



# BEML LIMITED BANGALORE

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## Procurement Technical Specification of Battery System for MRS1 Contract

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## 1. Introduction

### 1.1 General

This document describes Procurement Technical Specification of **Battery system** to be supplied for MRS1 contract for Mumbai Metropolitan Regional Development Authority.

BEML shall carry out all required works and activities as Supplier for MRS1 contract while the subcontractor shall be responsible for all works required in this PTS with regard to Design, supply, testing and commissioning of **Battery system** and shall be responsible for supporting the BEML activities as subcontractor for MRS1 contract.

The rake formation shall generally be as follows:

- \*DMC – TC – MC – - 3 car unit formation
- \*DMC – TC – MC – MC – TC – DMC\* - 6 car train formation

For increase in quantity (if required)

- TC – MC – - 2 car unit formation
- \*DMC – TC – MC– TC – MC – MC – TC – DMC\* - 8 car train formation

- DMC: Driving Motor Car, MC: Motor Car, TC: Trailer Car


The trains may have to be operated in GoA2/GoA3 modes with driver/ attendant during initial phase of the project and shall finally be upgraded to GoA4 (UTO).

As per ERTS 1.1.8 & ERTS 1.4, during initial phase of the project, all trains (including prototype train) shall be tested and commissioned for GoA2 modes of automation. Upgradation of all trains to GoA3/GoA4 modes shall be done subsequently (refer Note No. 6. of 'Attachment to Appendix FB-1' to 'Form of Bid'). The interface testing may have to be done separately for line 2 & 7 of Mumbai Metro.

### 1.2 Climatic and Environmental Condition

The MRS1 cars shall operate reliably and safely under Mumbai climatic and Environmental conditions as per ERTS 3.10 shown in the following Table.

Description	Limiting Values
Maximum ambient temperature (See note 1 below)	36 °C
Minimum temperature	14.3 °C
Humidity (See note 2 below)	≥ 95% RH
Rainfall	The annual precipitation is 2,078 mm with 34 % (709 mm) falling in the month of July.

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Atmosphere during hot season	Extremely dusty including bird feathers		
Maximum wind speed	150 km/hr.		
Vibration & 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.		
SO <sub>2</sub> level in atmosphere	80 - 120 mg/m <sup>3</sup>		
Suspended particulate matter in atmosphere	360 - 540 mg/m <sup>3</sup>		


Note:

1. 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.
2. Any moisture condensation shall not lead to any malfunction or failure.

### 1.3 Operating Environments

The proposed MRS1 cars will operate with the track geometry and requirements shown in the following Table as per ERTS Chapter 3 & 7.7.

Track Gauge	1435 mm
Min. radius of curvature (Main line)	110m – Elevated & At grade 200m – Underground
Min. radius of curvature in depot	100 m
Min. vertical radius of curvature	1500 m
Max. gradient (Mainline & Depot Connection)	4%
Safe Speed	90 kmph (with inflated secondary suspension)
	80 kmph (with deflated secondary suspension)
Maximum operational Speed	80 kmph (with inflated secondary suspension)
	70 kmph (with deflated secondary suspension)
Annual running distance of one train (for design purpose)	1,50,000 Km
Train control system	CBTC based On board Continuous Automatic Train Control system (CATC) consisting of i) Automatic Train Protection ii) Automatic Train Operation (ATO) iii) Automatic Train Super-vision (ATS) iv) Attended/Unattended train operation (GoA2/GoA3/GoA4)
Conditions in stations	All stations shall have Platform Screen Doors (PSD's). These doors shall not be of full height

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		and shall have provision to allow free flow of air for platform ventilation.

#### 1.4 Current Collection System (ERTS clause 3.17)

System Particulars	For all sections and depot
Supply Voltage System	25kV AC single phase 50Hz
Current Collection	Through Pantograph
Nominal Voltage	25.0 KV AC
Minimum voltage	19.0 kV AC
Maximum voltage	27.5 kV AC
Instantaneous minimum voltage	17.5 kV AC
Occasional maximum voltage	31.0 kV AC
Voltage for guaranteed performance	22.5 kV AC
Variation in frequency	48 to 52 Hz

## 2. Definitions and Abbreviations

The following definitions and abbreviations are applicable to the PTS.

“DMRC” means the Employer for the Mass Rapid Transport System (MRTS) for MRS1 contract.

“DMRC’s Representative” mean such persons appointed by DMRC to act as engineers for the purpose of the MRTS.

“BEML” means the Contractor to procure the **Battery system** for MRS1 Contract.

“Subcontractor” means the supplier of **Battery system** to BEML for MRS1 Contract.

“GS” means Employer’s Requirements-General Specification of MRS1 contract.

“TS” means Employer’s Requirements-Technical Specification of MRS1 contract.

“PTS” means BEML’s Procurement Technical Specification.

“GTC” means General Terms & Conditions of the tender issued by BEML for procurement of the **Battery system** for MRS1 contract.



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### 3. Precedence of Documents

The PTS shall be read in conjunction with the General Terms & Conditions (GTC) of the tender, GS and TS.

To the extent that any provision of the PTS is inconsistent with any provision of the General Terms & Conditions of the tender (GTC), the provisions of the GTC shall prevail.

To the extent that any provision of GTC is inconsistent with any provisions of the GS and TS, the provisions of GTC shall prevail.

In the event of any conflict between requirements of particular parts of this PTS, the Subcontractor shall seek clarification from BEML.

Order of precedence	Document Title
1	GTC, GS, TS
2	PTS

### 4. Standards

The design, manufacture and testing of the work and the materials shall conform to the latest editions of internationally recognized North American, European, Japanese standards. The standards to be used shall be as per Appendix TA of ERTS.

1. General Standards: IEC, UIC, EN, BS, JIS, NF, NFPA, ASTM etc.

2. Subcontractor's Standards.

Where no standard is identifiable, the subcontractor shall make a proposal, based on the best International practice, which shall be subject to review by BEML/DMRC.

During the preliminary design phase, the subcontractor shall submit a consolidated list of all the standards that he intends to use for the design, manufacturing and testing and other phases of the contract, for review of BEML/DMRC.

During the pre-final design phase, the subcontractor shall supply one original copy each of the standards and codes in form of searchable pdf format to BEML and DMRC representative.

### 5. Requirements of Documentation

All drawings, documents and information by Subcontractor shall be prepared in English and submitted to BEML for approval.

Except for drawings, all documents and information to be submitted shall be of Microsoft Office format on CD-ROM or e-mail.

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The Subcontractor shall provide BEML with the drawings of component of Battery System in a format readable with AutoCAD 2008 on CD-ROM or e-mail as requested by the requested by the DMRC or DMRC's Representative.

The drawings shall contain minimum three (3) view points (for example, front view, top view and left view) for three (3) dimensional modeling. The Subcontractor shall provide STEP file or CATIA file to BEML/DMRC.

## 6. Qualifying Criteria for subcontractor and Vendor approval

### 6.1 Proven Design (ERTS clause 3.2)

The proposed Battery system by the sub-contractor against this PTS shall satisfy the "Proven Design" clause 3.2.2 of ERTS. The proposed system shall have been in use and have established its 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.

The subcontractor shall manufacture and supply the Battery system only from such manufacturing units that have supplied the Battery system that fulfill the proven design requirements as above (Refer ERTS clause 3.2.2).

### 6.2 Qualifying Criteria (ERTS clause 3.2.2)

- (i) The subcontractor shall meet the qualification criteria as per **ERTS 3.2.2**.
- (ii) The subcontractor should be an OEM and should have carried out design and manufacturing of sub-assemblies and those subassemblies. Proposed **Battery system** shall be state-of-art & of proven design and 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. Proposed **Battery system** should have been in service during the preceding three years or more in respect of **Battery system** in similar metro system. To this effect, the subcontractor shall submit purchase order copies and satisfactory performance reports from the customers / Metro Corporations along with the technical offer. Where similar sub-systems of a different rating are already proven in service as per the above criteria then the design shall be based on such sub-systems.

The Battery system shall be procured from the approved vendors and sourced from only such manufacturing units that have supplied the sub-systems that fulfill the proven design requirements as above. The contract envisages commencement of manufacturing only after completion of Pre-final design. Accordingly, the number of years in revenue service and operation for the above requirements shall be calculated as on the contracted Key Date No. 3.1 corresponding to Pre-Final Design Completion.

In case the subcontractor proposes to use sub-system(s) that do not fulfill the above said criteria then the subcontractor shall furnish sufficient information to prove the

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basic soundness and reliability of the offered sub-system(s) for review of the Engineer. The Engineer's decision on subcontractor's proposal shall be final and binding.

- (iii) The subcontractor shall have established International Quality systems and certification like ISO 9001/ISO 14001/IRIS.
- (iv) The subcontractor shall submit Inspection & Test Plan / Quality Manual followed.
- (v) The subcontractor shall 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.
- (vi) The technical support of subcontractor shall be made available through permanent positioning of subcontractor's staff in Depots at Mumbai for meeting DLP obligation as per ERTS 3.2.5.
- (vii) The subcontractor shall give an undertaking to supply spares for a minimum period of 10 years from the date of date of completion of the contract as per ERGS 8.12.

### 6.3. Vendor approval (ERTS clause 3.2.5)

Vendor approval from DMRC is mandatory for all sub-system suppliers. Accordingly the request for Vendor approval with all relevant references and details as per Vendor approval format (Refer Annexure-1) shall be submitted along with the technical offer along with Company profile, Product range and the organization structure. The acceptance of the technical offer is subject to approval of the Vendor by DMRC based on the vendor approval details submitted by the subcontractor.

## 7. Scope of Supply


### 7.1 Hardware

Subcontractor shall consider ERGS & ERTS of MRS1 contract during design of the Battery and the Subcontractor shall provide, as a minimum, the following as per **ERTS 9.4 & 9.7.**

Part No.	Description	Quantity / M-car
525-21201	Battery – 110V, Ni-Cd	1 set

Part No.	Description	Quantity
525-21202	Battery electrolyte automatic topping up device	1 set (for each depot)

Part No.	Description	Quantity *
525-21203	Battery Control and Monitoring Unit (BCMU, which shall include current	4 sets

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	sensor, voltage sensor, temperature sensor, control unit/data logger, associated accessories etc.,)		

**Note \*:** Two trains (one on each line) shall be fitted with Battery Control and Monitoring Unit (BCMU) to monitor the charging, discharging current, voltage etc. It shall be possible to install the BCMUs in any of the trainsets at later stage as per ERTS 9.4.10.

- 7.1.1 Battery:** One set of battery to meet the emergency load of **15.081KW** for a duration of 60 minutes & supply startup load of **52 W** for **100 seconds** and shall contain as a minimum the following:
- Battery cells with centralized water topping system arrangement.
  - Rigid connection bars between cell to cell, crate to crate.
  - Connection Cables (tray to tray) along with mating lugs (Size of cables shall be 95 Sq mm)
  - Terminal lugs for input (+, -) cables of vehicle side to suit 95 Sq mm cable.
  - Integrated topping up facility: Suitable interconnection shall be provided so that topping up of all the cells can be carried out from a single point of battery box.
  - Terminal caps for proper insulation of Battery terminals
  - Supporting clamps for inlet, outlet connectors and inter cell & inter crate connector pipes
  - Fire/Flame retardant packing wood (as per **ERTS 2.19**), Non-flammable, electrolyte proof of suitable thickness for securing the movement of crates in the battery tray/box: Valid test certificates shall be provided. Additional packing shims (flame retardant) of suitable thickness shall also be provided.
  - One set of Temperature sensor shall be provided along with each battery set for temperature compensation charging of Battery by Battery charger.

**Note:**

- Pre-charging of battery cells shall be done before installation of battery on train by Battery supplier.
- Cell terminals to be applied with appropriate torque and an inspection check for application of torque with suitable marking for the same shall be carried out.
- Cell terminals and connectors shall be applied with a thin layer of petroleum jelly or anti-corrosion lubricant for protection against corrosion.
- The battery shall be capable of being charged from onboard battery charger having both boost and float modes. The current set points for change over from float to boost & vice-versa and charging voltage ranges shall be decided upon discussion with battery charger supplier.

**7.1.2 The proposed battery shall have capacity of around 260 Ah to meet the above mentioned load profile and the number of cells shall be preferably 76 cells. In any case, the no. of cells proposed shall not exceed 80.**

**7.1.3 Battery electrolyte automatic topping up device:**

One set of battery electrolyte Fully automatic topping up device shall be provided for each depot (as per ERTS 9.4.9)

**7.1.4. Commissioning and DLP Spares:**

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The subcontractor shall supply commissioning and DLP spares as per ERGS 8.11. Subcontractor shall submit to BEML for review and approval of BEML/DMRC a list of minimum spare parts that he intends to make available during the installation, commissioning and defect liability period.

The subcontractor shall position the approved commissioning and DLP spares at the designated depot as per ERGS Chapter 8.11.

The Subcontractor shall keep on site, at his own cost throughout the installation, commissioning and defect liability period, stocks of spare parts to enable rapid replacement of any item found to be defective or in any way in non-conformance with the specification.

**7.1.5 The following requirement shall be met by battery supplier as per ERTS section 9.3, 9.4, 9.5, 9.6 & 9.7.**

9.3.1 The battery shall be charged from the local (three-car unit) static battery charger. The battery charger with automatic control shall be capable of providing a temperature compensated high rate boost charge or float charge compatible with the characteristic of the Ni-Cd batteries.

9.3.2 The battery charger shall be capable of charging a discharged battery to 80% full charge within 4 hours. Once the battery is fully charged, float charge should stop after 10 minutes.

9.3.3 Batteries shall be connected to a common Battery Bus throughout the train.

9.4.1 Each three-car unit shall be equipped with a battery set consisting of nickel cadmium cells having a nominal voltage of 110V with PP cell casings. The battery shall be rated and tested in accordance with the requirements of IEC 60623 and shall also meet the requirements of IEC60993 and EN 50547.

9.4.2 The backup battery shall utilize a sufficient number of cells to ensure that it is capable of:

- i. Maintaining full DC loads when the train runs over neutral sections of the overhead line in case of 25 kV AC system.
- ii. Supply emergency load for at least 60 minutes (with doors open and close every two minutes) in case of failure of battery charger or its supply with the battery charged to a level as expected during service but not better than 80% of its full capacity. Contractor shall also demonstrate that at any time of service, stage of charge shall not be less than 80%, before the voltage level at any device falls below 77V DC Non-essential load shall be shed after 30 seconds of failure of battery charge supply. This feature shall be demonstrated during testing.

9.4.3 Emergency loads shall include, but need not be limited to:

- i. Emergency lighting.
- ii. All exterior lights.
- iii. Ventilation fans but not air conditioning.
- iv. Communication systems including public address, passenger emergency alarm.

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surveillance  
system and train radio.  
v. Propulsion and brake controls.  
vi. Door controls.  
vii. TCMS.  
viii. Electric horn.  
ix. Driving console indicators, lighting and interlocking.  
x. ATP train borne equipment.

9.4.4 The design and control of the battery shall ensure that there is sufficient capacity left under all conditions to raise all the pantographs simultaneously. Adequate circuit protection shall be provided to ensure the battery load shall be disconnected when the battery voltage has dropped below 70% of the nominal voltage and when the auxiliary load is re-connected.  
the initial battery load shall not cause the battery output to oscillate.

9.4.5 Battery electrolyte capacity shall be such that the batteries will not require topping up more than once in a year. Complete calculation of loss of water and float/boost charging shall be submitted. Batteries shall be designed with integrated topping up provisions. Suitable interconnection shall be provided so that topping up of all the cells can be carried out using from a single point on battery box. The design shall be submitted for review of the Engineer. For the calculation of sizing of battery at high and low temperature, ageing de-rating factor and charging de-rating factor shall be considered and calculations shall be submitted to Engineer during detailed design stage.

9.4.6 The battery terminal voltage shall float on the 110V DC output of the auxiliary power supply of which the output voltage shall have fine adjustments and good stability to avoid over or undercharging of the battery.

9.4.7 The control elements taking power from the battery shall be capable of operating between 77V and 138V DC The instantaneous battery voltage shall be monitored and recorded through TCMS.

9.4.9 One set of battery electrolyte automatic topping up devices shall be provided for each Depot. These devices shall be portable and easily operated by one person. They shall incorporate a feature to cut-off the electrolyte automatically when it has reached the correct level.

9.4.10 Two trains (one on each line) shall be fitted with Battery Control and Monitoring Unit (BCMU) to monitor the charging, discharging current, voltage etc. It shall be possible to install the BCMUs in any of the trainsets at later stage.

9.4.11 Battery Protection and Isolation:

(i) Battery fuses of suitable rating shall be fitted in a separate box located adjacent to one

of the battery boxes and shall enable easy access from track level.

(ii) Back connected fuse holders shall be provided and the battery fuse enclosure shall be sealed to IP65 in accordance with IEC 60529.

(iii) A battery contactor operable from inside the cab shall be provided to disconnect the battery from the car wiring electrically, when required.

(iv) A low voltage earth bar shall be provided and located close to the negative fuse.

(v) The status of fuse and circuit breakers shall be monitored by TCMS.

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9.4.12 Battery temperature shall be displayed in TCMS.

9.5.1 The box for battery shall be such that to avoid any corrosion throughout the service life on any account and the box shall last for the lifetime of the cars. Within the battery box, the battery shall be mounted in roll out trays to allow for easy maintenance.

9.5.2 The roll out system shall be corrosion resistant and shall be provided with the necessary stops and locks to limit the travel of the battery box and retain it in both extreme positions. When rolled out, the entire top of the battery shall be exposed. All the battery terminals, including battery positive and negative main connections shall be easily accessible for maintenance work.

9.5.3 The box interior / the roll out trays shall be lined with a non-flammable, electrolyte proof, insulating material of suitable thickness. The box shall be ventilated to preclude the possibility of built-up of any gas. Vibration proof automatic lock shall be provided to ensure absolutely no relative movement of the batteries inside the tray.

9.5.4 The battery box shall be sized to have at least 10% extra space to accommodate augmented capacity battery. Extra space shall be suitably packed.

9.5.5 Battery box shall not deshape/sag during lifetime of the car. Adequate strength shall be built in the battery box by providing suitable ribs etc. FEM & fatigue report of the battery box shall be submitted to establish the same.

9.7.1 The Contract deliverables (tools/equipment/software etc.) required to be supplied by the Contractor under this Chapter of ERTS are listed below:

S.No.	Clause No	Tools/Equipment/Software	Quantity
1.	9.4.9	Battery electrolyte automatic topping up devices.	One set for each depot.

**Note:**

1. The above mentioned list of deliverables is non exhaustive and only meant for the convenience for the Contractor and the Engineer.
2. The cost of these deliverables is deemed to be included in the quoted price of contract.

**7.1.6.** One Battery Box mounted in the under frame of M-car and cells of one Battery assy. have to be arranged in two trays of below dimensions.

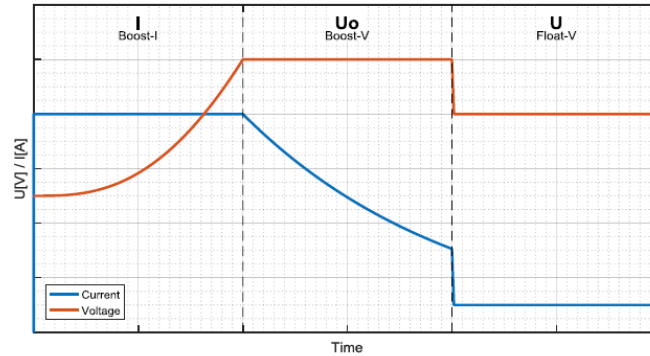
- Tray-1 Inner Dimension (LxWxH): 1020 x 724 x 306 mm**
- Tray-2 Inner Dimension (LxWxH): 1020 x 724 x 306mm**

**7.1.7.** In each 3-car unit, a Battery Charger Box & Battery assy. (inside a Battery box) will be mounted on the underframe of M-car. Each Battery Charger Box houses two battery charger units which will be charging one set of Battery assy.



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**7.1.8.** The Battery Charger characteristics proposed by the Battery Charger Manufacturer is of IUoU ,i.e., in three stages: namely constant current (I) or current limiting charging, constant voltage Boost charging ( $U_o$ ) and constant voltage float charging (U) with temperature compensation during the boost charging and floating charging process.



**Charger characteristics without temperature compensation (for reference only)**

**7.1.9.** The changeover from constant current (I) or current limiting charging to constant voltage Boost charging ( $U_o$ ) will be at a limit voltage value. The changeover from constant voltage Boost charging ( $U_o$ ) and constant voltage float charging (U) is proposed when the charger current is less than 10 A.

**7.1.10** The Battery model proposed by the subcontractor shall be compatible with the above charger characteristics and interface with the Battery Charger manufacturer for the finalization of voltage and current settings.

**7.2 Interface Responsibilities:**

7.2.1. The arrangement of Battery Cells proposed by the Subcontractor shall be within the space envelope mentioned at Clause no. 7.1.5 of this PTS and the same has to be approved by BEML/DMRC. The Subcontractor shall be responsible for the equipment and material to be supplied and recommended installation method and procedures.

3D model of Battery box will be shared to the sub contractor to check for interface with Battery box such as cell arrangement in tray, electrical & mechanical clearances, ventilation etc. and detailed report shall be submitted by the sub contractor. Battery Box design shall be validated by the subcontractor for the required clearances of battery assy. after installation in the battery box and ventilation requirements shall be recommended by the subcontractor.

7.2.2. BEML/ subcontractor shall be responsible for defining the technical requirements (refer to section 8) and the design constraints (refer to section 10) and shall be discussed with DMRC for approval. The Subcontractor shall be responsible for the design of the Battery system and the submission of design information (refer to section 10) and the performance of testing activities (refer to section 11) and the supply, installation and commissioning of Battery system (refer to section 7), and the maintenance and rectification of the Battery system (refer to section 8) during the defects liability period, etc.

**7.2.3** The Subcontractor shall be responsible for interface with TCMS/ Battery charger for temperature compensated charging of Battery as per ERTS 9.3.1.



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### 7.3 Design Submission:

The Subcontractor shall provide all necessary documents, drawings for BEML/DMRC approval.

The Subcontractor shall provide the technical requirements and design information.

The drawings and documents shall be submitted to BEML including preliminary, pre-final, and final design submissions, the final contract document, and all other submission both in the paper copies and electronic format.

These drawings and documents shall be delivered in English with the data format of, respectively, AutoCAD release 14 and MS office version 7.0 (document - MS word, spread sheet – MS excel, data base files – MS Access, Presentation file – MS PowerPoint). The drawings shall contain minimum three (3) view points (for example, front view, top view and left view) for three (3) dimensional modeling. If available, the Subcontractor shall provide STEP file or CATIA file to BEML. All drawings and design calculations shall use SI unit.

The Subcontractor shall require the interface information, which possibly affects performance, fitting and form, from BEML. The subcontractor shall comply with the requirements specified in ERGS & ERTS.

### 7.4 Testing:

The Subcontractor shall perform, as a minimum, the following for Battery:

- i. Routine and type tests
- ii. Type complete vehicle tests for Battery
- iii. Type Commissioning test for Battery

The following tests shall be carried out by BEML with assistance of subcontractor.

- i. Routine complete vehicle tests for Battery of each Train.
- ii. Routine commissioning test for Battery of each Train.
- iii. Service Trials.

The detailed requirements are specified in the section 11 of the PTS.

### 7.5 Operation & Maintenance Manuals and Spare Parts Catalogues:

The subcontractor shall provide the operation/maintenance manuals and spare parts catalogues for the Battery both in the hardcopies and electronic format as required in MRS1 ERTS & ERGS. The subcontractor shall provide the following O & M manual:

- i. Volume 1 – Technical Manual.
- ii. Volume 2 – Operation Manual.
- iii. Volume 3 – Maintenance Manual.
- iv. Volume 4 – Fault Diagnostics Manual.
- v. Volume 5 – Spare Parts Manual.
- vi. Volume 6 – Software Manual.

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vii. Volume 7 – Special Tools & Test Equipment Manual.

The subcontractor shall include detailed step wise procedure for replacement of individual cells of a battery bank in the Maintenance Manual.

The subcontractor shall provide the Operation/maintenance manuals and spare parts catalogues to BEML for approval of DMRC.

### 7.5.1 Submissions

The Supplier shall submit the draft of all manuals to BEML for approval of DMRC/BEML. The final manuals shall be provided after duly incorporating the changes indicated.

### 7.5.2 Electronic Manuals

The subcontractor shall provide manuals in electronic format. This is in addition to the submission of manuals in hard-copies.

The format of the electronic copies shall be proven in at least two other applications and shall allow for links between parts catalogue and maintenance instructions.

The Documents Management System and Language used shall be subject to Employer's Representative's Review.

## 7.6 Spares, Special Tools and Testing Equipment:

**7.6.1** The subcontractor shall hand over the Spares, Special tools and testing equipment in accordance with the delivery schedule of BEML. The supplier shall maintain the Battery system and supply of spares for at least 10 years from the date of completion of the contract (**as per Annexure-2, in line with Cost centre G**)

The subcontractor shall supply the following items of spares

- (i) Unit Exchange Spares
- (ii) Consumable spares for maintenance of all trains during commissioning, service trials and up to completion of Warranty period
- (iii) Mandatory spares
- (iv) Recommended spares
- (v) Overhauling spares
- (vi) Special tools, Testing and Diagnostic equipment
- (vii) Special Jigs, Fixtures & Gauges required for maintenance, repair and overhaul of various equipment, sub-systems in particular and the complete trains in totality

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The detailed requirements are specified in **ERGS 8**.

**7.6.2.** Employer at his sole discretion may exercise the option to increase/decrease the quantities (to any extent) of spares indicated under milestones G1, G2, G3, G4, G5 and G6. For increased quantities, payment to the contractor shall be on the basis of actual supplies made and quoted unit rates and no escalation or any other additional sums shall be payable. Any decrease in quantities, if considered by the Employer, shall be intimated by Employer within two years of the commencement date. However increase in quantities may be intimated at any time during the execution of Contract and the delivery period for the enhanced quantities only shall be mutually agreed.

The actual requirements (list & qty) as per above MRS1 cost center 'G' contract conditions are subject to DMRC/BEML approval. The subcontractor shall comply with the same.

### **7.7 Storage, Packing, Crating and Markings:**

The subcontractor shall provide all packing, crating and markings in accordance with the requirements specified in **ERGS 13**. When handing over, hand over the complete Battery and the spare parts, special tools and testing equipment.

The Subcontractor shall prepare, protect and store in a manner to be accepted by the Engineer, all equipment and materials so as to safeguard them against loss or damage from repeated handling, from climatic influences and from all other hazards arising during shipment or storage on or off the Site. Secure and covered storage shall be provided for all equipment and materials other than those accepted by the Engineer as suitable for open storage.

The subcontractor shall provide the instruction for proper storage, handling and logistic functions of components supplied by the subcontractor before handing over the first complete Battery.

All items shall be labeled with the maker's name and the type and form of the piece or item, discrete serial number and rating, and the date of manufacture of the particular piece of equipment.

The detailed requirements are specified in **ERGS 13**.

### **7.8 Training:**

The subcontractor shall provide the training for DMRC's operating staff and maintenance staff, BEML staff according to the requirements specified in **ERGS 9**.

The supplier shall provide training according to requirement of BEML and DMRC training schedule, time, method and site etc.

The detailed requirements are specified in **ERGS 9**.

#### **7.8.1 Training Manual:**

The subcontractor shall provide one original and five colored copies and electronic copies of

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the Training manual for use by the Employer for conducting in-house training. The Manuals shall cover all requirements specified in **ERGS 9**. After completion of the training, training aids and materials used shall become the property of BEML to enable and further training to take place.

## 7.9 Warranty

The subcontractor shall be responsible for any defect or failure of equipments provided in the cars, due to defective design, material or workmanship up to warranty period of 24 months from the date of taking over of trains.

The warranty period of special tools, test and diagnostic equipment, maintenance and unit exchange spares shall be 24 months from the date of acceptance by **DMRC**.

The repair and/or replacement of failed components and equipment and installation of repaired/ replaced components/equipment shall be taken by the subcontractor on his own charge at the Site.

The subcontractor shall bear custom duty, freight charges and all other expenses involved in collection of defective components and equipment from the Site, and transportation to the manufacturer's works in India or abroad and its return to Site after repairs. Further, should any design modification be required to any components or equipment as a consequence of failure analysis, the period of 24 months shall recommence from the date when the modified part is commissioned into service and modification shall be carried out free of charge.

The subcontractor shall carry out all replacement and repairs under the warranty promptly and satisfactorily on notification of the defect by BEML so that no car is out of revenue service for more than 48 hours.

The detailed requirements are specified in **ERGS 1.8** and **General Terms and Conditions (GTC)**.

## 8. Technical Requirements:

### 8.1 General:

The subcontractor shall be responsible for meeting all the technical requirements in PTS for Battery system design.

The general requirements for Battery system shall be met to the requirements specified in ERGS and ERTS.

- Interface Activities
- Quality Assurance
- System Safety Assurance
- Hazard Analysis
- Reliability & Availability

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- Maintainability
- Noise and Vibration
- Fire and Toxicity Standards

## 8.2 Battery system

The system requirements for Battery shall meet, but not be limited to, the following sections in ERTS:

- ERTS 1 Introduction
- ERTS 2 General Requirements
- ERTS 3 Design and Performance Requirements
- ERTS 4 Vehicle Body
- **ERTS 9 Auxiliary Supply Equipment**
- ERTS 10 Train Control Management System
- **ERTS 12 Electrical and Control Equipment**
- **ERTS 14 Material and Workmanship.**
- **ERTS 15 Inspections, Tests and Trials**
- ERTS Appendix TA International Standards
- ERTS Appendix TB Car body Mock-ups
- ERTS Appendix TC Abbreviations

## 8.3 Noise and Vibration:

The subcontractor shall comply with the Noise and Vibration requirements specified in **ERTS 2.18.**

## 8.4 Weight:

- (a) The weight of battery assy. shall not exceed 685kg.
- (b) The subcontractor shall submit estimated weights list and center of gravity and be approved by BEML. The actual weights must not exceed 2% compared to the agreed weights.

### (c) Monthly Weight Progress Report.

This weight progress report sheet format shall be provided by BEML that is Microsoft excel file. This sheet includes equipment name that is approved the breakdown list by BEML, equipment quantity, equipment unit weight, equipment center of gravity etc. This sheet shall be updated on a monthly basis by subcontractor during design stage, and then this sheet shall be submitted to BEML on a monthly basis.

The subcontractor shall also submit the weight and center of gravity revision history sheet to BEML on a monthly basis that includes previous figure (weight and center of gravity) of breakdown list, updated figure, the detail reason about updated figure etc.

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If the subcontractor were required the evidence by BEML such as weight calculation data, center of gravity calculation data etc, and the subcontractor should provide the evidence.

(d) Equipment Weighing Test

The subcontractor shall submit the actual weight of equipment to BEML on a monthly basis during manufacture stage.

### 8.5 Fastener Requirements

Normally screw threads smaller than M5 size shall not be used. Screw and bolt heads shall be of hexagonal form on all M5 and larger screws. Screws smaller than M10 shall be of high tensile material.

### 8.6 Label Requirements

- a) All items shall be labeled in English with the maker's name and type and form of the piece or item, discrete serial number and rating data and the date of manufacture of the particular piece of equipment. It is desirable that the labels used for different equipment / subsystems / systems on the train are of standard pattern.
- b) The labels shall be clearly stamped, cast or engraved and securely attached to the equipment. Where appropriate equipment shall be labeled with warnings of high temperature and electric shock risk. Wiring labels shall be multilingual (regional language(s) and English and/or Hindi) as per ERTS 14.17.

### 8.7 Product breakdown structure

The sub-contractor shall provide a list of technical breakdown of their sub-systems into components (Least Replaceable Units or LRU's). This breakdown stops at the lowest to a level where a failure can be associated with a remove action of maintenance. More detail explanation shall be given in the RAMS Guideline to be provided by BEML.

Breakdown of the material used in each component include:

- Identity
- Equipment name
- Quantity in vehicle
- Supplier part number
- Part Price(for LCC calculation)
- Quantity recommended for spare part

### 8.8 Project Management

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.

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- 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.
- The names, qualifications, positions and current resumes of key executive, supervisory and engineering staff to be employed full-time for the works.
- A narrative describing the sequence, nature and inter-relationship of the main Contract activities including timing for exchange of information.
- Procedure for documentation control.
- 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 the Project Head in at least one Rolling Stock Project in last 10 years. 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.
- To fulfill the subcontractor's obligations during the Testing and Commissioning and the Defect Liability Period, the subcontractor shall nominate experienced maintenance engineers and organise deployment before undertaking testing and commissioning in depots at Mumbai. Separate maintenance engineer shall be positioned in each depot.

The subcontractor shall submit relevant CVs of the Design Manager, Production Manager, Quality Manager, Interface Manager and Maintenance Engineer in addition to the Project manager in the technical offer.

## 8.9 RAMS requirements

The sub-contractor shall meet RAMS (Reliability, Availability, Maintainability and Safety) requirements given in the ERTS and the ERGS. Also, the sub-contractor should provide all information related to the RAMS requirements.

The sub-contractor shall comply with, but not limited to, the following requirements:

### 8.9.1. Reliability Analysis

The reliability data shall be based on actual operating information for the equipment.

In addition, the subcontractor shall submit a list of typical train withdrawal scenarios as per ERTS Appendix TG for review and acceptance by the 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.

The reliability block diagrams and prediction of reliability performance shall be submitted to BEML for acceptance.

The reliability block diagrams shall include all elements essential to the successful performance of the system and the interrelationships and interface of these elements.

The subcontractor shall submit reliability prediction to demonstrate by quantitative methods above the achievement of the specified levels of reliability for the scope of supply

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### 8.9.2. Reliability Target

The sub-contractor shall achieve the following two reliability targets during Defect Liability Periods specified in ERTS 2.8.

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

Equipment	MDBCF(train-km)
After 6 months of start of revenue service plus stabilization period of 6 months as per ERTS 2.8.2 (iv)	1,00,000
After 12 months of start of revenue service plus stabilization period of 6 months as per ERTS 2.8.2 (iv)	1,25,000

The sub-contractor shall achieve the following two reliability targets during Defect Liability Periods specified in ERTS 2.8.

The MDBCF (Mean Distance Between Component Failure) per 6 car train-set shall be as follows:

Equipment	MDBCF(train-km)
After 6 months of start of revenue service plus stabilization period of 6 months as per ERTS 2.8.2 (iv)	8,000,000
After 12 months of start of revenue service plus stabilization period of 6 months as per ERTS 2.8.2 (iv)	10,000,000

\* Operation Conditions as per ERTS 3.22

-Annual Operation Distance: 150,000 km

The reliability performance shall be assessed by the following measure:

$$\text{MDBCF} = \frac{\sum \text{Travelled kilometer per train set}}{\sum \text{Number of Service Failures}}$$

Where,

Mean Distance Between Component Failure (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 trains to the total number of Service failures occurring within the population identical items.



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**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:

- Non-availability of the train to start revenue service after successful completion of pre-departure checkout;
- Withdrawal of the train from revenue services as per ERTS Appendix TG
- A delay equivalent to or exceeding 3 minutes from the Schedule / Time table as noted at the destination station for the one way trip.

**Pattern Failure:** 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 predicted failure rate of the part, item or equipment.

The detailed methodology for identification of pattern failures shall be finalized during the design stage. The decision of the Engineer shall be final.

The sub-contractor shall submit 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.

For each case of de-boarding of commuters on account of reasons attributable to the contractor, Employer may at his sole discretion impose a penalty of Rs 15 lakh. Engineer's decision to impose the penalty shall be final as specified in ERTS 2.7.9.

### **8.9.3. Maintainability Requirements**

#### **8.9.3.1. Design requirements**


The design of all components will be such that maintenance is reduced to a minimum, and components will be so arranged that those requiring 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

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.

The sub-contractor shall also comply with the maintenance requirement of ERTS 2.12.

#### **8.9.3.2 Maintenance Interval**

<b>Maintenance Type</b>	<b>Interval (Service time or Running Distance)</b>
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

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Intermediate Overhaul		Every 3 years or 450,000km	
Periodic Overhaul		Every 6 years or 900,000 km	

Preventive Maintenance Interval should be compliance with the interval specified in the above table.

#### 8.9.3.3 Maintainability Target

- 1) The LRU replacement should be less than 30 minutes
- 2) The mean time to repair (MTTR) of equipment should be less than the specified value as follows:

Equipment	MTTR (hour)
Battery system	1 hour

- 3) Corrective Maintenance Operation that does not require car lifting shall be less than 4 hours as per ERTS 2.12.12.
- 4) Corrective Maintenance Operation that does require car lifting, excluding time required for shunting shall be less than 6 hours as per ERTS 2.12.12.
- 5) The Least Replaceable Units (LRU's) for the equipments/systems should not take more than 30 minutes for replacement. In order to achieve this requirement, quick release connections such as plugs and adaptor shall be provided between LRU's and the equipment

#### 8.9.4. Life Cycle Costs

The sub-contractor shall provide equipment that has minimum total Life Cycle Cost. The sub-contractor shall submit all information for Life Cycle Cost calculation in accordance with RAMS Guideline to be provided by BEML. The Life Cycle Cost which contains preventive and corrective maintenance activities shall be in compliance with the Maintenance Manuals prepared by the Contractor.

#### 8.9.5. Reliability and Maintainability Demonstrations

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 sub-contractor shall, at his own expense, take whatever action to meet the R&M target specified.

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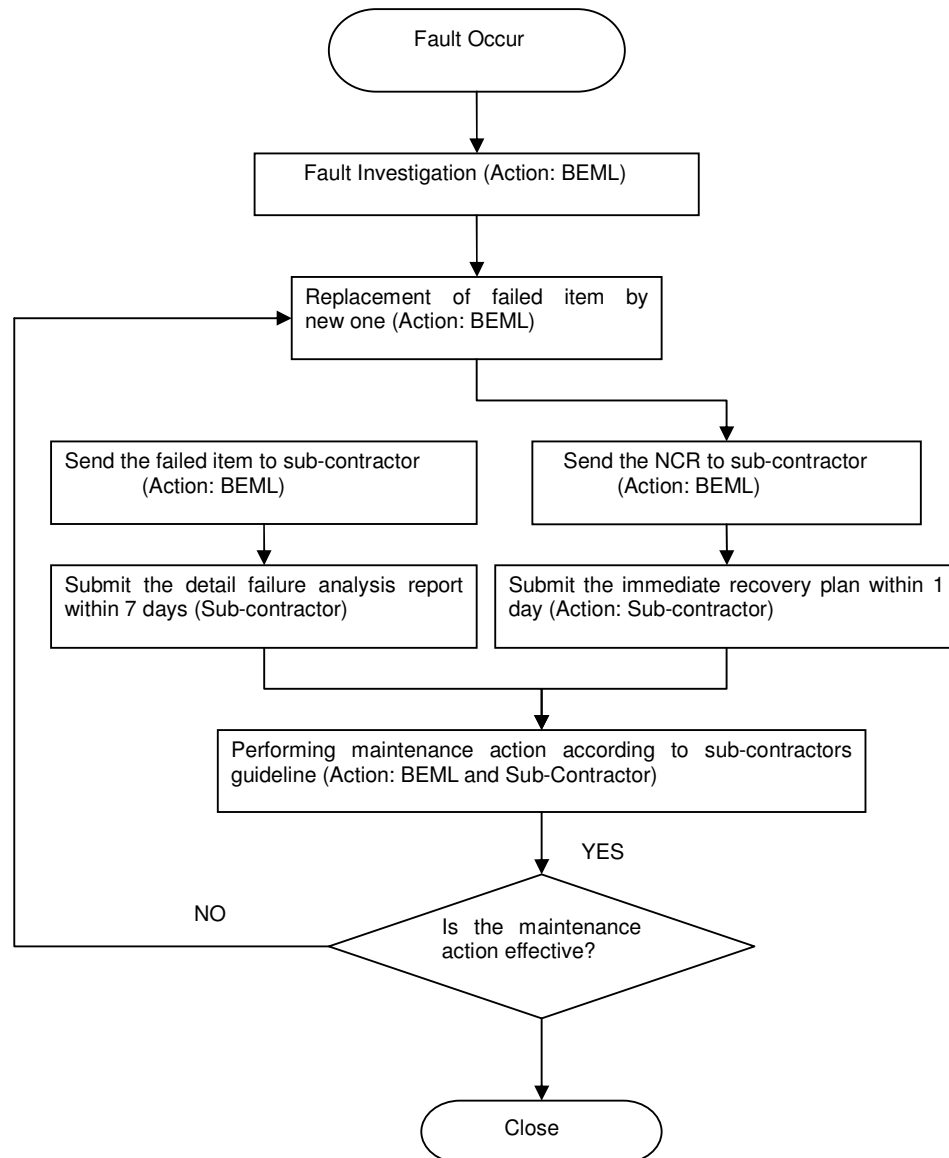


Fig-1: Maintenance Procedure

The sub-contractor shall support an active A/S for high availability. The A/S procedure of BEML is same as figure1. Therefore, the sub-contractor should be complied with BEML's procedure. If some failure needed the sub-contractor's support, the sub-contractor should dispatch engineer as soon as possible. Also, if the sub-contractor needs some training for BEML's maintenance engineer, the sub-contractor shall perform it.

The sub-contractor shall provide sufficient spare part for high availability. The sub-contractor shall submit a spare part list and recommended quantity at the maintenance depots at Mumbai.

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The sub-contractor also has to comply the ERGS clause 1.8.4 & 1.8.5.

#### **8.9.6 Safety Requirements:**

The subcontractor shall submit safety assurance plan for Battery system. This shall cover design, manufacture, testing, commissioning of the system. This shall also indicate features minimizing 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.

The sub-contractor shall perform all system safety tasks required to meet the Technical Specification and ensure that the safety critical hazards for scope of supply shall be eliminated or reduced to the level of ALARP.

To meet the safety requirement, the Subcontractor shall submit the following documentations as a minimum.

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

The subcontractor shall fully compliance with the RAMS (Reliability, Availability, Maintainability and Safety) requirements given in the Clause -2.4 to 2.14 of ERTS.

#### **8.9.7 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 and Reliability Prediction during Pre-final Design Stage
- 5) Hazard Analysis including PHA, Subsystem Hazard Analysis, Operating and 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 Stage
- 9) LRUs list during pre-final design stage
- 10) Safety FTA during Final design Stage
- 11) Life Cycle Cost Analysis during Final design Stage

#### **8.10. Fire Safety**

The subcontractor shall submit a Fire-safety Plan providing the list of Non-metallic material items, wires & cables that are proposed to be used in the Battery system with details of material, applied mass, fire safety compliance (Flammability, smoke, toxicity) and fire load calculations, during the preliminary design phase.

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The materials used shall conform to Fire Safety requirements of EN 45545 Part 1 to 7(Category 4-A, Hazard level HL3) latest editions as a minimum or better international standards applicable for similar Metro for underground operations with front evacuation, subject to the acceptance of the Engineer as per ERTS 2.5.8 & 2.19.

The Fire Performance Test Procedure and Criteria shall be met, but not be limited to, the following requirement:

- Flammable materials shall be well contained with At least IP 65 protection as per ERTS 2.19.1 (iii)
- ERTS 12.5.2: The insulation of all wires and cables including those used within equipment / subsystem shall be halogen-free flame- retardant and formulated to minimise generation of smoke, noxious emissions and corrosive fumes, in the case of overheating or fire in compliance with EN 45545 (Category 4-A, Hazard level HL3) latest edition. All Cables shall comply NF F 63-808 (for low voltages), and NF F 63-826 (for high voltages) or other international standards like EN 50264(Part 1 to 3) and EN 50306(Part 1 to 4) as approved by the Engineer.
- Particularly, the fire load of all non-metallic materials within the Battery shall be verified and controlled during design and production by the subcontractor in accordance with the requirement defined by BEML/DMRC.
- The Cable markers provided shall be **fire retardant heat shrinkable type**. The cable markers shall be protected against fading by providing Fire retardant heat shrinkable clear sleeve.

The Battery shall comply with the Fire performance requirements specified in ERTS 2.5.8, 2.19 & ERTS 15.26

#### 8.10.1 Fire Load Calculation


The maximum heat release rate per car shall be restricted to low levels.

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.

#### 8.10.2 Fire Performance Deliverables

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

Sl. No.	Deliverables	Remarks	Submission Schedule
1	Fire safety plan	As per EN45545 HL3	Preliminary Design stage
2	Fire safety Test Reports of the items including heat release rate for	As per EN45545 HL3	Pre-Final Design stage

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	standard items common with other projects of the subcontractor		
3	Fire safety Test Reports of the items including heat release rate for all other items	As per EN45545 HL3	Final Design stage

### 8.11 Materials and workmanship

The Subcontractor shall be responsible for meeting the requirement of constructional details, material, workmanship and cables. All materials and workmanship shall be in every respect in accordance with the proven up-to- date best practice.

The requirements for material and workmanship of Battery system aggregates shall meet the requirements as per ERTS 14.

## 9. Quality Assurance Program

### 9.1 General

This section describes quality assurance program required to assure the quality of products supplied from the Supplier to BEML. The supplier shall assure the quality of product and maintain quality system to achieve high quality of the product.

### 9.2 Quality Assurance Plan

The Supplier shall develop and submit to BEML QC team for review and approval a Quality Assurance Plan (QAP) based on ISO 9001 standard and GS&TS.

Submission of QAP shall not be later than 30(thirty) days after purchase order by BEML. The plan shall illustrate how the Supplier intends to meet the quality assurance requirements of this Technical Specification and shall include as a minimum:

- An organizational chart, including a definition of the responsibilities of personnel thereon, for receiving inspection, defect material handling (especially related to material found malfunctioning during production conformance testing), production conformance testing verification, process specification implementation, equipment calibrations, etc.
- The methods and procedures used to control the daily manufacturing processes and material quality.
- Flow charts of paperwork for the acceptance or rejection of material, for identification and disposition of Unacceptable items resulting from inspections, for the specific accountability of material found malfunctioning during production conformance testing, and configuration verification of the items to be Included in the submittal and etc.
- Forms to be used to convey, track and account for design changes implemented in the product regardless of their state of completion and any other forms necessary for the program. Each form shall be serial numbered.

The Quality Assurance plan shall have a live document status. Any and all changes must be submitted to Quality Control team of BEML. Changes affecting the project will be subject to approval by Quality Control team of BEML.

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### 9.3. Organization

The organization of the Supplier's Quality Assurance (QA) Program shall have sufficient, well-defined responsibility and organization. It shall report directly to the General Manager of the Supplier's facility or the Supplier's Project Manager. The QA/QC personnel shall have complete freedom to identify and evaluate problems; to recommend solutions; to verify implementation of solutions; and to control further processing, delivery, or installation of a Non-conforming or deficient item until proper and documented disposition has been obtained. The QA/QC organization shall be arranged to promote a control function that operates in an independent, objective manner unbiased by schedule, cost, and authority limitations imposed by personnel other than the Suppliers high level management starting with the General Manager or equivalent.

### 9.4. Certification of Personnel

The Suppliers QA/QC personnel performing inspections and tests shall be certified for such work. Certification of personnel shall be by the virtue of those skills which are obtained by experience or training and verified by testing. Manufacturing personnel performing special processes, such as welding, brazing, painting, crimping, NDT (Nondestructive tests), etc. shall be certified for such work. Records of personnel certifications shall be maintained and monitored by the Suppliers Quality Assurance personnel. These records shall be made available to the Engineer of BEML for review.

### 9.5. Evidence of Compliance

The Supplier's QA/QC personnel shall maintain objective, verifiable evidence of compliance with the Technical Specification as it pertains to hardware configuration, purchasing, inspecting, handling, assembling, fabricating, production conformance testing, storing, shipping and warranty/repair work in the interest of quality.

#### 9.5.1 Certificates Of compliance

The Supplier shall submit to BEML the certificate of compliance for each delivery lot of products. The certificate shall contain inspection/test result data in accordance with the specification of the product. The inspection/test result shall be summarized to an inspection / test report (or record) in which the specification and inspection/test result are described clearly.

And, the inspection / test report (or record) shall contain information, as a minimum, of Product name (description), Part number, Serial number(if specified or necessary), Drawing number, Specification number, Revision number of drawing & specification, Software name(description) & Software version of the product (if softwares installed to the product), Barcode number of the product(if barcode system is specified in the specification of product), Project name, Supplier's & Manufacturer's name, Inspection / test date, Acceptance decision, Name & Signature of inspector and approver and etc.

Each shall clearly identify the lot certified by the certificate and be signed by an authorized representative of the Supplier, stating the product complies in all respects with the specification of the product.

Each certificate shall contain the information specified for samples, the name and address of the organization performing the tests, the date of the tests and the quantity of materials

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shipped and also, if a test is performed by a licensed test laboratory, the test certificate issued by the laboratory shall be attached to the certificate of compliance of the Supplier.

## 9.6. Calibration

The Supplier shall demonstrate an effective time or usage cycled calibration program for testing of measurement equipment and tools. Validity of measurements and tests shall be ensured through the use of suitable inspection, measurement and test equipment of the range and type necessary to determine conformance of items with the specification. At intervals established to ensure continued validity, measuring devices shall be verified or calibrated against certified standards. Tooling used as a media of inspection shall be included in this program. Furthermore, every device so verified shall bear an indication attesting to the current status and showing the date (or other basis) on which inspection or recalibration is next required. Devices suspected of being out of calibration before the stated recalibration date shall be promptly recalibrated. Inspections performed with devices proven to be out of calibration must be re-inspected. All calibration certifications shall be recorded and become part of the Quality Assurance records.

## 9.7. Procedure Documents

The Supplier shall establish and maintain written procedures defining his Quality Assurance Program. The procedures shall encompass all phases of the program to include, but not be limited to, control of suppliers, inspection, production and process control, functional testing, discrepancy control, measuring and test equipment calibration, configuration control, quality assurance records, shipping inspection and other quality specifications to meet the requirements of the Contract. All such documents shall be made available to the Engineer of BEML upon request.

## 9.8. Quality Assurance Activities

The Supplier shall address, as a minimum, the following activities and shall provide a means of self-correcting any shortcomings in his Quality Assurance Plan (QAP) as per GS 2.6

### 9.8.1 Procurement

The Supplier shall document in writing the methods to be used for the selection and control of suppliers. These methods shall identify a means of:

- a) Selecting qualified procurement sources.
- b) Communicating and approving all product quality requirements and changes thereof.
- c) Monitoring the supplier's quality performance through the evaluation of procured items against purchase order requirements and/or through audits.
- d) Providing for early and effective information feedback and correction of non conformances, especially of items found malfunctioning during production conformance testing.
- e) Approving special processes.

The Supplier shall require each supplier to be responsible for maintaining and retaining records. Furthermore, the Supplier shall require each supplier, as a minimum, to submit with each shipment appropriate certifications, final inspection results and test results. Requirements shall be included for chemical or physical testing records in connection with the purchase of raw materials by the suppliers.



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### **9.8.2 Manufacturing Inspection**

Inspection shall occur at appropriate points in the manufacturing sequence to ensure quality consideration for compliance with drawings, test specifications, process specifications and quality standards. BEML may designate inspection hold (or witness) points into the Supplier's Inspection and Test Plan (ITP) upon review of the Supplier's efforts. Inspection/test shall be 100% (one hundred percent) unless there is a specified sampling plan in the specification of BEML. Non-conforming materials shall be identified as discrepant, and shall be segregated and reviewed for disposition.

### **9.8.3 Production Conformance Testing**

The Supplier's QA/QC personnel shall perform all Production Conformance inspections/tests and verify proper configuration of the equipment inspected/tested. If any item does not satisfy all performance or design criteria, the item shall be re-inspected/retested until the inspections/tests are passed with the necessary adjustments or repairs documented and certified by a witness.

### **9.8.4 Receiving Inspection**

The Supplier's receiving inspection activities shall provide for the inspection of all incoming materials. These inspection measures shall be used to preclude the use of incorrect or discrepant materials and to ensure that only correct and accepted items are used and installed. All material certifications and test reports used as the basis for acceptance by the Supplier shall be preserved. Inspection measures shall identify any item at any stage of production to an applicable drawing, specification or other pertinent technical document. Permanent physical identification shall be used to the maximum extent possible.

### **9.8.5 Shipping Inspection**

The Supplier's Quality Assurance Program shall provide and enforce procedures for the proper inspection of all products to assure completion and conformance as required by the Contract prior to shipment. All shipments shall be prepared as required precluding damage during shipment. The inspections and preparation for shipment shall be verified by the Supplier's QA/QC personnel.

### **9.8.6 Ensure Inspection with Latest Revisions/ Changes**

The Supplier shall ensure that inspection and tests are based on the latest approved revision or change to drawings and specifications. The Supplier shall ensure that obsolete drawings and change requirements are promptly removed from all points of issue and use. Means of recording the effective points of changes shall be employed.

### **9.8.7 Identification of Items using tags etc.**

The Supplier shall maintain a system for identifying the progressive inspection status of materials, components, sub assemblies and assemblies as to their acceptance, rejection or non inspection. The system shall provide for ensuring that required inspections and tests are performed and that the status of items with regard to inspections and test performance is known throughout manufacturing, installation and testing. Nonconforming items shall be

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identified by physical segregation and status indicators such as tags, serialization, markings, stamps and inspection records. The identification system shall ensure that only items that have passed the required inspection and tests are used or installed.

#### **9.8.8 Handling**

The Supplier's Quality Assurance Program shall provide for adequate surveillance work and inspection instructions for the handling, storing, preserving, packaging, marking and shipping to protect the quality of products.

#### **9.8.9 Non-conformance Control**

The Supplier shall establish and maintain an effective and positive system for controlling nonconforming material and workmanship, including procedures for its identification, segregation and disposition.

The supplier shall assure that nonconforming materials are not used. To assure prompt Correction, Corrective action Compensation and any necessary actions for any nonconformity caused by the Supplier or Supplier's suppliers, the Supplier shall establish nonconformity control procedure and includes it in the QAP.

All nonconforming issues shall be positively identified to prevent unauthorized use, shipment or intermingling with conforming material.

Corrective action and related information shall be documented and made available to BEML upon request. Corrective action shall extend to the performance of all sub-suppliers and include as a minimum:

- a) Immediate response, prompt action and prevention of recurrence for nonconformity.
- b) Analysis of data and examination of discrepant products to determine extent and causes with corrective action implemented in an expeditious manner prior the next shipment, order or inspection.
- c) Submission of detail documents (specifications, drawings, repair procedure, analyzed data, test/inspection data, measures, action plan and etc) required to resolve nonconformity detected.
- d) Introduction of required improvements and corrections, initial review of the adequacy of such measures, and monitoring of the effectiveness of corrective action taken.
- e) Analysis of trends in processes or performance of work to prevent nonconforming products.

#### **9.8.10 Quality Audit**

The Supplier shall permit Quality Audit by BEML and/or the Customer of BEML. The scope of the audit will be only the field related with the implementation of this project and the Supplier's QAP. If any Nonconformity is detected during the audit, Corrective Action request will be issued to the Supplier. For the Corrective Action Request, the Supplier shall prepare and submit appropriate action plan within 10 (ten) days, perform the action plan and reply the result to BEML QC team.

#### **9.9 Inspection and Test Plan (Herein After ITP)**

ITP shall be submitted to BEML QC team for review and approval as following no later than 30 days after purchase order by BEML.

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- i. The ITP includes all the major inspection and test activities planned prior and during the design, procurement and installation phases. The (ITP) will include, as a minimum, the following:
- Introduction of ITP (purpose, application scope etc)
  - Description of Symbols, Abbreviations and Definitions
  - Sampling Procedure if it is necessary
  - Inspection/Test Notification procedure
  - General Inspection/Test process/flow
  - (f) Manufacturing and Inspection/Test flow (block diagram) which describes manufacturing flows and inspection/test points.
  - Description of Inspection and test activity and item
  - Kinds of Inspection and Test such as Design Qualification/ verification test (Type test), FAI, Routine inspection/test
  - Inspection/Test Level such as 100%, Sampling, 1/Lot and etc
  - References of the inspection/test such as specification, procedure etc
  - Responsible entity of the inspections and tests
  - Places of the Inspection and test
  - Witness/hold points of BEML and/or the Customer of BEML
  - Description of Reports /checklists required and the Submission

A table format is recommended to describe the Items (g) to (n).

ii. Witness/Hold point of Inspection/Test

After review of the ITP received from the subcontractor, BEML will designate witness/hold point (if required) of BEML and/or the Customer of BEML and notify them to the subcontractor.

- Witness point of Inspection/test

To be witnessed randomly by BEML and/or the Customer of BEML. It requires the notification of inspection/test schedule written by the subcontractor. The subcontractor can proceed with his next process without agreement with BEML and/or the Customer of BEML if there is no written answer or intention from BEML and/or the Customer of BEML to witness the notified inspection/test.

- Hold point of Inspection/test

To be witnessed by BEML and/or the Customer of BEML. It requires the notification of inspection/test schedule written by the subcontractor to BEML. In case of hold point, subcontractor can do the next process after acceptance of the inspection/test or waiver (or agreement) by BEML and/or the Customer of BEML. Generally, Type Test (Design verification/qualification test) and First Article Inspection (FAI) are designated as the Hold Point.

iii. Inspection/Test Notification of Witness/Hold point

After receiving of ITP, BEML will inform Notification schedule and procedure to the subcontractor according to the Main Contract between BEML and the Customer of BEML.

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## 10. Design Information:

### 10.1 General:

The subcontractor shall submit, not limited to, the following general information.

Document/Deliverables	Reference/ description
Testing plan	ERGS 7, ERTS 15
Schedule of tests	ERGS 7
Test procedure of type & routing test of equipment, type test of complete vehicles, commissioning test of complete vehicles	ERGS 7
List of spares, special tools, testing and diagnostic equipment	ERGS 8
All relevant drawings, manuals and full operation instructions for the special tools, testing and diagnostic equipment.	ERGS 8
Training proposal	ERGS 9
Training course	ERGS 9
Training manual	ERGS 9
Operation and maintenance manuals and spare parts catalogue	ERGS 12
All As built drawings	ERGS 3
All tools, equipment and manuals necessary for maintenance	ERGS 8, ERGS 12
The requirements for the completion of the project management plan, interface management plan, work plan, quality assurance plan, safety assurance plan and site safety plan, environmental plan, inspection, tests and commissioning plan	ERGS 2

### 10.2 Design:

#### 10.2.1 General:

The design of battery shall basically comply with ERTS 9.3, 9.4, 9.5, 9.6, 9.7 and relevant specification of ERGS and ERTS.

The design submission shall be submitted to BEML according to the following three stages:

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

Sl No	Description of Stage	Submission from subcontractor to BEML (from LOI / contract award)
1	Preliminary design completion(ERGS 4&5)	2 weeks
2	Pre final design completion(ERGS 4&5)	4 weeks
3	Final design completion(ERGS 4&5)	12 weeks

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The subcontractor shall submit, not limit to, the following design information:

Submission Stage	Document / Deliverables
Preliminary Design Submission	<ul style="list-style-type: none"> <li>i. System description of battery system</li> <li>ii. Detailed specifications and drawings of all equipment ( Battery assembly, cabling, connector, WFS etc)</li> <li>iii. Connection diagram</li> <li>iv. Battery capacity Calculations (Sizing)</li> <li>v. Notice for mounting ,</li> <li>vi. Documentation for charging</li> <li>vii. Documentation for discharging</li> <li>viii. Service history</li> <li>ix. Reliability and maintainability proven data and letters</li> <li>x. Bill of Materials</li> </ul>
Pre-final Design Submission	<ul style="list-style-type: none"> <li>i. Upgraded System description; at this stage, the information described at the preliminary stage shall be fixed and finalized.</li> <li>ii. The evidence of or proposals for design verification</li> <li>iii. Test specification of Battery</li> </ul> <p>The detailed requirements will be specified later by BEML.</p>
Final Design Submission	<ul style="list-style-type: none"> <li>i. Completed calculations and analysis, studies, investigations and reports</li> <li>ii. The detailed requirements will be specified later by BEML.</li> </ul>

The subcontractor shall submit all data for each design submission to BEML as soon as possible so that they can be confirmed by BEML. BEML will furnish the review comments about the submission to the subcontractor.

The subcontractor shall meet with BEML to discuss the review comments. In case BEML deems the submission to be unacceptable, the subcontractor shall revise and re-submit the submission as soon as possible.


#### 10.2.2 Requirement of Battery:

The design of the battery shall comply with the requirement **ERGS & ERTS, IEC60623, IEC60993 and EN 50547.**

#### 10.3 SEM (System Engineering Management):

The Subcontractor shall submit, not limit to, the following design information: The technical requirements of noise, vibration, fire, weight, safety, reliability, maintainability and availability shall be submitted.

The subcontractor shall submit, not limit to, the following general information.

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<b>Classification</b>	<b>Document/ Deliverables</b>		
Proposal , plan & prediction	Design proposal for noise, Vibration and fire		
	Breakdown list and weight of each component		
	Detailed prediction of the power output from the flash over		
	Fire load schedule based on fire load density of materials of components		
	Material analysis on component level		
	RAM data		
	Hazard log & register of train failure		
	RAM modeling & prediction		
	RAM Table		
	Hazard analysis		
	FMECA		
	FTA		
Detail test procedures	Description of noise test procedure		
	Description of fire test procedure		
Test Reports	Report on weight measurement		
	Certificate of fire tested non-metallic materials of components		

## 11. Testing

### 11.1 General

The subcontractor shall provide BEML with all information for the completion of Inspection, Testing and Commissioning Plan and also comply with the plan defined according to the requirements specified in **ERGS 7** and **ERTS 15**.

The type tests for the Battery system at both the component level and complete train level shall be performed by the Subcontractor under BEML and DMRC participation.

All such tests shall be carried out at the subcontractor's cost, wherever performed, in the presence of and to the satisfaction of BEML and DMRC, who reserves the right to witness any or all of the tests.

All defects and shortfalls discovered during the tests shall be rectified and re-tested to the satisfaction of BEML and DMRC. The subcontractor shall provide full instrumentation to conduct all tests and carry out modifications as required.

All test procedures, reports including all maintenance activities and check lists shall be submitted and approved by BEML and DMRC within the defined period.

The results of all tests shall be submitted to BEML and DMRC, who will record his conclusions as to whether or not the equipment being tested has passed satisfactorily.

The subcontractor shall produce a test report, in three coloured copies (hard copy & softcopy) and in an approved format, within a defined period following the test, for acceptance by BEML and DMRC.

The detailed requirements are specified in **ERGS 7** and **ERTS 15**.

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### 11.1.1 Inspection

All the materials, fittings, equipment, manufacturing processes, and assembly workmanship shall be subject to inspection by BEML and DMRC, wherever carried out in accordance with the requirements specified in **ERGS 7.1**.

### 11.1.2 Inspection Hold Points

The subcontractor shall propose a set of inspection hold points in the Inspection, Testing and Commissioning Plan in accordance with the requirements specified in **ERGS 7.1**.

### 11.1.3 Test planning and Procedure

The test planning and procedure shall be as specified in TS 15.2

Following items shall be complied & all be borne by the subcontractor.

- i. All test equipment shall carry an appropriate and valid calibration label.
- ii. The subcontractor shall sign all reports of Tests
- iii. The subcontractor shall present a comprehensive Testing and Commissioning Program.
- iv. Test procedures shall be amended, as required by the subcontractor throughout the duration of the Contract, to reflect changes in system design or the identification of additional testing requirements.
- v. All costs including labor, supervision of testing, provision of specialized equipment and materials, and the cost of hiring Consultants and the services of other specialized personnel or independent assessors etc shall be borne by the subcontractor.

The subcontractor shall also bear any expenses incurred due to re-testing caused by defects or failure of equipment or any other account to meet the requirements of the contract.

The detailed requirements are specified in **ERGS 7**.

### 11.1.4 Sequence of Tests

- i. Routine and type test of equipment and sub-systems in accordance with relevant standard and specifications in Contractor/Sub-contractor's factories.
- ii. Factory and Site Tests (Depot and Mainline) of complete cars in accordance with **IEC 61133**.
- iii. Testing and commissioning of cars/trains in Depot and Mainline in accordance with **IEC 61133**.
- iv. Integration Tests in conjunction with all Designated Contractors.
- v. Instrumentation and Dynamometer Tests, and Oscillation Trials on Prototype rakes only.
- vi. Service Trials

## 11.2 Routine and type tests of equipment and sub-systems

The Battery shall comply with the following requirements of ERGS & ERTS.

### 11.2.1 Type Test-Battery:

- i. This test is required to verify that the battery operates in accordance with the Approved Design Data. Following Type tests shall be performed by the Subcontractor under BEML and DMRC participation as per **IEC 60623**:

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- a. Cell Designation
  - b. Marking
  - c. Dimensions
  - d. Discharge performance test
  - e. Charge retention test
  - f. Endurance test
  - g. Charge acceptance at constant voltage test
  - h. Overcharge test
  - i. Vent plug operation
  - j. Electrolyte retention test
  - k. Storage test
  - l. Random Vibration Test
  - m. Shock Test
- ii. Subcontractor has responsibility for the type test of the component. During test the criteria shall be observed and recorded in a log book and necessary alterations and adjustments carried out.
  - iii. The subcontractor shall also perform the following type tests with the requirements specified in accordance to **IEC 60623**:
    - a. Discharge performance at +20°C
    - b. Discharge performance at +5°C
    - c. Discharge performance at -18°C
    - d. High rate current test
    - e. Charge retention test
    - f. Endurance test
    - g. Charge acceptance at constant voltage test
    - h. Electrolyte retention test
    - i. Storage for a period of 12months at +20°C and relative humidity of 65 %  $\pm$ 20%
    - j. Visual inspection
    - k. Special test at +47°C and + 14.3°C
  - iv. In the event DMRC requests any other additional tests, the subcontractor shall carry out the same at no additional cost.

#### **11.2.2 Routine Test-Battery:**

This test is required to verify that the Battery has been built in such a way that it satisfies the requirements of the Approved Design Data as verified by the Type Test.

During test, the criteria shall be observed and recorded in a logbook and necessary alterations and adjustments carried out. Records from Routine test shall be held by the Subcontractor and made available timely for BEML and DMRC's inspection.

Copies of the approved routine test results shall be submitted together with the associated logbook. Additional copies of records of all tests/inspections result shall also be held at the Subcontractor work to be made available to BEML and DMRC on demand.

This test basically includes but not limited to functional test, visual inspection, dimensional inspection, open circuit voltage & polarity check and leakage test of water pipes.



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### 11.3 Fire Performance Test:

The sub-contractor shall perform the fire performance tests of battery in accordance with the requirements specified in **ERTS 2.19 and EN 45545**.

### 11.4 Capacity Guarantee Test

This test requirement shall meet, but not be limited to, the following sections in ERGS and ERTS:

- **ERTS 9.4: Back-up Batteries**

### 11.5 Shock and vibration test:

The sub-contractor shall perform the Withstanding Vibration and Shock test of battery in accordance with the requirements specified in **IEC 61373**. The test results shall be submitted for approval.

### 11.6 Others:

The subcontractor shall carry out any other tests as specified in **IEC 60623** and **IEC 60993**.

### 11.7 Integration Test:

BEML will perform the integration test with the assistance of sub-contractor according to **ERGS 7** and **ERTS 15**. The subcontractor shall submit all information for the integration test to BEML. If needed, the concerned engineer from subcontractor shall participate in the test.

### 11.8 Service Trials

BEML will perform the service trial for MRS1 project and the sub-contractor shall supply the sufficient information and assistance if necessary according to **ERGS 7** and **ERTS 15**. The subcontractor shall submit all information for the service trials to BEML. If needed, the concerned engineer from subcontractor shall participate in the service trial.

## 12. Submittals – Technical offer:

The sub contractor shall provide the following as the part of technical offer:

- Complete technical offer for Battery along with Technical description, specification, drawings and weight details.
- Battery Drawing (GA drawings indicating dimensions of cell and crate and overall battery set).
- Battery design & sizing calculations for DMRC approval.
- Battery discharge curves/graphs for load profile as indicated in PTS clause 7.1.1.
- Document/specification of wooden packing material and relevant test reports for conformance to Fire retardant property.
- Clause wise compliance against

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- ERGS and ERTS

In the following format

**Complied:** “Complied” shall be indicated by the supplier where the supplier is able to comply with the clause.

**Noted:** Where a clause merely provides information.

**Offers with Non-compliance and deviations to any of the ERTS, ERGS & PTS clauses with regard to Battery system, are liable for rejection.**

- vii. Supply details with references for same / similar design for the last 3 years for metro projects along with performance certificates from customers (Metro Corporation) to support the qualification criteria as per section 6 of this document.
- viii. The list of spares as detailed at clause 7.6 of this PTS.
- ix. The list of Commissioning and DLP spares as detailed at clause 7.1.3 of this PTS.
- x. Technical specification & drawings of BCMU to check for installation in Battery box.

### 13. Attachments:

- i) ERGS
- ii) ERTS
- iii) Annexure-1 : Vendor Approval Format
- iv) Annexure-2 : List of spares
- v) Annexure-3: Submittals check list