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Disc springs —

Part 2: Technical specifications

Ressorts à disques —

Partie 2: Spécifications techniques

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 227, *Springs*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

A list of all parts in the ISO 19690 series can be found on the ISO website.

Disc springs —

Part 2: Technical specifications

1 Scope

This document specifies two different grades of disc springs.

Grade A defines basic requirements of disc springs for static applications with low and moderate performance. Springs manufactured according to Grade A are not used for dynamic applications.

Grade B defines requirements on disc springs especially used for dynamic applications and high performance static applications. Disc springs according to Grade B ensure a better quality by higher demands on manufacturing processes and tolerance requirements. Grade B includes graphs showing the guaranteed fatigue life such as a function of stress.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 683-1, *Heat-treatable steels, alloy steels and free-cutting steels — Part 1: Non-alloy steels for quenching and tempering*

ISO 683-2, *Heat-treatable steels, alloy steels and free-cutting steels — Part 2: Alloy steels for quenching and tempering*

ISO 6507 (all parts), *Metallic materials — Vickers hardness test*

ISO 6508 (all parts), *Metallic materials — Rockwell hardness test*

ISO 16249, *Springs — Symbols*

ISO 26909, *Springs — Vocabulary*

EN 1654, *Copper and copper alloys — Strip for springs and connectors*

EN 10083-1, *Quenched and tempered steels — Technical delivery conditions for special steels*

EN 10083-2, *Quenched and tempered steels — Technical delivery conditions for unalloyed quality steels*

EN 10083-3, *Quenched and tempered steels — Technical delivery conditions for boron steels*

EN 10089, *Hot-rolled steels for quenched and tempered springs — Technical delivery conditions*

EN 10132-4, *Cold-rolled narrow steel strip for heat treatment — Technical delivery conditions — Part 4: Spring steels and other applications*

EN 10151, *Stainless steel strip for springs — Technical delivery conditions*

JIS G 3311, *Cold-rolled special steel strip*

JIS G 4801, *Spring steels*

JIS G 4802, *Cold-rolled steel strip for springs*

ASTM A240, *Standard specification for chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels and for general applications*

ASTM A332, *Specification for nickel-chromium-molybdenum steel bars for springs*

ASTM A506, *Standard specification for alloy and structural alloy steel, sheet and strip, hot-rolled and cold-rolled*

ASTM A568, *Standard specification for steel, sheet, carbon, structural, and high-strength, low-alloy, hot-rolled and cold-rolled, General requirements for*

ASTM A666, *Standard specification for annealed or cold-worked austenitic stainless steel sheet, strip, plate, and flat bar*

ASTM A682, *Standard specification for steel, strip, high carbon, cold rolled, General requirements for*

ASTM A684, *Standard specification for steel, strip, high carbon, cold rolled*

ASTM A689, *Standard specification for carbon and alloy steel bars for springs*

ASTM A693, *Standard specification for precipitation-hardening stainless and heat-resistant steel plate, sheet, and strip*

ASTM B103, *Standard specification for phosphor bronze pate, sheet, strip, and rolled bar*

ASTM B194, *Standard specification for copper-beryllium alloy plate, sheet, strip, and rolled bar*

ASTM B196, *Standard specification for copper-beryllium alloy rod and bar*

GB/T 1222, *Spring steels*

BS 970-2, *Specification for wrought steels for mechanical and allied engineering purposes: Requirements for steels for the manufacture of hot-formed springs*

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

4 Symbols and units

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

Table 1 — Symbols and units for design calculation

Symbol	Unit	Parameter
b_r	mm	width of scar (see Figure 2)
D	mm	external diameter of spring
D_0	mm	diameter of centre of rotation
d	mm	internal diameter of spring

NOTE 1 N/mm^2 = 1 MPa.

a r is not chamfered unless otherwise agreed between customer and supplier.

Table 1 *(continued)*

Symbol	Unit	Parameter
E	N/mm^2	modulus of elasticity of material (carbon steel and carbon alloy steel: 206 000 N/mm^2)
F	N	spring load
F_c	N	design spring load when spring is in the flattened position
F_G	N	spring load at the time of combining springs
F_t	N	spring test load at H_t
H_t	mm	height of spring when measuring spring test load, $H_t = H_0 - 0{,}75h_0$
H_0	mm	free height of spring
h_s	mm	clean cut (see Figure 2)
h_0	mm	initial cone height of spring without flat bearings, $h_0 = H_0 - t$
$h_{0,f}$	mm	initial cone height of spring with flat bearings, $h_{0,f} = H_0 - t_f$
i	—	number of springs combined in series
L_0	mm	free height at the time of combining springs
N	—	number of cycles for fatigue life
n	—	number of springs piled in parallel
OM	—	point at upper surface of the spring perpendicular to the centre line at point P
P	—	theoretical centre of rotation of disc cross section
R	N/mm	spring rate
r [a]	mm	radius at edge
s	mm	deflection of spring
s_G	mm	deflection of stack
s_1	mm	deflection of spring preloaded
t	mm	thickness of spring
t_f	mm	reduced thickness of single disc spring with flat bearings
V	mm	length of lever arms
V_f	mm	length of lever arms with flat bearings
ΔF	N	spring load loss
Δh_0	mm	initial cone height loss of spring
ν	—	Poisson's ratio of material
σ_H	N/mm^2	alternative stress, $\sigma_H = \sigma_{max} - \sigma_{min}$
σ_{OM}	N/mm^2	stress at position OM
σ_{max}	N/mm^2	maximum fatigue stress
σ_{min}	N/mm^2	minimum fatigue stress
σ_I	N/mm^2	stress at position I
σ_{II}	N/mm^2	stress at position II
σ_{III}	N/mm^2	stress at position III
σ_{IV}	N/mm^2	stress at position IV

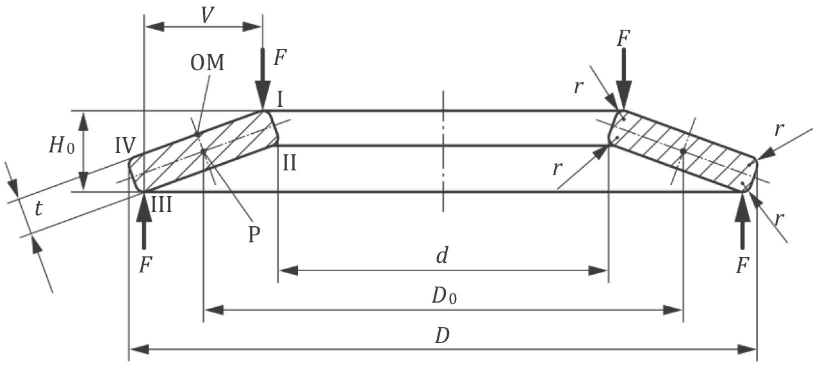
NOTE 1 N/mm^2 = 1 MPa.

[a] r is not chamfered unless otherwise agreed between customer and supplier.

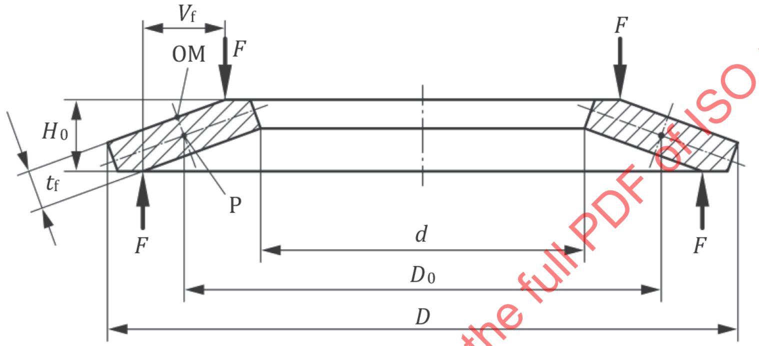
5 Dimensions and designation

5.1 General

Figure 1 illustrates a single disc spring, including the relevant positions of loading.



a) Without flat bearings — Group 1 and Group 2



b) With flat bearings — Group 3

Key

D	external diameter of spring
D_0	diameter of centre of rotation
d	internal diameter of spring
F	spring load
H_0	free height of spring
OM	point at upper surface of the spring perpendicular to the centre line at point P
P	theoretical centre of rotation of disc cross section
r[a]	radius at edge
t	thickness of spring
t_f	reduced thickness of single disc spring with flat bearings
V	length of lever arms
V_f	length of lever arms with flat bearings
I	position I
II	position II
III	position III
IV	position IV
a	r is not chamfered unless otherwise agreed between customer and supplier.

Figure 1 — Single disc spring (sectional view), including the relevant positions of loading

5.2 Disc spring groups

Table 2 shows the disc spring groups.

Table 2 — Disc spring groups

Group	t mm	With flat bearings and reduced thickness
1	$0{,}2 \le t < 1{,}25$	No
2	$1{,}25 \le t \le 6{,}0$	No
3	$6{,}0 < t \le 14{,}0$	Yes

5.3 Dimensional series

Table 3 shows the dimensional series.

Table 3 — Dimensional series

Dimensional series	h_0/t	t_f/t	D/t
A	≈ 0,40	≈ 0,94	≈ 18
B	≈ 0,75	≈ 0,94	≈ 28
C	≈ 1,30	≈ 0,96	≈ 40

NOTE Refer to Annex A for typical disc spring dimensions.

6 Grade A — Basic performance requirements for static applications

6.1 Material

Unless otherwise agreed between customer and supplier, disc springs should be made from material conforming to Table 4.

6.2 Manufacturing process

Unless otherwise agreed between customer and supplier, disc springs should be made by the manufacturing process shown in Table 4.

Table 4 — Manufacturing process and material

Group	t mm	Manufacturing process	Material
1	$0{,}2 \leq t < 1{,}25$	Stamping, cold or hot forming, edge rounding	Carbon steel or alloy steel
2	$1{,}25 \leq t \leq 6{,}0$	Stamping, cold or hot forming, *D* and *d* turning[a], edge rounding	Carbon steel[b] or alloy steel
3	$6{,}0 < t \leq 14{,}0$	Cold or hot forming, turning on all sides, edge rounding or Stamping[c], cold or hot forming, *D* and *d* turning, edge rounding	Alloy steel

[a] *D* and *d* turning are optional.

[b] Carbon steel used $1{,}25 \leq t \leq 2{,}0$ only.

[c] Stamping without *D* and *d* turning is not permitted.

6.3 Permissible stresses

For disc springs made of steels according to materials shown in Table 4, which are subject to static loading, the design stress, σ_{OM}, at maximum deflection shall not exceed 1 400 N/mm^2.

NOTE The design stress, σ_{OM}, is derived from the formulae given in ISO 19690-1.

6.4 Presetting

After heat treatment, each disc spring shall be loaded until it is in the flat position. After loading the disc spring with twice its spring test load, F_t, the tolerances for the spring load as specified in Table 8 shall be met.

6.5 Surface condition and corrosion protection

The surface treatment should be agreed between customer and supplier.

The surface shall be free from defects such as scars, cracks and corrosion.

As disc springs are easy to be rusted, it is preferable to apply suitable corrosion protection to them.

Whether and which corrosion protection is to be provided shall depend on the particular spring application. Suitable corrosion protections include phosphating, black finishing and the application of protective metallic coatings such as zinc or nickel. This shall be agreed between customer and supplier.

It is possible that the galvanizing processes using aqueous solutions that are currently available do not preclude the risk of hydrogen embrittlement. Disc springs with a hardness exceeding 40 HRC are more prone to the risk of hydrogen embrittlement than softer springs. Special care shall therefore be taken when selecting the material, manufacturing process, heat treatment and surface treatment. When ordering disc springs with galvanic surface protection, it is advisable to consult the spring manufacturer.

For disc springs, galvanic surface protection should be avoided.

Phosphating and oiling form the standard corrosion protection for disc springs.

6.6 Tolerances

6.6.1 Thickness

The tolerances on thickness are shown in Table 5.

For information on testing of thickness, see Annex B.

Table 5 — Tolerances on thickness

Dimensions in mm

Group	t	Tolerance
1	$0,2 \le t \le 0,6$	$^{+0,03}_{-0,06}$
	$0,6 < t < 1,25$	$^{+0,06}_{-0,09}$
2	$1,25 \le t \le 3,8$	$^{+0,09}_{-0,12}$
	$3,8 < t \le 6,0$	$^{+0,10}_{-0,15}$
3	$6,0 < t \le 14,0$	±0,15

6.6.2 External- internal diameter and coaxiality

The tolerances on external diameter and internal diameter are shown in Table 6. The tolerances are determined by the tolerance grade IT13, which is specified in ISO 286-2.

Coaxiality tolerance: 2 × IT13

For information on testing of external diameter and internal diameter, see Annex B.

Table 6 — Tolerances on external diameter and internal diameter

Dimensions in mm

D or *d*		Tolerance, *D*	Tolerance, *d*
over 3	up to 6	$^{0}_{-0,18}$	$^{+0,18}_{0}$
over 6	up to 10	$^{0}_{-0,22}$	$^{+0,22}_{0}$
over 10	up to 18	$^{0}_{-0,27}$	$^{+0,27}_{0}$
over 18	up to 30	$^{0}_{-0,33}$	$^{+0,33}_{0}$
over 30	up to 50	$^{0}_{-0,39}$	$^{+0,39}_{0}$
over 50	up to 80	$^{0}_{-0,46}$	$^{+0,46}_{0}$
over 80	up to 120	$^{0}_{-0,54}$	$^{+0,54}_{0}$
over 120	up to 180	$^{0}_{-0,63}$	$^{+0,63}_{0}$
over 180	up to 250	$^{0}_{-0,72}$	$^{+0,72}_{0}$

6.6.3 Free height

The tolerances on free height are shown in Table 7.

For information on testing of free height, see Annex B.

Table 7 — Tolerances on free height

Dimensions in mm

Group	t	Tolerance
1	$0{,}2 \le t < 1{,}25$	+0,10 −0,05
2	$1{,}25 \le t < 2{,}1$	+0,15 −0,08
	$2{,}1 \le t < 3{,}5$	+0,20 −0,10
	$3{,}5 \le t \le 6{,}0$	+0,30 −0,15
3	$6{,}0 < t \le 14{,}0$	±0,30

6.6.4 Spring load

The spring load, F_t, shall be determined at test height $H_t = H_0 - 0{,}75h_0$. The tolerances on spring loads are shown in Table 8. The measurement is taken while loading between flat plates, using a suitable lubricant. The flat plates shall be hardened, ground and polished. In the case of stacking the springs, the tolerance on spring load should be agreed between customer and supplier.

To comply with the specified load tolerances, it can be necessary to exceed the tolerance values specified for H_0 and t.

Table 8 — Tolerances on spring load

Group	t mm	Tolerance F_t ($H_t = H_0 - 0{,}75h_0$) N
1	$0{,}2 \le t < 1{,}25$	+30 % −10 %
2	$1{,}25 \le t \le 3{,}0$	+20 % −10 %
	$3{,}0 < t \le 6{,}0$	+15 % −7,5 %
3	$6{,}0 < t \le 14{,}0$	±10 %

6.7 Clearance between disc spring and guiding element

A guiding element is necessary to keep the disc spring in position. This should preferably be a mandrel. In the case of external positioning, a sleeve is preferred.

Table 9 shows clearance of guide.

Table 9 — Clearance of guide

Dimensions in mm

D or *d*		Clearance of diameter
	up to 15	0,2
over 15	up to 20	0,3
over 20	up to 26	0,4
over 26	up to 31,5	0,5
over 31,5	up to 45	0,6
over 45	up to 75	0,8
over 75	up to 140	1,0
over 140	up to 250	1,6

6.8 Hardness

The hardness of disc springs shall lie within the range of 42 HRC to 52 HRC.

For group 1 disc springs, the hardness shall be determined according to Vickers (425 HV10 to 510 HV10).

After heat treatment, the disc spring shall not exhibit a depth of decarburization exceeding 3 % of its thickness.

Vickers hardness testing shall be carried out according to ISO 6507 (all parts) and Rockwell hardness testing according to ISO 6508 (all parts).

6.9 Appearance

The appearance testing should be carried out according to B.3.6. The surface shall be free from cracks, impedimental defects, burrs, corrosion and so forth.

In addition, there shall be no sharp edge on the inner and outer circumferences.

7 Grade B — Requirements on disc springs for dynamic applications and high-performance static applications

7.1 Material

Disc springs shall be made from material conforming to Annex C.

7.2 Manufacturing process

Disc springs shall be made in accordance with the manufacturing process shown in Table 10 and Figure 2.

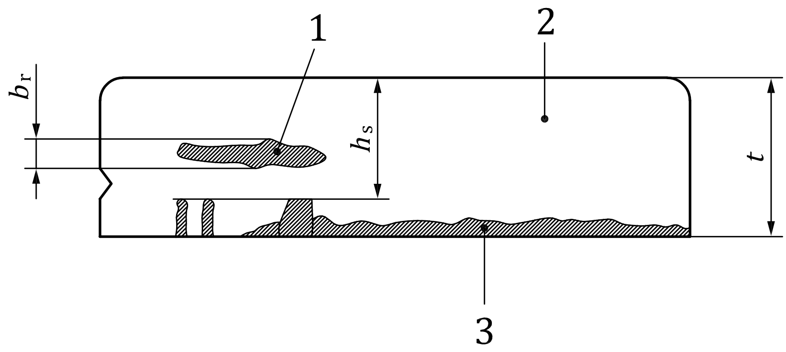
Table 10 — Manufacturing process and material

Group	t mm	Manufacturing process	Material according to Annex C
1	$0{,}2 \leq t < 1{,}25$	Stamping, cold or hot forming, edge rounding or Stamping, cold or hot forming, *D* and *d* turning, edge rounding or Fine blanking[b], cold or hot forming, edge rounding	Cold rolled carbon steel or cold rolled alloy steel or hot rolled if all surfaces are machined to remove scale and surface defects according to Annex C
2	$1{,}25 \leq t \leq 6{,}0$	Stamping[a], cold or hot forming, *D* and *d* turning, edge rounding or Fine blanking[b], cold or hot forming, edge rounding	Cold rolled carbon steel[c] or cold rolled alloy steel or hot rolled if all surfaces are machined to remove scale and surface defects according to Annex C
3	$6{,}0 < t \leq 14{,}0$	Cold or hot forming, turning on all sides, edge rounding or Stamping[a], cold or hot forming, *D* and *d* turning, edge rounding or Fine blanking[b], cold or hot forming, edge rounding	Cold rolled alloy steel or hot rolled if all surfaces are machined to remove scale and surface defects according to Annex C

[a] Stamping without *D* and *d* turning is not permitted.

[b] Fine blanking in accordance with Figure 2: clean cut min. 75 %, b_r/t max. 15 %, tear off max. 25 %.

[c] Carbon steel used $1{,}25 \leq t \leq 2{,}0$ only.



Key

1	scar	b_r	width of scar
2	clean cut part	b_r/t	scar width ratio of thickness, max. 15 %
3	tear off	h_s	clean cut
		h_s/t	clean cut ratio of thickness, min. 75 %
		t	thickness of spring

Figure 2 — Fine blanking

7.3 Permissible stresses

7.3.1 Static load

For disc springs made of steels according to materials shown in Table 10, which are subject to high-performance static loading or to dynamic applications, the design stress, σ_{OM}, at maximum deflection shall not exceed 1 600 N/mm^2.

NOTE The design stress, σ_{OM}, is derived from the formulae given in ISO 19690-1.

7.3.2 Dynamic loading

Minimum initial deflection is needed to avoid cracking.

Disc springs subject to fatigue loading shall be designed and installed in such a way that the initial deflection, s_1, is approximately 0,15h_0 to 0,20h_0 in order to avoid cracking at the upper inner edge, position I (see Figure 1) as a result of residual stresses from the presetting process.

To determine the number of load cycles, first calculate the tensile stresses of σ_{II} and σ_{III} at maximum and minimum load. Calculate the number of load cycles for positions II and III. Take into consideration the lower number of load cycles.

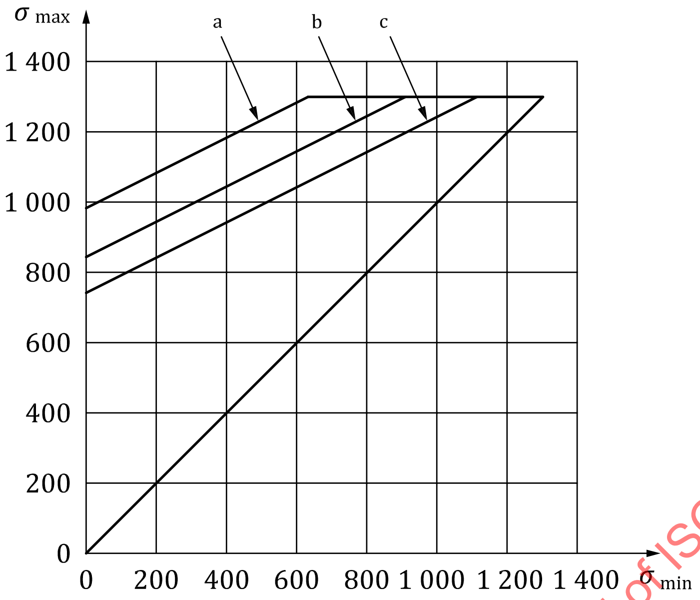
The durability charts of the spring steel without shot peening are shown in Figures 3 to 5.

Figures 3 to 5 illustrate the fatigue life of disc springs subject to dynamic loading that have not been shot peened. They specify guideline values for the alternative stress, σ_H, as a function of the minimum stress, σ_{min}, at three different numbers of stress cycles, N, namely where $N = 10^5$, $N = 5 \times 10^5$ and $N = 2 \times 10^6$.

Intermediate values for other numbers of stress cycles may be estimated based on this information.

The information given in Figures 3 to 5 represents the results of laboratory testing using fatigue testing equipment capable of producing sinusoidal loading cycles and the statistical results obtained for a 99 % probability of fatigue life. The figures are valid for single disc springs and stacks with $i \leq 10$ disc springs stacked in series. Test conditions are: room temperature; disc springs preloaded from s_1 approximately equal to 0,15h_0 to s_1 approximately equal to 0,20h_0; surface hardened and perfectly processed inner and outer guidance.

To ensure the expected fatigue life of disc springs, they shall be protected from mechanical damage and other adverse conditions.



Key

a N (number of cycles for fatigue life) = 1×10^5 cycles

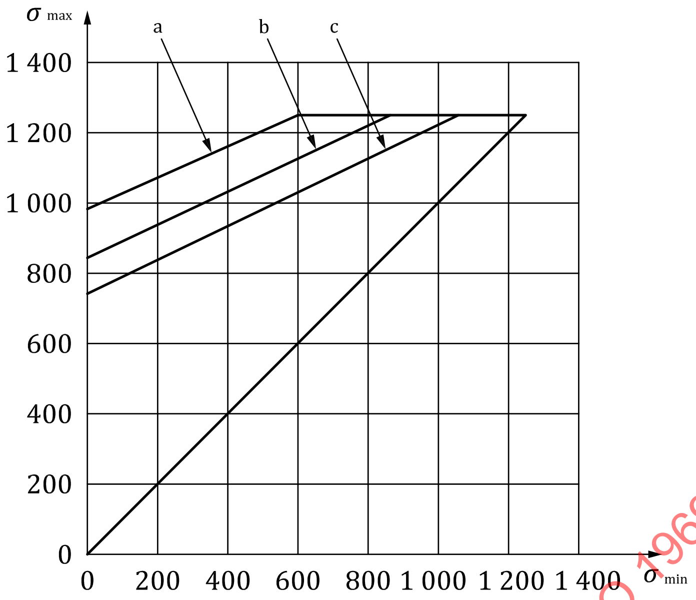
b N (number of cycles for fatigue life) = 5×10^5 cycles

c N (number of cycles for fatigue life) = 2×10^6 cycles

σ_{max} maximum fatigue stress, in N/mm^2

σ_{min} minimum fatigue stress, in N/mm^2

Figure 3 — Durability chart for not shot peened springs (group 1)



Key

a N (number of cycles for fatigue life) = 1 × 10^5 cycles

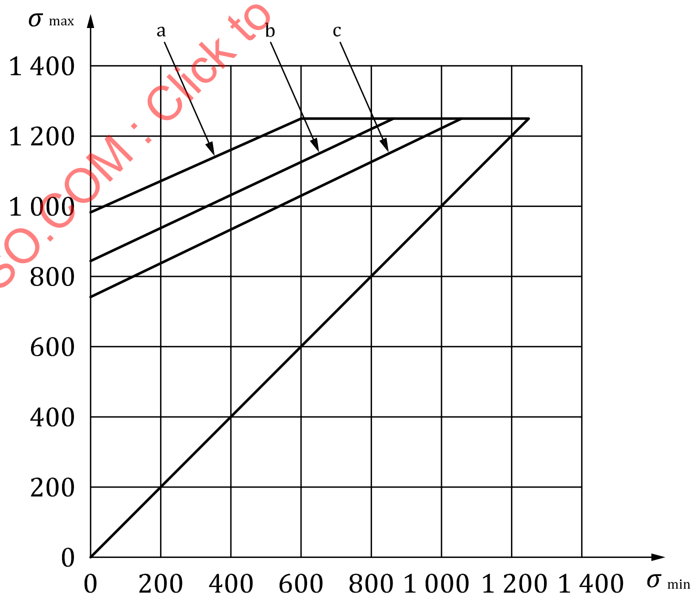
b N (number of cycles for fatigue life) = 5 × 10^5 cycles

c N (number of cycles for fatigue life) = 2 × 10^6 cycles

σ_{max} maximum fatigue stress, in N/mm^2

σ_{min} minimum fatigue stress, in N/mm^2

Figure 4 — Durability chart for not shot peened springs (group 2)



Key

a N (number of cycles for fatigue life) = 1 × 10^5 cycles

b N (number of cycles for fatigue life) = 5 × 10^5 cycles

c N (number of cycles for fatigue life) = 2 × 10^6 cycles

σ_{max} maximum fatigue stress, in N/mm^2

σ_{min} minimum fatigue stress, in N/mm^2

Figure 5 — Durability chart for not shot peened springs (group 3)

NOTE 1 Reliable information regarding the fatigue life is not available for disc springs made from materials other than those specified here (see Annex C), for disc springs consisting of more than 10 single disc springs stacked in series, for other arrangements of stacks of springs, nor for springs subjected to chemical or thermal effects, although some relevant information is usually obtainable from the spring manufacturer.

NOTE 2 In the case of stacks with a highly degressive load/deflection curve and a large number of single disc springs stacked in series, a non-uniform deflection of the single disc springs can be expected. This effect is caused by friction between the disc springs and the guiding element and dimensional tolerances.

NOTE 3 Disc springs at the moving end of the stack deflect more than others.

NOTE 4 The fatigue life of disc springs can be prolonged considerably by additional shot peening.

NOTE 5 The possible level of fatigue is diminished by friction as caused by excessive stacking (i, n), bad guiding or missing lubrication.

7.4 Shot peening

In order to increase the values given in Figures 3 to 5, shot peening according to ISO 26910-1 is recommended. This procedure shall be the subject of agreement between customer and supplier.

7.5 Presetting

After heat treatment, each disc spring shall be loaded until it is in the flat position. After loading the disc spring with twice its spring test load, F_t, the tolerances for the spring load as specified in Table 14 shall be met.

7.6 Creep and relaxation

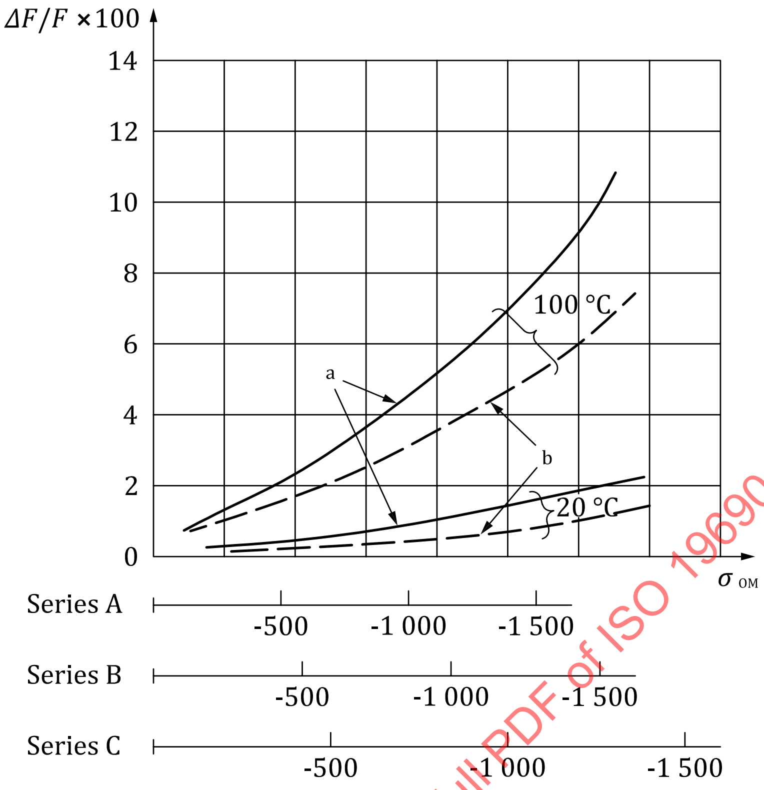
All disc springs lose load during usage. Depending on the application, this is expressed by creep or relaxation. Both creep and relaxation are largely a result of the stress distribution over the cross section of the disc spring. Its influence can be estimated on the basis of the design stress, σ_{OM}.

Creep is defined as the further decrease in height of the disc spring with time, Δh_0, when subjected to a constant load. Relaxation is defined as the decrease in load with time, ΔF, when the disc spring is compressed to a constant height.

The estimate values of relaxation of the spring which is applied to static loading, depending on temperature, time, compressive stress and material, are shown in Figures 6 and 7.

In the case of using springs in an environment of temperature over 100 °C, the spring manufacturers should be consulted.

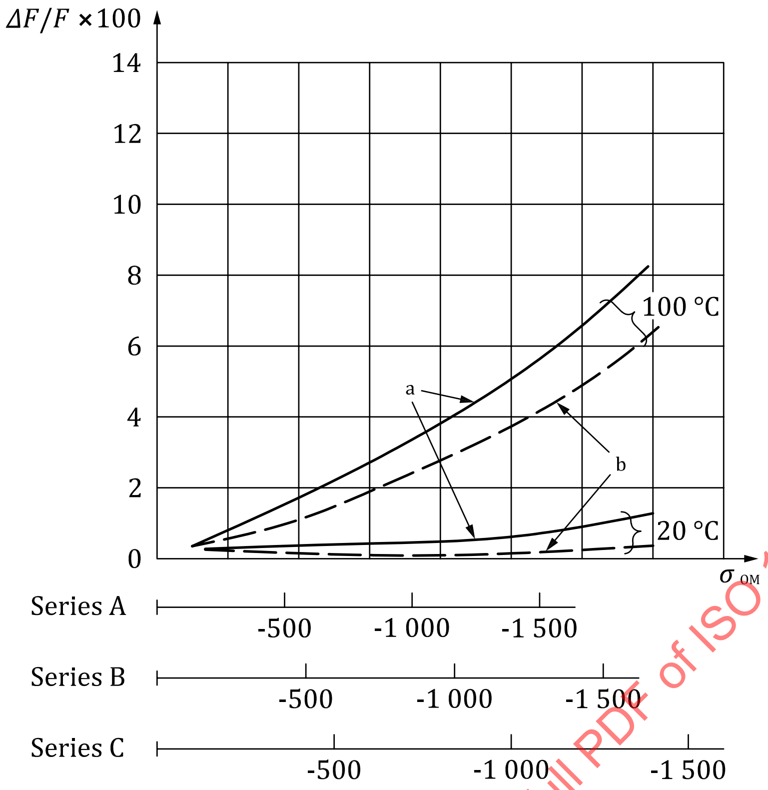
Other creep and relaxation test condition requirements should be agreed between customer and supplier.



Key

a	after 1 000 h
b	after 48 h
F	spring load
Series A	h_0/t, ≈ 0,40
Series B	h_0/t, ≈ 0,75
Series C	h_0/t, ≈ 1,30
ΔF	spring load loss
$\Delta F/F$	relaxation, in %
σ_{OM}	stress at position OM, in N/mm^2

Figure 6 — Permissible relaxation for disc springs made of carbon steel (according to Annex C)



Key

a	after 1 000 h
b	after 48 h
F	spring load
Series A	$h_0/t, \approx 0{,}40$
Series B	$h_0/t, \approx 0{,}75$
Series C	$h_0/t, \approx 1{,}30$
ΔF	spring load loss
$\Delta F/F$	relaxation, in %
σ_{OM}	stress at position OM, in N/mm^2

Figure 7 — Permissible relaxation for disc springs made of alloy steel (according to Annex C)

7.7 Surface condition and corrosion protection

The surface treatment should be agreed between customer and supplier.

The surface shall be free from defects such as scars, cracks and corrosion.

As disc springs are easy to be rusted, it is preferable to apply suitable corrosion protection to them.

Whether and which corrosion protection is to be provided shall depend on the particular spring application. Suitable corrosion protections include phosphating, black finishing and the application of protective metallic coatings such as zinc or nickel. This shall be agreed between customer and supplier.

The galvanizing processes using aqueous solutions that are currently available may not preclude the risk of hydrogen embrittlement. Disc springs with a hardness exceeding 40 HRC are more prone to the risk of hydrogen embrittlement than softer springs. Special care shall therefore be taken when selecting the material, manufacturing process, heat treatment and surface treatment. When ordering disc springs with galvanic surface protection, it is advisable to consult the spring manufacturer.

For disc springs, galvanic surface protection should be avoided.

Phosphating and oiling is the standard corrosion protection for disc springs.

7.8 Tolerances

7.8.1 Thickness

The tolerances on thickness shall be according to Table 11.

For information on testing of thickness, see Annex B.

Table 11 — Tolerances on thickness

Dimensions in mm

Group	t	Tolerance
1	$0{,}2 \le t \le 0{,}6$	$^{+0{,}03}_{-0{,}06}$
	$0{,}6 < t < 1{,}25$	$^{+0{,}06}_{-0{,}09}$
2	$1{,}25 \le t \le 3{,}8$	$^{+0{,}09}_{-0{,}12}$
	$3{,}8 < t \le 6{,}0$	$^{+0{,}10}_{-0{,}15}$
3	$6{,}0 < t \le 14{,}0$	±0,15

7.8.2 External-internal diameter and coaxiality

The tolerances on external diameter and internal diameter are shown in Table 12.

Coaxiality tolerance for $D \le 50$: 2 × IT11

Coaxiality tolerance for $D > 50$: 2 × IT12

For information on testing of external diameter and internal diameter, see Annex B.

Table 12 — Tolerances on external diameter and internal diameter

Dimensions in mm

D or d	Tolerance, D	Tolerance, d
Over 3 up to 6	$^{0}_{-0{,}12}$	$^{+0{,}12}_{0}$
Over 6 up to 10	$^{0}_{-0{,}15}$	$^{+0{,}15}_{0}$
Over 10 up to 18	$^{0}_{-0{,}18}$	$^{+0{,}18}_{0}$
Over 18 up to 30	$^{0}_{-0{,}21}$	$^{+0{,}21}_{0}$
Over 30 up to 50	$^{0}_{-0{,}25}$	$^{+0{,}25}_{0}$
Over 50 up to 80	$^{0}_{-0{,}30}$	$^{+0{,}30}_{0}$

Table 12 *(continued)*

D or *d*	Tolerance, *D*	Tolerance, *d*
Over 80 up to 120	0 −0,35	+0,35 0
Over 120 up to 180	0 −0,40	+0,40 0
Over 180 up to 250	0 −0,46	+0,46 0

7.8.3 Free height

The tolerances on free height are shown in Table 13.

For information on testing of free height, see Annex B.

Table 13 — Tolerances on free height

Dimensions in mm

Group	*t*	Tolerance
1	$0,2 \le t < 1,25$	+0,10 −0,05
2	$1,25 \le t < 2,1$	+0,15 −0,08
	$2,1 \le t < 3,5$	+0,20 −0,10
	$3,5 \le t \le 6,0$	+0,30 −0,15
3	$6,0 < t \le 14,0$	±0,30

7.8.4 Spring load

The spring load, F_t, shall be determined at test height $H_t = H_0 - 0,75h_0$. The tolerances on spring loads are shown in Table 14. The measurement is taken while loading between flat plates, using a suitable lubricant. The flat plates shall be hardened, ground and polished. In the case of stacking the springs, the tolerance on spring load should be agreed between customer and supplier.

To comply with the specified load tolerances, it can be necessary to exceed the tolerance values specified for H_0 and *t*.

Table 14 — Tolerances on spring load

Group	*t* mm	Tolerance F_t ($H_t = H_0 - 0,75h_0$) N
1	$0,2 \le t < 1,25$	+25 % −7,5 %
2	$1,25 \le t \le 3,0$	+15 % −7,5 %
	$3,0 < t \le 6,0$	+10 % −5 %
3	$6,0 < t \le 14,0$	±5 %

7.9 Clearance between disc spring and guiding element

A guiding element is necessary to keep the disc spring in position. This should preferably be a mandrel. In the case of external positioning, a sleeve is preferred.

The hardness of guide shall be ≥55 HRC. Where possible, the guiding element and the support plate shall be made from case-hardened materials, with a case depth of approximately 0,8 mm, and have a minimum hardness of 55 HRC. The surface of the guiding element should be smooth and perfectly finished.

Unhardened guiding elements may be used where the disc spring is subject to static loading.

Table 15 shows clearance of guide.

Table 15 — Clearance of guide

Dimensions in mm

D or *d*		Clearance of diameter
	up to 15	0,2
over 15	up to 20	0,3
over 20	up to 26	0,4
over 26	up to 31,5	0,5
over 31,5	up to 45	0,6
over 45	up to 75	0,8
over 75	up to 140	1,0
over 140	up to 250	1,6

7.10 Hardness

To ensure satisfactory fatigue life with minimum relaxation, the hardness of disc springs shall lie within the range of 42 HRC to 52 HRC.

For group 1 disc springs, the hardness shall be determined according to Vickers (425 HV10 to 510 HV10).

After heat treatment, the disc spring shall not exhibit a depth of decarburization exceeding 3 % of its thickness.

Vickers hardness testing shall be carried out according to ISO 6507 (all parts) and Rockwell hardness testing according to ISO 6508 (all parts).

7.11 Appearance

The appearance testing should be carried out according to B.3.6. The surface shall be free from cracks, impedimental defects, burrs, corrosion and so forth.

In addition, there shall be no sharp edge on the inner and outer circumferences.

Annex A
(informative)

Spring dimensions

A.1 Spring dimensions, sizes, design value

A.1.1 Dimensional series A

Disc springs with $D/t \approx 18$, $h_0/t \approx 0{,}4$, $E = 206\ 000\ \text{N/mm}^2$ and $\nu = 0{,}3$.

See Table A.1.

Table A.1 — Dimension of springs for series A

Group	D mm	d mm	t or (t_f)[b] mm	h_0 mm	H_0 mm	F_t N	H_t mm	σ_{II}[c] N/mm²	σ_{OM} N/mm²
	h12[a]	H12[a]				$s \approx 0{,}75h_0$			$s \approx h_0$
1	8	4,2	0,4	0,2	0,6	210	0,45	1 218	−1 605
	10	5,2	0,5	0,25	0,75	325	0,56	1 218	−1 595
	12,5	6,2	0,7	0,3	1	660	0,77	1 382	−1 666
	14	7,2	0,8	0,3	1,1	797	0,87	1 308	−1 551
	16	8,2	0,9	0,35	1,25	1 013	0,99	1 301	−1 555
	18	9,2	1	0,4	1,4	1 254	1,1	1 295	−1 558
	20	10,2	1,1	0,45	1,55	1 521	1,21	1 290	−1 560

[a] Given in ISO 286-1.

[b] The values specified for t are nominal values. In the case of springs with flat bearings (compared with group 3 in Clause 5), the desired spring load, F (where $s \approx 0{,}75h_0$), is obtained by reducing the thickness of single disc springs, t, which is then given the value t_f. In the case of dimensional series A and B, $t_f \approx 0{,}94 \times t$, and in the case of dimensional series C, $t_f \approx 0{,}96 \times t$.

[c] The values specified apply for the largest calculated tensile stress on the lower edges of the spring.

[d] The values are used mostly in Asia.

[e] According to Table 2, thickness 1,2 mm is categorized into group 1; however, 1,2 mm is regarded as an alternative for thickness 1,25 mm mostly in Asia, therefore thickness 1,2 mm is into group 2.

[f] The values specified apply for the largest calculated tensile stress at the position designated III.

Table A.1 *(continued)*

Group	D mm	d mm	t **or** (t_f)[b] mm	h_0 mm	H_0 mm	F_t N	H_t mm	σ_{II}[c] N/mm²	σ_{OM} N/mm²
	h12[a]	H12[a]				$s \approx 0{,}75h_0$			$s \approx h_0$
2	22,5	11,2	1,2[d,e]	0,5	1,7[d]	1 757[d]	1,32[d]	1 229[d]	−1 472[d]
			1,25		1,75	1 929	1,37	1 296	−1 534
	25	12,2	1,5	0,55	2,05	2 926	1,64	1 419	−1 622
			1,6[d]		2,15[d]	3 716 [d]	1,74[d]	1 538[d]	−1 730[d]
	28	14,2	1,5	0,65	2,15	2 841	1,66	1 274	−1 562
			1,6[d]		2,25[d]	3 592[d]	1,76[d]	1 385[d]	−1 666[d]
	31,5	16,3	1,75	0,7	2,45	3 871	1,92	1 296	−1 570
			1,8[d]		2,5[d]	4 380[d]	1,97[d]	1 343[d]	−1 615[d]
	35,5	18,3	2	0,8	2,8	5 187	2,2	1 332	−1 611
	40	20,4	2,2[d]	0,9	3,1[d]	6 275[d]	2,42[d]	1 290[d]	−1 560[d]
			2,25		3,15	6 500	2,47	1 328	−1 595
	45	22,4	2,5	1	3,5	7 716	2,75	1 296	−1 534
	50	25,4	3	1,1	4,1	11 976	3,27	1 418	−1 659
	56	28,5	3	1,3	4,3	11 388	3,32	1 274	−1 565
	63	31	3,5	1,4	4,9	15 025	3,85	1 296	−1 524
	71	36	4	1,6	5,6	20 535	4,4	1 332	−1 594
	80	41	5	1,7	6,7	33 559	5,42	1 453	−1 679
	90	46	5	2	7	31 354	5,5	1 295	−1 558
	100	51	6	2,2	8,2	48 022	6,55	1 418	−1 663
	112	57	6	2,5	8,5	43 707	6,62	1 239	−1 505
3	125	64	8 (7,5)	2,6	10,6	85 926	8,65	1 326	−1 708
	140	72	8 (7,5)	3,2	11,2	85 251	8,8	1 284[f]	−1 675
	160	82	10 (9,4)	3,5	13,5	138 331	10,87	1 338	−1 753
	180	92	10 (9,4)	4	14	125 417	11	1 201[f]	−1 576
	200	102	12 (11,25)	4,2	16,2	183 020	13,05	1 227	−1 611
	225	112	12 (11,25)	5	17	171 016	13,25	1 137[f]	−1 489
	250	127	14 (13,1)	5,6	19,6	248 828	15,4	1 221[f]	−1 596

[a] Given in ISO 286-1.

[b] The values specified for t are nominal values. In the case of springs with flat bearings (compared with group 3 in Clause 5), the desired spring load, F (where $s \approx 0{,}75h_0$), is obtained by reducing the thickness of single disc springs, t, which is then given the value t_f. In the case of dimensional series A and B, $t_f \approx 0{,}94 \times t$, and in the case of dimensional series C, $t_f \approx 0{,}96 \times t$.

[c] The values specified apply for the largest calculated tensile stress on the lower edges of the spring.

[d] The values are used mostly in Asia.

[e] According to Table 2, thickness 1,2 mm is categorized into group 1; however, 1,2 mm is regarded as an alternative for thickness 1,25 mm mostly in Asia, therefore thickness 1,2 mm is into group 2.

[f] The values specified apply for the largest calculated tensile stress at the position designated III.

A.1.2 Dimensional series B

Disc springs with $D/t \approx 28$, $h_0/t \approx 0{,}75$, $E = 206\,000$ N/mm² and $\nu = 0{,}3$.

See Table A.2.

Table A.2 — Dimension of springs for series B

Group	D	D	t **or** (t_f)[b]	h_0	H_0	F_t	H_t	σ_{III}	σ_{OM}
	mm	mm	mm	mm	mm	N	mm	N/mm^2	N/mm^2
	h12[a]	H12[a]				$s \approx 0{,}75\ h_0$			$s \approx h_0$
1	8	4,2	0,3	0,25	0,55	118	0,36	1 312	−1 505
	10	5,2	0,4	0,3	0,7	209	0,47	1 281	−1 531
	12,5	6,2	0,5	0,35	0,85	294	0,59	1 114	−1 388
	14	7,2	0,5	0,4	0,9	279	0,6	1 101	−1 293
	16	8,2	0,6	0,45	1,05	410	0,71	1 109	−1 333
	18	9,2	0,7	0,5	1,2	566	0,82	1 114	−1 363
	20	10,2	0,8	0,55	1,35	748	0,94	1 118	−1 386
	22,5	11,2	0,8	0,65	1,45	707	0,96	1 079	−1 276
	25	12,2	0,9	0,7	1,6	862	1,07	1 023	−1 238
	28	14,2	1	0,8	1,8	1 107	1,2	1 086	−1 282
2	31,5	16,3	1,2[c,d]	0,9	2,1[c]	1 738[c]	1,42[c]	1 156[c]	−1 384[c]
			1,25		2,15	1 913	1,47	1 187	−1 442
	35,5	18,3	1,2[c,d]	1	2,2[c]	1 541[c]	1,45[c]	1 045[c]	−1 208[c]
			1,25		2,25	1 699	1,5	1 073	−1 258
	40	20,4	1,5	1,15	2,65	2 622	1,79	1 136	−1 359
			1,6[c]		2,75[c]	3 249[c]	1,89[c]	1 186[c]	−1 449[c]
	45	22,4	1,75	1,3	3,05	3 646	2,07	1 144	−1 396
			1,8[c]		3,1[c]	4 058[c]	2,12[c]	1 165[c]	−1 435[c]
	50	25,4	2	1,4	3,4	4 762	2,35	1 140	−1 408
	56	28,5	2	1,6	3,6	4 438	2,4	1 092	−1 284
	63	31	2,5	1,75	4,25	7 189	2,94	1 088	−1 360
	71	36	2,5	2	4,5	6 725	3	1 055	−1 246
	80	41	3	2,3	5,3	10 518	3,57	1 142	−1 363
	90	46	3,5	2,5	6	14 161	4,12	1 114	−1 363
	100	51	3,5	2,8	6,3	13 070	4,2	1 049	−1 235
	112	57	4	3,2	7,2	17 752	4,8	1 090	−1 284
	125	64	5	3,5	8,5	29 908	5,87	1 149	−1 415
	140	72	5	4	9	27 920	6	1 101	−1 293
	160	82	6	4,5	10,5	41 008	7,12	1 109	−1 333
	180	92	6	5,1	11,1	37 502	7,27	1 035	−1 192
3	200	102	8 (7,5)	5,6	13,6	76 378	9,4	1 254	−1 409
	225	112	8 (7,5)	6,5	14,5	70 749	9,62	1 176	−1 267
	250	127	10 (9,4)	7	17	119 050	11,75	1 244	−1 406

a Given in ISO 286-1.

b The values specified for t are nominal values. In the case of springs with flat bearings (compared with group 3 in Clause 5), the desired spring load, F (where $s \approx 0{,}75\ h_0$), is obtained by reducing the thickness of single disc springs, t, which is then given the value t_f. In the case of dimensional series A and B, $t_f \approx 0{,}94 \times t$, and in the case of dimensional series C, $t_f \approx 0{,}96 \times t$.

c The values are used mostly in Asia.

d According to Table 2, thickness 1,2 mm is categorized into group 1; however, 1,2 mm is regarded as an alternative for thickness 1,25 mm mostly in Asia, therefore thickness 1,2 mm is into group 2.

A.1.3 Dimensional series C

Disc springs with $D/t \approx 40$, $h_0/t \approx 1{,}3$, $E = 206\,000$ N/mm^2 and $\nu = 0{,}3$.

See Table A.3.

Table A.3 — Dimension of springs for series C

Group	D mm	d mm	t **or** (t_f)[b] mm	h_0 mm	H_0 mm	F_t N	H_t mm	σ_{III} N/mm^2	σ_{OM} N/mm^2
	h12[a]	H12[a]				$s \approx 0{,}75\ h_0$			$s \approx h_0$
1	8	4,2	0,2	0,25	0,45	38	0,26	1 034	−1 003
	10	5,2	0,25	0,3	0,55	58	0,32	965	−957
	12,5	6,2	0,35	0,45	0,8	151	0,46	1 278	−1 250
	14	7,2	0,35	0,45	0,8	123	0,46	1 055	−1 018
	16	8,2	0,4	0,5	0,9	154	0,52	1 009	−988
	18	9,2	0,45	0,6	1,05	214	0,6	1 106	−1 052
	20	10,2	0,5	0,65	1,15	254	0,66	1 063	−1 024
	22,5	11,2	0,6	0,8	1,4	426	0,8	1 227	−1 178
	25	12,2	0,7	0,9	1,6	600	0,92	1 259	−1 238
	28	14,2	0,8	1	1,8	801	1,05	1 304	−1 282
	31,5	16,3	0,8	1,05	1,85	687	1,06	1 130	−1 077
	35,5	18,3	0,9	1,15	2,05	832	1,19	1 078	−1 042
	40	20,4	1	1,3	2,3	1 017	1,32	1 063	−1 024
2	45	22,4	1,25	1,6	2,85	1 891	1,65	1 253	−1 227
	50	25,4	1,25	1,6	2,85	1 550	1,65	1 035	−1 006
	56	28,5	1,5	1,95	3,45	2 622	1,99	1 218	−1 174
	63	31	1,8	2,36	4,15	4 238	2,39	1 351	−1 315
	71	36	2	2,6	4,6	5 144	2,65	1 342	−1 295
	80	41	2,25	2,95	5,2	6 613	2,99	1 370	−1 311
	90	46	2,5	3,2	5,7	7 684	3,3	1 286	−1 246
	100	51	2,7	3,5	6,2	8 609	3,57	1 235	−1 191
	112	57	3	3,9	6,9	10 489	3,97	1 218	−1 174
	125	64	3,5	4,5	8	15 416	4,62	1 318	−1 273
	140	72	3,8	4,9	8,7	17 195	5,02	1 249	−1 203
	160	82	4,3	5,6	9,9	21 843	5,7	1 238	−1 189
	180	92	4,8	6,2	11	26 442	6,35	1 201	−1 159
	200	102	5,5	7	12,5	36 111	7,25	1 247	−1 213
3	225	112	6,5 (6,2)	7,1	13,6	44 580	8,27	1 137	−1 119
	250	127	7 (6,7)	7,8	14,8	50 466	8,95	1 116	−1 086

[a] Given in ISO 286-1.

[b] The values specified for t are nominal values. In the case of springs with flat bearings (compared with group 3 in Clause 5), the desired spring load, F (where $s \approx 0{,}75\ h_0$), is obtained by reducing the thickness of single disc springs, t, which is then given the value t_f. In the case of dimensional series A and B, $t_f \approx 0{,}94 \times t$, and in the case of dimensional series C, $t_f \approx 0{,}96 \times t$.

A.2 Example of spring load deflection curve

See Figure A.1.