BS ISO 18137:2015

BSI Standards Publication

Leaf springs — Technical specifications

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National foreword

This British Standard is the UK implementation of ISO 18137:2015.

The UK participation in its preparation was entrusted to Technical Committee FME/9/3, Springs.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 227, *Springs*.

Leaf springs — Technical specifications

1 Scope

This International Standard specifies the technical specifications for leaf springs.

This International Standard is applicable to leaf springs for road vehicle (hereinafter simply "springs"). The leaf springs for other vehicle may refer to this International Standard.

2 Normative references

The following referenced documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 683-14, *Heat-treatable steels, alloy steels and free-cutting steels — Part 14: Hot-rolled steels for quenched and tempered springs*

ISO 3887, *Steels — Determination of depth of decarburization*

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 6508-1, *Metallic materials — Rockwell hardness test — Part 1: Test method*

ISO 16249, *Springs — Symbols*

ISO 18265, *Metallic materials — Conversion of hardness values*

ISO 26909, *Springs — Vocabulary*

ISO 26910-1, *Springs — Shot peening — Part 1: General procedures*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 26909 and Table 1 apply.

4 Symbols

For the purposes of this document, the symbols and units given in ISO 16249 and Table 1 apply.

Table 1 — Terms, symbols and units

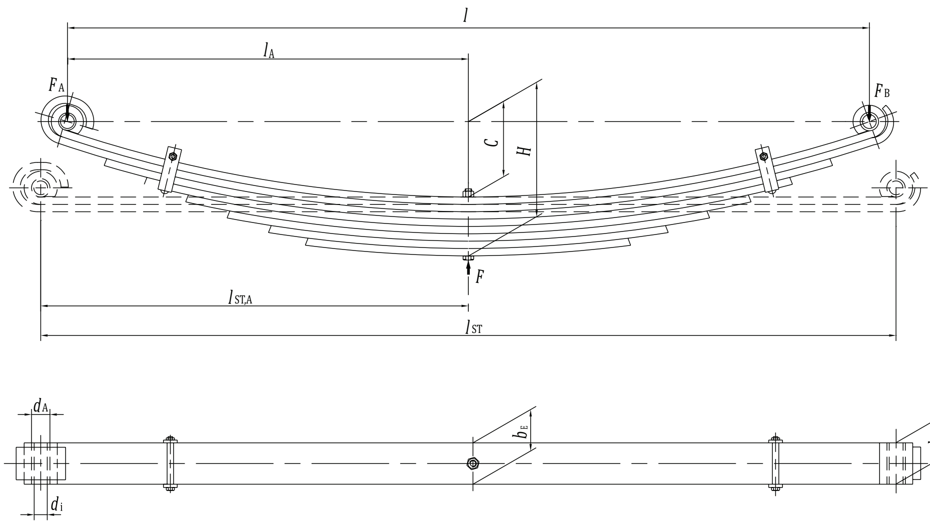
Term	Symbol	Unit	Meaning
Spring end width	b_A	mm	Width of the spring eye or sliding end.
Assembled spring width	b_E	mm	Width of the assembly in the range of U-clamping.
Camber	C	mm	Perpendicular distance from the surface where tensile stress is generated in use, of the uppermost leaf at the centre pin or the centre bolt, to the straight line connecting the centers of both eyes or connecting the load-supporting points of the spring.
Free camber	C_0	mm	Camber when free or at zero load.
Design camber	C_d	mm	Camber under design (nominal) load.

Table 1 *(continued)*

Term	Symbol	Unit	Meaning
Eye inner diameter	d_A	mm	Inner diameter of the spring eye.
Eye bush inner diameter	d_i	mm	Inner diameter of the spring eye bush.
Load	F	N	Total spring force.
Design load	F_d	N	Design (nominal) load of the spring.
Maximum test load	$F_{max.t}$	N	Maximum test force of the spring.
Height	H	mm	The overall height of the spring.
Free height	H_0	mm	Height when free or at zero load.
Design height	H_d	mm	Height under design (nominal) load.
Span	l	mm	Distance between the load-supporting points of the spring.
Free Span	l_0	mm	Span when free or at zero load.
Fixed half span	l_A	mm	Length of the span between the fixed end and the centre.
Straight span	l_{ST}	mm	Length of the span between the load-supporting points of the spring when the first leaf is straight.
Fixed half straight span	$l_{ST,A}$	mm	Length of the span between the fixed end and the centre when the first leaf is straight.
Spring rate	R	N/mm	Force required to deflect the spring by one unit of deflection.
Deflection	s	mm	Change of the vertical position of the centre pin or the centre bolt against the line connecting the centers of both eyes or connecting both load-supporting points of the spring.
Design deflection	s_d	mm	The deflection under the design load.
Maximum test deflection	$s_{max,t}$	mm	The deflection under the maximum test load.
Flank bending	δ	mm	Side bending deformation of the leaf.

5 Spring types

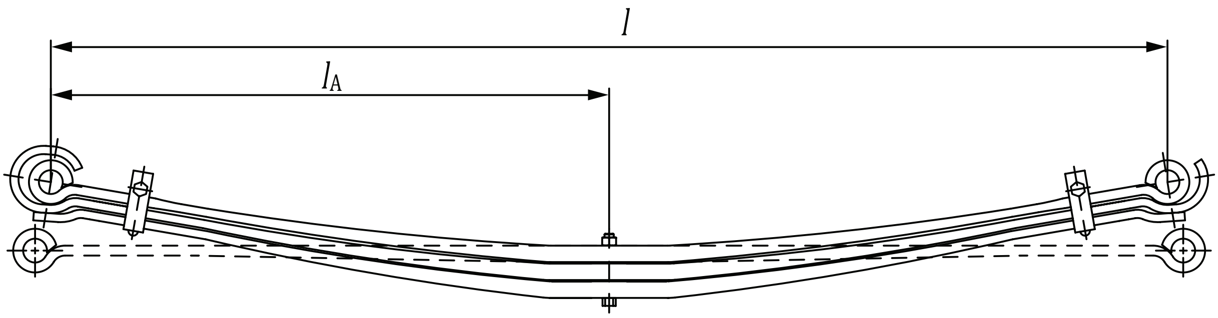
The most common spring types are shown in the following.



Key

b_A	spring end width	F	total spring load
b_E	assembled spring width	F_A, F_B	loads at eye A or eye B
C	camber	l	span
d_A	eye inner diameter	l_A	fixed half span
d_i	eye bush inner diameter	l_{ST}	straight span
H	height	$l_{ST,A}$	fixed half straight span

Figure 1 — Multi-leaf spring with eyes

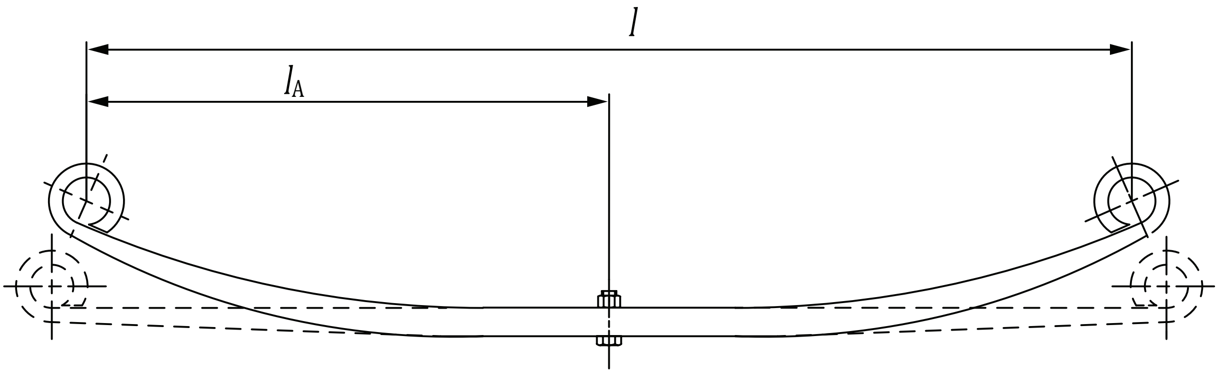


a) Multi-leaf parabolic spring with eyes

Key

l span

l_A fixed half span



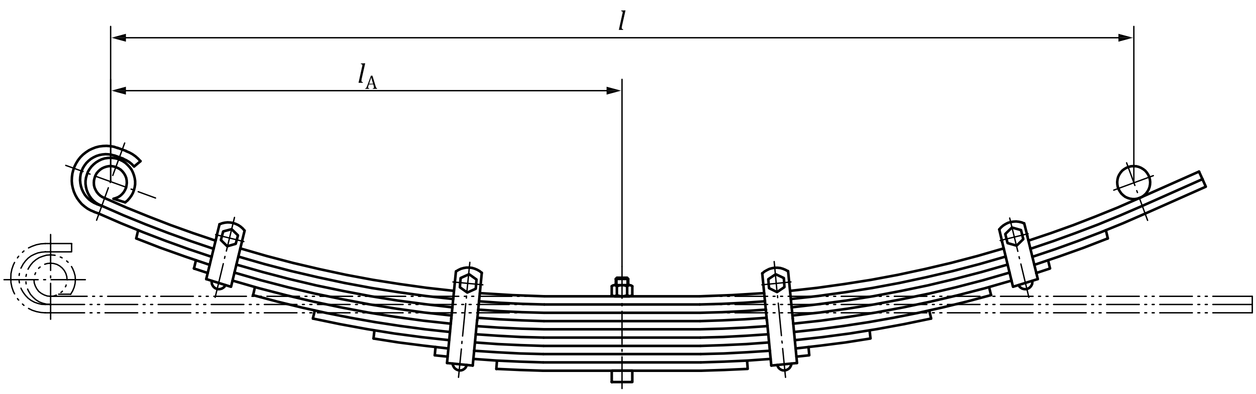
b) Single leaf parabolic spring with eyes

Key

l span

l_A fixed half span

Figure 2 — Parabolic spring with eyes

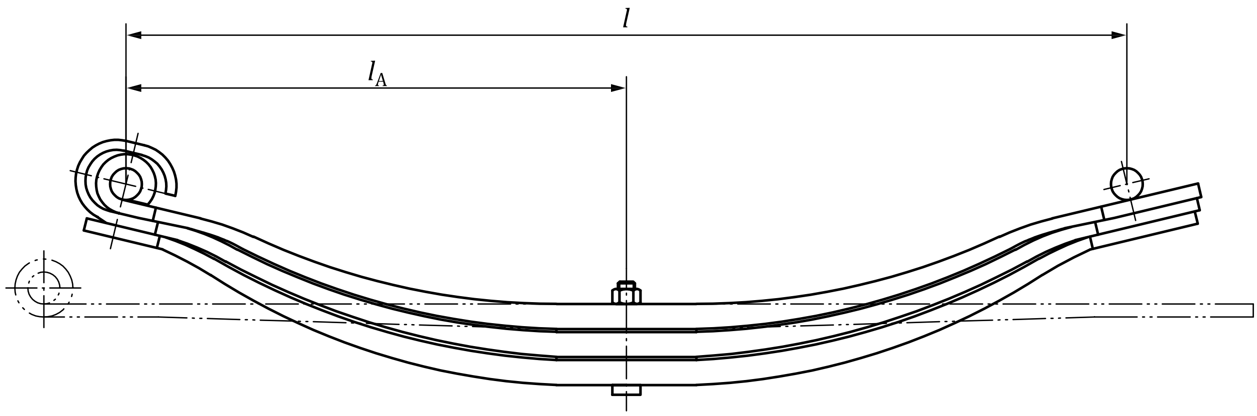


Key

l span

l_A fixed half span

Figure 3 — Multi-leaf spring with one eye and one sliding end

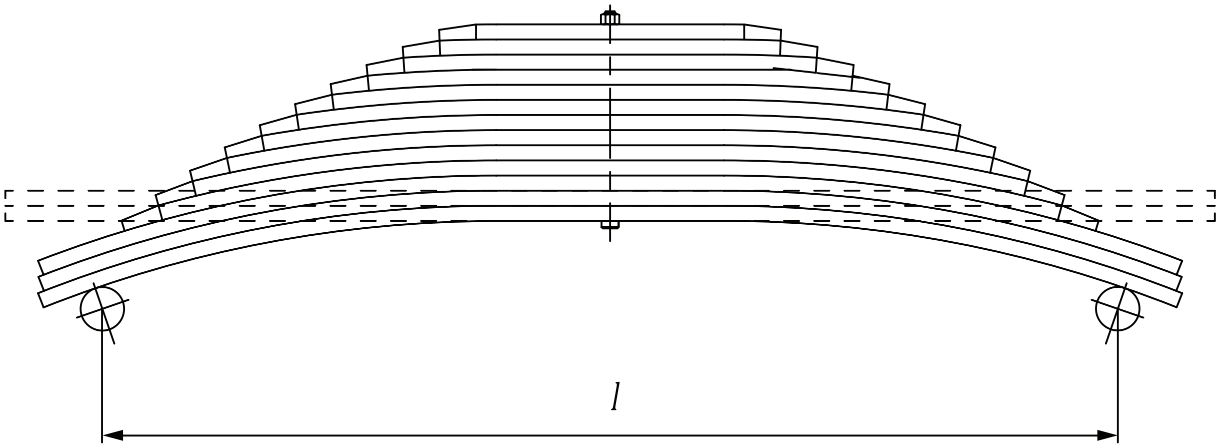


Key

l span

l_A fixed half span

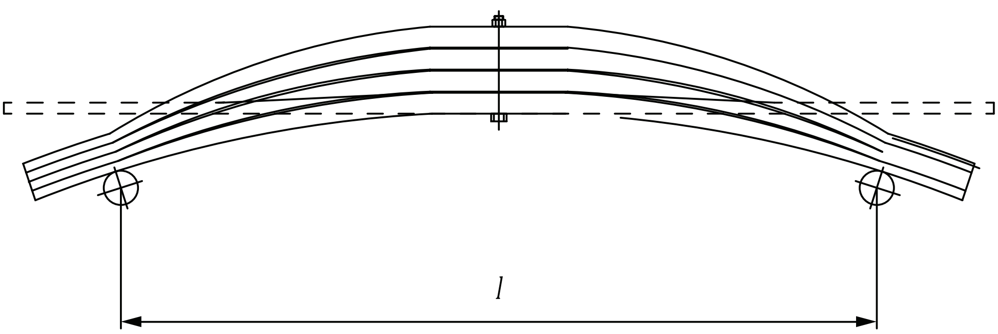
Figure 4 — Parabolic spring with one eye and one sliding end



Key

l span

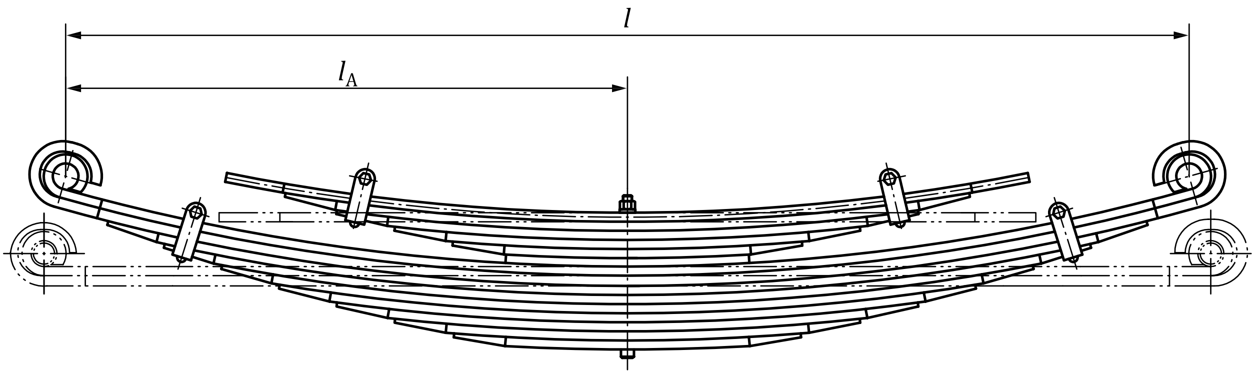
Figure 5 — Multi-leaf spring with sliding ends



Key

l span

Figure 6 — Parabolic spring with sliding ends

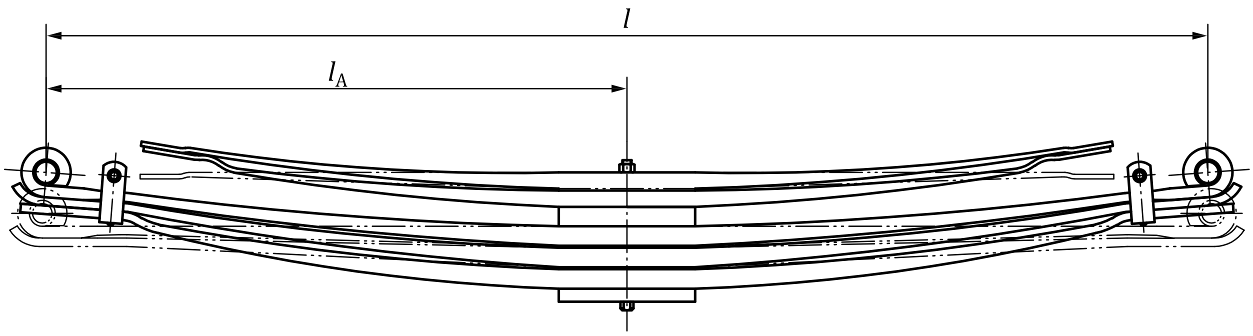


Key

l span

l_A fixed half span

Figure 7 — Two-stage progressive multi-leaf spring with helper spring

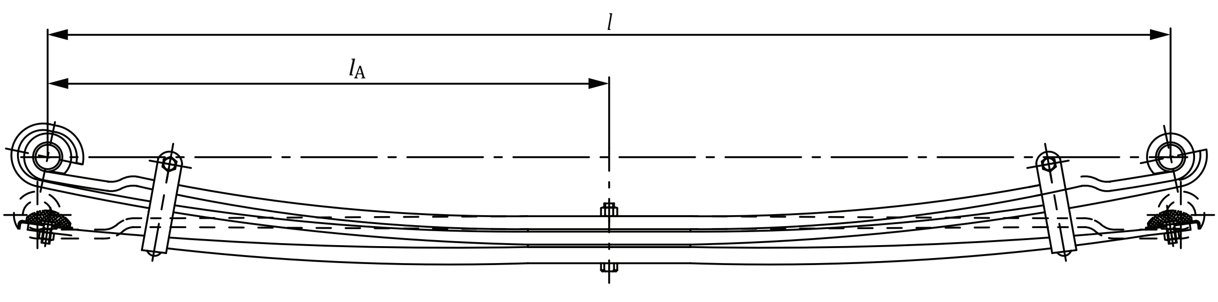


Key

l span

l_A fixed half span

Figure 8 — Two-stage progressive parabolic spring with helper spring

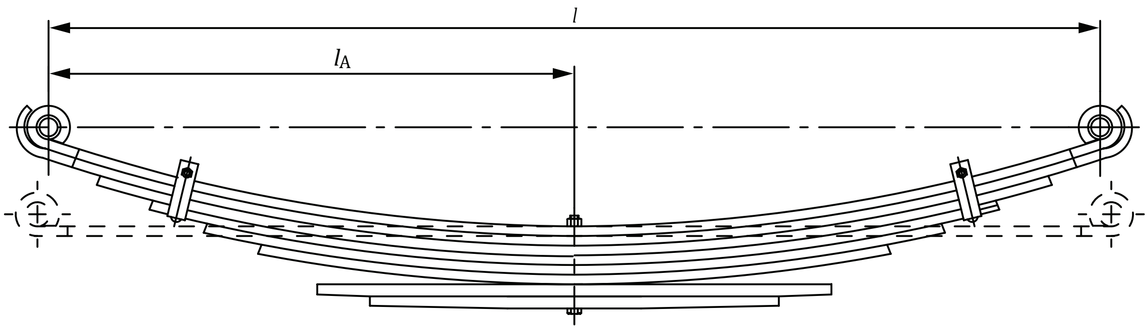


Key

l span

l_A fixed half span

Figure 9 — Two-stage rate parabolic spring with auxiliary spring



Key

l span

l_A fixed half span

Figure 10 — Progressive (rate) spring

6 Technical requirements

6.1 Materials

Unless otherwise agreed by the purchaser and the supplier, the springs should be made from the hot rolled spring flat bar conforming to ISO 683-14.

6.2 Tolerances of spring dimensions and shapes

6.2.1 Span

The tolerances of the straight span and the fixed half straight span should be in accordance with Table 2.

Table 2 — Tolerances of span

Dimensions in millimetres

Straight span, l_{ST}			**Fixed half straight span**, $l_{ST,A}$		
Range	**Tolerances**		**Range**	**Tolerances**	
	Type 1	Type 2		Type 1	Type 2
$l_{ST} \leq 1\,200$	±3,0	±3,5	$l_{ST,A} \leq 600$	±1,5	±2,0
$1\,200 < l_{ST} \leq 1\,600$	±3,0	±5,0	$600 < l_{ST,A} \leq 800$	±1,5	±2,5
$1\,600 < l_{ST} \leq 2\,000$	±3,0	±6,0	$800 < l_{ST,A} \leq 1\,000$	±1,5	±3,0
$l_{ST} > 2\,000$	±4,0	±6,5	$l_{ST,A} > 1\,000$	±2,0	±3,5

The type of the spring should be agreed between the purchaser and the supplier.

6.2.2 Assembled spring width

The tolerances of the assembly spring width should be in accordance with Table 3, the tolerances of the width of the machined part should be agreed between the purchaser and the supplier. (For test methods, see A.2.)

Table 3 — Tolerances of the assembly spring width

Dimensions in millimetres

Assembly spring width, b_E	Tolerances
$b_E \leq 75$	+2,5 -0,8
$75 < b_E \leq 100$	+3,0 -0,8
$100 < b_E \leq 125$	+3,5 -0,8
$b_E > 125$	+4,0 -0,8

6.2.3 Spring end width

The tolerances of the spring eye width should be in accordance with Table 4. (For test methods, see A.3.)

Table 4 — Tolerances of the spring eye width

Dimensions in millimetres

Spring eye width, b_A	Tolerances
Machined	$^{0}_{-0,5}$
Unmachined	±1,5

The tolerances of the spring sliding end width should be agreed between the purchaser and the supplier.

6.2.4 Eye inner diameter and bush inner diameter

The tolerances of the inner diameter of the unmachined eye should be in accordance with Table 5. The tolerances of the machined eye inner diameter should be agreed between the purchaser and the supplier. (For test methods, see A.1.)

Table 5 — Tolerances of the eye inner diameter

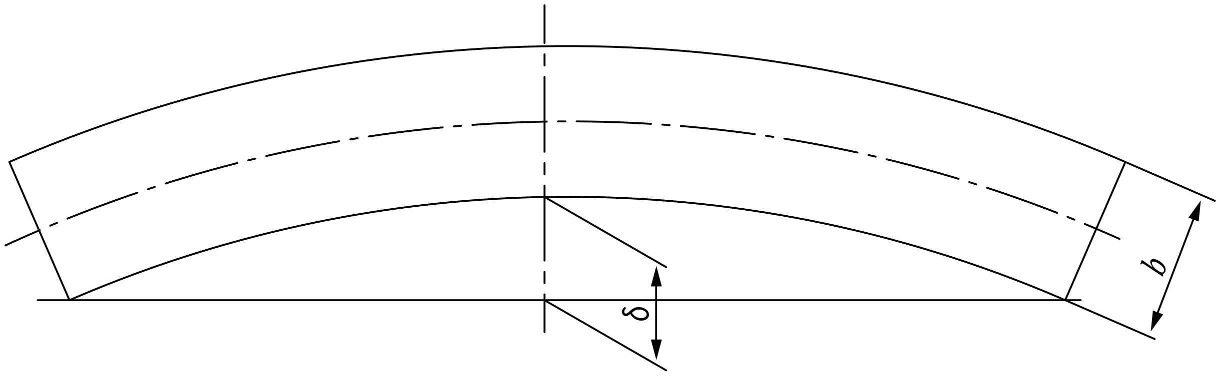
Dimensions in millimetres

Eye inner diameter, d_E	Tolerances
$d_E \leq 25$	±0,5
$25 < d_E \leq 40$	±0,6
$d_E > 40$	±0,7

The tolerances of the bush inner diameter should be agreed between the purchaser and the supplier.

6.2.5 Flank bending

The tolerances of the flank bending of each leaf that installed into the bracket should not exceed 2,0 mm/1 m, and the others should not exceed 3,0 mm/1 m, see Figure 11.



Key

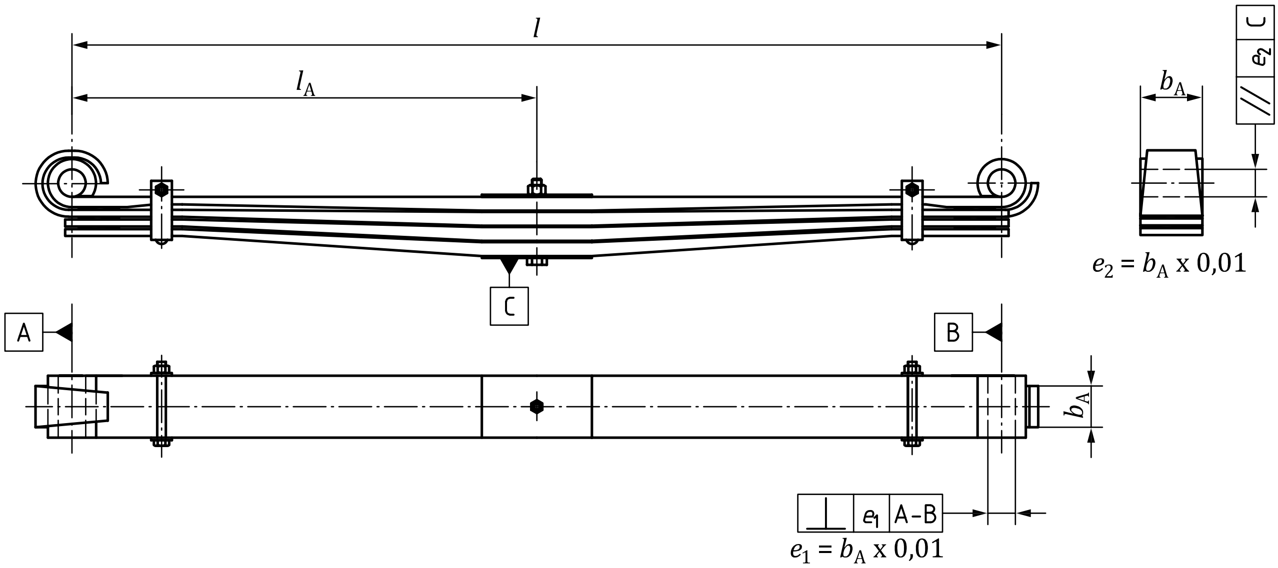
δ flank bending

b width of the leaf

Figure 11 — Flank bending

6.2.6 Perpendicularity and parallelism of the spring eye

The tolerances of the perpendicularity and parallelism of the spring eye should not exceed 1 % b_A, whenever other tolerances are specified (for example when a spring is supplied with a bushing); it should be agreed between the purchaser and the supplier. The measuring baseline is as shown in Figure 12. (For test methods, see A.4.)



Key

b_A spring end width

e_1 tolerance of the perpendicularity of the spring eye

e_2 tolerance of the parallelism of the spring eye

l span

l_A fixed half span

Figure 12 — The tolerances of the perpendicularity and parallelism of the spring eye

6.3 Requirements for characteristic

6.3.1 Spring rate

The tolerances of the spring rate should be in accordance with Table 6. Whenever other tolerances are specified, it should be agreed between the purchaser and the supplier. (For test methods, see A.8.)

Table 6 — Tolerances of the spring rate

Type	Type 1	Type 2
Parabolic springs	±6 %	±10 %
Other leaf springs	±8 %	±10 %

The type of the spring should be agreed between the purchaser and the supplier.

6.3.2 Design camber

The tolerances of the design camber should be in accordance with Table 7. Whenever other tolerances are specified, it should be agreed between the purchaser and the supplier. (For test methods, see A.9.)

Table 7 — Tolerances of the design camber

Dimensions in millimetres

Type	Type 1	Type 2
Tolerances	±3,0	±7,0

The type of the spring should be agreed between the purchaser and the supplier.

6.3.3 Fatigue

The requirement of fatigue life should be agreed between the purchaser and the supplier. (For test methods, see A.10.)

6.4 Requirements for manufacturing

6.4.1 Hardness

Unless otherwise agreed by the purchaser and the supplier, the hardness of springs after heat treatment should be specified according to the application condition, material and dimension. The guidance values for tensile strength and hardness for quenched and tempered springs and test pieces should be according to the values given in ISO 683-14 and ISO 18265. Whenever the hardness range is specified, it should be less than 82 HBW. (For test methods, see A.5.)

6.4.2 Decarburization

No harmful decarburization is allowed on the tension side surface of the springs, and the depth of decarburization of the springs shall be minimized. The depth of decarburization of the spring surface should be agreed between the purchaser and the supplier, based on the spring application and the nature of the spring material. (For test methods, see A.6.)

6.4.3 Shot peening

Whenever shot peening is required, the leaves should be shot peened after the heat treatment and before the assembly and coating, the process should be determined according to ISO 26910-1. The intensity and the coverage of shot peening should be agreed between the purchaser and the supplier.

6.4.4 Presetting

Unless otherwise agreed by the purchaser and the supplier, the springs should be preset. The presetting conditions should be agreed between the purchaser and the supplier.

6.4.5 Lubricant and surface protection

Whenever lubricating is required, the contact surface of the leaves should be coated with lubricating materials.

The springs should be coated with surface coating specified in the design drawing to protect against corrosion with surface.

6.4.6 Surface conditions

The harmful defects of the tension side surface of the springs should be minimized, such as laminations, grooves, tooling marks, racks, crevices, which are harmful in use.

The spring eyes may show traces of tooling in an arc of approximately 120° on the exterior side of the eye gap caused by the process. (For test methods, see A.7.)

7 Designation

Unless otherwise agreed by the purchaser and the supplier, the springs should be designated. The designation methods and the designation contents should be agreed between the purchaser and the supplier.

Annex A
(informative)

Test methods of leaf springs

A.1 Eye inner diameter and bush inner diameter

The eye inner diameter and the bush inner diameter should be checked using go-no-go gauge (plug gauge) or specific measurement gauge.

A.2 Assembled Spring width

The assembled spring width should be checked using the inspection gauge.

A.3 Spring end width

The spring end width should be checked using the inspection gauge.

A.4 Perpendicularity and parallelism of spring eye

The perpendicularity and parallelism of spring eye should be checked using the inspection gauge.

When the perpendicularity and parallelism of spring eye is checked, the spring with bushing or without bushing should be agreed between the purchaser and the supplier.

A.5 Hardness

Brinell hardness testing should be according to ISO 6506-1. Rockwell hardness testing should be according to ISO 6508-1.The hardness is determined on the compression side surface of the spring leafs after polishing, whose depth is above that of the highest permissible depth of decarburization. The tensile strength is determined where necessary from the Brinell hardness after re-evaluation compliant with ISO 18265, Table A.1. In the certain cases, other methods are permissible.

A.6 Decarburization

The depth of decarburization should be defined according to ISO 3887.

A.7 Surface conditions

The surface conditions of the springs should be inspected visually.

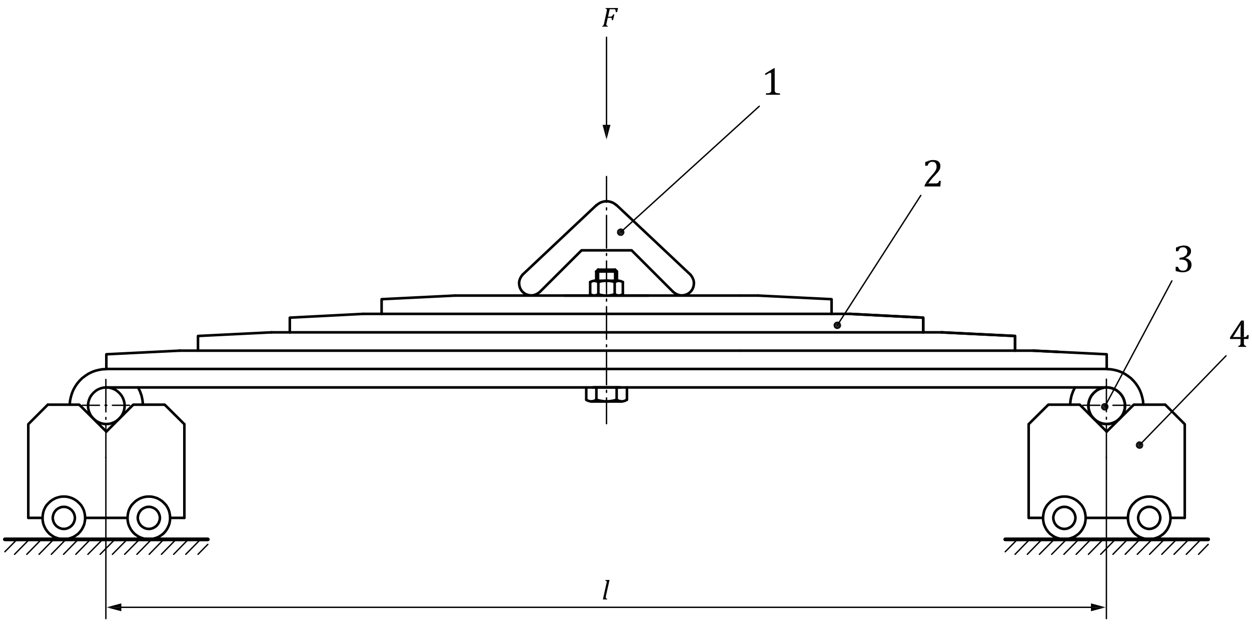
A.8 Spring Rate

A.8.1 Test equipment

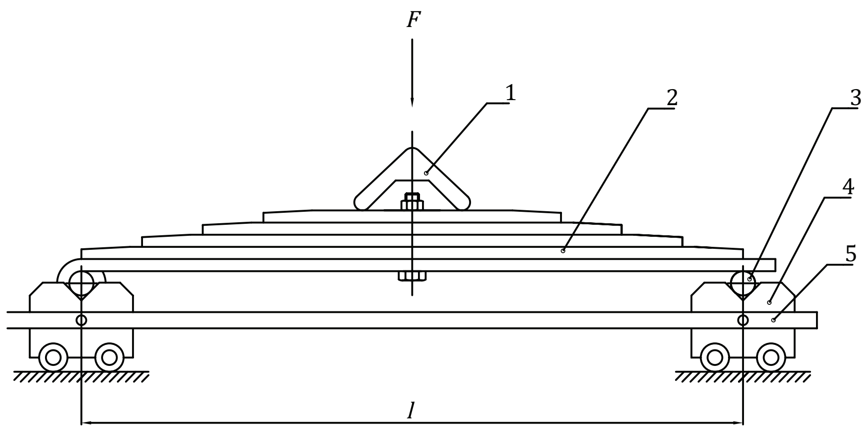
The test equipment should hold the leaf spring stably, should apply load gradually and continuously, equipped with apparatus for measuring force and deflection. The accuracy of load measuring should not exceed ±1 % of the maximum test load, and the accuracy of deflection measuring should not exceed ±0,5 mm.

A.8.2 Bearing and clamping methods

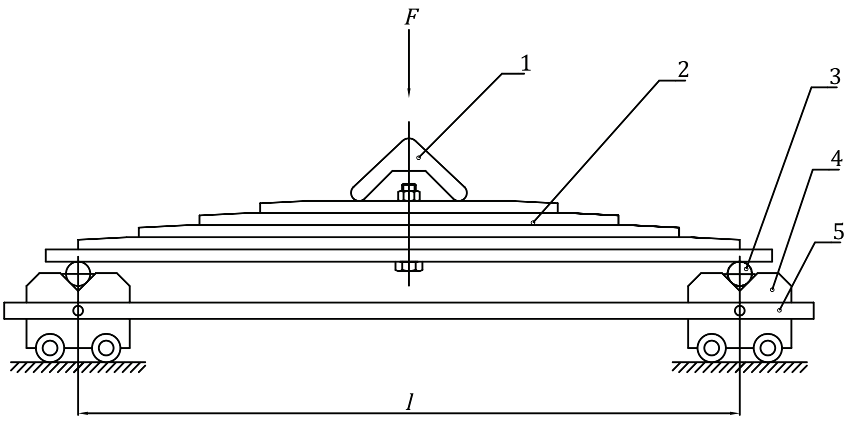
In order not to block deflection of the spring, the friction of bearing method should be as low as possible. Common bearing methods see Figure A.1. The clamping of the centre should be subject to the design drawings.



a) The bearing and clamping methods for the spring with eyes



b) The bearing and clamping methods for the spring with one eye and one sliding end



c) The bearing and clamping methods for the spring with sliding ends

Key

1 pressing fixture
2 spring
3 axis pin
4 carriage
5 connecting fixture

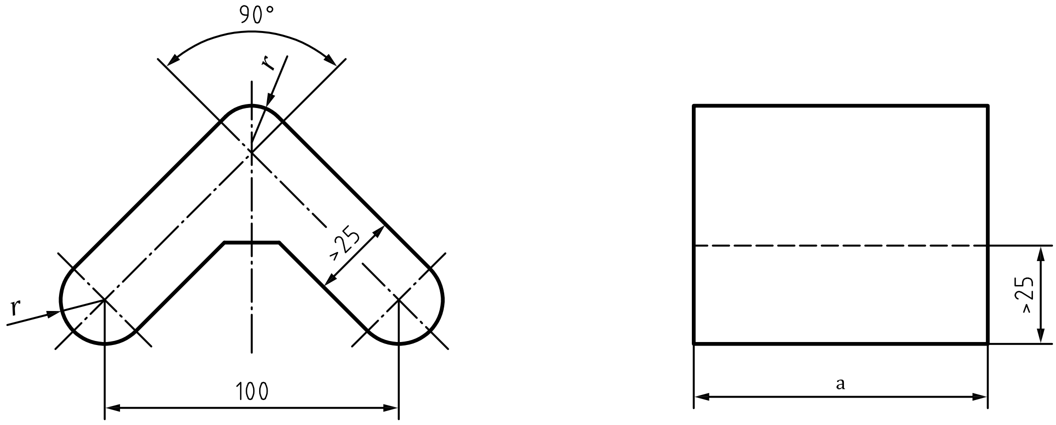
Figure A.1 — The bearing and clamping methods for the springs

A.8.3 Test methods

The load is applied through pressing fixture as shown in Figure A.2. First apply the load to the maximum test load gradually, then unload to zero. Repeat above step again, then record the load and corresponding deflection, draw load-deflection curve. See Figure A.3.

An inspection of mass production line allow the management on the pressurization load, rapping the spring with a soft mallet can be used to eliminate internal friction.

Dimensions in millimetres

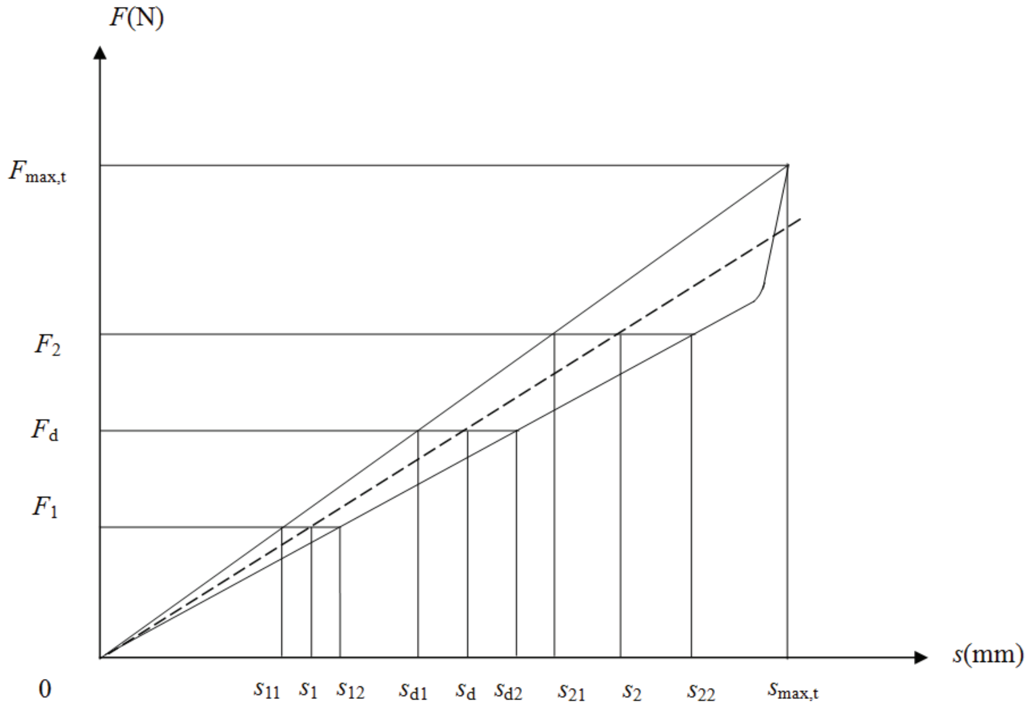


Key

r arc radius

a Not less than leaf spring width.

Figure A.2 — Pressing fixture (Example)



Key

s_1 average deflection at F_1

F_1 0,7 F_d or the load at s_d -25 mm

s_{11} deflection on the loading curve at F_1

s_{12} deflection on the unloading curve at F_1

s_2 average deflection at F_2

F_2 1,3 F_d or the load at s_d +25 mm

s_{21} deflection on the loading curve at F_2

s_{22} deflection on the unloading curve at F_2

s_d average deflection at F_d

s_{d1} deflection on the loading curve at F_d

s_{d2} deflection on the unloading curve at F_d

Figure A.3 — The load-deflection curve of the spring

A.8.4 Calculating methods for deflection at a specified load

The deflection at a specified load is calculated using Formulae (A.1), (A.2) and (A.3):

$$s_1 = \left(s_{11} + s_{12}\right) / 2 \quad \text{(A.1)}$$

$$s_2 = \left(s_{21} + s_{22}\right) / 2 \quad \text{(A.2)}$$

$$s_d = \left(s_{d1} + s_{d2}\right) / 2 \quad \text{(A.3)}$$

where all of the symbols has been given in Figure A.3.

A.8.5 Calculating methods for spring rate

For the springs listed in Figure 1 to Figure 6, the spring rate is calculated using Formula (A.4). For the other spring, the calculating methods for spring rate may refer to the formula or agreement between the purchaser and the supplier.

$$R = \left(F_2 - F_1\right) / \left(s_2 - s_1\right) \tag{A.4}$$

where

R is the spring rate;

F_1 is 0,7 F_d or the load at s_d -25 mm;

F_2 is 1,3 F_d or the load at s_d +25 mm;

s_1 is the average deflection at F_1;

s_2 is the average deflection at F_2.

The value of the spring rate should be rounded and accurate to the precision 0,1.

A.9 Design camber

A.9.1 Test equipment

See A.8.1.

A.9.2 Bearing and clamping methods

See A.8.2.

A.9.3 Test methods

The load is applied through pressing fixture as shown in Figure A.2. First apply the load to the maximum test load gradually, then unload to zero, record the free camber C_0. Repeat above step again, then record the load and corresponding deflection, draw load-deflection curve. See Figure A.3

A.9.4 Calculating methods for design camber

The design camber is calculated using Formula (A.5).

$$C_d = C_0 - s_d \tag{A.5}$$

where

C_d is the design camber

C_0 is the free camber

s_d is the average deflection at F_d

A.10 Fatigue test

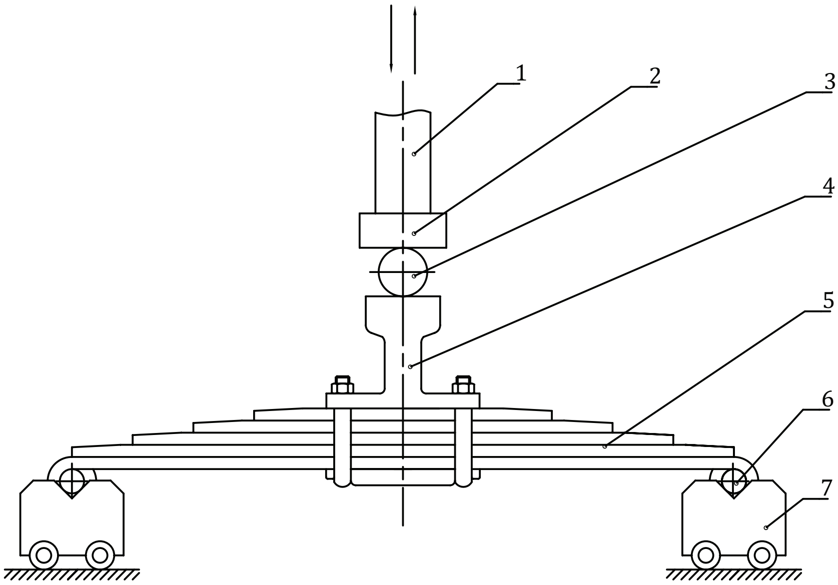
A.10.1 Test equipment

The test equipment should hold leaf spring stably, and keep the spring in the state as same as actual use, apply cyclic testing load at centre part to make leaf spring incur reciprocating deflection. The test equipment should be equipped with apparatus for measuring cyclic force and deflection. The accuracy of load measuring should not exceed ±1 % of the maximum test load, and the accuracy of deflection measuring should not exceed ±0,5 mm.

A.10.2 Bearing and clamping methods

The bearing and clamping methods of the springs are in accordance with A.8.2, the clamping method of the centre part should simulate its installation in the vehicle or similar function state.

Example of common clamping method is shown in Figure A.4.



Key

1 actuator
2 load sensor
3 spherical hinge
4 clamping device
5 spring
6 axis pin
7 carriage

Figure A.4 — Example of common clamping method

A.10.3 Test method

A.10.3.1 Fatigue test load or deflection should be agreed between the purchaser and the supplier.

A.10.3.2 In general, the test frequency should be less than 3 Hz, and test should not be interrupted until failure or meet customers' specification. If the test has to be interrupted, the interrupt time should be as short as possible, and record the interrupt condition.

A.10.3.3 During the test, the surface temperature of the sample should not be obvious hot. Forced cooling is permitted to reduce high temperature of the springs during testing.

A.10.3.4 The springs are considered to have failed if: 1) Any leaf fractured or shown visible crack line before the target fatigue cycle; 2) In case of the significant change of the camber or spring rate.

The number of cycles completed shall be the fatigue life of the springs.

A.10.3.5 The number of the samples for the fatigue testing should be no less than 3 or be agreed between the purchaser and the supplier.

ICS 21.160

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