1.0 **SCOPE**

1.1 This Technical Delivery Condition specifies the technical and inspection requirements for circular section wire, helical compression springs used in safety/safety relief valves. Primary considerations are for a spring designed to remain under static load with a compression load defined by (seat area X set pressure) for the major portion of its life. Load is intermittently added by virtue of the spring being compressed by the valve travel when the system pressure exceeds the valve set pressure and the valve opens. Approximately 10000 cycles of intermittent valve openings are expected. It is the responsibility of the supplier to design, manufacture, test, certify and supply the springs as per this standard.

2.0 **APPLICABLE STANDARDS**

2.1 **CODE REQUIREMENTS**

ASME CODE Sec-I (Power Boiler Code, Para PG 73.1.2)
ASME CODE Sec-IV (Heating Boiler Code)
ASME CODE Sec-VIII Div-1 & 2 (Unfired Pressure Vessels)
Indian Boiler Regulations : Regulation.Nos.307 to 314.
Dresser Specn MA 16.

2.2 **REFERENCE STANDARDS**

ASTM A-125	:	Heat treated steel Helical springs.
ASTM A-370	:	Mechanical Testing of Steel products.
ASTM E-6	:	Methods of Mechanical Testing.
ASTM E-10	:	Brinnell Hardness of metallic materials.
ASTM E-18	:	Rockwell hardness and Rockwell superficial hardness of metallic materials.
ASTM E-140	:	Standard Hardness conversion charts for Metals.
ASTM B-142	:	Recommended practice for the preparation of high carbon steel for electroplating.
IS: 7906	:	Part I,II,III & IV For Hot and Cold rolled springs.

Even though the reference standards are given the supply condition shall be in line with this TDC.

3.0 **SPRING DRAWING**

3.1 For each type of springs BHEL will provide a spring drawing which will be the basis for spring manufacturer. This drg shall provide details of dimension, material and process.

3.1.1 The steel shall be procured from Well known Steel makers indicated in IBR. If the steel maker is approved as a well known steel maker by IBR, then Mill TC is sufficient. If the steel maker is not approved as a well known steel maker by IBR, then the rounds shall be inspected and Mill Test certificates shall be counter signed by the concerned State CIB (If indigenously procured), or by the Authorised Inspection Agencies (like M/s Lloyds Register of Shipping) approved under IBR (If Imported).

3.1.2 Springs shall be made from steels made by basic oxygen, open-hearth process or electric furnaces. A Test certificate, melt wise, showing the chemical, mechanical properties and heat treatment condition shall be submitted along with the Spring Manufacturers test certificate. The raw material test certificate shall also indicate the mechanical properties of a specimen (tensile, hardness etc.,) from the melt in the final heat treat condition of the spring.

4.0 **DESIGN PARAMETERS**

4.1 Each Spring Design shall be analysed by the spring vendor. Calculations shall be submitted to BHEL for approval, if any change in design parameters.

4.2 **SPRING RATE**

4.2.1 BHEL requires springs that demonstrate a rate as specified in the spring drawing which vary by no more than 5% of the nominal rate specified. This requires that the operating range of the spring be in the linear portion of the spring rate curve (fig 1). For a given carbon steel or low alloy spring, the linear region of the spring is generally defined to be between 15% and 85% of the total average deflection. The spring drawing is developed on the basis of an initial loading of approximately 15% defection, then compressing the spring a given deflection (defined as test deflection) from which the load is measured. All springs shall have a load at test deflection within the limits specified in the spring drawing (See fig 2)

4.3 **SPRING RATE MEASUREMENTS**

4.3.1 Hysteresis as applied to a helical spring can be defined as that characteristic which causes a spring to follow a different load Vs deflection curve during a compression operation than during a relaxation operation. It is important that all load readings for the purposes of determining rate shall be made during a compression operation. If, for example a spring is inadvertently compressed beyond the 85% test load value, it is necessary to remove the load completely to zero (0) and recommence the test in order to obtain accurate results.

4.4 **SPRING RATE CALCULATION**

4.4.1 The Spring rates have been calculated using the following equation:

$$K = \frac{Gd^4}{8\ ND^3}$$

K = Spring rate (kg/mm)
d = Normal wire size (mm)
D = Mean Coil diameter (mm)
N = Active coils.

= Total coils - 2 for wire size < 12.7 mm.
= Total coils - 1.5 for wire size 12.7 mm and more
G = Torsional modulus of material (Kg/sq mm)

4.4.2 Springs shall be tested for spring rate in accordance with the requirements of paragraph 6.10.

4.5 **PERMANENT SET**

4.5.1 It is essential that springs be furnished in accordance with the requirements of the ASME Codes & IBR. The permanent set of the spring (defined as the difference between initial free height and free height measured 10 minutes after the spring has been compressed to its solid height 3 additional times after pre setting at room temperature) shall not exceed 0.5 % of the free height. Compressed solid height is defined in Appendix-A. If required, manufacturer may change the design with the approval of BHEL to meet the conditions.

4.6 **FREE HEIGHT**

4.6.1 The free height is a fixed parameter controlled by assembly physical considerations and subject only to the tolerance consideration as per Clause. 6.5.

4.7 **INSIDE & OUTSIDE DIAMETERS**

4.7.1 Assembly and machined part considerations determine whether the inside or outside diameter of the spring are critical, the spring drawing indicates the limits on the spring diameter within which a vendor can supply springs. suggested bar size is also noted in drawing to assist in checking spring designs. It is suggested that the inside diameter be held if possible, however, a larger inside diameter is permissible. Vendors are cautioned that eccentricities, bowing, and other factors that cause an apparent change in spring dimension must be considered by the vendor in the diameter limits specified on the spring drawing.

4.8 **LOAD LOSS**

4.8.1 Manufacturer shall be responsible for ensuring that spring fabrication, heat treatment, stress relieving etc., are adequate to ensure to proper spring manufacturing at an ambient temperature of 35 Deg.C. Because of load loss characteristic non prestressed springs are preferred.

4.9 **DECARBURISATION**

4.9.1 The bars shall be free from defects so that springs produced shall be free from total decarburisation and the depth of partial decarburisation shall not exceed as follws:
For dia > 10 mm to < 20 mm = 0.08 mm
For dia > 20 mm to < 80 mm = 0.13 mm.

4.9.2 The decarburisation shall be examined at 100 X on a test specimen suitably etched and cut from full cross section of the test spring showing atleast one line inch of original bar circumference.

5.0 **MANUFACTURE**

5.1 Material shall conform to the requirements specified in the spring drawing.

5.2 **HOT COILING.**

5.2.1 Hot coiled springs are generally made from wires of dia 16 mm and above.

5.2.2 Springs shall be made out of machined and suitably finished bars to avoid surface defects and to minimise decarburisation.

5.2.3 The bar heating and subsequent heat treatments shall be done preferably atmosphere controlled furnace, if not available the same shall be done only in electric furnaces. Usage of oilfired furnaces shall be mutually agreed prior to the placement of order.

5.2.4 The depth of partial decarburisation shall not exceed the limits specified in Clause 4.9.

5.2.5 Springs shall be uniformly heat treated for developing the required physical properties specified in spring drawing.

5.2.6 Unless otherwise agreed upon the direction of coiling shall be right hand only.
5.2.7 Pitch correction by wedging after coiling is prohibited. The correct pitches shall be obtained in the coiling process itself.

5.2.8 For transmitting axial loads on the connecting bodies the spring end shall be formed by grinding to provide smooth flat bearing surface of a minimum of 3/4 of the circumference as per fig.4.

5.2.9 The tip thickness `t' in fig.3, shall be between d/3 and d/4 approximately, where d is the diameter of wire.

5.2.10 The tips shall not protrude outside or inside of the spring. Such projections shall be ground smoothly to match the spring outside or inside diameter as the case may be. This is shown in fig.4.

5.2.11 The end coils shall have smooth consistent taper to minimise spring out of squareness under load. Common type of unacceptable and acceptable are shown in fig.5.

5.3 **COLD COILED SPRINGS**

5.3.1 All wire diameters below 16 mm shall be manufactured by cold or hot coiling process.

5.3.2 All requirements specified through cl.5.2.6 to 5.2.11 are applicable for cold coiled springs also.

6.0 **INSPECTION**

6.1 All springs shall be 100% tested for conformance as per this specification.

6.2 **SURFACE FINISH INSPECTION**

6.2.1 A visual inspection shall ensure that no projections on the inside or outside diameters exist that will exceed the nominal inner or outer spring diameters respectively. Manufacturers are responsible for ensuring that no laps, seams, folds, scaling or other defects which may act as stress risers or masked defects are present in any spring. Stress raisers are subject to evaluation by BHEL, however gas holes, pitting, or large sections where nominal spring wire diameter is reduced by more than (1.5 %) are considered unacceptable. The 1.5 % limitation also applies to surface ground flat for hardness readings.

6.3 **INSIDE - OUTSIDE DIAMETER INSPECTION**

6.3.1 Inside - Outside diameters shall be checked as per the spring drawing. For all springs the following tolerances apply to the diameters specified on spring drawing.

In side diameter	Tolerance
25mm and smaller	+ 0.8 mm - 0
over 25mm to 50mm inclusive	+ 1.6 mm - 0
over 50mm to 100mm inclusive	+ 2.4 mm - 0
over 100mm	+ 3.2 mm - 0

6.3.2 The suggested wire diameters are indicated in the spring drawing.

6.4 **END COIL INSPECTION**

6.4.1 End coils should be wound closed against the adjacent full pitch coils. Deviation from this closure shall not exceed the following (Ref. Fig.3.)

Wire Size	Max. opening
Less than 11.1mm	0.8 mm
Over 11.1 - 31.8	1.6
Over 31.8 - 44.5	3.2
Over 44.5 - 57.2	4.0
Over 57.2	4.8

6.4.2 Maximum Tip thickness shall be in accordance with cl. 5.2.9 (Ref. Fig.3)

6.4.3 The end coils shall be in accordance with Cl.5.2.8 & Cl.5.2.11.

6.5 **FREE HEIGHT INSPECTION**

6.5.1 The free height is determined by placing a straight edge across the top of the spring and measuring the perpendicular distance from the plate on which the spring stands to the bottom of the straightedge at the approximate centre of the spring. tolerances are shown below:-

Nominal free height	Tolerance
75mm and smaller	plus/minus 0.8mm
over 75mm to 165mm inclusive	plus/minus 1.6mm
over 165mm to 254mm incl.	plus/minus 2.4mm
Over 254mm to 356mm incl.	plus/minus 3.2mm
Over 356mm to 559mm incl.	plus/minus 4.8mm

6.5.1.1 Springs which "Rock" in their free standing position are considered acceptable under the following conditions:-

(a) A reasonable determination of free height of the centre line can be made, and variation in free height is within the tolerances specified above. A spring out of square by more than 2 Deg as measured in Cl.6.8 is considered unacceptable (This applies for springs larger than 12mm diameter wire).

(b) Check wire diameter of Spring ends are within the limits specified in fig.6.

6.6 **SQUARENESS AND CONCENTRICITY FOR SPRINGS LARGER THAN 14MM WIRE SIZE.**

6.6.1 A centrally located ball and washer mechanism, as shown in fig.7 shall be used for testing. The end plates shall be centrally fixed and not movable during test. When under final load, the ends of the spring shall sit squarely on the test plates with the ground surface in full contact with the test plates.

6.6.2 Deflect spring to 85% of the total deflection three times prior to taking tilt measurement.

6.6.3 The total included angle of the tilted washers at final load shall not be more than 3 deg. Angular tilt at one end of the spring shall not exceed 1 - 1/2 Deg.

6.6.4 The effects of bowing, eccentricites etc., shall be limited to the tolerances specified in Clause 6.3.

6.6.5 Tilt measurement shall be taken when the spring is loaded to 85 % of total deflection as in spring drg.

6.6.6 Following the three deflection tests, the free height shall be measured. The spring shall be within tolerances as specified in Clause.6.5.1. Furthermore, loss in its free height shall not exceed 0.5% of the original measurement.

6.7 **SQUARENESS AND CONCENTRICITY FOR SPRINGS 14MM AND LESS WIRE SIZE**

6.7.1 Springs shall be checked in accordance with Fig.8. "Y" values when measured with a scale not to exceed Tan 1.5 deg. x spring length.

6.7.2 To accurately determine the spring end coil concentricity the actual inside diameter of either end coil must be measured. The smaller end should be placed against the surface plate. The difference between either inside diameter must be divided by 2 and this amount subracted out of measured "Y" value.

(i.e) Condn

$$\left\{Y-\frac{(ID1-ID2)}{2}\right\} < (\text{Tan } 1.5 \text{ Deg}) \times FL$$

6.8 **SPRING RATE VERIFICATION**

6.8.1 Springs shall be checked to verify spring rate between initial load and final load values specified. The spring drawing indicates load and deflection values required. Springs larger than 14mm wire will be checked with washers and bearing in accordance with Fig.7. Other springs may be checked between flat end plates. The testing procedure shall be as follows:

(a) Spring shall be installed and tested with the stamped code facing the tester and at the upper side of the spring. This is to ensure consistency in testing.

(b) Apply initial load specified in spring drawing, set deflection recorder to zero.

(c) Apply test deflection specified in spring drawing, observe the load at test deflection.This load should be within the limits specified in spring drawing.

6.9 **NON DESTRUCTIVE EXAMINATION**

6.9.1 Unless and otherwise specified each Carbon & Low alloy Springs with wire size 25mm and larger and Tungsten springs with a wire size of 19mm and larger shall be magnetic particle inspected at manufacturers works. Acceptance shall be as per standard.BHE:NDT:PB:MT 5. Non ferromagnetic springs shall be tested using PT the vendor shall submit his PT procedure along with the acceptance standards to BHEL for approval.

6.9.2 All Non Destructive examination shall be done prior to Spring Testing.

7.0 **SURFACE TREATMENT**

7.1 All springs sand/shot blasted before magnetic particle inspection. This blasting procedure to be approved.

7.2 Unless specified otherwise, carbon steel and low alloy steel springs shall be furnished by the manufacturer in the phospated condition.

7.3 Springs will be given special coating when specified in spring specification sheet as per cl.7.4.

7.4 **PLATING**

7.4.1 **CADMIUM PLATING**

7.4.1.1 Springs shall be plated to a minimum thickness of 0.012mm.

7.4.1.2 Immediately after plating, spring shall be baked in a heat treating furnace to prevent possibility of hydrogen embrittlement. Baking shall consist of

(1) Three hours at 150 Deg.C.or
(2) One hour at 200 Deg.C.

7.4.1.3 After baking Chromate convertion coating shall be given by dipping in Chromate acid.

8.0 **IDENTIFICATION**

8.1 All springs of wire size 5mm and below shall be tagged individually to show the details of spring no.and supplier code , serial no and specification and heat No of actual material.

8.2 All springs of wire size above 5mm and below 12mm should be vibro etched to indicate the spring no. serial no., supplier code and specification and heat No of actual material.

8.2.1 The Purchase order no. should be tagged on individual spring.

8.3 All springs of wire sizes more than 12mm should be punched the following details on the outside diameter of an inactive coil along with the material specification and actual heat No of material.

XXXXXXX-	XX	XX	XXX
Spring No.given in drg	Matl** Code	Manufac-turer's symbol.	Running sl.no.for each type of spring

**
Material Specification to be used are as follow:

CODE	REFERENCE TABLE
CR	TABLE 1
E	TABLE 2
SY	TABLE 3
MO,KM	TABLE 4
NC,PH,C7,I,IX, IXS,I6X,MP	TABLE 5

9.0 **RECORDS**

9.1 The following records shall be furnished with all springs. Typical test record is indicated in Annexure II .

(1) Spring Test Certificate approved by Chief Inspector of Boilers of the respective State or by approved inspection agencies listed in IBR.

(2) Spring Material Test certificate (Mill TC)

(3) Coiling and heat treatment temperature,soaking time, cooling media.

(4) Dimensional report.

(5) Test report-scragging test and spring rate.

(6) Hardness

(7) Compliance certificate to IBR

****

TABLE 1
MATERIAL :ALLOY STEEL
Reference Specification ASTM A689 CARBON AND ALLOY STEEL
BARS FOR SPRINGS

MATERIAL SPECN.	TYPE OF COILING	TORSION MODULUS @70 deg. F $x10^{6}$ PSI	HARD NESS Rc	TENSILE STRENGTH PSI	SPRING MARKING
ASTM A231 ASTM A232	COLD	11.5	---	---	CR
ASTM A322 GRADE 6150 TDC 4: PREFERRED ASTM A304 GRADES 4161H 5160H 51B60H 6150H 9260H	HOT	10.5	50	210,000	CR

TABLE 2
MATERIAL : TUNGSTEN ALLOY STEEL

MATERIAL SPECN.	TYPE OF COILING	TORSION MODULUS @70 deg.F x10^6 PSI	HARD NESS Rc	TENSILE STRENGTH PSI	SPRING MARKING
ASTM A681 TYPE H-12	COLD OR HOT	11.0	44 TO 48	210000	E

TABLE 3
MATERIAL : STAINLESS STEEL

MATERIAL SPECN.	TYPE OF COILING	TORSION MODULUS @70 deg. F x10^6 PSI	HARD NESS Rc	TENSILE STRENGTH PSI	SPRING MARKING
ASTM A313 TYPE 316	COLD	10.0	---	SPEC	SY
ASTM A276 TYPE 316	COLD ST HARD	9.8	---		

TABLE 4
MATERIAL : NON FERROUS

MATERIAL SPECN.	TYPE OF COILING	TORSION MODULUS @70 deg.F x10^6 PSI	HARD NESS Rc	TENSILE STRENGTH PSI	SPRING MARKING
ASTM B164 CLASS A (MONEL 400 FULL HARD, SPRING TEM-PER)	COLD	9.2	23 TO 26	120,000	MO
MONEL K-500 (AMS 4676)	COLD	9.2	34 TO 38	160,000	KM

TABLE 5
MATERIAL : HIGH TEMPERATURE

MATERIAL SPECN.	TYPE OF COILING	TORSION MODULUS	HARD NESS	TENSILE STRENGTH	SPRING MARKING
		@70 deg.F x10^6 PSI	Rc	PSI	
ASTM A564 TYPE 631 17-7PH CONDN C	COLD	11.0	42 TO 46	210,000	NC
ASTM A 564 TYPE 630 17-4 PH	HOT	10.5	40 TO 44	180,000	PH
ASTM A638 GRADE 660	COLD	10.5	40 TO 44	180,000	C7
	HOT	10.75	34 TO 38	160,000	C7
ASTM B166 (INCONEL 600 AND 601)	COLD ST HARD	11.0	34 TO 38	160,000	I
ASTM B637 GRADE 688 OR AMS 5699 HEAT TREATED TO AMS 5699D PARA 1.2.1	COLD	11.5	40 TO 44	190,000	IX
ASTM B637 GRADE 688 OR AMS 5699 HEAT TREATED TO AMS 5699D PARA 1.2.2	COLD	11.5	36 TO 40	170,000	IXS
ASTM B446 GRADE 625 INCONEL 625 ROD & BARS (UNS NO6 625)	COLD OR HOT	11.5	88Rb	120,000	I6X
AMS 5844 (MP35N UNS R30035)	COLD	11.5	44 TO 55	260,000	MP

ANNEXURE 1

DEFINITIONS

TOTAL DEFLECTION:- - The amount of deflection achieved when the Spring is compressed to its solid height.

COMPRESSED SOLID HEIGHT:- The perpendicular distance between the plates of the testing machine when the spring is compressed with a test load sufficient to bring all coils into contact.

SOLID CAPACITY: - Calculated from:

$$P = \frac{Gd\ F^4}{8\ ND^3}$$

Where,
G = Effective torsional modulus of elasticity (Kg/sq.mm)

d = Nominal bar diameter (mm)
D = Mean Coil or helix diameter (mm)
N = Active turns.
P = Solid capacity.(kgf)

UNCORRECTED SOLID STRESS - calculated from:

$S = 8\ PD / 3.1416\ d^3$

FINAL DEFLECTION: - A distance specified on the SD sheet for a particular spring which reflects a percentage of the average deflection. The value is used for rate measuring purpose only, within the linear region.

LINEAR REGION:- The part of the load /deflection curve of a particular spring in which deflection increases linearly with increased load. For this purposes of this specification of this range is defined as between 15% and 80% of nominal solid deflection for carbon and low alloy springs.

FREE HEIGHT: - The perpendicular height of the spring measured along the centerline after all external loads have been removed.

PERMANENT SET:- The difference between the free heights measured before and after the spring has been compressed to its solid height and released, 3 times.

ANNEXURE II

TEST CERTIFICATE FOR SAFETY VALVE /SAFETY RELIEF VALVE SPRINGS

Inspection Report No:
Date:

1 Name of Manufacturer:
2 PO Number and Date :
3 Order Quantity :
4 Drawing No/Spring No:
5 Type of Spring :
6 Serial No of Spring :
7 Coiling Practice :
8 Direction of Coiling:
9 Spring record:

Sl. No	Description	As reqd	Actual	Remarks
9.1	Serial number of Spring			
9.2	Material Spec			
9.3	Melt no			
9.4	Raw Matl TC No			
9.5	Wire dia			
9.6	Outside dia			
9.7	Inside dia			
9.8	Mean dia			
9.9	No of Active turns			
9.10	Total no of turns			
9.11	Free Length			
9.12	Ends Ground/ unground			
9.13	Ends open/closed			
9.14	End Thickness			
9.15	Solid Height			
9.16	Squareness			
9.17	Spring Rate			
9.18	Initial Load			
9.19	Final Load			
9.20	Permanent set			
9.21	MPI Results			
9.21.1	MPI Report No			

to be submitted

9.22 Surface Coating

9.23 Others Pl Specify

9.24 Note to be added to signify compliance to IBR

Inspected by

NOTE: THE ABOVE CERTIFICATE SHALL BE APPROVED BY CHIEF INSPECTOR OF BOILERS IN THE STATE OF MANUFACTURE

Figure – 1

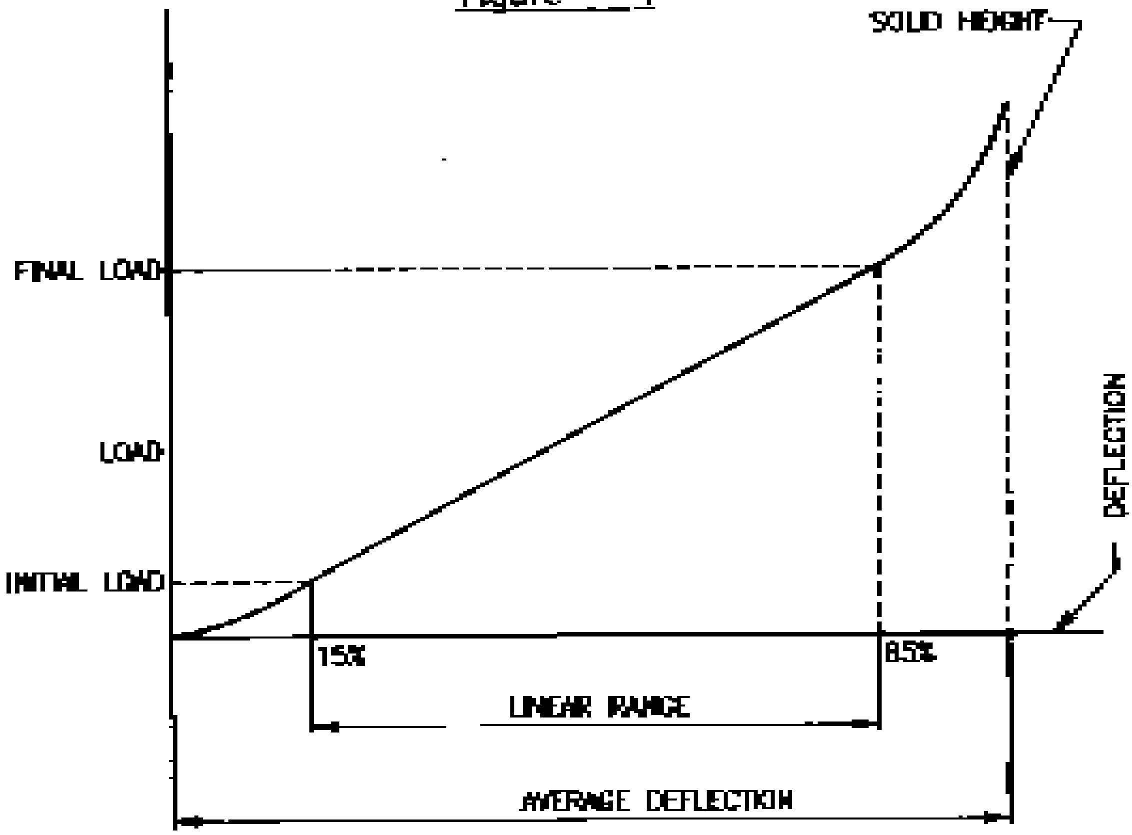


Figure – 2

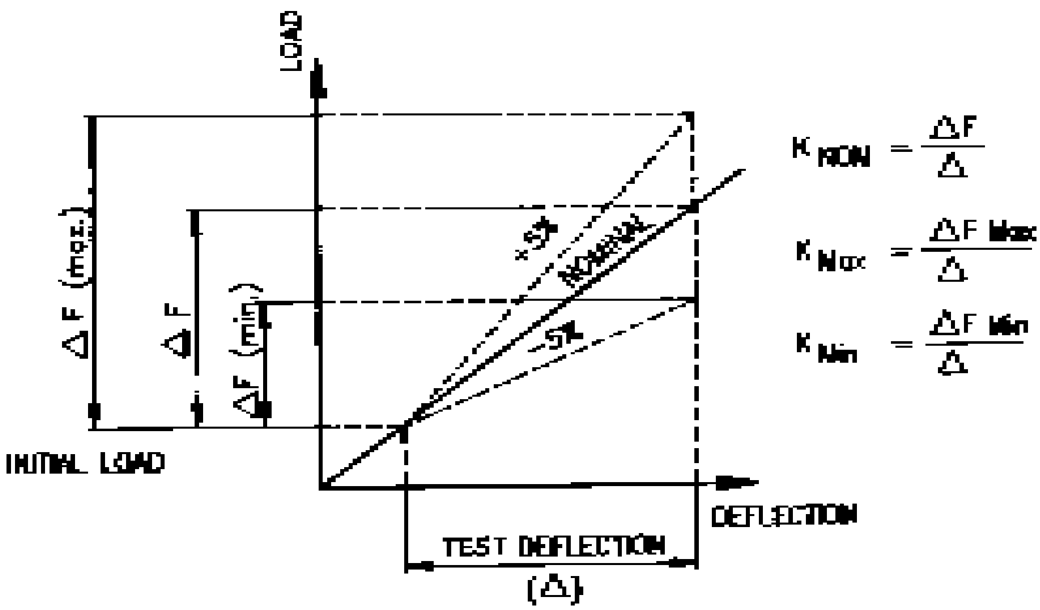
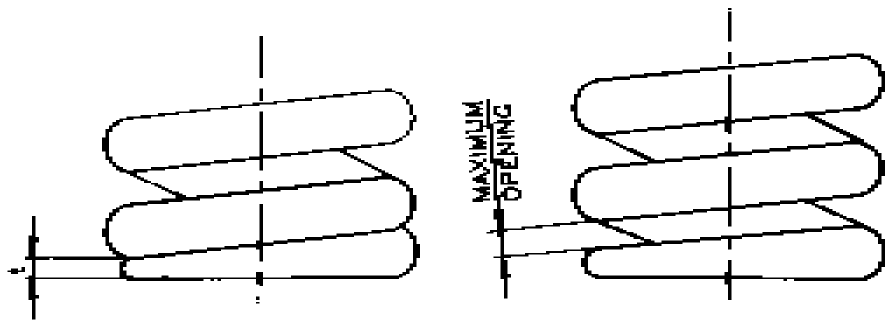


Figure – 3

SIDE VIEW OF SPRING



IDEAL ALLOWABLE

Figure – 4

END VIEW OF SPRING

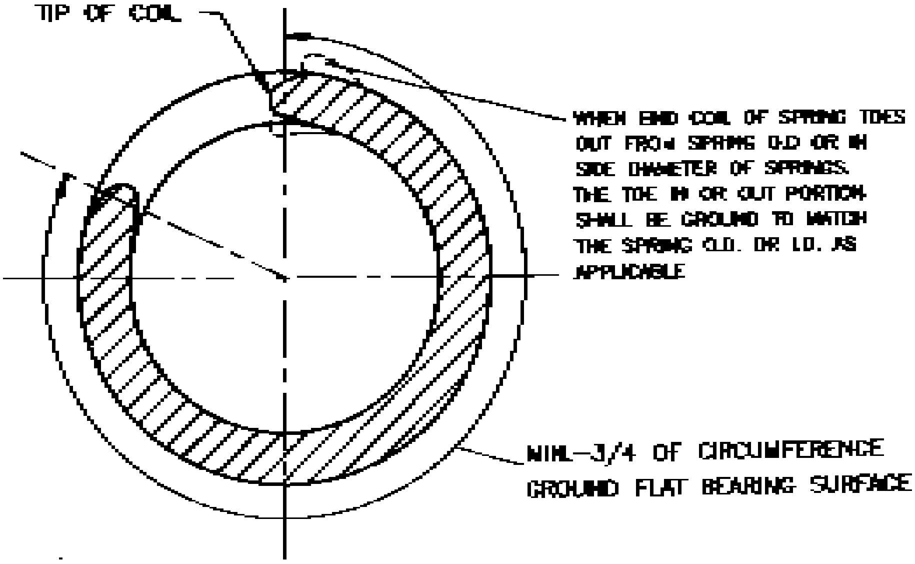


Figure – 5

SIDE VIEW OF SPRING

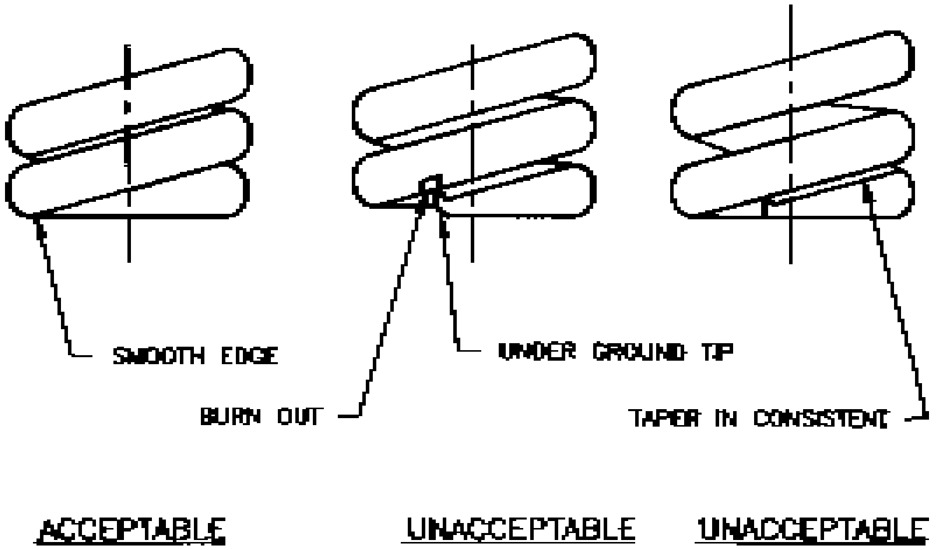


Figure – 6

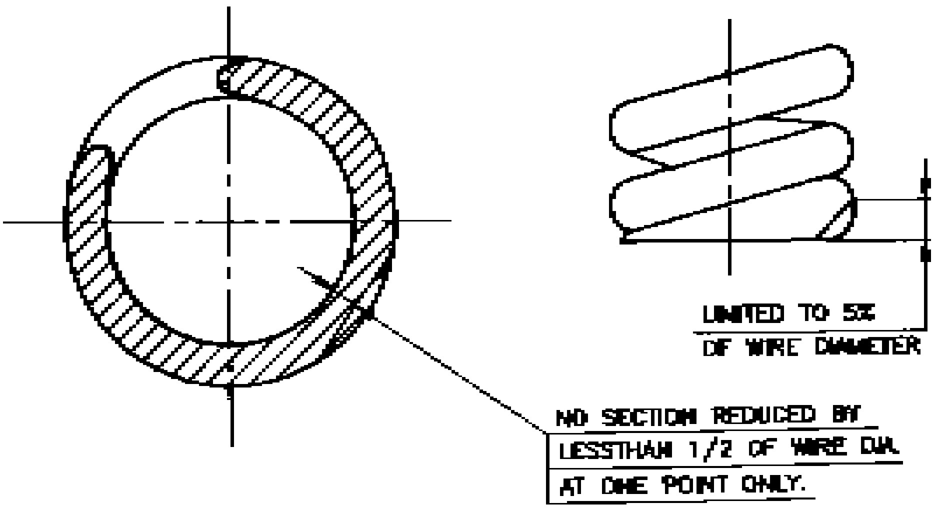
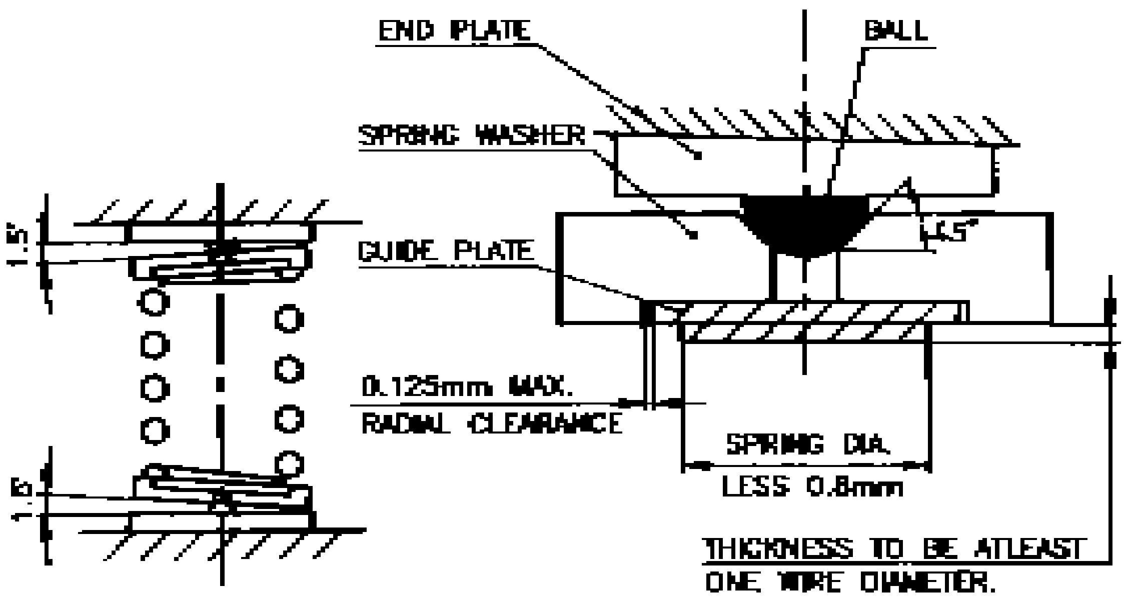


Figure – 7

FOR WIRD DIAMETER ABOVE 14MM



SQUARENESS CHECK
for WIRE DIA. 14mm
and ABOVE

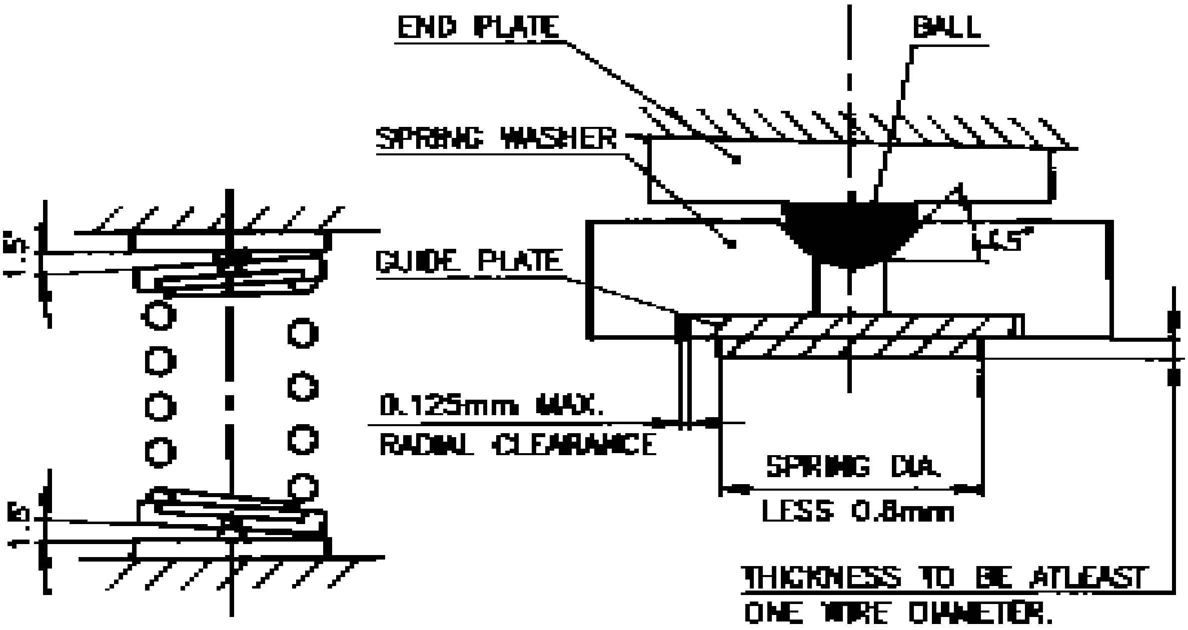
TYPICAL UPPER AND LOWER
ENDS OF SPRING TEST
WASHERS

NOTES:

1. ENDS PLATES TO BE CENTRALLY FIXED AND NOT MOVABLE DURING TEST.
2. SPRING WASHER AND BALL SIZES DEPEND ON LOADS BEING TESTED. SURFACES SHOULD BE ANTI-GALLING AND HAVE [illegible] FINISH. LUBRICATE WITH MOLY-KOTE. IT IS SUGGESTED THIS BEARING SURFACES BE HARDENED.

Figure – 7

FOR WIRD DIAMETER ABOVE 14MM



SQUARENESS CHECK
for WIRE DIA. 14mm
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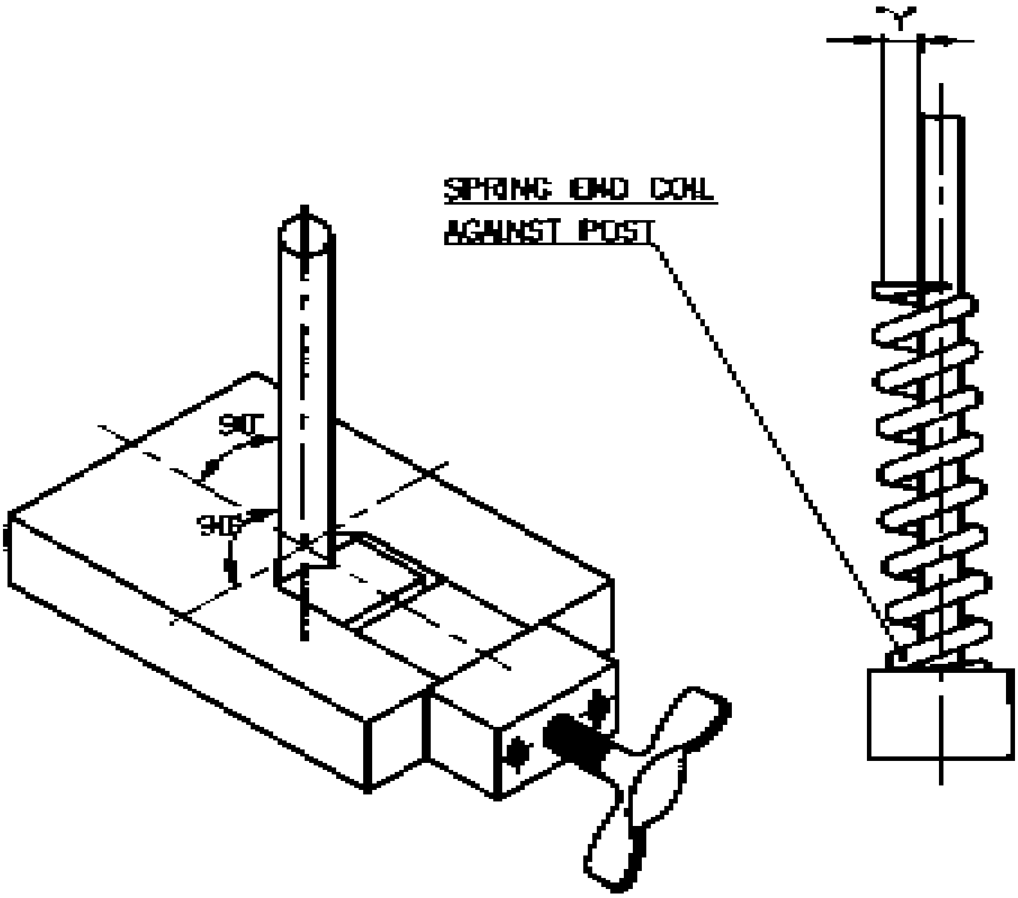
Figure – 8



APPARATUS SET UP

CHECKING CONCENTRICITY AND SQUARENESS OF ENDCOILS

(WIRE DIA 14mm AND BELOW)

NOTES:

1. "Y" VALUES WHEN MEASURED WITH A SCALE SHALL NOT EXCEED TAN 1.5° MULTIPLIED BY SPRING LENGTH.
2. TO ACCURATELY DETERMINE SPRING END COIL CONCENTRICITY THE ACTUAL INSIDE DIAMETER OF EITHER END COIL MUST BE MEASURED. THE SMALLER END SHOULD BE PLACED AGAINST THE SURFACE PLATE.
3. THE DIFFERENCE BETWEEN EITHER INSIDE DIAMETER MUST BE DIVIDED BY 2 AND THIS AMOUNT SUBTRACTED OUT OF MEASURED "Y" VALUE.

Record of Revisions:

REV NO.	CLAUSE NO.	DETAILS OF REVISIONS
01	---	Editorial correction
02	7.4.1.3	Introduced
	Fig. 1	Charted average deflection changed as average deflection
	Fig. 2	Final deflection changed as Test deflection
03	3.1.2	Heat treatment condition added
	5.3.1	Wire dia. Increased from 10 to 16 mm for cold Coiling based on IBR amendment
	9.1	Point No.7 added. Point No.3 and 5 clarity brought
		In Annexure II point no 9.24 added

K.Ganesan	K.Nagarajan	M.Shanmugam	K.Rengachari	Amit Roy	C.Mani
Qual. Assurance	Engg/Valves	Purchase/Valves	Quality Control	Quality assurance	Quality Assurance
Prepared by			**Reviewed by**		**Approved by**