1. This standard establishes the allocation and designation of the ratios and gauges of model railroads.

2. The **relative size** of railroad models is expressed by the term "**scale**." Each scale ratio is given a "name" which consists of one or more letters or a Roman numeral (table 1).

   The distance between the rails of a railroad (model or prototype) is indicated by the term "**gauge**." In the model world, the various prototype track gauges are grouped in four subsets. The scale without auxiliary letter denotes all "standard" track gauges 1250 mm and larger. Models of narrow-gauge railroads having prototype gauges less than 1250 mm are designated by one of three auxiliary letters m, e, or i appended to the scale. For this combined scale and gauge designation the term "gauge" is used.

   Examples:
   Modeling a standard gauge railroad at 1 : 87 ratio:
   H0 Scale, H0 (Standard) Gauge (Track Gauge 16.5 mm)
   Modeling a meter-gauge railroad at 1 : 45 ratio:
   0 Scale, 0m (Meter) Gauge (Track Gauge 22.5 mm)

Table 1

Ratio [1)2)]	Scale Meter in mm	Scale	Corresponding model gauge for given prototype gauge			
			1250 to 1700	850 to < 1250	650 to < 850	400 to < 650
1:220	4,5	Z	6,5	-	-	-
1:160	6,3	N	9	6,5	-	-
1:120	8,3	TT	12	9	6,5	-
1:87	11,5	H0	16,5	12	9	6,5
1:64	15,6	S	22,5	16,5	12	9
1:45 [3)]	22,2	0	32	22,5	16,5	12
1:32	31,3	I	45	32	22,5	16,5
1:22,5	44,4	II	64	45	32	22,5
1:16	62,5	III	89	64	45	32
1:11	90,9	IV	127	89	64	45
1:8	125	V	184	127	89	64
1:5,5	181,8	VI	260	184	127	89
Auxiliary letter to be appended to the scale:			**-**	**m**	**e**	**i**

Notes:
1) Individual functional components can deviate from established standards which, in turn, may be outside of tolerance values specified in applicable datasheets..
2) For broad-gauge (prototype track gauge greater than 1435 mm), scale can be computed starting with the track gauge (prototype compared to model). This can be particularly useful for scales greater than scale I.
3) In some countries the ratio 1 : 43,5 is used. In such case, a scale meter equals 23,0 mm.

3. Previously, the track gauges specified in table 1 corresponded to the following:

mm	32	45	64	89	127	184	260
Inches	1 ¼	1 ¾	2 ½	3 ½	5	7 ¼	10 ¼

4. Besides the track gauges listed in Table 1, large scale exhibition models of standard gauge railroad vehicles are often built to the gauges 72 mm and 144 mm (being respectively 1:20 and 1:10 ratio).

5. The model ratios specified in table 1 differ somewhat from those used in earlier years. Also, it was sometimes the practice to measure track gauge as the distance between the center (electrical pick-up) rail and the outer (running) rail.

   Prior to 1950, H0 scale and 00 scale were indistinguishable. Today, 00 scale is largely confined to Great Britain and indicates 1:76 ratio models running on 16.5 mm gauge track.

   Previously, Gauge II indicated 1:27 ratio models and 51 mm gauge track; this ratio and gauge is no longer common.

6. In Anglo-Saxon countries, the ratio is often expressed in terms of "mm per foot."

For example, the ratio indicated by the terminology

3,5 mm scale is 1:87,
4 mm scale is 1:76, and
7 mm scale is 1:43,5.

7. To convert measurements from one scale into another determine the multiplicative factor by dividing the design ratio by the desired scale ratio. The example below shows the conversion factor from 0 to H0 scale.

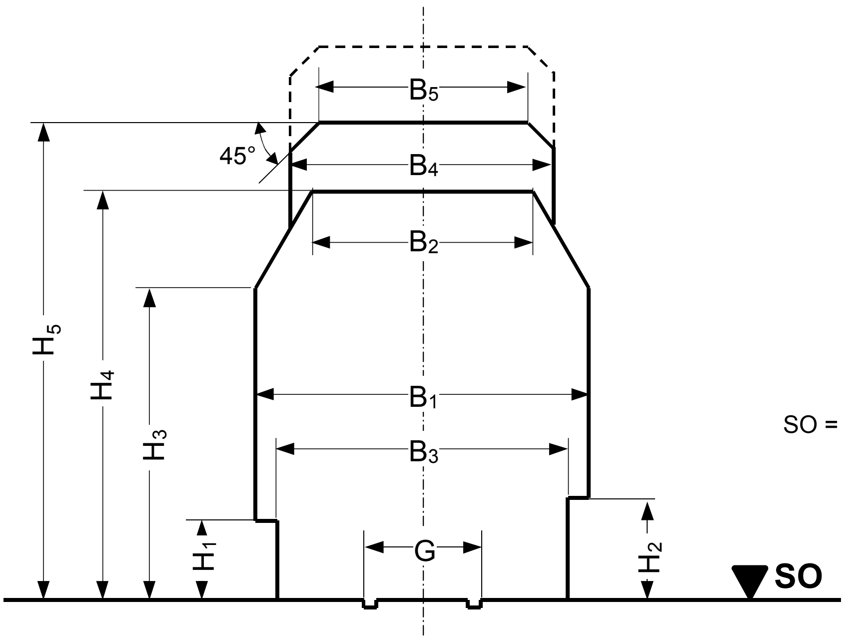
Example: Drawing M 1:45
Model M 1:87

$$\text{Multiplicative factor} = \frac{45}{87} = 0{,}517 \text{ (or 51.7\%)}$$

MOROP	Norms of European Model Railroads **Track Clearance Diagram** **for Straight Track**	**NEM** **102** 1 Page

Binding Norm **Measurements in mm** **1979 Edition**

This standard describes the proper placement of standard and wide gauge track [1], defining the clearance area into which no fixed object shall project [2], thereby allowing rail vehicles conforming to NEM 301 to pass without obstruction.



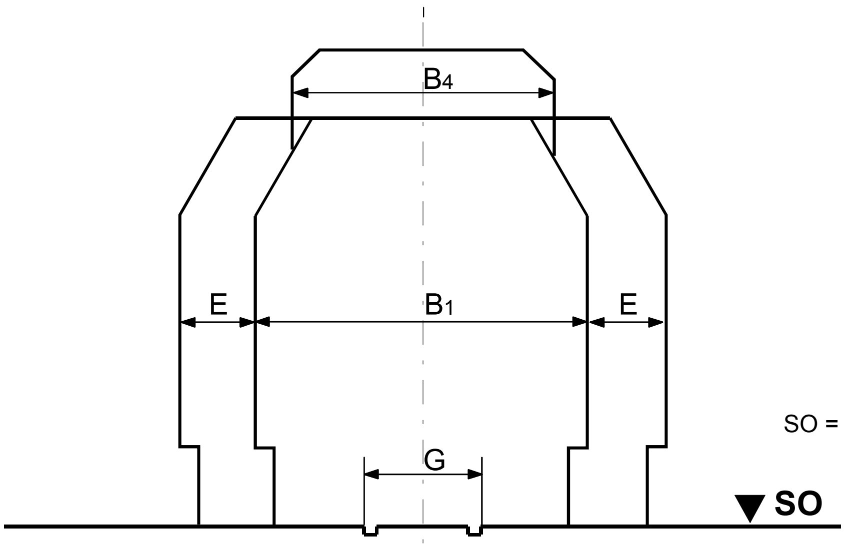
SO = Rail Head

Table of Measurements

Scale	G	B_1	B_2	B_3	H_1	H_2 [3]	H_3	H_4	with overhead wire [4]		
									B_4	B_5	H_5 [5]
Z	6,5	20	14	18	4	6	18	24	16	13	27
N	9,0	27	18	25	6	8	25	33	22	18	37
TT	12,0	36	24	32	8	10	33	43	28	22	48
H0	16,5	48	32	42	11	14	45	59	38	30	65
S	22,5	66	44	57	15	19	60	78	50	38	87
0	32,0	94	63	82	21	27	85	109	68	52	120
I	45,0	130	87	114	30	38	118	150	93	71	165

1 For wide gauge vehicles conforming to NEM 010, the standard track width ***G*** is used as a basis.
2 Functional elements and side rails for current supply ("third rail" systems) may project into the lower part.
3 Only for tracks adjacent to freight platforms.
4 For overhead wire (catenary) standards, see NEM 201 and 202.
5 Measurement H_5 is the standard clearance with the overhead contact wire in the standard position. The contact wire, its mounting, and the pantograph may project into the area above this box..

Within the range of curved track radii, the track clearance is to be extended by the dimension ***E*** beyond the specifications of NEM 102 as a function of the curve radius and the vehicles that will be used. Pantograph clearance remains unchanged from NEM 102.



The vehicle's lateral overhang on the curve is the determining factor. Bogie equipped vehicles have the greatest overhang. The scale length of the vehicle combined with the radius of the curve determine the dimension of ***E***.

Bogie-equipped vehicles are therefore divided into three groups:

Vehicle Group A
length up to 20,0 m and wheelbase (bogie-pivot to bogie-pivot) up to 14,0 m

Vehicle Group B
length up to 24,2 m and wheelbase up to 17,2 m

Vehicle Group C
length up to 27,2 m and wheelbase up to 19,5 m

Note:

Shortened models of Vehicle Group C (e.g. H0 scale but built to 1:100 length) may be accommodated within Vehicle Group B.

The **vehicle length limits** correspond to the following model lengths (by scale):

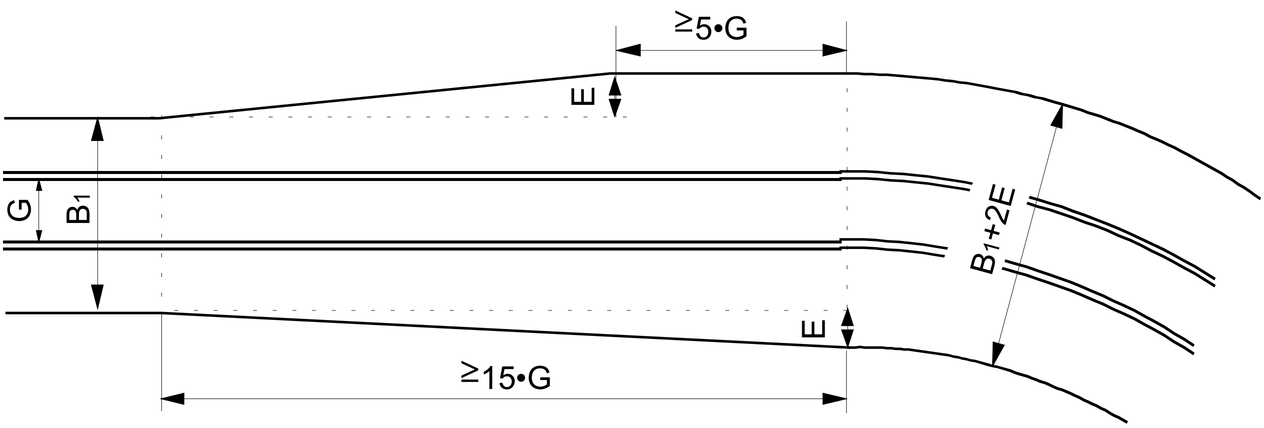
Scale	**Z**	**N**	**TT**	**H0**	**S**	**0**	**I**
Vehicle Group A	91	125	167	230	313	460	625
Vehicle Group B	110	151	202	278	378	556	756
Vehicle Group C	124	170	227	313	425	625	850

Refer to Table 2 for the dimensions of ***E***. The value ***E*** for Vehicle Group A is the minimum and should not be reduced even if bogie-equipped vehicles are not used.

Table of Measurements

Scale	Z			N			TT			H0			S			0			I		
Curve Radius	Vehicle Group																				
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
175	2	3	5	4																	
200	2	3	4	4	6																
225	2	2	4	3	5	7															
250	1	2	3	3	5	6	6														
275	1	2	3	3	4	6	5	8													
300	1	2	3	2	4	5	5	7	10												
325	1	1	2	2	3	5	4	6	9	9											
350	1	1	2	2	3	4	4	6	8	8	12										
400	0	1	2	1	2	4	3	5	7	7	11	14									
450	0	1	1	1	2	3	3	4	6	6	9	12	12								
500	0	0	1	1	1	3	2	4	5	5	8	11	10	16							
550	0	0	1	0	1	2	2	3	4	4	7	10	9	14	19						
600	0	0	1	0	1	2	1	3	4	4	6	9	8	13	17	19					
700	0	0	0	0	0	2	1	2	3	3	5	7	7	11	15	16	25				
800	0	0	0	0	0	1	0	2	3	3	4	6	6	9	13	14	22	29			
900	0	0	0	0	0	1	0	1	2	2	3	5	5	8	11	12	19	25	23		
1000	0	0	0	0	0	0	0	1	2	2	3	4	4	7	9	10	17	22	20	31	
1200	0	0	0	0	0	0	0	0	1	1	2	3	3	5	7	8	14	18	16	25	34
1400	0	0	0	0	0	0	0	0	1	1	2	2	2	4	6	7	11	15	13	21	28
1600	0	0	0	0	0	0	0	0	1	0	1	2	2	3	5	6	9	13	11	18	24
1800	0	0	0	0	0	0	0	0	0	0	1	1	1	2	4	5	8	11	9	15	21
2000	0	0	0	0	0	0	0	0	0	0	0	1	1	2	3	4	7	9	7	13	18
2500	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	5	7	5	10	13
3000	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	3	5	3	7	10

Clearance shall widen beginning at a point not less than 15 times the track gauge from the beginning of the curve. In this transition area, the clearance increases linearly.



Note:
Double-track separation in the curve is to be measured in accordance with NEM 112.

1. General Information

This recommended practice serves as a construction aid for the calculation of tunnel cross-section. It is particularly useful in difficult cases, such as a tunnel on a curve or when the distance between parallel tracks is large. To avoid tunnel entrances that appear overly wide, they should be positioned on straight or slightly curved tracks where increased clearances are not needed (see NEM 103).

The interior tunnel wall should be modeled for some distance within the tunnel entrance.

The size of the tunnel cross-section will vary depending on:

- - the mode of operation (with or without catenary),
- - the curve radius,
- - the length of the rolling stock used,
- - the distance between track centerlines.

This standard conforms with the following NEM standards:

NEM 102 - Track Clearance Diagram for Straight Track,

NEM 103 - Track Clearance Diagram for Curved Track,

NEM 112 - Track Separation.

When constructing a rectangular cross-section tunnel, allow additional side clearance for safety reasons as is the practice with most modern installations. In the case of the circular cross-section tunnel this additional clearance is built in as a result of the cross-section curvature.

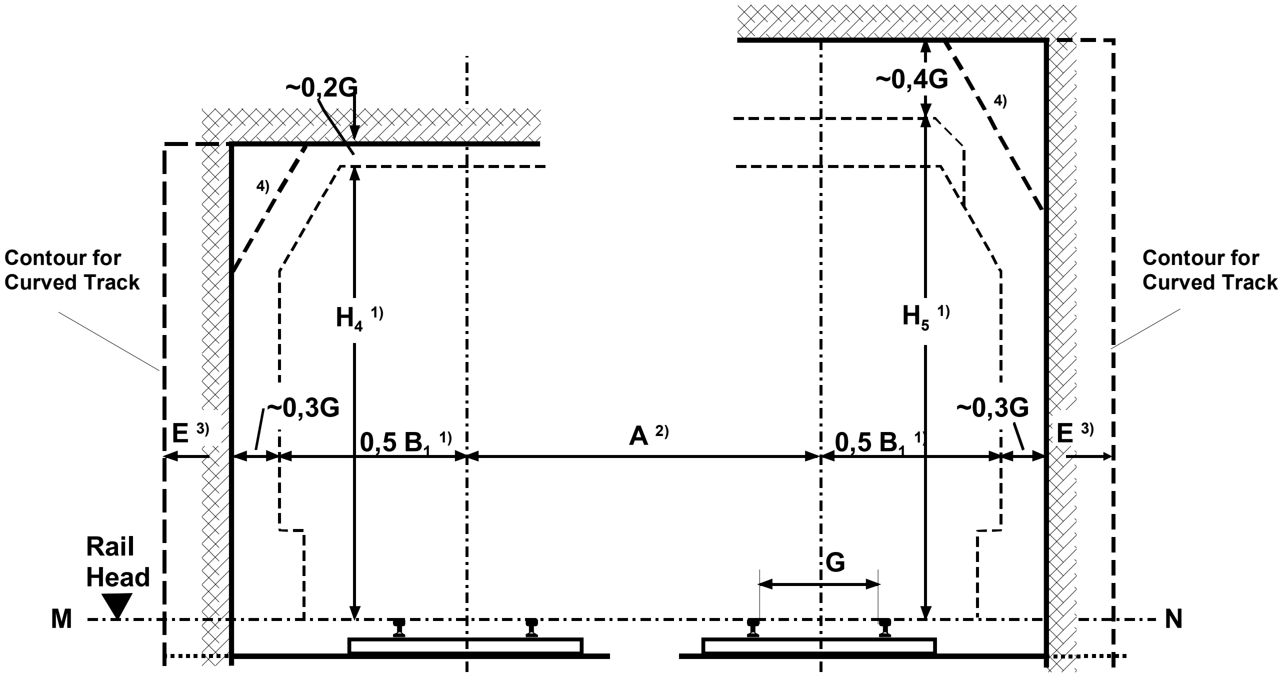
When used, it is advisable to lower the overhead line to the minimum height permitted by NEM 201.

Rectangular tunnel clearances are also applicable to bridge underpass construction.

The tunnel cross sections take into account the possible increased height brought about by NEM 114.

2. Descriptions

2.1 Tunnel with Rectangular Cross-section



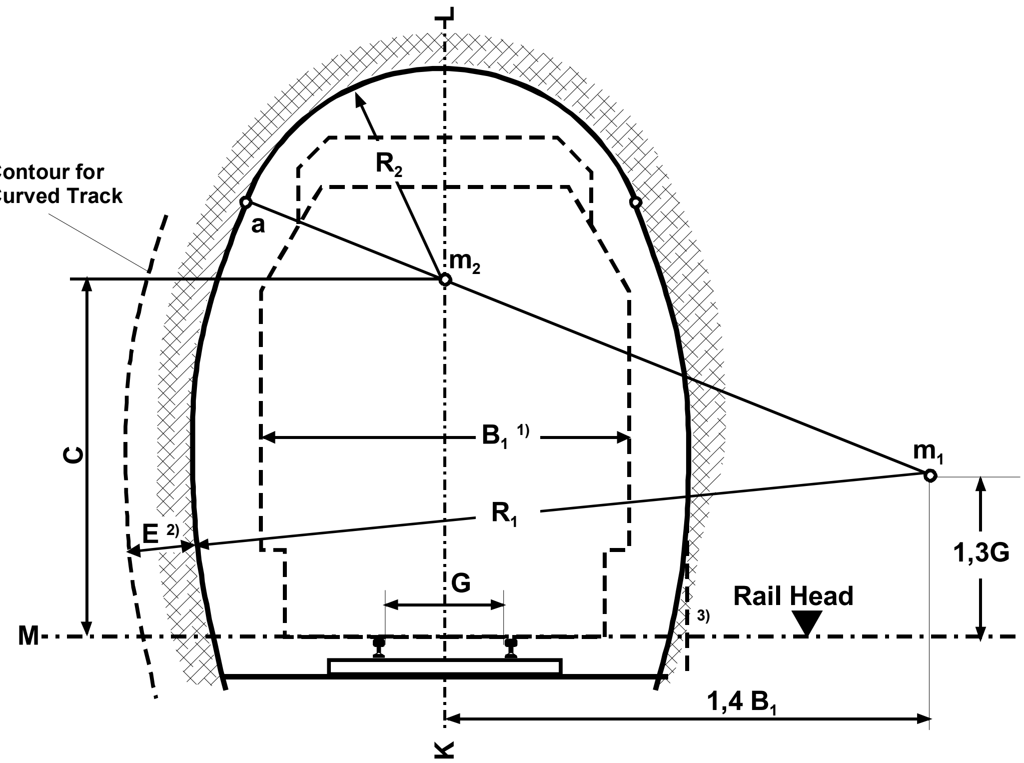
Notes: 1) Measurements B_1, H_4 and H_5 from NEM 102.
2) Track separation ***A*** from NEM 112.
3) Extension ***E*** from NEM 103.
4) The tunnel wall may be tapered in the upper corners.

Construction

1. The tunnel height is measured as shown in the design.
2. The tunnel width is governed by the width measure of B_1 (plus the track separation for multi-track tunnels in accordance with NEM 112) plus the additional side clearance 0.3*G.

   On curves, the tunnel width should be extended on both sides by the measurement E (NEM 103).

2.2 Single-track Tunnel with Circular Cross-section



Notes: 1) Measurements B_1 from NEM 102.
2) Extension ***E*** from NEM 103.
3) The lower portion of the tunnel wall may drop perpendicularly to the ground.

Construction

1. Tunnel axis ***K*** - ***L*** and horizontal over rail head (SO) ***M*** - ***N*** derived from Column A measurements in NEM 112.
2. Points m_1 and m_2 are the radius points for determining the outline of the tunnel bore.

   Table of dimensions for ***C***:

Tunnel without catenary:	***C*** = 2.2*G
Tunnel with catenary:	***C*** = 2.8*G for straight track,
	C = 2.3*G for curved track.

3. For straight track: Draw a circular arc with radius R_1 = 2*B1 around the point m_1 (this outlines the lower portion of the tunnel wall below the horizontal intersecting point ***a***).

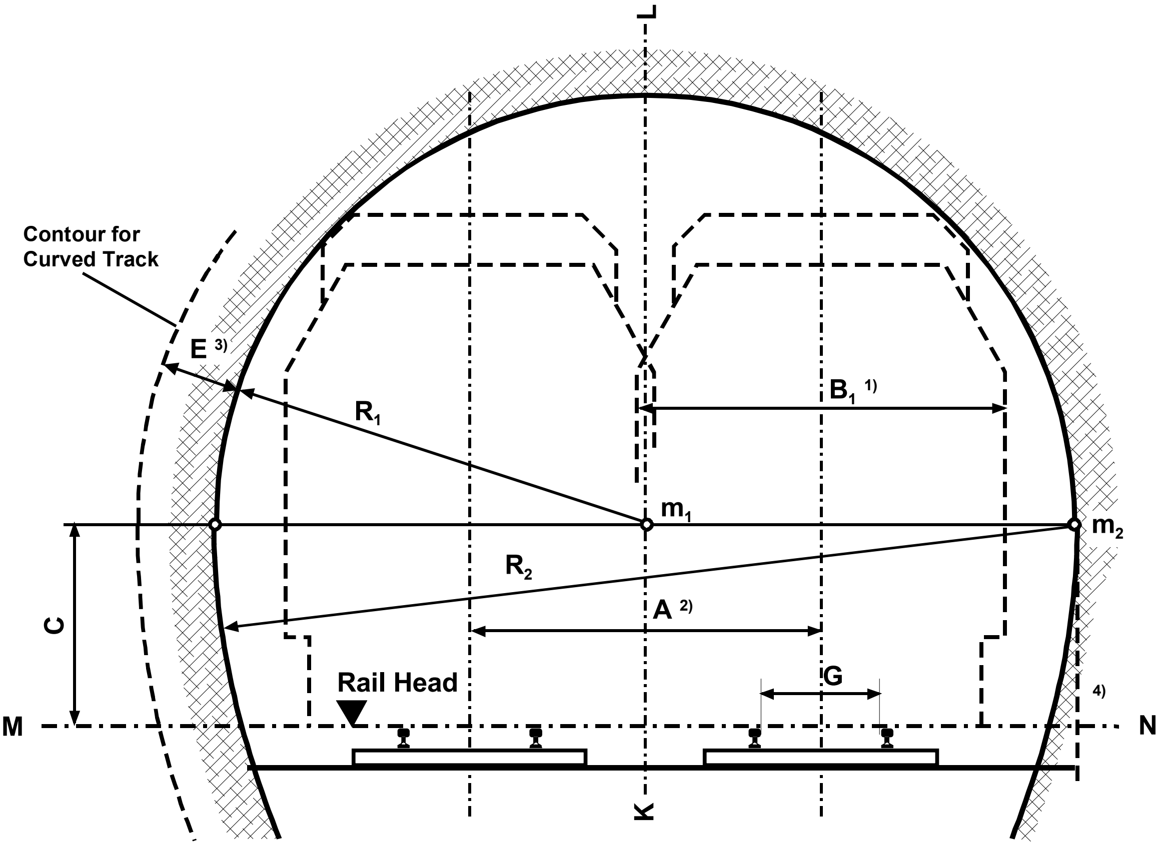
   On curves, measurement R_1 should be increased by the measurement ***E*** (from NEM 103).

   Example for H0: *Curve radius 700,* $B_1 = 48$*,* $E = 7$ *mm*

   $R_1 = 2\ B_1 + E = 96 + 7 = 103$ *mm*

4. The profile of opposite sides of the tunnel should be a mirror image of one another.
5. Draw a circular arc with radius R_2 (= distance from point m_2 to point ***a***) around the point m_2 (this outlines the upper portion of the tunnel wall above the horizontal line intersecting point ***a***).

2.3 Double-track Tunnel with Circular Cross-section



Notes:
1) Measurements B_1 from NEM 102.
4) Track separation ***A*** from NEM 112.
3) Extension ***E*** from NEM 103.
4) The lower portion of the tunnel wall may drop perpendicularly to the ground.

Construction

1. Tunnel axis ***K*** - ***L*** and horizontal over rail head (SO) ***M*** - ***N*** derived from Column A measurements in NEM 112.
2. Point m_1 on the tunnel axis and a horizontal line through m_1 determine the tunnel outline

   Table of dimensions for ***C***:

Tunnel without catenary:	***C*** = 1.5*G for straight track,
	C = 1.7*G for curved track,
Tunnel with catenary:	***C*** = 1.8*G for straight track,
	C = 1.7*G for curved track.

3. For straight track: Draw a circular arc with radius R_1 = 0.5*A + 0.6*B1 around the point m_1 (this outlines the upper portion of the tunnel wall above the horizontal line at height C (point m_1)).

   On curves, R_1 should be increased by the measurement ***E*** (from NEM 103).

   Example for HO: *Curve radius (inner track) 700, A = 52, B1= 48, E = 7 mm*
   R1 = 0.5 A + 0.6 B, + E = 26 + 29 + 7 = 62 mm

4. Draw a circular arc with radius ***R2*** = 2*R1 around point m_2 (this outlines the lower portion of the tunnel wall below the horizontal line at height C (through point m_2)).

The profile of opposite sides of the tunnel should be a mirror image of one another.

	Norms of European Model Railroads **Track Curvature**	**NEM** **111** 1 Page

Recommendation **1989 Edition**

1. Purpose

An accurate scale reduction of prototype dimensions, as is usual with the construction of railroad models, normally is not possible if rolling stock is to be used on the tracks of a model layout. In particular, the radius of model curves must be reduced significantly in order to construct an operating model railroad in the typical space available.

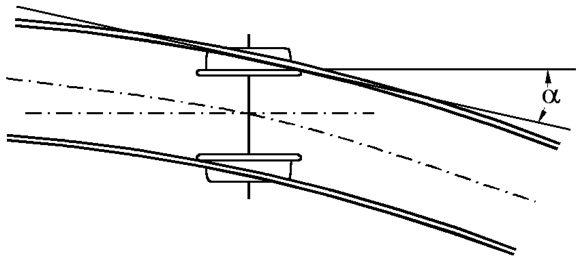
A limit to the over-reduction of curve radii is necessary, as much for visual realism as for the mechanical exigencies of smooth operation of the rolling stock. On the other hand, the important kinetic influence of speed, so important in prototype operations in curves, is insignificant in modelling, especially when incorporating easements in accordance with NEM 113.

The solutions described below only provide a solution for the mechanical aspects of reliably negotiating curves, and do not address the largely subjective judgements of presenting a realistic appearance.

2. Relationship between Rolling Stock and Curve Radius

2.1 Rolling Stock with Fixed-Axles

For rolling stock where the end axles cannot turn radially, the angle of approach α of the wheel against the rail is decisive (see illustration). This angle may not exceed 12º. To minimize friction resistance and to diminish the likelihood of derailments, it is recommended not to exceed the minimum values recommended in the table.



2.2 Rolling stock with trucks

For rolling stock with trucks, it is generally the method of attachment and the lateral displacement of the couplers that limits the angle of rotation of the trucks. Maintaining the recommended minimum radius in accordance with the table ensures that rolling stock with trucks will also enjoy satisfactory performance.

3. Minimum Radius

Using the preceding information, the following radii result as a function of track use and vehicle group (from NEM 103), multiplied by G (= track gauge from NEM 310):

	Standard - Vehicle Group			**Narrow Gauge**
	A	**B**	**C**	
Minimum allowable radius	22 G	25 G	30 G	15 G
Recommended minimum radius				
- for branch lines in stations	25 G	30 G	35 G	20 G
- for the main track on branch lines	30 G	35 G	40 G	25 G
- for the main track on main lines	35 G	40 G	45 G	30 G

Track Spacing

Recommendation | **Measurements in mm** | **1985 Edition**

1. This Recommendaton serves as an aid:
   - to determine the minimum track distance on a given curve as a function of the length of rail vehicles in service,
   - to determine the maximum vehicle length as a function of existing curvature and track spacing.
2. The separation between **straight** standard gauge track - centerline to centerline - should be equal to or greater than the values listed in the following table.

	Z	N	TT	H0	S	0	I
On Open Track	19	25	34	46	63	89	125
In Stations/Yards	21	28	38	52	71	103	141

3. In **Curves** the track separation must be increased. For each radius, use the value from the following table that corresponds to the Vehicle Group A, B, or C as defined in NEM 103. The track separation specified for Vehicle Group A is the minimum and should not be reduced even if bogie-equipped vehicles are not used. The specified track separation must be present wherever straight track transitions into a curve.

Table of Track Center-line Distances

Scale	Z			N			TT			H0			S			0			I		
Radius of the **inner** Curve	Vehicle Group																				
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
175	21	23	25	31																	
200	20	22	24	30	33																
225	19	21	23	29	32	35															
250	19	20	22	28	31	33	40														
275	19	20	21	27	30	32	39	44													
300	19	19	21	27	29	31	38	42	46												
325	19	19	20	26	28	30	37	41	45	57											
350	19	19	20	26	28	29	36	40	43	55	62										
400	19	19	19	25	27	28	35	38	41	53	59	64									
450	19	19	19	25	26	27	34	37	40	51	57	61	76								
500	19	19	19	25	25	26	34	36	38	50	55	59	74	83							
550	19	19	19	25	25	26	34	35	37	49	53	57	72	80	88						
600	19	19	19	25	25	26	34	34	36	48	52	55	70	78	84	116					
700	19	19	19	25	25	25	34	34	35	46	50	52	67	74	80	110	125				
800	19	19	19	25	25	25	34	34	34	46	48	50	65	71	76	106	119	130			
900	19	19	19	25	25	25	34	34	34	46	47	48	64	68	73	103	114	123	154		
1000	19	19	19	25	25	25	34	34	34	46	46	47	63	66	70	100	110	118	149	166	
1200	19	19	19	25	25	25	34	34	34	46	46	46	63	64	67	96	104	111	142	155	169
1400	19	19	19	25	25	25	34	34	34	46	46	46	63	63	64	93	99	105	136	147	159
1600	19	19	19	25	25	25	34	34	34	46	46	46	63	63	63	91	96	101	132	141	151
1800	19	19	19	25	25	25	34	34	34	46	46	46	63	63	63	89	93	98	129	137	145
2000	19	19	19	25	25	25	34	34	34	46	46	46	63	63	63	89	91	95	126	133	140
2500	19	19	19	25	25	25	34	34	34	46	46	46	63	63	63	89	89	90	125	126	132
3000	19	19	19	25	25	25	34	34	34	46	46	46	63	63	63	89	89	89	125	125	126

1. Purpose and Concept

The passage of rolling stock over the sudden transition between a radial curve and straight track or a reverse curve results in:

- lurching attributable to the sudden change of direction or
- an opposing push to adjoining cars.

In order to minimize these distracting occurrences it is recommended to lay easements both on the open road and in stations.

An easement is a curve with a constantly varying radius which reduces from infinity on the straight down to the constant radius of the curve. Easements are especially useful on tight curves while they may be omitted on curves > 60 G [1].

2. Description

Each half of the easement replaces a corresponding length of the straight and of the curve.

To connect the easement to the straight and the curve it is necessary to:

- either displace the straight by the value ***f*** (Fig 1);
- or diminish the radius of the curve by the value ***f*** (Fig 2)

Fig. 1

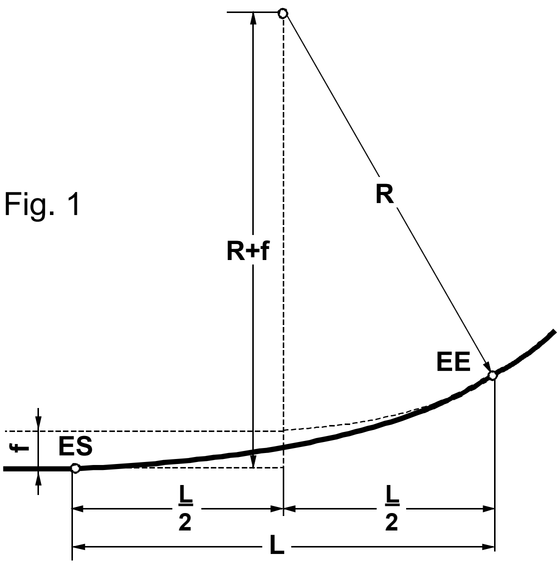
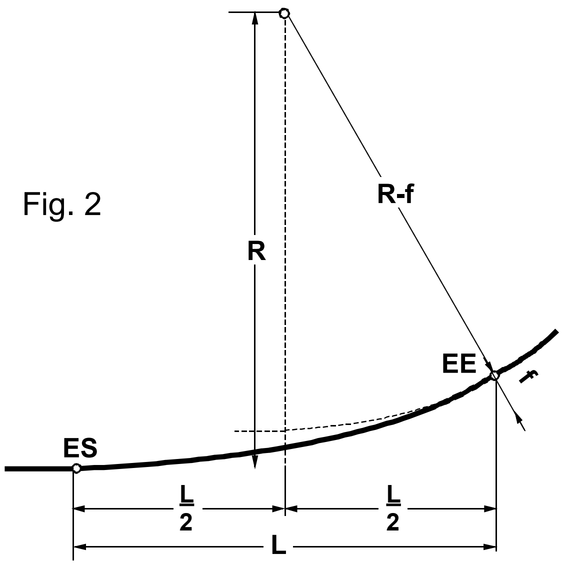


Fig. 2



Reverse curves with easements can eliminate a connecting straight track.

For curve superelevation, NEM 114 should be followed.

[1] G = track gauge

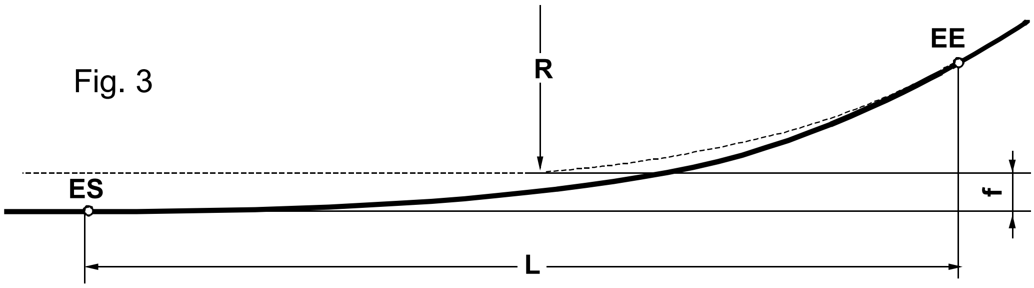
3. Dimensions

The values in Figure 3 for the easement key dimensions are as follows:

L = Length of the easement

f = Displacement of the straight and reduction of the radius.

Fig. 3



In order to obtain the proper combination of values ***L*** and ***f*** that complement a curve with a given radius ***R***, two methods are possible:

3.1 Use of Recommended Values

According to this method, for any gauge a constant value ***f*** can be obtained from Table 1:

Table 1

Gauge G	6,5	9	12	16,5	22,5	32	45
Value **f**	3	4	6	9	13	18	25

The easement may be computed using the formula:

$$L = \sqrt{f \bullet 24\,R}$$

or may be taken from Table 2 for the selected radii::

Table 2

G \ R	150	175	200	250	300	350	400	500	600	700	800	1000	1200	1400	1600	2000
6,5	100	110	120	135	145	160										
9		130	140	155	170	185	195	220								
12				190	210	225	240	270	295	320						
16,5						275	295	330	360	390	415	465				
22,5								395	430	465	500	560	610	660		
32										550	590	655	720	780	830	980
45												775	850	915	980	1095

3.2 Pre-Selection of Easement Length

The Easement length **L** may be selected independently of the radius **R** as long as the following conditions are met:

- ***L*** must be smaller than ***R***, preferably < 0.8 R;
- ***L*** must be at least the length of the longest piece of equipment in use on the layout
- The value ***f*** varies as a function of the relationship ***L / R*** according to Table 3.

Table 3

L/R	<0,6	0,6 – 0,8	>0,8 (undesirable)
f	$\frac{L^2}{24\,R}$	$\frac{L^2}{23\,R}$	$\frac{L^2}{22\,R}$

4. Design and Construction [2]

After the values **L** and **f** are determined, the easement endpoints **ES** and **EE** may be determined by:

- extending the line of the intended straight track and drawing a line parallel to the straight track with the stand-off of $y_E = 4f$ which intersects the circle. This intersection is the endpoint **EE** of the easement;
- the startpoint **ES** is determined by tracing the length ***L*** from the perpendicular of the intersection at **EE** back along the extension of the straight track.

Either of two methods may be used to trace the easement.

4.1 Construction using intermediate points

The intermediate points y_i may be obtained as fractions of the end ordinate y_E according to Table 4.

Fig. 4

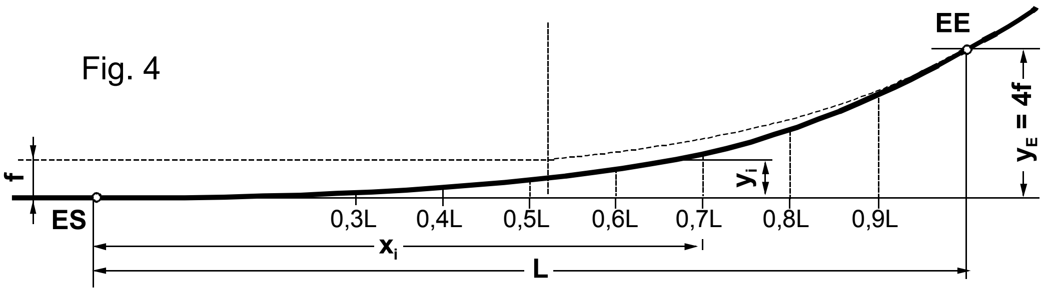


Table 4

x_i	0	0,3 L	0,4 L	0,5 L	0,6 L	0,7 L	0,8 L	0,9 L	1,0 L
y_i	0	0,03 y_E	0,06 y_E	0,125 y_E = 0,5 f	0,21 y_E	0,33 y_E	0,49 y_E	0,72 y_E	1,0 y_E = 4 f

Examples: Given: Gauge 16.5 and curve radius R = 600

<u>Method 3.1</u>		<u>Method 3.2</u>	
Value ***f*** per Table 1	**f** = 9	Selected easement length:	L = 0.7 R = 420
Easement length per Table 2	L = 360	Value ***f*** per Table 3	$L^2 / 23R \approx 13$
End points:	$y_E = 4f = 36$	End points:	$y_E = 4f = 52$

Intermediate points: At $x_i = 0.7$ L , $y_i = 0.33\ y_E$ (Table 4), thus:

0.33 * 36 ≈ 12 etc. | 0.33 * 52 ≈ 17 etc.

[2] Since the model railroader is generally limited to a few selected curve radii, it is recommended to fabricate templates for the necessary easements according to the above described methods.

4.2 Use of an "elastic staff"

The path of the easement can be marked using an elastic staff according to Fig. 5. The preferred staff would be a perfectly elastic, square metal ruler with the approximate measurements of the rail profile. One end of the staff should be reinforced by soldering a plate to it, which can be used to affix the staff to the material beneath.

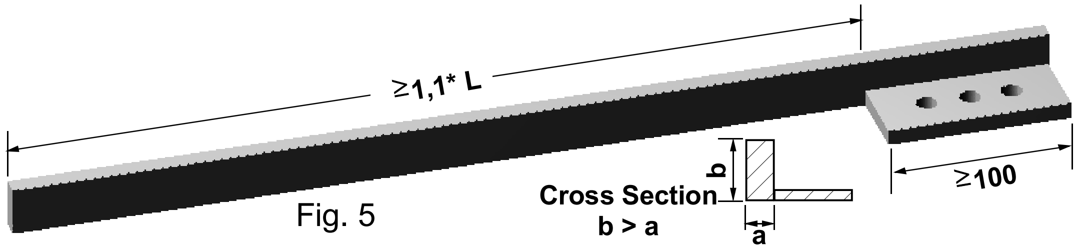
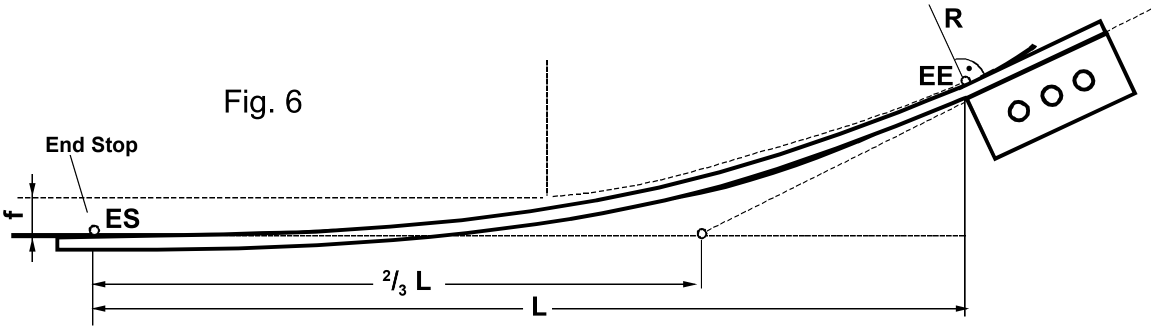


Fig. 5

At the point **EE**, the staff should be placed tangentially to the curve radius and the plate should be firmly affixed to the material underneath. By bending the staff until it reaches the point **ES** it will trace the line of the easement and serve as a template to mark it (Fig. 6).

If the radius center point is unknown or inaccessible, the tangent may be determined by finding the point K.

Fig. 6



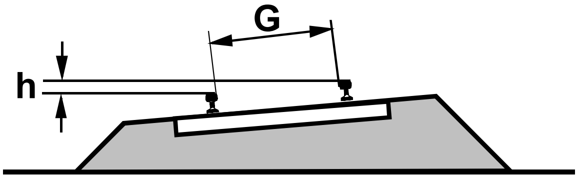
Superelevation in Curves

Recommendation | Measurements in mm | 1983 Edition

1. Purpose and Terminology

For prototype trains, banking is necessary to ensure safety in curves, in which the lateral acceleration created by the curve is compensated in total or in part by the superelevation of the outer rail by the value ***h*** above the level of the inner rail (fig. 1).

Fig. 1



In model railroad operation, superelevation is not required for reasons of physics and actually increases the likelihood of rolling stock toppling from the track. Rather, its use is for strictly aesthetic reasons and should be kept within the maximum (G/15) specified by the following table:

G	6,5	9	12	16,5	22,5	32	45
h_{max}	0,4	0,6	0,8	1	1,5	2	3

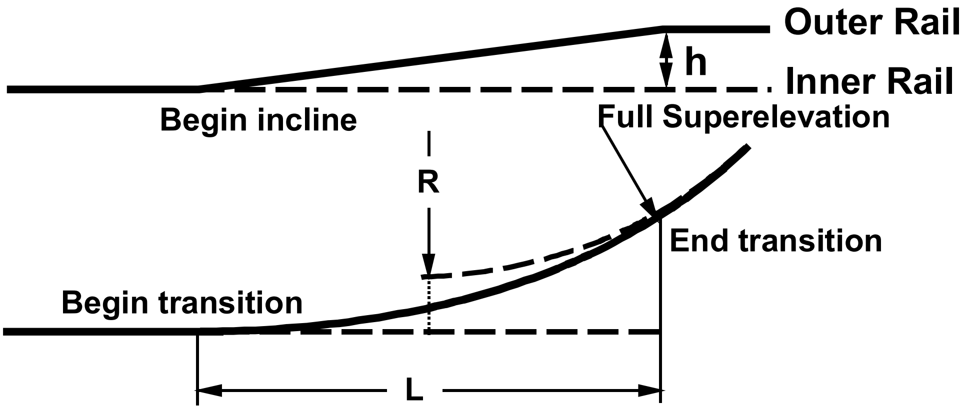
2. Description

In the curve, the interior rail maintains the level of the straight track, while the outer rail is superelevated by the value ***h*** above the inner rail.

Banked curves should also be laid in conjunction with easements (NEM 113). The length of the ramp superelevating the outer rail should equal the length of the easement.

The banking superelevation shall be applied to the easement in a linear fashion over the length of the easement (Fig. 2).

Fig. 2



MOROP	Norms of European Model Railroads **Rail Profiles and Connectors**	**NEM** **120** 1 Page

Recommendation | **Measurements in mm** | **1993 Edition**

1. Rail Profile

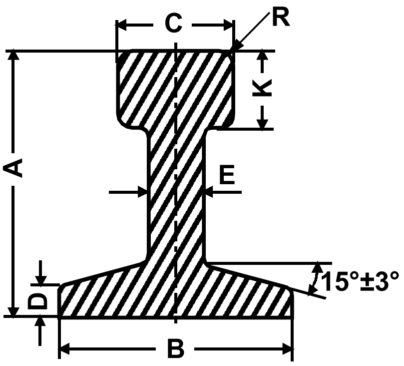


Table of Measurements

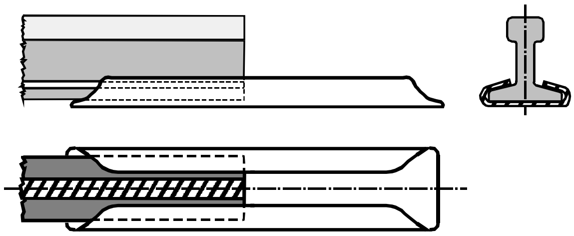
Nomenclature 1)	A 1)	B 2)	C 2)	D_{max}	E 2)	K 2)	R_{max}	Code 3)	Best used for Scale: 7) 4)	5)	6)
Profile 50	$5{,}0^{+0,3}$	4,5	2,3	0,6	1,2	1,3	0,4	208	I		
Profile 42	$4{,}2^{+0,3}$	3,8	1,9	0,5	1,0	1,1	0,35	172		I	Im/e
Profile 35	$3{,}5^{+0,3}$	3,2	1,6	0,4	0,8	0,9	0,3	148	0	0m	Ie
Profile 30	$3{,}0^{+0,2}$	2,7	1,3	0,35	0,7	0,8	0,25	125		0	0m/e, Ii
Profile 25	$2{,}5^{+0,2}$	2,2	1,1	0,3	0,6	0,6	0,2	100	S; H0	Sm	0e
Profile 20	$2{,}0^{+0,2}$	1,8	0,9	0,25	0,5	0,55	0,2	83	H0; TT	S, H0m	Sm/e, 0i
Profile 18	$1{,}8^{+0,1}$	1,6	0,8	0,25	0,4	0,5	0,15	70	TT, N	H0, TTm	H0m/e, Si
Profile 14	$1{,}4^{+0,1}$	1,3	0,7	0,2	0,4	0,4	0,15	55	N, Z	TT, N, Nm	TTm/e, H0i
Profile 10	$1{,}0^{+0,1}$	0,9	0,5	0,2	0,3	0,35	0,1	40	Z	Z	Nm

Notes

1) The Profile shall be identified by a number that represents the height of the dimension A in mm multiplied times ten.
2) Recommended reference dimension.
3) Comparable to the NMRA profile code in accordance with RP 15.1.
4) For modeling modern mainlines.
5) For modeling mainlines from earlier eras and for branch lines and narrow gauge lines from Eras IV and V.
6) For modeling other narrow gauge lines.
7) If several profiles are listed for a single scale, the smaller profile should be used for new construction. For securing rails the dimension H from NEM 310 should be observed!

2. Rail Connectors

Rail connectors may take various forms; the figure shows a representative sample style.



The connectors must provide a secure mechanical connection and guarantee a proper electrical connection while complying with all safety requirements. The length of the connectors should be about four times the height of the rail. Fixed connectors should be attached to the left rail (as viewed from the middle of the track section).

1. Purpose

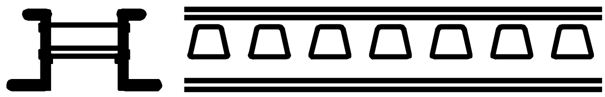
This standard specifies the dimensions necessary to ensure proper function of cog traction. ISO standards for involute teeth are hereby taken into account for the purpose of using typically available tools.

2. Prototype Systems

2.1 Riggenbach System

Ladder-shaped rack with teeth welded or riveted in between.

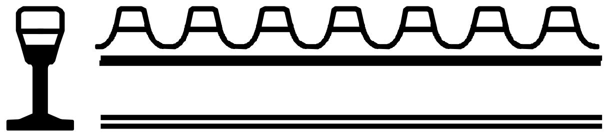
Pitch = 100 mm



2.2 Strub System

Machined rack with wedge-shaped teeth.

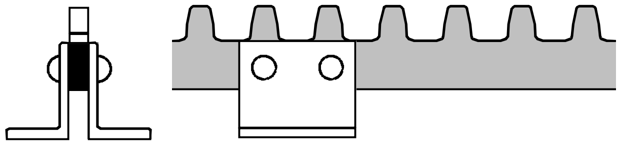
Pitch = 100 mm.



2.3 Von Roll System

Single blade gear rack up to 120 mm thick.

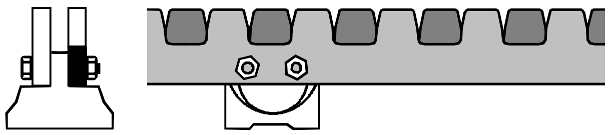
Pitch = 100 mm.



2.4 Abt System

Double blade gear rack with blades up to 35 mm thick.

Pitch = 120 mm. Each blade is staggered approx. 60 mm from the other.



2.5 Other Systems

The **Klose** design does not differ significantly from the Riggenbach system.

The **Marsch** (ladder-shaped rack with round gear bars) and **Locher** systems (horizontally oriented double-blade gear rack with 85 mm pitch) are outside the purview of this standard.

3. Height of the Gear Racks

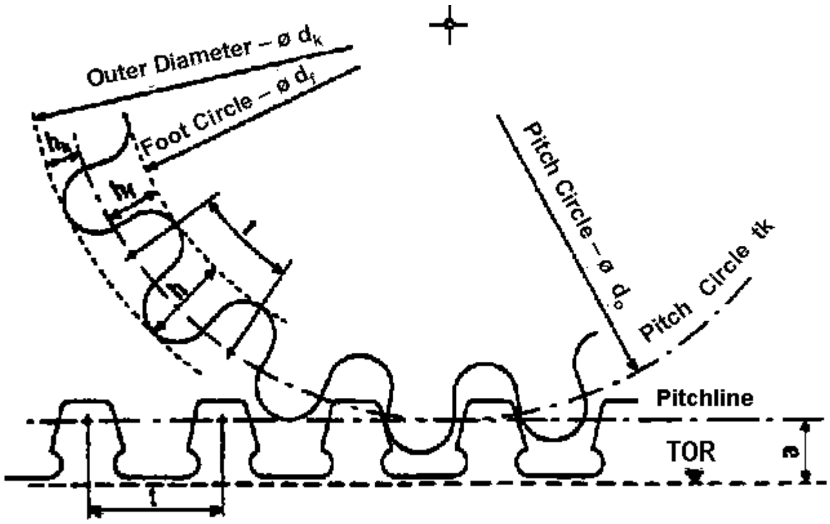
In mixed adhesion/cog traction, in order to navigate points the outer diameter of the cog wheel (the tip of the gear teeth) must lie above the top of the rail (TOR). The height may vary, even among prototype railroads using the same system, so that compatibility of traction equipment in many cases is not possible.

In pure cog railroad systems, it is possible to reduce the height of the gear rack, although this requires a more complicated points design.

Apart from the potential difference in height of the gear rack, the Riggenbach, Strub, and von Roll systems are otherwise basically compatible.

4. Terms

Pitch Circle	tk	Theoretical rolling radius between two cog wheels or between a cog wheel and a gear rack.
Pitch	t	Distance between two adjacent gear spaces on the at their respective pitch circles or at the pitch line
Module	m	$= {}^{t}/_{\pi}$ (π = 3.1416)
Crown Height	h_k	$= m$
Foot Height	h_f	$= 1.166 \cdot m$
Tooth Height	h	$= h_f + h_k = 2.166 \cdot m$
Number of Teeth	z	
Reference Diameter	d_0	$= z \cdot m$
Outside Diameter	d_k	$= (z + 2) \cdot m$
Distance of Pitch Line over TOR	a	
Width of Teeth on the Cogwheel	b	



5. Reproduction in Miniature

The gear racks are referred to by the prototype system, along with the pitch measurement:

- t 100 Riggenbach / Strub / von Roll
- t 120 Abt

In contrast with the prototype, for the sake of interchangeability the distance between the pitch line and the TOR is fixed.

Table of Measurements

Gauge	m		a	b
	t 100	t 120		max.
H0	0,4	0,4	0,6	0,9
S	0,5	0,6	0,75	1,2
0	0,7	0,8	1,1	1,7
I	1	1,25	1,5	2,5
II	1,5	1,75	2,15	3,5
III	2	2,5	3	5
IV	3	3,5	4,35	7,25
V	4	5	6	10
VI	6	7	8,75	14,5

Note for N and TT Scale

For reliable operation of a cog railroad, module ≥ 0.4 is necessary; a more or less true scale cog rack is not achievable. If necessary, the values for HO scale may be used.

	Norms of European Model Railroads	NEM
MOROP	**Roadbed Profile for Standard Gauge**	**122** 1 Page

Recommendation **Measurements in mm** **1989 Edition**

1. This recommended practice prescribes the ideal cross section for roadbed construction (including subgrade) so that the completed model is representative of standard railroad practice for standard gauge lines.

2. This figure shows the ideal cross section of single straight track installation. In special geological conditions, e.g. rock slopes, retaining walls, etc., deviation in the cross section of the subroadbed profile is allowed.

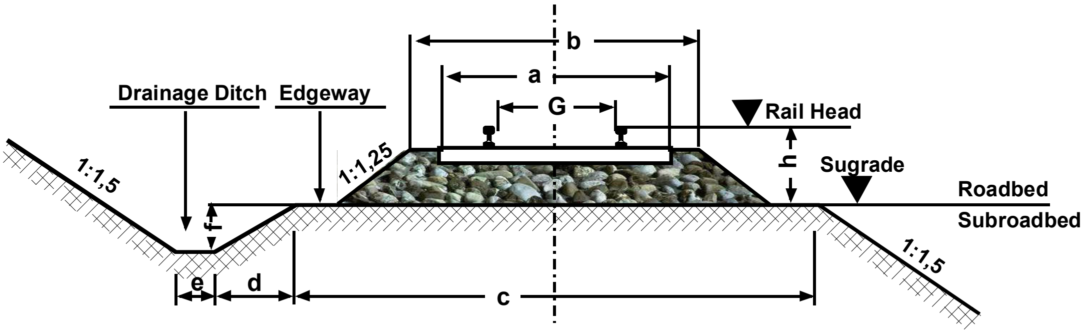


Table of Measurements

Scale	Gauge G	a [1)]	b	c	d	e	f	h
Z	6,5	12	16	28	3	2	2	4
N	9	16	22	38	5	3	3	6
TT	12	22	28	50	7	4	5	8
H0	16,5	30	38	70	9	5	6	10
S	22,5	40	52	94	13	7	9	12
0	32	58	76	134	18	9	12	16
I	45	82	106	188	26	12	17	22

Note 1): Applies only to track with wooden sleepers.

3. In multiple track situations (see NEM 112), a continuous roadbed may be installed. When adjacent tracks are within a station's boundaries pathways may be placed between tracks to provide safe footing for railroad personnel.

4. Concerning superelevation in curves, see NEM 114.

5. Signals, catenary masts, and the like may occupy the edgeway, however clearances as detailed in NEM 102 and NEM 103 must be maintained.

Contact Wire Position

Binding Norm **Measurements in mm** **1999 Edition**

1. Purpose

This standard establishes the position of the contact wire for overhead line operation of models of European normal- and broad-gauge railroads and is in accordance with NEM 202

2. Preface

Among European railroads there exist different measurements for the usable pantograph contact width and overall pantograph shoe width, and to a lesser extent, for the contact wire height. Given the reduced curve radii employed in model railroad construction, the usable pantograph contact width will determine the required distance between the supporting masts (e.g. mast spacing).

Therefore, two contact wire applications are allowed:

- **Wide** System: For operation with wide-shoe pantographs (e.g., modeling the DB, ÖBB, and others that employ 300-400 mm of lateral deviation (zig-zag) in the overhead line),

- **Narrow** System: For operation with narrow-shoe pantographs (e.g., modeling the SBB, FS, SNCF, and others that employ 200-300 mm of lateral deviation in the overhead line).

3. Contact wire position

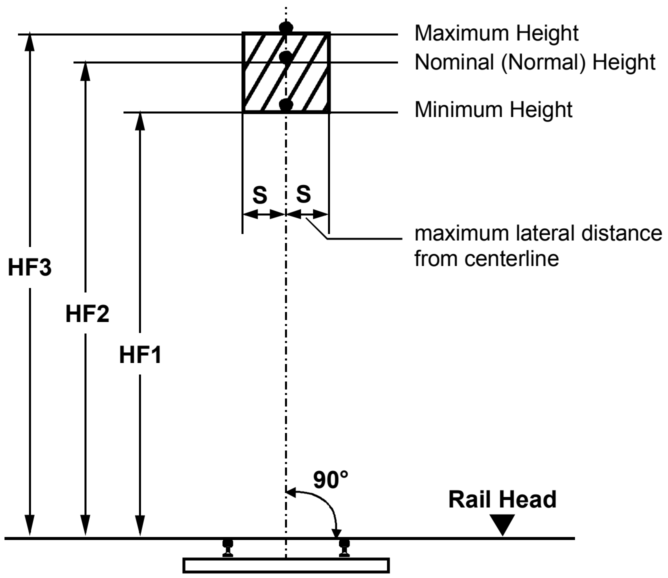


Table of Measurements:

Scale	Wide	Narrow	HF 1	HF 2	HF 3
Z	2	1	25	28	30
N	3,5	1,5	34	38	40
TT	4,5	2	44	50	52
H0	6,5	3	60	69	73
S	8,5	4	80	93	98
0	11	6	110	130	139
I	17	8	150	180	194

Notes :

1) The lateral distance (S) is the maximum allowed. It is appropriate to employ the full measurement only in curves. On tangent (straight) track, a zig-zag in the wire is recommended, but should be limited to approximately 2/3 of the maximum.

2) The dimension ***HF2*** is the Normal wire height mandated for unobstructed locations and should be followed as strictly as possible. Height may be increased in stations and decreased in tunnels and other locations where the terrain requires, but in all cases, the position of the contact wire must remain between the Maximum and Minimum heights (HF3 and HF1).

3) Mast Spacing

The distance between masts ***L*** on curved track with radius ***R***, is a function of the lateral distance ***S*** and can be calculated with the following formula:

$$L_{max.} = 4 \sqrt{R \; S}$$

In multiple track arrangements with standard spacing (centerline to centerline), compute the distance between masts using the largest track radius. In other situations, calculation for several radii is recommended. To maintain reasonable (and visually pleasing) mast spacing, use the minimum radii recommended in NEM 111.

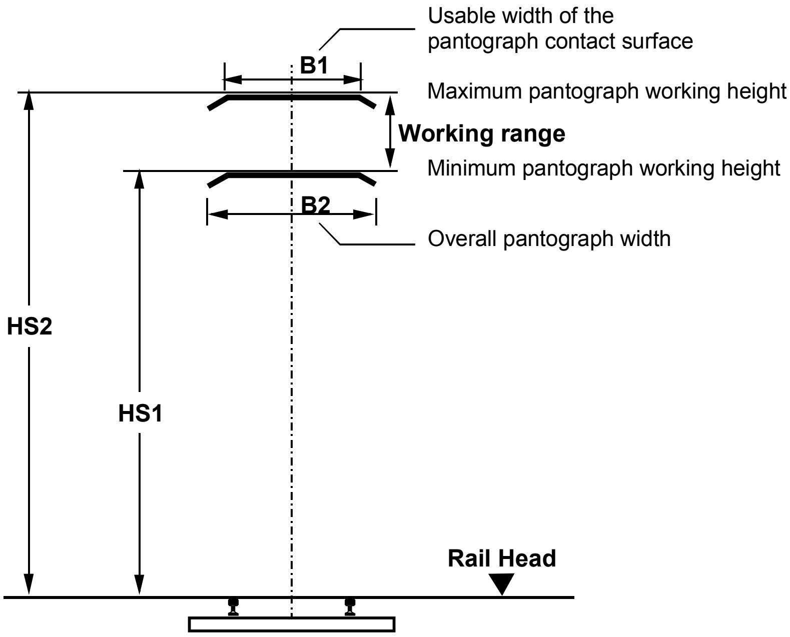
1. Purpose

This norm determines the usable sharpening width and the work position of the current collector (pantograph) with overhead line operation according to NEM 201.

2. Organization

The terms "**Wide** System" and "**Narrow** System" are defined in NEM 201.

3. Pantograph dimensions and working range



Note :

The shape of the curve from the contact surface to the downward-turned tips, the inclination of the tips, and the overall pantograph width ***B2*** are somewhat determined by the pantograph manufacturer. Nevertheless, the width ***B2*** and height ***H4*** as defined in NEM 301 measurements of the fully-lowered pantograph shall not exceed the standards prescribed in NEM 301.

Table of Measurements:

Gauge	B1 Wide	B1 Narrow	HS 1	HS 2
Z	7,5 + 0,5	3,5 + 0,5	25	31
N	10 + 1	5 + 1	34	41
TT	13,5 + 1,5	7,5 + 1,5	44	54
H0	18 + 2	10 + 2	60	75
S	25 + 2	14 + 2	80	101
0	34 + 2	22 + 2	110	142
I	48 + 2	30 + 2	150	198

4. Curved Track

This standard works with NEM 201 to provide for trouble-free operation of models using overhead wire so long as the pantograph contact surface is in close proximity to the locomotive's truck (bogie) pivot point. If the pantograph is mounted some distance from the pivot point, it might lose contact with the overhead wire, or otherwise come into contact with other parts of the wire suspension system, particularly on curves. The possibility of this occurring increases with the decrease in curve radius.

Remedies include closer mast spacing (to effectively reduce the zig-zag on the curve), reducing the curve length, increasing the curve radius, or by fitting the locomotive with wider, non standard pantograph shoes.

Normen Europäischer Modellbahnen

Radsatz und Gleis

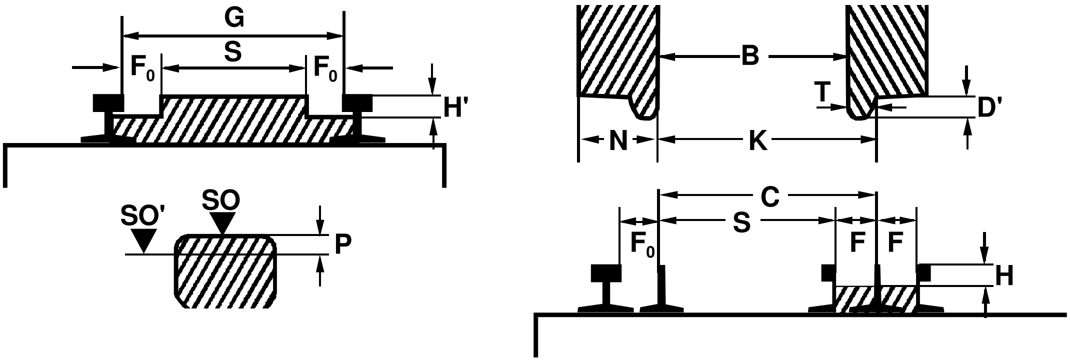
NEM 310

1 Seite

Verbindliche Norm **Maße in mm** **Ausgabe 1977**

Diese Norm ist Grundlage für die Prüfung von Gleisen, Weichen und Kreuzungen einerseits, Rädern und Radsätzen anderseits. Nach NEM hergestellte Modellbahnen müssen dieser Norm entsprechen. Die NMRA-Normen S 3, S 4 und die NMRA-Empfehlung RP 25 wurden soweit wie möglich berücksichtigt.

Die Maße weichen von der maßstäblichen Verkleinerung des Vorbildes im Interesse der Betriebssicherheit ab.



SO = Schienenoberkante
SO'= Messebene für alle waagrechten Maße dieser Norm

Maßtabelle für Spurweite G [1]		Gleis				Radsatz		Rad				
		C [2]	S	F [3]	H [4]	K	B	N [5]	T		D [6]	P
Nennwert	max	min	max	max	min	max	min	min	min	max	max	
6,5	6,8	5,9	5,2	0,75	0,6	5,9	5,25	1,55	0,41	0,46	0,6	0,1
9	9,3	6,1	7,3	1,0	0,9	8,1	7,4	2,2	0,5	0,6	0,9	0,15
12	12,3	11,0	10,1	1,1	1,0	11,0	10,2	2,4	0,6	0,7	1,0	0,20
16,5	16,8	15,2	14,1	1,3	1,2	15,2	14,3	2,8	0,7	0,9	1,2	0,25
22,5	22,8	20,9	19,5	1,6	1,4	20,9	19,8	3,5	0,9	1,1	1,4	0,30
32	32,3	29,9	28,0	2,2	1,6	29,9	28,4	4,7	1,2	1,4	1,6	0,40
45	45,3	41,8	39,3	2,8	2,2	41,8	39,8	5,7	1,5	1,7	2,2	0,50

Anmerkungen

1) Im geraden Gleis ist der Nennwert anzustreben. Im Gleisbogen ist eine Spurerweiterung zweckmäßig, zum Beispiel, wenn Fahrzeuge mit einem großen Achsabstand verkehren sollen.
2) Die Begrenzung C_{min} gilt nur im kritischen Bereich des Radlenkers, also zum Beispiel nicht bei Leitschienen, wie sie bei Gleißbogen mit kleinen Halbmessern verwendet werden, oder bei Schutzschienen auf Brücken.
3) Am Herzstück darf die Begrenzung F_{max} überschritten werden, wenn ein Spurkranzauflauf (Rad läuft auf dem Spurkranz statt auf dem Laufkranz) vorgesehen ist.

   $$F_0 = \tfrac{1}{2}(G - S) \text{ bzw. am Radlenker: } F_0 = G - C$$

   Die Einhaltung der maximalen Rillenweite am Herzstück gestattet den gemeinschaftlichen Betrieb mit Rädern, deren Spurkränze eine unterschiedliche Höhe ***D*** haben. Werden Infolge der Schrägstellung der Radsätze im Rillenbereich Erweiterungen über das angegebene Maß hinaus notwendig oder muss aus dem gleichen Grund der Wert ***S*** verkleinert werden, so darf das Minimum der Spurkranzhöhe ***D*** nur 0,1 kleiner sein als das Maximum. Die Rillentiefe H_{max} darf dann nur $\geq H_{min} + 0{,}1$ sein. Gleisstücke mit vergrößerter Rillenweite ***F*** sind für Fahrzeuge nach NMRA-Standards nicht geeignet.
4) H_{min} gilt nur für die Tiefe der Rillen am Herzstück. Im übrigen ist eine Tiefe $H' > 1{,}3\ H$ unter SO einzuhalten. Die Kanten der nichtmetallischen Herzstücke sollen 0,1 unter SO liegen.
5) Die Radbreite darf kleiner als N_{min} sein, wenn die Bedingungen des Spurkranzauflaufs nach Anmerkg.3) erfüllt sind und wenn $K + N > G_{max}$ gewählt wird.
6) Das Maß ***D*** kann bis zur maßstäblichen Wiedergabe verkleinert werden. wenn ein Spurkranzauflauf nicht vorgesehen ist.

1. Purpose of the Norm

This norm serves to create the prerequisites for electrical measurements of the occupation of track sections by vehicles at rest and/or in motion (static-dynamic occupation signalling) in the case of **two rail operation** to NEM 620.

2. Bridging resistance

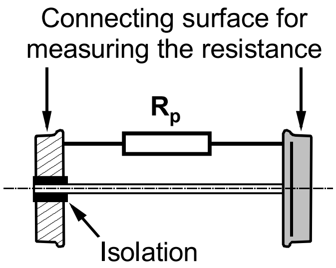
In the case of **vehicles without electrical equipment** a resistance element is attached for bridging the isolation of the wheelset **(bridging resistance)**. Design, shape and installation of the bridging resistance can be carried out in any suitable form. Its value is determined as:

$$R_p = 15\ k\Omega\ \text{(Kilo Ohms)} \pm 20\%$$

3. Measurement of the bridging resistance

Bridging resistance R_p is determined between the running surfaces of the wheelset.

Fig. 1 Schematic depiction of the wheelset
with electrical isolation,
bridging resistance and measuring surfaces



4. Note

The number of axles within one train bridged according to this standard is not prescribed.

MOROP	Norms of European Model Railroads **Digital Track Signal SX[1]** **Technique for Encoding Bits**	**NEM 680** Page 1 of 2

Documentation **Edition 2003**

1. Purpose of this specification

This text describes the digital representation of the SX-Format[1].

2. The digital format

a) Using the SX-Format, transmitting data is done by switching the DC-voltage on the track (the track signal).

b) The SX- track signal consists of a ~~con~~sequence of pulses with 3 different voltage levels.

c) A clock- or sync-pulse with 0 V is used to separate the data pulses (data bits).

d) A pulse of either + Vs or – VS (supply voltage) is called a "bit". A bit is either „0" or „1".

e) The decision–if a bit is „0" or „1" is taken comparing two consecutive bits; that is, the comparison of the polarity before and after the sync-pulse.

2.1 The clock- or sync-pulse

a)	Duration[2]	**10 µs**	**+ 12 µs / - 2 µs**
b)	Voltage level	**0 V**	**± 2 V**

2.2 The data-pulse

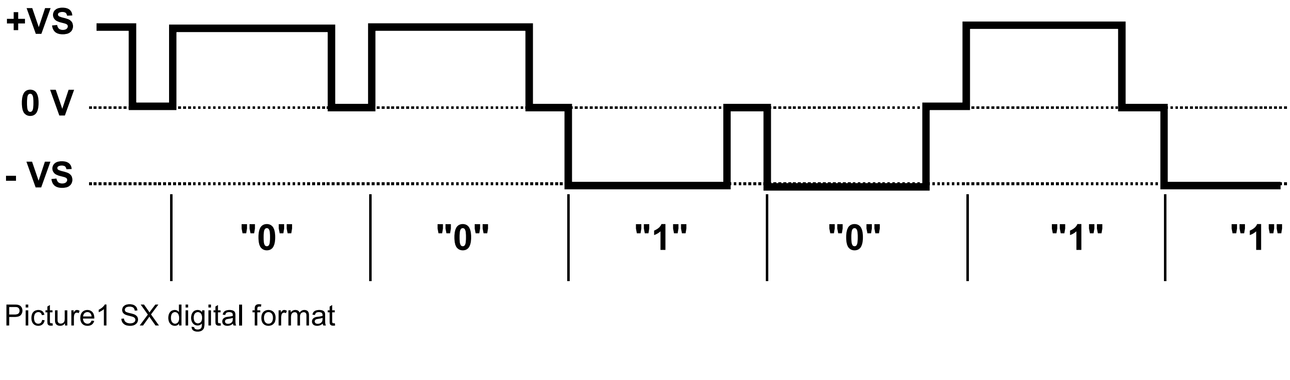
a)	Duration	**40 µs**	**+ 50 µs / - 2 µs**
b)	Voltage	**± 18 V**	**± 6 V**

2.3 „0"-Bit (Zero-bit) or „1"-Bit (One-bit)

If a data represents „0" or a „1", is is determined by comparing the voltage levels before and after the clock-pulse:

a) If both voltage levels are equal (either + VS / + VS, or - VS / - VS), the data pulse represents a "0"-bit.

b) If both voltage levels are not equal (either + VS / - VS, or - VS / + VS), the data pulse represents a "1"-bit.



Picture1 SX digital format

[1] The abbreviation SX is derived from **S**elec***TRIX***®, the digital control system from the TRIX company.
[2] All timings are referential on the median value of the trigger-value of there recipient (= | 6,5V |).

3. Further specifications of the SX-signal

3.1 Trigger values at the receiver

To ensure the proper functionality of the receiver/decoder, the following trigger values of the track voltage must be met:

Min. trigger value	**> | 4V |**
Max. trigger value	**< | 9V |**

3.2 Rise/Fall time of the track-signal

The voltage change between the max. voltage level of the clock-pulse (± 2V, refer to 2.1), and the min. voltage of the data-pulse (± 12 V, refer to 2.2) is defined as rise/fall time of the track voltage. It must meet the following condition:

$$|Ss| \geq 2{,}5\ V/\mu s$$

3.3 Ripple of the track-signal

The track signal can be overlaid by any other wave forms, as long as the resulting wave forms conforms with 2.1, 2.2 and 3.2. [3)]

3.4 Self-inflicted distortions

Every equipment using this specification has to meet the current CE-regulations (or FCC-regulations for the US).

3.5 Compatibility

a) On all tracks using the described digital track signal only vehicles with digital decoders can be used. Using the digital track signal to directly drive the motor of a locomotive can result in damages to the motor.

b) The SX-receiver has to be build in a way that also waveforms of other digital systems do not lead transmitting errors.

4. Energy-transfer and Voltage limits

4.1 Energy-transfer

Since the track-signal is also used as the energy-source for all locomotives and other vehicles, the continuously transmission of data bits is essential. [4)]

4.2 Voltage limits

a) The virtual value of the track signal shall not exceed the specifications in NEM 630 [5)] by more than 2 V.

b) The max. peak-to-peak value of the digital track-signal must not exceed ± 24 V.

c) The min. peak-value of the SX-signal~~s~~, driving the digital receiver, amounts ± 9 V, measured at the track.

d) The receivers have to have a direct current (d. c.) voltage life of at least 25 V.

[3)] These overlaid signals can be used for any other control options.
[4)] The typical way for measuring the energy supply is the bridge-circuit.
[5)] The additional voltage serves the compensation of the voltage-drop in the decoder in order to secure the NEM 630 (table 1) specified maximum-voltage at the motor-brushes.

1. Purpose of this specification

This specification describes the output of serial data, which has to be generated by SX-main units[1)].

2. Explanations

– SX-data-packet is a defined set of bits as described in NEM 680 (the track-signal).
– The SX-data-packet consists of a specified number of bit groups.
– Each bit groups consist of 12 bits. They are named either "synchronization"- or "data"-bit-groups (also called channels).

3. Format of a SX-data-packet

The subsequently described components of a data packet define the generally valid composition of the SX-data-packet to activate the decoders.[2)] The SX-data-packet consists from following parts:

1. Start synchronize-bit-group (S): The **Synchronization (Sync)** activates the decoder and consists of a combination of bits, which do not occur in normal operation. Additionally, the Sync contains the so-called **"base address" (BA)**.
2. 7 successive data-bit-groups, the so-called **"channels" (K6...K0)**. The channel numbers combined with the base addresses (BA) are the addresses of the locomotives.
3. End synchronize-bit-group: (see 1. Perhaps with a different BA which could also be used as the synchronize-bit-group of the following data bit groups.

Sync+BA K6 K5 K4 K3 K2 K1 K0 Sync+BA?

4. SX-Synchronize bit group

4.1 Synchronizing and transmission of the base address (BA)

Format of the synchronize-bit-group (Sync+BA):

0 0 0 1 Z 1 BA3 BA2 1 BA1 BA0 1

The bits contain the following information

0 0 0 Sync with 3 times „0"

1 Separation bits, to prevent the occurrence of "000" anywhere else than in the Sync-bit-group.

BA0..BA3 The base address (BA),
BA3 = MSB (most significant bit), valence 8
BA0 = LSB (least significant bit), valence 1

Z Condition-bit of the command-station („0" = off, „1" = on)

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1) *In the* most cases *the SX-main unit contains* an amplifier, *which* delivers the necessary energy for the *locomotives*. If *that is not sufficient,* more amplifiers *could be used.*

2) *For the decoder it is also allowed to accept* other command-formats *in addition to the SX-format* (*e. g.* DCC in accordance with NEM 671).

4.2 Determination of the decoder-addresse~~s~~

The base-address (BA) is transmitted in inverted format, f. i. the bits of the base-address have to be inverted to calculate the decoder address.

BA = 0 0 0 0	BAinv = 1 1 1 1	decimal = 15	
BA = 0 0 0 1	BAinv = 1 1 1 0	decimal = 14	
BA = 0 0 1 0	BAinv = 1 1 0 1	decimal = 13	etc.

The address of the decoder is calculated as:

Loco-address = 16 · (K?) + BAinv

Example:

BA = 0100 (equals BAinv = 1011), channel number 4 (? = 4) :

Locomotive-address = (16 · 4) + 11 = 75

4.3 The SX-data-bit-group controlling ~~of~~ speed, direction, light and addition-functions

Format of the data-bit-group:

S0 S1 1 S2 S3 1 S4 D 1 L F 1

The bits have the following meaning

1 Separation-bits, to prevent same combination of bits in the data-bit-group as in the Sync-bit-group.

S0..S4 Speed (S0 = LSB, least significant bit **-** S4 = MSB most significant bit). With 5 bits, there are 2^5 = 32 possible values (31 speed steps and 00000 = full stop)

S4	S3	S2	S1	S0	Speed level ~~step~~
0	0	0	0	0	0 (full stopp)
0	0	0	0	1	1
		...			...
1	1	1	1	0	30
1	1	1	1	1	31

D Direction
„0“ means forward.[3)]
„1“ means backwards.

L Light. The two decoder-outputs for the light have to be combined with the direction bit D (front light / back light).

F Bit for the additional-function F1 (e.g. smoke generator).
„0“ means, the additional-function is switched off.
„1“ means, the additional-function is switched on.

[3)] Forward *means, that vehicle end 1 is in front of direction of motion.*

5. Repetition of the SX-data packets

The SX-data packets can be repeated in any order, but it is however recommended to transmit all 16 possible base-addresses in consecutive order. Mixing with digital signals of other control systems is possible as long as the rules for building the data packets are obeyed (see 3.)

6. Decoder behaviour with automatic recognition of different commands control-systems

Decoders with automatic recognition of control-commands any other systems (multi-system-decoder), including the NEM-DCC-System (NEM 670 / NEM 671), should have the ability to switch it off. If switched on, the decoder has to keep its current status until a known and correct control command of any other control system is recognized (especially important for the address of the locomotive).

The history of the European railroad system can be divided into five different eras (Standards for European Model Railroads NEM 800). The five eras are marked according to technical as well as social characteristics. The differences can be recognized by the track appearance (i.e. construction and signals) as well as by the types, colors and identification markings of the rolling stock. The various eras are listed using Roman numerals.
The five eras cannot be defined clearly – transitions are fluid. Further division into periods is therefore necessary. However, these cannot be standardized because the development differs in various countries.

The First Era: 1835 – 1920 "Era of State Railroads"

The First Era includes the time from the beginnings of railroad construction until the completion of a comprehensive network of lines. Large state owned railroad networks grow as well as private train systems with regional significance. The steam locomotive reaches to its final form. The carriages and the locomotives show themselves in various colors.

1835-1875 (Period a)
The first regional railroads - state or private ownership – are built. The construction of lines grows into a joined basic network. Various basic designs of steam locomotives are manufactured.

1875-1895 (Period b)
Nine extensive state-owned networks in Prussia, Bavaria, Saxony, Wuerttemberg, Baden, Hessen, Mecklenburg, Oldenburg and Alsace Lorraine are constructed. The track systems are enlarged. The first branch systems, small and local lines and companies with narrow gauge line system are being built. Steam locomotives with compound systems and tank locomotives are being developed. The compressed air brake system is used for passenger trains. The first norms are set for cars and color schemes (yellow, green, brown, grey) for the four different classes of passenger cars and are introduced in Prussia.

1895-1910 (Period c)
The construction of networks is completed and the state railroad systems are reorganised. The Prussian-Hessen state railroads consolidate their administration. Common rules for construction, administration, signals, driving and technical equivalents unify the system. The superheated steam locomotive, the first railcar with combustion engine, accumulator railcars and express train wagons with four axles are developed.

1910-1920 (Period d)
Developments stagnate during the First World War (1914-1918). In Prussia the locomotives are painted black and passenger cars olive green. The first large locomotives for express trains appear and for the first time electrically powered operation is introduced. Freight cars are built according to the norms set by the association “Deutscher Staatsbahnwagenverband” and for the first time it is possible to run freight cars among different lines and railroad companies. The compressed air brake system is introduced for freight trains. The MITROPA (The Middle European Sleeping- and Diningcar company) is founded.

The Second Era: 1920-1950 "Era of the German State Railroad"

The Second Era is characterized by the takeover of the German Railroad System by the German State. Standardized models for locomotives and cars are introduced. The electrical railroad system was enlarged and rail car trains are developed further. Building and operational regulations, as well as color and lettering are further standardized.
The many types of wagons and locomotives from the previous era result in a great variety of vehicles in the fleet.

1920-1925 (Period a)
The different state owned railroads are now part of the German State and headquarters of the German State Railroad are established. The first norms for types of electrical locomotives are introduced. The first standard passenger cars are produced and painted green-brown.
Freight cars with interchangeable parts are introduced. Freight cars are marked with the inscription “Deutsche Reichsbahn” and the names of the various regions. The exchange of wagons is facilitated by international agreements (RIC; RIV).

1925-1937 (Period b)
This is the period of the German State Railroad Company (DRG). The separate administration for Bavaria is dissolved. Steam and electrical locomotives are renamed and standardized steam locomotives are developed. First rail cars for fast train operation are produced. Passenger cars are renamed (modified 1930). Fourth-class cars are taken out of the system. Sleeved buffers are introduced. All MITROPA sleeping and dining cars are now burgundy red. Freight cars are equipped with connected compressed air brakes.

1937-1950 (Period c)
The Saarland Railroads and the Austrian National Railroads are integrated into the system. The rules for signals are changed. The Imperial Eagle is mounted on the locomotives and the passenger cars. Passenger cars are now bottle-green and have new identification markings. Wartime locomotives, temporary passenger cars and wartime freight cars are developed. The Imperial Eagle is removed at the end of the war. Electrical train operation is abandoned in the soviet zone.

The Third Era: 1949 - 1970 "Early Federal Railroad (D) and East German State Railroad Era (GDR)"

The railroad systems are built and modernized independently in the Federal Republic of Germany and in the German Democratic Republic. Operation with diesel and electrical locomotives expands. Using the steam powered trains is gradually reduced. A fleet of modern cars as well as new safety technologies are introduced.

The German Federal Railroad (Deutsche Bundesbahn - DB)
1949-1956 (Period a)
The German State Railroad is renamed to German Federal Railroad in the area of the Federal Republic of Germany. The first new steam locomotives are constructed. The “blue long-distance trains” are introduced. Accumulator and combustion railcars are renamed. Passenger cars are divided into three classes. The German Dining and Sleeping Car Association DSG is founded. Passenger cars with a length of 26 meters are introduced. The military zone identification is added to the DR classification for all freight cars. A new DB marking system is introduced with new symbols and numbers.

1956-1970 (Period b)
The use of steam locomotives declines further. The use of diesel and electrical engines gains. New boilers are added to steam locomotives and rebuilt for the use of oil as fuel. Diesel and electrical engines are mass-produced. Trans European Express (TEE) service takes up its service. A new system for signals is introduced (2 ditch lights and one headlight). The two-class system replaces the three-class system for passenger cars. The first class is identified by a line. Passenger cars are now dark-green. A program for rebuilding local passenger cars is begun. The “DB” logo is brought in.

The East German State Railroad (Deutsche Reichsbahn - DR)
1949-1956 (Period a)
The German State Railroad has a separate administration for the German Democratic Republic. All privately owned railroad companies are nationalized. Steam locomotives are converted to use coal dust. There are three classes for passenger trains. Double-decker trains are widely used. The military zone identification is added to the DR classification for all freight cars. A new DR marking system is introduced with new symbols and numbers.

1956-1970 (Period b)
New and redesigned steam locomotives are built and mass-produced, whilst new diesel engines are imported in large numbers. Later, the electrical system returns and a new system for signals is used (2 ditch lights and one headlight). The two-class system replaces the three-class system for passenger cars. Passenger cars are modified and receive new markings. The “DR” logo is brought in. An international association for freight cars within the Warsaw Pact countries is founded.

The Fourth Era: 1970-1990 "Late Federal Railroad (D) and East German State Railroad Era (GDR)"

The change to diesel and electrical engines is virtually completed. Internationally agreed identification markings are in use together with new color schemes.

German Federal Railroad "Deutsche Bahn" DB
1970-1980 (Period a)
A new system for the marking of locomotives, passenger cars and freight cars complies with international agreements. The one-class intercity system commences. An experiment is made using trendy new colors to decorate passenger cars. Gradually, a new concept with trendy new colors begin to decorate locomotives and passenger cars (beige/red and beige/turquoise). Articulated passenger cars are used for the last time.

1980-1990 (Period b)
The changing in the colors of passenger cars and locomotives is virtually completed.
Inter-City now offers two classes. A modified international freight train identification marking system comes into operation.

East German State Railroad DR
1970-1980 (Period a)
A new system for the markings of locomotives, passenger cars and freight cars is complies with international agreements. A new color design is applied to locomotives. Steam locomotives using oil as fuel are used for the last time. A traditional fleet of trains is collected.

1980-1990 (Period b)
The service with steam locomotives on regular tracks is phased out. A new color design is applied to passenger cars (red-brown/beige/green) and for City-Express trains (red brown/beige/orange). Articulated passenger cars are used for the last time.

The Fifth Era: after 1990 “The Era of the Deutsche Bahn AG“

The two state-run German railroads cooperate and are consolidated into the Deutsche Bahn AG. The Inter-City-Express (ICE) system is introduced. A color design is applied based on the utilization of the different cars.

1990-1994 (Period a)
Both of the German railroad administrations cooperate and apply first measures for alignment. The German Federal Railroad locomotives are now red. Certain railcars and passenger cars are decorated according to their use (four colors). The numbering system for railcars of the East German State Railroad is integrated into the system used by the German Federal Railroad. The Inter-City-Express service begins. The first railcars with tilting mechanism come into use. The international freight car numbering system is modernized.

After 1994 (Period b)
The two companies, the German Federal Railroad and the East German State Railroad, fully consolidate into the Deutsche Bahn AG. A new corporate logo is created. All railcars and passenger cars now use the same and new color scheme whilst for freight cars another design is applied.

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