



BEML LIMITED BANGALORE

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Procurement Technical Specification for Helical Coil Springs

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1. Introduction

This document describes the technical requirements of helical coil springs for Mumbai Metropolitan Regional Development Authority (MMRDA), hereafter MRS1 project. The helical coil springs shall comply in all respects with Employer's Requirements General Specifications (ERGS) & Employer's Requirements Technical Specifications (ERTS).

BEML shall carry out all required works and activities as contractor for MRS1 project, while supplier shall be responsible for all works required in this PTS with regard to helical coil springs and shall be responsible for supporting the BEML activities.

2. General Specifications

The supplier shall supply helical coil springs with necessary subsidiary materials to ensure its functionality. The supplier shall have responsibility for investigation & consideration of suitability of Helical Coils springs for the environmental condition specified in ERTS.

The scope of work covers design, development, manufacture & supply, testing & commissioning and training of operation and maintenance personnel of the Employer and includes all items of work which may be required to meet the performance requirements, trouble free and efficient operation of trains and meeting the best international practices even if not specifically mentioned in the PTS and/or in ERTS section-1.1.3 (i) to (ix) and ERTS 1.1.7.

The scope also covers supply of spares, special tools, testing and diagnostic equipment, jigs and fixtures for maintenance, repair and overhaul.

The subcontractor shall comply with GTC, ERGS, PTS and chapter - 1, 2, 3, 5, 14 & 15 of ERTS to a minimum.

2.1. Car configuration

The configuration of train formation is as follows.

DM: Driving Motor Car, M: Non-driving Motor Car, T: Trailer Car with pantograph

- *DM - T - M- - (3 car unit formation)
- *DM - T - M - M - T - DM* - (6 car train formation)

For increase in quantity (If required)

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- - T - M - (2 car train formation)
- *DM - T - M - M - T - DM* - (6 car train formation)

2.2. Car Weight

The subcontractor shall make all attempts in reducing the weight of the equipment as specified in the ERTS 3.21.3 to minimize energy costs, whilst meeting specified structural and performance requirements.

Approximate car weights and train configuration are show below:

	DMC	TC	MC
Tare (AW0)	≤ 42,000 kg	≤ 41,000 kg	≤ 42,000 kg
Crush	≤ 68,000 kg	≤ 68,000 kg	≤ 68,000 kg
Max. Dynamic	≤ 95,200 kg	≤ 95,200 kg	≤ 95,200 kg
Axle Load	17,000 kg	17,000 kg	17,000 kg

2.3. Vehicle performance

The subcontractor shall meet vehicle performance requirements as specified in section-3.22 of ERTS.

Item		All Corridors
Safe speed	With inflated secondary suspension	90 kmph
	With deflated secondary suspension	80 kmph
Maximum operational speed	With inflated secondary suspension	80 kmph
	With deflated secondary suspension	70 kmph
Minimum Design Average Acceleration rate for fully loaded (AW3) train on level tangent track shall be as under: 0 kmph to 40 kmph 0 kmph to 60 kmph 0 kmph to 80 kmph		1.0 m/s ² 0.75 m/ s ² 0.40 m/ s ²
Minimum Operational Average Acceleration rate for AW2 loaded train on level tangent track shall be as under: 0 kmph to 35 kmph 0 kmph to 60 kmph 0 kmph to 80 kmph		1.20 m/ s ² 0.80 m/ s ² 0.45 m/ s ²
Average Service braking rate from 80 kmph to standstill for fully loaded (AW3) train on level tangent track.		1.0 m/ s ²
Average Service braking rate from 80 kmph to standstill for AW2 train on level tangent track.		1.1 m/ s ²

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Average Emergency braking rate from 80 kmph to 0 kmph for fully loaded trains on level tangent track	1.3 m/ s ²
Jerk rate (Maximum)	0.75 m/ s ³
Annual running distance of one train (for design purpose)	150,000 km
The specified average minimum acceleration shall be the finally achieved values inclusive of the specified jerk rate. Test procedure has been specified in Chapter 15 of ERTS.	

2.4. Wheel diameter

Wheel Diameter (New)	860 mm
Wheel Diameter (Half Worn)	820 mm
Wheel Diameter (Fully Worn)	780 mm

2.5. Track parameters

The subcontractor shall use track parameters as specified in section-3.14 & 3.15 of ERTS for designing of coil springs to be used for MRS1 project.

Description	Elevated and At-grade Corridor		Underground Corridor
	Ballasted	Ballast less (DFF)	Ballast less (DFF)
Track Laying Gauge	1435 mm		
Rail Type (Main Line & Depot)	60 EI (UIC 60) 880/HH	60 EI (UIC 60) 1080/HH	60 EI (UIC 60) 1080/HH
Rail Profile	UIC 861-3		
Inclination Of Rail	1 in 20		
Sleeper Spacing (Main line)	600 mm ± 10mm	600 mm ± 10mm	700 mm ± 10mm
Sleeper Spacing (Depot)	650 mm ± 10mm	Not applicable	
Ballast Cushion Depth(Main line)	300mm	Not applicable	
Ballast Cushion Depth (Depot)	250mm	Not applicable	
Standard Rail Length	13m and 18m	18m	
Rail Panel Lengths	Longer than 200m		
Minimum Radius of Curvature	200m-Underground 110m-Elevated 100m-Depot		

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Minimum Turn out Radius.- (Main line)	1 in 9 - 300m radius 1 in 7- 190m radius		
Minimum Turn Out Radius Depot	1 in 7 - 190m radius		
Maximum Cant Permissible	110 mm		
Maximum Cant Desirable	110 mm		
Maximum Cant Deficiency Permissible	85mm		
Maximum Cant Deficiency Desirable	85 mm		
Maximum Permissible Cant Gradient	1 in 440		
Maximum Desirable Cant Gradient	1 in 720		
Turn-out Speed : Turnout (1 in 9) R-300	45 km/h	45 km/h	40 km/h
Turn-out Speed : Scissors (1in 9) R-300	45 km/h	45 km/h	40 km/h
Turn-out Speed : Depots (1in 7) R-190	35 km/h	35 km/h	25 km/h
Turn-out Speed : Turnout (1 in 7) R-190	35 km/h	35 km/h	25 km/h
Turn-out Speed : Turnout(1 in 12) R-410	50 km/h	50 km/h	50 km/h
Turn-out Speed : Turnout(1in 12) R-410	50 km/h	50 km/h	50 km/h
Turn-out Speed : Turnout (1in8.5) R-218	30 km/h	30 km/h	30 km/h
Turn-out Speed : Turnout(1in8.5) R-218	30 km/h	30 km/h	30 km/h
Maximum Gradient Main Line	4%		
Maximum Gradient Depot Connection	4%		
Minimum vertical curve radius of curvature	1500m		

2.6. Climatic Conditions

The subcontractor shall supply coil springs to satisfy climatic & environmental conditions as specified in section- 3.10 & 3.11 of ERTS.

Description	Limiting Values
Maximum ambient temperature (See note below)	36°C
Minimum temperature	14.3°C
Humidity	≥ 95% RH
Rainfall	The annual precipitation is 2,078 mm with 34 % (709mm) falling in the month of July.
Atmosphere during hot season	Extremely dusty including bird feathers
Maximum wind speed	150 km/h

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Description	Limiting Values
Vibration and Shocks	The subsystems & their mounting arrangements shall be designed to withstand satisfactorily the vibration and shocks encountered in service as specified in IEC 61373 and IEC 60571.
SO2 level in atmosphere	80 – 120 micro gram/m3
Suspended particulate matter in atmosphere (TSPM)	360 – 540 micro gram/m3
Flood Proofing	The traction sub-systems mounted on the under-frame will be designed to permit propulsion of the train at 10 kmph through water up to a depth of 50mm above rail level. Traction sub-systems shall be made splash proof in accordance with International Standards
Life	The Metro car is designed for min.35 year of life. Accordingly, the subject items & accessories shall also not deteriorate in their performance for 35 years

Note:

- The temperature of the metal surfaces of the vehicles when exposed directly to the sun, for long periods of time, may be assumed to rise to 70°C.
- Any moisture condensation shall not lead to any malfunction or failure.
- Adequate margin shall specially be built into the design particularly to take care of the higher ambient temperatures, high humidity, dusty and corrosive conditions, etc. prevailing in Mumbai area.

2.7. Principal notional vehicle dimensions

Description	Dimension	
Gauge	1,435 mm	
Maximum Length over body(including end-fairings)	DM car	22,010 mm
	T and M cars	22,010 mm
Maximum Length over couplers for all cars	23,000 mm	
Maximum Width over Body	3,200 mm	
Minimum Passenger Saloon Headroom	2,050 mm	
Locked down pantograph height for 25kV AC cars from rail level at Car Centre Line	4,048 mm	

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Description		Dimension
Maximum Floor height above rail level of any unloaded vehicle		1,130 mm
Minimum Floor height above rail level of fully loaded vehicle		1,100 mm
Maximum height of coupler above rail level for unloaded vehicle		815 mm
Minimum height of coupler above rail level for fully loaded vehicle		740 mm
Bogie Wheel Base	Maximum	2400 mm
	Minimum	2200 mm
Distance between bogie centers	Maximum	15,100 mm
	Minimum	14,400 mm
Wheel diameters	New	860 mm
	Fully worn	780 mm
Maximum Axle load		17 Ton (including all tolerances as per IEC 1133-1992)

2.8. Unclear Aspects

If any term/clause/definition is unclear in this specification, supplier shall seek clarifications from design team in BEML, prior to signing the contract, to confirm the same.

After signing the contract, supplier shall follow the definition and opinion of design team in BEML.

2.9. Responsibility of subcontractor

The supplier shall be responsible for design, manufacture, supply and performance of helical coil springs to BEML. The responsibility of BEML as a contractor for helical coil springs in MRS1 project as per requirements of GCC, ERGS & ERTS shall be obligatory for subcontractor.

The subcontractor shall seek information from BEML for all interfaces between coil springs and related equipments of bogie required by supplier for meeting design & performance requirements.

The subcontractor shall provide BEML with all interface related information in detail as requested by other system/equipment manufacturer for interface compatibility, as & when required and in a time bound manner.

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2.10. Precedence of Documents

Subcontractor should read PTS in conjunction with the General Terms & Conditions (GTC) of BEML tender, ERGS and ERTS. To the extent that any provision of the PTS is inconsistent with any provision of the GTC, the provisions of the GTC shall prevail.

To the extent that any provision of GTC is inconsistent with any provisions of the ERGS and ERTS, the provisions of ERTS & ERGS shall prevail.

This PTS in no way relieves the supplier from any requirements specified in the technical specification. The complete requirements are those found in the previously mentioned documents, it shall be the subcontractor's responsibility to ensure that equipment, documentation, and services furnished against this PTS are in full compliance with all the above documents.

However, if conflict is found among any of the above documents, the following order of priority shall govern:

Order of Precedence	Document Title
1	ERTS, ERGS
2	GTC
3	PTS

2.11. Standards

- 1) The design, manufacture & testing of the proposed aggregates by subcontractor shall conform to the latest editions of UIC/EN standards or equivalent international standards on first priority. Metric system with SI units shall be used wherever applicable
- 2) The subcontractor's own standards shall be on second priority. The subcontractor shall request and justify with reasonable, sufficient & necessary support documents for choosing alternate standards as compared to UIC/EN/any other international standards.
- 3) BEML/Employer reserves the right to accept or reject any such request (s).
- 4) Following are some of the standards applicable for helical coil springs:

STANDARD	DESCRIPTION
EN 13298	Railway Applications- Suspension Components - Helical Suspension Springs - Steel
EN 10089	Hot-rolled steels for quenched and tempered springs - Technical

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	delivery conditions
IS 3618	Specification for Phosphate Treatment of Iron and Steel for protection against corrosion
IS 13871	Powder Coating - Specifications
ISO 4288	Geometric Product Specification (GPS) — Surface texture — Profile method: Rules and procedures for the assessment of surface texture
IS 7906 -5	Helical Coil Springs - Hot Coiled Springs Made From Circular Section Bars — Specification
ASTM E-112	Standard Test Methods for Determining Average Grain Size
ISO 2808	Paints and varnishes — Determination of film thickness
ISO 2064	Metallic and other inorganic coatings –Definitions and conventions concerning the measurement of thickness
ISO 2409	Paints and varnishes — Cross-cut test
EN ISO 6506-1	Metallic materials — Brinell hardness test
EN ISO 6508-1	Metallic materials — Rockwell hardness test
ISO 3887	Steels — Determination of the depth of decarburization
ISO 643	Steels — Micrographic determination of the apparent grain size
EN ISO 6892-1	Metallic materials — Tensile testing
EN ISO 148-1	Metallic materials - Charpy pendulum impact test
DIN 2089 T1	Helical coil springs made from round wire and rod
DIN EN 13906	Cylindrical Helical springs made from round wire and bar

Apart from the stated standards, subcontractor shall specify the standards used in the design, manufacture, analysis, quality and testing of helical coil springs.

3. Definitions and Abbreviations

3.1. Definitions

The following definitions are applicable:

- “MMRDA/DMRC” means the Employer for the Mass Rapid Transport System (MRTS) in Mumbai.
- "MMRDA/DMRC Representative" mean such persons appointed by MMRDA / DMRC to act as Engineer for the purpose of MRS1 project.
- “BEML” means the contractor to procure the helical coil springs for MRS1 project.
- "Supplier/Subcontractor" means the supplier of helical coil springs to BEML.
- "PTS" means Procurement Technical Specifications.

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3.2. Abbreviations

The following abbreviations shall be used as applicable:

- GTC: General Terms and Conditions of contract of BEML
- ERGS: Employer's Requirement General Specifications
- ERTS: Employer's Requirement Technical Specifications
- PTS: Procurement Technical Specifications
- MMRDA: Mumbai Metro Rail Development Authority
- DMRC: Delhi Metro Rail Corporation
- RAMS: Reliability, Availability, Maintainability & Safety
- ISO: International Standard Organization
- MDBF: Mean distance between failures
- MDBCF: Mean distance between component failures.
- LCC: Life cycle cost
- LRU: Line Replaceable Unit
- DLP: Defect liability period
- OEM: Original Equipment Manufacturer
- MRTS: Mass Rapid Transport System
- CG: Center of Gravity
- MTTR: Mean Time to Repair
- FAI: First Article Inspection
- QAP: Quality Assurance Plan
- RDSO: Research Design & Standards Organization
- O&M :Operation & Maintenance

4. Qualifying Criteria & Vendor Approval

The subcontractor shall satisfy the following conditions:

- 1) Subcontractor should be a reputed OEM of the proposed aggregate for Metro Railway Rolling stock and should have capability to design & manufacture and testing & commissioning. The firm shall submit company profile and the infrastructure details

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along with the technical bid.

- 2) The subcontractor shall meet the qualification criteria mentioned in ERTS 3.2.2 for supply of helical coil springs. Proposed helical coil springs shall have been in use and have established their satisfactory performance and reliability on at least three mass rapid transit systems in revenue service over a period of three years or more (in each MRTS) either outside the country of origin in three different countries or in an MRTS in India.
- 3) The supplier shall submit certificate of satisfactory performance & reliability from metro operators/end-users for a period of 3 years or more along with technical offer for proposed aggregates.
- 4) The subcontractor shall provide necessary documents for obtaining vendor approval for helical spring as per ERTS 3.2.5
- 5) The submissions for vendor approval may require further modifications, additional documents & updates based on BEML/Employer feedback. The subcontractor shall provide the same within 5-7 working days to BEML/Employer.
- 6) The vendor approval format is attached as an enclosure to this document (Annexure - 4)
- 7) Vendor approval is mandatory for all the subcontractors. Only approved vendors are considered for the supplies. The acceptance of technical offer by BEML submitted by subcontractor is subject to approval of Employer.
- 8) The subcontractor should undertake to provide support during testing & commissioning, service trials, revenue service and DLP period either by themselves or through sister company or a partner in India. The subcontractor shall submit detailed proposal in this regard.
- 9) The supplier shall undertake to provide complete details & information to BEML, for all such items in his proposed equipments/aggregates for which he is not an OEM.
- 10) The subcontractor should give an undertaking to supply spares for a minimum period of 10 years from the date of last car supplied by BEML to MMRDA.

5. Technical Requirements

5.1. General

The Subcontractor shall be responsible for meeting the all technical requirement in PTS and requesting the all required data for Coil Spring.

The following is a brief of requirements for a quick reference.

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- Helical Coil Spring
- ERTS Chapter 5. "Bogie"

The proposed coil spring shall be of proven helical coil steel springs.

5.2. Interface

The Coil Springs shall be incorporated with all bogie equipment in any operating condition without any interference.

5.2.1. Subcontractor's advice to BEML

- 1) Advice all the interface issues related with the Helical Coil Spring for information of other designated systems/ equipment.
- 2) Provide BEML with the interface information in detail that is requested by other systems / equipment for interface compatibility.
- 3) Depute an interface engineer at either/both at depot and/or manufacturing site on request by BEML/DMRC

5.2.2. BEML's advice to Subcontractor

- 1) Advice all the interface issues related with the Helical Coil Spring as requested by Subcontractor.
- 2) Provide subcontractor with the interface information in detail that is requested by the subcontractor for interface compatibility.

5.3. Design Philosophy & Requirements

The design philosophy and requirements should meet the following criteria:

- Application of state-of-the-art technology
- Service proven design
- Minimum life cycle cost
- Low maintenance and overhaul cost
- Use of interchangeable, modular components.
- Extensive and prominent labelling of parts
- Use of unique serial numbers for traceability of components
- High reliability
- System safety

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- Fire, smoke detection and protection
- Use of fire retardant materials
- Low noise level
- Adherence to operational performance requirements
- Maximum utilisation of indigenous materials and skills, subject to quality conformity to performance requirements and quality standards.
- Adequate margin shall specially be built into the design particularly to take care of the higher ambient temperatures, high humidity, dusty and corrosive conditions, etc. prevailing in Mumbai area.

5.4. Helical Coil Spring Requirements

The Coil Spring shall be meeting the following requirements:

- 1) Applicable standard in the latest version
 - EN 13298: Railway applications - Suspension - Helical suspension springs, steel
 - EN10089: Hot-rolled steels for quenched and tempered springs - Technical delivery conditions
- 2) The coil spring system shall consist of two-nested concentric coil spring.
- 3) The design life of springs shall not need any rebuilding/repair.
- 4) The supplier shall declare the natural frequency and excitation frequency at various loading conditions.
- 5) Sub-contractor shall declare the estimated mean service life for operation in the Mumbai environment.
- 6) Use of Chrome vanadium grade Steel as per EN10089 shall be ensured.
- 7) The proposed spring to be integrated properly with the link arm type suspension.
- 8) The coil shall have an infinite lifetime for AW2 load condition ($0.7 \times AW2 \sim 1.3 \times AW2$).
- 9) When car has a maximum dynamic load ($1.3 \times AW3$), there must still be an adequate reserve of deflection remaining in the springs to prevent spring bottoming. Supplier shall specify the maximum load where spring bottoming shall occur.
- 10) Solid load stress in springs must be well below permissible stress (or yield strength) of material.
- 11) Coil Spring shall be coated on designated surface with primer and finish paint. The color of finish coat will be defined at detail design stage. There shall not be corrosion in its lifetime.
- 12) Springs must have stamped marking indicating serial number, tolerance

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classification, manufacturer and date of manufacture.

- 13) Coil spring shall be manufactured by the hot formed method.
- 14) The end shape of spring shall be with featuring closed and ground ends.
- 15) The Coil Spring shall be designed for the load cases mentioned in clause 2.2 of this document.
- 16) Target characteristics of Coil Spring assembly:

Description	Target Value of Coil Spring (inner and outer)
Axial Stiffness	958 N/mm
Lateral Stiffness	984 N/mm

- 17) Inner and outer coil springs shall conform to drawings 525-81106 and 525-81107 latest revision and signed between both parties respectively.
- 18) 20% of the coil springs shall be tested for lateral stiffness values and the inspection sheet shall be submitted by the vendor.
- 19) At home/broken conditions for various load cases, the height and speed limit calculations has to be performed for springs. Also grading of springs has to be described.

5.5. Material & Workmanship

The material for springs shall conform to drawings 525-81106 and 525-81107 latest revision.

The material grade in respect of chemical composition, heat treatment, microstructure and mechanical properties shall be as stipulated in the drawing and applicable national/ international standards. The supplier shall submit the reports for the above along with the supplies.

The subcontractor shall be responsible for meeting the requirement of constructional details, material and workmanship. All materials and workmanship in every aspect shall be as per proven up-to-date best practices (Chapter 14 of ERTS)

5.6. MANUFACTURE OF SPRING

5.6.1. General

The shape and dimension of coil springs manufactured shall conform to the BEML drawing. Springs shall be made of bars of fine-grained special quality spring steel as per drawing of this specification. Before taking up manufacturing of springs, the

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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.

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 to prevent cracking at the ends. Flame/Gas cutting is strictly prohibited.

5.6.2. Straightening of Spring Steel Rounds

The bars shall be straightened in the bar straightening machine.

5.6.3. Peeling and Centreless Grinding

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 ISO 4288. 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 as per IS 7906 part 5 or relevant international standard. The limit for cut of straightness for peeled and centreless ground bars shall be 1mm/meter length (maximum).

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

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 EN13298 or relevant international standard. Open seams

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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.

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.

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.

5.6.4. End Tapering

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 certain predetermined period depending upon the type of spring steel.

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.

5.6.5. Coiling and Heat Treatment

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

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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.

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.

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, is necessary to ensure that the heated material remains in contact with air for minimum possible time 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 BEML 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 does not bite 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.

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It shall be ensured that the plane of tapered un-ground 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 clause 5.6.6 (End grinding)

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 be in the range 150°C - 180°C. There shall be an appropriate arrangement to ensure proper maintenance of temperature of the oil bath in the range 45°C to 90°C. These temperatures shall be specified in the QAP of the manufacturer.

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.

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 $\pm 15^\circ\text{C}$ in each zone of the furnace. The temperature of the tempering furnace shall also be maintained within this range of variation. For proper heat treatment of springs, the following table shall be used for guidance.

Steel Grade	Temperature of Spring before Quenching (°C)	Tempering Temperature (°C)
51 Cr V4	830-860	350
52 Cr Mo V4	830-860	350

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.

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The tempered martensitic distribution across the complete cross section of the active coil of the Chrome Molybdenum spring steel. The martensitic distribution shall not be less than as specified above.

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.

The hardness of the spring shall be in the range of 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.

5.6.6. 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.

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:

SI. No.	Nominal bar diameter (d) in mm	Variation in Tip Thickness over the cross section of Spring End (mm)	
		Minimum t_{min}	Maximum t_{max}

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1	$d \leq 33$	$0.25 * d$	$(0.25 * d) + 5$	
2	$33 < d \leq 60$	$0.20 * d$	$(0.25 * d) + 5$	

5.6.7. Scragging

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

5.6.8. Shot Peening

Test equipment + method

Test sample-steel strip are fixed on the gauging fixture (special spring) and shot peened with the same condition as the springs. Because a steel strip is shot peened on one of its surface only, this strip will be concave when removed from gauging fixture. After shot-peening process the bow (magnitude of deflection) of tested steel strip is evaluation by micrometer and recorded.

Shot Peening and test sample as per EN 13298

Evaluation of test

Intensity 0.4 to 0.6 Almen A = OK

Otherwise = NOT OK

5.6.9. Crack Detection

Springs made from ground bars should be subjected to magnetic crack detection, the percentage of springs to be checked and the acceptance criteria should be mutually agreed between the purchaser and the supplier. This crack detection must be immediately carried out after shot peening for 100% of the supplies.

5.7. Machining

Machining as per the approved drawing/interface requirement shall be carried out. Care shall be taken to ensure that the tolerances as specified in the drawing are

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achieved. Dimensional inspection report for all the springs shall be submitted along with the supplies.

5.8. Coating System and Painting System

- 1) Coil springs shall be protected using an internationally accepted painting system proven in railway applications, which will protect the springs from damage by corrosion in climate conditions prevailing in MRS1 project. The subcontractor shall furnish details of guaranteed life cycles of paint system, class details, reference standards, painting procedure etc. for review and approval of BEML (ERTS 14.19)
- 2) Performance of the paint system shall be proven for lifetime in specified environmental conditions of the contract.
- 3) The systems shall have excellent substrate and inter-coat adhesion, outstanding long term corrosion protection, very high order of abrasion resistance, chip & impact resistance and shall meet fire safety standards.
- 4) The machined surfaces to be covered with anti-corrosive coat. The anti-corrosive coating plan shall be submitted to BEML for approval.
- 5) Performance of the paint system shall be proven for lifetime in specified environmental conditions of the contract. Painting system shall meet salt spray test 1000 hrs and adhesion cross-cut test 0-1.
- 6) Color of finish coat shall be decided by BEML/Employer before painting process.
- 7) The painting of all surfaces except machining surface shall follow below requirements:

Paint	Nominal Value	Minimum Value	Maximum Value	Maximum Point
Primer	50 µm	40 µm	80 µm	120 µm
Finish	50 µm	40 µm	80 µm	120 µm

Coating specification as below

Process	Product name			Mixing Ratio (vol.)	D.F.T (µm)	Recoating Interval (hr)	Thinner	Drying time
Surface Preparation	Remove oil and grease from the surface to be painted and grit blast to SIS SA 2½							
Primer	1 st	Epoxy primer	EP1119	3:1	60 ± 20	6 hrs	024	6 hrs
Top 1 st	2 nd	Urethane top	UT5119	4:1	60 ± 20	Min. 10 hrs	037U	8 hrs

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5.9. Weight

5.9.1. Target Weight Limit

The subcontractor shall specify the following equipment weight limit.

- 1) The maximum weight of a Coil Spring assembly (outer + inner) shall never exceed 60 kg.
- 2) The above maximum weight shall cover the equipment manufacture weight tolerance. Therefore, the subcontractor shall control the equipment weight with 0 / - 4% manufacture tolerance.
- 3) If any equipment weight, that is estimated, calculated and measured, exceeded the target weight limit, the subcontractor should immediately advise BEML regarding the steps to be taken to achieve the target weight limit.

5.9.2. Subcontractor Weight Control Activity

- 1) Weight Progress Report.

The subcontractor shall submit a weight control document on a monthly basis. The weight control document shall list all the estimated weights (or measured weight) with tolerance and CG of all components that are included in each drawing.

The list shall be broken down for each separate enclosure or part of the equipment that is independently installed on the vehicle. The subcontractor shall initially release the document filled with the available information, subsequently the list has to be updated with precise data in the later stage. The document shall provide a listing as well as computed value of weights and CG locations with tolerances for each of the supplied enclosures.

Even for the existing design, weight progress report should be submitted on a change basis. The sheet includes equipment name, equipment quantity, equipment unit weight, equipment center of gravity etc. as following table. This sheet shall be updated on a change basis by subcontractor up to manufacturing stage. The subcontractor shall also submit the weight and CG revision history sheet to BEML on change basis that includes previous figure (weight and CG) of breakdown list, updated figure, the detail reason about updated figure, etc. On requirement the subcontractor shall provide necessary proof on weight calculation data, CG calculation data, etc., if BEML asks for.

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Sl. No.	Drawing No.	Description	Unit	Unit Weight	CG			Status	Remark
					X	Y	Z		
1			EA	42.3				E	Estimated Weight
2			EA	22.4				C	Calculated Weight
3			EA	15.2				M	Measured Weight

2) Equipment Weighing Test

The weighing facility shall be timely calibrated, and calibration certificates shall be submitted prior to the test. The subcontractor shall submit the actual weight of equipments to BEML before commencing mass production.

6. Scope of Supply

6.1. General

The subcontractor shall provide, as a minimum, the followings:

- 1) Coil Springs (Inner and Outer)
- 2) Spare Parts
- 3) Specification of spring testing machine to be submitted by the supplier. The specification/information shall be detail enough to ensure BEML can procure the spring testing machine.
- 4) The quantity for above items will be defined by the commercial contractor.
- 5) The subcontractor shall provide all required documentation for computer based training (CBT) and maintenance simulator to BEML/simulator supplier

6.2. Hardware

The subcontractor shall be responsible for supplying helical spring set with all necessary hardware/accessories.

Sl. No.	Drawing No.	Description	Qty./car
1	525-81106	* Spring outer	8 No's
2	525-81107	* Spring inner	8 No's
Spares Requirement			
Sl. No.	Drawing No.	Description	Remarks
1	525-81106	* Spring outer	
2	525-81107	* Spring inner	
3	525-81099	Assembly tools	
<p>* Procurement for serial no. (1) & (2) shall be from the same vendor. § Consumable spares till DLP shall not include items like lubricants, oil, grease, paint, polish, etc.</p>			

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Sl. No.	DESCRIPTION	BEML			Subcontractor		
		Design	Supply	Fit	Design	Supply	Fit
1	Spring Outer	X		X	X2	X	X2
2	Spring Inner	X		X	X2	X	X2

X: Leader, i.e. responsible for the design activity required for the specified element of the scope of supply including any calculation, drawing, documentation and test connected with the design.

X2: Supporter, i.e. responsible for supporting the design leader by supplying of any relevant information required by the design leader to produce a satisfactory design.

6.3. Spares

The subcontractor shall supply spares (if any) as per requirements specified in chapter - 8 of ERGS for a period of 10 years to BEML/MMRDA from the date of last car supplied by BEML.

6.4. Split of Responsibilities

- 1) The subcontractor shall be responsible for the overall design and engineering of Helical Coil Springs in accordance with his scope of supply and work.
- 2) The subcontractor shall be responsible for design change of his scope of supply and work from the technical discussion between BEML and/or the End User and/or the subcontractor under the contracted price and delivery between BEML and the subcontractor.
- 3) The subcontractor shall be responsible of dispatching his engineer to BEML or the place designated by BEML for the technical meeting required from BEML.
- 4) The technical details may change on minor aspects as requested by Employer or as required by BEML. Such a change request must not be considered as change order issue for revision of contract pricing, delivery conditions etc after acceptance of contract.
- 5) Finalization of drawings or design documents may take considerable time from employer end. Hence, the subcontractor shall ensure that all reviewed & commented drawings or documents after proper revision & updates are submitted to BEML/Employer acceptance within 1-2 weeks at maximum.
- 6) The procedure for assembly & installation shall be provided by subcontractor to

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BEML in order to avoid any mechanical interference with other equipments/systems of the vehicle

- 7) The subcontractor shall be responsible for providing all design documents, conducting type test & routine test, finish painting, technical documentation, training (if any) and warranty against defects.
- 8) The helical coil springs drawings and characteristics shall be approved by BEML/Employer before mass production is started.
- 9) The supplier shall submit the documents conforming to the applicable Drawing/standards/specifications/PTS along with every batch of supplies specified in the drawing.

The table below provides activity & responsibility details for contractor & subcontractor:

No	Description	Details	Scope		Remarks
			BEML	Subcontractor	
1	Interface	According to PTS		X	
2	Design	According to PTS		X	
3	RAMS	According to PTS		X	
4	Calculation documents	According to PTS		X	
5	Technical documentation	According to PTS		X	
6	Approval of drawing	According to PTS	X2	X	
7	Type Test & Routine test	According to PTS		X	
8	Manufacturing	According to PTS		X	
9	Commission test	According to PTS		X	
10	Technical Documentation	According to PTS		X	
11	Training	According to PTS		X	
12	Warranty for each components	According to PTS		X	
13	Manual	According to PTS		X	

NOTE:

- X: Design leader, i.e. responsible for the design activity required for the specified element of the scope of supply including any calculation, drawing, documentation and test connected with the design.
- X2: Design support, i.e. responsible for supporting the design leader by supplying of any relevant information required by the design leader to produce a satisfactory design.

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7. Design Information

7.1. General

- 1) The objective of the design submission process is to ensure that the proposed systems shall comply with the specifications and are capable of being produced consistently to exact quality standards with minimum LCC and can be operated safely to the satisfaction of the Engineer.
- 2) The design submissions shall include design calculations, design reports and design drawings. All design submissions shall include a 'clause by clause' compliance status to all applicable contract clauses of ERTS.
- 3) The design submissions acceptable to BEML shall be further submitted to Employer for approval/acceptance. If any review comments are given on such design submissions, the subcontractor shall update/revise its design submissions for re-submission to the satisfaction of BEML/Employer. Each revision shall consist of response sheet enclosed with the revised documents.
- 4) The subcontractor shall submit revised documents incorporating BEML/Employer's request/comments in no later than 2 weeks
- 5) In the event that a statutory body (e.g. Government of India Ministry of Railways, RDSO, Commissioner of Metro Railway Safety, etc.) requires design information in a particular format, it shall be incumbent upon the subcontractor to provide the same, as directed by BEML/ Employer.
- 6) Along with the offer, the subcontractor shall submit a list of documents for coil springs (inner and outer) that will be submitted by the subcontractor during the project execution.
- 7) The subcontractor shall submit all necessary documents viz., documents and drawings describing function description, product description, design calculations, interface requirement description, RAM requirement description, Life cycle calculations, Fire safety, Type test & routine test specifications, list and details of spares, related calculations, etc.
- 8) A monthly progress report for weight details in BEML/Employer format in MS-Excel file shall be submitted by the subcontractor. The worksheet shall include equipment breakdown list, quantity, unit weight, CG, etc. The subcontractor shall update the worksheet on monthly basis during design stage.
- 9) All necessary interface information must be provided by the subcontractor to ensure that the proposed aggregates satisfy ERTS & ERGS requirements with respect to complete running/operation of rolling stock.

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- 10) The subcontractor shall also submit weight & CG revision history sheet to BEML on monthly basis which includes previous figures also. The detail reason for revision shall also be mentioned in the progress report.
- 11) Any other additional documents as required by BEML/Employer shall be provided by the subcontractor.

The Design Phase will be undertaken in three stages:

- Preliminary Design
- Pre-final Design and
- Final Design.

7.2. Preliminary Design

The purpose of the Preliminary Design submission is as follows:

- State the design criteria;
- Design the overall system and propose the system configuration;
- Identify the functions of each system, sub-system, equipment or other element within the overall design and specify the relationships and interfaces between elements of the system;
- Identify the functions of each system, sub-system, equipment or other element within the overall design and identify the relationships and interfaces between elements of the Contractor's system and those of other Designated Contractors; and
- Verify the tender designs and calculations. In case of simulations, the inputs, relevant formulae, principles, assumptions, algorithm and logic followed shall be submitted with a sample calculation for each case. It shall be obligatory on the subcontractor to submit any further details as required by the Engineer to approve the results. Any spreadsheet if submitted shall be supported with the linked formulae and calculations.
- Incorporate the Engineer's suggestions and changes based on the Technical Specification and/or operational requirements.

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7.3. Pre-Final Design

- In the Pre-final design stage the conceptual designs (including interfaces with those of Designated Contractors of the Employer, and of the Contractor's vendors) are required to be fully developed. In this stage, each element of the system will be considered and preliminary specifications with supporting calculations developed.
- Manufacturing units will be allowed to commence production only after receiving 'no objection' advice from the Engineer. This submission shall include sufficient detail from prospective suppliers to demonstrate that they have adequate understanding of the requirements. It will include either evidence of or proposals for design verification. Interfaces with other designated subcontractors shall be finalised by this stage.
- Development of maintenance manuals & methodology of other derived maintenance activities. At pre-final design stage, the subcontractor will develop this FMEA to include required maintenance derived from each failure mode. Any other maintenance required for the train should be indicated at this stage. Methodology for the deriving maintenance activities including service checks, maintenance work instructions etc. based on failure modes shall be finalized at pre-final design stage only and the same shall be further reviewed by the Engineer during the DLP period.

7.4. Final Design

The purpose of the Final Design submission is to agree with the Engineer that the equipment is satisfactory, compliant with the specification, fit for purpose and safe. The Final Design shall be the level of design developed to the stage where all manufacturing drawings (including those received from Designated Contractors of the Employer, and Vendors of the Contractor) are fully defined and specified and in particular:

- calculations and analyses are complete;
- all main and other significant elements are delineated;
- All other work, including studies, investigations and reports are complete.

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7.5. Design Stages

Sl. No.	Description of stage	Submission from subcontractor to BEML(from LOI / contract award)
1	Preliminary design completion including Employer's approval	15 Days
2	Pre final design completion including Employer's approval	30 Days
3	Final design completion including Employer's approval	45 Days

The subcontractor shall provide BEML with all drawings, reports, calculations, specifications, technical design data, system safety plan, quality assurance plan, manufacturing process, testing and training with respect to PTS, ERTS and ERGS strictly within time schedule defined by BEML and MRS1 project requirements.

The technical details, drawings and documents shall be delivered in English language only. These shall be compatible with AutoCAD 2000 (dwg file), 3D model (stp / iges file) and MS office version 2003 (document MS word, spread sheet – MS excel, data base files – MS access, Presentation file – MS PowerPoint). The quantities of these drawings and documents submitted to BEML shall conform to chapter-5 of ERGS. The soft copy of documents/drawings shall be submitted in pdf format compatible with Adobe Acrobat Reader version-6 or above.

The subcontractor shall request relevant interface information from BEML, which possibly affects performance, fitting and form of the aggregate to be supplied. The subcontractor shall comply, but not be limited to, chapter-5 of ERGS & ERTS section 3.7

7.6. Documents and drawings

The subcontractor shall provide, but not be limited to the design documents / information of the helical coil as mentioned below:

Sl. No.	Document	Submission Phase
1	Detailed Drawing with all general/technical data	Preliminary Design
2	3D stp file - Spring Inner coil and Outer coil	Preliminary Design
3	General technical description of proposed helical springs service / delivery and other information	Preliminary Design



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Sl. No.	Document	Submission Phase
4	Technical write-up	Preliminary Design
5	General description	Preliminary Design
6	Material Certification	Preliminary Design
7	Certificate of conformity and material certification	Preliminary Design
8	Spare parts catalogue	Pre-final Design
9	Manufacturing process flow chart along with applied standards.	Preliminary Design
10	Detailed technical specification and data of helical springs	Preliminary Design
11	Specification and life of components	Preliminary Design
12	Estimated/measured noise attenuation data	Pre-final Design
13	Marking/stamping drawings	Pre-final Design
14	NDT test specification	Pre-final Design
14	NDT films and reports	Final Design
15	Analysis and calculation data	Pre-final Design
16	Anti-corrosion plan	Pre-final Design
17	Paint specification & procedure	Pre-final Design
18	Magnetic Particle Inspection test and other NDT procedures	Pre-final Design
19	Routine test specification	Pre-final Design
20	Routine test check sheets/report	Final Design
21	Type test specification	Pre-final Design
22	Type test report	Final Design
23	Operation & Maintenance manual for springs and special tools if any.	Final Design
24	Hazard Analysis	Final Design
25	RAMS details	Final Design
26	The manufacturing details of all Equipment	Pre-final Design
27	Installation Instruction of all Equipment	Final Design
28	Cleaning, storage and handling instruction of Equipment	Final Design
29	Maintenance & Inspection Instructions	Final Design
30	Monthly progress report	Continuous
31	Painting Procedure	Pre-final Design
32	Analysis & Calculation data	Pre-final Design
33	Training manual for special tools, jigs and fixtures	Pre-final Design
34	Final Inspection and Test Plan	Final Design
35	Quality Assurance plan	Pre-final Design

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8. Testing of Springs

8.1. Test Procedures

Test procedures shall describe the individual test cases and the steps comprising each case, with emphasis on the methods and processes to be followed. Test procedures shall include, but not be limited to, the following:

- The objective of the test and acceptance criteria.
- For each test case, the requirement(s) to be demonstrated and verified.
- The required setup and conditions for each test case, including descriptions of the test equipment and data to be supplied by the subcontractor.
- Descriptions, listings and instructions for all test software tools and displays.
- Step-by-step descriptions of each test case, including the inputs and user actions for each test step.
- The expected results for each test case including the Pass/ Fail criteria.
- Descriptions of the techniques and scenarios to be used to simulate system field inputs and controlled equipment.

8.2. Test Records

Complete certified test records of all factory and field acceptance test results shall be maintained by the subcontractor and submitted to BEML. The test records shall be keyed to test procedures and shall include, but not be limited to, the following:

- The reference to the corresponding test procedure.
- The date the test procedure was executed.
- Description of any test conditions, input data, or user actions differing from that described in the Test Procedure.
- The test results for each test case including a Pass/ Fail indication.
- Identification of the subcontractor's test engineer.
- Provision for comments by the Employer/his Representative's.
- Copies of any deficiency reports generated as a result of the execution of the

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test procedure.

- Copies of reports, display copies and any other hard copy generated as a result of the execution of the test procedure.
- Configuration data that fully describes the hardware and software that was tested, including software version and build numbers/ identifiers for every software module.

Calibration certificate of equipment and tool which are used for test and inspection.

8.3. Testing of Springs

The subcontractor shall carry out the type test and routine test of the helical coil springs. Vendor should conform to clause 7 of EN 13298:2003. In addition, the fatigue testing needs to be carried out as per clause 8.6 of this PTS document.

All test procedures, type test reports including all corrective actions and checklists shall be submitted by the subcontractor and approved by BEML and/or Employer /Representatives. Test procedure submitted shall show all the safety aspects. In addition, the subcontractor shall prepare a test plan listing for tests to be performed. The plan shall briefly describe the scope of each test.

In the event that any test for spring fails, the subcontractor at his own expense and responsibility shall take required corrective action as deemed necessary, to the satisfaction of BEML and/or Employer/Representative, in order to meet the testing requirements. Subcontractor shall supply the report for the same.

Only with the written consent of BEML/Employer the type test or certification requirements may be waived off. Nevertheless, if the type test should be carried out, the subcontractor at his own expense shall perform the type test which shall be witnessed by BEML/Employer/Representative.

In case BEML seeks to waive off type test for the helical coil springs already type tested or certified for other projects of identical design, the subcontractor shall provide all the requisite documents including supply details, customer details, and year of supply, quantity, etc and certificates necessary for getting waiver. For variations in design parameters between the previous tests and the specifications, extrapolated calculations must support the test report.

After testing, the subcontractor shall document the test conditions and results. Report

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shall be submitted to BEML for approval. Any design changes, adjustments, etc., that are required to meet the performance requirements, shall be fully retested and documented at the subcontractor expense. Equipment design changes shall be subject to prior approval by BEML and/or the end user /his representative.

8.4. Routine Test

- 1) Subcontractor has responsibility for the routine test of the helical coil spring as per relevant national/international standard. During the test, the criteria shall be observed and recorded. Copies of routine test records along with soft copy shall be submitted along with each batch of supply.
- 2) The subcontractor shall submit the details of ultrasonic testing of springs. The detail shall include the testing procedure and pattern used as reference for this test, which shall be used by BEML or Employer maintenance staff/personnel.
- 3) Additional copies of records of all tests/inspections shall also be available at the subcontractor works for BEML and/or Employer /Representative on demand.

8.5. Chemical Composition Analysis

The supplier shall carry out ladle analysis on a sample of each melt and product analysis on a test piece or a casting representing each melt as per the material standards mentioned in the drawings and shall submit test reports.

8.6. 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. BEML'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, BEML 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 BEML, shall conduct fatigue testing of that spring. The springs shall have a fatigue life of 35 years in AW2 operating conditions ($0.7 \cdot AW2 \sim 1.3 \cdot AW2$).

Type testing of newly designed springs (fatigue testing) shall be done as per the fatigue test scheme enclosed in the Annexure-1.

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8.7. Surface Protection

Measuring is provided according ČSN ISO 2808 and ISO 2064.

Cross cut test to be performed acc. to standard ISO 2409. For surface protection with paint thickness higher than 120um to be used cross cut 3mm. Test to be performed on testing plate utilized for the manufacture of the spring.

8.8. External appearance

Test is carried out without any tools. Visual method of checking is used.

8.9. Surface hardness

Measurement provided acc. CSN EN ISO 6506-1 for Brinell hardness or CSN EN ISO 6508-1 for Rockwell hardness.

Place for testing of hardness is situated on the outer side of the end coil.

8.10. Bowing direction

Test to be performed on TIRA test equipment or equivalent. The direction of outward bowing is marked on the spring by white strip on the first active bottom coil.

8.11. Surface quality (Magnetoscopy)

Testing provided acc. EN 13298

8.12. Core hardness (laboratory)

Measurement provided acc. CSN EN ISO 6506-1 for Brinell hardness or CSN EN ISO 6508-1 for Rockwell hardness. The test piece shall be taken from the bar, utilized for the manufacture of the spring and heat treated acc. to identical process as the spring.

8.13. Other Tests

Other tests include Decarburization, grain size, tensile strength, impact strength, inclusion and cleanliness:

- decarburization ISO 3887

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- grain size acc. to ISO 643
- tensile strength acc. to ČSN EN ISO 6892-1
- impact strength type KU acc. to ČSN ISO 148-1
- inclusion cleanliness acc. to EN 13298

The test piece shall be taken from the bar, utilized for the manufacture of the spring and heat treated acc. to identical process as the spring.

8.14. Lateral stiffness of spring

Apply lateral movement and record value of lateral forces using proper equipments and test setup. 10% to 20% of the coil springs shall be tested for lateral stiffness values. The same has to be submitted along with the supplies.

8.15. First Article Inspection (FAI)

The helical coil spring shall be subjected to First Article Inspection (FAI) at supplier's manufacturing unit by BEML and/or Employer / Representative(s).

Only after verification and approval of FAI reports by BEML, parts shall be taken up for mass production. The subcontractor shall inform BEML for carrying out FAI at least one month before the FAI date.

8.16. Production Conformance Testing

The subcontractor shall conduct Production Conformance Testing on each piece of equipment to be furnished to ensure that the equipment is functioning correctly. These tests shall be performed in accordance with a Production Conformance Testing Procedure prepared by the subcontractor and approved by BEML and/or the Employer/his Representative.

The subcontractor shall perform the routine test of equipment/assembly under his responsibility.

During the test, the criteria shall be observed and recorded in a log book and necessary alterations and adjustments shall be carried out.

The routine test records shall be held by the subcontractor and made available timely for BEML and/or the Employer/his Representative's inspection. Copies of the routine

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test records shall be submitted together with the associated log book.

Additional copies of records of all tests/inspections result shall also be held at the Subcontractor work to be made available to BEML and/or the Employer/his Representative on demand.

8.17. Type Test & Commission Test for completed car and train, service trials

The vehicle level type test shall be performed by BEML on the basis of information from subcontractor. The subcontractor shall provide BEML with full record of the modification status at the type test.

In case of any problems happening in the coil spring during the test of train, the subcontractor shall immediately appoint appropriate staff in order to aid BEML in rectifying the problems and be responsible for correcting any interfacing defects.

The subcontractor shall provide full support by way of instructions, staff and materials during the integrated test at the request of BEML. BEML will perform the service trials for the trains.

9. Marking

Marking shall conform to EN 13298: 2003. The marking must be approved by BEML/DMRC.

10. Validation, Inspection & Test Plan

10.1. General

The validation, inspection, and test plan shall describe the subcontractor's overall validation, inspection and test process, including the responsibilities of individuals and the documentation of the validation and test results and shall include, but not be limited to, the following items:

- 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 PTS.
- 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 arrange

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

- 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.
- 4) A flow diagram indicating the logical sequence of validations and tests starting with material receiving tests and inspections and concluding with system demonstrations tests.
- 5) Validation schedule
- 6) Test schedule
- 7) Responsibilities of the subcontractor
- 8) Record-keeping assignments, procedures and forms
- 9) Procedures for performing validation
- 10) Procedures for monitoring, correcting and re-testing deficiencies
- 11) Procedures for controlling and documenting all changes made to the hardware and software after the start of testing

10.2. 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.

- 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.

- 2) The Inspecting Official shall carry out the necessary checks on the finished springs during regular inspection.

Note: 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.

- 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.
- 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 centre-less ground.

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- 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 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.
- 6) 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.
- 7) 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.

In addition the quality of the springs shall conform to clause 8 of EN 13298.

- 1) Configuration data that fully describes the hardware and software that was tested, including software version and build numbers/ identifiers for every software module.
- 2) Calibration certificate of equipment and tool which are used for test and inspection.

11. Acceptance Criteria For Springs

- 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.
- 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.
- 3) Failure of any of the sample in the double samples, will however result in rejection of the entire offered quantity.
- 4) In the event of rejection, the entire quantity offered for inspection shall be made unusable for rolling stock 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. Handling of Springs

The springs shall be properly handled since they are highly stressed components of suspension system. Due care shall be taken in handling during manufacture,

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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.

13. Protection against Corrosion Of Springs

Powder coating as per IS 3618 & IS 13871 shall be done on the springs for protection of corrossions. 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

14. Operation & Maintenance Manual

- 1) The requirements for the O&M manual shall meet, but not be limited to Chapter 12 in ERGS. The subcontractor shall support BEML in meeting timelines for submission of manuals.
- 2) It shall be the responsibility of subcontractor to provide O&M manual complete in all aspects which includes spare parts catalogue, general maintenance instructions, heavy maintenance instructions, spring testing machine instructions, details of special tools and test equipment, technical description, defects identification & rectification details, etc
- 3) The O&M manual provided by the subcontractor must contain all the information necessary to operate and maintain the equipment within his scope of supply in a safe and efficient manner.
- 4) The subcontractor shall deliver six coloured hard copies in English language as well as soft copy strictly within timeline as specified by BEML.
- 5) The technical information provided in each volume of the O&M manual must be in sufficient detail to ensure that the different categories of readers/users are provided with all the information in the form of text, illustrations and tables, which can be readily understood and assimilated.

15. Training Needs

The subcontractor shall meet training requirements as specified in chapter-9 of ERGS.

16. Warranty

The subcontractor shall be responsible for warranty of its supplies as per Chapter 1

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section-1.8 of ERGS.

17. 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 in marking clause of this PTS or for a period of four years from the date of installation on train set, 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.

18. Delivery

- 1) The subcontractor shall deliver helical coil springs as per delivery schedule agreed by BEML.
- 2) The subcontractor shall provide instructions for proper storage, handling and logistics of components 4 weeks before handing over the first shipment.
- 3) The subcontractor shall pack & deliver the helical coil springs suitably to avoid any damage during transit/transportation.
- 4) The O&M manuals shall be supplied 4 weeks before the first supply.

19. System Assurance and Safety

The subcontractor shall comply with ERGS 2.7 & ERTS 2.4 for system safety assurance. The safety assurance program for helical coil springs shall be consistent with the assurance program of the overall rolling stock.

20. Quality

All works for the helical coil springs shall be executed and controlled by a quality management system, in accordance with the requirement of ISO 9001. The subcontractor shall comply with ERGS 2.6 & ERTS 2.3 to a minimum.

20.1. Quality System Requirements

The subcontractor shall have relevant quality certification and shall manufacture the product accordingly. The subcontractor shall maintain and perform his internal management plans for the following:

- Design change control

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- After sales service
- Purchasing control
- Process control

In addition, the subcontractor shall submit a copy of his ISO certificate including the certification body details. In case the certificate is expired, the subcontractor shall renew and submit the same.

20.2. Quality Assurance Plan (QAP)

The subcontractor shall issue the QAP in accordance with the relevant Quality System and the Employer's Requirements, and submit it to BEML for approval.

Following content shall be included in the QAP:

- Process Control
- Purchasing
- Quality Audit
- Inspection and Test Plan (ITP)
- Quality Record
- Design Control
- Nonconformity control
- Inspection and Test procedure

20.3. Inspection and Test Plan (ITP)

ITP shall be submitted to the BEML along with technical offer. It shall include at least the following:

- Sequence of inspection/testing activities
- Inspection and testing requirements of either activities or materials
- Acceptance criteria or relevant specification
- Level of inspection required including the provision for witnessing by BEML and/or End User/his Representative
- Any certification requirements or records to be kept; and

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- Records of any non-conformance identified during inspection or testing
- BEML will designate witness/Hold point of BEML and/or Employer /his Representative and notify it to the Subcontractor.

20.4. Quality Audit

The subcontractor shall develop a quality audit program in accordance with the ISO 9000 Quality System and submit to BEML for information. The subcontractor shall comply with ERGS 2.6.3 to a minimum and shall submit the audit report to BEML for information. In addition, a copy of audit report issued by the accredited ISO certification body shall also be submitted to BEML on demand.

21. Project Management Plan

Along with the technical offer, the subcontractor shall submit a Project Management Plan, which shall provide a clear overview of the subcontractor's organization, the management system and methods to be used for completion of the works. The organization resources for the design, procurement, manufacture, installation, testing and commissioning and setting to work, shall be clearly defined. The Project Management Plan shall provide the following information:

- 1) A diagram showing the organizational structure for the management of the contract, with locations, names and position titles of staff and their line and staff relationship. The diagram shall include associate organizations and sub-suppliers and show clearly the individuals and lines of responsibility linking the various groups. It shall also identify the persons designated as contacts with BEML.
- 2) The names, qualifications, positions and current resumes of key executive, supervisory and engineering staff to be employed full-time for the works.
- 3) A narrative describing the sequence, nature and inter-relationship of the main contract activities including timing for exchange of information.
- 4) Procedure for documentation control.
- 5) The subcontractor shall nominate a suitably qualified and experienced English speaking engineer from his staff to be Project Manager. The proposed Project Manager shall have total experience of minimum 15 years and shall have been Project Head in at least one Rolling Stock Project in last 10 years.
- 6) The proposed project manager shall be the employee of the subcontractor. The CV of the Project Manager shall be submitted along with the technical offer.
- 7) To fulfill the subcontractor's obligations during the testing and commissioning and

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the DLP, the subcontractor shall nominate experienced maintenance engineers and organize deployment before undertaking testing and commissioning in depots. Separate maintenance engineer shall be positioned in each depot.

- 8) The subcontractor shall submit relevant CV's of the design manager, production manager, quality manager, interface manager & maintenance engineer in addition to project manager in the technical offer.

22. RAMS Requirements

The subcontractor shall comply in every aspect with the requirements of RAMS as per section 2.7 to 2.13 of ERTS and section 2.8 of ERGS. During DLP, the values from RAMS target shall be calculated from the records of all the faults and service failures. In the event that the target is not achieved, the subcontractor shall, at his own expense, take whatever action necessary to meet the target specified. The subcontractor shall comply with, but not limited to, the following ERTS requirements:

22.1. General

The subcontractor shall comply with ERTS 2.7 for general RAMS requirements.

22.2. Reliability Requirements

The subcontractor shall comply with reliability requirements as specified in ERTS 2.8. Additionally, for pattern failure, following method shall be used:

- 1) Three or more relevant service failures of the replaceable part, item or equipment in same manner in identical or equivalent applications occurring at a rate which is at least 20% higher than the predicted failure rate of the part, item or equipment and/or
- 2) At least 20% of the same replaceable part, item or equipment in the fleet has a relevant failure in the same manner in identical or equivalent applications during a moving 18 months window starting when the reliability demonstration starts and ending at the end of the DLP

22.3. Reliability Analysis

- 1) The reliability data shall be based on actual operating information for the equipment.
- 2) In addition, the subcontractor shall submit a list of typical train withdrawal scenarios for review and acceptance by the BEML. The list shall include all anticipated failure scenarios, which can affect safety, punctuality and passenger comfort. In addition, a

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list of typical train withdrawal scenarios should be based on the reliability analysis.

- 3) The reliability block diagrams and prediction of reliability performance shall be submitted to BEML for acceptance in the format, units and parameters as desired by the Employer.
- 4) The reliability block diagrams shall include all elements essential for successful performance of the system and the interrelationships and interface.
- 5) The subcontractor shall submit reliability prediction to demonstrate by quantitative methods, the achievement of the specified levels of reliability for the scope of supply.

22.4. Reliability Target

The fleet average levels of MDBF, during DLP are as specified in Clause-2.8.2 of ERTS.

Duration	Minimum fleet average MDBF
	6 -car fleet
After 6 months of start of revenue service plus stabilization period of 6 months	100,000
After 12 months of start of revenue service plus stabilization period of 6 months	125,000

$$MDBF = \frac{\sum \text{Travelled kilometer per train} - \text{set}}{\sum \text{Number of service failures}}$$

Mean Distance Between Failures (MDBF): The MDBF is the ratio of the total operating distance accumulated by the total available fleet of the trains to the total number of Service Failures.

MDBF for coil springs in 6 cars train-set shall meet the train level MDBF (shall be provided by BEML) during detail design phase.

The Reliability performance shall be assessed by the following measure:

$$MDBCF = \frac{\sum \text{Travelled kilometre per train-set}}{\sum \text{Number of relevant Failures}}$$

where,

Mean Distance Between Component Failures (MDBCF): The MDBCF of a system is the ratio of the total operating distance accumulated by the total population of identical items in the available fleet of the system to the total number of relevant

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failures occurring within the population identical items.

$$MDBSF = \frac{\sum \text{Travelled kilometre per train-set}}{\sum \text{Number of Service Failures}}$$

Where,

Mean Distance Between Service Failures (MDBSF): The MDBSF of a system is the ratio of the total operating distance accumulated by the total population of identical items in the available fleet of the system to the total number of service failures occurring within the population identical items.

	MDBSF	MTTR
Helical Coil Springs	80,000,000 km	3.5 hour

Relevant Failure

A relevant failure of an item is an independent failure which results in a loss of function of that item caused by any of the following:

- 1) A fault in an equipment or sub-system while operating within its design and environmental specification limits;
- 2) Improper operation, maintenance, or testing of an item as a result of the subcontractor supplied documentation.
- 3) Failures of transient nature including those with post investigation status as 'No fault found', shall be considered as relevant failure if in the opinion of the Engineer these are attributable to rolling stock. The decision of the Engineer shall be final.

Service Failure

Any relevant failure or combination of relevant failures during revenue service operations, simulated revenue operations or during pre-departure equipment status checkouts to determine availability for revenue service, which results in one of the following:

- 1) Non-availability of the train to start revenue service after successful completion of pre-departure checkout.
- 2) Withdrawal of the train from revenue services.
- 3) A delay equivalent to or exceeding 3 minutes from the Schedule / Time table as noted at the destination station for the one way trip.
- 4) The discretion of declaring a train as not-available to start revenue service after successful completion of pre-departure checkout or withdrawing a train from

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revenue service on account of any relevant failure rests solely with the Engineer and shall be final. The train withdrawal scenario is placed at Appendix TG of ERTS and includes possible anticipated failure scenarios which can affect safety, punctuality and passenger comfort. The train withdrawal scenario defined in Appendix TG shall be considered as a service failure irrespective of whether the DMRC is able to withdraw the train or not due to its operational constraints. This list shall be further developed during DLP.

Pattern Failure

- 1) Repeated occurrence of three or more relevant failures of the same replaceable part, item or equipment in same manner in identical or equivalent applications when they occur at a rate which is inconsistent with the predicated failure rate of the part, item or equipment.
- 2) The detailed methodology for identification of pattern failures shall be finalized during the design stage. The decision of the Engineer shall be final.

22.5. Maintainability Requirements

The subcontractor shall comply with ERTS 2.12 & 2.14 for maintainability and maintenance requirements as given below:

- 1) The design of all components will be such that maintenance is reduced to a minimum, substantially improving service intervals.
- 2) Components shall be so arranged that those requiring frequent attention are easily accessible and readily removable. All equipment should be designed using the Least Replacement Unit (LRU) principle whereby the repair of a fault merely involves the replacement of a faulty module.
- 3) The design shall also minimize mean time to repair (MTTR) and costs throughout design life. MTTR is the ratio of cumulative time, including the access time expended during a time interval to the total number of relevant failures.
- 4) The subcontractor at his own cost, in Employer's depot, in coordination with BEML, shall demonstrate the periodic & intermediate overhaul, LRU replacement and corrective maintenance activities with/without car lifting.
- 5) The procedures used in the demonstration shall be the same as those included in the maintenance manuals submitted.
- 6) The subcontractor shall submit the list of required spares, consumable spares, tools etc. for such demonstration
- 7) The subcontractor shall support an active supply for high availability.

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- 8) The subcontractor shall comply with procedure of BEML for fault rectification. If some failure needs the subcontractor's support, the subcontractor shall depute the engineer in the earliest possible time.
- 9) The subcontractor shall provide training/requisite knowledge to BEML maintenance staff if any, needed at the time of maintenance.

22.6. Maintenance interval

The proposed coil spring shall have obtained enough performance and durability to get the following inspection period without an additional maintenance & equipment change.

Maintenance Type	Interval (Service time or Running Distance)
A Service Check	Every 15 days or 6,000km
B1 Service Check	Every 45 days or 18,000km
B4 Service Check	Every 180 days or 72,000km
B8 Service Check	Every 360 days or 150,000 km
Intermediate Overhaul	Every 3 years or 450,000km
Periodic Overhaul	Every 6 years or 900,000 km

Preventive maintenance interval shall be compliant with the interval as specified in the table above.

22.7. Maintainability Target

The LRU replacement should be less than 30 minutes. MTTR in corrective maintenance operation that requires lifting of cars shall be less than 6 hours and 4 hours if lifting of car is not required (ERTS 2.12.12 table 2.5). Proposed MTTR for coil springs is 3.5 hrs.

22.8. Master Maintenance Schedule

- 1) The master maintenance schedule shall be provided stating clearly the parts needing attention in service checks and major overhauls.
- 2) The subcontractor shall submit work instructions/manuals for all scheduled maintenance activities, fault finding and corrective maintenance of all faults likely to be found during maintenance and servicing.
- 3) The master maintenance schedule should be incorporated in maintenance manual

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and subcontractor shall provide the relevant chapter reference in maintenance manual against the each maintenance task in master maintenance schedule.

22.9. Maintenance

The trains shall operate with minimum attention between the specified inspection periods, and shall, under the operating conditions specified, operate between overhaul periods without requiring replacement of components other than those on the agreed list of consumable parts to be proposed by the subcontractor and accepted by the contractor.

Special tools shall be avoided for maintenance. If unavoidable, they shall be supplied by the subcontractor in requisite quantities in all the depots to meet the maintenance requirements.

Equipment design shall be modular to minimize down time following failures of equipment and components. Provision for mechanical handling devices shall be provided for any single piece of equipment weighing more than 35kg and all such items shall be identified as a part of Final Design Review (FDR). Equipment covers shall be provided with secure, visible, latching arrangements easily inspectable from the side of trains.

All bogie equipment which cannot be handled manually shall be configured such that it can be removed and replaced from track level using fork lift trucks or lift tables, with recognition being given to the confined environment of the pit and the rail level and underframe dimensions. All bogie equipment shall be arranged such that it is capable of being removed and replaced without disturbing any other equipment. All such items, that may be required to be accessed and worked upon (including operation) in the event of any unusual occurrence on line shall be such mounted that it shall be very easily accessible to the train operator from PF/track level.

If any equipment mounted above the ceiling requires the use of lifting equipment for its removal or refitting this shall be readily achievable without the risk of damage to the vehicle interior.

Removal and re-assembly of moving and wearing parts on bogies shall generally be carried out without the use of special tools.

Bogies shall be capable of being disconnected and reconnected to vehicle bodies

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with a minimum of operations. All connections must be easily and safely accessible to personnel located in pits or alongside the bogie at rail level. It shall be easy to inspect for correct reconnection, from alongside the bogie where possible. Preference will be given to a design which permits release of the bogie to permit the raising of the car body, without the need for a pit in the Lifting Berth.

Each vehicle shall be capable of being lifted complete with bogies without the need to attach extra restraints or supports for the bogies or wheels.

Lubrication points shall have button head type grease nipples, and shall be easily accessible from rail level and shall, where possible, be grouped together.

On-vehicle test equipment shall be used on a vehicle to discriminate between a fault on the main equipment and a fault on the control electronic equipment.

22.10. Life Cycle Costs (LCC)

The subcontractor shall provide equipment that has minimum total LCC. The subcontractor shall submit LCC calculation in accordance with ERTS 2.21. The LCC which contains preventive & corrective maintenance activities shall be in compliance with the maintenance manuals submitted by the subcontractor.

22.11. Reliability and Maintainability (R&M) Demonstrations

- 1) The reliability demonstration of each train will start after six months of that train in revenue service and will continue till the end of the DLP.
- 2) Reliability of the trains and of the identified major systems will be demonstrated on fleet basis. Accordingly, the subcontractor shall be required to demonstrate compliance with specified equipment reliability.
- 3) During DLP, the values of the R&M target shall be calculated from the records of all faults and service failures. In the event that the R&M target is not achieved, the subcontractor shall, at his own expense, take whatever corrective action(s) to meet the R&M target specified, either by way of change of design of the relevant equipment/ component or software modification.
- 4) The subcontractor shall analyze and submit detail report to BEML/Employer for each and every failure/defect of whether of component, sub-system or system to determine the cause of failure and to propose corrective measures, which would be reviewed by BEML/ Employer.
- 5) Correction shall be made to components or subsystems that either fail to attain

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predicted reliability levels or show Pattern Failure, at subcontractor's own cost.

- 6) At the subcontractor cost, in depot at Mumbai, in coordination with BEML, the subcontractors shall demonstrate the maintainability for Periodic Overhaul, Intermediate Overhaul, LRU Replacement and Corrective Maintenance with car lifting and without car lifting.
- 7) The procedures used in the demonstration shall be the same as those included in the manuals delivered and the subcontractor is required to submit the list of required spares, consumable spares and tools for the Maintainability Demonstration.
- 8) The subcontractor shall support an active supply for high availability. If some failure needs subcontractor's support, the subcontractor shall depute his engineer as soon as possible. The subcontractor shall provide requisite training to maintenance personnel of Employer/BEML team for the same if needed.

22.12. Safety Requirements

The subcontractor shall comply with ERGS 2.7 & ERTS 2.4 for system safety assurance. The safety assurance program for the coil springs shall be consistent with the assurance program of the overall rolling stock and covers design, manufacture, testing & commissioning. The subcontractor shall indicate the magnitude and seriousness of events or malfunctions, which could result in injury to passengers and damage to the equipment but cannot be eliminated.

To meet the safety requirement, the subcontractor shall submit the following documentations as a minimum:

- 1) System Safety assurance plan as per ERTS 2.4
- 2) Hazard analysis including preliminary & sub-system hazard analysis, operation & support hazard analysis and interface hazard analysis as per ERTS 2.5.
- 3) FMECA (Failure Mode, Effects and Criticality Analysis)
- 4) Quantitative Fault Tree Analysis (FTA) for Safety Critical Events

22.13. RAMS Deliverables

The subcontractor shall submit the following RAMS Deliverables.

- 1) RAMS Plan during preliminary design.
- 2) Product breakdown structure during preliminary design stage.
- 3) Reliability analysis with train withdrawal scenarios as per Appendix-TG of ERTS.
- 4) Reliability block diagram & reliability prediction during both pre-final design stage.
- 5) Hazard analysis including PHA, sub-system hazard analysis, operating & support

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hazard analysis and interface hazard analysis during pre-final design stage.

- 6) Preventive and corrective maintenance analysis during pre-final design stage.
- 7) Master maintenance schedule during pre-final design stage.
- 8) FMECA (Failure Mode, Effects and Criticality Analysis) during both Pre-final design Stage.
- 9) LRU list during pre-final design stage.
- 10) Safety FTA during Final design Stage.
- 11) LCC Analysis during Final design Stage.

23. Fire safety

The subcontractor shall comply with ERTS-2.19 for fire performance and fire safety.

23.1. Material Properties

- 1) All non-metallic materials used in proposed system shall be selected so as to reduce to maximum extent practical heat load, rate of heat release, propensity to ignite, rate of flame spread, smoke, emission and toxicity of combustion gases.
- 2) All non-metallic materials used in proposed system shall conform to fire safety requirements of EN45545 Part 1 to 7 (Category 4-A, Hazard level HL3) latest edition.
- 3) The subcontractor shall submit a fire-safety plan providing the list of non-metallic material items that are used in proposed system with details of material, applied mass, fire safety compliance (flammability, smoke, toxicity and heat release rate etc) during preliminary design phase.

23.2. Fire Load Calculation

- 1) The maximum heat release rate per car shall be restricted to low levels.
- 2) Fire load calculation for all non-metallic materials have to be calculated with heat release rate data tested in accordance with EN 45545 HL3. The calculations shall be included in the fire safety plan submitted as the source of heat value.

23.3. Fire Performance Deliverables

The fire performance deliverables shall be provided in accordance with following table:

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SI. No.	Deliverables	Remarks	Submission Period
1	List of Non-Metallic Materials with details of material, mass & calorific value	As per EN45545	During Pre-Final Design stage
2	Fire Test Report	HL3	
3	Heat Release rate Test report		

24. Noise and Vibration Requirement

- 1) The supplier shall devote particular attention to the design of equipment to obtain quiet operation and shall ensure that the specified noise & vibration levels are inline with ERTS clause 2.18.
- 2) Vibration isolators or enclosures shall be incorporated into the equipment design to adequately attenuate noise & vibration.

25. Compliance for PTS, ERTS & ERGS

- 1) The subcontractor shall provide a valid and fully compliant proposal for the coil springs as detailed in the ERTS, ERGS and PTS.
- 2) The subcontractor shall submit a detailed clause by clause commentary (CBC) on the relevant clauses of the ERTS, ERGS and PTS.
- 3) Subcontractor shall note that their comments in CBC shall only be of the following forms:
 - “Complied” shall be indicated by the subcontractor where the subcontractor is able to comply fully with the clause.
 - “Noted” where a clause merely provides information and no other comment is necessary, “Noted” will suffice.
- 4) Offers with non-compliance and deviations to any of PTS, ERTS & ERGS clauses are liable for rejection.

26. Attachments

- MRS1 ERGS & ERTS
- Drawing No. 525-81106(latest revision): Helical Coil Spring (Outer)
- Drawing No. 525-81107(latest revision): Helical Coil Spring (Inner)
- Annexure 1: Fatigue Testing Procedure
- Annexure 2: Submittals Check sheets
- Annexure 3: Vendor Approval Form

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➤ Annexure 4: Calculation Sheet

27. Submissions

The subcontractor shall submit the documents along with technical offer in format enclosed as Annexure-2. All the required documents mentioned in Annexure-2 shall be submitted without fail; else the vendor is liable for rejection.