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(*तीसरा पुनरीक्षण*)

Draft *Indian Standard*

HELICAL COMPRESSION SPRINGS
PART 5 HOT COILED SPRINGS MADE FROM CIRCULAR
SECTION BARS — SPECIFICATION

(*Third Revision*)

ICS 21.160

Springs and Suspension Systems Sectional Committee, TED 34	**Last date for receipt of comments is 12/10/2024**

FOREWORD
(Formal clauses will be added later)

This standard was originally published in 1979 and subsequently revised in 1989 and 2004. The third revision of the standard was undertaken as a result of further experience gained in the manufacture and use of the components and other developments in the field.

The following technical changes have been incorporated:

a) Allowable variations in the nominal diameter for rods with both rolled and machined surfaces;
b) Acceptable deviations in the spring force;
c) Update of reference standards that are essential supplements to this standard; and
d) Inclusion of IS 13190, 'Guidelines for eddy current testing of round steel bars using the rotating probe method,' which was previously being developed.

This standard is one of the series of standards on helical coiled compression springs. The other parts in this series are as follows:

(Part 1) Design and calculations for springs made from circular section wire and bar
(Part 2) Specification for cold coiled springs made from circular section wire and bar
(Pall 3) Data sheet for springs made from circular section wire and bar
(Part 4) Selection of standard cold coiled springs made from circular section wire and bar

(Part 6) Design and calculations for springs made from rectangular section bar steel
(Part 7) Quality requirements for cylindrical coil compression springs, used mainly as vehicle suspension springs
(Part 8) Method of inspection of hot coiled compression springs made from circular section bars

The composition of the Committee responsible for the formulation of this standard is given at Annex A. (Will be added later)

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2: 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Draft *Indian Standard*

HELICAL COMPRESSION SPRINGS
PART 5 HOT COILED SPRINGS MADE FROM CIRCULAR SECTION BARS — SPECIFICATION

(*Third Revision*)

1 SCOPE

1.1 This standard (Part 5) covers hot coiled cylindrical compression springs made from round bar steel which are hardened and tempered after coiling.

1.2 This standard is applicable to springs having the following parameters:

a) Bar diameter, d from 8 to 60 mm;
b) Outside diameter, $D_e \leq 460$ mm;
c) Unloaded length, $L_o \leq 800$ mm
d) Number of active coils, n ≥ 3; and
e) Coil ratio, w from 3 to 12.

1.3 In case the lot size exceeds 5000, then the dimensional tolerances as given in IS 7906 (Part 7) shall be applicable.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
1500 (Part 1): 2013/ ISO 6506-1 : 2005	Metallic Materials – Brinell Hardness Test Part 1 Test Method
2500	Sampling inspection procedures
(Part 1): 2000	Attribute sampling plans indexed by acceptable quality level (AQL) for lot-by
(Part 2): 1965	Inspection by variables for percent defective
3195:1992	Steel for manufacture of volute and helical springs (for railway rolling stock) (*third revision*)
3431:1982	Steel for the manufacture of volute, helical and laminated springs for automotive suspension (*second revision*)
3703: 2004	Recommended practice for magnetic particle flaw detection (*second revision*)
7001: 2017	Springs - Shot peening – General procedures (*second revision*)
7906	Helical compression springs:
(Part 1): 1997	Design and calculations for springs made from circular section wire and bar (*first revision*)
(Part 3): 1975	Data sheet for springs made from circular section wire and bar
(Part 7): 1989	Quality requirements for cylindrical coil compression springs used mainly as vehicle suspension springs
13190:1991	Recommended practice for eddy current examination by rotating probe method of round steel bars

3 TERMINOLOGY

The following symbols and units shall apply (*see* also Fig. 1):

Symbol	*Term*	*Unit*

A_D	Permissible deviation of the mean coil diameter, D, of the unloaded spring	mm
A_d	Permissible deviation of the nominal diameter, d	mm
A_{De}	Permissible deviation of the external coil diameter, D_e, of the unloaded spring	mm
A_{Di}	Permissible deviation of the internal coil diameter, D_i, of the unloaded spring	mm
AF	Permissible deviation of the spring force, F, at a specified spring length, L	N
A_{Lo}	Permissible deviation of the Length, L_O,of the unloaded spring	mm
A_{nt}	Permissible deviation of the total number, nt, of turns	—
A_R	Permissible deviation of the spring rate, R	N/mm
$D = \frac{D_e + D_i}{2}$	Mean coil diameter	mm
D_e	External coil diameter	mm
D_i	Internal coil diameter	mm
d	Wire or rod diameter prior to the coiling of the spring	mm
d_{Max}	Upper deviation of nominal diameter	mm
e_1	Permissible deviation of generatix from the vertical, measured on the unloaded spring (*see* Fig. 1)	mm
e_2	Permissible deviation from absolute parallelism of two ground spring ends of the unloaded spring, measured at the external diameter, D_e	mm
F_1 *or* F_n	Spring forces, correlated to the spring length, L, to L_n	N
F_p	Spring force, correlated to the test length, L_p	N
$L_{c\ theo}$	Theoretical spring force, correlated to the solid length, L_c	N
L_o	Length of the unloaded spring	mm
L_1 *to* L_n	Lengths of the loaded spring, correlated to the spring forces, F_1 to F_n	mm
L_c	Solid length, shortest possible spring length (all the coils in contact with one another)	mm
$L_n = L_c + S_a$	Shortest permissible test length	mm
L_p	Length of loaded spring, correlated to the test force, Fp	mm
L_s	Length of spring during presetting	mm
n	Length of spring during mm presetting	—
n_t	Total number of turns	—
$R = \frac{\Delta F}{\Delta S}$	Spring rate	N/mm
s_1 *to* s_n	Spring deflections, correlated to the spring forces, F1 to F	mm
$s_c = L_o - L_c$	Solid spring deflection, correlated to thetheoretical spring force, $F_{c\ theo}$	mm

$S_a = L_n - L_c$	Safety gap, sum of the minimum clear distance between adjoining active turns at the spring length, L_n	mm
S_p	Spring deflection, correlated to test force, F_p	mm
$w = \frac{D}{d}$	Coiling ratio	mm

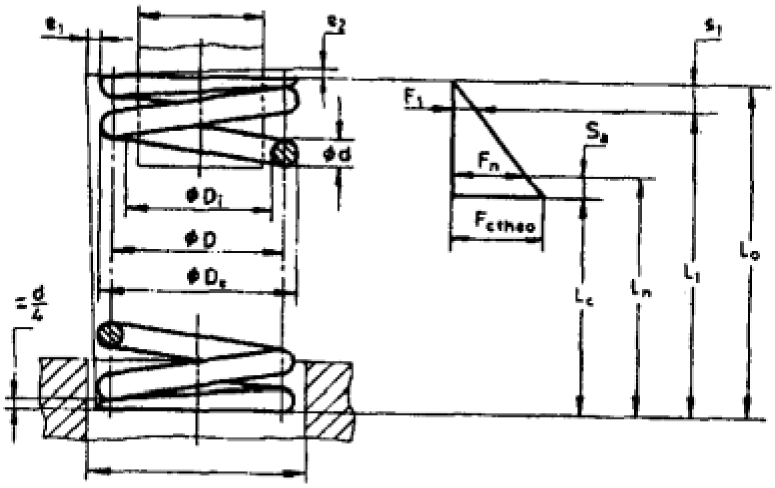

FIG.1 COMPRESSION SPRING WITH ENDS CLOSED AND GROUND WITH THEORETICAL CHARACTERISTIC LINE

4 DESIGN

4.1 Material

The steel of different grades as given in IS 3195 and IS 3431 shall be used as the starting material for springs. Any other material of special composition for special applications may be used in accordance with the requirements of the user.

4.2 Direction of Coiling

Helical compression springs have a right-handed (clockwise) winding as a general rule. Springs for application in nested sets (assemblies) or where one spring is working inside the other, the direction of coiling is alternatively left and right. the outer springs are generally with right-hand coiling. if the springs are required to have a left-hand (anticlockwise) coiling, the same must be mentioned in the order and enquiry or appropriately in data sheet as given in is 7906 (Part 3).

4.3 Spring Ends

For transmitting axial loads on the connecting body, the spring ends shall be so formed that for any position of the spring, the spring action is axial as far as possible. this is generally achieved by decreasing the pitch at the runout coil. The spring end is then ground so that a flat seating surface is obtained. other types of spring ends are shown in Fig. 2 to Fig. 5.

4.4 Total Number of Coils, n_t

The total number of coils (n_t) varies depending on the end construction of the spring. For different construction the number of coils is given below:

Types of Ends According to	*Total Number of Coils, n_t*

Fig. 1 and Fig. 2	n + 1.50
Fig. 3	n + 1.00
Fig. 4	n + 1.50
Fig. 5	n + 1.67

4.5 Detailed design calculations for springs are covered by IS 7906 (Part 1).

5 WIRE OR ROD DIAMETER BEFORE COILING

5.1 Roads with Rolled Surface (*see* Table 1)

Table 1 Nominal Diameter and Permissible Deviations
(*Clause* **5.1**)

Sl No.	**Nominal Diameter** d	**Permissible Deviations** A_d
(1)	(2)	(3)
i)	$8 < d < 11.5$	± 0.15
ii)	$12 < d < 21.5$	± 0.2
iii)	$22 < d < 29.5$	± 0.25
iv)	$30 < d < 39$	± 0.3
v)	$40 < d < 50$	± 0.4
vi)	$52 < d < 60$	± 0.5

5.2 Roads with Machined Surface, that is with Turned, Peeled or Ground Surface (see Table 2)

Table 2 Permissible Deviations of the Nominal Diameter
(*Clause* **5.2**)

Sl No.	**Nominal Diameter** d	**Permissible Deviations** A_d
(1)	(2)	(3)
i)	$8 < d < 10$	± 0.05
ii)	$10 < d < 20$	± 0.08
iii)	$20 < d < 30$	± 0.10
iv)	$30 < d < 40$	± 0.12
v)	$40 < d$	± 0.15

6 MANUFACTURING

6.1 Preparation of Bars

6.1.1 Springs for non-critical application can be manufactured from as rolled bars.

6.1.2 Springs for critical applications, or where specific fatigue life is to be met, or where load-rate characteristics are important are generally made from centreless ground bars. In case the springs are to be manufactured from centreless ground bars, the-same must be. mentioned in the order and enquiry or appropriately in data sheet as given in IS 7906 (Part 3).

6.1.2.1 If specified in the drawing/data sheet/ purchase order, all ground bars should be subjected to crack detection, by any one of the following methods:

a) Magnetic particle method as given as IS 3703; and
b) Eddy current method as given in IS 13190.

6.1.3 Before coiling, both ends of the bars should be properly tapered (if specified in the spring drawing) to give the finished spring a firm bearing. The taper length should be approximately equal to 0.75 of the mean circumference of the spring. The taper portion should be smoothly tapered with the tips rounded off and tip thickness at the edge should be approximately 1/4 of the bar diameter.

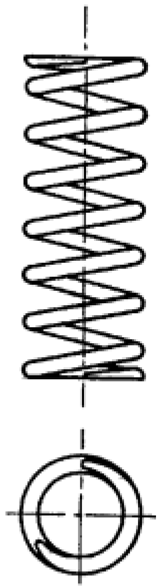

FIG. 2 END CLOSED AND GROUND

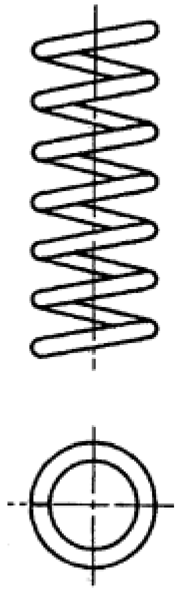

FIG. 3 END OPEN AND UNGROUND

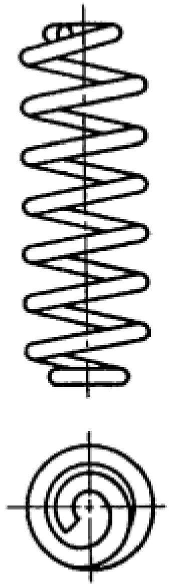

FIG. 4 PITAIL ENDS

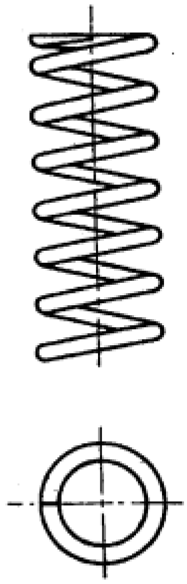

FIG. 5 ONE END FORGED AND GROUND AND ONE END OPEN

6.2 Coiling and Heat Treatment

The bars for coiling should be uniformly heated in an indirectly heated furnace and soaked sufficiently. The heated bars should be immediately coiled and pitched, taking care to ensure that the red hot material remains in contact with air for minimum possible time so as to avoid oxidation. The springs shall be uniformly heat treated for developing the required physical properties of materials and shall have the following final hardness:

Material	*Hardness*
Carbon Steels	360 to 420 HB
Silica-manganese steel	380 to 460 HB
Chrome-alloy	400 to 460 HB

NOTES
1 The hardness should be measured only on inactive coils.
2 The hardness of the spring shall be measured on the outside surface after removal of the decarburized layer.

6.2.1 For springs made from unground bars, the limit for decarburization may be fixed by agreement between the purchaser and the supplier.

6.2.2 Hardness checking shall be done in accordance with IS 1500 (Part 1)/ ISO 6506-1.

6.2.3 For springs made from centreless ground bars, the total depth of decarburization shall not exceed 1 percent of the bar diameter.

6.3 Scragging

Each and every spring should be scragged 3 times in quick succession. The scragging height should be as indicated in the spring drawing/data sheet. In case there is no such indication the springs should be scragged home. The scragging load in such cases should not exceed 1.5 times the theoretical axial load corresponding to the block length.

6.4 End Grinding

Springs having ends as shown in Fig. 1 and Fig. 2. Springs should be ground to ensure square seating of the spring. The ends should not have any sharp edges or burrs. Unless otherwise specified, the tip shall not protrude beyond the outside diameter by more than 20 percent of the bar diameter.

6.5 Shot Peening

For increasing the fatigue life, the springs shall be shot peened. After shot peening, the Almen arc height shall conform to those given in IS 7001 with a minimum arc height of 0.4 mm.

6.6 Surface Protection

The springs may be covered with suitable protective coating, immediately after shot peening to protect against corrosion. The protective coating to be applied/anti-corrosive treatment to be given to the springs, is subject springs, is subject to agreement between the purchaser and the manufacturer, and should be specified in the purchase order/drawing/data sheet.

6.7 Crack Detection

6.7.1 This is not applicable for springs made from rolled bars.

6.7.2 If specified in the purchase order/data sheet/drawing, springs made from ground bars should be subjected to magnetic crack detection, the percentage of springs to be checked and the acceptance criteria should be mutually agreed to between the purchaser and the supplier. This crack detection must be immediately carried out after shot peening.

7 TOLERANCES

For reasons of economy in production, tolerances could be prescribed only for those parameters which are necessitated by the particular application. If closer tolerances than those specified here are required, these shall be agreed to between the manufacturer and the purchaser.

7.1 T**olerances on Bar Diameter, A_d**

7.1.1 Tolerance on bar diameter d, before coiling, ‘both for rolled bars and ground bars shall be according in to IS 3195 or IS 3431 as applicable.

7.1.2 After coiling/heat treatment the tolerance on finished bar diameter for springs made from centreless ground bars, shall be ± 0.5 percent of the bar diameter or k 0.25 mm, whichever is higher.

7.2 Tolerance, A_D on Coil Diameter D, D_e, D_i for Unloaded Springs

Tolerance shall be as given in Table 1. Only one diameter shall be indicated for tolerance in the order or enquiry [*see* also IS 7906 (Part 3)] as follows:

a) D_e, when the spring is working in a guide, and
b) D_i, when the spring is working over a guide (arbor).

The numerical values of the permissible deviations in Table 3 below apply solely to the end turn.

Because the active turns of the spring exhibit wider tolerances than those specified in Table 1 for the end turns, it is recommended, in the case of springs which operate inside a sleeve or over a mandrel, to specify in addition either the minimum diameter of the sleeve and the maximum diameter of the mandrel, respective y, on drawings and in enquiry data sheet purchase order.

NOTE — The tolerance of D, De, Di is applicable where coil diameter is not means for manufacturing compensation.

7.3 Permissible Deviation of Ant, Total Number of Turns

This requirement is applicable in cases where total number of coils is not a means of manufacturing compensation.

NOTE — The tolerance of turns as per agreement between purchaser and/or manufacturer.

7.3.1 The following relationship is applicable to springs made from as rolled bars:

$$A_{nt} = \pm 0.015 n_t$$

7.3.2 The following relationship is applicable to springs made from centreless ground bars:

$$A_{nt} = \pm 0.012\, n_t$$

7.4 Tolerances on Squareness and Parallelism for Springs with Ground Ends Made from as Rolled or Ground Steel Bars

These shall be as given in Table 4.

7.5 Tolerance, A_{LO} on Unloaded Length, L_o of the Spring

In the case of springs with stipulated axial loads and their associated spring height, the length L of the unloaded spring must in principle be regarded only asa guideline value. However, in cases where the length L_O is tolerance, the following formulae apply to the permissible deviation:

a) In case of springs made from as rolled bars:

$$A_{Lo} = \pm 0.015 \left[(L_o + S_c) \frac{2}{n} + 1 \right]$$

b) In case of springs made from ground bars:

$$A_{lo} = \pm 0.012 \left[(L_o + S_c) \frac{2}{n} + 1 \right]$$

In the above cases, only the spring rate R may be specified additionally.

7.6 Tolerance on Spring Rate, A_R

The spring rate shall be tolerance only if it has a decisive influence on functional behaviour of the spring. In such cases, only one additional spring force, F, shall be tolerance in addition to the tolerance on the spring rate, R.

The tolerance shaIl be as follows:

For spring made from as rolled bars

$$A_R = \pm 0.065 \left[\frac{2}{n} + 1 \right] \times R$$

Table 3 Tolerances on Coil Diameter for Unloaded Springs
(*Clause* 7.2)

Sl No.	***De* or *Di***		***ADe* or *ADi***			
			Springs Made of Rods with a Rolled Surface, for a Coiling Ratio, *w*		**Springs Made of Rods with a Machined Surface for a Coiling Ratio, *w***	
	Over	Up to	Up to 8	Over 8	Up to 8	Over 8
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)		50	± 0.8	± 1.2	± 0.6	± 0.8
ii)	50	65	± 1	± 1.5	± 0.7	± 1
iii)	65	80	± 1.2	± 1.8	± 0.8	± 1.2

iv)	80	100	± 1.5	± 2.3	± 1	± 1.5
v)	100	125	± 1.7	± 2.6	± 1.1	± 1.7
vi)	125	160	± 2	± 3	± 1.3	± 2
vii)	160	200	± 2.2	± 3.3	± 1.5	± 2.2
viii)	200	250	± 2.6	± 3.9	± 1.8	± 2.6
ix)	250	300	± 3.1	± 4.6	± 2.1	± 3.1
x)	300	460	± 4	± 5.5	± 2.5	± 4

Table 4 Tolerance on Squareness and Parallelism
(*Clause* **7.4**)

Sl No.	Feature	Springs with Forged or Rolled Flattered Ends	
(1)	(2)	(3)	(4)
i)	Deviation in squareness, e_1	0.03 L_O (corresponds to 1.7 º)	0.01 L_o (0.57 º)
ii)	Deviation in parallelism, e_2	0.025 D_C (corresponds to 1.5 º)	0.015 D_c (0.9 º)

For spring made from ground bars:

$$A_R = \pm 0.045 \left(\frac{2}{n} + 1\right) \times R$$

7.7 Block Length, L_C of Spring (Solid Length)

The length of the completely compressed spring dependent on the type of its ends as given below:

Types of Ends According to Figures	*Block Length*
a) Fig. 1 and Fig. 2	
1) Spring made from as rolled bars	$L_c < (n_t - 0.3)\ d_{Max}$
2) Springs made from ground bars	$L_c < (n_t - 0.4)\ d_{Max}$
b) Fig. 3	$L_c < (n_t + 1)\ d_{Max}$
c) Fig. 4	$L_c < (n_t - 1.15)\ d_{Max}$
d) Fig. 5	$L_c < -1.01\ n_t\ d_{Max} + t$

The actual (existing) total number of turns, rounded to one decimal place after the decimal point must enter in the equation for n_t.

NOTE — The solid height of the spring may not be specified as a rule on the spring drawing. In case the solid height is specially required depending on the spring application only then it is to be specified as a maximum value. In normal case the solid height is not to be checked.

7.8 Permissible Deviation of the Spring Force

The relationship below applies to springs made of rods with a rolled surface:

$$A_f = \pm 0.015 \left[L_o + S_p \left(\frac{2}{n} + 1\right) \times R\right]$$

The following relationship applies to springs made of rods with a machined surface:

$$A_f = \pm 0.012 \left[L_o + S_p \left(\frac{2}{n} + 1\right) \times R\right]$$

In special cases, the tolerance zone of the spring force for springs which operate together in pairs or groups can be sub divided into test groups.

7.9 Minimum Space Between Individual Working Coils Under Maximum Permissible Test Load

The minimum spaces between the individual working coils at L_n is given by $S_a = \frac{L_n - L_c}{n_t + 1}$

7.10 Workmanship

The surface of springs shall be free from injurious defects within normal limitations of hot coiled springs.

7.11 Bow

Bow shall be half the permitted tolerance of the out-of-squareness and the maximum shall occur in the middle one-third of the spring if it's stated on drawing.

7.12 Uniformity of Pitch

The pitch of the coils shall be sufficiently uniform so that -when the spring is compressed to a height representing a deflection of 85 percent of nominal total travel, none of the coils shall be in contact with one another, excluding the inactive end coil.

8 COMPLEMENTARY ADJUSTMENT FOR MANUFACTURING

To enable springs to be held within limits of axial loads, the manufacturer requires complementary adjustments during production. These shall be specified by the following methods:

Prescribed Parameters (1)	*Manufacturer's Discretion for* (2)
One axial load and the corresponding load length are specified	L_O
One axial load with corresponding load length and the spring rate	L_O, d, n
One axial load with corresponding load length and unloaded length	n and d or n and D_e, D_i, D
Two axial loads and corresponding load lengths	L_O, n, d or L_O, n and D_e D_i D
Length of the unloaded spring and the d, n spring rate	d, n

9 SAMPLING

Sampling shall be done in accordance with IS 2500 (Part 1) and IS 2500 (Part 2).

10 TEST

10.1 Static Load Testing

The percentage of springs to be subjected to this test must be specified in purchase order/data sheet.

This testing is carried out on the spring in the normal direction of loading with the spring standing vertically. In each case, before carrying out the static test, the spring shall be compressed three times in quick succession to the block length or to a length corresponding to the maximum permissible static stress value, whichever is more. If then it is scragged further, there shall be no further change in height. It is recommended to gradually approach the prescribed load length and read off the corresponding axiaI load. An instrument error of ~1 percent in the load indication shall be allowed.

10.1.1 Springs which are liable to buckle shall be tested over or in a guide. The method of testing shall be as agreed to between the purchaser and the manufacturer.

10.2 Characteristic Curve

The theoretical characteristic curve force deflection diagram (*see* Fig. 6) of a cylindrical helical compression spring, calculated according to IS 7906 (Part 1), is a straight line. In practice, however, the start and finish of the spring characteristics show a departure from linearity. If it is intended to check the spring rate by finding the characteristic of the spring, this shall be carried out over the range 0.3 to 0.7 F_n so as to cover the linearity with certainty. F_n here corresponds to the minimum permissible test length L_n. The spring rate is given by:

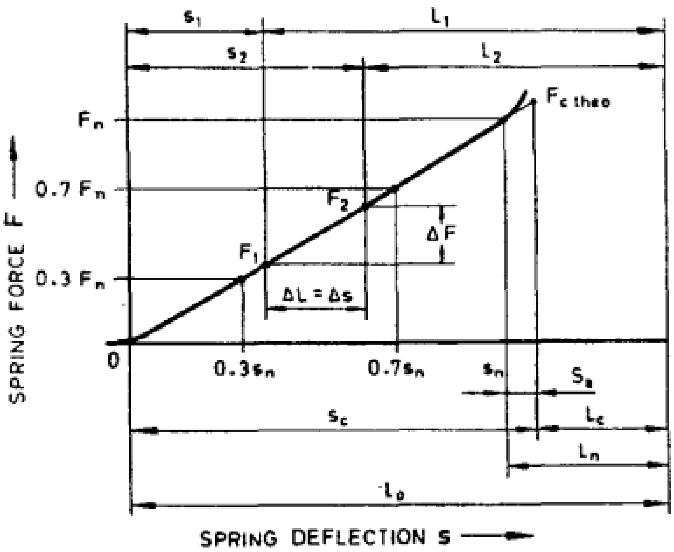

FIG. 6 SPRING CHARACTERISTIC CURVE

where AF is the force increment due to the length reduction or to the deflection increment.

10.3 Test Load for Compressing to Block Length When compressing to block length, & for test purposes, the maximum spring force load to be applied would be 1.5 times the theoretical axial load spring force corresponding to block length, L_c.

10.4 Springs subjected to alternating loads shall be fatigue tested when manufactured from centreless ground bars subject to agreement between the purchaser and the manufacturer.

10.5 Special tests, such as, tests for endurance, cramp and temperature relaxation are subject to agreement between the purchaser and the manufacturer.

11 MARKING

11.1 The following markings shall appear appropriately on the spring:

e) Manufacturer's name or trade-mark; and
b) Year of manufacture.

These markings shall be stamped on springs made with wire diameters of 15 mm and above and shall be so applied that they are not detrimental to the life and the functioning of the springs or as per agreement between manufacturer and purchaser.

11.2 BIS Certification Marking

The product may also be marked with the Standard Mark.

11.2.1 The use of Standard Mark is governed by the provisions of the Bureau of Indian Standards Act, 2016 and the Rules and Regulations made thereunder. The details of conditions under which the licence for use of Standard Mark maybe granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A
(*Foreword*)

COMMITTEE COMPOSITION

Springs and Suspension Systems Sectional Committee, TED 34

Will be added later