



# BEML LIMITED BANGALORE

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## Procurement Technical Specification For Damper

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## REVISION DETAILS

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## 1. Introduction

This document specifies the technical requirements of damper to be supplied for Mumbai Metropolitan Regional Development Authority (MMRDA), hereafter MRS1 project. The dampers 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 damper and shall be responsible for supporting the BEML activities.

## 2. General Specifications

The supplier shall supply damper with necessary subsidiary materials to ensure its functionality. The supplier shall have responsibility for investigation & consideration of suitability of damper 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 unit 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 given in the below table:

	<b>DMC</b>	<b>TC</b>	<b>MC</b>
Tare	≤42,000 kg	≤41,000 kg	≤41,000 kg
Crush	≤68,000 kg	≤68,000 kg	≤68,000 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 for designing of damper as given below:

<b>Item</b>		<b>All Corridors</b>
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 <sup>2</sup> 0.75 m/s <sup>2</sup> 0.40 m/s <sup>2</sup>
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 <sup>2</sup> 0.80 m/s <sup>2</sup> 0.45 m/s <sup>2</sup>
Average Service braking rate from 80 kmph to standstill for fully loaded (AW3) train on level tangent track.		1.0 m/s <sup>2</sup>
Average Service braking rate from 80 kmph to standstill for AW2 train on level tangent track.		1.1 m/s <sup>2</sup>
Average Emergency braking rate from 80 kmph to 0 kmph for fully loaded trains on level tangent track		1.3 m/s <sup>2</sup>
Jerk rate (Maximum)		0.75 m/s <sup>3</sup>



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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 (full 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 damper to be used for MRS1 project.

Description	Elevated Corridor	and At-grade	Underground Corridor
	Ballasted	Ballast less (DFF)	Ballast less (DFF)
Track Laying Gauge	1435 mm		
Rail Type (Main Line & Depot)	60E1(UIC 60) 880/HH	60E1(UIC 60) 1080/HH	60 E1(UIC 60) 1080/HH
Rail Profile	UIC 861-3		
Inclination Of Rail	1 in 20		
Sleeper Spacing (Main line)	600mm±10m m	600mm±10mm	700mm±10mm
Sleeper Spacing (Depot)	650mm± 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		
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		

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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 in9) 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(1in7) R-190	35 km/h	35 km/h	25 km/h
Turn-out Speed: Turnout (1in7) R-190	35 km/h	35 km/h	25 km/h
Turn-out Speed: Turnout(1in12) R-410	50 km/h	50 km/h	50 km/h
Turn-out Speed: Turnout(1in12) 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 damper to satisfy conditions as specified in section- 3.10 & 3.11 of ERTS given below:

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
Vibration and Shocks	The sub-systems & 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 subsystems 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.

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	Accordingly, the subject items & accessories shall also not deteriorate in their performance for 35 years
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**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
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 PTS or there is any conflict among the requirements of particular clauses of the PTS, ERTS and ERGS, the sub-contractor

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shall seek clarification from design team in BEML prior to making 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

- a. The subcontractor shall be responsible for design, manufacture, supply and performance of damper to BEML. The responsibility of BEML as a contractor for damper in MRS1 project as per requirements of GTC, ERGS & ERTS shall be obligatory for sub-contractor.
- b. The subcontractor shall seek information from BEML for all interfaces between damper and related equipments of bogie required by subcontractor for meeting design & performance requirements.
- c. The subcontractor shall provide BEML with all interface related information in detail as requested for interface compatibility, as & when required and in a time bound manner.

## 2.10. Precedence of Documents

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

This PTS in no way relieves the supplier from any requirements specified in the technical specification. If a conflict is discovered among any of the above contract documents, the following order of priority shall govern:

Order of Precedence	Document title
1	ERTS, ERGS
2	GTC
2	PTS

## 2.11. Standards

- a. The design, manufacture & testing of the proposed aggregates by sub contractor shall conform to the latest editions of UIC/EN standards or

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equivalent international standards on first priority. Metric system with SI units shall be used wherever applicable.

- b. 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.
- c. BEML/Employer reserves the right to accept or reject any such request(s).
- d. Following are some of the standards applicable for dampers:

Standard	Description
EN 13802	Railway applications - Suspension components Hydraulic dampers
EN 45545	Railway applications - Fire protection on railway vehicles

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

### 3. Definitions and Abbreviations

The following definitions and abbreviations are applicable to PTS.

#### 3.1. Definitions

The following definitions shall be used as 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 damper for MRS1 project.
- "BEML" means the contractor to procure the damper for MRS1 project.
- "Supplier/Subcontractor" means the supplier of damper to BEML.
- "PTS" means Procurement Technical Specifications.

#### 3.2. Abbreviations

The following abbreviations shall be used as applicable:

- GTC: General Terms & Conditions
- ERGS: Employer's Requirement General Specifications

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- ERTS: Employer's Requirement Technical Specifications
- PTS: Procurement Technical Specifications of BEML
- MMRDA: Mumbai Metro Rail Development Authority
- DMRC: Delhi Metro Rail Corporation
- RAMS: Reliability, Availability, Maintainability & Safety
- LCC: Life Cycle Cost
- ISO : International Standards Organization
- OEM: Original Equipment Manufacturer
- DLP: Defect liability period
- CG :center of gravity
- LRU: Line Replaceable Unit
- MDBF: Mean Distance Between Failures
- MTTR: Mean Time To Repair
- FAI: First Article Inspection
- QAP : Quality Assurance Plan
- MRTS : Mass Rapid Transport System
- RDSO: Research Design & Standards Organization
- O&M :Operation & Maintenance

#### 4. Qualifying Criteria & Vendor Approval

The subcontractor shall satisfy the following conditions:

- a. 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. Company profile and the infrastructure details shall be submitted by the subcontractor along with technical bid submission.
- b. The subcontractor shall meet the qualification criteria mentioned in ERTS 3.2.2 for supply of damper. Proposed damper 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

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different countries or in an MRTS in India.

- c. The subcontractor shall provide all the required documents for obtaining the vendor approval for damper as per the ERTS 3.2.5.
- d. 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.
- e. The vendor approval format is attached as an enclosure (Appendix-3) to this document.
- f. Vendor approval is mandatory for all subcontractors by Employer. Only approved vendors shall be considered for supplies. The acceptance of technical offer by BEML submitted by subcontractor is subject to approval of Employer.
- g. 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.
- h. 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

The subcontractor shall meet the technical requirements for damper as per clause 5.4 of ERTS & following requirements as a minimum:

### 5.1. General

The subcontractor shall be responsible for meeting the all technical requirement in PTS and requesting the all required data for damper.

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

- Dampers
- ERTS Chapter 5. "Bogie"

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## 5.2. Interface

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

### 5.2.1. Subcontractor's advice to BEML

- a. Advise all the interface issues related with the dampers for information of other designated systems/ equipment.
- b. Provide BEML with the interface information in detail that is requested by other systems /equipment for interface compatibility.
- c. 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

- a. Advise all the interface issues related with the Dampers as requested by Subcontractor.
- b. 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
- Fire, smoke detection and protection
- Use of fire retardant materials
- Low noise level



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- 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. Dampers

The system requirements for dampers shall be met, but not be limited to, for the following;

- The expected life of the proposed damper with resilient joints should be more than 10 years without any maintenance.
- All dampers are free about rotation between bogie and carbody in curves.
- Required damping characteristics are as follows. However detail characteristics of damper will be modified during the detail design stage.

	Piston speed (m/s)	Damping force (N)	
Primary Vertical	0.1	2500	Extension = Compression Tolerance will be less than $\pm 15\%$ .
	0.3	5800	
Secondary Vertical	0.1	3000	
	0.3	6800	
Secondary Lateral	0.1	6000	
	0.3	9200	

The characteristics may vary within the range of  $\pm 20\%$

- The vendor has to provide option to vary the damper characteristics by  $\pm 20\%$  at any stage of project, even on the supplied components. The characteristics will be fine tuned to ensure better ride quality.
- Stroke and dimension requirement

Following dimension does not involved the mounting tolerance. Damper should be designed to have some stroke margin in consideration of some mounting tolerance.

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Items	Installation length (Between both mounting centers)	Required stroke (from compression to extension)	Remark
Primary Vertical damper	460 ± 3mm	134mm	
Secondary Vertical damper	494± 3mm	197mm	
Secondary Lateral damper	398 ± 3mm	164mm	

- f. The attachment of damper should have sufficient allowable stiffness, torsion and conical angle. Below the suggested values for the characteristics. The values may vary within the range of +/-20%.

		Primary Vertical	Secondary Vertical	Secondary Lateral	Unit
Radial stiffness		>22	20 ±20%	20 ±20%	KN/mm
Allowable rotational angle	Conical	≥ 12	±13	±13	Degree
	Torsion	≥ 12	±19	±19	

- g. There shall not be any defects like scares, etc. on the appearance, which are harmful in the functioning of dampers.
- h. Maximum axle load: 17.0 ton
- i. Layout drawing of Bogie assembly will be provided later.

## 5.5. Material & Workmanship

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. Coating and painting System

- a. Damper shall be protected using an internationally accepted painting system proven in railway applications, which will protect the Damper from damage by corrosion in climate conditions prevailing in MRS1 project, for at least the period between major bogie overhauls without maintenance. The subcontractor shall furnish details of guaranteed life cycles of paint system,

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class details, reference standards, painting procedure etc. for review and approval of BEML (ERTS 14.19)

- b. Performance of the paint system shall be proven for lifetime in specified environmental conditions of the contract.
- c. 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
- d. The machined surfaces shall be covered with anti-corrosive coat. The anti-corrosive coating plan shall be submitted to BEML for approval
- e. Color of finish coat shall be decided by BEML/Employer before painting process
- f. The painting except machining surface shall be taken according to below requirements.

TABLE OF PAINTING PRODUCTS AS PER THE RULE OF THE SPECIFIED AVERAGE					
Products		Nominal value	Minimum value	Maximum value	Maximum point (individual points)
System	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 <sup>st</sup>	Epoxy primer	EP1119	3:1	60 ± 20	6 hrs	024	6 hrs
Top 1 <sup>st</sup>	2 <sup>nd</sup>	Urethane top	UT5119	4:1	60 ± 20	Min. 10 hrs	037U	8 hrs

## 5.7. Weight

### 5.7.1. Target Weight Limit

- 1) The weight of the damper assembly including the mountings frame shall not

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exceed weight described in below table.

Equipment	Target Weight
Primary Vertical Damper	8.0kg
Secondary Vertical Damper	7.0kg
Lateral Damper	6.2kg

- 2) The above maximum weight shall cover the equipment manufacture weight tolerance. Therefore, the subcontractor shall control the equipment weight with 0 / - 5% 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.

#### 5.7.2. Subcontractor Weight Control Activity

Weight Progress Report.

- 1) 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

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

- 1) Dampers (Primary Vertical, Secondary Vertical and Lateral).
- 2) Spare Parts
- 3) Damper Testing machine and other special tools and testing equipment if required.
- 4) Consumable materials needed for assembling/ disassembling of dampers (Loctite, sealant, paste, etc.): required amount for 504 trains and spares.

### 6.1. Hardware

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

Sl. No.	Drawing No.	Description	Qty./car
1	525-81032	Primary Vertical Damper	8 No's
2	525-83067	Secondary Vertical Damper	4 No's
3	525-82005	Lateral Damper	2 No's
<b>Spares Requirement</b>			
Sl. No.	Drawing No.	Description	Remarks
1	525-81032	Primary Vertical Damper	As per MRS-1 spares contract list
2	525-83067	Secondary Vertical Damper	
3	525-82005	Lateral Damper	
4	525-82032	Assembly Tools, Damper testing machine, Damper repair tools	
5	525-82034	Tools for assembly/disassembly of dampers	

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Sl. No	DESCRIPTION	BEML			Subcontractor		
		Design	Supply	Fit	Design	Supply	Fit
1	Primary Vertical Damper	X2		X2	X	X	X
2	Secondary Vertical Damper	X2		X2	X	X	X
3	Secondary Lateral Damper	X2		X2	X	X	X

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.

## 6.2. 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.

## 6.3. Split of Responsibilities

- 1) The subcontractor shall be primarily responsible for design and fitment of damper and its sub components.
- 2) The subcontractor shall be responsible for any design change within his scope of supply. The design change shall be done only after technical meeting with BEML/Employer under original contract rates & delivery schedule.
- 3) The subcontractor shall send its engineer to BEML/Employer's designated place for technical meetings.
- 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 &

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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 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, assembly of damper, finish painting, technical documentation, training (if any) and warranty against defects.
- 8) The damper drawings 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	Design	According to PTS		X	
2	RAMS	According to PTS		X	
3	Calculation documents	According to PTS		X	
4	Approval of drawing	According to PTS	X1	X	
5	Type & routine test	According to PTS		X	
6	Manufacturing	According to PTS		X	
7	Technical documentation	According to PTS		X	
8	Manual	According to PTS		X	
9	Training	According to PTS		X	
10	Warranty for each Components	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.

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- 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.

## 7. Design Information

### 7.1. General

- 1) The objective of the design submission process is to ensure that the proposed systems 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 the dampers 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, RAMS 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-



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Excel file shall be submitted by sub-contractor. The worksheet shall include equipment breakdown list, quantity, unit weight, center of gravity 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.
- 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:

- a) Preliminary Design
- b) Pre-final Design and
- c) 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

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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.
- Damper testing machine specification, operating procedure

### 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:

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

## 7.5. Design Stages

SI 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:

SI. No.	Document	Submission Phase
1	Detailed Drawing	Preliminary Design and technical offer
	3D stp file	Preliminary Design

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Sl. No.	Document	Submission Phase
		and technical offer
2	General technical description of proposed dampers service / delivery and other information	Preliminary Design and technical offer
3	Technical write-up	Preliminary Design and technical offer
4	General description	Preliminary Design
	Certificate of conformity and material certification	Preliminary Design
5	Manufacturing process flow chart along with applied standards	Preliminary Design and technical offer
6	Detailed technical specification and data of all the three dampers	Preliminary Design
7	Specification and life of components	Preliminary Design
8	Estimated/measured noise attenuation data as per EN13802	Pre-final Design
9	Drawing of dampers with all general/technical data	Preliminary Design
10	Marking/stamping drawings	Pre-final Design
13	Analysis and calculation data	Pre-final Design
14	Anti-corrosion plan	Pre-final Design
15	Paint specification & procedure	Pre-final Design
16	Routine test specification	Pre-final Design
18	Routine test check sheets/report	Final Design
19	Type test specification as per EN13802	Pre-final Design
20	Type test report as per EN13802	Final Design
21	Operation & Maintenance manual for dampers and special tools	Final Design
22	Hazard Analysis	Final Design
23	RAMS details	Final Design
24	The manufacturing details of all Equipment	Pre-final Design
25	Installation Instruction of all Equipment	Final Design
26	Cleaning, storage and handling instruction of Equipment	Final Design
27	Maintenance & Inspection Instructions	Final Design
28	Monthly progress report	Continuous
29	Painting Procedure	Pre-final Design
30	Analysis & Calculation data like Damping rate calculation, Stroke calculation & detail attachment characteristics with stiffness and allowable angle	Pre-final Design
31	Training manual for dampers, special tools, jigs and fixtures	Pre-final Design
32	Final Inspection and Test Plan	Final Design
33	Quality Assurance plan	Pre-final Design
34	Spare parts catalogue if any	Pre-final Design
35	Assembling and disassembling instruction	Pre-final Design

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## **8. Inspection and Testing of Dampers**

### **8.1. 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:

The Inspecting Official shall have free access to the works of the manufacturer at all reasonable times.

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

The Inspecting Official is free to have the sample for various tests.

A flow diagram indicating the logical sequence of validations and tests starting with material receiving tests and inspections and concluding with system demonstrations tests.

- Validation schedule.
- Test schedule.
- Responsibilities of the subcontractor.
- Record-keeping assignments, procedures and forms.
- Procedures for performing validation.
- Procedures for monitoring, correcting and re-testing deficiencies.
- Procedures for controlling and documenting all changes made to the hardware and software after the start of testing.

### **8.2. 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

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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.

### 8.3. 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 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

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software module.

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

#### **8.4. Testing Scope**

- 1) The subcontractor shall carry out the type test and routine test of the damper. BEML and/or Employer/Representatives shall have the right to witness any or all of these tests at any stage of testing.
- 2) 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 related to facilities of the damper.
- 3) The subcontractor shall prepare a test plan listing all tests to be performed, acceptable limits, etc along with scope of each test. After testing, the subcontractor shall submit a test report for BEML/Employer approval.
- 4) Any design changes, adjustments etc required to meet performance requirements, shall be fully re-tested & documented; the expense for the same shall be borne by the sub-contractor. Design changes if any, shall be subject to prior approval by BEML/Employer.
- 5) The subcontractor shall conduct product conformity testing on every supply to ensure that the equipment is functioning correctly as per performance requirements. The subcontractor shall submit test procedure for the same to be approved by BEML/Employer.
- 6) Service trials shall be done by BEML at designated depots of Employer. In case any problems are encountered during the testing for items supplied by sub-contractor, the subcontractor shall send his person in reasonable time for identification & rectification of root cause and shall provide full support to BEML for successful completion of testing & commissioning. Any cost associated with travel, lodging etc shall be borne by subcontractor for his personnel.
- 7) BEML and/or Employer/Representatives will carry out the First Article Inspection (FAI) on the damper under sub-contractor's responsibility.
- 8) In the event that any test for damper fails, the subcontractor at his own expense and responsibility shall take corrective action as deemed necessary, such as,


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rectification, readjustment or design modifications to the satisfaction of BEML and/or Employer/Representative, in order to meet the testing requirements.

- 9) Only with the written consent of BEML/Employer will type test or certification requirements 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.
- 10) In case BEML seeks to waive off type test for the damper & its components 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.
- 11) The work test for damper shall be in line with best up to date proven international practice. The scope & level of work tests shall be submitted by subcontractor for approval by BEML. Following are some of the work tests along with level of testing of produced parts:

Item		Type Testing /First Article Inspection	Production Conformance Testing	Testing Schedule	Acceptance Criteria	
Dimensional Inspection		O	100%	With each batch of supply	Within the range	
Checking of the appearance		O	100%	Approved by BEML		
Checking of dimensions		O	100%	Approved by BEML		
DAMPER	Weight test		O	Batch	Approved by BEML	
	Characteristic test	Static	O	100%	Approved by BEML	
		Dynamic		100%	Approved by BEML	
	Temperature test	Low @ -25 <sup>o</sup> C	O	Batch	Approved by BEML	no oil leakage
		High @ +70 <sup>o</sup> C	O	Batch	Approved by BEML	no oil leakage
		Ambient	O	Batch	Approved by BEML	no oil leakage
	Leakage test		O	Batch	Approved by BEML	no oil leakage
	Fatigue test		O	X	Approved by BEML	



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ATTACHMENT	Characteristic test	Radial	O		Approved by BEML	
		Axial	O		Approved by BEML	
		Torsional	O		Approved by BEML	
		Conical	O		Approved by BEML	
Stamping control		O	100%	Approved by BEML		
Painting control		O	100%	Approved by BEML		
Packing		O	100%	Approved by BEML		

### 8.5. First Article Inspection (FAI)

The damper and sub-assemblies 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. FAI is performed on the first production batch of dampers manufactured in accordance with the applicable standard EN 13802. The subcontractor shall inform BEML for carrying out FAI at least one month before the FAI date.

### 8.6. Type test

The subcontractor shall submit the type test details along with acceptance criteria for damper as per relevant international standard and minimum to ensure EN13802 all clauses are tested and complied. Copies of type test report for each batch of supply shall be submitted along with damper supplies. The subcontractor shall be responsible for rectification/repair of any defects if observed.

### 8.7. Routine Test

- 1) The subcontractor has responsibility for the routine test of the damper as per relevant international standard. During the test, the criteria shall be observed and recorded. Copies of routine test records shall be submitted along with each batch of supplies for every damper.
- 2) Additional copies of records of all tests/inspections shall also be available at the subcontractor works for BEML and/or Employer/Representative on demand.

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## 8.8. Type test & Commission test for completed car and train, service trials

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

In case of any problems happening in the Dampers during the test of train, the Subcontractor shall immediately dispatch 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.

The subcontractor shall provide full support by way of instructions, staff and materials during the Service Trials at the request of BEML.

## 9. 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, 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 6 hard copies in color 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.

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## 10. Training needs

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

## 11. Warranty

The subcontractor shall be responsible for warranty of its supplies as per Chapter 1 Section-1.8 of ERGS.

## 12. Delivery

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

## 13. System Assurance and Safety

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

## 14. Quality

All works for the damper shall be executed and controlled by a quality management system, in accordance with relevant standard. The subcontractor shall comply with ERGS 2.6 & ERTS 2.3 to a minimum.

### 14.1. 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.

#### **14.2. 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

#### **14.3. Inspection and Test Plan (ITP)**

ITP shall be submitted to the BEML within 2 weeks from purchase order placement date. It shall include at least the following:

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

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- f. Records of any non-conformance identified during inspection or testing
- g. BEML will designate Witness/Hold point of BEML and/or Employer/his Representative and notify it to the Sub-contractor.

#### **14.4. Quality Audit**

The subcontractor shall develop a quality audit program in accordance with the relevant 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.

### **15. Project Management Plan**

Along with the technical offer, the subcontractor shall submit a Project Management Plan which shall provide a clear over-view of the Contractor'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:

- a. 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.
- b. The names, qualifications, positions and current resumes of key executive, supervisory and engineering staff to be employed full-time for the works.
- c. A narrative describing the sequence, nature and inter-relationship of the main contract activities including timing for exchange of information.
- d. Procedure for documentation control.
- e. 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

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have been Project Head in at least one Rolling Stock Project in last 10 years.

- f. 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.
- g. To fulfill the sub-contractor's obligations during the testing and commissioning and 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.
- h. 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.

## 16. RAMS Requirements

The subcontractor shall comply in every aspect with the requirements of RAMS as per section 2.7 to 2.13 of ERTS chapter-2 and section 2.8 of ERGS. During DLP, the values of the RAMS target shall be calculated from the records of all 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:

### 16.1. General

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

### 16.2. Reliability Requirements

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

- a. 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
- b. At least 20% of the same replaceable part, item or equipment in the fleet has

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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.

### 16.3. Reliability Analysis

- a. The reliability data shall be based on actual operating information of the equipment.
- b. The subcontractor shall submit a list of typical train withdrawal scenarios for review and acceptance by BEML. The list shall include all anticipated failure scenarios, which can affect safety, punctuality and passenger comfort. Also, a list of typical train withdrawal scenarios should be based on the reliability analysis.
- c. The reliability block diagrams and prediction of reliability performance shall be submitted to BEML for acceptance in the format, parameters & units as desired by the Employer
- d. The reliability block diagrams shall include all elements essential for successful performance of the system and their inter-relationship & interface.
- e. The subcontractor shall submit reliability prediction to demonstrate by quantitative methods, the achievement of the specified levels of reliability for the scope of supply.

### 16.4. Reliability Target

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

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

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

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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 damper 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 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

**Relevant Failure:**

- a. 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:
- b. A fault in an equipment or sub-system while operating within its design and environmental specification limits;
- c. Improper operation, maintenance, or testing of the item as a result of the subcontractor supplied documentation.
- d. 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.



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**Service Failure:**

- a. 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:
- b. Non-availability of the train to start revenue service after successful completion of pre-departure checkout.
- c. Withdrawal of the train from revenue services.
- d. A delay equivalent to or exceeding 3 minutes from the Schedule / Time table as noted at the destination station for the one way trip.
- e. 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 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:**

- a. 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.
- b. The detailed methodology for identification of patter failures shall be finalized during the design stage. The decision of the Engineer shall be final.

## **16.5. Maintainability Requirements**

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

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- a. The design of all components will be such that maintenance is reduced to a minimum, substantially improving service intervals.
- b. 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.
- c. 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.
- d. The sub-contractor 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.
- e. The procedures used in the demonstration shall be the same as those included in the maintenance manuals submitted.
- f. The sub-contractor shall submit the list of required spares, consumable spares, tools etc for such demonstration
- g. The sub-contractor shall support an active supply for high availability. The active supply procedure of BEML is same as figure below.
- h. The sub-contractor shall comply with procedure of BEML for fault rectification. If some failure needs the sub-contractor's support, the sub-contractor shall depute the engineer in the earliest possible time.
- i. The sub-contractor shall provide training/requisite knowledge to BEML maintenance staff if any, needed at the time of maintenance.

#### 16.6. Maintenance Interval

The proposed damper 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)
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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.

#### **16.7. 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 dampers is 2 hrs.

#### **16.8. 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 and sub contractor shall provide the relevant chapter reference in maintenance manual against the each maintenance task in master maintenance schedule.

#### **16.9. 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

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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, which 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 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.

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#### **16.10. 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.

#### **16.11. 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 defects liability period.
- 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 Defects Liability Period, 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 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 predicted reliability levels or show Pattern Failure, at sub-contractor'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

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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.

## 16.12. Safety Requirements

The subcontractor shall comply with ERGS 2.7 & ERTS 2.4 for system safety assurance. The safety assurance program for the damper shall be consistent with the assurance program of the overall rolling stock and covers design, manufacture, testing & commissioning. The sub-contractor 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 completely eliminated.

To meet the safety requirement, the sub-contractor shall submit the following documentations as a minimum:

- 1) System Safety assurance plan as per ERTS 2.4
- 2) Hazard analysis including preliminary & subsystem 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

## 16.13. 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 pre-final design stage
- 5) Hazard analysis including PHA, subsystem hazard analysis, operating &

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support 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 pre-final design.
- 9) LRU list during pre-final design stage
- 10) Safety FTA during final design Stage
- 11) Life Cycle Cost (LCC) Analysis during final design Stage

## **17. Fire safety**

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

### **17.1. 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.

### **17.2. 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.

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### 17.3. Fire Performance Deliverables

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

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

### 18. Compliance for PTS, ERTS & ERGS

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

### 19. Attachments

- MRS1 ERGS & ERTS
- Primary Vertical Damper Drawing no: 525-81032
- Secondary Vertical Damper Drawing no: 525-83067
- Lateral Damper Drawing no: 525-82005
- Annexure 1: Submittals Check sheets
- Annexure 2: Vendor Approval Form



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## 20. Submissions

The subcontractor shall submit the documents along with technical offer in format enclosed as Annexure-1.