SPECIFICATION FOR
HOT COILED HELICAL COMPRESSION SPRING
FOR USE ON WAG-9, WAG-9H, WAP-7 & WAP-5
3-PHASE ELECTRIC LOCOMOTIVES OF INDIAN RAILWAY

CLW DRAFT SPECIFICATION

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DETAILS OF ALTERATION

ALT. No.	DATE	DESCRIPTION	REASON	SIGNATURE
1	15.11.2017	Drg. No.1209-01.015-008 is to be corrected as 1209-01.115-008 & Drg. No. 1209-01.015-009 is to be corrected as 1209-01.115-009 appeared in page no. 22 of 26 (Annexure-I).	Due to over sight	Sd/- 15.11.2017
2	26.12.2024	Para 6.11 at page no.15 of 26 revised. At Annexure-I CLW Drg. No. allotted to WAG-9H loco.	Steel Band coding replaced by Colour coding. Digitized CLW Drg. is allotted.	Sd/- 26.12.2024
3.	04.09.2025	i) Annexure-IV deleted. ii) In para 14.0, "Field performance shall be monitored as per format at Annexure-IV" deleted.	Static Height of spring can be checked during IOH/AOH as per Sr. DEE/TRS/WAT, dtd. 17.04.2024.	Sd/- 04.09.2025

Specification has been digitized and all alterations have been incorporated.

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TECHNICAL SPECIFICATION FOR HOT COILED HELICAL COMPRESSION SPRING FOR USE ON WAG-9, WAG-9H, WAP-7 & WAP-5, 3-PHASE ELECTRIC LOCOMOTIVES

1.0 SCOPE:

1.1 This specification is intended to cover technical requirements of heavy-duty steel springs. There are requirements for strict control in raw material quality, manufacturing processes Testing/Inspection standards for reliability and long service period.

1.2 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 as per the list included in Annexure-I of this document. It covers the springs, which are to be manufactured from circular section bars.

2.0 DEFINITIONS:

- Wherever "Inspecting Officer" 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".

3.0 INSTRUCTIONS FOR PURCHASER:

3.1 The tenderer shall be 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 or specified inspection agency. 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.

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 at spring manufacturer's premises or steel manufacturer's premises to ensure their proper & prescribed quality and to avoid non-conformance/ failure of final product (i.e. springs) during inspection and service. Only spring steel rounds duly inspected and cleared by purchaser shall be used for manufacturing of springs.

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

Sl. No.	Specification		Details
1.	ASTME-112		Test Methods for Determining Average Grain Size.
2.	ASTME-381		Method of Macrotech Testing of Steel Bars, Billets, Blooms and Forgings.
3.	ASTMA-125		Standard Specification for Steel Springs, Helical, Heat –Treated.
4.	IS:228 (Part 1 to 24)		Methods of Chemical Analysis of the Steels.
5.	IS:1500		Method of Brinell Hardness Test for Metallic Materials.
6.	DIN 2089		Helical compression spring made from round wire or rod (Calculation and Design).
7.	DIN 2096		Helical compression spring made from round wire or rod (Calculation and Design).
8.	IS:3073		Assessment of Surface Roughness.
9.	IS:3195		Steel for the manufacture of Volute and Helical Springs (for Railway Rolling Stock).
10.	IS:3618		Specification for Phosphate Treatment of Iron and Steel for Protection against Corrosion.
11.	IS:3703		Recommended practice for Magnetic Particle Flaw Detection.
12.	IS:3848		Method for End Quench Test for Hardenability of Steel.
13.	IS:4163		Method for determination of inclusion Content in Steel by Macroscopic Method.
14.	IS:6396		Methods of measuring Decarburized Depth of Steel.
15.	IS:7001		Shot Peening of Steel Parts-Specification.
16.	IS:7739 Part 5		Code of practice for preparation of Metallographic Specimens-For Iron & Steel and their Examination.
17.	IS:7906	Pt.5	Specification for hot-coiled springs made from circular section bars.
18.		Pt.7	Quality Requirements for Cylindrical Coil Compression Springs used mainly as Vehicle Suspension Springs.
19.		Pt.8	Method of Inspection of Hot Coiled Compression Springs made from Circular Section Bars.
20.	IS:9139		Specification for malleable iron shots and grits for use in foundries.
21.	IS:13871		Powder Coating Specification.
22.	UIC-822		Technical Specification for the supply of Helical Compression Springs, hot coiled for Tractive and Trailing Stock.
23.	EN 10089		Hot rolled steel for quenched and tempered springs.
24.	EN 13298		Railway applications - Suspension components - Helical suspension springs, steel.

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4.4 The reference to the ASTM / IS / UIC, DIN, EN, ISO specifications quoted herein shall be taken as the reference to the latest version of these specifications and shall be available with the firm.

4.5 Specific provisions in this specification will override those in the above ASTM / IS / UIC, DIN, EN, ISO specifications where these are not in conformity.

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

5.0 RAW MATERIAL OF SPRING STEEL RODS:

5.1 GENERAL:

The 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 for trace elements shall be maintained for all the grades given below:

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

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 during peeling/centreless grinding and scaling, and 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 or any other alternative method.

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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 or specified in relevant specification:

Table 1: Hardness of Spring Steel

Steel Grade	Surface Hardness BHN(Maximum)	
	Untreated Condition (For reference only)	Annealed Condition
50Cr4V2/51CrV4	310	255
52Cr4MO2V/52CrMoV4	310	255

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. Any other international suitable standard like ASTM E-45 or DIN 50602 also may be considered.

5.2.5 Average grain size of the bar shall be to ASTM No. 6 or finer when checked as per ASTM E-112 or any other suitable relevant international standard (ISO:643) may be considered.

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 2.0 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.

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5.3 INSPECTION OF SPRING STEEL ROUNDS:

Apart from the documents pertaining to the steel manufacturing & refining details, 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 other 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 must 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 ratio of 16:1 is ensured for the rolled bars offered for inspection.

5.3.2 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.

5.3.3 Check all other aspects specified in Clause 5.

5.4 SAMPLING (RANDOM) OF SPRING STEEL ROUNDS FOR TESTS:

Sl. No.	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 Decarburization	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 bar per heat per section.

However, any other suitable international standard may also be considered.

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5.4.1 Sample of these tests shall be preserved for at least 12 months and records for at least 3 years from date of dispatch for crosscheck, as and when required.

5.4.2 The inspection official may pick up two samples per 500 tons of material offered and send the same to approved agency for confirmatory test for chemical and metallurgical properties at Spring Steel at Manufacturer's expense. This test should not form part of purchase acceptance test but will only serve as a cross examination 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' and 'rejected'. The manufacturer shall then undertake to render the log unserviceable for Railway use.

6.0 MANUFACTURE OF SPRING:

6.1 GENERAL:

The shape and dimension of locomotive springs manufactured shall conform to the relevant RDSO/CLW or approved 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 conforming to the specified standards, it shall be taken up for manufacturing 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.

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 grinding of peeled bars before coiling is mandatory. The surface finish 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, if the extent of peeling is not 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 out during straightening process for peeled and centreless ground bars shall be limited to 1mm/meter length (maximum).

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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 also permitted provided state of the art facilities are available.

6.3.4 Magnetic Particle Testing facilities shall be sufficient to accommodate spring bars of 6.0 m 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.

6.4 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 or induction heater, duly equipped with online 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 adequate 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 optimum 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 which is a cause of failures.

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6.5 MARKING 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.

1st, 2nd and 3rd character will denote manufacturer identification (like X, Y, Z).
4th and 5th character will denote year of manufacturing (for 2016 will be 16 like this).
6th, 7th and 8th will denote Batch No. of the production.
9th, 10th and 11th character will denote last three numbers of drawing number.
(for example, Identification No. will be 028 for Drg. No. 1209-01.115-028).

It shall be ensured that proper records traceability of springs from raw material to finished product stage is maintained and preserved for minimum 3 years.

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 at least for 3 years from date of dispatch.

6.6 COILING AND HEAT TREATMENT:

6.6.1 The spring steel bars with tapered ends shall be heated electrically or oil or gas fired indirectly heating in Walking Beam Furnace with variable speeds, and soaked for a predetermined period as per the bar diameter and type of spring. The temperature should be 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 or induction heater 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 & PITCHING:

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

6.6.3.2 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 drawing. When it is not specified, the direction of coiling shall be to the "right hand".

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6.6.3.3 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 $1/5^{th}$ of mean coil circumference. Moreover, under 85% deflection, the pitch shall generally be uniform.

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

6.6.3.5 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 does not bite the effective coil under load as well as under no load.

6.6.3.6 End gap between 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 to be maintained. Moving circumferentially along the spring, the gap between inactive coil and first active coil shall gradually increase.

6.6.3.7 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.

6.6.3.8 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.

6.6.3.9 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 is to be maintained within the predetermined limit to ensure optimum quenching conditions. The temperature of spring coming out of quenching bath shall not be less than 100 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.

6.6.3.10 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 specified spring hardness throughout the section. The furnace shall be oil fired/gas fired/electric indirectly heating with automatic temperature controller and recorder.

6.6.3.11 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. The following table shall be used for guidance.

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Table 2: Temperature for Heat Treatment of Spring

Steel Grade	Temperature of spring before quenching (°C)	Tempering Temperature (°C)
50Cr4V2/51CrV4	830 – 860	350 – 550
52Cr4Mo2V/52CrMoV4	830 – 860	350 – 550

6.6.3.12 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-112or any other suitable relevant international standard. The tempered martensitic distribution across the complete cross section of the active coil of the Chrome Molybdenum spring steel. Martensitic distribution shall not be less than as specified above.

6.6.3.13 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.

6.6.3.14 The hardness of the spring shall be in the range of 415 to 460 BHN or to be maintained as per tensile strength mentioned in each relevant drawing. 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 placing the spring on its base and measuring the same along the outer circumference from a perpendicular to the surface plate on which spring is placed. This will be done by a suitable measuring device 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 not 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:

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Table 3: Dimension of Spring Tip Thickness

Sl. No.	Nominal Bar Diameter (d) (mm)	Variation in Tip 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 spring shall be scragged 3 times in quick succession. Scragging load/height shall be as laid down in the relevant 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 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. During 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.

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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. UIC 822 or EN 13298 may also be considered.

6.11 GROUPING AND COLOUR 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 tolerance specified in the CLW drawing. Based on the working height observed, the springs shall be grouped and colour coded for identification as specified in the relevant drawing. Any spring which is found to defective or which does not confirm to the limits of working height specified in the relevant drawing shall be rejected. Yellow colour preferably to be used for spring with plus(+) tolerance and Red colour to be used to minus(-) tolerance. Spring to be supplied with same colour 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 drawing on Spring Testing Machine. Each load is to be maintained till the load is stabilised. The corresponding height of the spring (under load) is determined. The tolerance in 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 or as per chapter 5.2.3.1 to EN 13298.

7.3 LATERAL DEFLECTION:

When prescribed on the relevant drawing, the lateral deflection characteristics shall be checked as per drawing. Tolerance may be considered as guidance ± 25% of specified value for load or displacement. Suitable arrangement for this test to be described in QAP.

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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, spring shall never be thrown or rolled on the floor at any stage to avoid damage to them.

9.0 FATIGUE TESTING OF SPRINGS:

Fatigue testing of each type of spring shall be done during type testing or with new introduced design or significant changes in the design or material of the spring or manufacturing process/ method, purchaser's decision shall be final. Also, purchaser may advise any manufacturer to conduct fatigue test any time. The manufacturer, on such advice shall also 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 in nominated agencies and bear the cost of testing.

10.1.3 The finished spring shall be offered for inspection in batches of not more than 500 springs. The springs shall be offered 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.

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10.2 Stage I : Inspection of Raw Material:

This shall be done by the nominated 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 test 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 Inspecting 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 Routine Inspection Schedule:

The Inspecting Official shall carry out the following checks on the finished springs during regular inspection.

Sl. No.	Check performed	Sample Size	Equipment Used	Acceptable Limits	Remarks
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 lesser	Visual	As per Clause 6.5	
3	Free Height	10% of Lot or 20 springs, whichever is lesser	Gauge	As per Drawing	
4	Out of Squareness	10% of Lot or 20 springs, whichever is lesser	-	As per Drawing	
5	Parallelism	10% of Lot or 20 springs, whichever is lesser	-	As per Drawing	

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6	a. End Preparation	10% of Lot or 20 springs, whichever is less	Measurement by Vernier Caliper	As per Clauses 6.4 & 6.7	
			Visual	Tapered faces shall not have steps/ pits/ cracks/sharp edges/ butts/blue marks	Radius of tip end also to be checked
	b. Tip thickness		Vernier Caliper	As per Clauses 6.4 & 6.7	
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 of contact area between inactive coil & active coil at working load	10% of Lot or 20 springs whichever is less	Spring Testing Machine	Para 6.6.3	
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 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	

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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 decarburi-zation	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	Spectro-meter/ Chemical Testing Equip-ment	Shall conform to material specification given in relevant CLW drawing	IS:228	
18	Grain Structure	2% lot or 2 springs whichever is less		Photo Microscope	ASTM No.6 or finer	ASTME-112
19	Macro Etching	2% 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.: i) Removal of powder coating on spring by using effective method is required before the crack detection test. Use of caustic soda for this purpose shall be avoided.
ii) Any other suitable international relevant standard may also be considered.

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PREPARED BY	CHECKED BY	APPROVED BY
SSE/DRG. (MECH.)	AME/D&D	DY. CME/D&D

10.4.3 Tested cut Samples for all the above tests shall be preserved for at least 12 months and records for 5 years from date of dispatch for cross examination.

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 (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 felt/required.

10.4.7 Consistency Type Test:

This test may be carried out for any approved supplier at a suitable interval decided by purchaser to check the consistency in quality. All tests will be done as per 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 spring do not get mixed up with the other springs/passed springs at any stage.

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12.0 PROTECTION AGAINST CORROSION OF SPRINGS:

Powder coating as per IS: 3618 & IS: 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, suitable international standard may also be used for priming by phosphate treatment followed by powder coating or paint of minimum 40 micron thick, colour jet black (RAL 9005 or equivalent).

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. the manufacturer has to compulsorily ensure packing as per Method described below.

Method: 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 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 preferable. 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 FIELD TRIALS:

Prototype helical coil spring after successfully passing the prototype tests shall be put under trial. 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.

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Annexure-I

List of material for springs

Sl. No.	Item Description	Qty./ Loco	Used in Loco	Drg. No.	Alternative material
i)	Secondary outer	8 Nos.	WAG-9H	1209-01.115-028	52 Cr MoV4 to EN10089 or 52 Cr4Mo2V to IS:3195:2001
ii)	Secondary inner	8 Nos.	WAG-9H	1209-01.115-028	51 Cr V4 to EN10089 or 50 Cr4V2 to IS:3195:2001
iii)	Primary outer	24 nos.	WAG-9H	1209-01.215-027	
iv)	Primary inner	24 Nos.	WAG-9H	1209-01.215-027	
v)	Secondary	8 Nos.	WAG-9/WAP-7	1209-01-015-010	52Cr MoV4 to EN10089 or 52 Cr4 Mo2V to IS:3195:2001
vi)	Primary End Axle	16 Nos.	WAG-9/WAP-7	1209-01-115-008	51 Cr V4 to EN10089 or 50 Cr4V2 to IS:3195:2001
vii)	Primary Middle Axle outer	8 Nos.	WAG-9/WAP-7	1209-01-115-009	
viii)	Primary Middle Axle inner	8 Nos.	WAG-9/WAP-7	1209-01-115-009	
ix)	Primary	16 Nos.	WAP-5	1210-01-115-007	51Cr V4 to EN10089 or 50 Cr4V2 to IS:3195:2001
x)	Secondary	8 Nos.	WAP-5	1210-01-015-010	52Cr MoV4 to EN10089 or 52 Cr4Mo2V to IS:3195:2001

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PREPARED BY	CHECKED BY	APPROVED BY
SSE/DRG. (MECH.)	AME/D&D	DY. CME/D&D

Annexure-II

PROCEDURE FOR FATIGUE TESTING OF HOT COILED HELICAL COMPRESSION 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 (ID) 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 drawing.
  iii. Actual load for the static height specified in the 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:

i) Static height of the spring **:** As per the relevant drawing.

ii) 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".

iii) The test shall not include any lateral displacement under loading.

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iv) 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 (Not less than 1.5 Hz). The frequency at which the spring has been tested shall be recorded.

v) 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.

vi) 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.

vii) Inspection and Test Report:

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

a) Free height.
b) Actual height at the static load specified in the drawing.
c) Actual load for the static height specified in the drawing.
d) 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.

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Annexure-III

IMPORTANT TERMS USED IN THE SPECIFICATION:

i) 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.

ii) 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.

iii) 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.

iv) 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.

v) 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.

vi) 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.

vii) Nominal Free Coil Spacing:
Nominal Total Deflection of the spring divided by the total number of active coil is Nominal Free Coil Spacing.

viii) Working Load:
Load coming on the spring under static condition of the locomotive.

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