UIC CODE 517

7th edition, May 2007

Translation

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Wagons - Suspension gear - Standardisation

Wagons - Organes de suspension - Normalisation
Güterwagen - Teile der Federaufhängung - Normung

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

Leaflet to be classified in Volume:

V - Rolling stock

Application:

With effect from 1 December 2004 for the suspensions defined in Appendix D.2 and D.3
All members of the International Union of Railways

Record of updates

4th edition, January 1965	with 2 amendments
5th edition, July 1976	
6th edition, July 1979	with 10 amendments
7th edition, May 2007	Addition of amendments approved by the study group (GE2) in January 2005 : points 4, 5, 6, 7 et 8 and Appendix D.

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

Contents

Summary

This leaflet defines the suspension components to be used for two-axled wagons.

It deals with springs, axle guards and suspensions that use springs or links.

The standardised sub-assemblies and constituent parts are given in the drawing list (see "standardised UIC drawings", on the UIC website).

1 - Leaf springs

1.1 - Leaf springs for two-axle wagons

o **1.1.1 -** Leaf springs for use on future two-axle wagons designed for 20 t axle loads (or possibly higher) shall, except when this is impossible for technical reasons, fall into one of the following categories:

- standard springs with constant stiffness of type A as defined in Appendix A - page 10;
- standardised springs with constant stiffness of type B as defined in Appendix A;
- standard springs with progressive stiffness as defined in Appendices I.1 - page 34, I.3 - page 37, I.4 - page 38, J.1 - page 39, J.3 - page 41, K.1 - page 44 and K.2 - page 45;

1.1.2 - If, for technical reasons, leaf springs other than those described in point 1.1.1 have to be used, the recommendations given in Appendix M - page 49 should be followed.

1.1.3 - Moreover, the leaf springs specified hereafter may be used on existing two-axle wagons for a 20 t axle load, namely:

- standardised leaf springs with constant stiffness as defined in Appendix B - page 11;
- standard springs with progressive stiffness as defined in Appendices I.1, I.3, I.4, J.1 and J.2 - page 40.

o 1.2 - Leaf springs for bogies

For standard bogies with leaf springs for a 22,5 t axle load, springs of the following type should be used:

- standard springs with progressive stiffness for a 22,5 t axle load as defined in Appendices I.2 - page 36, I.3, I.4, J.4 - page 42 and J.5 - page 43.

o 1.3 - Mean flexibility

The definition and determination by measurement and calculation of the mean flexibility of leaf springs are specified in Appendix H - page 21.

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2 - Coil springs

For standard bogies equipped with coil springs for 20 t and 22,5 t axle loads, the standard springs defined in Appendix C - page 12 should be used.

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3 - Axle guards and liners

3.1 - Lateral rigidity

The rigidity of the two axle guards of the same axle box mounted in the frame must be such that when a lateral force F is applied to this assembly at a height of 70 mm above the centre line of the axle, the wagon being empty and in new condition[1], an elastic deflection dy is produced from the application point (including frame distortion) in accordance with the diagrams:

- in Appendix L.1 - page 46, for ordinary axle guards with constant stiffness;
- in Appendix L.2 - page 47, for reinforced axle guards with constant stiffness;
- in Appendix L.3 - page 48, for axle guards with progressive stiffness.

Moreover, the elastic deflection at the same application point should be able to reach the specified limit values without causing permanent deformation.

Axle guards of constant stiffness, of both ordinary and reinforced types, together with tie bars and stirrups, are standardised: see Appendix E - page 17.

3.2 - Longitudinal strength

The strength of each axle guard and its mounting in the underframe must be sufficient to withstand a longitudinal force of 50 kN applied at a height of 70 mm above the centre line of the axle, when the wagon is empty.

When the axle guard is attached to the underframe by rivets, the strength of the assembly must be calculated on the basis of a frictional force of 6 kN per cm^2 of cross-section of the rivet at the centre line of each rivet.

The position and shape of the axle guards must be such that the longitudinal force applied by the box produces only negligible torsional stresses.

The tie bars and their mountings should be able to transmit the force related to deformation of one of the axle guards.

3.3 - Liners

Liners must be used to protect against wear : Appendix D - page 13.

The distance between the liner and the box shall be :

- laterally a minimum of 20 mm;
- longitudinally equal in mm to 3 times the number representing the wheelbase of the vehicle in metres, up to a maximum of 22.5 mm.

1. i.e. approx. 380 mm below the bottom edge of the longitudinal member in the case of wheel diameters between 920 and 1000 mm.

4 - Double link suspensions and suspension brackets

4.1 - New two-axled wagons may be equipped with UIC double link suspensions. Dynamic behaviour tests may be dispensed with if the requirements of *UIC Leaflet 432* (see Bibliography - page 50) are complied with.

4.2 - A complete running gear, with double link suspension, is shown in point D.1 - page 13

The distance between the centre lines of the suspension bracket bores is equal to the developped length L of the main leaf (measured between the centre lines of the spring rolled ends of the spring assumed straight) increased by 300 mm.

The amplitude of the lateral oscillations of the lower links with respect to the median position shall be limited to 10 mm.

4.3 - The suspension components related to double link suspensions and support brackets are given in Appendix F - page 18. These components are standardised.

Their wear limits are given in Appendix G - page 19.

5 - Single link suspensions

For wagons with single link suspensions, it is recommended to use link pins and bearings defined in point 4.3 - page 5 and Appendix F - page 18.

6 - Suspensions with S 2000 springs

Suspensions with S 2000 springs are approved for two-axle wagons. Dynamic behaviour tests may be dispensed with if the requirements of *UIC Leaflet 432* (see Bibliography - page 50) are complied with.

The assembly drawing in point D.2 - page 15 shows running gear with S 2000 springs.

7 - Suspensions with Niesky 2 springs

The suspension with Niesky 2 springs is approved for two-axle wagons. Dynamic behaviour tests may be dispensed with if the requirements of *UIC Leaflet 432* (see Bibliography - page 50) are complied with.

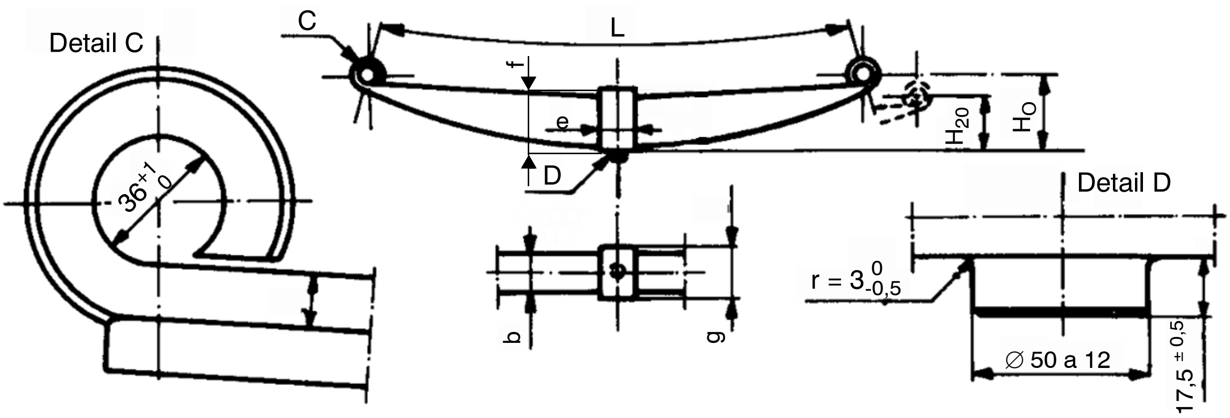
The assembly drawing in point D.3 - page 16 shows running gear equipped with Niesky 2 suspension.

8 - Intellectual property

Licences must be paid for, to the copyright holders at the time of manufacture of suspensions using Niesky 1, Niesky 2 and S 2000 springs protected by patents. For the UIC networks, the use of copyrights is free.

Appendix A - Leaf springs with constant stiffness for two-axle wagons

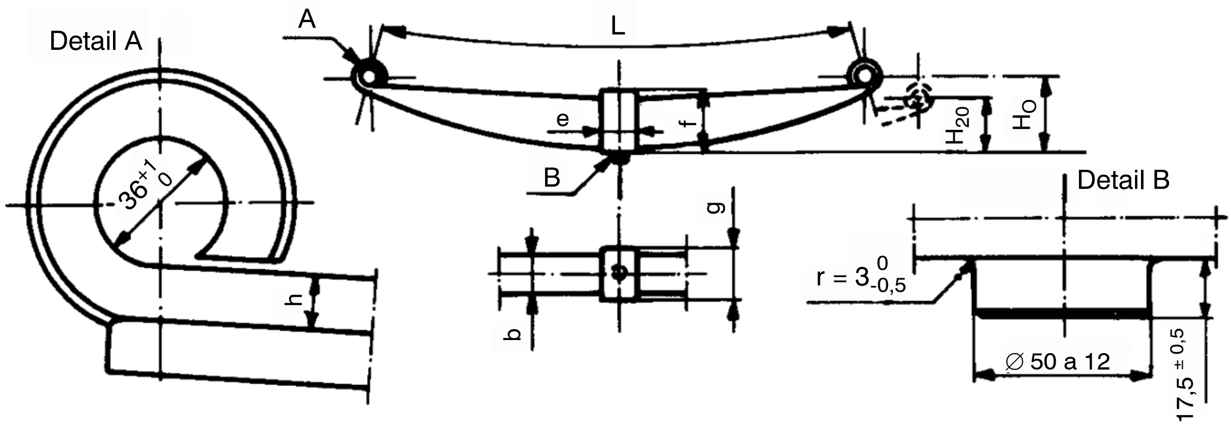
Standardisation and/or standard parts



Spring type				A	B
Characteristics		Symbol	Unit	Standardisation	Standard parts
Permissible axle-load: - ordinary and S conditions - SS conditions		P	t	20 20	20 20
Length of main spring leaf (between the centres of the rolled eyes of the leaf assumed to be straight)		L	mm	1 400 ± 4	1 200 ± 3
Spring height under zero load		H_O	mm	243	212
Mean flexibility of spring alone [a]		C_a	mm/kN	0,94 ± 8 %	0,66 ± 8 %
Spring height under a load of 20 kN applied in trolley mounting [b]		H_{20}	mm	224^{+3}_{-2}	199^{+3}_{-2}
Spring leaves	Width	b	mm	120 ± 0,5 [c]	120 ± 0,5 [c]
	Thickness	h	mm	16 ± 0,2 [c]	16 ± 0,2 [c]
	Number	n	leaf	9	8
Spring buckle:	Width	e	mm	100 ± 2	100 ± 2
	Height	f	mm	$193{,}5^{+3}_{-1}$	$177{,}5^{+3}_{-1}$
	Length	g	mm	153^{+2}_{-1}	153^{+2}_{-1}
Mean stiffness of link suspension - Overall value [a]		c_z	kN/mm	0,97	1,37

a. See Appendix H.
b. H_{20} : mean value between height obtained with increasing load and height obtained with decreasing load (see UIC Leaflet 821).
c. The tolerances given are those for untoleranced dimensions defined in UIC Leaflet 800-50.

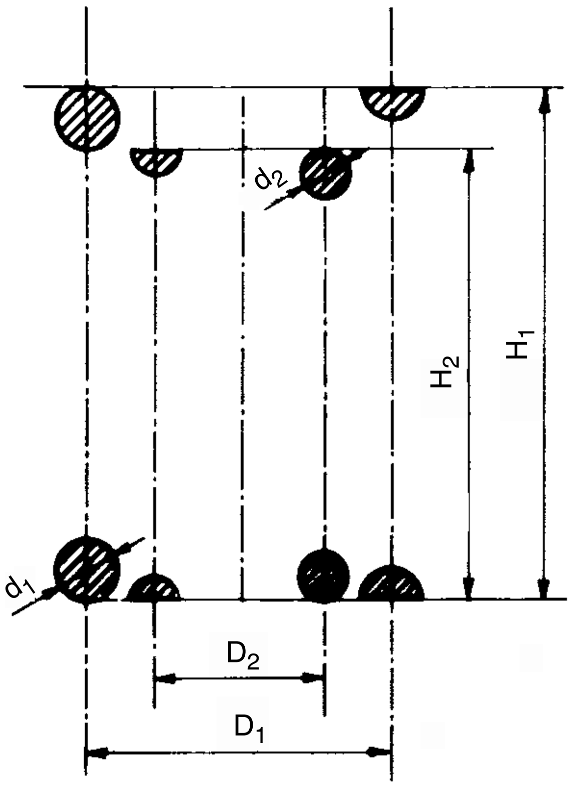
Appendix B - Leaf spring with constant stiffness in ordinary use for existing two-axle wagons - Standard parts



Characteristics		Symbol	Unit	
Permissible axle-load: - ordinary conditions - S conditions - SS conditions		P	t	20 20 18
Length of the main spring leaf (measured between the centres of the rolled eyes of the leaf assumed to be straight)		L	mm	1 400 ± 4
Spring height under zero load		H_O	mm	224
Mean flexibility of spring alone[a]		C_a	mm/kN	1,05 ± 8 %
Spring height with load of 20 kN applied in trolley mounting[b]		H_{20}	mm	203^{+5}_{0}
Spring leaves:	Width	b	mm	120 ± 0,5 [c]
	Thickness	h	mm	16 ± 0,2 [c]
	Number	n	leaf	8
Spring buckle:	Width	e	mm	100 ± 2
	Height	f	mm	$177{,}5^{+3}_{-1}$
	Length	g	mm	153^{+2}_{-1}
Mean stiffness of link suspension - Overall value[a]		c_z	kN/mm	0,86

a. See Appendix H.
b. H_{20} : mean value between height obtained with increasing load and height obtained with decreasing load (see UIC Leaflet 821).
c. The tolerances given are those for untoleranced dimensions defined in UIC Leaflet 800-50.

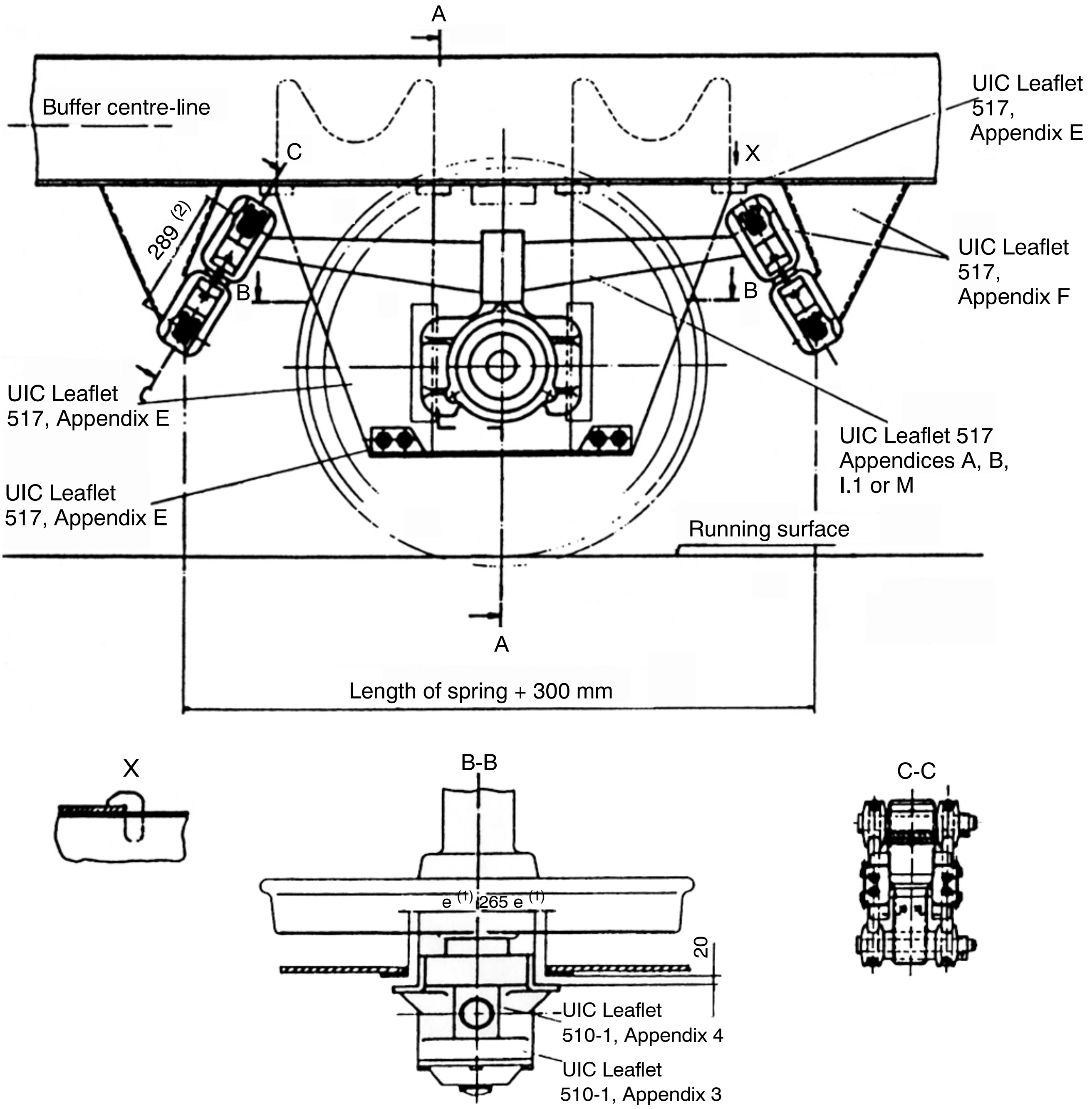
Appendix C - Coil springs - Standardisation



Characteristics	Unit	Bogies suitable for 20 t axle load		Bogies suitable for 22,5 t axle load	
		Outer spring	**Inner spring**	**Outer spring**	**Inner spring**
Wire diameter	mm	d_1 = 30	d_2 = 24	d_1 = 31	d_2 = 24,4
Mean coil diameter	mm	D_1 = 162	D_2 = 90	D_1 = 163	D_2 = 90
Total number of coil windings		6,1	7,5	5,7	7,4
Number of useful coil windings		4,6	6	4,2	5,9
Free height	mm	H_1 = 264	H_2 = 234 ± 2	H_1 = 260	H_2 = 234 ± 2
Height under load of 8,8 kN	mm	242^{+1}_{-3}		242^{+1}_{-3}	
Flexibility	mm/kN	2,41	1,32	1,97	1,21
Direction of spiral:		right 	left 	left 	right 

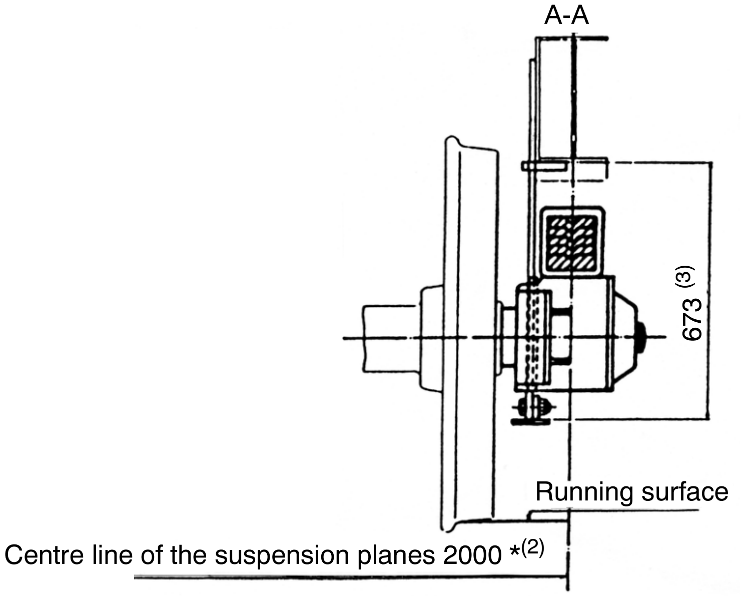
Appendix D - Running gear for two-axle wagons

D.1 - Running gear and suspension for wagons



1) Distance "e" in mm is 3 times the number representing the vehicle wheel base expressed in metres. However this distance may not exceed 22,5 mm.

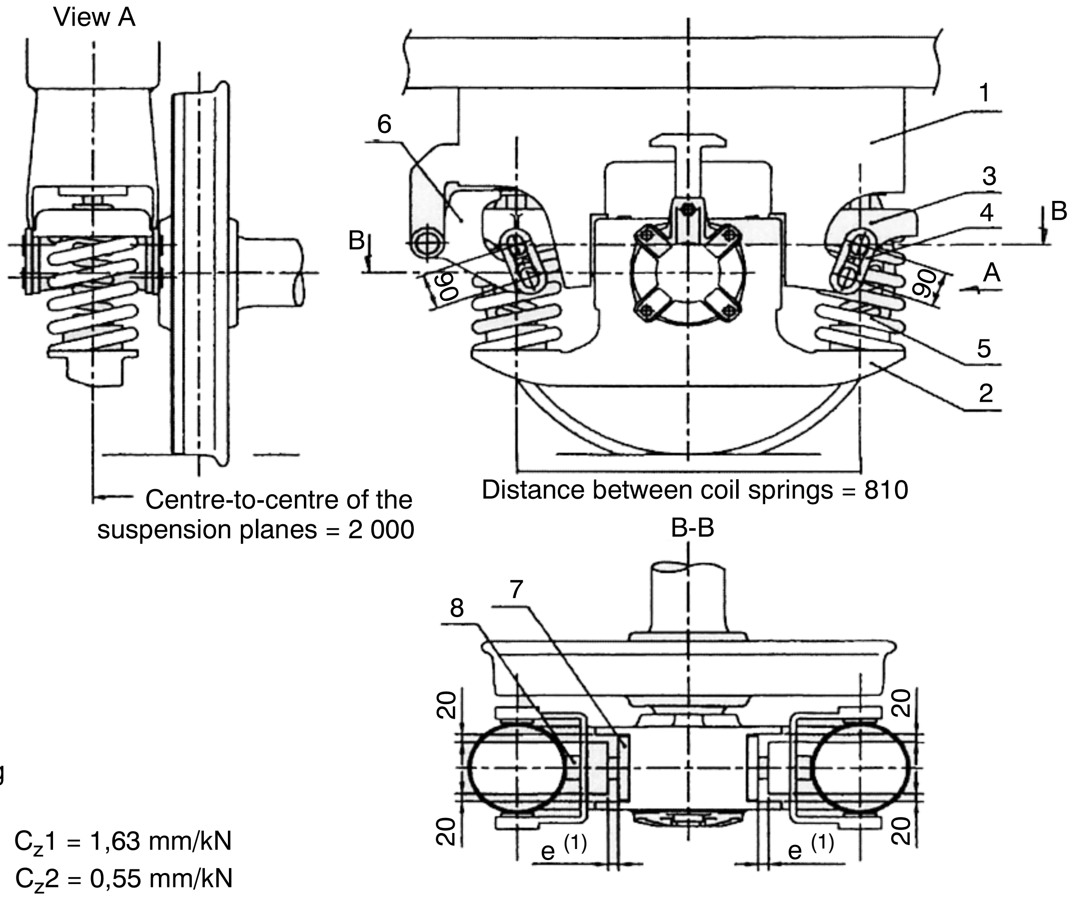
2) Dimension 289 represents the distance between the suspension pin centres. Given the functional clearance between the suspension pins and the fixing eyes or the bores of the suspension bracket, the centre-to-centre length of the fixing eyes is 290 mm.



2) Dimension 289 represents the distance between the suspension pin centres. Given the functional clearance between the suspension pins and the fixing eyes or the bores of the suspension bracket, the centre-to-centre length of the fixing eyes is 290 mm.

3) Dimension 673 mm only represents a theoretical centre-line. The exact dimension must be established using the corresponding calculation sheet in accordance with DT 135, Appendix F.

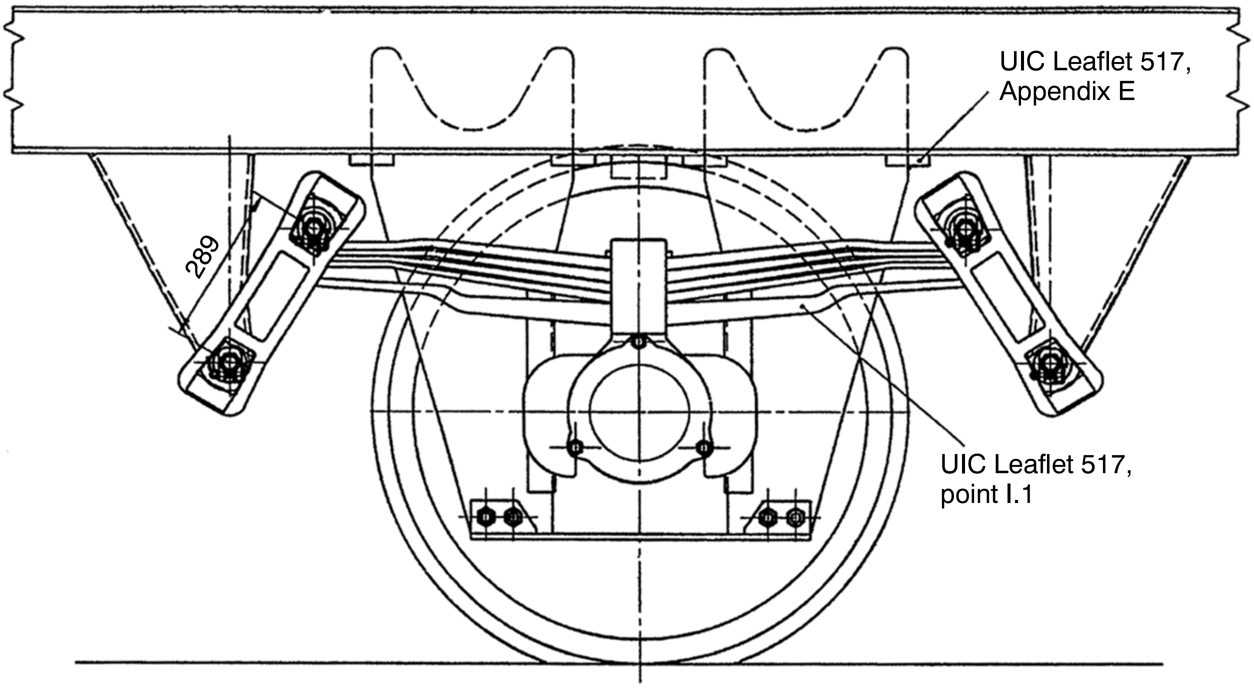
D.2 - Running gear with suspension using S 2000 springs



1 : Bracket
2 : Axle box
3 : Spring casing
4 : Damping link
5 : Coil spring C_z1 = 1,63 mm/kN
C_z2 = 0,55 mm/kN
Transition weight = 40,5 kN
6 : Articulated stirrup ; Patent n° 91400457.7
7 : Axle damper slide push rod
8 : Axle damper push rod

(1) The distance "e" in mm is 3 times the number representing the vehicle wheelbase expressed in metres. However, this figure may not exceed 22,5 mm.

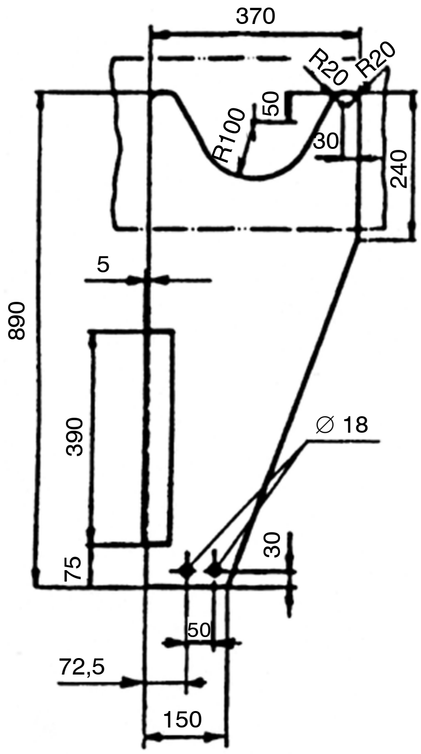
D.3 - Running gear with suspension using Niesky 2 springs



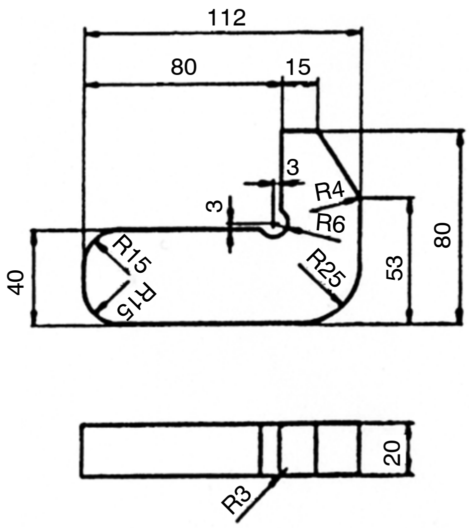
The spring suspension link of this running gear is the only constructional detail that is different to those of the double link running gear suspension given in point D.1 - page 13.

Appendix E - Axle guard, stirrup and axle guard tie bar - Standardisation

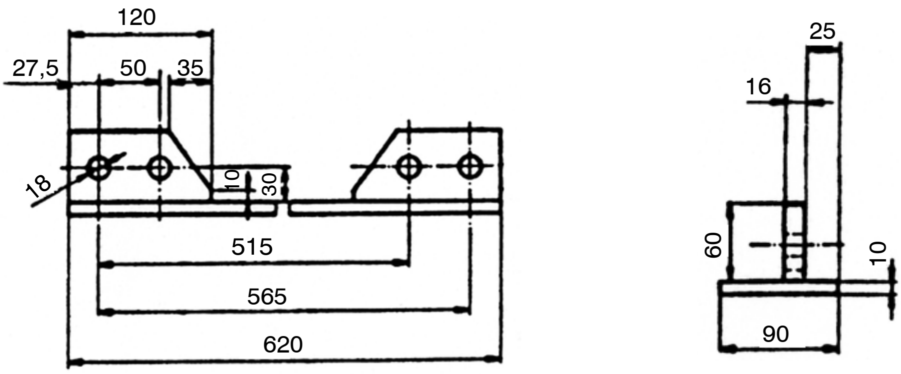
Axle guard



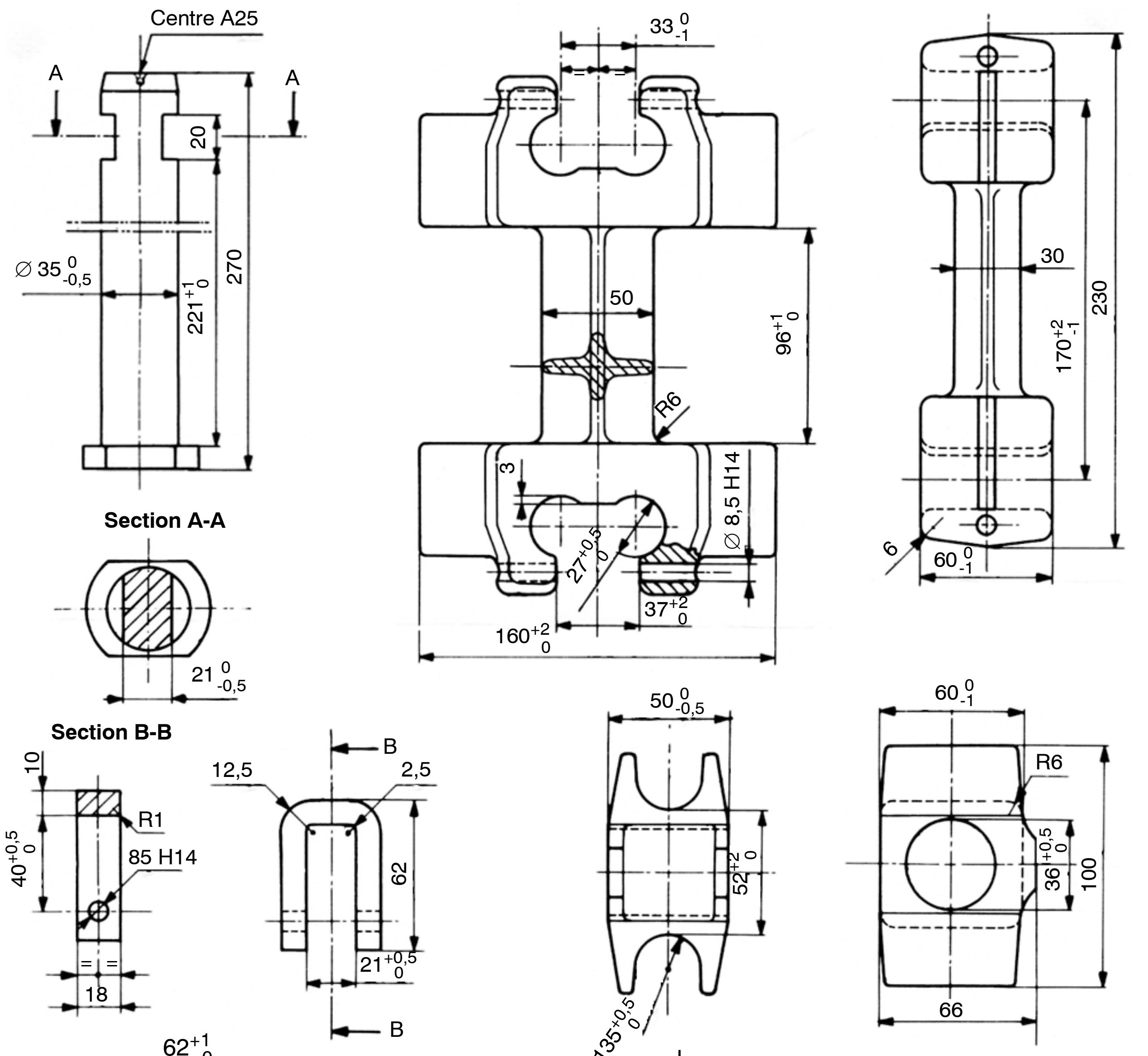
Stirrup

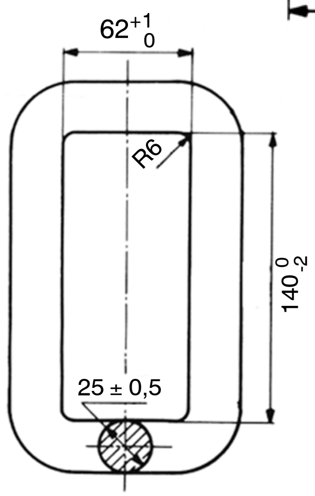


Axle-guard tie bar

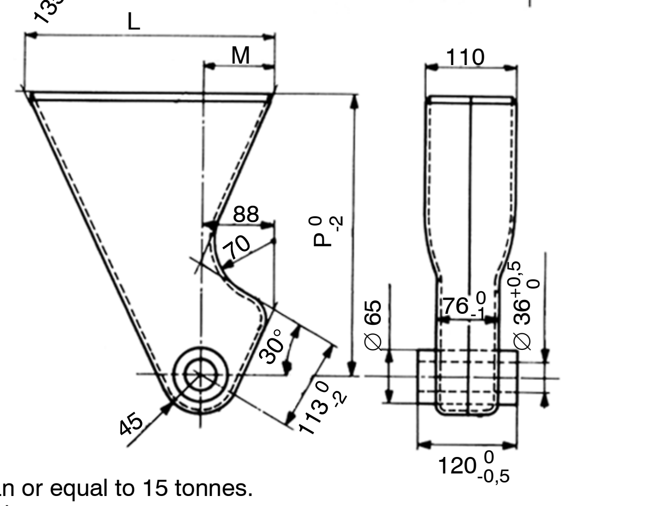


Appendix F - Double-link suspension components and suspension brackets - Standardisation





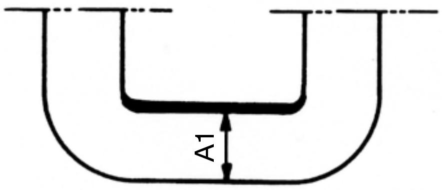
P	340	365
L	300	322
M	85	95



Dimensions P, L and M apply to wagons with a tare less than or equal to 15 tonnes.
For higher tare weights, larger dimensions may be permitted.

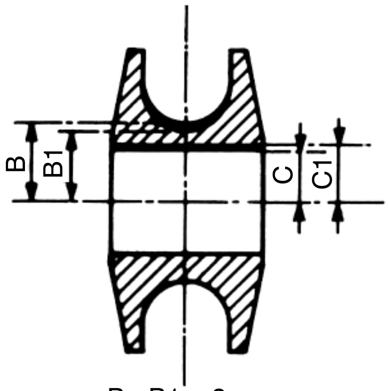
Appendix G - Double link suspension and suspension bracket wear limits

LINK



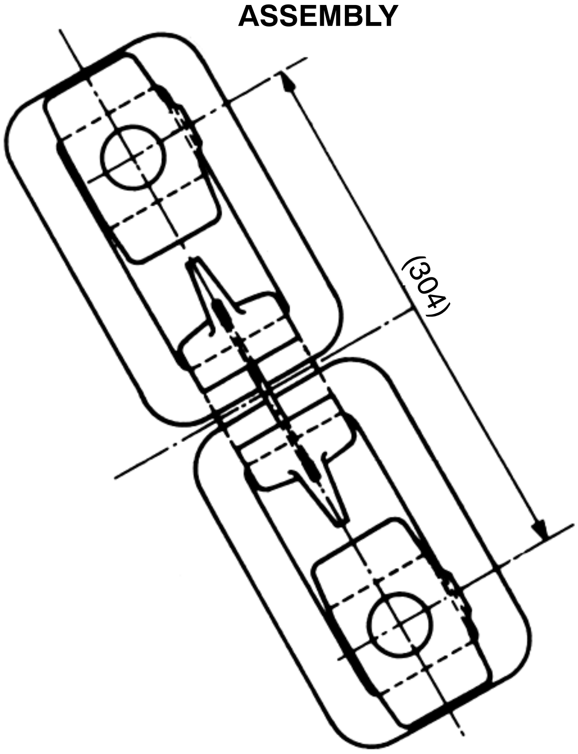
A1 = 23 mm

END BEARING

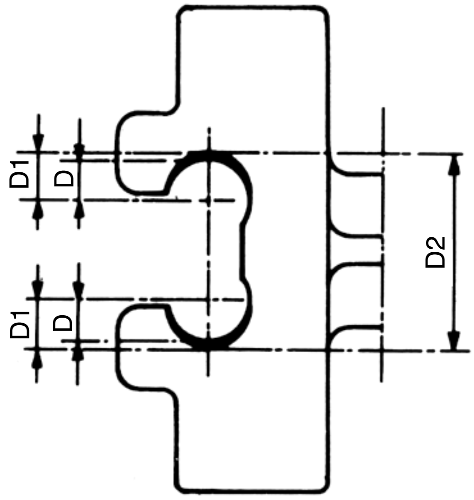


B - B1 = 2 mm
C1 - C = 2 mm
B1 - C1 = 4 mm

ASSEMBLY

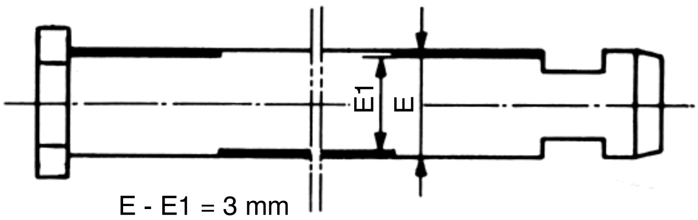


INTERMEDIATE BEARING



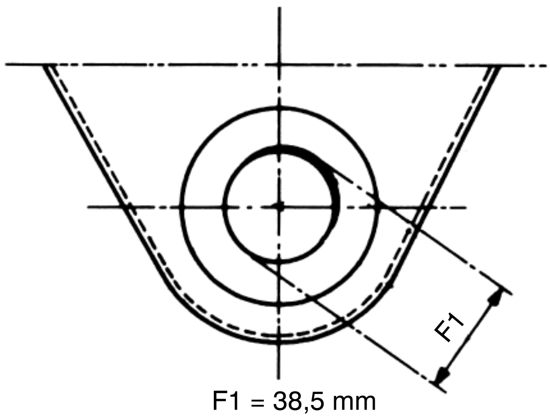
D1 - D = 1,5 mm
D2 = 63,5 mm

LINK PIN



E - E1 = 3 mm
E1 = 31,5 mm

SUSPENSION BRACKET



F1 = 38,5 mm

The maintenance regulations of railway networks must ensure that the length of the double link suspension, measured between the centres of the suspension pins, does not exceed 304 mm between two overhauls.

The difference in lengths of the sections of the same link must not exceed 3 mm at the time of maintenance.

NB : Taking account of the initial play and wear of the suspension pins and bore of the suspension bracket, the distance between the centre of the spring eye and that of the bore of the suspension bracket must not exceed 309 mm.

Appendix H - Leaf springs - Definition and determination of mean flexibility

H.1 - Definitions

H.1.1 - Mean flexibility of the spring : C_a

The mean flexibility of the spring C_a (mm/kN) is the ratio between spring deflection and loading. For springs with linear characteristics it is assumed to be constant over the whole range of loading and for springs with progressive characteristics it is assumed to be constant in the 1st and 2nd tier (of the whole spring).

This value is the average of the flexibility values measured under increasing and decreasing loading.

H.1.2 - Mean flexibility of the spring in the suspension : C_z

The mean flexibility C_z (mm/kN) is the ratio between the deflection and loading of the whole assembly formed by spring and the link mounting. It varies due to the effect of the suspension. For simplification it is assumed to be constant over the whole range of loads for springs with linear characteristics and for springs with progressive characteristics it is assumed to be constant in the 1st and 2nd tiers (of the whole spring).

This value is the average of the flexibility values measured under increasing and decreasing loading.

H.1.3 - List of symbols used

The following symbols are used, when calculating mean flexibility (C_a and C_z):

L	=	Length of the main leaf measured between the centres of the rolled eyes with the leaf assumed to be straight (mm)	
n	=	Total number of leaves (-)	For trapezoidal springs with linear characteristics
n'	=	Number of leaves with length L (-)	
h	=	Thickness of leaves (mm)	
n_o	=	Number of leaves in upper set (-)	For trapezoidal springs with progressive characteristics
n'_o	=	Number of leaves with length L (-)	
n_u	=	Number of leaves in lower set (-)	
h_o	=	Thickness of leaves in upper set (mm)	
h_u	=	Thickness of leaves in lower set (mm)	
b	=	Leaf width (mm)	
E	=	Young's modulus (kN/mm^2)	
e	=	Width of spring bracket (mm)	

S_{po} = Deflection of 1st spring leaf without load (mm)

z_c = Deflection of spring until the additional spring comes into action (mm)

o H.2 - Measurement of mean flexibility

H.2.1 - Determination of C_a

C_a is determined on a test rig using a trolley arrangement as shown in Fig. 1.

Measurements are to be taken according to the requirements of *UIC Leaflet 821* (see Bibliography - page 50).

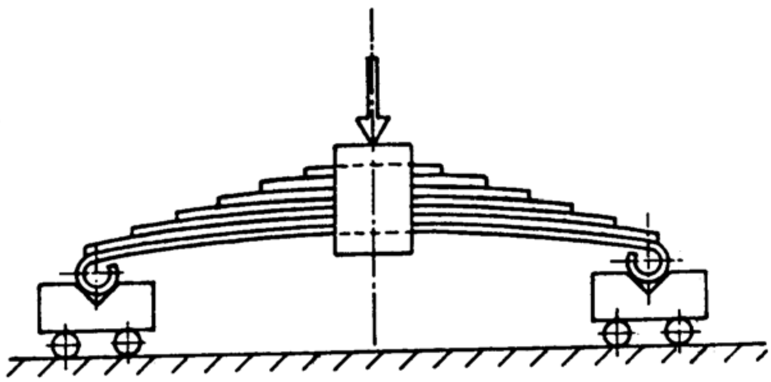


Fig. 1 -

H.2.2 - Determination of C_z

C_z is determined in the same manner as was described for C_a in point H.2.1, but with the link suspension shown in Fig. 2.

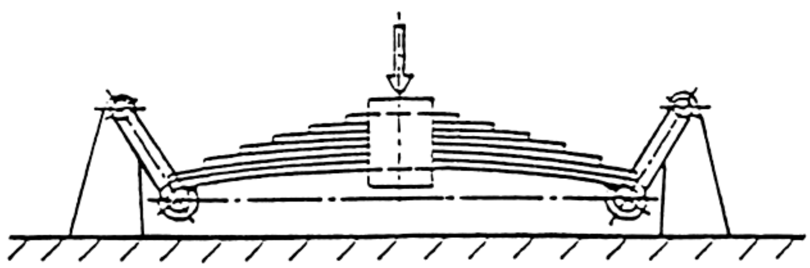


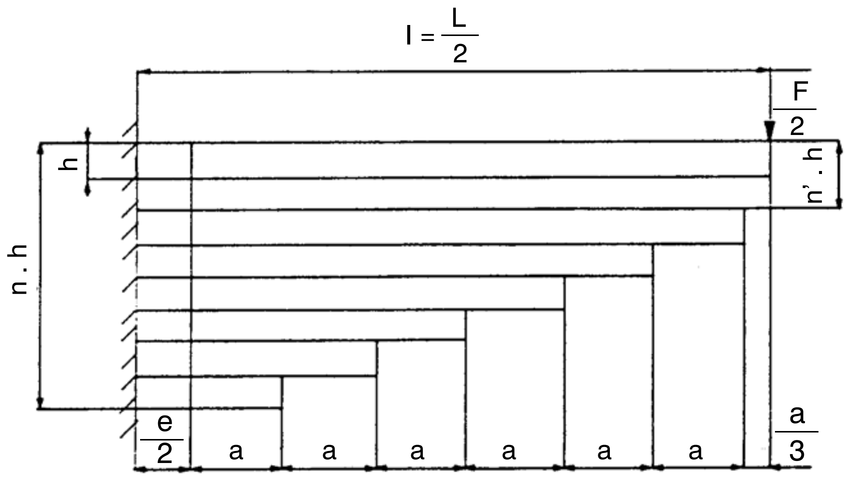
Fig. 2 -

H.3 - Calculation of mean flexibility

H.3.1 - Leaf springs (according to B 12/RP 25 - 2nd edition) (see Bibliography - page 50)

H.3.1.1 - Leaf springs with linear characteristics conforming to the following conditions:

- tier arrangement of the leaves according to the theoretical model of Fig. 3,
- rectangular cross-section of spring leaves,
- identical thickness of leaves.



$$a = \frac{L - e}{2 \cdot \left(\frac{1}{3} + n - n'\right)}$$

Fig. 3 - Leaf spring with linear characteristics

The mean flexibility C_{ar} is calculated with the following formula, using a trolley device:

$$C_{ar} = \frac{L^3}{n \cdot b \cdot h^3 \cdot E} \cdot K_1 \cdot K_2 \ (mm/kN)$$

K_1 is either taken from Table 1 - page 24 or is calculated with the following formula:

$$K_1 = \frac{1}{4}\left\{1 + \left(1 - \frac{e}{L}\right)^3 \cdot \left[3 \cdot \frac{\frac{1}{2} - 2 \cdot v + v^2 \cdot \left(\frac{3}{2} - \ell n\ v\right)}{(1 - v)^3} - 1\right]\right\}$$

$$v = \frac{n'}{n}$$

Table 1 : Coefficient K_1 for calculating the flexibility leaf springs with linear characteristics

v \ e/L	$\frac{1}{8}$	$\frac{1}{9}$	$\frac{1}{10}$	$\frac{1}{11}$	$\frac{1}{12}$	$\frac{1}{13}$	$\frac{1}{14}$	$\frac{1}{15}$	$\frac{1}{16}$
$\frac{1}{7}$	0,30960	0,31248	0,31485	0,31684	0,31852	0,31997	0,32123	0,32233	0,32330
$\frac{1}{6}$	0,30661	0,30935	0,31160	0,31349	0,31509	0,31646	0,31766	0,31870	0,31963
$\frac{2}{11}$	0,30480	0,30745	0,30963	0,31146	0,31301	0,31434	0,31549	0,31651	0,31740
$\frac{1}{5}$	0,30271	0,30526	0,30736	0,30911	0,31060	0,31188	0,31299	0,31397	0,31483
$\frac{2}{9}$	0,30026	0,30270	0,30470	0,30637	0,30779	0,30901	0,31007	0,31100	0,31182
$\frac{1}{4}$	0,29736	0,29965	0,30154	0,30312	0,30446	0,30561	0,30661	0,30748	0,30825
$\frac{3}{11}$	0,29510	0,29729	0,29908	0,30058	0,30186	0,30296	0,30391	0,30474	0,30548
$\frac{2}{7}$	0,29386	0,29598	0,29772	0,29918	0,30042	0,30149	0,30241	0,30323	0,30394
$\frac{3}{10}$	0,29252	0,29457	0,29627	0,29768	0,29888	0,29992	0,30081	0,30160	0,30229
$\frac{1}{3}$	0,28952	0,29143	0,29300	0,29432	0,29543	0,29639	0,29723	0,29796	0,29860

$k_2 = 1$, when $S_{po} \geq 0$

$$K_2 = \sqrt[3]{1 - \frac{16}{3} \cdot \left(\frac{S_{po}}{L}\right)^2} \quad \text{, when } S_{po} < 0$$

The mean flexibility C_{zr} in a link suspension is calculated with the following formula:

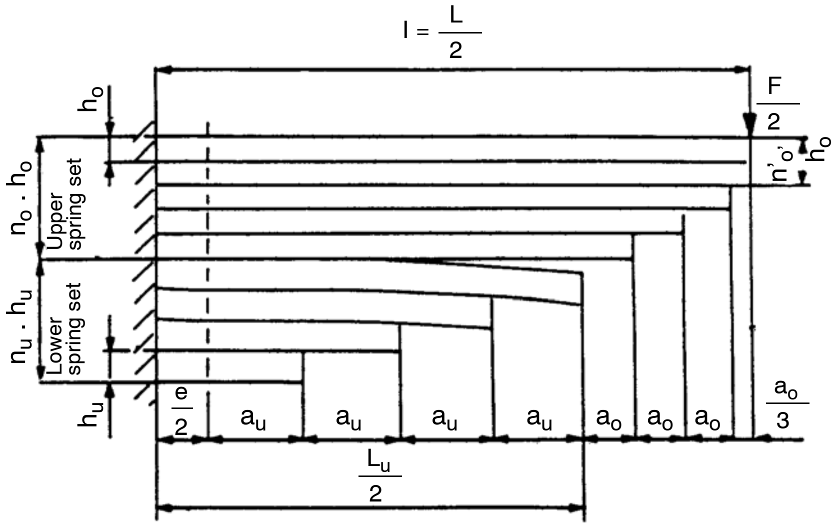
$$C_{zr} = C_{ar}(1{,}9 \cdot 10^{-3} \cdot S_{po} + 1)(mm/kN)$$

H.3.1.2 - Leaf springs with progressive characteristics conforming with the following characteristics:

- tier arrangement of the leaves in accordance with the theorical model shown in Fig. 4 - page 25,
- rectangular cross-section of the spring leaves,
- identical thickness of leaves in both the upper and lower sets.

As in the measurements, in the calculations for leaf springs with progressive characteristics, a distinction must be made between two types of flexibility:

C_{a1r} (1st tier) and C_{a2r} (2nd tier) for the trolley or C_{z1r} and C_{z2r} for the link suspension.



$$a_o = \frac{\frac{1}{2} \cdot (L - e)}{\frac{1}{3} + n_o - n'_o + n_u \cdot \left(\frac{h_u}{h_o}\right)^3} \; ; \; a_u = a_o \cdot \left(\frac{h_u}{h_o}\right)^3 \; ; \; L_u = L - 2 \cdot a_o \cdot \left(\frac{1}{3} + n_o - n'_o\right)$$

Fig. 4 - Leaf spring with progressive characteristics

The calculations are made with the following formulae:

- For the 1st tier:

$$C_{a1r} = \frac{L^3}{n_o \cdot b \cdot h_o^3 \cdot E} \cdot K_3 \text{ (mm/kN)}$$

$$K_3 = \frac{1}{4} \cdot \left\{ 1 + \left(1 - \frac{L_u}{L}\right)^3 \cdot \left[3 \cdot \frac{\frac{1}{2} - 2 \cdot v_o + v_o^2 \left(\frac{3}{2} - \ell n \; v_o\right)}{(1 - v_o)^3} - 1 \right] \right\}$$

$$v_o = \frac{n'_o}{n_o}$$

- for the whole spring (2nd tier):

$$C_{a2r} = \frac{L^3}{b \cdot E \cdot (n_o \cdot h_o^3 + n_u \cdot h_u{}^3)} \cdot K4 \ (mm/kN)$$

$$K_4 = \frac{1}{4} \cdot \left\{ 1 + \left(1 - \frac{e}{L}\right)^3 \cdot \left[3 \cdot \frac{\frac{1}{2} - 2 \cdot v + v^2 \cdot \left(\frac{3}{2} - \ell n \ v\right)}{(1 - v)^3} - 1 \right] \right\}$$

$$L_u = L - 2 \ a_o \cdot \left(\frac{1}{3} + n_o - n'_o\right) \quad (mm)$$

$$v = \frac{n'_o \cdot h'^3_o}{n_o \cdot h_o^3 + n_u \cdot h_u^3}$$

Calculation of the mean flexibility within the link suspension is carried out with the following formulae:

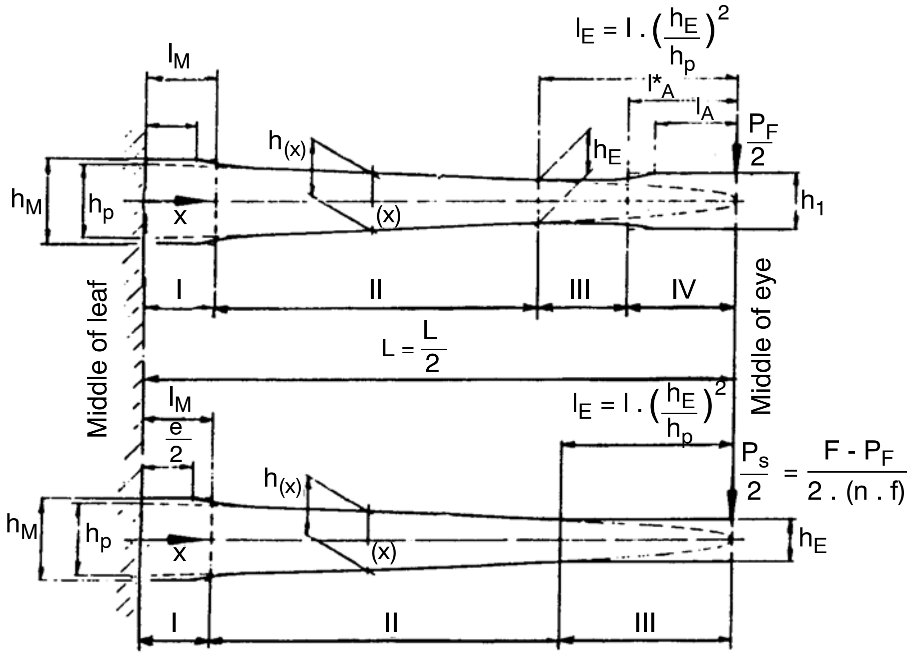
$$C_{z1r} = C_{a1r}(1{,}9 \cdot 10^{-3} \cdot S_{po} + 1) \quad (mm/kN)$$

$$C_{z2r} = C_{a2r}(1{,}9 \cdot 10^{-3} \cdot (S_{po} - z_c) + 1) \quad (mm/kN)$$

H.3.2 - Parabolic springs (according to report B 12/RP 43) - see Bibliography - page 50

H.3.2.1 - Parabolic springs with linear characteristics fulfilling the following conditions:

- all leaves of identical length,
- all leaves of identical width,
- tier arrangement of leaf thicknesses according to Fig. 5 - page 27,
- cross-section of leaves with semi-circular edges or rounded corners according to Fig. 6 - page 27.



a) Characteristics of main leaves of springs arranged in one or two tiers:

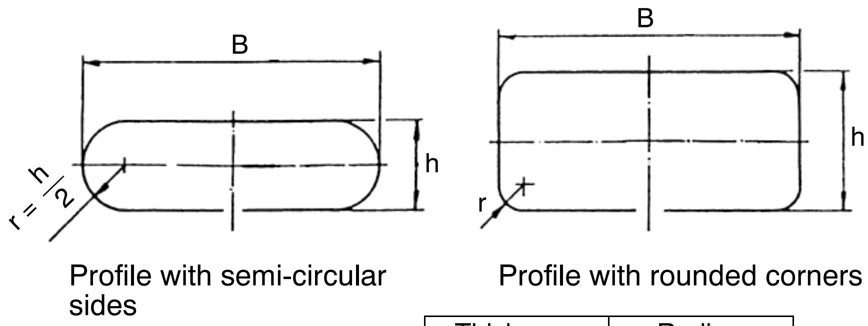
– — — – Theoretical tier arrangement of leaves

——— Actual tier arrangement of leaves

– · — · – Tier arrangement of leaves for calculations

b) Characteristics of secondary leaves of springs arranged in one or two tiers and in general for supplementary springs

Fig. 5 - Tier arrangement of leaf thickness in parabolic springs



Thickness h (mm)	Radius r (mm)
≤ 40	8 ± 2
> 40	12 ± 2

Fig. 6 - Forms of leaf cross-sections of parabolic springs

Flexibility "C_{ar}" with the trolley arrangement.

Calculation of the mean flexibility of a spring C_{ar}, with the trolley arrangement is carried out in accordance with the following formulae by adding the inverse values of the flexibilities of the individual leaves:

$$C_{ar} = \frac{C_{aF} \cdot C_{aS}}{C_{aF} \cdot (n-1) + C_{aS}} \cdot K_p \qquad \text{[mm/kN]}$$

with

$$C_{aF} = \frac{L^3}{48 \cdot E \cdot I_p} \cdot K_{CF} \qquad \text{[mm/kN] (main leaf)}$$

$$C_{aS} = \frac{L^3}{48 \cdot E \cdot I_p} \cdot K_{CS} \qquad \text{[mm/kN] (secondary leaf)}$$

$$K_{CF} = \left(\frac{h_p}{h_M}\right)^3 \cdot \left[1 - \left(1 - \frac{\ell_M}{\ell}\right)^3\right] + 2 \cdot \left(1 - \frac{\ell_M}{\ell}\right)^{\frac{3}{2}} - \left(\frac{h_E}{h_p}\right)^3 \cdot \left(\frac{\ell^*_A}{\ell}\right)^3 \cdot \left[\left(\frac{h_p}{h_E}\right)^3 - \left(\frac{h_p}{h_A}\right)^3\right]$$

$$K_{CS} = \left(\frac{h_p}{h_M}\right)^3 \cdot \left[1 - \left(1 - \frac{\ell_M}{\ell}\right)^3\right] + 2 \cdot \left(1 - \frac{\ell_M}{\ell}\right)^{\frac{3}{2}} - \left(\frac{h_E}{h_p}\right)^3$$

$$p = \frac{h_p^3}{12} \cdot (b - 0{,}41 \cdot h_p) \ [\text{mm}^4] \qquad \text{(Profiles with semi-circular sides)}$$

or

$$p = \frac{h_p^3}{12} \cdot (b - r \cdot \delta) \ [\text{mm}^4] \qquad \text{(Profiles with rounded edges)}$$

$$\delta = 3 \cdot \frac{r}{h_p} \cdot \left\{4 - \pi - \frac{r}{h_p} \cdot \left[\frac{40}{3} - 4 \cdot \pi - \frac{r}{h_p} \cdot (16 - 5 \cdot \pi)\right]\right\}$$

$$Kp = \left\{1 - \frac{p^*_{Kp} - K}{L^2} \cdot \left[\frac{8}{3} \cdot (p^*_{Kp} + 2\,K) - 2 \cdot (D_M + D_E) - 0{,}16L\right]\right\}^3$$

$$p^*_{Kp} = H_{20} - D - (F_{Kp} - F_{20}) \cdot \frac{C_{aF} \cdot C_{aS}}{C_{aS} + (n-1) \cdot C_{aF}} \quad [\text{mm}]$$

$$F_{Kp} = \frac{F_1 + F_2}{2} \quad [\text{kN}]$$

F_1, F_2 : Loads for checking the flexibility according to *UIC Leaflet 821* (see Bibliography - page 50)

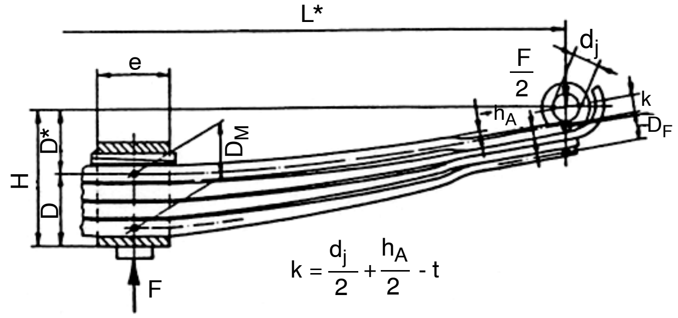


Fig. 7 - Drawing of a parabolic spring with constant flexibility defining the magnitudes D_M, D_E and k to be calculated

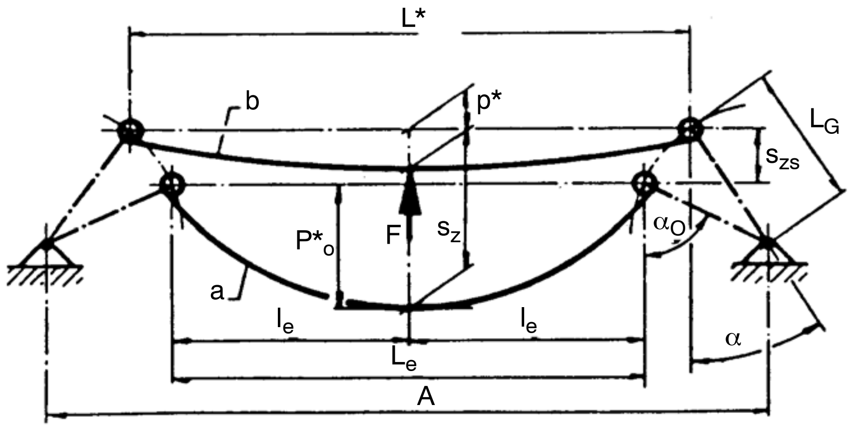
Flexibility "C_{zr}" with inclined link suspension.

As can be seen in Fig. 8, the compression of the springs of axle "s_z" is composed of the following parts:

S_{zf} = deflection of the spring

S_{zs} = kinematic deflection due to the change of angle of the link

S_{zA} = extension of link by expansion of the elements.



$s_z = s_{zF} + s_{zS} = s_{zA}$

Fig. 8 - Diagram of a parabolic spring with link suspension
a = in no-load condition, b = under load

If the sum of the partial elastic movements is related to the spring force, a force-deflection diagram is obtained, which shows a different slope for each point (flexibility). It is best at first to calculate fully this characteristic and then to linearise it for practical use. The mean flexibility C_{zr} must be calculated for the same forces as the ones specified in *UIC Leaflet 821* for determining C_a with the trolley arrangement.

The calculation of the characteristic is carried out with a known construction height and, therefore, also with known deflection "$p*_o$" (spring not loaded, distance between the centre line of the attachment eye and the middle of leaf 1 in the spring buckle for each assumed deflection "p*") using the following formulae:

$$F_{(p*)} = \frac{p*_o - p*}{C_{ar} \cdot (1 + 2 \cdot \lambda \cdot [(p* + \Delta p) / L] \cdot \tan\alpha_{(p*)})} \qquad [kN]$$

$$s_{z(p*)} = p*_o - p* + \ell_G \cdot (\cos\alpha_{(p*)} - \cos\alpha_o) + C_{zA} \cdot F_{(p*)} \qquad [mm]$$

with

λ = 1,37 and C_{zA} = 0,006 [mm/kN].

$$p*_o = H_{20} + \frac{C_{ar}}{F_{20}} - D \qquad [mm]$$

$$L_o = L \cdot \left[1 - \frac{8}{3} \cdot \left(\frac{p*_o - k}{L}\right)^2 - 8 \cdot k \cdot \frac{p*_o - k}{L^2}\right] \qquad [mm]$$

$$L*_{(p*)} = L \cdot \left[1 - \frac{8}{3} \cdot \left(\frac{p* - k}{L}\right)^2 - 8 \cdot k \cdot \frac{p* - k}{L^2}\right] \qquad [mm]$$

$$\tan\alpha_{p*} = \frac{(A - L*_{(p*)}) / (2 \cdot \ell_G)}{\sqrt{1 - \left(\frac{A - L*_{(p*)}}{2 \cdot \ell_G}\right)^2}}$$

$$\cos\alpha_{p*} = \sqrt{1 - \left(\frac{A - L*_{(p*)}}{2 \cdot \ell_G}\right)^2}$$

$$\cos\alpha_o = \sqrt{1 - \left(\frac{A - L_o}{2 \cdot \ell_G}\right)^2}$$

$$\Delta_p = \frac{1}{2} \cdot (D_M - D_E) \qquad [mm]$$

H.3.2.2 - Parabolic springs with progressive flexibility, which fulfil the conditions of point H.3.2.1 - page 26.

Flexibility "C_{ar}" with the trolley arrangement.

Calculation of the mean flexibility of a spring C_{ar} with the trolley arrangement is carried out in accordance with the following formulae by adding the inverse values of the flexibilities of the individual leaves:

C_{a1r} = Flexibility of the 1st spring tier [mm/kN]

$$C_{a1r} = \frac{C_{aF} \cdot C_{aS}}{C_{aF} \cdot (n-1) + C_{aS}} \cdot k_{p1}$$

(Calculation of C_{aF} and C_{aS} as in point H.3.2.1 - page 26)

C_{a2r} = Flexibility of the whole spring [mm/kN]

$$C_{a2r} = \frac{C_{a1r} \cdot C_{aZu}}{C_{a1r} + C_{aZu}} \cdot k_{p2}$$

(Calculation of C_{aZu} as C_{aS} in point H.3.2.1 - page 26)

With (see also Fig. 9 - page 32)

$$k_{p1} = \left\{1 - \frac{p*_{Kp1} - k}{L^2} \cdot \left[\frac{8}{3} \cdot (p*_{Kp1} + 2k) - 2 \cdot (D_{M1} + D_{E1}) - 0{,}16L\right]\right\}^3$$

$$p*_{Kp1} = H_{20} - D - (F_{Kp1} - F_{20}) \cdot \frac{C_{aF} \cdot C_{aS}}{C_{aF} \cdot (n-1) + C_{as}} \quad \text{[mm]}$$

$$F_{Kp1} = \frac{F_1 + F_2}{2} \quad \text{[kN]}$$

$$k_{p2} = \left\{1 - \frac{p*_{Kp2} - k}{L^2} \cdot \left[\frac{8}{3} \cdot (p*_{Kp2} + 2k) - 2 \cdot (D_{M2} + D_{E2}) - 0{,}16L\right]\right\}^3$$

$$p*_{Kp2} = H_{100} - D - (F_{Kp2} - F_{100}) \cdot \frac{C_{a1r} \cdot C_{aZu}}{C_{a1r} + C_{aZu}} \quad \text{[mm]}$$

$$F_{Kp2} = \frac{F_3 + F_4}{2} \quad \text{[kN]}$$

F_1, F_2, F_3, F_4 : loads for checking the flexibility according to *UIC Leaflet 821*.

Flexibility "C_{zr}" with inclined link suspension.

As was the case for linear parabolic springs, it is best for progressive parabolic springs, to begin with the establishment of the force-deflection diagram in order to be able to determine the flexibilities C_{z1r} and C_{z2r}. The flexilibilty is calculated separately for the first and second spring tiers taking into account the transition point.

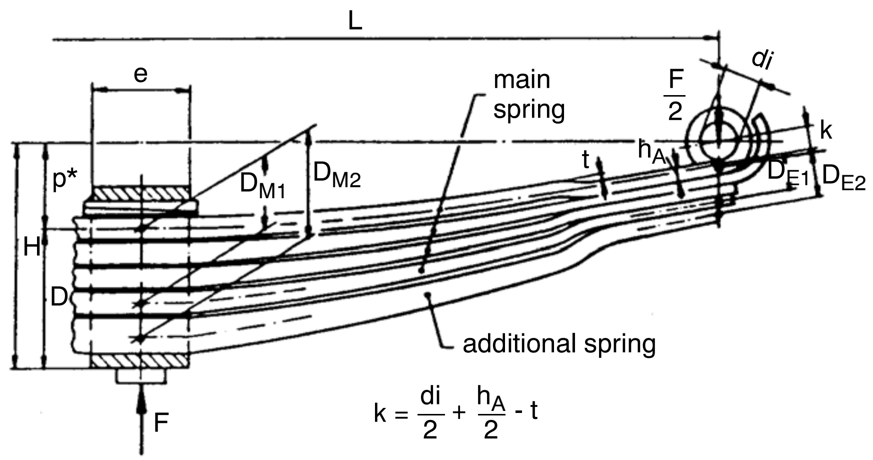


Fig. 9 - Drawing of a parabolic spring with progressive flexibility and definition of magnitudes k, D_{M1}, D_{M2}, D_{E1}, D_{EZ} and D to be calculated

The main spring must be calculated exactly like the linear parabolic spring (see point H.3.2.1 - page 26) with $C_{ar} = C_{a1r}$ and $\Delta_p = \Delta_{p1}$.

$$\Delta_{p1} = \frac{1}{2} \cdot (D_{M1} - D_{E1}) \qquad \text{[mm]}$$

The calculation of the spring as a whole is carried out in accordance with the following formulae:

$$F_{ges(p*)} = F_o + \frac{p*_o - p*}{C_{a2r} \cdot (1 + 2 \cdot \lambda \cdot [(p* + \Delta_{p2})/L] \cdot \tan\alpha_{(p*)})} \qquad \text{[kN]}$$

$$s_{z(p*)} = p*_o - p* + \ell_G \cdot (\cos\alpha_{(p*)} - \cos\alpha_o) + C_{zA} \cdot F_{ges(p*)} \qquad \text{[mm]}$$

The calculation of the magnitudes required for λ, C_{zA}, $p*_o$, $\cos\alpha_{(p*)}$, $\tan\alpha_{(p*)}$ and $\cos\alpha_o$ is carried out in the same way as in point H.3.2.1 with $C_{ar} = C_{a1r}$.

$$\Delta_{p2} = \frac{1}{2} \cdot (D_{M2} - D_{E2}) \qquad \text{[mm]}$$

$$F_o = F_{ges_c} - \frac{p*_o - p*_c}{C_{a2r} \cdot \{1 + 2 \cdot \lambda \cdot [(p*_c + \Delta_{p2})/L] \cdot \tan\alpha_c\}} \qquad \text{[kN]}$$

The position of the transition point (index E) is determined from:

$$F_{ges_c} = F_{zc} = \frac{p*_o - p*_c}{C_{a1r} \cdot \{1 + 2 \cdot \lambda \cdot [(p*_c + \Delta_{p1})/L] \cdot \tan\alpha_c\}} \qquad \text{[kN]}$$

$$s_{ges_c} = s_{zc} = s_{Rc} + \ell_G \cdot (\cos\alpha_c - \cos\alpha_o) + C_{zA} \cdot F_{ges_c} \qquad \text{[mm]}$$

with

$$F_{Rc} = \frac{H_{20} - H_2 + F_1 \cdot C_{a1r} - F_2 \cdot C_{a2r}}{C_{a1r} - C_{a2r}} \qquad [kN]$$

$$S_{Rc} = \frac{C_{a1r}}{F_{Rc}} \qquad [mm]$$

$$p*_c = p*_o - s_{Rc} \qquad [mm]$$

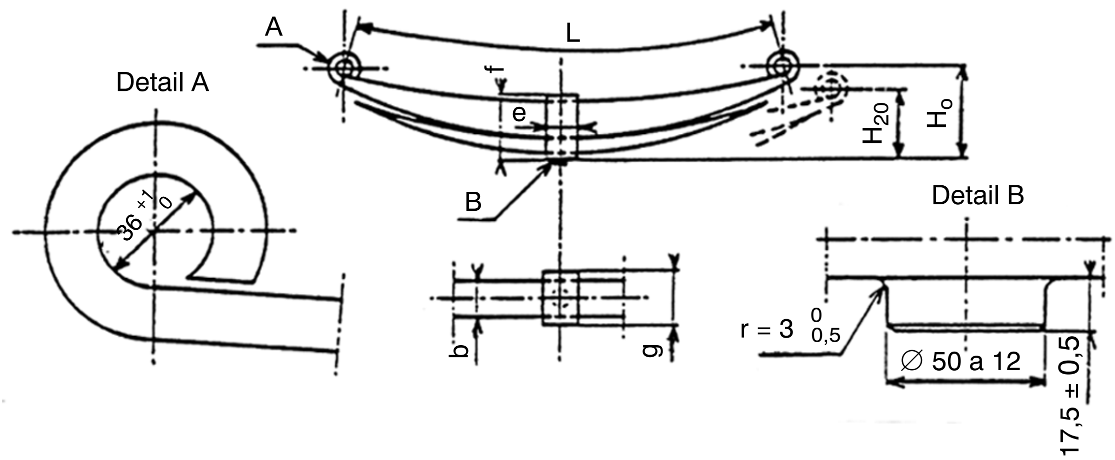
$$\boxed{L_c = L \cdot \left[1 - \frac{8}{3} \cdot \left(\frac{p*_c - k}{L}\right)^2 - 8 \cdot k \cdot \frac{p*_c - k}{L^2}\right]} \qquad [mm]$$

$$\tan\alpha_c = \frac{(A - L_c)/(2 \cdot \ell_G)}{\sqrt{1 - \left(\frac{A - L_c}{2 \cdot \ell_G}\right)^2}}$$

$$\cos\alpha_c = \sqrt{1 - \left(\frac{A - L_c}{2 \cdot \ell_G}\right)^2}$$

Appendix I - Leaf springs with progressive stiffness

I.1 - Leaf springs with progressive stiffness for two-axle wagons - Standardisation

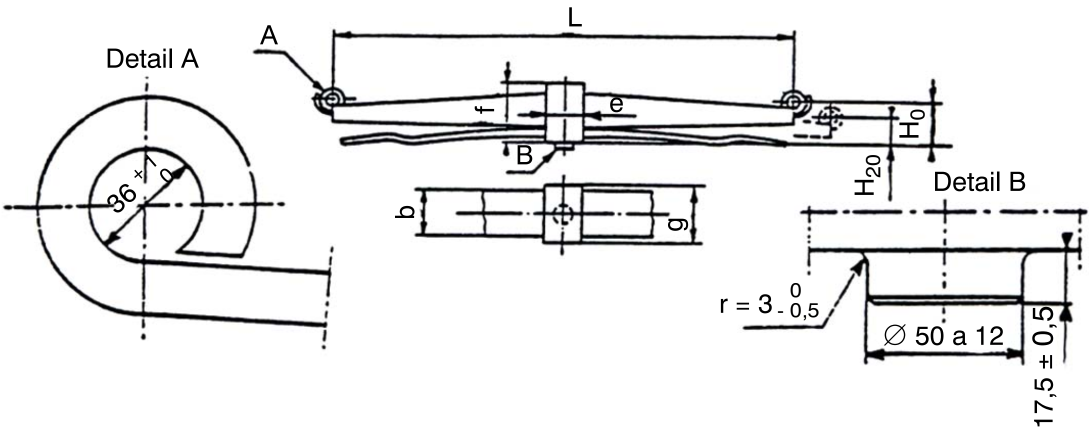


Spring type			Parabolic 20 t [a] cf. points J.1 - page 39, J.2 - page 40	Parabolic 22,5 t cf. points J.1 - page 39, J.2 - page 40		Leaf 20 t cf. points K.1 - page 44, K.2 - page 45
Characteristics	Symbol	Unit				
Permissible axle-load - ordinary and S conditions - SS conditions	P	t	20 20	22,5 [b] 22,5 [b]		20 20
Length of main spring leaf (measured between the centres of the rolled eyes of the leaf assumed to be straight)	L	mm	1 200 ± 3	1 200 ± 3		1 200 ± 3
Spring height under zero load	H_o	mm	232	227		216
Spring height under load of 20 kN applied in trolley mounting [c]	H_{20}	mm	202^{+3}_{-2}	202^{+3}_{-2}		$194{,}6^{+3}_{-2}$
Cross-section of spring leaves: - of the 1st set - of the 2nd set	$b \times h_o$ $b \times h_u$	mm mm	120 x 20 120 x 35	120 x 21 120 x 36		120 x 15 120 x 20

Spring type			Parabolic 20 t [a] cf. points J.1 - page 39, J.2 - page 40	Parabolic 22,5 t cf. points J.1 - page 39, J.2 - page 40		Leaf 20 t cf. points K.1 - page 44, K.2 - page 45
Characteristics	Symbol	Unit				
Number of spring leaves:						
- in the 1st set	n_o	leaf	4	4		5
- in the 2nd set	n_u	leaf	1	1		4
Clearance between 2 sets (measured at the end of the 1st leaf of the 2nd set) under zero load	J	mm	-	-		14^{+1}_{-2}
Buckle dimensions:						
width	e	mm	100^{+4}_{-2}	100^{+4}_{-2}		100 ± 2
height	f	mm	170^{+3}_{-2}	170^{+3}_{-2}		$204,5^{+3}_{-1}$
length	g	mm	150 ± 3, 5	150 ± 3, 5		153^{+2}_{-1}
Mass	m	kg	97	103		130
ERRI standard drawing n°:			100 M 1340 0005-Ens A[d]	100 M 1340 0005-Ens C[d]		200 M 1340 0004

a. For existing wagons only.
b. The maximum axle load permitted in international traffic is however limited to 20 t under S and SS running conditions.
c. H_{20} : mean value between the height obtained under increasing load and the height obtained under decreasing load (see UIC Leaflet 821 - see Bibliography).
d. Standard parabolic springs are defined in patents; the references and conditions of use of these patents are specified in ERRI DG4 - Appendix 4 (UIC member railways are allowed to use the drawings of these springs exclusively for their own requirements).

I.2 - Parabolic spring with progressive stiffness for bogies - standardisation



Spring type			Parabolic 22,5 t cf. points J.4 - page 42, J.5 - page 43			
Characteristics	Symbol	Unit				
Permitted axle-load - ordinary and S conditions - SS conditions	P	t	22,5 [a] 22,5 [a]			
Length of main spring leaf (measured between the centres of the rolled eyes of the leaf assumed to be straight)	L	mm	1 200 ± 3			
Spring height under zero load	H_o	mm	116			
Spring height under a load of 20 kN in a trolley mounting[b]	H_{20}	mm	92^{+3}_{-2}			
Cross-section of spring leaves: - of the 1st set - of the 2nd set	$b \times h_o$ $b \times h_u$	mm mm	120 x 21 120 x 28			
Number of spring leaves: - of the 1st set - of the 2nd set	n_o n_u	leaf leaf	4 1			
Buckle dimensions: Width Height Length	 e f g	 mm mm mm	 100^{+4}_{-2} $163^{+3,5}_{-2}$ 150 ± 3, 5			
Mass	m	kg	95			
ERRI standard drawing n° :			100 M 1340 0011[c]			

a. The maximum axle load permitted in international traffic is 20 t under S and SS running conditions.
b. H_{20} : mean value between the height reached under increasing load and under decreasing load respectively (see UIC leaflet 821 - see Bibliography).
c. Standard parabolic springs are defined in patents; the references and conditions of use of these patents are specified in ORE DG4, Appendix 4 (UIC member railways are allowed to use the drawings of these springs for their own requirements).

I.3 - Leaf springs with progressive stiffness for bogies and two-axle wagons

Elastic characteristics

			Bogies		2-axle wagons					
Spring type			Parabolic 22,5 t		Parabolic 20 t[a]		Parabolic 22,5 t		Leaf 20 t	
Characteristics	Symbol	Unit	as-made	in use	as-made	in use	as made	in use	as-made	in use
Mean flexibility of the spring alone (measured with F = 1 kN - of the 1st set of spring leaves - of the spring as a whole	C_{a1} C_{a2}	mm/kN mm/kN	1,15 ±7% 0,61		1,52 ±7% 0,63		1,27 ±7% 0,56		1,07 ±8% 0,48	
Mean flexibility of the unit (spring and unified link suspension) - 1st set of spring leaves - spring as a whole	C_{z1} C_{z2}	mm/kN mm/kN		1,13 ±7% 0,54		1,82 ±7% 0,59		1,55 ±7% 0,55		0,88 ±8% 0,48
Mean stiffness of the unit (spring and suspension) - 1st set of spring leaves - spring as a whole	C_{z1} C_{z2}	kN/mm kN/mm		0,89 ±7% 1,86		0,55 ±7% 1,69		0,65 ±7% 1,82		1,14 ±8% 2,08
Load corresponding to the change in flexibilities C_z	F_{zc}	kN		40		37,9		41,1		40,5
Maximum load for testing of springs in accordance with *UIC Leaflet 821*	F_m	kN	170		170		170		170	
Maximum permissible stress	σ_{max}	N/mm^2	1 350		1 350		1 350		1 100	
Deflection corresponding to a maximum permissible stress: this deflection determines the positioning of the stop on the wagon	s_{max}	mm		123		154		146,5		111
Loads for checking the specific flexibility by using a trolley device during acceptance tests: - 1st set of spring leaves - spring as a whole	F_2 F_p F_3 F_4	kN kN kN kN	10 30 80 120		10 30 80 120		10 30 80 120		5 15 50 100	
Loads for checking the flexibility of the suspension (spring + double link suspension) - 1st set of spring leaves - spring as a whole	F'_2 F'_p F'_3 F'_4	kN kN kN kN		10 30 80 120		10 30 80 120		10 30 80 120		20 30 50 100

a. For existing wagons only

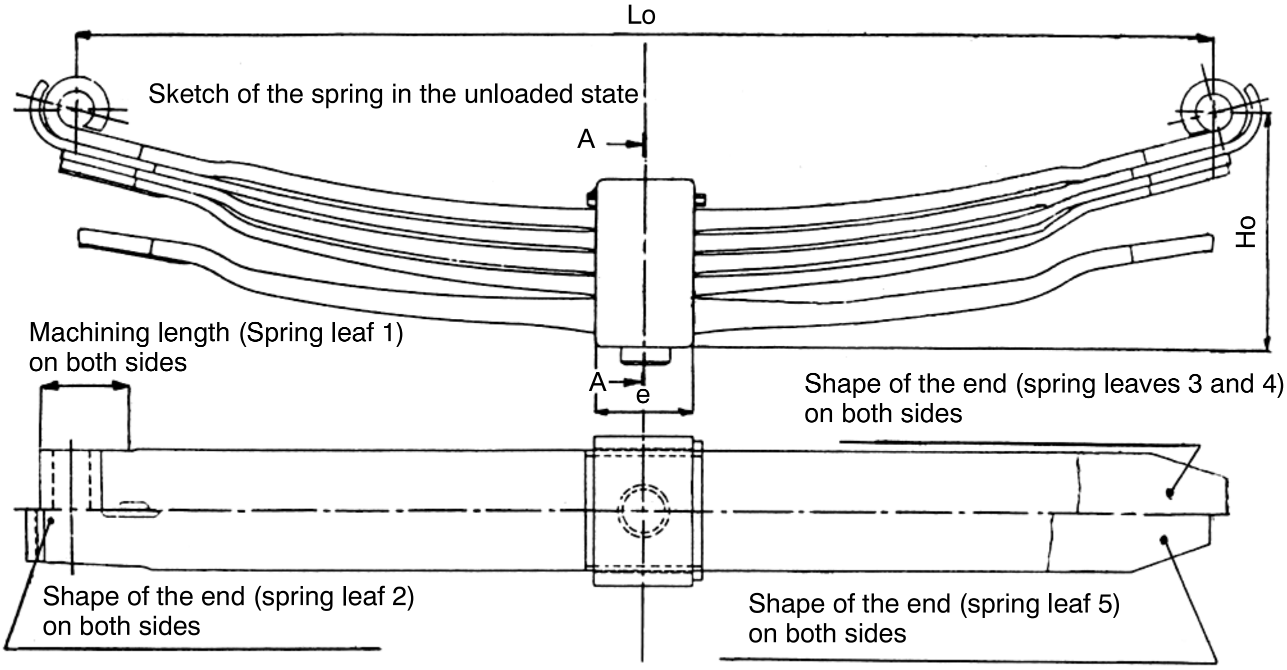
I.4 - Leaf springs with progressive stiffness for bogies and two-axle wagons - Special manufacturing characteristics

			Bogies	Two-axle wagons		
			Parabolic spring			Leaf spring
			22,5 t	20 t [a]	22,5 t	
Steel	Main spring leaf	Grade	13 according to ISO 683/XIV			13 according to ISO 683/XIV
		Mechanical characteristics after heat treatment	$1\,450\ N/mm^2 \le R_m \le 1\,600\ N/mm^2$			$R_m \ge 1\,380\ N/mm^2$ [b]
	Other spring leaves	Grade	13 according to ISO 683/XIV			4 or 7 according to ISO 683/XIV
		Mechanical characteristics after heat treatment	$1\,450\ N/mm^2 \le R_m \le 1\,600\ N/mm^2$			$380 \le HB \le 420$ [b]
Shot-peening			under pre-stressing on the face of all spring leaves			on the spring leaves of the primary set
Preliminary shaping (geometry)						on main spring leaf curvature radius: - in free condition: 36 000 mm - after clamping: 7 811 mm
Preliminary shaping (force)			1°) of the spring assembly			
			154 kN	125 kN	155 kN	
			2°) complete spring, under			
			197 kN	230 kN	255 kN	
Buckle assembly			when cold			when hot
Protection against corrosion			- 1 coat of paint with a high zinc content dry film thickness: 30 μm to 50 μm before clamping - 1 coat of finishing paint dry film thickness: 20 μm to 25 μm after clamping			- 1 coat of bituminous paint dry film thickness: ≥ 100 μm after clamping

a. Only for existing wagons
b. Rm = Tensile strengh - HB = BRINELL hardness

Appendix J - Parabolic springs

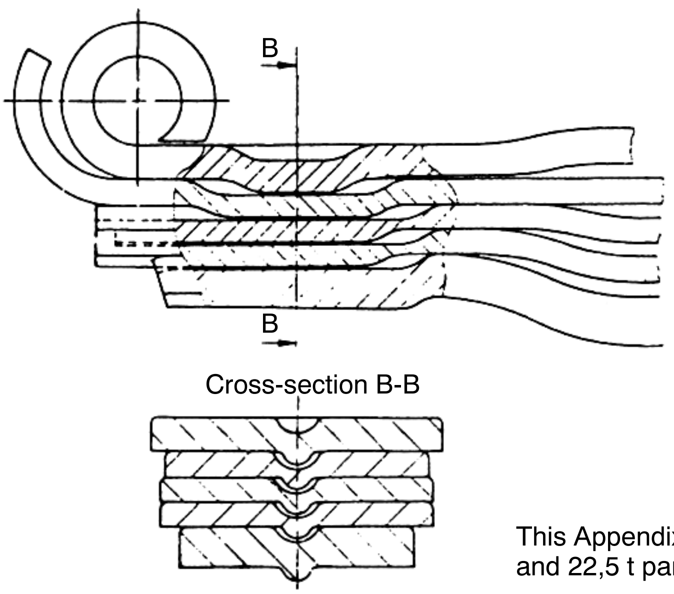
J.1 - Parabolic springs with progressive stiffness for two-axle wagons - Assembly



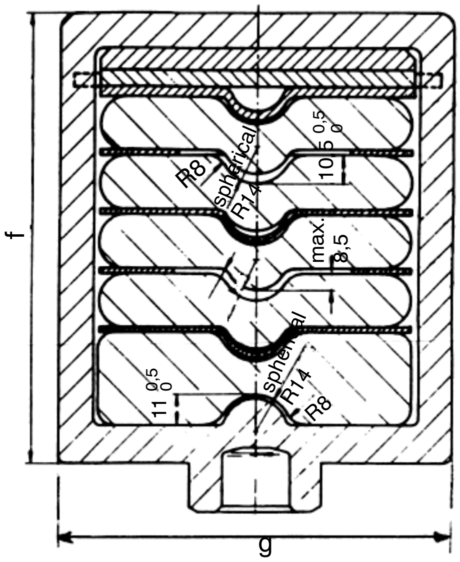
Spring	Lo
20 t [a]	1 173
22,5 t	1 175

a. Only for existing wagons

Shape of the end, the spring being in the extended state
(ribs only on one end of the spring)

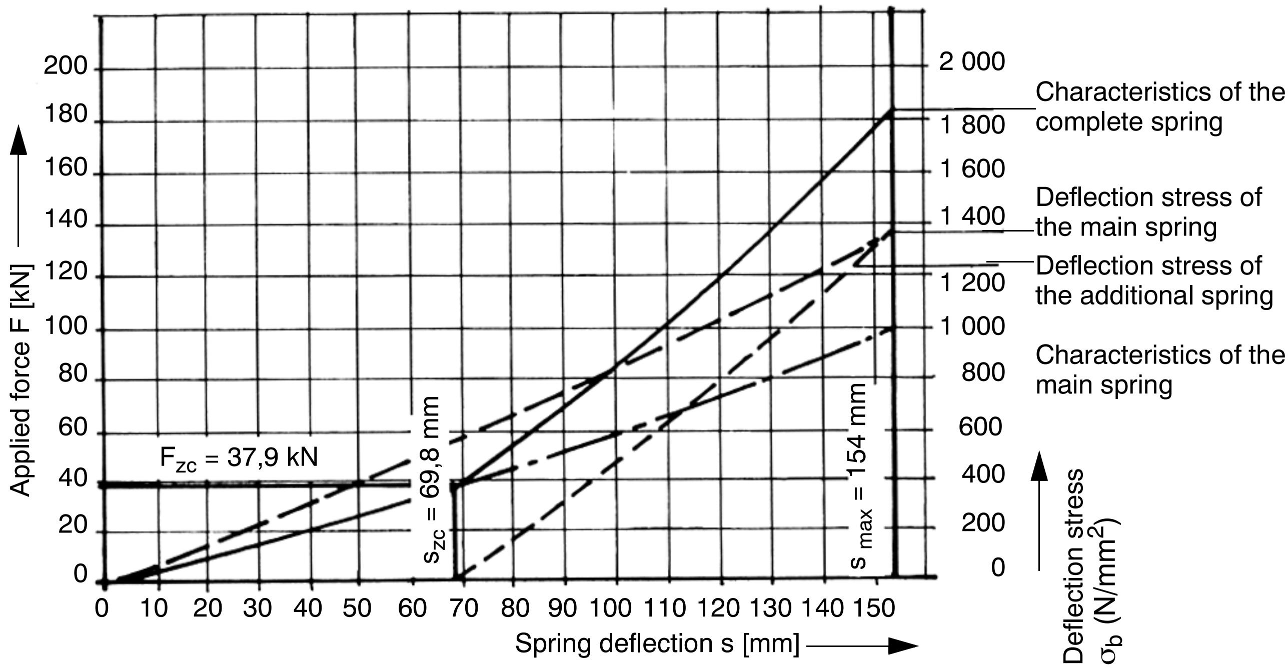


Cross-section A-A



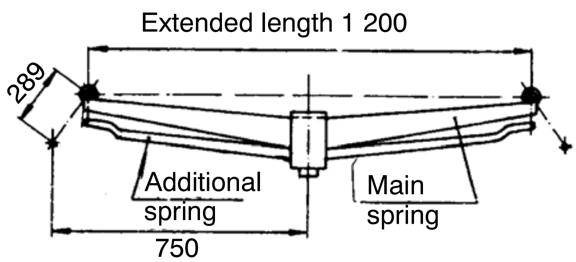
This Appendix applies to 20 t
and 22,5 t parabolic springs

J.2 - Parabolic spring with progressive stiffness, 20 t, for existing two-axle wagons - Characteristics of use

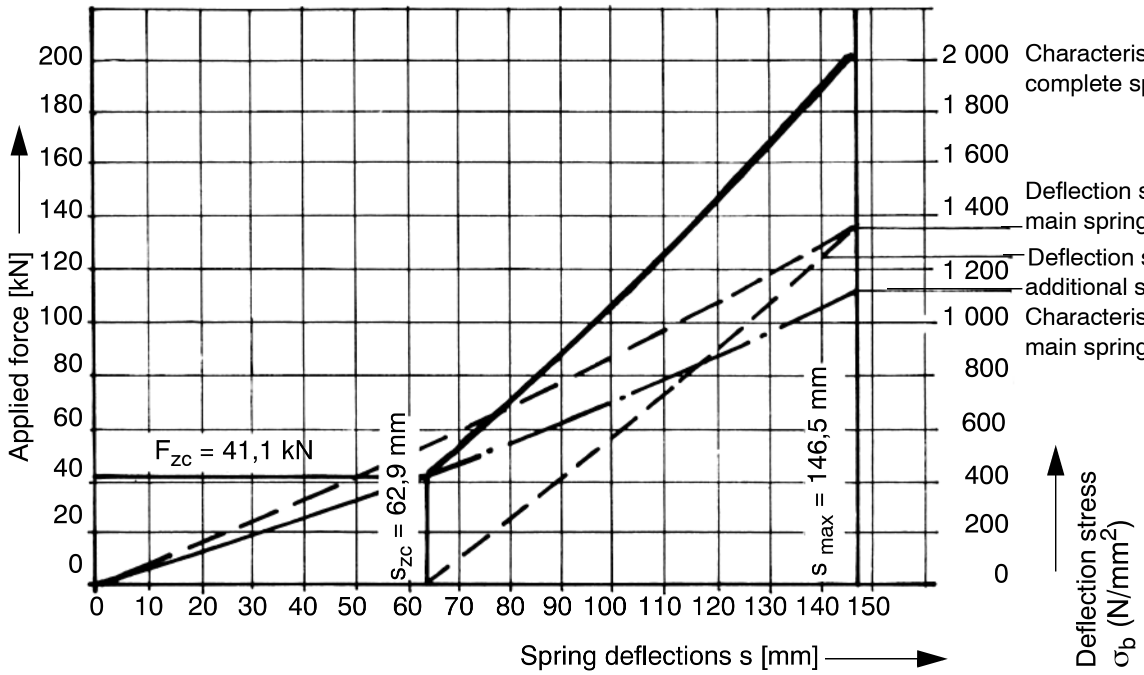


Characteristic values of the double link suspension		Symbol	Unit	Value
Maximum axle-load permitted under S or SS conditions		P	t	20
Mean flexibility [a]	of the 1st set of spring leaves	C_{z1}	mm/kN	1,82 ± 7 %
	of the spring as a whole	C_{z2}		0, 59 ± 7 %
Mean stiffness [a]	of the 1st set of spring leaves	C_{z1}	kN/mm	0, 55 ± 7 %
	of the spring as a whole	C_{z2}		1,69 ± 7 %
Load corresponding to the change in flexibilities Cz		F_{zc}	kN	37,9
Deflection corresponding to the change in flexibilities Cz		s_{zc}	mm	69,8
Spring height under a load of 20 kN (spring, as mounted)		H_{20z}	mm	194
Maximum deflection corresponding to the maximum permitted stress (σ_{max} 1 350 N/mm^2)		$s_{max.}$	mm	154

a. In accordance with the test method described in UIC Leaflet 821.

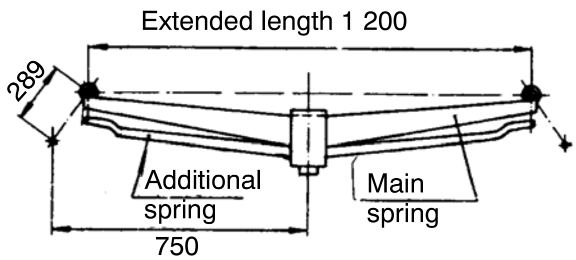


J.3 - Parabolic spring with progressive stiffness, 22,5 t, for two-axle wagons - Characteristics of use

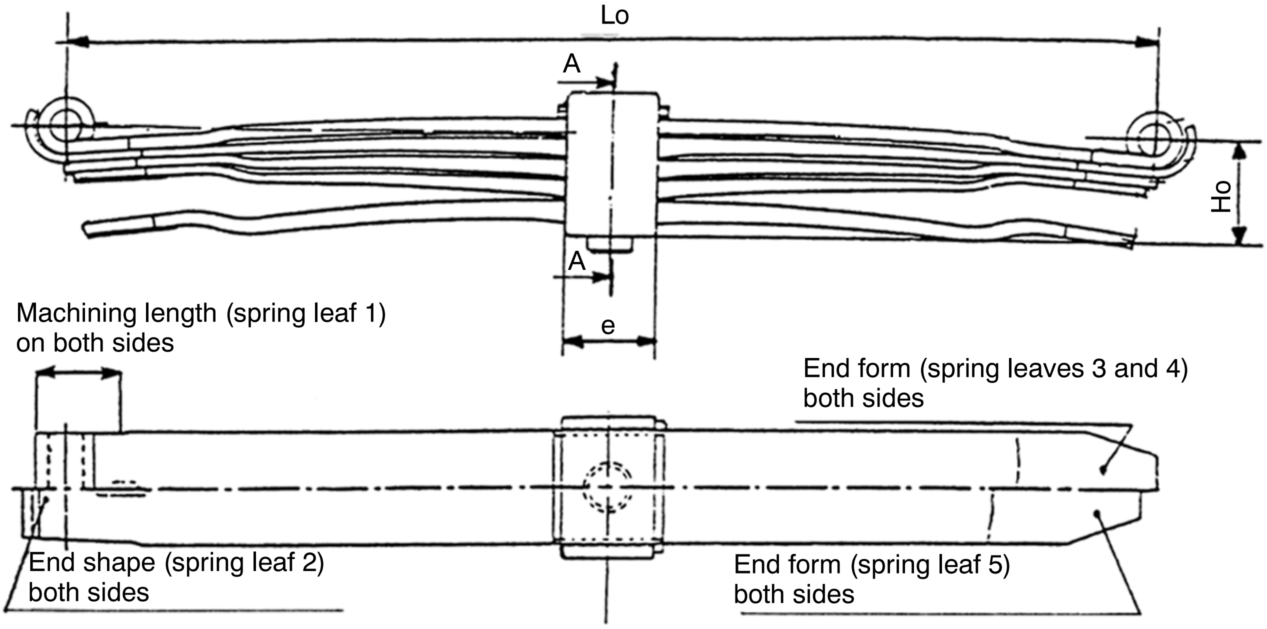


Characteristic values of the double link suspension		Symbol	Unit	Value
Maximum axle-load permitted under S or SS conditions		P	t	22,5
Mean flexibility [a]	of the 1st set of spring leaves	C_{z1}	mm/kN	1,55 } ± 7 %
	of the spring as a whole	C_{z2}		0,55 }
Mean stiffness [a]	of the 1st set of spring leaves	C_{z1}	kN/mm	0, 65 } ± 7 %
	of the spring as a whole	C_{z2}		1,82 }
Load corresponding to the change in flexibilities Cz		F_{zc}	kN	41,1
Deflection corresponding to the change in flexibilities Cz		s_{zc}	mm	62,9
Spring height under a load of 20 kN (spring as mounted)		H_{20z}	mm	195
Maximum deflection corresponding to the maximum permitted stress (σ_{max} 1 350 N/mm²)		$s_{max.}$	mm	146,5

a. According to the test method described in UIC Leaflet 821.

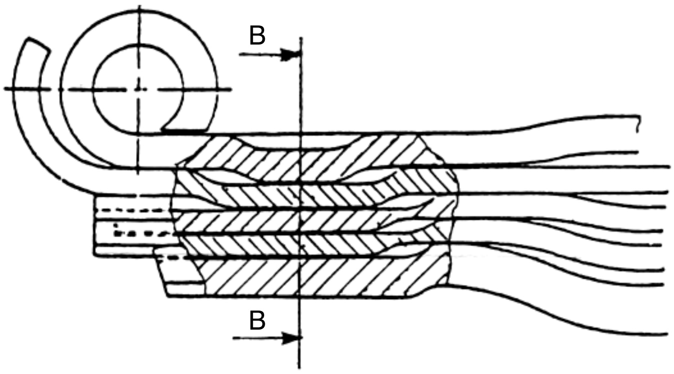


J.4 - Parabolic spring with progressive stiffness for bogies - Assembly

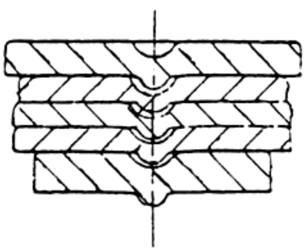


Spring	Lo
22,5 t	1 203

End shape with spring extended
(ribs only at one end of spring)

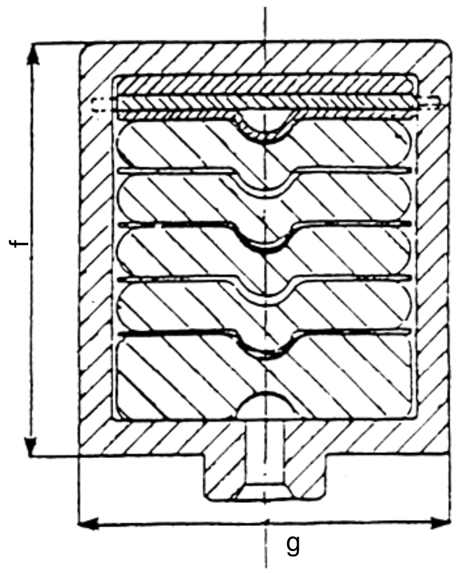


Section B-B

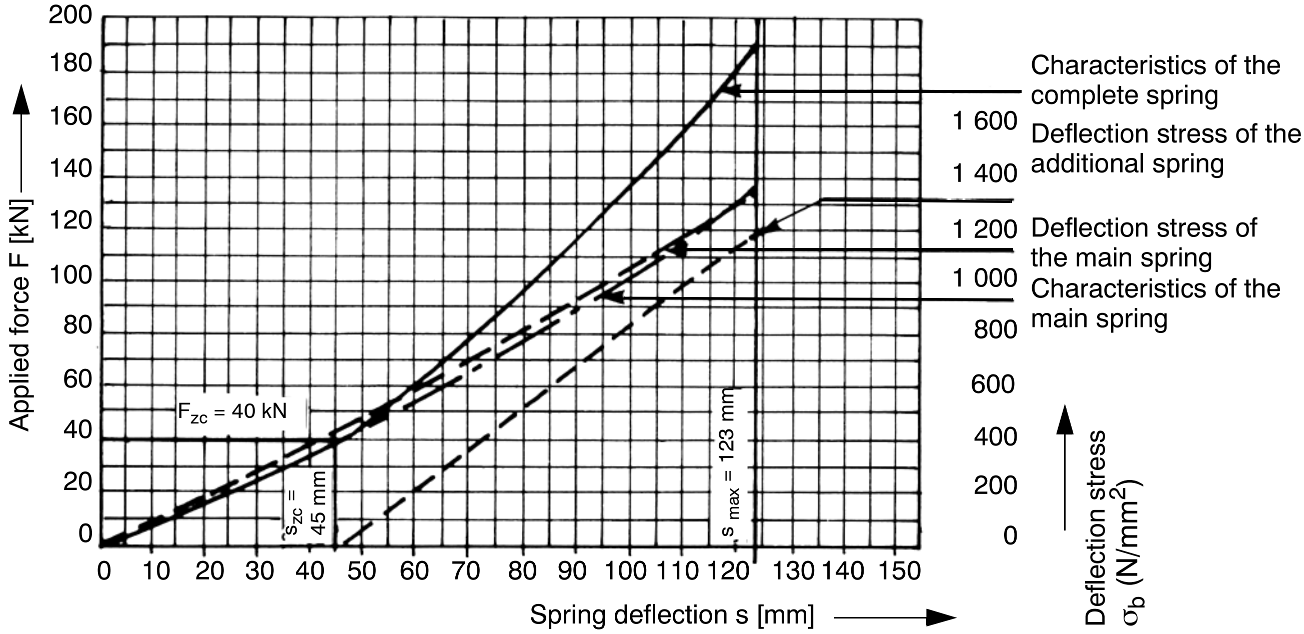


This appendix is only applicable to parabolic springs of 22,5 t for 65 L bogie

Section A-A

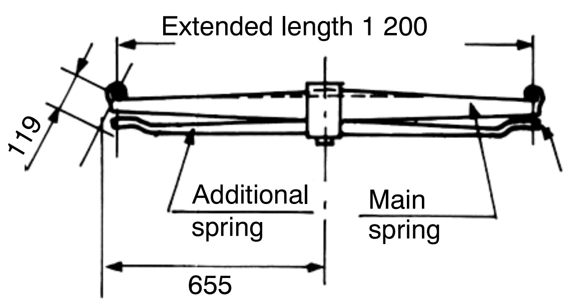


J.5 - Parabolic spring with progressive stiffness for bogies - Characteristics of use



Characteristic values of the inclined link suspension		Symbol	Unit	Value
Maximum axle-load permitted under S or SS conditions		P	t	22,5
Mean flexibility [a]	of the 1st set of spring leaves	C_{z1}	mm/kN	1,13 } ± 7 %
	of the spring as a whole	C_{z2}		0, 54 } ± 7 %
Mean stiffness [a]	of the 1st set of spring leaves	C_{z1}	kN/mm	0, 89 } ± 7 %
	of the spring as a whole	C_{z2}		1,86 } ± 7 %
Load corresponding to the change in flexibilities Cz		F_{zc}	kN	40
Deflection corresponding to the change in flexibilities Cz		s_{zc}	mm	45
Spring height under a load of 20 kN (spring, as mounted)		H_{20z}	mm	92
Maximum deflection corresponding to the maximum permitted stress (σ_{max} 1 350 N/mm^2)		$s_{max.}$	mm	123

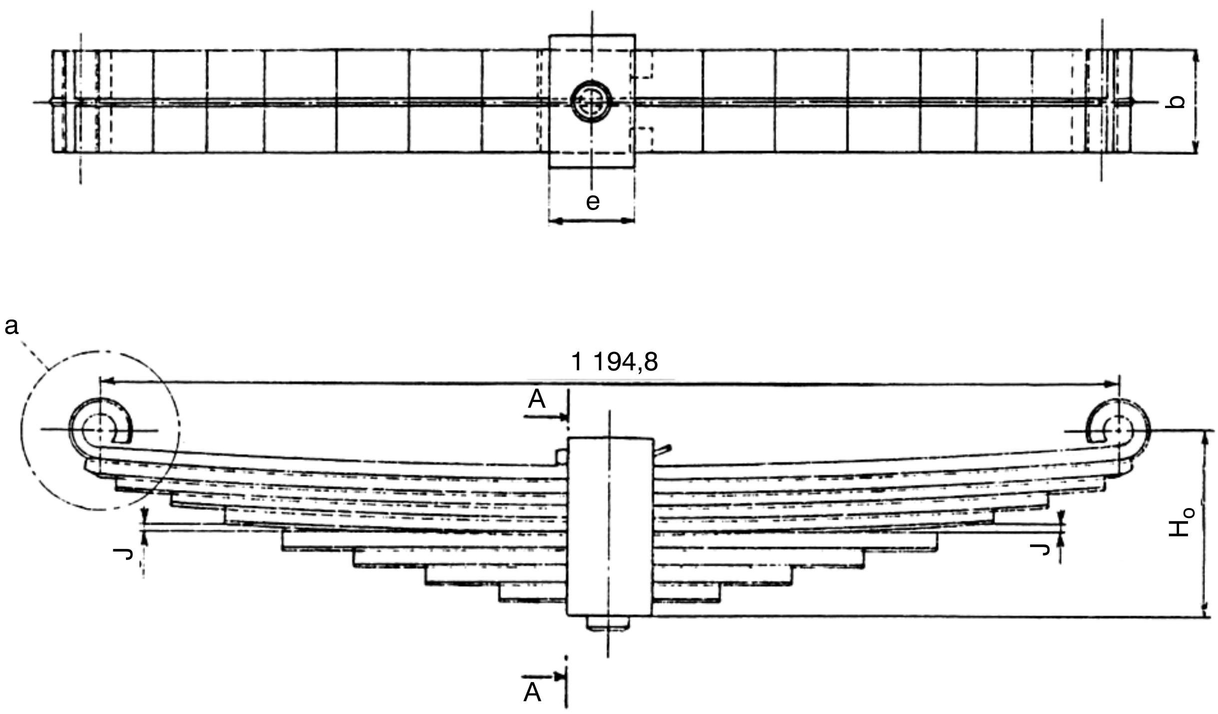
a. According to the test method described in UIC Leaflet 821.



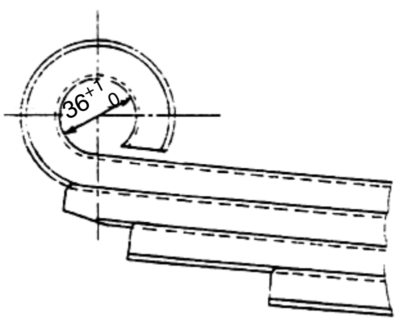
Appendix K - Leaf springs

K.1 - Leaf springs with progressive stiffness for two-axle wagons - Assembly

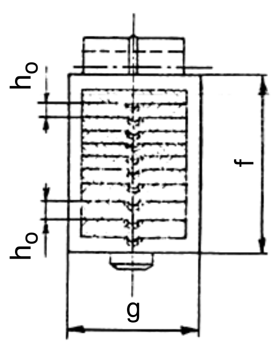
Diagram of the spring in the unloaded state



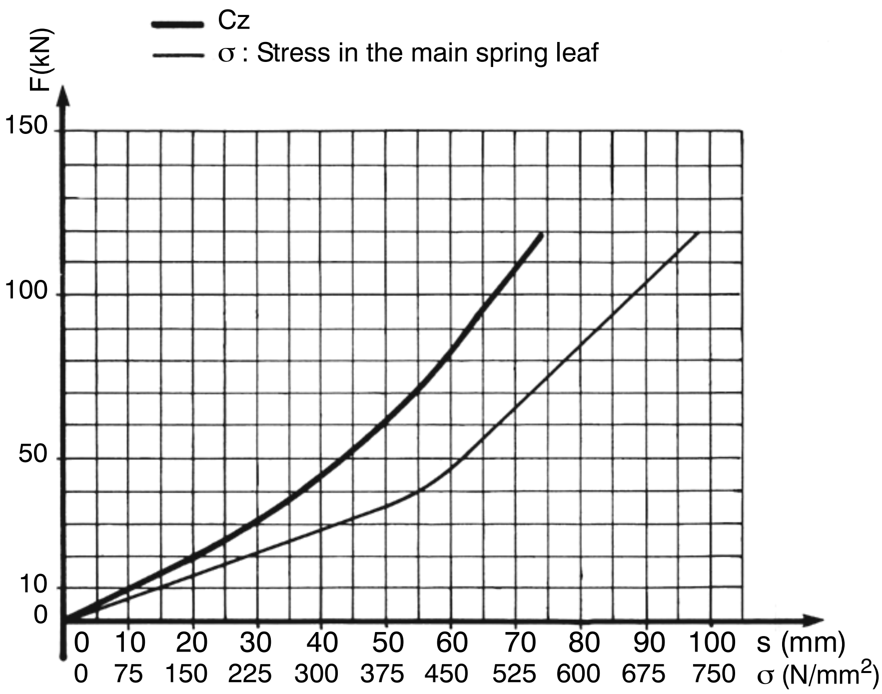
Detail a



Cross-section A-A

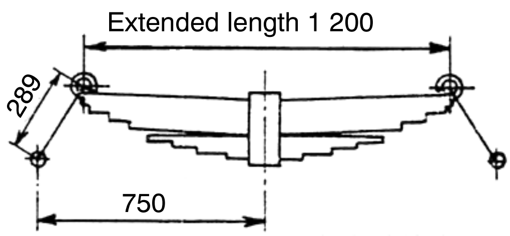


K.2 - Leaf springs with progressive stiffness for two-axle wagons - Characteristics of use



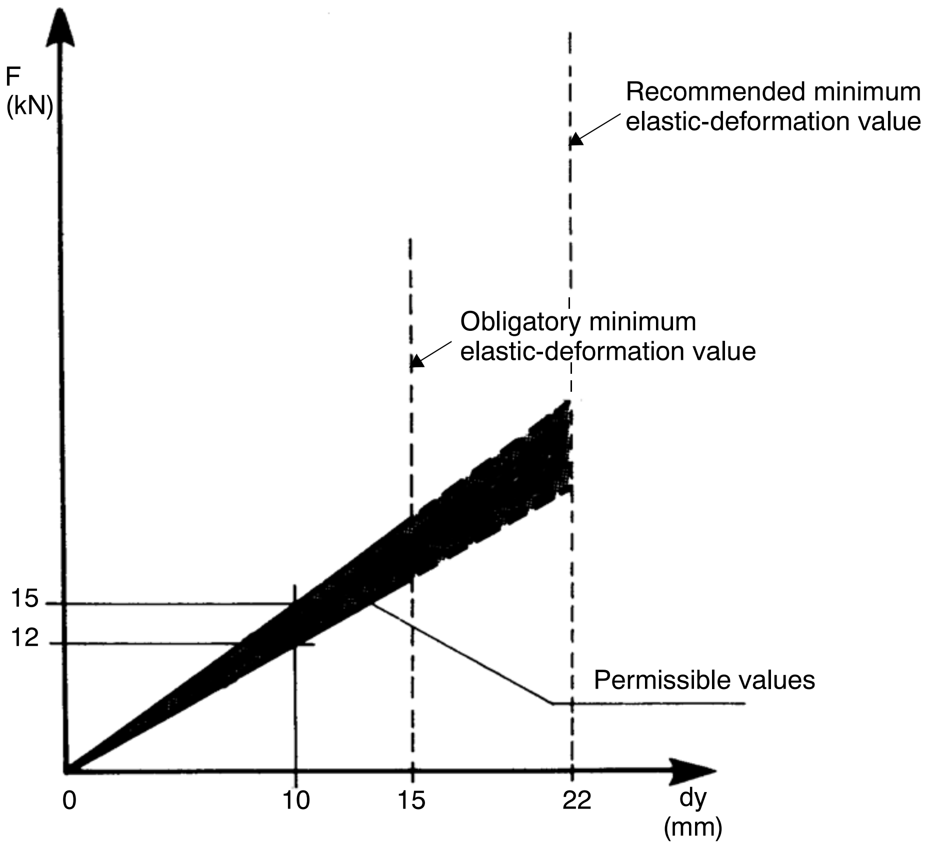
Characteristic values with double link suspension		Symbol	Unit	Value
Permitted axle-load	under ordinary and S conditions	P	t	20
	under SS conditions			20
Mean flexibility [a]	1st set of spring leaves	C_{z1}	mm/kN	0,88 } ± 8 %
	spring as a whole	C_{z2}	mm/kN	0,48 } ± 8 %
Mean stiffness [a]	1st of spring leaves	C_{z1}	kN/mm	1,14
	spring as a whole	C_{z2}	kN/mm	2,08
Load corresponding to the change in flexibilities Cz		F_{zc}	kN	40,5
Spring height under zero load		H_{0z}	mm	216
Spring height under a load of 20 kN		H_{20z}	mm	198,4
Deflection corresponding to the maximum stress permitted		$s_{max.}$	mm	111

a. Measured under loads of 20-30 and 50-100 kN.

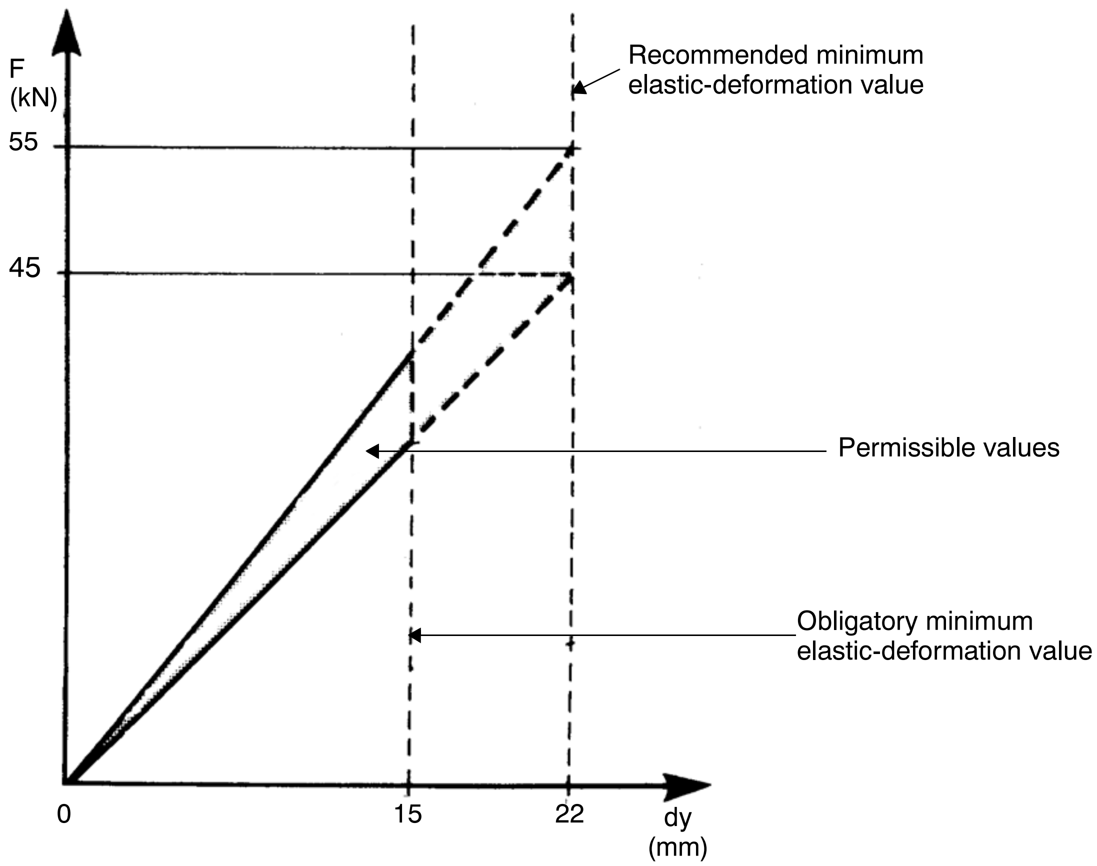


Appendix L - Rigidity of axle guards

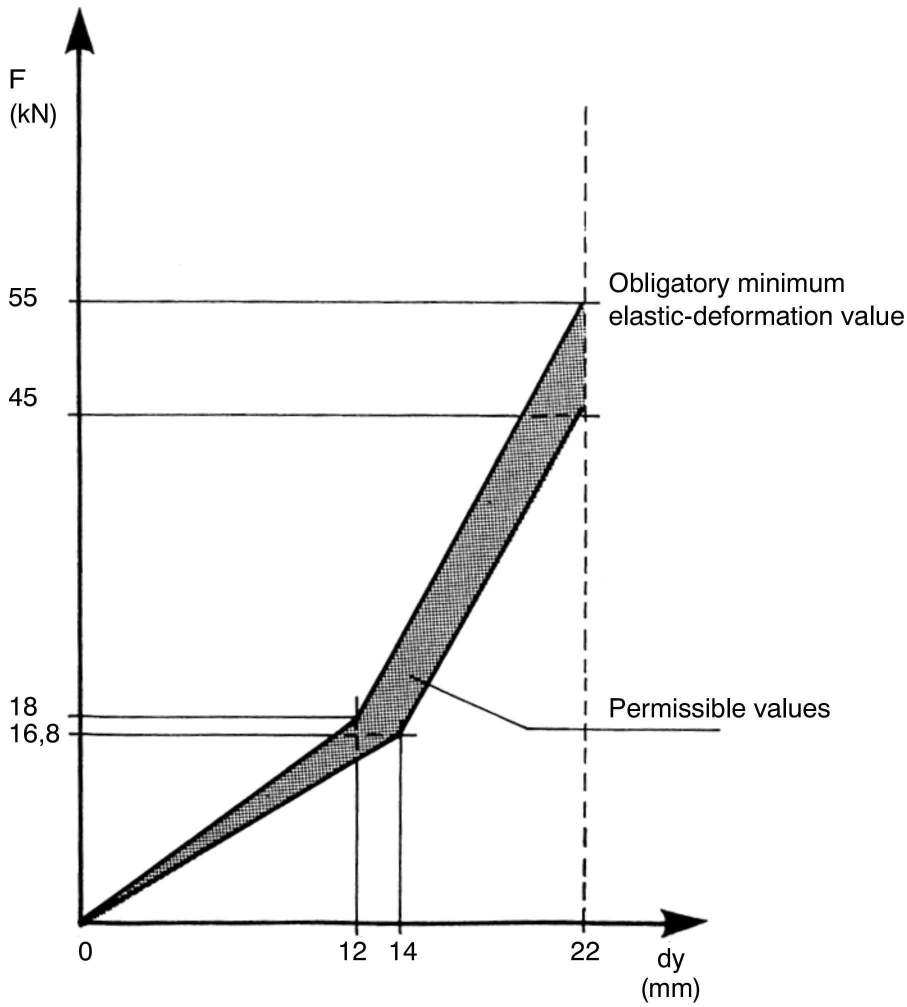
L.1 - Rigidity of ordinary axle guards with constant stiffness



L.2 - Rigidity of axle guards with constant stiffness (reinforced type)



L.3 - Rigidity of axle guards with progressive stiffness



Appendix M - Conditions to be met for the approval of non-standard leaf springs for wagons by the registering railway

Recommendation

1. For approval of non-unified leaf springs for use on rail vehicles, a list of the characteristics of such springs should be submitted in the form of tables similar to those shown in Appendices I.1 - page 34 and I.3 - page 37 above, together with the design drawings.

2. Information on the material and manufacture should be provided in a table similar to that shown in Appendix I.4 - page 38.

   Maintenance guidelines for use in workshops should also be provided.

3. A spring calculation should be made (in line with *B 12/RP 25* (see Bibliography - page 50) in the case of leaf springs), together with a comparison of the maximum stresses calculated and the permissible stresses.

4. The tests should be carried out in the laboratory, on the track and during impact as with standard springs *(B 12/RP 34)* (see Bibliography - page 50).

   The stresses in the spring should be compared with those undergone by a known standardised spring of similar design mounted on a comparable vehicle.

   Wherever the stresses are too high as compared with the corresponding standardised spring, fatigue tests should be carried out. In this case, 1 million load cycles should be applied with a base load corresponding to the total load of the vehicle with a load variation range of ± 25 %.

   RUs are at liberty to extend the test programme.

5. RUs are reminded that the ride qualities of wagons fitted with such springs should comply with the conditions of *UIC Leaflet 432* (see Bibliography - page 50).

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UIC Leaflet 571-4: Standard wagons - Wagons for combined transport - Characteristics, 4th edition, October 2004

UIC Leaflet 583: Wagons - Application of a special mark on interchangeable parts, 5th edition of 1.1.86 - reprint dated 1.7.95

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UIC Leaflet 822: Technical specification for the supply of helical compression springs, hot or cold coiled for tractive and trailing stock, 5th edition, November 2003

2. ERRI reports

International Union of Railways (UIC)
B 12/RP 25: Flexibility of trapezoidal springs , 2nd edition, 01/09/1986

B 12/RP 34: Standardisation of leaf springs with progressive characteristics for 2-axle wagons, 2nd edition, 01/04/1989

B 12/RP 43: Parabolic springs for wagons (design, calculation, treatment), 01/09/1988

3. Minutes of meetings

International Union of Railways (UIC)
Question 45/B/FIC - Amendments to be made to Leaflet 517 "Wagons - Suspension gear" (Joint Sub-Committee for wagons), January 1990

Question 45/B/FIC - Revision of leaflets. Supplements to the leaflet following proposals from ORE Committee B.12 (Joint Sub-Committee for wagons), January 1991

Question 45/B/FIC - Revision of leaflets. Item 7.7 - Approval of amendments proposed by ERRI SC B12 (Joint Sub-Committee for wagons), January 1995

Question 45/B/FIC - Point 10.6 - Approval of modificatifs to the standard axle-guard submitted by ERRI SC12 (Joint Sub-Committee for wagons), January 1997

Point 6.2 - Approval of modificatifs to points 4, 5, 6, 7 and 8 and to Appendices D.1, D.2 and D.3 (Study group 2 "Freight Technology", January 2005

4. International standards

International Standards Organisation (ISO)
ISO 683-14: Heat-treatable steels, alloy steels and free-cutting steels - Part 14: Hot-rolled steels for quenched and tempered springs, 2004

Warning

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