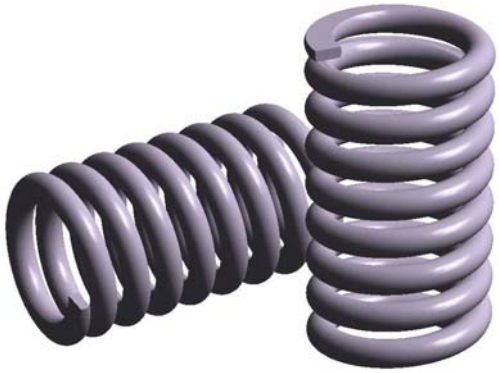
भारत सरकार, रेल मन्त्रालय

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

TECHNICAL SPECIFICATION OF HOT COILED HELICAL SPRINGS USED IN LOCOMOTIVES



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अनुसंधान अभिकल्प और मानक संगठन
लखनऊ–226 011
RESEARCH DESIGNS & STANDARDS ORGANISATION
LUCKNOW - 226 011

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TECHNICAL SPECIFICATION OF HOT COILED HELICAL SPRINGS USED IN LOCOMOTIVES

1.0 SCOPE

1.1 This specification is intended to cover requirements of heavy-duty steel springs, which call for stricter control in raw material quality, manufacturing infrastructure & processes and Testing/ Inspection standards to improve their reliability and life.

1.2 This Specification is applicable for high performance hot-coiled helical compression springs used in the suspension system of Diesel & Electric Locomotives on Indian Railways included in Annexure I of this document. It covers springs, which are to be manufactured from circular section bars.

1.3 This specification also stipulates the minimum requirements of infrastructure, manufacturing, testing and quality control for RDSO approval for supply of helical coil springs of locomotives.

2.0 DEFINITIONS

- Wherever “Inspecting Official” has been mentioned in this document, it shall be taken as “Authorised Representative of RDSO” as mentioned in the Purchase Order.
- The “Hot Coiled Helical Compression Steel Springs used in the suspension system of Diesel & Electric Locomotives” shall henceforth be referred as “springs” in this specification.
- Other terms and their definitions used in this specification are:
  - “STR” means “Schedule of Technical Requirements”.
  - “QAP” means “Quality Assurance Plan”.
  - “Manufacturer” means the “manufacturer of springs”.
  - “Purchase Order” means “Purchase Order for springs”.

3.0 INSTRUCTIONS FOR PURCHASER

3.1 The tenderer shall be an RDSO Approved Vendor for supply of hot-coiled helical compression springs for locomotives.

3.2 Inspection of helical coil springs shall be carried out by RDSO. The Purchaser shall clearly indicate this in the Purchase Order.

3.3 The material, manufacturing and testing of helical coil springs shall conform to this specification. The Purchaser shall clearly indicate this in the Purchase Order.

4.0 REFERENCE DOCUMENTS AND STANDARDS

4.1 This specification covers manufacture and supply of locomotive springs to be supplied to Railways.

The manufacturers should comply infrastructure & manufacturing, testing and quality control requirements for these springs.

4.2 Procurement of spring steel rounds shall be done only from reputed spring steel manufacturers approved by RDSO. The inspection of spring steel rounds shall be carried out by RDSO to ensure their proper & prescribed quality and to avoid non-conformance / failure of final product (i.e. springs) during inspection/ service. Only spring steel rounds duly inspected and passed by RDSO shall be used for manufacture of springs.

4.3 The following ASTM / IS / UIC Specifications have been referred in this document:

S. No.	Specification		Details
i	ASTM E-112		Test Methods for Determining Average Grain Size
ii	ASTM E-381		Method of Macroetch Testing of Steel Bars, Billets, Blooms and Forgings
iii	IS: 228 (Part 1 to 24)		Methods of Chemical Analysis of the Steels
iv	IS: 1500		Method for Brinell Hardness Test for Metallic Materials
v	IS: 2074		Ready Mixed Paint, Air Drying, Red Oxide Zinc Chrome Priming – Specification
vi	IS: 2932		Enamel, Synthetic, Exterior: a) Undercoating (b) Finishing – Specification
vii	IS: 3073		Assessment of Surface Roughness
viii	IS: 3195		Steel for the manufacture of Volute and Helical Springs (for Railway Rolling Stock)
ix	IS: 3618		Specification for Phosphate Treatment of Iron and Steel for Protection against Corrosion
x	IS: 3703		Recommended practice for Magnetic Particle Flaw Detection
xi	IS: 3848		Method for End Quench Test for Hardenability of Steel
xii	IS: 4163		Method for determination of Inclusion Content in Steel by Macroscopic Method
xiii	IS: 6396		Methods of measuring Decarburised Depth of Steel
xiv	IS: 7001		Shot Peening of Steel Parts - Specification
xv	IS: 7739 Part 5		Code of practice for preparation of Metallographic Specimens - For Iron & Steel and their Examination
xvi	IS: 7906	Part 5	Specification for hot-coiled springs made from circular section bars
		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
xvii	IS: 13871		Powder Coating Specification
xviii	UIC-822		Technical Specification for the Supply of Helical Compression Springs, hot coiled, for Tractive and Trailing Stock

4.4 The reference to the ASTM / IS / UIC Specifications quoted herein shall be taken as the reference to the latest version of these Specifications, which shall be available with the firm.

4.5 Specific provisions in this Specification will override those in the above ASTM / IS / UIC Specifications where these are not in conformity with one another.

4.6 Any special requirements given in the relevant drawings will override this specification.

5.0 MINIMUM INFRASTRUCTURE, MANUFACTURING, TESTING & QUALITY CONTROL REQUIREMENTS FOR THE FIRM FOR RDSO APPROVAL

5.1 General Infrastructure

.1 The firm shall have acquired ISO: 9000 series certification and the scope of the certification shall cover manufacturing of Hot Coiled Helical Compression Steel Springs for locomotives.

.2 The manufacturer shall have adequate space for storage of raw materials i.e. spring steel rounds / bars and covered area with cemented floor to accommodate the following:

a. Manufacturing facilities
b. Inspection and testing
c. Painting
d. Storage and dispatch of finished springs

5.2 Manufacturing Facilities

The following manufacturing facilities shall be available with the firm:

.1 Two Bar Straightening Machines equipped with rollers and capable of straightening the bars to the accuracy of 1mm per metre having automatic arrangement for handling of bars.

.2 Two sets of Gauges for measuring straightness of bars.

.3 Two Bar Peeling Machines equipped with cutter head, rod clamping and unclamping device capable of removing minimum 2.5mm material on diameter in a single pass.

.4 Two Centreless Grinding Machines for grinding of bars capable of removing minimum 0.25mm material on diameter in a single pass with surface finish of minimum 5 µRa.

.5 One Surface Tester and two sets of Surface Finish Comparators for checking of surface finish of the ground bars.

.6 An overhead crane / fork lifter and suitably designed lifting tackles for transportation of ground bars to avoid any probability of formation of dents / pitting marks on ground bars. If handling of bars is done manually, it should be ensured that no dents / pitting marks occur on these bars.

.7 One Magnetic Particle Testing Machine for Crack Detection of bars in accordance with Appendix 'B' of Specification UIC-822, for detection of both longitudinal as well as transverse cracks / seams by wet method capable of accommodating bars upto 6 metre in length and detecting open seams as well as sub surface defects upto 1mm from the surface. The machine should have suitable device for rotation of bars in position to facilitate testing of entire surface of the bar in single setting.

.8 One End Heating Furnace of indirect heating type having Conveyors to transport the bars ensuring *first–in-first-out* system equipped with temperature indicators and controller with recording type pyrometer.

.9 One Taper Rolling Machine equipped with dies of suitable size having adjustable feature to produce required taper on ends. The machine shall have provision for stamping of the required particulars on the tapered ends of the bar.

.10 One Walking Beam Indirect Type Heating Furnace equipped with hydraulic adjustable walking beam. There should be no flame impeachment of bars in the furnace. The furnace should be equipped with temperature indicator, automatic temperature controller and recorder with adequate number of thermostats. The rods should enter from one side and come out from another side following first-in-first-out principle. Gradual heating & soaking time should be defined. The temperature inside the furnace should be such that decarburisation on any rod during heating remains well within the specified limits.

.11 High Speed Coiling and Pitching Machine with inbuilt end closing feature equipped with replaceable lead screws and mandrels to suit different type of spring designs as per this specification.

However, such non-CNC coiling and pitching machines shall be considered acceptable only till 30th April 2009. After which, availability of a fully automatic computer controlled CNC machine shall become mandatory. This CNC coiling and pitching machine shall have facilities for coiling and producing constant pitch according to spring design with inbuilt end closing feature, three axis control feature viz. the linear axis, the helix angle of the guiding roller & the vertical axis to follow the diameter of the mandrel to provide the accurate control of pitches and bar positioning.

.12 A Quenching Tank of adequate capacity equipped with temperature indicator and provision of strainer / filters, agitation pumps, heat exchangers and cooling towers etc to prevent oil temperature going beyond 80^{0}C at any time.

The quenching tank should be located adjacent to the coiling machine so that the movement of springs after coiling to the quenching tank is minimum. The quenching tank with ample volume of oil having a conveyor system with variable speed settings should be provided so that the springs once taken out from the coiling machine are placed directly in the tank and then conveyed immediately through the conveyor to the tempering furnace.

.13 One Indirect Convective Heating Continuous Type Tempering Furnace equipped with variable speed conveyor, temperature controllers, recorders and indicators. There should be no flame impeachment on the springs. The tempering furnace should be in line with quenching tank conveyor. The furnace should have multiple thermocouples to facilitate measurement of temperature in the furnace at different locations.

.14 A Continuous Type Shot Peening Machine equipped with automatic spring transportation system and rotation during shot peening to achieve required Almen intensity.

.15 Two End Grinding Machines equipped with adequate coolant facility, controlled speed, feed rate etc to prevent burning of end coils during grinding.

.16 Two Magnetic Particle Testing Machines with adjustable current to cater the requirements for different diameter of springs having a provision for detection of cracks in longitudinal as well as in transverse directions. Provision for automatic loading / unloading of springs shall be preferred. The test facility shall have a suitable automatic device for rotation of the spring in position to facilitate testing of entire surface of the spring in one setting. The facility shall also have provision for demagnetization of springs after crack detection.

.17 Two Scragging Machines capable of scragging the springs in quick succession. The capacity of the machine should be sufficient to scrag the springs to solid height and should be capable of applying the load for long duration of 48 hours as described in UIC–822.

.18 A Paint Booth for painting of springs with a suitable system for drying of the paint. The handling of springs during painting and after painting should be such that the dirt and dust does not get embedded with the paint.

.19 Adequate setup for powder coating of springs to suit the powder coating requirements as per the stipulations in relevant RDSO drawing, if any.

.20 Adequate number of pallets for storing / handling of springs at various intermediate stages of manufacturing. The springs shall be transported using pallets type trolleys.

5.3 INSPECTION & TESTING FACILITIES

The firm shall have atleast the following inspection & testing facilities:

.1 A chemical laboratory to conduct Wet Analysis of all types of alloy steels required as per this specification.

However, Emission Spectrometer along with printer for analysis and recording of chemical composition of spring steel rounds / bars and finished springs should be installed.

.2 The facilities for preparation of Metallographic specimen as per IS:7739 .

.3 One Metallographic Microscope with minimum magnification of 100x and photographic attachment to meet requirements of IS: 4163 and IS: 6396.

.4 Two Brinell Hardness Testers, one in the laboratory and other in the shop floor.

.5 Three Eye pieces / low power microscopes.

.6 One load-deflection testing machine of minimum 20t capacity with a least-count of 5 kg and accuracy of $\pm$1% on load measurement which is calibrated against standard proving ring. Apart from facility to measure the deflection of the springs using digital meter, the machine should also have an inbuilt arrangement for drawing the load-deflection characteristics graphs for the springs.

.7 Facilities of checking of Paint quality as per IS: 2074 & IS: 2932:

Adequate setup for checking the powder coating of springs to suit the powder coating requirements as per the stipulations in relevant RDSO drawing including Elcometer for measuring Dry Film Thickness (DFT) should be available.

The facility should be periodically checked at monthly intervals for Gun characteristics, DFT and paint quality to suit the requirements.

.8 Fatigue Testing machine for carrying out the fatigue testing of springs as per the relevant test scheme.

.9 A surface table of size at least 2m x 3m and one set of gauges (Vernier Caliper, Micrometer, Scale, Square, Feeler Gauges, etc) duly calibrated for purchase inspection.

.10 At least three sets of gauges for checking of the following parameters of springs:

- Steel Bar Diameter (peeled & ground bar)
- Outer Diameter of Spring
- Inner Diameter of Spring
- Free Height
- End Taper
- Out-of-squareness
- Parallelism

Two sets of gauges shall be available in the Shop for carrying out necessary checks at various stages during manufacturing and one set of gauges shall be available in the Inspection Section for carrying out checks on finished springs by the internal inspecting officials & Authorized Inspecting Agency.

5.4 QUALITY CONTROL REQUIREMENTS

The Quality Control Systems given below shall exist and strictly followed:

.1 Measurement of straightness, surface finish and dimensions of the peeled & ground bars and maintenance of their records.

.2 Measurement and recording of as-quenched hardness of the springs.

.3 Magnetic Particle Testing Machine for crack detection of springs should be calibrated in accordance with IS: 3703 or relevant ASTM specification for insuring correct level of Ultra Violet illumination and appropriate wavelength, sensitivity level of penetrant and magnetizing current. The calibration frequency shall be decided and undertaken by the manufacturer which shall in no case be more than a year and a proper record thereof shall be maintained. The calibration results should be in conformation to the permissible limits.

ASNT/ISNT Level II certified operator for Magnetic Particle Testing should be deployed.

.4 Pre-determine the temperature to which the ends of the ground bars are to be heated according to chemical composition and a method of gradual heating & required soaking time as defined.

.5 Checking of oil in Quenching Tank and topping up / replenishment as required.

.6 Pre-determining heat-treatment cycle product-wise during tempering.

.7 Ensuring the traceability of the product from raw material stage to finished product stage. The system should help in identifying the raw material details – Heat No., Supplier, Inspection details from the finished product stage.

.8 Proper stacking of raw material heat wise and the record detailing Despatch Memo No., Quantity, Heat No., Inspection, the Purchase Order details of the products against which the raw material has been procured.

.9 A Quality Assurance Plan for the product detailing various aspects shall be available:

- Organisation Chart
- Flow Process Chart
- Stage Inspection details
- Various parameters and to ensure control over it

.10 There should be at least one full time spring technologist having a minimum bachelor's degree in relevant field with 5 years experience or a person with diploma in relevant field with 12 years experience. He should be free from day-to-day production, testing & quality control responsibility. He should be mainly responsible for development for product, analysis of products, control over raw material and corrective action in case of difficulties in achieving the parameters.

.11 The in-charge of the Quality Control Section should have a minimum bachelor's degree in the relevant field & have minimum 5 years experience or a diploma holder with minimum 12 years experience. He should be actively involved in day-to-day activities of quality control / stage inspection / compliance of QAP etc.

.12 The Quality Manual of the firm should clearly indicate at any stage the control over manufacturing and testing of the helical coil springs for locomotives.

.13 Proper analysis to be done on monthly basis to study the rejection at various internal stages and it is documented.

.14 Proper record of complaints received from users (Railways) shall be maintained and corrective action is taken.

.15 The latest versions of ASTM / IS / UIC Specifications given at Para 4 of this specification shall be available with the firm.

6.0 QUALITY ASSURANCE PLAN

6.1 The firm shall submit two copies of Quality Assurance Plan (QAP) for manufacture of locomotive springs to RDSO for approval.

The QAP shall include the following:

i. Organisation Chart emphasising Quality Control Setup.

ii. Qualification of key personnel and the officials deployed in Quality Control Cell.

iii. Calibration Policy for Testing Equipments, Gauges, Measuring Devices etc.

iv. Process Flow Chart indicating process of manufacture for an individual product or for a family of products if the process is same.

v. Stage wise details of spring Manufacture, Testing & Inspection.

vi. Record of finished product as per Identification Markings & Quality Assurance System - Inspection & Testing Plan.

This shall cover the following:

- Incoming material
- Process control
- Product control
- System control

vii. Policy of disposal of rejected product

6.2 The manufacturer shall proceed for manufacturing of locomotive springs only after approval of QAP. The firm shall strictly follow the stipulations of QAP.

The firm shall maintain a record of QAP implementation for documentary evidence.

6.3 The QAP shall require renewal after every two years. Any changes incorporated in the manufacturing procedure/ Machinery and Plants associated with the manufacture of locomotive springs should be duly incorporated in QAP and approved.

7.0 RAW MATERIAL

7.1 General

Unless otherwise specified in the relevant RDSO drawings, the material of springs as applicable to different locomotives shall be:

Table 1

S.No.	Finished Bar Diameter (d) (mm)	Grade of Steel as per IS: 3195-92 (Amendment No. 2 of Sept.2000)
a.	$d \leq 30$	60 Si_7
b.	$30 < d \leq 60$	52 Cr_4Mo_2V

The contents of Sulphur, Phosphorus and tramp elements shall be maintained as under for the above grades:

S : 0.025% (maximum)

P : 0.025% (maximum)

S & P Together : 0.040% (maximum)

Sn + Pb + As : 0.10 % (maximum)

7.1.1 Steel making through basic oxygen, electric arc process shall be employed and steel made through Open-Hearth process shall not be used. Steel shall be processed through secondary refining for close control of composition and removal of harmful elements. Vacuum degassing and purging with Argon gas shall be mandatory.

7.1.2 The size of ingots, billets or continuous cast billets for any given size of finished steel product shall be such that a minimum reduction ratio of 16:1 from the minimum cross-sectional area of the ingot or continuous cast billets to the maximum cross-sectional area of the product is ensured to have freedom from "Primary" dendritic structure.

7.1.3 While ordering the raw material, suitable allowance in the bar diameter shall be made for loss of material in peeling/centreless grinding and scaling during heat treatment.

7.1.4 Marking on each steel bar over 15 mm diameter or of equivalent cross-section shall be done with the name or trade mark of the steel manufacturer, grade and the cast number or identification mark by which the steel bar may be traced to the cast from which it has been made. Such marking shall be made at the extreme ends of each bar by stamping using indelible ink.

However, markings at both ends of each steel bar using “Bar Code” shall be preferable from 1st December 2008.

7.2 Quality of Spring Steel Rounds

7.2.1 The hot rolled material shall be reasonably smooth & free from distortion, twist, kinks and shall be straight. The hot rolled bars shall also be free from harmful defects namely seams, folds, laps, cracks, holes, deep pits, grooves, excessive scaling and non-metallic inclusion which may lead to cracking during hardening or impair the serviceability of material. The material shall also be free from harmful internal defects such as piping and segregations.

7.2.2 The hardness of spring steel round material when tested in accordance with IS: 1500 shall be as given below:

Table 2

Steel Grade	**Surface Hardness BHN (**Maximum**)**	
	Untreated Condition (For reference only)	Annealed Condition
60 Si_7	255	245
52 Cr_4Mo_2V	310	255

In case of as-rolled material, the limits of hardness other than those specified above, may be mutually agreed upon at the time of enquiry.

7.2.3 Macro etching shall be used for evaluating the heterogeneity of steel and to ensure freedom from harmful internal defects. The macro etching test sample shall be prepared as per IS: 7739. Macro etch level shall not be worse than C2, R2, S2 of ASTM E-381 Plate 1 for billets and blooms.

7.2.4 Macroscopic Examination shall be conducted on a longitudinal section for evaluation of non-metallic inclusion content. Method of sampling and the magnified photomicrographs for evaluation shall be as per IS: 4163. The inclusion rating shall be 2.0 ABCD for thin series and 1.0 ABCD for thick series when compared to the chart for determining the inclusion content of secondary refined steels (Fig.2) of IS: 4163-1982.

7.2.5 Average grain size of the bar shall be to ASTM No.6 or finer when checked as per ASTM E-112.

7.2.6 Permissible depth of seam and lap in the rolled bar shall be d/100 or 0.4 mm whichever is less (where d is bar diameter in mm). The test procedure for detecting surface seams shall be as per IS: 3703.

7.2.7 Tolerance on diameters of hot rolled steel bars shall be within +1.0% and -0.8%.

The ovality of bars should be checked so as to ensure minimum removal of the material on minor diameter as specified in Clause 8.3.1.

7.2.8 The hot rolled bars shall be supplied in straightened condition and the limit for out of straightness shall not be more than 1.0 mm/ meter length.

7.2.9 All other conditions shall be as per IS: 3195. Proper precautions must be taken to ensure safe transportation of hot rolled bars to avoid possible damage during transit.

7.3 Inspection of Spring Steel Rounds

Apart from the documents pertaining to the steel manufacture & refining details, ingot shape and size of the rolled product, cropping yield etc, the Steel Manufacturer shall submit necessary test certificates of the following tests carried out by them:

a) Chemical composition of ladle analysis and product analysis determined as per IS: 228

b) Inclusion Contents of rounds

c) Reduction Ratio

d) Depth of decarburisation on rounds

e) Surface Hardness

f) Grain Size

g) Dimensions

h) Miscellaneous

For each cast/heat, the steel manufacturer can be asked to compulsorily provide:

i. Test results of End Quench Hardenability (Jominy Band) as per IS: 3848.

ii. Test certificate for chemical composition including the contents of Tramp elements in the ladle and product analysis.

7.3.1 While carrying out inspection of rolled bars, the Inspecting Official shall pay special attention to:

a) Size of ingots/billets used by the steel manufacturer.

b) Dressing of complete billet by general surface grinding and freedom from surface defects.

c) Discarding of end portions at both ends of each billet and freedom from piping.

d) The size of ingot used shall be checked, recorded and verified that minimum reduction ratio of 16:1 is ensured for the rolled bars offered for inspection.

7.3.2 The Inspecting Official shall randomly select samples for the following minimum checks to be carried out in his presence as per sampling given in Clauses 7.3.2.1, 7.3.2.2 & 7.4 and maintain records thereof. He may draw any additional number of samples and carry out tests at his discretion.

The Inspecting Official shall also have the right to cross check any of the above parameters mentioned in Clause 5.0 by actual tests of the samples drawn from steel rounds received by the spring manufacturer at his discretion at the cost of spring manufacturer.

7.3.2.1 Examine various registers and records maintained by the steel manufacturer to verify heat wise checks carried out on various parameters and manufacturing practices like production of ingots with wide end up and hot top cropping of each ingot/primary rolled billet etc.

7.3.2.2 Check all other aspects specified in Clause 7.0.

7.3.2.3 In case, the spring manufacturer wants to stock raw material, approval should be taken from the office of the DG(Quality Assurance)/RDSO. In such cases, inspection charges (1% of the value of goods inspected) will be realized from the firm, as the raw material procured will not be against any Railway Order.

7.4 Sampling (Random) of Spring Steel Rounds for Tests

Srl.	Checks/Tests	Relevant Specification	Sampling
a.	Chemical Analysis	IS: 228	2 samples per heat per section
b.	Inclusion Content	IS: 4163	3 samples per heat per section
c.	Macro Examination	IS: 7739	0.5% subject to minimum of 5 bars per heat
d.	Depth of Decarburisation	IS: 6396	3 bars per heat per section
e.	Hardness	IS: 1500	10 bars per heat
f.	Grain size	ASTM E-112	3 bars per heat per section
g.	Verification of dimensional tolerance	IS: 3195	5 samples per heat per section
h.	Visual checks for defects	IS: 3195	2% of black bars per heat per section

7.4.1 Samples of these tests shall be preserved for atleast 6 months and records for at least 3 years for counter check, as and when required.

7.4.2 The Inspecting Official may pick up two samples per 500 tonnes of material offered and send the same to approved agency for confirmatory test for chemical and metallurgical properties at Spring Steel Manufacturer's expense. This test should not form part of purchase acceptance test but will only serve as a counter check on Steel Manufacturer's quality control practice.

7.5 Acceptance Criteria

In case the material offered for inspection fails to meet any of the requirements laid down in Clauses 7.1, 7.2 & 7.3, twice the size of the original sample shall be drawn and tested for the parameter(s) for which the original sample had failed. If any of the re-test samples fails, the complete lot shall be treated as ‘failed’. The manufacturer shall then undertake to render the lot unserviceable for Railways’ use for spring manufacture.

8.0 MANUFACTURE OF SPRINGS

8.1 General

The shape and dimension of locomotive springs manufactured shall conform to the relevant RDSO drawing. Springs shall be made of bars of fine-grained special quality spring steel to IS: 3195. Before taking up manufacturing of springs, the manufacturer shall inspect and again check all steel rounds for conformance with the raw material requirements as given in this specification and any possible damage during transit / material handling. Only when the raw material is found to be within the specified standards, it should be taken up for manufacture of the springs. It will be the responsibility of spring manufacturer to ensure the quality of spring steel rounds.

8.1.1 Generally, the steel manufacturers supply the spring steel rounds to the specified lengths ordered by the spring manufacturers. Hence, no cropping of the rounds is necessary at this stage. In case of multiple lengths/excess lengths, rods may be cut to length by shearing/cutting carefully so as to prevent cracking at the ends. *Flame /Gas cutting is strictly prohibited*.

8.2 Straightening of Spring Steel Rounds

The bars shall be straightened in the bar straightening machine.

8.3 Peeling and Centreless Grinding

8.3.1 The straightened bar should be peeled and centreless ground. Centreless grinding of peeled bars before coiling is mandatory and the surface finish level of the ground bar as per IS: 3073 shall be 5 microns (µm) Ra values or better.

Digital Surface Roughness Tester should be used to ascertain the surface finish.

The reduction in the bar diameter after peeling and centreless grinding shall be 3% of nominal bar diameter or 1 mm, whichever is higher. However, should this extent of peeling not found to be adequate to remove seams completely, it shall be the responsibility of the manufacturer to remove the same by peeling or any other suitable process.

The tolerances on centreless ground steel bar diameter shall be within ± 0.05 mm.

The limit for out of straightness for peeled and centreless ground bars shall be 1mm/ meter length (maximum).

8.3.2 Centreless ground bars having tool marks, grooves either shallow or deep, dent marks or black spots due to non-uniform grinding shall be rejected.

8.3.3 100% of the peeled and ground bars shall be subjected to Magnetic Particle Test by Fluorescent Wet Method. The test procedure for detecting surface and sub-surface defects should be as per IS: 3703. Open seams are not acceptable and sub-surface seams i.e. closed seams upto a depth of 1.0mm from the surface is not acceptable. *Eddy Current Testing Method as an alternative method for checking Surface Defect is not permitted*.

8.3.4 Magnetic Particle Testing facilities should be sufficient to accommodate spring bars of 6.0m length such that it can be tested in one setting. A suitable device to rotate the bars in position is also essential to facilitate testing of entire surface of the bars in one setting. *Magnetic particle Testing Machine should be calibrated with standard blocks before testing of spring bars for comparing the depth of sub-surface defects.*

8.3.5 No traces of arc burns or spots shall be permitted on the centreless ground bars due to the passage of electric current following Magnetic Particle Testing.

8.4 End Tapering

8.4.1 The ends of peeled and centreless ground bars should be heated in an oil fired or electric indirectly heated furnace equipped with temperature controllers and recorders. The temperature to which the ends of ground bars are to be heated should be pre-determined depending on the chemical composition of material used. The temperature shall be recorded by graphical/digital temperature recorders.

8.4.2 Both the ends of ground bar shall be uniformly tapered by Taper Rolling Machine to give the finished spring about 75% firm bearing (i.e. the taper length should be approximately equal to 0.75 of the mean circumference of the spring). The tapered faces should be smooth and should not have steps/pits or cracks due to hammer blows since line contact with the effective coils is required under load.

8.4.3 The tip thickness of tapered ends of the bar after end grinding should not be less than $1/4^{th}$ of nominal bar diameter up to 33 mm nominal bar diameter and $1/5^{th}$ beyond 33 mm nominal bar diameter. It should not be more than 25% of nominal bar diameter plus 5 mm.

These permissible values for tip thickness can be tabulated as follows based on nominal bar diameter (d):

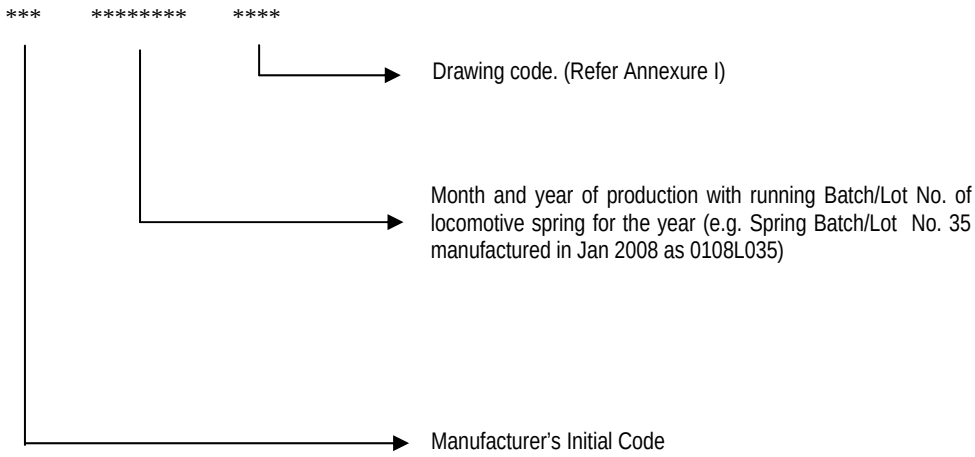
Srl. No	Nominal Bar Diameter (mm)	Tip Thickness (mm)	
		Minimum (t_{min})	Maximum (t_{max})
1.	$d \leq 33$	0.25 x d	(0.25 x d) + 5
2.	$33 < d \leq 60$	0.20 x d	(0.25 x d) + 5

8.4.4 No burrs / sharp edges should be allowed on the tapered ends to avoid possibility of end biting into the adjacent active coil in service leading to a probable spring failure.

8.5 Stamping

8.5.1 The manufacturing/ spring details shall be legibly hot stamped on both tapered ends of each spring in such a way that the particulars are visible on the outer surface of the ineffective coils and they do not get erased during end grinding or interfere with the performance/ reliability of the spring. The size of letters shall be 5mm on bars having wire diameter above 20mm and 3mm for bars having wire diameter 20mm or less.

8.5.2 The serial order in which the manufacturing / spring details are to be stamped on the ineffective coils on each spring shall be as given below:



e.g. **CSN 0108L035** VL01

The 1st and 2nd groups of spring details stamped, form together a unique **S**pring **B**atch **I**dentification (**SBI**) Number which can be used for reference and documentation. The first part of this SBI No. i.e CSN identifies the manufacturer while its second part i.e 0108L035 identifies the month (01 or January), year (2008) of manufacture and type of application i.e L (locomotive) along with the running Batch/Lot Serial No. 035 of locomotive spring manufactured during year 2008. This Batch/Lot Serial No. shall continue upto 999 during the year. Its shall restart every year.

The 3rd group indicates the drawing codes of springs as specified in Annexure I.

It must be ensured that proper traceability of springs from raw material to finished product stage is properly maintained.

8.5.3 No marking shall be done on springs made from bar diameter of 9.5 mm and below.

8.5.4 The record of all the tests/ checks conducted on each spring shall be maintained by the manufacturer as per SBI number for future reference.

8.6 Coiling and Heat Treatment

8.6.1 The spring steel bars with tapered ends should be heated in an oil fired or electric indirectly heating walking beam furnace with variable speeds and soaked sufficiently at that temperature in a controlled

atmosphere so that excessive scaling and decarburisation do not take place.

8.6.2 The furnace in which the bars are heated for coiling and heat treatment, should be equipped with automatic temperature indicators, controllers & graphical/ digital recorders & the furnace temperatures should be recorded during operation. The temperature data can be digitally recorded for ease and saved.

8.6.3 Coiling and pitching should be carried out on a high speed automatic coiling and pitching machine, taking specific care to ensure minimum time lag between heating, coiling and starting of quenching operation.

Use of high-speed automatic coiling machine is necessary to ensure that the heated material remains in contact with air for minimum possible time so as to avoid oxidation. Bars shall be coiled on a preheated mandrel such that uniform pitch is maintained. The direction of coiling shall conform to the relevant RDSO drawing. When it is not specified, the direction of coiling shall be to the "right hand".

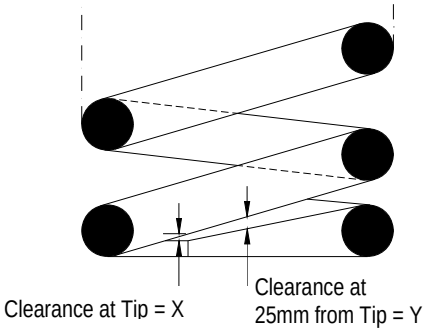
The Pitch of the coils shall be sufficiently uniform so that when the spring is compressed to a height representing a deflection of 85% of nominal total travel, none of the coils shall be in contact with one another, excluding the inactive end coils. It should be ensured that as and when contact between the ineffective coils and the adjacent effective coil is made, it should occur over a minimum length of 1/3rd of mean coil circumference. Moreover, under 85% deflection, the pitch should generally be uniform.

No water shall be allowed to come in contact with the heated bar at any time.

It should be ensured at the time of end closing of the spring that *the end gap between tip and the adjacent effective coil is such that the tip <u>does not bite</u> the effective coil under load as well as under no load.*

End gap between the tip of the last coil and adjacent active coil shall not in any way affect the load test requirement given in the drawing and uniformity of pitch as specified below.

Moving circumferentially along the spring, the gap between inactive coil and first active coil should gradually increase (i.e the gap ‘Y’ at 25mm from tip should be more than the gap ‘X’ at the tip. Similarly, the gap at 50mm from tip should be proportionately more than the gap at 25mm from the tip).



Clearance ‘Y’ should be proportionately greater than ‘X’

Closing of end coils should be inbuilt feature of the coiling machine and manual adjustment should not be done. The tip shall not protrude beyond the outside diameter of the spring.

It should be ensured that the plane of tapered unground end of the spring after coiling remain within a prescribed limit of angularity (due

to twisting of the bar during coiling) from the plane perpendicular to the longitudinal axis of the spring to achieve the conditions laid down in Para 8.7.

8.6.4 The springs shall be quenched from coiling heat immediately after coiling and while still above the transformation temperature. They shall be quenched in an ample volume of circulating or agitated oil or other suitable quenching medium, conforming to the standard specification for this purpose, the temperature of which is maintained within the predetermined limit in order to ensure optimum quenching conditions.

The springs are to be removed from the quenching medium allowing a residual temperature of not less than 80°C.

8.6.5 After quenching, the springs shall be conveyed immediately through a continuous Tempering Furnace with conveyor. During tempering, the springs shall be heated to desired pre-determined temperature range and for a sufficient length of time to produce the required spring hardness throughout the section. The furnace should be oil fired or electric indirectly heating with automatic temperature controller and recorder.

8.6.6 In order to ensure the uniform heating of springs, it is recommended that each zone of the furnace should be provided with independent pyrometer for temperature control. The temperature shall be controlled within ±10º C in each zone of the furnace. The temperature of the tempering furnace should also be maintained within this range of variation.

For proper heat treatment of springs, the following table shall be used for guidance:

Table 3

Temperatures for Heat Treatment of Springs

Steel Grade	Quenching Oil Temperature (ºC)	Tempering Temperature (ºC)
60 Si7	830 - 860	350 - 550
52 Cr4Mo2V	830 - 860	350 - 550

8.6.7 The heat treatment should be carried out with the aim to achieve a homogenous grain structure of the spring material.

Average grain size of the spring shall be to ASTM No.6 or finer when checked as per ASTM E-112.

The tempered martensitic distribution across the complete cross section of the active coil of the Chrome Molybdenum spring steel and Silico Manganese spring steel should be 90% martensite minimum in the core (upto 70% of radius). On the surface and sub-surface region, the martensite may vary between 90-100%.

The martenstic distribution shall not be less than as specified above.

8.6.8 The total depth of decarburisation, partial plus complete on the finished spring in the quenched and tempered condition shall not exceed 0.5% of the bar diameter.

Depth of decarburisation shall be checked by cutting and preparing suitable samples from the active coil of the spring.

The amount of decarburisation shall be examined at 100X magnification on a test specimen covering at least 25mm length of original circumference and cut from a full cross section of the spring.

8.6.9 The hardness of the spring should be in the range of 380 to 440 BHN for silico manganese steel and 415 to 460 BHN for chrome molybdenum spring steels.

The hardness shall be measured on the outside surface of the spring on inactive coils after removal of the decarburised material. The hardness of springs shall be measured at not less than two places, one at each end.

Hardness at core & periphery shall be checked by cutting and preparing suitable samples from the active coil of the spring.

The difference in hardness between the surface and core as well as across the cross section should not be more than 20 BHN. Surface hardness should be more than core hardness.

8.7 End Grinding

Both the end faces of the spring should be ground to ensure square seating of the spring. The deviation in squareness shall be determined by standing the spring on its base and measuring the same along the outer circumference from a perpendicular to the surface plate on which spring is standing with the help of a set/try square and a suitable measuring device.

The actual ground end surface shall be at least 75% of the mean coil circumference of the spring.

The ends should not have any sharp edges/burrs.

Uniform feed rate of springs should be maintained during end grinding.

The end faces of the spring should not have blue marks due to end grinding as the same leads to temper brittleness.

The dimensions of the spring tip thickness should be maintained as tabulated below:

Srl. No	Nominal Bar Diameter (d) (mm)	Variation in Tip Thickness over the Cross Section of Spring End (mm)		Permissible Value of t_{abs} (mm) i.e $\lvert t_{max} - t_{min} \rvert$
		Minimum (t_{min})	Maximum (t_{max})	
1.	$d \leq 33$	0.25 x d	(0.25 x d) + 5	5
2.	$33 < d \leq 60$	0.20 x d	(0.25 x d) + 5	(0.05 x d) + 5

To achieve the tip thickness and minimum required mandatory seating of end coil mentioned above, it is recommended that grouping of unground springs should be done based on free height for end grinding.

8.8 Scragging

Each and every spring should be scragged 3 times in quick succession. Scragging load/height should be as laid down in the relevant RDSO drawing. In case there is no indication in the drawing, the spring 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.

8.8.1 The Solid Height or Block Length (LB) of the spring made from centreless ground steel bar should be measured unless otherwise specified in the RDSO drawing:

$LB < (\text{Total No. of Coils} - 0.4) \times d_{max}$ (where Total No. of Coils = No. of Active Coils + 1.5)

where d_{max} is the maximum bar diameter.

IS: 7906 Part 5 should be followed for solid height measurement.

8.8.2 Long duration scragging is to be introduced as a process check at 6 months intervals and necessary documentation of the test results are to be maintained. For long duration scragging, the spring shall be compressed three times holding it at the home load for 2 minutes in the first two strokes and for 48 hours at the last stroke. Proper record of long duration scragging should be maintained.

8.8.3 The scragged spring should not show permanent set on subsequent loading. Permanent set shall not exceed 3 mm of free height of spring, which is measured before scragging.

8.9 Crack Detection

100% of the springs shall be tested for crack detection in accordance with Appendix 'B' of Specification UIC-822, for both longitudinal and transverse cracks. A suitable device to rotate the springs in position is also essential to facilitate testing of entire surface of the spring in one setting. After crack detection, the spring shall suitably be demagnetized.

8.10 Shot Peening

All the springs shall be shot peened in a continuous type shot peening machine, preferably with self-sieving arrangement in accordance with IS: 7001 to improve fatigue life of the spring. During shot peening, it should be ensured that the springs are shot peened uniformly over the entire area of the springs. The intensity and coverage should be checked with the help of almen strip in accordance with IS: 7001. Almen intensity should be checked minimum two times per shift of production. The minimum coverage (when checked visually) should be 90% and intensity when checked with Almen strip Type - A in accordance with IS: 7001 should be minimum 0.40 mm (0.016").

8.11 Grouping and Steel Band Coding

100% of the springs shall be compressed with specified Working Load and the loaded height of the individual spring shall be measured on the Spring Testing Machine. The working height of the spring shall be within the tolerances specified in the RDSO drawing. Based on the working height observed, the springs shall be grouped and steel band coded for identification as specified in the relevant RDSO drawing. Any spring which is found to be defective or which does not confirm to the limits of working height specified in the relevant RDSO drawing should be rejected.

9.0 LOAD TESTING

9.1 The spring placed on a flat rigid metal support should be subjected to incremental increasing load upto the value indicated in the RDSO drawing on Spring Testing Machine. Each load is to be maintained till the load is stablised, after which the corresponding height of the spring (under load) is determined. The tolerance on height of the spring under nominal load and at other loads shall be as indicated on the drawing or in absence thereof, it should not be more than ± 3% of design deflection value at nominal working load and - 4% / + 6% of design deflection value at other loads.

9.2 The spring stiffness shall be within ± 3.4% upto nominal bar diameter upto 18 mm and ± 5% beyond 18 mm nominal bar diameter. It should be determined by dividing the difference of load between 70% and 30% of the designed solid load by the difference of measured deflection between these two loads.

9.3 Lateral Deflection

When prescribed on the relevant RDSO drawing, the lateral deflection characteristics shall be checked by means of suitable device approved by RDSO.

10.0 HANDLING OF SPRINGS

The springs should be properly handled since they are highly stressed components of suspension system. Due care should be taken in handling during manufacture, inspection, testing, packing or transportation to avoid any dent marks/ damage which might lead to failure in service.

Hence, springs should never be thrown or rolled on the floor at any stage to avoid any damage to them.

11.0 FATIGUE TESTING OF SPRINGS

Fatigue Testing of spring should be done during the initial approval of a manufacturer as RDSO approved source for supply of springs to Railways/ PUs. It should subsequently be done every alternate year for the first lot of the spring to be supplied by the manufacturer.

Type testing of newly designed springs (Fatigue Testing) shall be done if mentioned in the relevant RDSO drawing.

Fatigue Testing of springs shall be undertaken as per the Fatigue Testing Scheme enclosed in the Annexure II.

12.0 INSPECTION OF SPRINGS

12.1 General

Inspection shall be undertaken to ascertain the quality and characteristics of the springs. The Inspecting Official shall be permitted to carryout all the checks necessary to ensure that all the conditions specified for the manufacture of the material and of the springs are adhered to.

12.1.1 The Inspecting Official shall have free access to the works of the manufacturer at all reasonable times. He shall be at liberty to inspect

the springs at any stage of manufacture and to reject any material that does not conform to the Specification.

12.1.2 The manufacturer shall provide the Inspecting Official, free of charge, all reasonable facilities by way of labour, appliances and necessary assistance for such tests as may be required to be carried out in accordance with this specification. Where facilities are not available at manufacturer's works, the manufacturer shall make arrangements for carrying out such tests elsewhere and bear the cost of testing.

12.1.3 The finished spring shall be presented for inspection in batches of not more than 500 springs. The springs shall be presented for inspection after the application of the protective coating against corrosion. The Inspecting Official is free to have the sample springs shot peened for various tests.

12.2 Stage I – Inspection of Raw Material

Shall be done by the RDSO Inspecting Official as per Clauses 7.3, 7.4 and 7.5 of this Specification.

12.3 Stage II – Inspection during Manufacture

The spring manufacturer shall carryout all necessary checks on the centreless ground bars for minimum required material removal, surface finish, crack detection, the depth of decarburisation of springs during the heat treatment, surface hardness etc. and maintain records for each tests as per QAP.

These records must be presented to the Inspecting Official during the purchase inspection.

12.4 Stage III – Inspection of Finished Springs

For each batch of finished springs or part thereof presented for inspection, the following checks shall be carried out on the randomly selected springs by the Inspecting Official:

12.4.1 Checking of records for Quality Verification of Raw Material used by the Firm:

The Inspector Official shall check the records and ensure that the verification has been done by the firm on the spring material used before commencing the manufacture of the springs as per checks specified in this specification.

12.4.2 The Inspecting Official shall carry out the following checks on the finished springs:

Sl. No	Check Performed	Sample Size	Equipment Used	Acceptable Limits	Specification Used
1.	Spring Surface	100% Springs	Visual as finished	Crocodile skin on the spring is not acceptable	--
		2% of Springs	Visual after shot peening		--
2.	Stamping	10% of Lot or 20 springs, whichever is less	Visual	As per Clause 8.5	--
3.	Free Height	10% of Lot or 20 springs, whichever is less	Gauge	As per RDSO Drawing	--
4.	Out of Squareness	10% of Lot or 20 springs, whichever is less	--	Shall not exceed 0.57º	IS:7906 Part-8
5.	Parallelism	10% of Lot or 20 springs, whichever is less	--	Shall not exceed 0.9º	IS:7906 Part-8
6.	End Preparation	10% of Lot or 20 springs, whichever is less	Measurement by Vernier Caliper	As per Clause 8.4 & 8.7	--
		10% of Lot or 20 springs, whichever is less	Visual	Tapered faces shall not have steps/pits/cracks/ sharp edges /burrs/blue marks	--
7.	Tip thickness	10% of Lot or 20 springs, whichever is less	Vernier Caliper	As per Clause 8.4.3	--
8.	Scragging	10% of Lot or 20 springs, whichever is less	Spring Testing Machine	As per Clause 8.8	--
9.	Permanent Set	10% of Lot or 20 springs, whichever is less	Gauge	Shall not be more than 3 mm	--
10.	Length of contact area between inactive coil & active coil at working load	10% of Lot or 20 springs, whichever is less	Spring Testing Machine	10-15%of the nominal coil diameter. The point contact shall not be acceptable. The contact length should steadily increase with increasing load.	--
11.	Static Load Test -Stiffness	10% of Lot or 20 springs, whichever is less	Spring Testing Machine	As per Clause 9.0	--
12.	Working Height	10% of Lot or 20 springs, whichever is less	Spring Testing Machine	As per RDSO Drawing	--
13.	Maximum spacing between any two adjacent active coils under 85% deflection	10% of Lot or 20 springs, whichever is less	Spring Testing Machine	As per Clause 8.6.3	--

Sl. No	Check Performed	Sample Size		Equipment Used	Acceptable Limits	Specification Used
14.	Uniformity of Pitch	10% of Lot or 20 springs, whichever is less		Spring Testing Machine	As per Clause 8.6.3	--
15.	Crack Detection	2% of lot size subject to minimum of 10 springs		--	As per Clause 8.9	Appendix 'B' of Specification UIC-822, both for longitudinal & transverse cracks.
16.	Shot Peening	Internal Test Records		--	As per Clause 8.10	IS: 7001
17.	Depth of decarburisation	2% of Lot or 2 springs, whichever is less		Photo Microscope	As per Clause 8.6.8	IS: 6396
18.	Hardness	Core	2% of Lot or 2 springs, whichever is less	BHN Hardness Tester	As per Clause 8.6.9	IS: 1500
		Surface	10% of Lot or 20 Springs, whichever is less			
19.	Chemical composition	2% of Lot or 2 springs, whichever is less		Spectrometer / Chemical Testing Equipment	Shall conform to material specification given in relevant RDSO drawing.	IS: 228
20.	Grain Structure	2% of Lot or 2 springs, whichever is less		Photo Microscope	ASTM No. 6 or finer	ASTM E-112
21.	Inclusion Rating	2% of Lot or 2 springs, whichever is less		Photo Microscope	As per Clause 7.2.4	IS: 4163
22.	Macro Etching	2% of Lot or 2 springs, whichever is less		Photo Microscope	As per Clause 7.2.3	IS: 7739
23.	Paint quality	10 % of Lot		DFT to be checked by Elcometer	As per Clause 14.0	IS: 2074 & IS: 2932
24.	Powder Coating	10 % of Lot		DFT to be checked by Elcometer	As per Clause 5.3.7	IS: 3618 & IS: 13871
25.	Grouping and Steel Band Coding	10 % of Lot		Spring Testing Machine	As per Clause 8.11	--

12.4.3 Samples for all the above tests shall be preserved for at least 12 months and Records for 5 years for counter check, if required.

12.4.4 The Spring Manufacturer should submit certificate ascertaining that "Magnetic Particle Test as per Clause 8.3.3 has been carried out on full length of 100% of the centreless ground bars against particular Purchase Order". This Certificate should be submitted to the Inspecting Official as well as to Consignee Railways.

12.4.5 The spring manufacturer should submit a certificate to the effect that spring steel rounds purchased by the firm against specific purchase order from RDSO approved source and inspected as per corresponding Dispatch Memo Number has been used for manufacturing a particular batch of springs against particular purchase order and no other material has been used.

13.0 ACCEPTANCE CRITERIA FOR SPRINGS

13.1 The firm shall not withdraw the material offered for inspection during the course of inspection. Any move by the firm in any way to withdraw the material or interfere/ hinder the inspection, shall render rejection of the entire quantity of material offered for inspection.

13.2 If any sample fails in one or more criteria of inspection, double the sample size shall be drawn and tested against the criteria in which the sample had failed. If all the samples of double sampling pass the criteria, the entire quantity shall be accepted.

13.3 Failure of any sample of the double samples will, however, result in rejection of the entire offered quantity.

13.4 In the event of rejection, the entire quantity offered for inspection shall be made unusable for Railway application in presence of the Inspecting Official either by gas cutting or cross marking on one of the effective coils with the help of grinder cutter so that the rejected springs do not get mixed up with the other springs/ passed springs at any stage.

14.0 PROTECTION AGAINST CORROSION OF SPRINGS

Finished springs shall be given one coat of zinc chromate primer to IS: 2074 followed by one coat of Black Synthetic Enamel to IS: 2932 for protection against corrosion.

Any special instructions with respect to powder coating on the springs as mentioned in the relevant RDSO drawings should be followed.

15.0 PACKING OF SPRINGS FOR TRANSPORTATION

The springs are one of the most stressed components of the locomotive suspension. Hence, they should be suitably packed to ensure their safe transportation.

For packing the springs, a seamless polythene sleeve of minimum 500 micron thickness and appropriate diameter (matching the finished spring bar diameter) should be slided on the finished spring wire/ bar and sealed from both the ends. The whole spring bar should then be wrapped with a thick jute strip such that no portion of the spring is exposed open.

Spring covered with Polythene Sleeve & wrapped with Protective Jute Strip (shown partially covered)

Transportation of springs in wooden boxes / pallets shall be preferable. Any other precaution in packing as may be deemed fit for safe transportation should be taken by the spring manufacturer to avoid damage during transportation.

16.0 GUARANTEE FOR SPRINGS

The spring shall be guaranteed for a period of five years against any defect imputable to manufacture from the date of delivery of the spring, as indicated by stamping of month and year of manufacture on the tapered ends of the spring vide Para 8.5.2 of this Specification or for a period of four years from the date of actual fitment on Locomotive, whichever is earlier. Springs that show, during the guarantee period, defects making them either unfit for service or reduce the effectiveness of the life and such defects which may be imputable to manufacture, shall be replaced free of cost by the manufacturer.

17.0 FIELD TRIALS

For fresh approval as RDSO approved source for supply of locomotive springs, a field trial for at least one year is essential.

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Annexure I

DRAWINGS OF LOCOMOTIVE SPRINGS AND THEIR CODES

S.No.	Drawing No.	Locomotive	Type	Nos./Loco	Code
1.	SK.DL 3742	WAG5	OUTER	16	DL 08
2.	SK.DL 3743	WAG5	INNER	8	DL 09
3.	SK.DL 3744	WAG5	SNUBBER	8	DL 10
4.	SK.DL 3843	WAG5	OUTER	16	DL 11
5.	SK.DL 3844	WAG5	INNER	8	DL 12
6.	SK.DL 3845	WAG5	SNUBBER	8	DL 13
7.	SK.DL 3745	YAM1	OUTER (Primary)	8	DL 14
8.	SK.DL 3739	WAM4, WCAM1	OUTER	16	DL 23
9.	SK.DL 3741	WAM4, WCAM1	SNUBBER	8	DL 24
10.	SK.DL 3858	WAM4, WCAM1	OUTER	16	DL 25
11.	SK.DL 3859	WAM4, WCAM1	INNER	8	DL 26
12.	SK.DL 3860	WAM4, WCAM1	SNUBBER	8	DL 27
13.	SK.DL 3740	WAM4, WCAM1	INNER	8	DL 28
14.	SK.DL 3736	WAM4A	OUTER	16	DL 29
15.	SK.DL 3737	WAM4A	INNER	8	DL 30
16.	SK.DL 3738	WAM4A	SNUBBER	8	DL 31
17.	SK.DL 3855	WAM4A	OUTER	16	DL 32

S.No.	Drawing No.	Locomotive	Type	Nos./Loco	Code
18.	SK.DL 3856	WAM4A	INNER	8	DL 33
19.	SK.DL 3857	WAM4A	SNUBBER	8	DL 34
20.	SK.DL 3472	WAP1, WAP3, WAP4, WAP6	PRIMARY	24	DL 35
21.	SK.DL 3473	WAP1, WAP3, WAP4, WAP6	SECONDARY	16	DL 36
22.	SK.DL 3733	WCG2	OUTER	16	DL 37
23.	SK.DL 3734	WCG2	INNER	8	DL 38
24.	SK.DL 3852	WCG2	OUTER	16	DL 40
25.	SK.DL 3735	WCG2	SNUBBER	8	DL 39
26.	SK.DL 3853	WCG2	INNER	8	DL 41
27.	SK.DL 3854	WCG2	SNUBBER	8	DL 42
28.	SK.DL 3463	WDM2, WDM3A	OUTER	16	DL 43
29.	SK.DL 3464	WDM2, WDM3A	INNER	8	DL 44
30.	SK.DL 3465	WDM2, WDM3A	SNUBBER	8	DL45
31.	SK.DL 4281	WDM4	SECONDARY	16	DL 46
32.	SK.DL 4282	WDM4	PRIMARY	24	DL 47
33.	SK.DL 3466	WDS5, WDS6	OUTER	16	DL 48
34.	SK.DL 3467	WDS5, WDS6	INNER	8	DL 49
35.	SK.DL 3468	WDS5, WDS6	SNUBBER	8	DL 50
36.	SK.DL 3746	YAM1	INNER (Primary)	8	DL 51

S.No.	Drawing No.	Locomotive	Type	Nos./Loco	Code
37.	SK.DL 3748	YAM1	INNER (Secondary)	8	DL 52
38.	SK.DL 3747	YAM1	OUTER (Secondary)	8	DL 53
39.	SK.DL 3469	YDM4, VDM4	OUTER	16	DL 54
40.	SK.DL 3470	YDM4, VDM4	INNER	8	DL 55
41.	SK.DL 3471	YDM4	SNUBBER	8	DL 56
42.	SK.DL 3474	YDM6	OUTER	16	DL 57
43.	SK.DL 3475	YDM6	INNER	16	DL 58
44.	SK.DL 4024	WAM4, WCAM1, WAG5, WCG2	PRIMARY	24	DL 60
45.	SK.DL 3476	WAM2	PRIMARY (OUTER)	16	DL 61
46.	SK.DL 3477	WAM2	PRIMARY (INNER)	16	DL 62
47.	SK.DL 3478	WAM2	SECONDARY (OUTER)	8	DL 63
48.	SK.DL 3479	WAM2	SECONDARY (INNER)	8	DL 64
49.	SK.DL 3913	WAG1 700 SERIES	PRIMARY (OUTER) R.H.	8	DL 65
50.	SK.DL 3914	WAG1 700 SERIES	PRIMARY (OUTER) L.H.	8	DL 66
51.	SK.DL 3915	WAG1 700 SERIES	PRIMARY (INNER) L.H.	8	DL 67
52.	SK.DL 3916	WAG1 700 SERIES	PRIMARY (INNER) R.H.	8	DL 68
53.	SK.DL 3954	WAG1, WAG3, WAG4 (SOFTER)	PRIMARY (OUTER) L.H.	8	DL 69
54.	SK.DL 3955	WAG1, WAG3, WAG4 (SOFTER)	PRIMARY (OUTER)	8	DL 70
55.	SK.DL 3956	WAG1, WAG3, WAG4 (SOFTER)	PRIMARY (INNER) R.H.	8	DL 71
56.	SK.DL 3957	WAG1, WAG3, WAG4 (SOFTER)	PRIMARY (INNER) L.H.	8	DL 72

S.No.	Drawing No.	Locomotive	Type	Nos./Loco	Code
57.	SK.DL 4092	WAM1	PRIMARY (OUTER) R.H.	8	DL 73
58.	SK.DL 4093	WAM1	PRIMARY (OUTER) L.H.	8	DL 74
59.	SK.DL 4094	WAM1	PRIMARY (INNER) R.H.	8	DL 75
60.	SK.DL 4095	WAM1	PRIMARY (INNER) L.H.	8	DL 76
61.	SK.VL 030	WDP1	PRIMARY	16	VL 01
62.	SK.VL 032	WDP1	SECONDARY	12	VL 02
63.	SK.VL 037	WAG7	INNER	16	VL 03
64.	SK.VL 039	WAG7	OUTER	16	VL 04
65.	SK.VL 147	WDG2, WDG3A	INNER	16	VL 05
66.	SK.VL 148	WDG2, WDG3A	OUTER	16	VL 06
67.	SK.VL 160	WDP1	OUTER (Primary)	16	VL 07
68.	SK.VL 161	WDP1	SECONDARY	12	VL 08
69.	SK.VL 166	WDP1	INNER (Primary)	16	VL 09
70.	VL.FM5 C.03	WDP3A	PRIMARY	24	VL 10
71.	VL.FM5 C.04	WDP3A	SECONDARY	16	VL 11
72.	VL.FM5 C.04M	WDP3AM (Modified Guide Link)	SECONDARY	16	VL 12
73.	VL.FM5 C.05	WDP3AM (Modified Guide Link)	PRIMARY (End Axle)	16	VL 13
74.	49.07.04	SRI LANKA	PRIMARY	24	VL 14
75.	50.07.02	CAPE/MG, MOZAMBIQUE	PRIMARY	24	VL 15
76.	50.07.03	CAPE/MG, MOZAMBIQUE	SECONDARY	16	VL 16

S.No.	Drawing No.	Locomotive	Type	Nos./Loco	Code
77.	51.07.02	IRAQ	PRIMARY	24	VL 17
78.	51.07.03	IRAQ	SECONDARY	12	VL 18
79.	52.07.02	STD GAUGE	PRIMARY	24	VL 19
80.	52.07.03	STD GAUGE	SECONDARY	12	VL 20
81.	53.07.03	WDM3D, WDM3B	OUTER	16	VL 21
82.	53.07.04	WDM3D, WDM3B	INNER	16	VL 22
83.	54.07.02	YARD GAUGE (Co-Co)	PRIMARY	24	VL 23
84.	54.07.03	YARD GAUGE (Co-Co)	SECONDARY	16	VL 24
85.	56.07.02	YARD GAUGE (Bo-Bo)	PRIMARY	16	VL 25
86.	56.07.03	YARD GAUGE (Bo-Bo)	SECONDARY	12	VL 26
87.	SK.VL235	WCAM3	OUTER (Primary)	16	VL 27
88.	SK.VL236	WCAM3	INNER (Primary)	16	VL 28
89.	SK.VL237	WCAM2	OUTER	16	VL 29
90.	SK.VL238	WCAM2	INNER	8	VL 30
91.	SK.VL239	WCAM2	SNUBBER	8	VL 31
92.	SK.VL240	WAG5HB	OUTER	16	VL 32
93.	SK.VL241	WAG5HB	INNER	16	VL 33
94.	SK.VL 231	WDM3D (Without equalizer)	PRIMARY	24	VL 34
95.	SK.VL 263	1-Co-Co-1	PRIMARY	30	VL 36

S.No.	Drawing No.	Locomotive	Type	Nos./Loco	Code
96.	SK.VL 314	ANGOLA	PRIMARY	24	VL 37
97.	SK.VL 351	SENEGAL	PRIMARY	24	VL 38
98.	VL.FM5 C.04M	WDP3AM (Modified Guide Link)	INNER (Secondary)	16	VL 39
99.	SK.VL 441	Mozambique (Cape Gauge)	OUTER	16	VL 40
100.	SK.VL 442	Mozambique (Cape Gauge)	INNER	16	VL 41
101.	SK.VL 468	A.T.H.S	OUTER	16	VL 42
102.	SK.VL 469	A.T.H.S	INNER	16	VL 43
103.	SK.VL 492	WDP1	INNER (Primary)	16	VL 44
104.	SK.VL 493	WDP1	OUTER (Primary)	16	VL 45
105.	SK.VL 494	WDP1	INNER (Secondary)	12	VL 46
106.	SK.VL 495	WDP1	OUTER (Secondary)	12	VL 47
107.	SK.DL-4514	All BG Locos wherever applicable	Buffer Coil spring LH (BG)	4	LB01
108.	SK.DL-4515	All BG Locos wherever applicable	Buffer Coil Spring RH (BG)	4	LB02
109.	SK.MP-87	ZDM2R, ZDM4A	Pony Truck Spring (Revised Design)	04 forZDM2R, 08 for ZDM4A	MP01
110.	SK.MP-113	ZDM2R, ZDM3, ZDM4A, ZDM5	Bogie Suspension Spring	16	MP02
111.	SK.MP-160	NDM5	Bogie Suspension Spring	16	MP03

Annexure II

PROCEDURE FOR FATIGUE TESTING OF HOT COILED HELICAL SPRINGS USED IN LOCOMOTIVES

1. BACKGROUND

The purpose of fatigue test of the coil spring is to prove that springs meet the expected endurance life. The fatigue test shall be carried out on springs as per the procedure given below.

2. TEST MACHINE

The springs can be tested as single spring or in a fixture together with other springs. The fixture should be designed in such a way that both ends of the spring remain parallel and perpendicular to the loading direction. The end plates of the fixture should not allow spring ends move sideways. Spring pilot on the spring Inner diameter (ID) or guide on the outer diameter (OD) should not be used. The test setup should allow measuring height and load simultaneously. The test machine should be properly calibrated. The machine should have facility to seal the Fatigue Cycle Counters.

Fatigue Testing Setup for Locomotive Springs

3. TEST PREPARATION

- All spring samples should be marked before commencing testing.
- In addition, the following key parameters should be verified in the test machine for each spring individually:

i. Free height

ii. Actual height at the static load specified in the RDSO drawing.

iii. Actual load for the static height specified in the RDSO drawing.

iv. Load Vs. Height curve from free height to stop height and solid height.

4. FATIGUE TESTING

The test should be displacement controlled with the following values:

.1 **Static height of the spring** : As per the relevant RDSO drawing

.2 **Alternating displacement** : ± 30% of the static deflection

.3 The test should not include any lateral displacement loading.

.4 **Frequency for Testing**

The springs should be tested at the highest frequency safely obtainable by the fatigue-testing machine based on the actual displacement values (not less than 2Hz). The frequency at which the spring has been tested shall be recorded.

.5 **Monitoring of testing**

The test machine should be monitored at least once a day to ensure that the test setup is performing well. The actual height for the static load should be recorded for each spring individually for every 2.5 lakh cycles.

.6 **Criteria for Acceptance**

After completion of fatigue test, all springs shall be checked by magna flux testing for any indications of cracks. All spring samples shall satisfactorily complete at least 2 million cycles of fatigue test without any cracks.

.7 **Inspections and Test Report**

After completion of fatigue test, the following parameters shall be verified in the test machine for each spring individually:

i. Free height

ii. Actual height at the static load specified in the RDSO drawing.

iii. Actual load for the static height specified in the RDSO drawing.

iv. Load vs. Height curve from free height to stop height & solid height.

A test report shall be furnished that includes a description of the test, all measured spring data prior to the test, during the test and after the test and a failure analysis for the failed springs.

Annexure III

IMPORTANT TERMS USED IN THE SPECIFICATION

a. **Solid Height** or **Block Length (LB)**

The solid height is the perpendicular distance between the plates of the testing machine when the spring is compressed with a test load to bring all coils in contact, but in no case shall the test load exceed by more than 50% of the load beyond which no appreciable deflection takes place.

b. **Free Height**

The free height is the height of the spring when the load is released completely, and 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 straight edge at the approximate centre of the spring.

c. **Working Height**

The working height is the perpendicular distance between the plates of the spring testing machine when the specified static (working) load has been applied.

d. **Uniformity of Pitch**

The pitch of the coils shall be sufficiently uniform that when the spring is compressed, unsupported laterally to a height representing a deflection of 85% of the nominal total travel, none of the coils shall be in contact with one another, excluding the inactive end coils. Under 85% deflection, the maximum spacing between two adjacent active coils shall not exceed 40% of the nominal free coil spacing. The nominal free coil spacing is equivalent to the specified total travel divided by the number of active coils.

e. **Permanent Set**

The permanent set is the difference, if any, between the free height and the height after the spring has been compressed solid three times with the test load specified in the Para ‘a’ above, measured at the same point and in the same manner.

f. **Nominal Total Deflection of the Spring**

The difference between the nominal free height and solid height of the spring is Nominal Total Deflection of the spring.

g. **Nominal Free Coil Spacing**

Nominal Total Deflection of the Spring divided by the total number of active coil is Nominal Free Coil Spacing.

h. **Working Load**

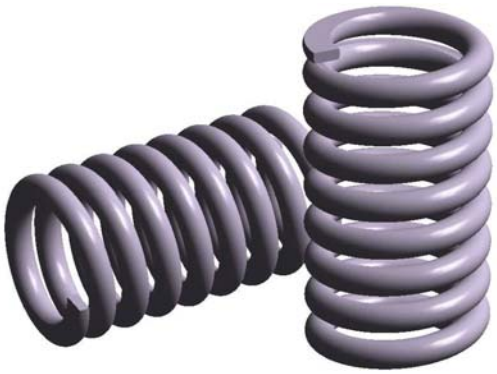
Load coming on the spring under static condition of the locomotive.

R.D.S.O

भारत सरकार, रेल मन्त्रालय

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

TECHNICAL SPECIFICATION OF HOT COILED HELICAL SPRINGS USED IN LOCOMOTIVES



Specification No. MP.0.4900.12

(Revision - 01)

July 2008

Prepared By	Checked By	Approved By
S.P.Govil Asstt. Design Engineer (MP/VDG)	Naresh Kumar Director (MP/VDG)	S.Mani Executive Director (MP)

अनुसंधान अभिकल्प और मानक संगठन
लखनऊ–226 011
RESEARCH DESIGNS & STANDARDS ORGANISATION
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