SLOVENSKI STANDARD
SIST EN 13906-1:2009

01-julij-2009

Vijaļ ne valjaste vzmeti iz okrogle ģice in palic - Izraļ un in naļ rtovanje - 1. del: Tlaļ ne vzmeti

Cylindrical helical springs made from round wire and bar - Calculation and design - Part 1: Compression springs

Zylindrische Schraubenfedern aus runden Drähten und Stäben - Berechnung und Konstruktion - Teil 1: Druckfedern

Ressorts hélicoïdaux cylindriques fabriqués à partir de fils ronds et de barres - Calcul et conception - Partie 1: Ressorts de compression

Ta slovenski standard je istoveten z: EN 13906-1:2002

ICS:

21.160	Vzmeti	Springs

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EUROPEAN STANDARD

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English version

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This document (EN 13906-1:2002) has been prepared by CEN/CS SUBSECTOR M18, the secretariat of which is held by CMC.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2002, and conflicting national standards shall be withdrawn at the latest by October 2002.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

This European Standard has been prepared by the initiative of the Association of the European Spring Federation ESF and is based on the German Standard DIN 2089- 1 - «Helical compression springs out of round wire and rod; calculation and design» edition 1984-12, which is known and used in many European countries.

1 Scope

This standard specifies the calculation and design of cylindrical helical compression springs with a linear characteristic, made from round wire and bar of constant diameter with values according to Table 1, and in respect of which the principal loading is applied in the direction of the spring axis.

Table 1

Characteristic	Cold coiled compression spring	Hot coiled compression spring [1)]	Hot coiled compression spring [2)]
Wire or bar diameter	$d \leq 17$ mm	8 mm $\leq d \leq$ 60 mm	9 mm $\leq d \leq$ 18 mm
Coil diameter	$D \leq 200$ mm	$D \leq 460$ mm	$D \leq 180$ mm
Length of unloaded spring	$L_0 \leq 630$ mm	$L_0 \leq 800$ mm	$L_0 \leq 600$ mm
Number of active coils	$n \geq 2$	$n \geq 3$	$5 \leq n \leq 12$
Spring index	$4 \leq w \leq 20$	$3 \leq w \leq 12$	$6 \leq w \leq 12$
1) Batch size $\leq$ 5000 parts 2) Batch size > 5000 parts			

NOTE Quality Standards for compression springs will be developed later.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 10270-1:2001, *Steel wire for mechanical springs - Part 1: Patented cold drawn unalloyed steel spring wire.*

EN 10270-2:2001, *Steel wire for mechanical springs - Part 2: Oil hardened and tempered spring steel wire*.

EN 10270-3:2001, *Steel wire for mechanical springs - Part 3: Stainless spring steel wire.*

EN 12166, *Copper and copper alloys - Wire for general purposes.*

EN ISO 2162-1:1996, *Technical product documentation - Springs - Part 1: Simplified representation (ISO 2162-1:1993).*

EN ISO 2162-3:1996, *Technical product documentation - Springs - Part 3: Vocabulary (ISO 2162-3:1993).*

prEN 10089:2000, *Hot-rolled steels for quenched and tempered springs – Technical delivery conditions.*

3 Terms, definitions, symbols, units and abbreviated terms

3.1 Terms and definitions

For the purposes of this European Standard, the following terms and definitions apply.

3.1.1
spring
mechanical device designed to store energy when deflected and to return the equivalent amount of energy when released.[2.1 from EN ISO 2162-3:1996]

3.1.2
compression spring
spring that offers resistance to a compressive force applied axially.[2.3 from EN ISO 2162-3: 1996]

3.1.3
helical compression spring
compression spring made from wire of circular, square or rectangular cross-section wound around an axis with distances between its coils.

Helical compression springs are available in cylindrical or other forms, e.g. conical, double- conical (convex: barrel spring; concave: wasted spring) or tapered. [2.9 from EN ISO 2162-3:1996]

NOTE In the following text of this Standard the term spring is used with the meaning of helical compression spring

3.2 Symbols, units and abbreviated terms

Table 2 contains the symbols, units and abbreviated terms used in this standard.

Table 2

Symbols	Units	Terms
a_0	mm	gap between active coils of the unloaded spring
$D = \frac{D_e + D_i}{2}$	mm	mean diameter of coil
D_e	mm	outside diameter of the spring
ΔD_e	mm	increase of outside diameter of the spring, when loaded
D_i	mm	inside diameter of the spring
d	mm	nominal diameter of wire (or bar)
d_{max}	mm	upper deviation of d
E	N/mm²	modulus of elasticity (or Young's modulus)
F	N	spring force
F_1, F_2 ...	N	spring forces, for the spring lengths L_1, L_2... (at ambient temperature of 20°C)
$F_{c\,th}$	N	theoretical spring force at solid length L_c NOTE The actual spring force at the solid length is as a rule greater than the theoretical force
F_K	N	buckling force
F_n	N	spring force for the minimum permissible spring length L_n
F_Q	N	spring force perpendicular to the spring axis (transverse spring force)
f_e	s^{-1} (Hz)	natural frequency of the first order of the spring (fundamental frequency)
G	N/mm²	modulus of rigidity
k	-	stress correction factor (depending on D/d)
L	mm	spring length
L_0	mm	nominal free length of spring
L_1, L_2...	mm	spring lengths for the spring forces F_1, F_2...
L_c	mm	solid length
L_K	mm	buckling length
L_n	mm	minimum permissible spring length (depending upon S_a)
m	mm	mean distance between centres of adjacent coils in the unloaded condition (pitch)
N	-	number of cycles up to rupture
n	-	number of active coils
n_t	-	total number of coils
R	N/mm	spring rate
R_m	N/mm²	minimum value of tensile strength

Table 2 (concluded)

Symbols	Units	Terms
R_Q	N/mm	transverse spring rate
S_a	mm	sum of the minimum gaps between adjacent active coils at spring length L_n
s	mm	spring deflection
s_1, s_2 ...	mm	spring deflections, for the spring forces F_1, F_2 ...
s_c	mm	spring deflection, for the solid length, L_c
s_h	mm	deflection of spring (stroke) between two positions
s_K	mm	spring deflection, for the buckling force F_K (buckling spring deflection)
s_n	mm	spring deflection, for the spring force F_n
s_Q	mm	transverse spring deflection, for the transverse force F_Q
v_{St}	m/s	impact speed
W	N mm	spring work,
$w = \frac{D}{d}$	-	spring index
η	-	spring rate ratio
λ	-	slenderness ratio
ξ	-	relative spring deflection
υ	-	seating coefficient
ρ	kg/dm³	density
τ	N/mm²	uncorrected torsional stress (without the influence of the wire curvature being taken into account)
τ_1, τ_2 ...	N/mm²	uncorrected torsional stress, for the spring forces F_1, F_2 ...
τ_c	N/mm²	uncorrected torsional stress, for the solid length L_c
τ_k	N/mm²	corrected torsional stress (according to the stress correction factor k)
τ_{k1}, τ_{k2} ...	N/mm²	corrected torsional stress, for the spring forces F_1, F_2 ...
τ_{kh}	N/mm²	corrected torsional stress range, for the stroke s_h
$\tau_{kH\,(...)}$	N/mm²	corrected torsional stress range in fatigue, with the subscript specifying the number of cycles to rupture or the number of ultimate cycles
τ_{kn}	N/mm²	corrected torsional stress, for the spring force F_n
$\tau_{kO\,(...)}$	N/mm²	corrected maximum torsional stress in fatigue, with the subscript specifying the number of cycles to rupture or the number of ultimate cycles.
$\tau_{kU\,(...)}$	N/mm²	corrected minimum torsional stress in fatigue, with the subscript specifying the number of cycles to rupture or the number of ultimate cycles
τ_n	N/mm²	uncorrected torsional stress, for the spring force F_n
τ_{St}	N/mm²	impact stress
τ_{zul}	N/mm²	permissible torsional stress

4 Theoretical compression spring diagram

The illustration of the compression spring corresponds to Figure 4.1 from EN ISO 2162-1: 1996.

The theoretical compression spring diagram is given in Figure 1**.**

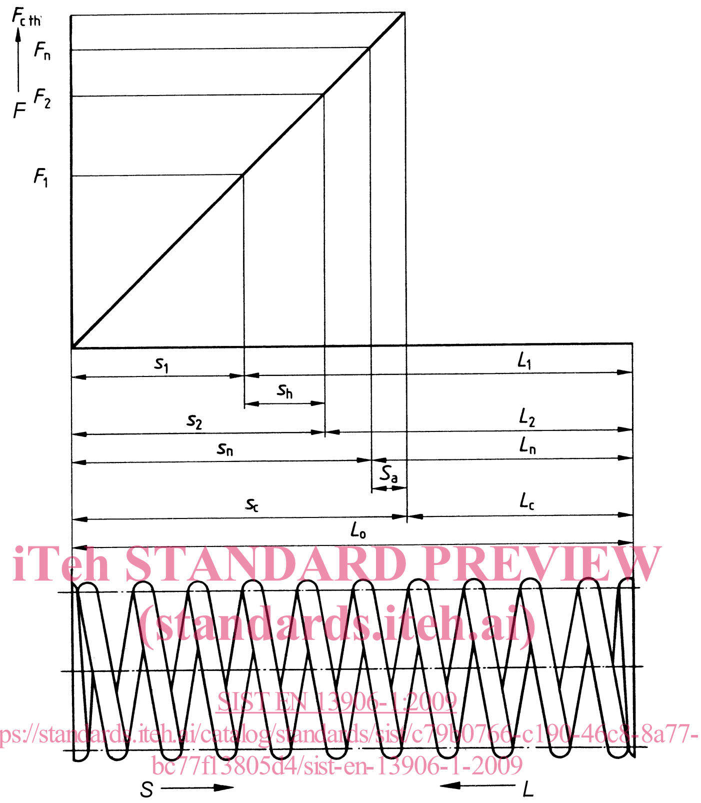

Figure 1 — Theoretical compression spring diagram

5 Design principles

Before carrying out design calculations for a spring, the requirements to be met shall be considered, particularly taking into account and defining:

— a spring force and corresponding spring deflection or two spring forces and corresponding stroke or a spring force, the stroke and the spring rate,

 — loading as a function of time: is static or dynamic,

 — in the case of dynamic loading the total number of cycles, N, to rupture,

 — operating temperature and permissible relaxation,

 — transverse loading, buckling, impact loading,

 — other factors (e.g. resonance vibration, corrosion)

NOTE In order to optimise the dimensions of the spring by taking the requirements into account sufficient working space should be provided when designing the product in which the spring will work.

6 Types of Loading

NOTE Before carrying out design calculations it should be specified whether they will be subjected to static loading, quasi-static loading, or dynamic loading.

6.1 Static and/or quasi-static loading

A static loading is:

— a loading constant in time

A quasi-static loading is:

— a loading variable with time with a negligibly small torsional stress range (stroke stress) (e.g. torsional stress range up to 0,1 × fatigue strength)

— a variable loading with greater torsional stress range but only a number of cycles of up to 10^4

6.2 Dynamic loading

In the case of compression springs dynamic loading is:

Loading variable with time with a number of loading cycles over 10^4 and torsional stress range greater than 0,1 × fatigue strength at

a) constant torsional stress range

b) variable torsional stress range

Depending on the required number of cycles N up to rupture it is necessary to differentiate the two cases as follows:

a) infinite life fatigue in which the number of cycles

— $N \geq 10^7$ for cold coiled springs

— $N \geq 2 \times 10^6$ for hot coiled springs

In this case the torsional stress range is lower than the infinite life fatigue limit.

b) limited life fatigue in which

— $N < 10^7$ for cold coiled springs

— $N < 2 \times 10^6$ for hot coiled springs

In this case the torsional stress range is greater than the infinite life fatigue limit but smaller than the low cycle fatigue limit.

In the case of springs with a time- variable torsional stress range and mean torsional stress, (set of torsional stress combinations) the maximum values of which are situated above the infinite fatigue life limit, the service life can be calculated as a rough approximation with the aid of cumulative damage hypotheses. In such circumstances the service life shall be verified by means of a fatigue test.

6.3 Operating temperature

The data relating to the permissible loading of the materials used as given in clause 10 apply at ambient temperature.

The influence of temperature shall be taken into consideration especially in the case of springs with closely toleranced spring forces. At operating temperatures below -30°C the reduction of the notch impact strength shall also be taken into account.

6.4 Transverse loading

If an axially loaded spring with parallel guided ends is additionally loaded perpendicular to its axis, transverse deflection with localised increase in torsional stress will occur, and this shall be taken into account in the calculation.

6.5 Buckling

Axially loaded springs have a tendency to buckle when they are compressed to a certain critical length. Consequently, their buckling behaviour shall be checked. An adequate safety against buckling shall be allowed for in the design of these springs, because the buckling limit is reached in practice sooner than calculated theoretically. Springs which cannot be designed with an adequate safety against buckling shall be guided inside a tube or over a mandrel. Friction will be the inevitable consequence, and damage to the spring will occur in the long run. It is therefore preferable to split up the spring into individual springs, which are safe against buckling, as far as possible, and to guide these springs via intermediate discs over a mandrel or in a tube.

It shall be always borne in mind that the direction of the spring force does not coincide precisely with the geometric axis of the spring. Consequently, the spring will tend to buckle before the theoretical buckling limit has been attained. It is very difficult to allow for this effect by calculation. Buckling occurs in smooth progression.

6.6 Impact loading

Additional torsional stresses will be generated in a spring, if one end of the spring is suddenly accelerated to a high speed, e.g. through shock or impact. This impact wave will travel through the successive coils of the spring and will be reflected at the other end of the spring.

The level of this additional torsional stress depends on the speed with which the impact is delivered, but not on the dimensions of the spring.

6.7 Other factors

6.7.1 Resonance vibrations

A spring is prone to resonance vibrations by virtue of the inert mass of its active coils and of the elasticity of the material. A distinction is made between vibrations of the first order (fundamental vibrations) and vibrations of higher order (harmonic vibrations). The frequency of the fundamental vibration is called the fundamental frequency, and the frequency of the harmonic vibrations are integral multiples thereof.

When calculating springs, subject to high frequency forced vibration, care shall be taken to ensure that the frequency of the forced vibration oscillation (excitation frequency) does not come into resonance with one of the natural frequencies of the spring. In the case of mechanical excitations (e.g. via cams), resonance may also occur if a harmonic component of the excitation frequency coincides with one of the natural frequencies of the spring. In cases of resonance, an appreciable increase in torsional stress will arise at certain individual points of the spring, known as nodes. In order to avoid such increases in torsional stress due to resonance phenomena, the following measurers are advised.

— Avoid integral ratios between excitation frequencies and natural frequencies;

— Select the natural frequency of the first order of the spring as high as possible; avoid resonance with the low harmonics of the excitation.

— Use springs with a progressive characteristic (variable pitch);

— Design the cam with a favourable profile (low peak value of the excitation harmonics);

— Provide for damping by means of spacers.