BS 1726-1:2002

Cylindrical helical springs made from round wire and bar — Guide to methods of specifying, tolerances and testing —

Part 1: Compression springs

ICS 21.160

Committees responsible for this British Standard

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British Impact Treatment Association

Institute of Spring Technology

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Contents

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 1987 to take account of current manufacturing processes.

BS EN 13906-1 was published in 2002 and under the rules of CEN the UK is obliged to withdraw conflicting standards.

This edition of BS 1726-1 includes those provisions of the previous edition not included in the EN standard.

Together with BS 8726-1:2002 and BS EN 13906-1:2002, this edition of BS 1726-1 supersedes BS 1726-1:1987, which is withdrawn.

BS 1726 is published in three parts:

— *Part 1: Compression springs*;
— *Part 2: Extension springs*;
— *Part 3: Torsion springs*.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 23 and a back cover.

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1 Scope

This Part of BS 1726 provides guidance on methods of specifying, tolerancing and testing of parallel sided helical compression springs manufactured from circular section material.

Two grades of tolerance, 1 and 2, are given for circular section springs.

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 diameter or axial dimension of material is 0.5 mm or greater.

This Part of BS 1726 differentiates between springs that have or have not been stress relieved after forming (designated group A), and springs, the material of which has undergone a structural change by heat treatment after forming (designated group B).

This 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.*

BS EN 13906-1, *Cylindrical helical springs made from round wire and bar — Calculation and design — Part 1: Compression springs.*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this Part of BS 1726 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 **6.2.13**.

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
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

3.1.18
extension spring
spring whose length, in the direction of the applied force, increases under the application of that force

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 (**2.66**) 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
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
initial tension
part of the force exerted, when a close coiled spring is axially extended, that is not attributable to the product of the theoretical rate and the measured deflection

3.1.36
inside coil diameter of a spring
diameter of the cylindrical envelope formed by the inside surface of the coils of a spring

3.1.37
linearity
degree by which the force-deflection curve of a spring approaches a straight line

3.1.38
load test
test on a spring to determine either the force at a given length or the length under a given force

3.1.39
loop
eye (non-preferred)

hook (non-preferred)

formed anchoring point of a helical spring or wire form

NOTE 1 When applied to an extension spring, it is usually called a loop.

NOTE 2 If closed, it may be termed an eye and if partially open may be termed a hook.

3.1.40
mean coil diameter
mean diameter of the outside coil diameter and inside coil diameter of a spring

NOTE This is calculated as $D_o - d$.

3.1.41
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.

3.1.42
natural frequency
frequency at which a spring will freely vibrate once it has been excited

3.1.43
open end
end of an open coiled helical spring in which the helix angle of the end coil has not been progressively reduced

3.1.44
outside coil diameter
diameter of the cylindrical envelope formed by the outside surface of the coils of a spring

3.1.45
parallelism
degree to which the two ground ends of a spring are parallel to each other

3.1.46
permanent set
set (non-preferred)

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

3.1.47
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

3.1.48
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.

3.1.49
rate
stiffness (non-preferred)

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

3.1.50
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.

3.1.51
residual range
deflection of a spring available beyond the maximum working position up to the solid position

3.1.52
safe deflection
maximum deflection that can be applied to a spring without exceeding the elastic limit of the material

3.1.53
screw insert
plug screwed into the ends of a helical extension spring as a means of attaching a spring to another component

NOTE The plug has an external thread, the diameter, pitch and form of which match those of the spring.

3.1.54
shot peening
cold working process in which shot is impacted on to 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.

3.1.55
solid length
overall length of a helical spring when each and every coil is in contact with the next

3.1.56
solid force
theoretical force of a spring when compressed to its solid length

3.1.57
space
coil gap space (non-preferred)

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

3.1.58
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

3.1.59
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 **6.2.11**).

3.1.60
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.

3.1.61
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.

3.1.62
stress range
difference between the stresses induced by the minimum and maximum applied forces in a component subjected to cyclic loading

3.1.63
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.

3.1.64
stroke
range (non-preferred)

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

3.1.65
swivel hook
loop (hook or eye) fitted to the end of an extension spring so that it is capable of rotating about the axis of the spring

3.1.66
torsion spring
spring, the material of which is stressed in bending, the radial dimension reducing, and the axial dimension increasing, under the action of the applied torque

3.1.67
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.

3.1.68
variable pitch spring
helical spring in which the pitch of the active coils is not constant

3.1.69
variable rate spring
helical spring whose load deflection curve is intentionally made non-linear

3.2 Symbols

Symbol	Term	Unit
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
d	material diameter	mm
$d_{max.}$	maximum material diameter allowing for material diameter tolerance	mm
f	natural frequency of unloaded spring	Hz
F	spring force	N
F_s	theoretical solid force	N
ΔF	change in spring force	N
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
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
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
ν	seating coefficient	—

4 Specifying springs for general purposes

4.1 Introduction

There are two methods by which a customer may specify a spring. In the first method the customer presents the supplier with a complete design and indicates what manufacturing processes, such as stress relieving, prestressing and shot peening, should be carried out. In this case the information should be supplied on Data Sheet 1 (Figure 1).

When the customer does not have the information to complete Data Sheet 1, the customer should complete Data Sheet 2 (Figure 5). This is an application for spring design in which the customer should specify the requirements from an operational point of view, giving such information as dimensional constraints, force–length parameters, fatigue life, resistance to corrosion, in order that the supplier can produce a spring design to meet these requirements.

When the spring supplier has prepared a design from the information on Data Sheet 2, the spring supplier will complete Data Sheet 1 and submit it to the customer for approval.

4.2 Method one (customer design) using Data Sheet 1

4.2.1 *General*

It is not necessary to prepare a detailed scale drawing for a helical compression spring and details should be specified on Data Sheet 1 (Figure 1). Only essential dimensions and properties, for which the spring is to be inspected, need be toleranced, other features being given in the design for information only.

In completing the Data Sheet users should:

a) specify only those particulars which are of functional importance by marking the appropriate squares in boxes 1, 3, 5, 6, 7, 8, 9, 10 and 12 of Data Sheet 1;

b) avoid redundant dimensioning;

c) follow the recommendations of BS EN 13906-1, for the method of calculation used to determine values for rate, force, stress and maximum solid length;

d) attach further details on a separate sheet and draw attention to this fact in the relevant box on the form if space is insufficient in any box.

4.2.2 *Material*

Complete box 1 (Figure 1) by giving the material type and complete specification code, quoting the relevant British Standard where possible, the section shape and its dimensions and the heat treatment details, e.g. austemper, harden and temper, including the hardness required, if relevant.

4.2.3 *Direction of coiling*

The direction of coiling is rarely important for the spring function, and unless it is included in box 2 it will be assumed that the supplier is free to coil either hand.

Figure 2 shows the generally accepted convention for defining hand of coiling. A simple practical method of determining the hand of a spring is as follows.

Hold the spring at eye level and look through it along its major axis. Rotate the spring about this axis until the visible cut end is at the bottom. If the cut end now points to the left it is a left hand coiled spring.

4.2.4 *End coil form*

Complete box 3 by indicating the type of end coil required, these being:

a) open ends, where the helix is uniform throughout [see Figure 3(a)];

b) closed ends, where the helix in the end coil is equal to the material diameter or thickness [see Figure 3(b)];

c) closed and ground ends [see Figure 3(c)].

NOTE 1 It is possible that the end coils may not be completely closed and that a gap may occur between the end coil tip and its adjacent coil.

NOTE 2 It is permissible for group B springs to have their ends formed by tapering the ends of the material before coiling (see Figure 4). Edge dressing is frequently necessary in this method of manufacture.

If any other end form is required it should be illustrated, dimensioned and toleranced in a separate drawing and submitted to the manufacturer for agreement.

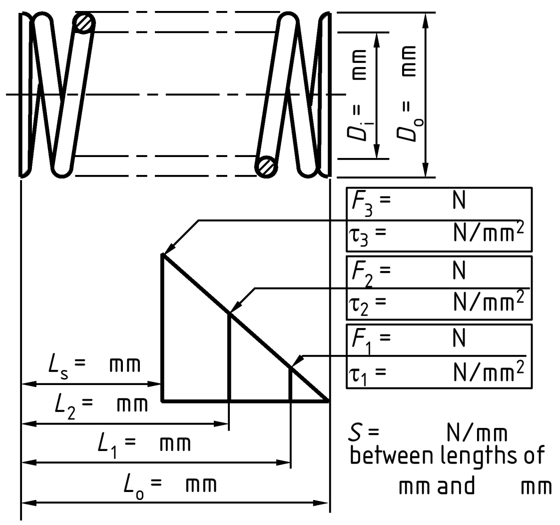
4.2.5 *Total number of coils*

The total number of coils may be given in box 4 for reference, but should not be toleranced.

NOTE Variation of the total number of coils is the most common method of achieving in-manufacture correction and for this reason it is not a measured parameter unless there is special agreement between the customer and the supplier to do so.

SPECIFICATION FOR HELICAL COMPRESSION SPRING **BS 1726-1:2002 DATA SHEET 1**	**Part** **Serial No.________**

This form should be completed with reference to BS 1726-1:2002 Clause 4.2



For nomenclature see BS 1726-1:2002, Clause **3**

1 Material
Specification number
Diameter = ___________ mm
Heat treatment

2 Direction of coiling
Right Left No preference

3 End coil shape
Open Closed
Closed and ground Other

4 Total number of coils
N =

5 Thermal treatment
a) Stress relieving (group A)
No Yes
If yes
Time_______________ min Temperature_____°C
b) Heat treatment and hardness (group B)

6 Prestressing
No Yes
Compression to:
Solid length L_s
Minimum compressed length____________mm
Shall not cause permanent set

7 Heat stabilization
No Yes
Relaxation requirements:

8 Shot peening
No Yes
Fatigue requirements:

9 Performance tests
Relaxation: No Yes
Details:
Fatigue: No Yes
Details:

10 Chamfering of spring ends
No Yes
Radius to clear:
Internally Externally

11 Surface coating

12 Tolerances: mandatory requirements only

	Grade 1 value	Grade 2 value	Other (specify)
D_o			____________
D_1			____________
F_1			____________
F_2			____________
S			____________
L_o			____________
L_s			____________
—			____________
—			____________
—			____________

13 Identification

14 Special requirements

Sheet 1 of ____________________________ Serial/Design/Part No.

Figure 1 — Data sheet 1

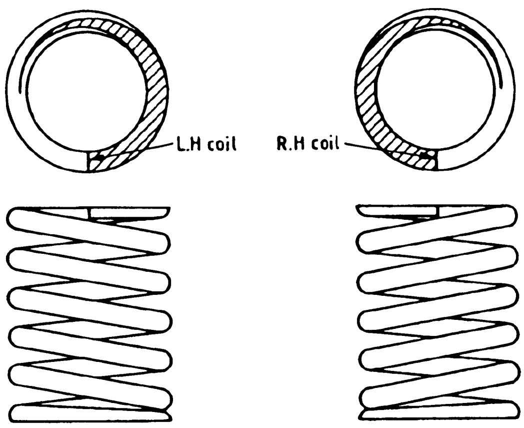
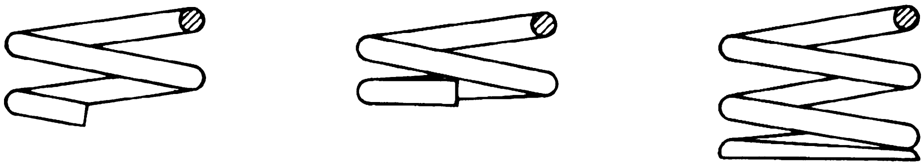


Figure 2 — Hand of coiling



(a) Open end

(b) Closed end

(c) Closed and ground end

Figure 3 — End coil form

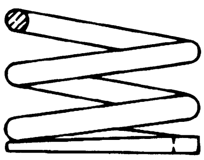


Figure 4 — Coil end formed from tapered bar

4.2.6 ***Thermal treatment***

4.2.6.1 Stress relieving requirements for group A springs should be indicated in box 5a). If stress relieving is required, the time and temperature should be given.

4.2.6.2 Heat treatment and hardness requirements for group B springs should be given in box 5b).

4.2.7 ***Prestressing***

Prestressing is a process in which the spring is stressed beyond its elastic limit. The spring therefore takes a permanent set, but the spring can subsequently be used at a much higher stress since the elastic limit is raised to the prestressed value.

When the specified solid stress of the spring is lower than the torsional yield stress of the material, then prestressing is not possible. If the specified solid stress is above the torsional yield stress, prestressing may be necessary. When the stress at the minimum compressed length is above the torsional yield stress, the springs have to be prestressed. If the minimum compressed length is greater than the solid length, this dimension should be stated in box 6.

The designer should therefore indicate whether prestressing is required or not, and to which length the spring is to be compressed.

4.2.8 ***Heat stabilization***

To reduce relaxation at high temperature, heat stabilization of the spring may be required. In general, the optimum process is determined by the supplier to meet the relaxation requirements given in the space provided in box 7. However, if the designer requires a specific process then details should be given in box 14.

4.2.9 ***Shot peening***

Shot peening requirements should be indicated in box 8.

This process improves the fatigue performance of dynamically loaded springs. Certain configurations of compression springs, e.g. small material diameter or large spring index, need careful selection of the shot peening parameters and application of the process otherwise distortion of the spring can result.

A specification for shot peening is not available. Shot peening parameters should be established considering the material type and section involved. The parameters are peculiar to the shot peening plant used, and the optimum process is, in general, determined by the supplier to meet the fatigue requirements given in box 8. If the designer requires a specific process, details should be given in box 14.

Shot peened springs should be subjected to a further low-temperature heat treatment in the range 220 °C to 240 °C for approximately 30 min.

4.2.10 ***Performance tests***

The most common tests are relaxation and fatigue tests. Details of the tests should be given in the space provided in box 9. For relaxation tests the minimum information to be supplied is clamped length, temperature and test duration along with the maximum allowable load loss. For fatigue tests the maximum and minimum working positions, temperature and life required should be stated. For both types of test the batch size should also be given.

If other more specialized tests are required, such as dynamic relaxation or corrosion tests, then these details are to be given in box 14.

4.2.11 ***Chamfering***

Internal and/or external chamfering of springs with ground ends may be required to clear radii in the spring seating. If so, the radii to be cleared should be stated in box 10.

4.2.12 ***Surface coating***

Requirements for surface coatings can be specified in box 11. Where possible the number of the relevant British Standard should be quoted.

4.2.13 ***Tolerances***

Tolerances on coil diameter, free length, force, etc., should be calculated as indicated in Clause **5**.

Marking the appropriate tolerance grade indicates the tolerances required are those calculated using the expressions/data given in Clause **5**.

If the designer has requirements for tolerances other than those calculated in Clause **5** these should be given under the heading "Other (specify)" in box 12.

When establishing the spring dimensions and tolerances it should be borne in mind that no single parameter can be changed without affecting one or more of the remaining parameters. Only those parameters which have to be met should be toleranced and the supplier should be left free to adjust the remainder in order to meet the specification in Data Sheet 1.

For example, where two force–length dimensions, material diameter and a coil diameter are specified as of critical importance, the number of turns and free length should only be specified as reference values. Similarly, where a coil diameter, one force–length dimension, the material diameter and number of turns are of importance, variation in the free length should be allowed.

4.2.14 ***Identification***

If identification of individual springs is required, this should be indicated in box 13.

NOTE Colour marking is the most common method used.

4.2.15 ***Special requirements***

Where the designer has requirements for the spring which cannot be detailed elsewhere on the form, they should be given in box 14.

4.3 Method two (application for spring design) using Data Sheet 2

4.3.1 ***General***

This is an application for spring design in which the customer should specify the requirements from an operational point of view, giving such information as dimensional constraints, force–length parameters, fatigue life, resistance to corrosion, in order that the supplier can produce a spring design to meet these requirements. The customer should specify the requirements using Data Sheet 2 (Figure 5).

Insert relevant dimensions on the drawing, giving only those which are dictated by the design of the mechanism in which the spring is to operate.

Where the spring has to seat within a housing or over a spigot it may be necessary to chamfer the ends to clear the radii. Such radii should be specified in the spaces provided.

4.3.2 ***Compression***

Springs should be designed on the assumption that they are capable of being compressed solid very infrequently during their life. If it is physically impossible for the spring to be compressed to the solid position in operation, for example owing to some mechanical stop, then the minimum compressed length should be given in box 8. The spring may then be designed only to be capable of being compressed to this length. Care should be taken to prevent such a spring being compressed solid in manufacture and assembly.

4.3.3 ***Free length***

A limiting free length L_0 should not be specified unless it is necessary for assembly purposes.

4.3.4 ***Force-length conditions***

The required force–length conditions should be specified, together with either the maximum load or minimum length.

4.3.5 ***Spring rate***

Where the spring rate is deemed more important than specific force–lengths, it should be specified between two lengths.

NOTE A single force–length may also be specified.

4.3.6 ***End coil formation***

The type of end coil should be specified in box 1.

4.3.7 ***Operation***

It should be assumed that normal operation will involve the spring remaining static at a force–length with occasional, gradual movement to another specified loaded length.

If the spring is expected to withstand dynamic operation, i.e. greater than 10 000 cycles, then the minimum required life, operating levels of length, force or stress, speed of operation, and mode of operation (if an approximation to simple harmonic motion would not be acceptable) should be specified in box 2.

4.3.8 ***Temperatures, assembly and other processing details***

The maximum and minimum temperatures to which the spring will be subjected during its working life should be specified in box 3. Where a spring is subjected to temperatures outside this range, the conditions of temperature, time and force should be specified in box 5.

4.3.9 ***Relaxation***

Where it is important to maintain a force within close limits throughout the life of a spring the maximum allowable force loss (relaxation) should be given in box 4 along with details of temperature, force and duration.

4.3.10 ***Atmosphere and special protection details***

Where special cleanliness, resistance to corrosive atmospheres or such qualities as magnetic or electrical resistance are required, these conditions should be specified in box 6, and performance criteria agreed between the customer and the supplier.

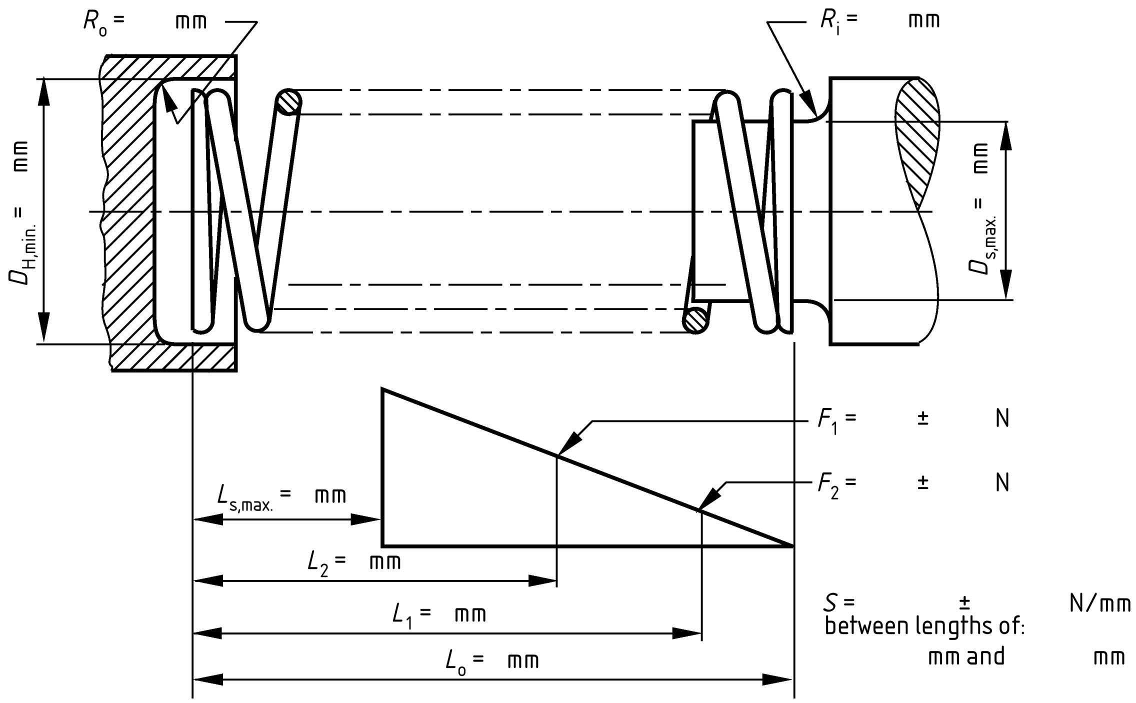
4.3.11 ***Surface coating***

If a specific surface coating is required, such as for identification, protection or decorative purposes, this should be given in box 7.

4.3.12 ***Other requirements***

Any requirements other than those detailed in **4.3.1** to **4.3.11** should be given in box 8.

SPECIFICATION FOR HELICAL COMPRESSION SPRING BS 1726-1:2002 DATA SHEET 2	Part Serial No.___________
This form should be completed with reference to BS 1726-1:2002 Clause 4.3	



For nomenclature see BS 1726-1:2002, Clause **3**

1 End coil formation Closed Open Closed and ground	**5 Assembly, or further processing details**
2 Operation (if dynamic) Minimum required life_________________ cycles Speed of operation _________________Hz Maximum force–length_________________ N·mm Minimum force–length_________________ N·mm	**6 Atmosphere, special protection details**
3 Temperature Minimum operating temperature __________ °C Maximum operating temperature __________ °C	**7 Surface coating**
4 Relaxation Permissible relaxation ________________ % length = ________________ mm time = ________________ h temperature = ________________ °C	**8 Other requirements**
Sheet 1 of ______________________________	Serial/Design/Part No.

Figure 5 — Data sheet 2

5 Tolerances

NOTE 1 Tolerances are based on experience gained within the spring industry, but no process control capability is implied. Where process control capability is required this will need to be agreed between the customer and the supplier.

NOTE 2 The tolerances calculated are the maximum deviations from the specified dimension.

5.1 General

The tolerances given in this clause are those recommended for economic production in two grades, 1 and 2, and apply only to springs with an index in the range 3.5 to 16 and a total number of coils, N, not less than 3.5. The property tolerances in **5.3** are not valid for unstable springs subject to buckling at deflections greater than the critical deflection when calculated using an seating coefficient, ν, of 0.5 (see BS EN 13906-1).

NOTE The choice of tolerance grades will be governed by operational requirements. Grade 1 covers tolerances where close agreement with nominal specification is required while grade 2 allows wider tolerances. Generally, where several features are toleranced a combination of grades 1 and 2 is used. Where designers find it necessary to specify tolerances tighter than grade 1 they should consult their supplier as to the practicability or economy of the design in question. The use of wider tolerances should result in more economical production.

The tolerances apply to springs manufactured from:

a) carbon or carbon alloy steel, martensitic and precipitation hardened stainless steel, where the solid stress does not exceed 70 % of the tensile strength of the material; or

b) austenitic stainless steel and copper alloy material where the solid stress does not exceed 60 % of the tensile strength of the material; or

c) high nickel alloy and cobalt alloy material where the solid stress does not exceed 55 % of the tensile strength of the material; or

d) other materials subject to agreement between the supplier and the user.

5.2 Dimensional tolerances

5.2.1 ***Material diameter***

Tolerances relating to the material being used apply prior to the spring being coiled.

5.2.2 ***Coil diameter***

5.2.2.1 The expressions in **5.2.2.2** and **5.2.2.3** give the tolerance (in mm) on mean coil diameter, D. They may be applied either to the inside or the outside diameters, depending on the application, but not to both.

5.2.2.2 The grade 1 tolerance for material diameter up to and including 15 mm is either:

a) $\pm\dfrac{1\,000 + (c + 30)(D + 8)}{10\,000}$ mm; or

b) ±1.5 % of the mean diameter,

whichever is the greater.

The grade 1 tolerance for material diameter over 15 mm is $\pm\dfrac{(1.5D + 0.166L_o)}{100}$, with a minimum tolerance of 1.5 mm.

5.2.2.3 The grade 2 tolerance is 1.5 × the grade 1 tolerance.

5.2.3 ***Free length***

5.2.3.1 For group A springs, the tolerance on free length, L_o, is

$$\pm\frac{(L_o + 10)(c + 25)}{2\,000}\ \text{mm.}$$

5.2.3.2 For group B springs, the tolerance on free length, L_o, is

$$\pm\frac{1.2(L_o + 10)(c + 25)}{2\,000}\ \text{mm.}$$

5.2.4 ***Tip thickness***

It is only necessary to specify a limiting value on tip thickness in the case of highly dynamic applications, and in these instances it should be agreed between the customer and the supplier.

5.2.5 ***Squareness***

5.2.5.1 The squareness tolerances given in **5.2.5.2** and **5.2.5.3** apply only to springs made from material sizes of 0.5 mm or greater which have closed and ground ends.

5.2.5.2 The grade 1 end squareness tolerance for:

a) material diameter up to and including 15 mm should be 0.030 mm per millimetre of nominal free length;

b) material diameter over 15 mm should be 0.015 mm per millimetre of the nominal free length.

NOTE The squareness of the spring in the free condition is rarely critical for spring performance. It is therefore strongly recommended that the squareness tolerance should only be specified when there are special requirements.

5.2.5.3 The grade 2 end squareness tolerance for:

a) material diameter up to and including 15 mm should be 0.05 mm per millimetre of the nominal free length;

b) material diameter over 15 mm should be 0.03 mm per millimetre of the nominal free length.

5.2.6 ***Parallelism of ends***

5.2.6.1 The tolerances on parallelism given in **5.2.6.2** and **5.2.6.3** apply only to springs made from material of diameters 0.5 mm and greater and which have closed and ground ends.

5.2.6.2 The grade 1 parallelism tolerance for:

a) material diameter up to and including 15 mm should be 0.05 mm per millimetre of the nominal outside diameter;

b) material diameter over 15 mm should be 0.025 mm per millimetre of the nominal outside diameter.

NOTE The parallelism of the spring in the free condition is rarely critical for spring performance and it is therefore strongly recommended that the parallelism tolerance should only be specified when there are special requirements.

5.2.6.3 The grade 2 parallelism tolerance for:

a) material diameter up to and including 15 mm should be 0.1 mm per millimetre of the nominal outside diameter;

b) material diameter over 15 mm should be 0.05 mm per millimetre of the nominal outside diameter.

5.2.7 ***Angle of grind***

This is applicable to closed and ground ends only. The angle of the grind should be:

a) grade 1, within the range 260° to 340°;

b) grade 2, within the range 200° to 350°.

5.2.8 ***Bow***

The maximum tolerance on bow should be 0.025 mm per millimetre of the nominal free length, L_o.

5.2.9 ***Solid length***

A theoretical solid length can be calculated from the total number of coils, the material diameter and the end condition. However, it should be emphasized that this presupposes that all coils are in perfect contact and that the section of the material has not changed during coiling, conditions which are never met in practice. A maximum solid length that is practically attainable should be specified and in this part of BS 1726 it is given by:

a) $L_{s,\ max.} = N(d_{max.} + 2t)$, for a ground spring;

b) $L_{s,\ max.} = (N + 1.5)(d_{max.} + 2t)$, for an unground spring.

5.2.10 ***Effect of coating thickness on spring rate***

Surface coating, e.g. electroplating, of a spring wire increases the effective diameter of that wire and may cause a substantial increase in spring rate. Account should be taken of this by the spring designer when specifying the spring.

5.3 Property tolerances

5.3.1 ***Force at length***

5.3.1.1 The tolerances given by the expressions in **5.3.1.2** and **5.3.1.3** do not apply above 85 % of the safe deflection from the free position.

NOTE It is possible, although not normal practice, to specify spring length under a given force. In this case the tolerances are to be agreed between the customer and the supplier.

5.3.1.2 For group A springs:

a) the grade 1 tolerance on force at length (in N) should be

$$\pm\frac{S}{2\,000}\,[40\delta + (L_o + 10)(c + 25)]$$

b) the grade 2 tolerance on force at length (in N) should be 1.5 times the grade 1 tolerance.

5.3.1.3 For group B springs:

a) the grade 1 tolerance on force at length (in N) should be

$$1.2 \times \frac{S}{2\,000}\,[40\delta + (L_o + 10)(c + 25)]$$

b) the grade 2 tolerance on force at length (in N) should be 1.5 times the grade 1 tolerance.

5.3.2 ***Rate***

5.3.2.1 The rate tolerances given in **5.3.2.2** and **5.3.2.3** apply only to springs with more than 3.5 total coils and in the range of 20 % to 80 % of the safe deflection from the nominal free length of the spring.

5.3.2.2 For group A springs with more than 3.5 and less than 5 total coils:

a) the grade 1 tolerance on rate should be

$$\pm\frac{2.224N(N+2.5)}{(N-2.9)}\,\%$$

b) the grade 2 tolerance on rate should be

$$\pm 1.5 \times \frac{0.224N(N+2.5)}{(N-2.9)}\,\%$$

The tolerances calculated using the above expressions are given in Table 1 but in cases of dispute values should be calculated directly from the expressions.

Table 1 — Calculated tolerances for group A springs made from circular section material, with more than 3.5 and less than 5 total coils

Number of coils *N*	% Tolerance		Number of coils *N*	% Tolerance	
	Grade 1	Grade 2		Grade 1	Grade 2
3.5	7.8	11.7	4.3	4.7	7.1
3.6	7.0	10.5	4.4	4.5	6.8
3.7	6.4	9.6	4.5	4.4	6.6
3.8	6.0	9.0	4.6	4.3	6.5
3.9	5.6	8.4	4.7	4.2	6.3
4.0	5.3	8.0	4.8	4.1	6.2
4.1	5.1	7.7	4.9	4.1	6.2
4.2	4.8	7.2	5.0	4.0	6.0

For group A springs with 5 or more coils, the tolerance on rate should be 4 % for grade 1 and 6 % for grade 2.

5.3.2.3 For group B springs with more than 3.5 and less than 5 total coils:

a) the grade 1 tolerance on rate should be

$$\pm 1.2 \times \frac{0.224N(N+2.5)}{(N-2.9)}\,\%$$

b) the grade 2 tolerance on rate should be

$$\pm 1.8 \times \frac{0.224N(N+2.5)}{(N-2.9)}\,\%$$

The tolerances calculated using the above expressions are given in Table 2 but in cases of dispute values should be calculated directly from the expressions.

Table 2 — Calculated tolerances for group B springs made from circular section material, with more than 3.5 and less than 5 total coils

Number of coils N	% Tolerance		Number of coils N	% Tolerance	
	Grade 1	Grade 2		Grade 1	Grade 2
3.5	9.4	14.0	4.3	5.6	8.5
3.6	8.4	12.6	4.4	5.4	8.1
3.7	7.7	11.5	4.5	5.3	7.9
3.8	7.2	10.8	4.6	5.2	7.7
3.9	6.7	10.1	4.7	5.0	7.6
4.0	6.4	9.5	4.8	4.9	7.4
4.1	6.1	9.2	4.9	4.9	7.4
4.2	5.8	8.6	5.0	4.8	7.2

5.3.2.4 For group B springs with 5 or more coils the tolerance should be 4.8 % for grade 1 and 7.2 % for grade 2.

6 Methods of verification

6.1 General

The methods of testing a spring parameter are numerous and any may be used. The methods given in **6.2**, **6.3** and **6.4** should be used in cases of arbitration or disagreement.

Nominal dimensions and those marked for reference only need not be checked.

NOTE It is appreciated that for very small quantities the production of suitable gauges may not be economical and in these cases alternative methods should be agreed between the customer and the supplier.

6.2 Dimensional verification

6.2.1 ***General***

Carry out all dimensional tests with the spring in its free state.

Compress prestressed springs to their minimum compressed length and release before testing.

6.2.2 ***Material diameter***

Use a micrometer with ball-ended anvils to measure the material diameter, d

NOTE The dimension obtained can be only an indication since it will change due to slight distortion during coiling, and tolerances cannot therefore apply.

6.2.3 ***Spring diameter***

Use a GO–NOT GO system of ring and/or plug gauges, in accordance with BS 969, to verify that the outside diameter, D_o, and the inside diameter, D_i, are within tolerance.

The gauges should have a minimum length of 1.25 times the maximum pitch of the spring where the diameter of the spring body is important, or 1.5 times the material diameter d, where the diameter of the end coil is important.

NOTE The mean diameter D cannot be measured.

6.2.4 ***Spring length***

Use a precision vernier calliper in accordance with BS 887 to measure the free length L_0 of springs if the tolerance on the free length is equal to or greater than 0.8 mm, holding the axis of the spring parallel to the measuring scale. When the diameter of the spring is greater than the length of the jaws of the vernier, rotate the spring to determine the maximum length.

6.2.5 ***Free length***

When the tolerance on the free length is less than 0.8 mm, use one of the following tests, as applicable.

a) For springs which have a rate *S,* greater than 15 N/mm, place the spring on a flat horizontal base plate and lower a second plate, parallel to the base plate, onto the spring until first contact is made and measure the distance between the plates using gauge blocks in accordance with BS EN ISO 3650 and/or length bars in accordance with BS 5317 see Figure 6.

b) For springs which have a rate, *S*, equal to or less than 15 N/mm, place the spring between the measuring surfaces of a GO–NOT GO gap gauge, the measuring surfaces of which are longer than the spring diameter. The spring should fall through the GO section under its own weight, but not through the NOT GO section of the gauge.

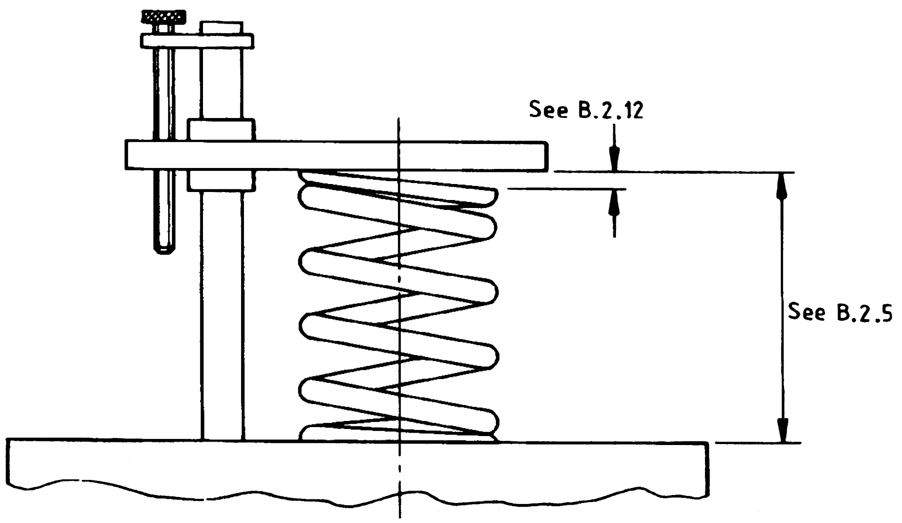


Figure 6 — Measurement of free length and parallelism

6.2.6 ***Number of coils***

Determine the total number of coils, *N*, by counting the number of complete coils from one end coil tip to the other and measure any remaining fraction with a protractor.

NOTE The number of active coils, *n*, cannot be measured.

6.2.7 ***End grinding***

Measure the amount of end grinding, expressed as the angle of grind, using a protractor.

6.2.8 ***End coil tip***

For material diameters or axial dimensions equal to, or greater than, 5 mm, measure the thickness of the tip of the end coil with a vernier depth gauge in accordance with BS 6365 or a depth micrometer in accordance with BS 6468. For material diameters less than 5 mm, measure the tip thickness by projection.

NOTE Where the ends are not closed, a strip wedge acting as an alternative reference surface may be used.

6.2.9 ***Chamfers***

Check chamfers by using a gauge that matches the components adjacent to the spring.

NOTE Chamfers cannot be measured accurately owing to the nature of the helixed coil, but usually they are only required to clear radii on adjacent components.

6.2.10 ***Coating thickness***

Measure the thickness of coating in accordance with the relevant Part of BS 5411.

6.2.11 ***Squareness***

To measure squareness of springs with ground ends stand the spring on a datum surface, e.g. a surface plate in accordance with BS 817, place an engineer's square, in accordance with BS 939, against it and measure the largest deviation between the top end coil and the square with a feeler gauge, in accordance with BS 957, see Figure 7.

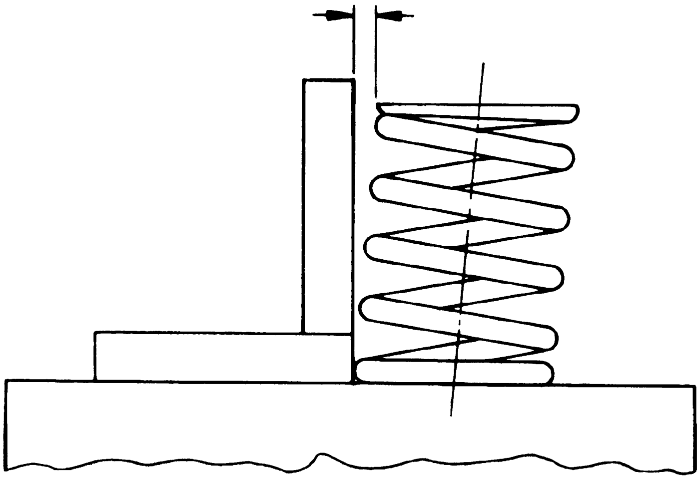


Figure 7 — Measurement of squareness

6.2.12 ***Parallelism of ends***

To measure the parallelism of the ground ends of springs, which have a rate, *S*, greater than 15 N/mm, place the spring on a flat horizontal base plate and lower a second plate, parallel to the base plate, on to the spring until first contact is made, and measure the gap between the upper end coil and the upper plate with a feeler gauge, see Figure 6.

6.2.13 ***Bow***

To measure bow, lay the spring on a datum surface or straight edge, in accordance with, BS 5204 and measure the maximum deviation between any coil and the surface with a feeler gauge, see Figure 8.

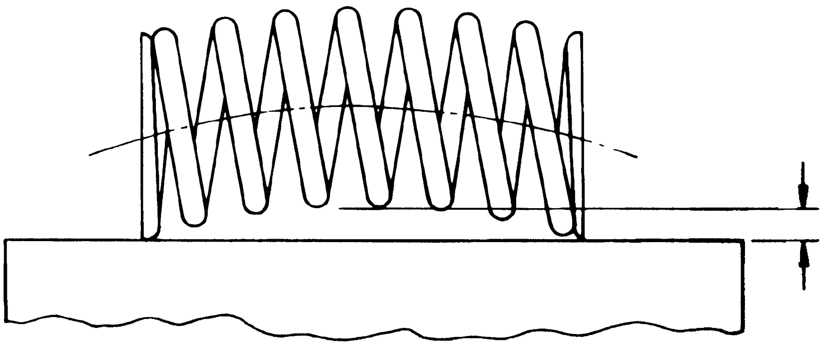


Figure 8 — Measurement of bow

6.3 Property verification

6.3.1 *Compression*

Compress prestressed springs to their minimum compressed length and release before testing.

6.3.2 *Measurement*

Measure the spring force using a testing machine calibrated to class 1 of BS EN ISO 7500-1, or better. Measure spring length using a system calibrated to an accuracy of ±0.02 mm over the whole measuring range by means of gauge blocks which meet the requirements of grade 2 of BS EN ISO 3650 or better.

NOTE If force measurements are only to be made at several discrete lengths, each position can be exactly established by using gauge blocks which meet the requirements of grade 2 of BS EN ISO 3650.

6.3.3 *Spring force*

Determine the force at length or the length at force value using the testing equipment specified in **6.3.2**.

NOTE Springs that are not resistant to buckling using a seating coefficient ν of 0.5 (see BS EN 13906-1) should be mounted on a mandrel or in a sleeve. In those cases the method of test is to be agreed between the customer and the supplier.

6.3.4 *Spring rate*

Determine the spring rate use one of the following methods as applicable.

a) For springs which have a constant pitch, determine the spring rate in the range of 20 % to 80 % of the safe deflection by carrying out force measurements (F_1 and F_2) at two agreed lengths (L_1 and L_2) and calculate the rate as follows:

$$S = \frac{F_2 - F_1}{L_1 - L_2}$$

b) For springs in which the pitch is not constant, determine the spring rate by a number of force tests at agreed lengths and calculate the spring rate as above.

6.3.5 *Solid length*

Determine the solid length by applying a force of not less than 1.5 ± 10 % times the theoretical solid force and measuring the spring length using equipment specified in **6.3.2**, the method of application of the force being the subject of agreement between the customer and the supplier.

NOTE 1 The solid force cannot be measured.

NOTE 2 The mechanical properties of the material cannot be determined after it has been coiled.

NOTE 3 Hysteresis in compression springs covered by this Part of BS 1726 is extremely small. If a determination is required for special applications the method of test and tolerances applied are to be the subject of agreement between the customer and the supplier. However, it should be borne in mind that in view of the small magnitude of this effect very accurate testing equipment is necessary to undertake such measurements.

NOTE 4 Linearity of compression springs is rarely specified. For springs covered by this part of BS 1726 non-linearity of the force-deflection curve is not normally significant. If, however, it is necessary to determine this property then the test method and tolerances applied are to be the subject of agreement between the customer and the supplier.

NOTE 5 The amount of prestressing cannot be measured. If the spring has satisfactorily met the force-length requirements, it can be assumed that the necessary prestressing has been carried out.

6.4 Performance verification

6.4.1 Owing to the nature of these tests and the time involved in carrying them out, test only a small sample of springs, the size of the sample being agreed between the customer and the supplier, and discard these after testing.

6.4.2 ***Relaxation***

Determine the relaxation characteristics of a spring by clamping the spring to the length corresponding to the required force and exposing the spring to a period at a specified temperature. The relaxation characteristic is determined by measuring the specified force at length or length at force and comparing with a value measured before exposure.

NOTE The period and temperature at which exposure is carried out will vary according to the intended use of the spring and will need to be agreed between the customer and the supplier.

6.4.3 ***Corrosion***

Obtain an indication of the effects of corrosion on the characteristics of a spring by carrying out static or dynamic tests in conditions that simulate the working environment.

NOTE The test environment and criteria for acceptance will need to be agreed between the customer and the supplier.

6.4.4 ***Spring life***

Determine the spring life by carrying out tests which simulate factors that will contribute to its degradation, e.g. environment, fatigue, stress.

NOTE These tests will need to be agreed between the customer and the supplier.

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389 Chiswick High Road
London
W4 4AL