

Cylindrical helical springs made from rectangular and square section wire and bar — Guide to calculation and design —

Part 1: Compression springs

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Foreword

BS 1726-1 was first published in 1951 and revised in 1964 to incorporate much of the essential information from ADE Design Data Sheets, which were no longer available from HM Stationery Office and for which copyright permission to republish was obtained. The standard was revised in 1988 to take account of current manufacturing processes.

BS 1726-1:1988, was withdrawn on the publication of BS EN 13906-1 in 2001. The provisions for the design, specification, tolerances and testing of rectangular section compression springs are now published in this separate standard.

Together with BS 1726-1:2002 and BS EN 13906-1:2002, this new standard, BS 8726-1, supersedes BS 1726-1:1987, which is withdrawn.

BS 8726 is published in two parts:

- *Part 1: Compression springs;*
- *Part 2: Torsion springs.*

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 29 and a back cover.

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1 Scope

This British Standard provides guidance on the design of parallel sided helical compression springs manufactured from rectangular and square section wire and bar.

This standard applies only to springs made from rectangular section material where the ratio of radial dimension, b , to the axial dimension, h , termed the shape factor, m , is not greater than 2.5 and not less than 0.4.

NOTE 1 This applies because, outside the shape factor range 2.5 to 0.4, it is difficult to coil a spring accurately.

NOTE 2 There are numerous methods of calculating the parameters necessary for the design of springs and initially the designer is free to use any one of these.

Three types of end coils are provided for, i.e. open end, closed end and closed and ground end, the last of these being applicable only to springs where the axial dimension of material is 0.5 mm or greater.

This British Standard differentiates between springs that have or have not been stress relieved after forming, designated group A springs, and springs, the material of which has undergone a structural change by heat treatment after forming, designated group B springs.

This British Standard gives two methods of specifying springs for general purposes and one method of testing springs.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document applies.

BS 817, *Specification for surface plates.*

BS 887, *Specification for precision vernier callipers.*

BS 939, *Specification for engineers' squares (including cylindrical and block squares).*

BS 957-2, *Specification for feeler gauges — Metric units.*

BS 969, *Specification for limits and tolerances on plain limit gauges.*

BS EN ISO 7500-1, *Tension/compression testing machines — Verification and calibration of the force measuring system.*

BS EN ISO 3650, *Geometrical product specifications (GPS) — Length standards — Gauge blocks.*

BS 5204, *Specification for straight edges.*

BS 5317, *Specification for metric length bars and their accessories.*

BS 5411, *Methods of test for metallic and related coatings.*

BS 6365, *Specification for precision vernier depth gauges.*

BS 6468, *Specification for depth micrometers.*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this Part of BS 8726 following terms and definitions apply.

3.1.1

active coils

effective coils (non-preferred)

working coils (non-preferred)

coils of a spring that at any instant are contributing to the rate of the spring

3.1.2

angle of grind

angle subtended by the ground end surface of the spring at the intersection of the plane of the ground surface with the major axis of the spring

3.1.3

bow

maximum deviation between any coil of a spring and a datum surface or straight edge on which the spring is laid

NOTE See 8.2.13.

3.1.4

buckling

unstable lateral distortion of the major axis of a spring when compressed

3.1.5

chamfering

removal of a corner on the inside and/or outside diameter of the ground face of a spring to clear any radius on the spring seat

3.1.6

closed end

end of a helical spring in which the helix angle of the end coil has been progressively reduced until the end coil touches the adjacent coil

3.1.7

compression spring

spring whose dimension, in the direction of the applied force, reduces under the action of that force

3.1.8

compression test

test carried out by pressing a spring to a specified length a specified number of times

3.1.9

coning

operation in which the diameter of the ends of an extension or compression spring is reduced

3.1.10

countersink

internal chamfer

3.1.11

cramp test

test carried out by compressing a spring to a specified length for a defined period

3.1.12

creep

change in length of a spring with time when subjected to a constant force

3.1.13

damper coils

coils that are active at the free length but inactive at the normal operating length

3.1.14

dead coils

coils of a spring that do not affect the rate of the spring

3.1.15

deflection

relative displacement of the ends of a spring under the application of a force

3.1.16**edge dressing**

removal of material from the outside edge of the end coils where they protrude beyond the outside diameter of the spring

3.1.17**elastic deformation**

deformation that takes place when a material is subjected to any stress up to its elastic limit

NOTE On removal of the force causing this deformation the material returns to its original size.

3.1.18**seating coefficient**

end fixation factor (non-preferred)

factor used in the calculation of buckling to take account of the method of locating the end of the spring

3.1.19**fatigue**

phenomenon giving rise to a type of failure which takes place under conditions involving repeated or fluctuating stresses below the elastic limit of the material

3.1.20**fatigue limit**

value, which may be statistically determined, of the stress condition below which material may endure an infinite number of stress cycles

3.1.21**fatigue strength**

endurance limit (non-preferred)

stress condition under which a material will have a life of a given number of cycles

3.1.22**fatigue test**

test to determine the number of cycles of stress that will produce failure of a component or test piece

3.1.23**finish**

coating applied to protect or decorate springs

3.1.24**fitted length**

length of a spring when assembled into position within a mechanism from which it is required to function

3.1.25**free length**

length of a spring when it is not loaded

NOTE In the case of extension springs this may include the anchor ends.

3.1.26**grinding**

removal of metal from the end faces of a spring by the use of abrasive wheels to obtain a flat surface which is square with the spring axis

3.1.27**group A springs**

springs that have or have not been stress relieved (**3.1.59**) after forming

3.1.28**group B springs**

springs, the material of which has undergone a structural change by heat treatment after forming

3.1.29

hand

the direction in which the helix of a spring is formed, i.e. right or left.

3.1.30

heat stabilization

process of removing primary creep and inducing beneficial stresses into a spring, so that, when the spring is subjected to an operating stress and temperature, it will exhibit improved stress temperature relaxation properties

3.1.31

helical spring

spring made by forming material into a helix

3.1.32

helix angle

angle of the helix of a helical coil spring

3.1.33

hysteresis

lagging of the effect behind the cause of the effect

NOTE A measure of hysteresis in a spring is represented by the area between the loading and unloading curves produced when the spring is stressed within the elastic range.

3.1.34

index

ratio of the mean coil diameter of a spring to the material diameter for circular sections or radial width of cross-section for rectangular or trapezoidal sections

3.1.35

inside coil diameter of a spring

diameter of the cylindrical envelope formed by the inside surface of the coils of a spring

3.1.36

linearity

degree by which the force–deflection curve of a spring approaches a straight line

3.1.37

load test

test on a spring to determine either the force at a given length or the length under a given force

3.1.38

modulus of elasticity

ratio of stress to strain within the elastic range

NOTE The modulus of elasticity in tension or compression is also known as Young's modulus and that in shear as the modulus of rigidity.

3.1.39

natural frequency

frequency at which a spring will freely vibrate once it has been excited

3.1.40

open end

end of an open coiled helical spring in which the helix angle of the end coil has not been progressively reduced

3.1.41

outside coil diameter

diameter of the cylindrical envelope formed by the outside surface of the coils of a spring

3.1.42

parallelism

degree to which the two ground ends of a spring are parallel to each other

3.1.43**permanent set**

set (non-preferred)

permanent deformation of a spring after the application and removal of a force

3.1.44**pitch**

distance from any point in the section of one coil to the corresponding point in the next coil when measured parallel to the axis of the spring

3.1.45**prestressing**

scragging (non-preferred)

blocking (non-preferred)

process during which internal stresses are induced into a spring

NOTE It is achieved by subjecting the spring to a stress greater than that to which it is subjected under working conditions and higher than the elastic limit of the material. The plastically deformed areas resulting from this stress cause an advantageous redistribution of the stresses within the spring. Prestressing can only be performed in the direction of applied force.

3.1.46**rate**

stiffness (non-preferred)

force that has to be applied in order to produce unit deflection

3.1.47**relaxation**

loss of force of a spring with time when deflected to a fixed position

NOTE The degree of relaxation is dependent upon, and increases with, the magnitude of stress, temperature and time.

3.1.48**residual range**

deflection of a spring available beyond the maximum working position up to the solid position

3.1.49**safe deflection**

maximum deflection that can be applied to a spring without exceeding the elastic limit of the material

3.1.50**shot peening**

cold working process in which shot is impacted onto the surfaces of springs thereby inducing residual stresses in the outside fibres of the material

NOTE The effect of this is that the algebraic sum of the residual and applied stresses in the outside fibres of the material is lower than the applied stress, resulting in improved fatigue life of the component.

3.1.51**solid length**

overall length of a helical spring when each and every coil is in contact with the next

3.1.52**solid force**

theoretical force of a spring when compressed to its solid length

3.1.53**space**

coil gap space (non-preferred)

the distance between one coil and the next coil in an open coiled helical spring measured parallel to the axis of the spring

3.1.54

spring seat

part of a mechanism that receives the ends of a spring and which may include a bore or spigot to centralize the spring

3.1.55

squareness

maximum out of alignment of one end of a spring from the other

NOTE This is the measurement obtained by standing the spring on a datum surface and measuring the maximum deviation of the top coil from a square edge placed against the datum (see 8.2.11).

3.1.56

stress

bending stress (non-preferred)

shear stress (non-preferred)

force divided by the area over which it acts

NOTE This is applied to the material of the spring, and for compression and extension springs is in torsion or shear, and for torsion springs is in tension or bending.

3.1.57

stress correction factor

factor that is introduced to make allowance for the fact that the distribution of shear stress across the wire diameter is not symmetrical

NOTE This stress is higher on the inside of the coil than it is on the outside.

3.1.58

stress range

difference between the stresses induced by the minimum and maximum applied forces in a component subjected to cyclic loading

3.1.59

stress relieving

low-temperature heat treatment carried out at temperatures where there is no apparent change in the metallurgical structure of the material

NOTE The purpose of the treatment is to relieve stresses induced during manufacturing processes.

3.1.60

stroke

range (non-preferred)

the distance between the minimum and maximum working positions of a spring

3.1.61

vapour blasting

process by which the surface of a component is modified by the action of a stream of liquid carrying solid particles of abrasive energized by compressed air

NOTE The results of this process can be to remove scale, produce a clean matt surface finish and induce compressive stresses into the outer fibres of the material.

3.1.62

variable pitch spring

helical spring in which the pitch of the active coils is not constant

3.1.63

variable rate spring

helical spring whose load deflection curve is intentionally made non-linear

3.2 Symbols

Symbol	Term	Unit
b	radial dimension of rectangular section material	mm
c	spring index	—
D	mean coil diameter	mm
D_o	outside diameter of spring	mm
$D_{H, \min.}$	minimum diameter of pocket into which spring has to fit	mm
D_i	inside diameter of spring	mm
$D_{s, \max.}$	maximum diameter of spigot over which spring has to fit	mm
f	natural frequency of unloaded spring	Hz
F	spring force	N
F_s	theoretical solid force	N
ΔF	change in spring force	N
G	modulus of rigidity (see Annex A)	N/mm ²
h	axial dimension of rectangular section material	mm
h'	axial dimension of rectangular section material after coiling	mm
$h'_{\max.}$	maximum axial dimension of rectangular section material after coiling allowing for section size tolerance (see Annex B)	mm
k	material constant for calculation of upset height of rectangular section material after coiling	—
K	stress correction factor	—
L	spring length	mm
L_o	free length of spring	mm
L_s	theoretical solid length of spring	mm
$L_{s, \max.}$	maximum allowable solid length of spring	mm
ΔL	change in spring length	mm
M	shape factor for rectangular section material	—
n	number of active coils in spring	—
N	total number of coils in spring	—
R_i	inside radius to clear on spring seat	mm
R_o	outside radius to clear on spring seat	mm
S	spring rate	N/mm
T	thickness of any surface coating	mm
δ	deflection from nominal free length to loaded length	mm
λ	stress factor for rectangular section material	—
μ	rate factor for rectangular section material	—
v	seating coefficient	—
ρ	density of material	kg/mm ³
τ	shear stress in spring	N/mm ²
τ_s	theoretical solid stress in spring	N/mm ²