TENDER SPECIFICATION
FOR
HELICAL COMPRESSION SPRING FOR WAG-9H, WAG-9, WAP-7 & WAP-5 3-PHASE LOCOMOTIVES

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TECHNICAL SPECIFIATION OF HOT COILED HELICAL SPRINGS USED IN LOCOMOTIVES

1. SCOPE:

1.0 This specification is intended to cover requirements of heavy-duty steel springs, which call for strict control in raw material quality, manufacturing processes Testing/Inspection standards so as to have high reliability and life.

1.1 This Specification is applicable to high performance hot-coiled helical compression springs used in the suspension system of 3-Phase Electrical Locomotives WAG-9, WAG-9H, WAP-7 & WAP-5 of Indian Railways, **list included in Annexure** I of this document. It covers springs, which are to be manufactured from circular section bars.

2. DEFINITIONS

- Wherever "Inspecting Official" has been mentioned in this document, it shall be taken as "Authorized Representative of CLW" as mentioned in the Purchase Order.
- The "Hot Coiled Helical Compression Steel Springs used in the suspension system of 3-Phase & Electric Locomotives" shall henceforth be referred to as "springs" in this specification.
- Other terms used in this specification, and their definitions 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. INSTRUCTIONS FOR PURCHASER

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

3.2 Inspection of helical coil springs shall be carried out by CLW/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. REFERENCE DOCUMENTS AND STANDARDS

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

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

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

Sl. No.	Specification	Details
i.	ASTME-112	Test Methods for Determining Average Grain Size.
ii.	ASTME-381	Method of Macrotech Testing of Steel Bars, Billets, Blooms and Forgings
iii.	ASTMA-125	Standard Specification for Steel Springs, Helical, Heat – Treated
iv.	IS:228 (Part 1 to 24)	Methods of Chemical Analysis of the Steels
v.	IS:1500	Method of Brinell Hardness Test for Metallic Materials
vi.	DIN 2089	Helical compression spring made from round wire or rod (Calculation and Design)
vii.	DIN 2096	Helical compression spring made from round wire or rod (Calculation and Design)
viii.	IS:3073	Assessment of Surface Roughness
ix.	IS:3195	Steel for the manufacture of Volute and Helical Springs (for Railway Rolling Stock)
x.	IS:3618	Specification for Phosphate Treatment of Iron and Steel for Protection against Corrosion
xi.	IS:3703	Recommended practice for Magnetic Particle Flaw Detection
xii.	IS:3848	Method for End Quench Test for Hardenability of Steel
xiii.	IS:4163	Method for determination of Inclusion Content in Steel by Macroscopic Method
xiv.	IS:6396	Methods of measuring Decarburised Depth of Steel
xv.	IS:7001	Shot Peening of Steel Parts – Specification
xvi.	IS:7739 Part 5	Code of practice for preparation of Metallographic Specimens -For Iron & Steel and their Examination
xvii.	IS: 7906 Part 5	Specification for hot-coiled springs made from circular section bars
	IS: 7906 Part 7	Quality Requirements for Cylindrical Coil Compression Springs used mainly as Vehicle Suspension Springs
	IS: 7906 Part 8	Method of Inspection of Hot Coiled Compression Springs made from Circular Section Bars
xviii.	IS:9139	Specification for malleable iron shots and grits for use in foundries
xix.	IS:13871	Powder Coating Specification
xx.	UIC-822	Technical Specification for the Supply of Helical Compression Springs, hot coiled, for Tractive and Trailing Stock
xxi.	EN 10089	

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. RAW MATERIAL OF SPRING STEEL RODS

5.1 General

For raw material of spring DIN 17221 has been mentioned in relevant drawing which is now obsolete, therefore the material for springs as applicable to different locomotives shall be as per Annexure-I of this specification:

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

S	:	0.025% (maximum)
P	:	0.025% (maximum)
S & P Together	:	0.040% (maximum)
Sn + Pb + As	:	0.10% (maximum)

However, suppliers may suggest suitable material for the springs before finalization of this specification.

5.1.1 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.

5.1.2 The size of 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 continuous cast billets to the maximum cross-sectional area of the product is ensured to have freedom from “Primary” dendritic structure.

5.1.3 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.

5.1.4 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.

5.2 **Quality of Spring Steel Rounds**

5.2.1 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.

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

Table 1

Steel Grade	**Surface Hardness BHN (Maximum)**	
	Untreated Condition (For reference only)	Annealed Condition
50Cr4V2/51CrV4	310	255
52 $Cr4M_{o2}V$/52CrMoV4	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. However, firm may suggest suitable hardness before finalization of specification.

5.2.3 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.

5.2.4 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 1.5 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. However, firm may suggest suitable value and reference standard for this test before finalization of this specification.

5.2.5 Average grain size of the bar shall be to ASTM No.6 or finer when checked as per ASTM E-112. For material EN 10089 grain size test will be as per 6 or finer to Euro Norm 1.3.

5.2.6 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 or any relevant international standard.

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

The quality of bars shall be checked so as to ensure minimum removal of the material on minor diameter as specified in Clause 6.3.1.

5.2.8 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.

5.2.9 All other conditions shall be as per IS:3195 or DIN 2089. Proper precautions must be taken to ensure safe transportation of hot rolled bars to avoid possible damage during transit.

5.3 **Inspection of Spring Steel Rounds**

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

a) Chemical composition of ladle analysis and product analysis determined as per IS:228 or any relevant international standard.

b) Inclusion Contents or rounds

c) Reduction Ratio

d) Depth of decarburization on rounds

e) Surface Hardness

f) Grain Size

g) Dimensions

h) Miscellaneous

For each cast/heat, the steel manufacturer shall compulsorily submit:

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.

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

a) Size of 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 billets used shall be checked; recorded and verified that minimum reduction ration of 16:1 is ensured for the rolled bars offered for inspection.

5.3.2.1 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 billets with wide end up and hot top cropping of each primary rolled billets etc.

5.3.2.2 Check all other aspects specified in Clause 5.0.

5.4 **Sampling (Random) of Spring Steel Rounds for Tests**

Sl.	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

However, suppliers may suggest suitable relevant specification for above mentioned test before finalization of this specification.

5.4.1 Sample of these tests shall be preserved for at least 24 months and records for at least 5 years for countercheck, as and when required.

5.4.2 The Inspection 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.

5.5 **Acceptance Criteria**

In case the material offered for inspection fails to meet any of the requirements laid down in Clauses 5.1, 5.2 & 5.3, twice the size of the original sample shall be drawn and tested for the parameter(s) for which the original sample has 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 log unserviceable for Railways' use for spring manufacture.

6.0 **MANUFACTURE OF SPRING**

6.1 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 as per drawing or Annexure-I of this specification. 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 shall be taken up for manufacture of the springs. It shall be responsibility of spring manufacturer to ensure quality of spring steel rounds.

6.1.1 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.***

6.2 **Straightening of Spring Steel Rounds**

The bars shall be straightened in the bar straightening machine.

6.3 **Peeling and Centreless Grinding**

6.3.1 The straightened bar shall be peeled and centreless ground. Centreless grinding of peeled bars before coiling is mandatory and the surface finish level of the ground bar shall be 5 microns (µm) Ra values or better in terms of IS:3073.
DIGITAL Surface Roughness Tester shall be used to ascertain the surface finish.

The reduction in the bar diameter after peeling and centreless grinding shall be minimum 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 tolerance on centreless ground steel bar diameter shall be as mentioned in drawing.
The limit for cut of straightness for peeled and centreless ground bars shall be 1mm/meter length (maximum).

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

6.3.3 100% 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 or relevant international standard. Open seams are not acceptable and sub-surface seams i.e. closed seams upto a depth of 1.0 mm from the surface is not acceptable. *Eddy Current Testing Method as an alternative method for checking Surface Defect is not permitted.*

6.3.4 Magnetic Particle Testing facilities shall 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 shall be calibrated with standard blocks before testing of spring bars for comparing the depth of sub-surface defects.*

6.3.5 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.

4.6 **End Tapering**

6.4.1 The ends of peeled and centreless ground bars shall be heated in electrical, oil or gas fired indirectly heated furnace, equipped with temperature controllers and recorders. The temperature, to which the ends of ground bars are to be heated, shall be predetermined depending upon the chemical composition of the material used and bar diameter. The temperature shall be recorded by graphical/digital temperature recorders. There shall be some arrangement for ensuring that the end heating of each bar is done for a certain predetermined period depending upon the type of spring steel.

6.4.2 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). Minimum width of end bearing surface will be two-third of the bar. The tapered faces shall be smooth and shall not have steps/pits/cracks since line contact with the effective coils is required under load. No burrs/sharp edges shall be allowed on the tapered ends to avoid possibility of end biting into the adjacent active coil in service to a probable spring failure.

6.5 Stamping

6.5.1 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 5 mm on bars having wire diameter above 20 mm, and 3 mm for bars having wire diameter 20 mm or less.

6.5.2 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.

1^{st}, 2^{nd} and 3^{rd} character will denote manufacturer identification (like X, Y, Z).
4^{th} and 5^{th} character will denote year of manufacturing (for 20016 will be 1/6 like this).
6^{th}, 7^{th} and 8^{th} will denote Batch No. of the production.
9^{th}, 10^{th} and 11^{th} character will denote last three numbers of drawing number (for example, Identification No. will be 842 for Drg. No.IB011-00842).

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

6.5.3 The record of all the tests/checks conducted on each spring shall be maintained by the manufacturer as per Batch No. for future reference.

6.6 Coiling and Heat Treatment

6.6.1 The spring steel bars with tapered ends shall be heated in an electrically heated or, oil or gas fired indirectly heating walking beam furnace with variable speeds, and soaked for a predetermined period as per the bar diameter and type of spring at that temperature in a controlled atmosphere so that excessive scaling and decarburization do not take place. The temperature of different zones of the furnace shall be measured and recorded to ensure controlled atmosphere.

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

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

Use of high-speed automatic coiling machine as in the STR, is necessary to ensure that the heated material remains in contact with air for minimum possible time so as to a void 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 shall be ensured that as and when contact between the ineffective coils and the adjacent effective coil is made, it shall occur over a minimum length of 1/3rd of mean coil circumference. Moreover, under 85% deflection, the pitch shall generally be uniform.
No water shall be allowed to come in contact with the heated bar at any time.

It shall 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.***

Moving circumferentially along the spring, the gap between inactive coil and first active coil shall gradually increase.

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

It shall 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 6.7.

6.6.4 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 temperature of spring coming out of quenching bath shall not be less than 100 degree centigrade (Preferably in the range 150 to 180 degree centigrade). There shall be an appropriate arrangement to ensure proper maintenance of temperature of the oil bath in the range 45 to 90 degree centigrade. These temperatures shall be specified in the QAP of the manufacturer.

6.6.5 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 shall be oil fired, gas fired or electric indirectly heating with automatic temperature controller and recorder.

6.6.6 In order to ensure uniform heating of springs, it is recommended that each zone of the furnace shall be provided with independent pyrometer for temperature control. The temperature shall be controlled within ±15°C in each zone of the furnace. The temperature of the tempering furnace shall also be maintained within this range of variation. For proper het treatment of springs, the following table shall be used for guidance.

Table 2
Temperatures for Heat Treatment of Springs

Steel Grade	Temperature of spring before quenching (°C)	Tempering Temperature (°C)
50Cr4V2/51CrV4	830 – 860	350 – 350
52 Cr4M_{o2}V/52CrMoV4	830 – 860	350 – 350

6.6.7 The heat treatment shall 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.

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

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

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

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

6.6.9 The hardness of the spring shall 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 decarburized material. The hardness of springs shall be measured at not less than two places, one at each end.

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

6.7 End Grinding

Both the end faces of the spring shall 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 dimension as mentioned in drawing.

The actual ground end surface shall be at least 75% of the mean coil circumference of the spring. The ends shall not have any sharp edges/burrs. Uniform feed rate of springs shall be maintained during end grinding. The end faces of the spring shall no have blue marks due to end grinding as the same leads to temper brittleness. The dimensions of the spring tip thickness shall be maintained as tabulated below:

Sl. No.	Nominal Bar Diameter (d) (mm)	Variation in Tip Thickness over the Cross Section of Spring End (mm)	
		Minimum t_{min}	Maximum t_{max}
1	d ≤ 33	0.25 x d	(0.25 x d) + 5
2	33 < d ≤ 60	0.20 x d	(0.25 x d) + 5

6.8 Scragging

Each and every spring shall be scragged 3 times in quick succession. Scragging load/height shall be as laid down in the relevant RDSO drawing. In case there is no indication in the drawing, the spring shall be scragged home. The scragging load in such cases shall not exceed 1.5 times the working load corresponding to the block length.

6.8.1 The Solid Height or Block Length (LB) of the spring made from centreless ground steel bar shall be measured. Unless otherwise specified in the RDSO drawing, the solid height shall be as follows:

LB < (Total No. of Coils – 0.4) x 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 shall be followed for solid height measurement. The permissible tolerance on the solid height shall be as per relevant para of ASTM A 125 unless otherwise specified in the drawing.

6.8.2 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 shall be maintained.

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

6.9 **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.

6.10 **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 or suitable international standard to improve fatigue life of the spring. During shot peening, it shall be ensured that the springs are shot peened uniformly over the entire area of the springs. The intensity and coverage shall be checked with the help of almen strip in accordance with IS:7001. Almen intensity shall be checked minimum two times per shift of production. The minimum coverage (when checked visually) shall be 90% and intensity when checked with Almen strip Type – A in accordance with IS:7001 shall be minimum 0.40 mm (0.016"). The shots as per IS:4606, grade S-S 1180 shall be used. *Firm may indicate relevant standard for this test before finalization of this specification.*

6.11 **Grouping and Steel Ban 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 CLW drawing. Based on the working height observed, the springs shall be grouped and steel band coded for identification as specified in the relevant CLW drawing. Any spring which is found to defective or which does not confirm to the limits of working height specified in the relevant CLW drawing shall be rejected. One number band (preferably copper strip to be used for spring with plus tolerance and two numbers bands to be used to minus tolerance. **Spring to be supplied same band per loco set wise**.

7.0 **LOAD TESTING**

7.1 The spring placed on a flat rigid metal support shall be subjected to incremental increasing load upto the value indicated in the CLW 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 shall not be more than ± 3% of design deflection value at nominal working load and – 4% / + 6% of design deflection value at other loads.

7.2 The spring stiffness shall be within ±3.4% upto nominal bar diameter upto 18 mm and ±5% beyond 18 mm nominal bar diameter. It shall 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.

7.3 **Lateral Deflection**

When prescribed on the relevant CLW drawing, the lateral deflection characteristics shall be checked as shown in CLW drawing. Tolerance for the lateral load to be suggested by the firm before finalization of this specification.

8.0 HANDLING OF SPRING

The springs shall be properly handled since they are highly stressed components of suspension system. Due care shall 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 shall never be thrown or rolled on the floor at any stage to avoid any damage to them.

9.0 FATIGUE TESTING OF SPRINGS

Fatigue testing of each type of spring shall be done during type testing at the time of initial approval, or when a new design is introduced, or when there has been some significant change in the design or material of the spring or manufacturing process/method. CLW's decision regarding this (i.e. whether fatigue testing is required to be carried out or not), shall be final and binding. Apart from that, CLW may, based upon field performance report, advise any manufacturer or conduct fatigue test of any spring at any time. The manufacturer, on such advice by CLW, shall conduct fatigue testing of that spring.

Type testing of newly designed springs (fatigue testing) shall be done as per the fatigue test scheme enclosed in the Annexure-II.

10.0 INSPECTION OF SPRINGS

10.1 General

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

10.1.1 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.

10.1.2 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 arrangement for carrying out such tests elsewhere and bear the cost of testing.

10.1.3 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.

10.2 **Stage I – Inspection of Raw Material**

Shall be done by the CLW Inspecting Official as per Clauses 5.3, 5.4 and 5.5 of this Specification.

10.3 **Stage II – Inspection during Manufacture**

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

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

10.4 **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.

10.4.1 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.

10.4.2 The Inspecting Official shall carry out the following checks on the finished springs during regular inspection except Sl. No.15, 18 & 19:

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 6.5	..
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	-	As per drawing	...
5.	Parallelism	10% of Lot or 20 springs, whichever is less	-	As per drawing	…

6.	a. End Preparation	10% of Lot or 20 springs, whichever is less	Measurement by Vernier Caliper	As per Clause 6.4 & 6.7	..
			Visual	Tapered faces shall not have steps/pits/ cracks/sharp edges/burrs/blue marks	Radius of tip end also to be checked.
	b. Tip thickness		Vernier Caliper	As per Clause 6.4.3	..
7.	a. Scragging	10% of Lot or 20 springs, whichever is less	Spring Testing Machine	As per Clause 6.8	..
	b. Permanent Set		Gauge	Shall not be more than 3 mm	..
8.	Length off 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 shall steadily increase with increasing load.	..
9.	Static Load Test- Stiffness	10% of Lot or 20 springs, whichever is less	Spring Testing Machine	As per Clause 7.0	..
10.	a. Working Height	10% of Lot or 20 springs, whichever is less	Spring Testing Machine	As per RDSO Drawing	..
	b. Grouping and Steel Band Coding		Spring Testing Machine	As per Clause 6.11	..
11.	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 6.6.3	..
12.	Uniformity of Pitch	10% of Lot or 20 springs, whichever is less	Spring Testing Machine	As per Clause 6.6.3	..

13.	Crack Detection	2% of lot size subject to minimum of 10 springs		-	As per Clause 6.9	Appendix 'B' of Specification UIC-822, both for longitudinal & transverse cracks.
14.	Shot peening	Internal Test Records		-	As per Clause 6.10	IS:7001
15.	Depth of decarburization	2% of Lot or 2 springs, whichever is less		Photo Microscope	As per Clause 6.6.8	IS:6396
16.	Hardness	Core	2% of lot or 2 springs, whichever is less	BHN Hardness Tester	As per Clause 6.6.9	IS:1500
		surface	10% of lot or 20 springs, whichever is less			
17.	Chemical composition	2% of lot or 2 springs, whichever is less	Spectrometer/ Chemical Testing Equipment	Shall conform to material specification given in relevant CLW drawing.	IS:228	
18.	Grain Structure	2% of lot or 2 springs, whichever is less		Photo Microscope	ASTM No.6 or finer	ASTME-112
19.	Macro Etching	2% of lot or 2 springs, whichever is less		Photo Microscope	As per Clause 5.2.3	IS:7739
20	Powder Coating	10% of Lot		DFT to be checked by Elcometer	As per Clause 12.0	IS:3618 & IS:13871

N.B. Removal of powder coating on spring by using some effective method is required before the crack detection test. Use of caustic soda for this purpose shall be avoided.

10.4.3 Tested cut Samples for all the above tests shall be preserved for at least 12 months and Records for 5 years for counter check.

10.4.4 The Spring Manufacturer shall submit certificate ascertaining that "Magnetic Particle Test as per Clause 6.3.3 has been carried out on full length of 100% of the centreless ground bars against particular Purchase Order". This certificate shall be submitted to the inspecting official.

10.4.5 The spring manufacturer shall submit a certificate to the effect that spring steel rounds purchased by the firm against specific purchase order from their approved source as mentioned in QAP (RDSO approved source for indigenous firm) 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.

10.4.6 **Prototype Inspection:**

Prototype Inspection to be done by purchaser for new source or after major changes made in this specification or as decided by purchaser. All the tests mentioned in Para 10.4.2 to be done during prototype inspection. Any additional test may be carried out by Inspector, if it is failed require.

10.4.7 **Consistency Type Test:**

This test may be carried out for any approved supplier at an interval decided by purchaser to check the maintaining of quality. This test will be done as prototype inspection.

10.4.8 Cost of spring for any destructive test will be borne by the purchaser. Therefore, additional numbers of springs as required to be manufactured by the supplier for necessary test

11.0 ACCEPTANCE CRITERIA FOR SPRINGS

11.1 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.

11.2 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.

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

11.4 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.

12.0 PROTECTION AGAINST CORROSION OF SPRINGS

Powder coating as per IS:3618 & 13871 shall be done on the springs for protection of corrosions. Powder coating thickness shall be minimum 80 microns both inside and outside of springs. Powder coating film thickness layer shall be checked by Elcometer. *Any suitable method of protective coating with reference standard may be suggested by the supplier before finalization of this specification.*

13.0 PACKING OF SPRINGS FOR TRANSPORTATION

Packing of springs shall be done properly so as to protect the spring from transportation damage as well as from water etc. Manufacturer shall adopt either of the following two methods, depending upon the agreement with the consignee. In case, the type of packing is not specifically stated in the contract or purchase order, the manufacturer has to compulsorily ensure packing as per Method 'B'.

Method A: Packing with ethylene vinyl acetate sheet bag: Each spring shall be packed in a bag of ethylene vinyl acetate of minimum thickness 1.5 mm. The open end of the bag shall be sealed and folded in the spring ensuring that no portion of the spring remains exposed or likely to get exposed during handling. The individual spring shall then be packed in suitably sized corrugated boxes of triple walled 7 ply virgin Kraft paper (GSM 150-250) and corrugated flutes of grade A or C, as per IS:2771 (Part I), and with minimum bursting strength 16 kgf per sq cm. The joints shall be lapped and glued. The box after packing shall be sealed with water proof sealing tape. Type of spring, spring band, manufacturer's name and P.O. number to be mentioned on packing box.

Method B: Packing with polythene bag: Each spring shall be packed in a polythene bag of 250 micron thickness. The open end of the bag shall be sealed and folded in the spring ensuring that no portion of the spring remains exposed or likely to get exposed during handling. The individual spring shall then be packed in suitably sized corrugated boxes of triple walled 7 ply virgin Kraft paper (GSM 150-250) and corrugated flutes of grade A or C, as per IS:2771 (Part I), and with and with minimum bursting strength 16 kgf per sq cm. The joints shall be lapped and glued. The box after packing shall be sealed with water proof sealing tape.
Transportation of spring in wooden pallets/boxes shall be preferably. Any other precaution in packing as may be deemed fit for safe transportation shall be taken by the spring manufacturer to avoid damage during transportation. Type of spring, spring band, manufacturer's name and P.O. number to be mentioned on packing box.

14.0 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 6.5.2 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 off cost by the manufacturer. No repairing is allowed in the spring if failed.

15.0 FIELD TRIALS

Prototype helical coil spring after successfully passing the prototype tests shall be put under trial for at least one year. Field performance shall be monitored as per format at Annexure-IV. After successful field trial of one year; the firm may be considered for provisional approval in Part-II. The performance of the helical coil springs under field trial shall be monitored up to two years and in that period the performance of the additional helical coil spring kept under extended field trial shall also be monitored. After successful field trial, regular approval in Part-II can be given.

Annexure-I

List of Spring and Alternative Material

Sl. No.	Item Description	Qty. / Loco	Used in Loco	Drg. No.	Alternative material
i)	Secondary outer	8 nos.	WAG-9H	IB011-00842-003	52 Cr MoV4 to EN10089 or 52 Cr4Mo2V to IS:3195:2001
ii)	Secondary inner	8 nos.	WAG-9H	IB011-00842-001	51 Cr V4 to EN10089 or 50 Cr4V2 to IS:3195:2001
iii)	Primary outer	24 nos.	WAG-9H	IB011-00843-003	
iv)	Primary inner	24 nos.	WAG-9H	IB011-00843-001	
v)	Secondary	8 nos.	WAG-9/WAP-7	1209-01-015-010	52 Cr MoV4 to EN10089 52 Cr MoV4 to EN10089 or 52 Cr4Mo2V to IS:3195:2001
vi)	Primary End Axle	16 nos.	WAG-9/WAP-7	1209-01-015-008	51 Cr V4 to EN10089 or 50 Cr4V2 to IS:3195:2001
vii)	Primary Middle Axle outer	8 nos.	WAG-9/WAP-7	1209-01-015-009	
viii)	Primary Middle Axle inner	8 nos.	WAG-9/WAP-7	1209-01-015-009	
ix)	Primary	16 nos.	WAP-5	1210-01.115-007	51 Cr V4 to EN10089 or 50 Cr 4V2 to IS:3195:2001
x)	Secondary	8 nos.	WAP-5	1210-01.015-010	52 Cr MoV4 to EN10089 or 52 Cr4 Mo2V to IS:3195:2001

Annexure-II

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

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 shall 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 shall not allow spring ends move sideways. Spring pilot on the spring Inner diameter (ID0 or guide on the outer diameter (OD) shall not be used. The test setup shall allow measuring height and load simultaneously. The test shall be properly calibrated. The machine shall have facility to seal the Fatigue Cycle Counters.

3. **TEST PREPARATION**

- All spring samples shall be marked before commencing testing.
- In addition, the following key 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 CLW drawing.
  iii. Actual load for the static height specified in the CLW drawing.
  iv. Load Vs. Height curve from free height to stop height and solid height.

4. **FATIGUE TESTING**

The test shall be displacement controlled with the following values:

1. **Static height of the spring :** As per the relevant CLW drawing.
2. **Alternating displacement :** ±30% of the static deflection unless the maximum deflection exceed 85% of the nominal travel. In this case the amplitude shall be limited to +/- (85% of nominal travel minus nominal static deflection).

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

4. **Frequency for Testing**
   The springs shall be tested at the highest frequency safely obtainable by the fatigue-testing machine based on the actual displacement values (Note less than 1.5Hz). The frequency at which the spring has been tested shall be recorded.

5. **Monitoring of testing**

The test machine shall be monitored at least once a day to ensure that the test setup is performing well. The actual height for the static load shall 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 of new design springs.

7. **Inspection 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 CLW drawing.
iii. Actual load for the static height specified in the CLW 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 be 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 different, 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.

Prepared by	Checked by	Reviewed by	Tender Specification for Helical Compression Spring for WAG-9H, WAG-9, WAP-7 & WAP-5 3-Phase Locomotives.	Approved by	Spec. No.
SSE/Drg.	SSE/Drg.	SME/D		Dy.CEE/D-II	**CLW/MS/3/SPEC/004**
					Alt. No.

ANNEXURE-IV

Proforma for field trial scheme of hot coiled helical spring used in locomotives.

Sl. No.	Loco No.	Make of spring	Date of putting in service in loco	Railway	Initial static height of springs	Static height of springs after one year (Tolerance referred in RDSO Drg.)		Detection of any crack during visual check including sound tapping test		Date of failure for any reason (if any)	Reason for failure	Remarks
						Date	Spring height	Date	Crack location			

Prepared by	Checked by	Reviewed by		Approved by	Spec. No.
SSE/Drg.	SSE/Drg.	SME/D	Tender Specification for Helical Compression Spring for WAG-9H, WAG-9, WAP-7 & WAP-5 3-Phase Locomotives.	Dy.CEE/D-II	**CLW/MS/3/SPEC/004**
					Alt. No.