	-40	-44	-47	-50	-56	-57	-61	-62
Tolerancias de caja	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flecha	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Total	**-156**	**-162**	**-166**	**-168**	**-170**	**-173**	**-175**	**-177**	**-178**	**-182**	**-184**	**-187**	**-191**	**-200**	**-209**	**-219**	**-238**	**-240**	**-253**	**-257**
Coche N Parte Central																				
Inscripción en curva vertical	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7	-7
Desgaste de ruedas no compensado	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
Descenso de suspensión	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43	-43
Cruce de dinámicos	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17
Tolerancias de caja	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flecha	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
Total	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**	**-167**

Table 6.4.2 N Car. Minimum nominal vertical clearance of lower parts of the vehicle to the running surface