BS 1726-1:2010

BSI Standards Publication

Cylindrical helical springs made from round wire and bar – Guide to methods of specifying and tolerancing hot coiled springs, and cold coiled springs not covered by BS EN 15800, and general spring testing

Part 1: Compression springs

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Contents

Summary of pages
This document comprises a front cover, an inside front cover, pages i to ii, pages 1 to 22, an inside back cover and a back cover.

Foreword

Publishing information

This part of BS 1726 is published by BSI and came into effect on 30 November 2010. It was prepared by Technical Committee FME/9, *Fasteners*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

Together with BS EN 15800:2008, this part of BS 1726 supersedes BS 1726-1:2002, which is withdrawn.

Relationship with other publications

BS EN 13906-1 was published in 2002 and under the rules of CEN the UK is obliged to withdraw conflicting standards. The 2002 edition of BS 1726-1 included those provisions of the previous edition not included in the EN standard. The publication of BS EN 15800 has prompted this revision of BS 1726-1 to reflect the reduced scope of this standard.

Information about this document

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 1726 is published in three parts:

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

Use of this document

BSI permits the reproduction of BS 1726-1:2010, Figure 1 and Figure 5. This reproduction is only permitted where it is necessary for the user to record findings on the figures during each application of the standard.

As a guide, this part of BS 1726 takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Any recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This part of BS 1726 provides guidance on methods of specifying and tolerancing hot coiled compression springs, and cold coiled springs that fall outside the size range limits specified in BS EN 15800. In addition, this standard includes in Annex A the general testing methods for parallel sided helical compression springs that are applicable to both hot and cold coiled springs manufactured from circular section material.

Two grades of tolerance, 1 and 2, are given for hot coiled circular section springs, or cold coiled springs that fall outside the size ranges specified in BS EN 15800.

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 EN 13906-1, *Cylindrical helical springs made from round wire and bar – Calculation and design – Part 1: Compression spring*s

BS EN 15800, *Cylindrical helical springs made of round wire – Quality specifications for cold coiled compression springs*

BS EN ISO 26909, *Springs – Vocabulary*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this part of BS 1726, the terms and definitions given in BS EN ISO 26909 and the following apply.

3.1.1 edge dressing

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

3.1.2 group A springs

springs with material that has not undergone a structural change by heat treatment after forming

NOTE This may include both springs that have been stress relieved and those that have not.

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

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

3.2 Symbols

For the purposes of this part of BS 1726-1, the symbols in Table 1 apply.

Table 1 **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	spring force	N
F_s	theoretical solid force	N
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
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
δ	deflection from nominal free length to loaded length	mm
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 and 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 should 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; 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) comply with 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

Box 1 (Figure 1) should be completed 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 is 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.

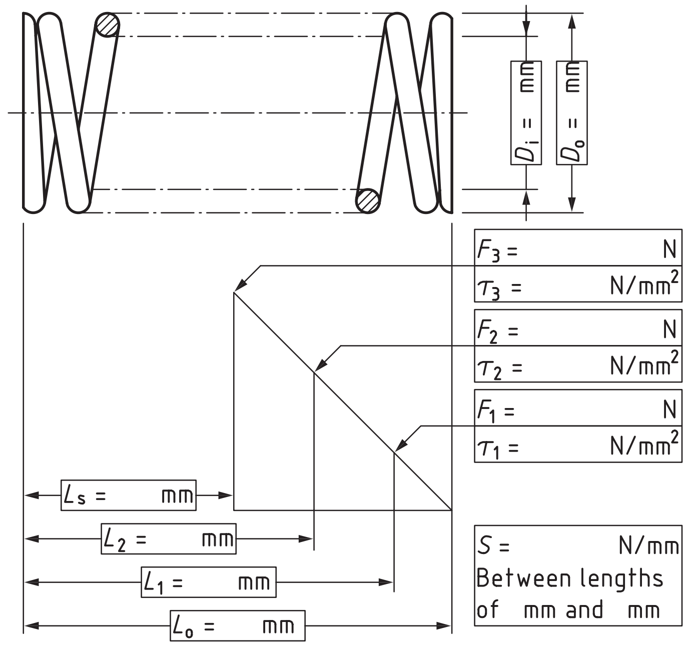
Hold the spring at eye level and look through it along its major axis. Rotate the spring about this axis until the visible cut end is at the bottom. If the cut end now points to the left, it is a left-hand coiled spring.

Figure 1 **Data Sheet 1**

SPECIFICATION FOR HELICAL COMPRESSION SPRING
BS 1726-1:2010 DATA SHEET 1

Part Serial No. ________________

This form should be completed with reference to BS 1726-1:2010, 4.2.



For nomenclature, see BS 1726-1:2010, 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 Tolerance: 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.

4.2.4 End coil form

Box 3 should be completed by indicating the type of end coil required, these being:

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

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

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

NOTE 1 It is possible that the end coils might not be completely closed and that a gap might 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.

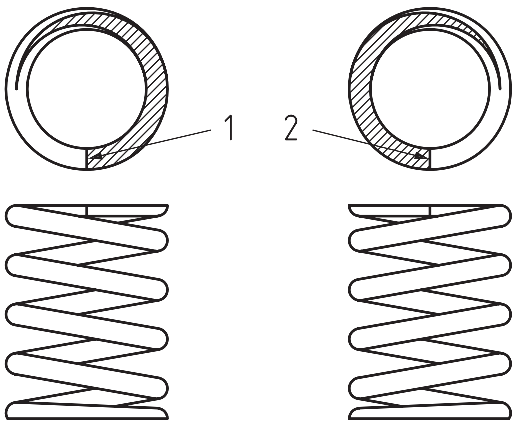
If any other end form is required, it should be illustrated, dimensioned and toleranced in a separate drawing and submitted to the manufacturer for agreement.

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.

Figure 2 **Hand of coiling**

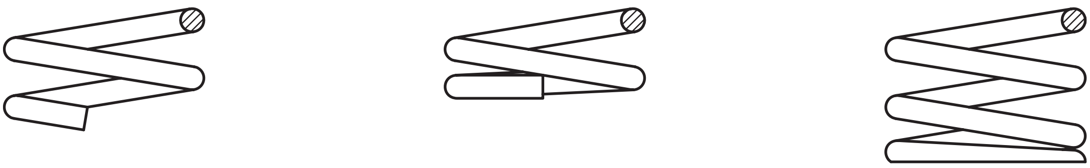


Key

1 Left-hand coil

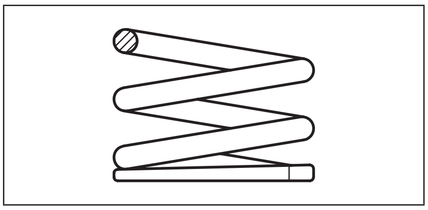
2 Right-hand coil

Figure 3 **End coil form**



a) Open end b) Closed end c) Closed and ground end

Figure 4 **Coil end formed from tapered bar**



4.2.6 Thermal treatment

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.

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, prestressing is not possible. If the specified solid stress is above the torsional yield stress, prestressing might 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 might 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, 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 that should 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 should be given in box 14.

4.2.11 Chamfering

Internal and/or external chamfering of springs with ground ends might 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

Dimensional tolerances and property tolerances 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 and 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).

Relevant dimensions should be inserted 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 might 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, the minimum compressed length should be given in box 8. The spring can 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_o, 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.

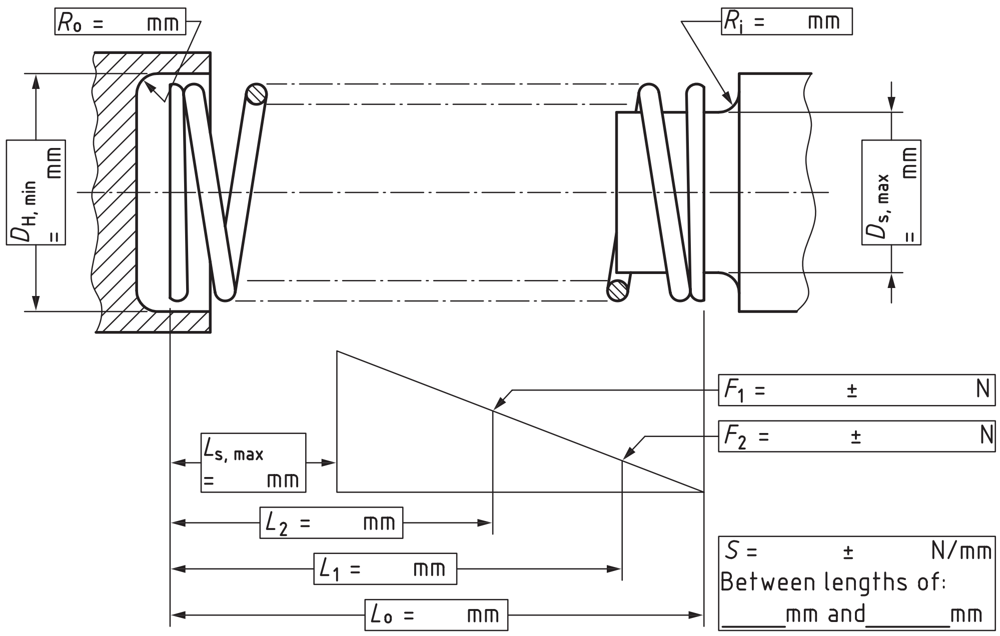
4.3.6 End coil formation

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

Figure 5 **Data sheet 2**

SPECIFICATION FOR HELICAL COMPRESSION SPRING **BS 1726-1:2010 DATA SHEET 2**	**Part Serial No.** ______________

This form should be completed with reference to BS 1726-1:2010, 4.3.



For nomenclature, see BS 1726-1:2010, Clause **3**.

1 End coil formation Closed Open Closed and ground	**5 Assembly, or further processing instructions**
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.

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 is likely to be subjected during its working life should be specified in box 3. Where a spring could be 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.

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 needs 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 Clause **5** 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 fewer 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 a seating coefficient, v, of 0.5 (see BS EN 13906-1).

NOTE The choice of tolerance grades is 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 are advised to consult their supplier as to the practicability or economy of the design in question. The use of wider tolerances is likely to 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) $\pm\frac{1000+(c+30)(D+8)}{10\,000}$ mm; or

b) ±1.5% of the mean diameter,

whichever is the greater.

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

5.2.2.3 The grade 2 tolerance is 1.5 times 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 $\pm\frac{(L_o+10)(c+25)}{2\,000}$ mm.

5.2.3.2 For group B springs, the tolerance on free length, L_o, is $\pm\frac{1.2(L_o+10)(c+25)}{2\,000}$ 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.

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 is only specified when there are special requirements.

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 mm of nominal free length;

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

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 mm of the nominal free length;

b) material diameter over 15 mm should be ±0.03 mm per mm 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.

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 is only specified when there are special requirements.

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 mm of the nominal outside diameter;

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

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 mm of the nominal outside diameter;

b) material diameter over 15 mm should be ±0.05 mm per mm 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 mm 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 practicably attainable should be specified and in this part of BS 1726 it is given by:

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

b) $L_{s,\,max} = (N + 1)d_{max}$ for an unground spring,

where t is the thickness of the wire at the tip of the 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 might 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

$$\pm\frac{S}{2\,000}\left\{40\delta+\left(L_o+10\right)(c+25)\right\};$$

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

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

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 fewer than 5 total coils:

a) the grade 1 tolerance on rate should be $\pm \frac{0.224N(N+2.5)}{N-2.9}$ %;

b) the grade 2 tolerance on rate should be $\pm 1.5 \times \left\{ \frac{0.224N(N+2.5)}{N-2.9} \right\}$ %.

The tolerances calculated using the expressions in **5.3.2.2** are given in Table 2 but in cases of dispute, values should be calculated directly from the expressions.

Table 2 **Calculated tolerances for group A springs made from circular section material, with more than 3.5 and fewer 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

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

5.3.2.4 For group B springs with more than 3.5 and fewer than 5 total coils:

a) the grade 1 tolerance on rate should be $\pm 1.2 \times \left\{ \frac{0.224N(N+2.5)}{N-2.9} \right\}$ %;

b) the grade 2 tolerance on rate should be $\pm 1.8 \times \left\{ \frac{0.224N(N+2.5)}{N-2.9} \right\}$ %.

The tolerances calculated using the expressions in **5.3.2.4** are given in Table 3 but in cases of dispute, values should be calculated directly from the expressions.

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

Table 3 **Calculated tolerances for group B springs made from circular section material, with more than 3.5 and fewer 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

Annex A (informative) Methods of verification

A.1 General

The methods of testing a spring parameter are numerous and any may be used. The methods given in **A.2**, **A.3** and **A.4** ought to 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 might not be economical and in these cases alternative methods ought to be agreed between the customer and the supplier.

A.2 Dimensional verification

A.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.

A.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 changes due to slight distortion during coiling, and tolerances cannot therefore apply.

A.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 ought to 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.

A.2.4 Spring length

Use a precision vernier calliper conforming to BS 887 to measure the free length, L_o, 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.

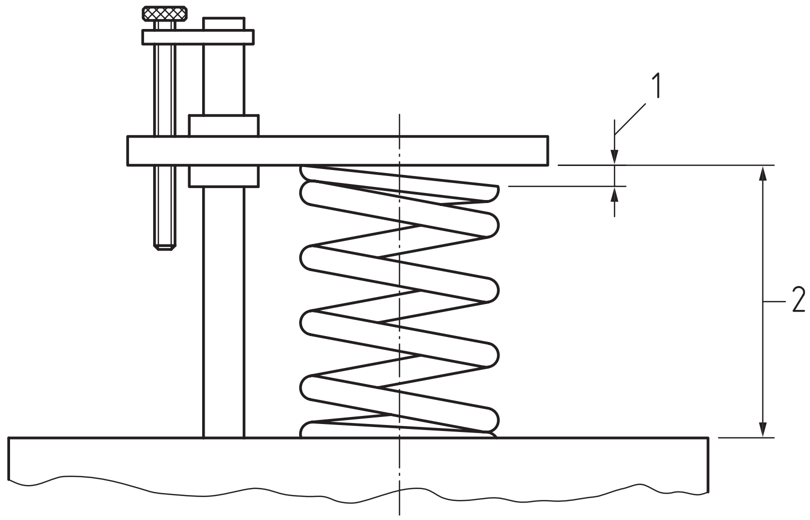
A.2.5 Free length

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 conforming to BS EN ISO 3650 and/or length bars conforming to BS 5317 (see Figure A.1).

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 ought to fall through the GO section under its own weight, but not through the NOT GO section of the gauge.

Figure A.1 **Measurement of free length and parallelism**



Key

1 See **A.2.12**, parallelism of ends

2 See **A.2.5**, free length

A.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.

A.2.7 End grinding

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

A.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 conforming to BS 6365 or a depth micrometer conforming to 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.

A.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.

A.2.10 Coating thickness

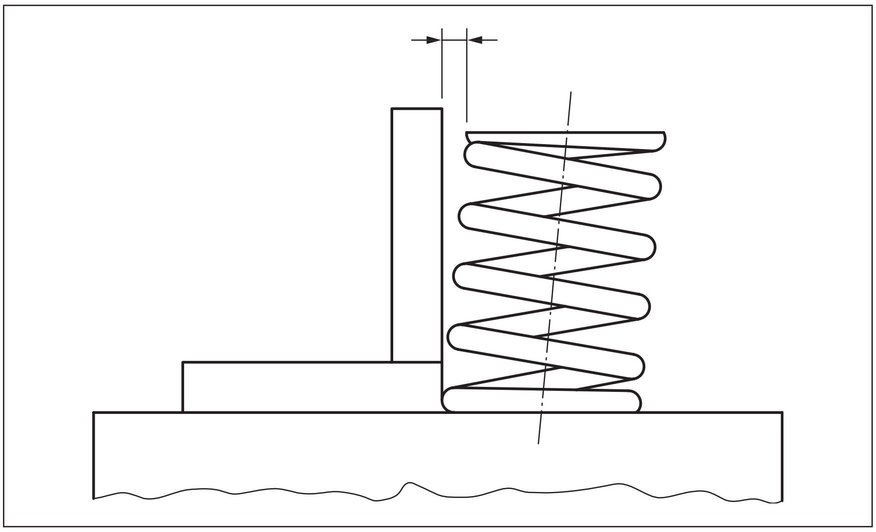
Measure the thickness of coating in accordance with a suitable test method for the type of coating applied.

NOTE BS EN ISO 3882 gives a review of the methods of measurement for metallic and other inorganic coatings. This standard might help when deciding which test method to use.

A.2.11 Squareness

To measure squareness of springs with ground ends, stand the spring on a datum surface, e.g. a surface plate conforming to BS 817, place an engineer's square conforming to BS 939 against it and measure the largest deviation between the top end coil and the square with a feeler gauge conforming to BS 957 (see Figure A.2).

Figure A.2 **Measurement of squareness**



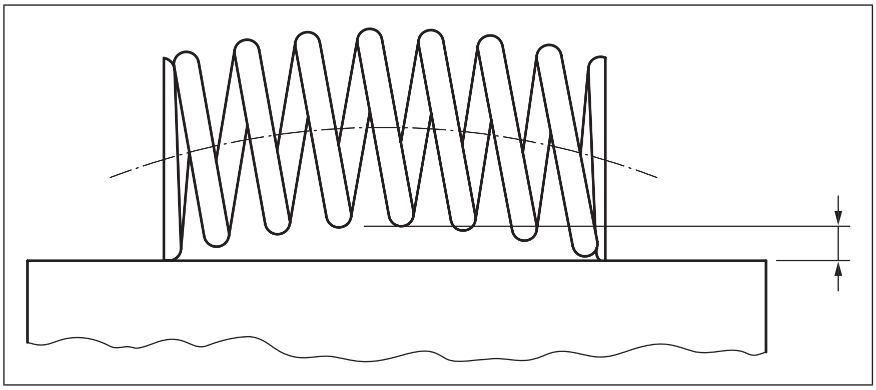
A.2.12 Parallelism of ends

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 A.1).

A.2.13 Bow

To measure bow, lay the spring on a datum surface or straightedge conforming to BS 5204-1 or BS 5204-2 and measure the maximum deviation between any coil and the surface with a feeler gauge (see Figure A.3).

Figure A.3 **Measurement of bow**



A.3 Property verification

A.3.1 Compression

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

A.3.2 Measurement

Measure the spring force using a testing machine calibrated to class 1 of BS EN ISO 7500-1:2004, 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 3650:1999 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 3650:1999.

A.3.3 Spring force

Determine the force at length or the length at force value using the testing equipment specified in **A.3.2**.

NOTE Springs that are not resistant to buckling using a seating coefficient, ν, of 0.5 (see BS EN 13906-1) ought to 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.

A.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 in a).

A.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 **A.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 ought to 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, 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.

A.4 Performance verification

A.4.1 Sampling

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.

A.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 vary according to the intended use of the spring and need to be agreed between the customer and the supplier.

A.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 need to be agreed between the customer and the supplier.

A.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 need to be agreed between the customer and the supplier.

Bibliography

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 817, *Specification for surface plates*

BS 887, *Precision vernier callipers – Requirements and test methods*

BS 939, *Engineers' squares (including cylindrical and block squares) – Specification*

BS 957, *Specification for feeler gauges*

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

BS 5204-1, *Specification for straightedges – Part 1: Cast iron straightedges (bow shaped and I-section)*

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BS 5317, *Specification – Metric length bars and their accessories*

BS 6365, *Specification for precision vernier depth gauges*

BS 6468, *Specification for depth micrometers*

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