



**Procurement Technical
Specification for
Pantograph**

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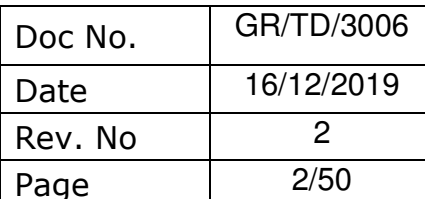
Procurement Technical Specification for Pantograph for DMRC RS15 Project

(Supplies to be compatible with and suitable for integration
with existing 'RS1, RS6 & RS13 BG' type trains of DMRC

supplied by

MRM Consortium & BEML with required
modifications/improvements as per RS15 Contract)

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1. Introduction

1.1 General

This document describes **Pantograph system** to be supplied for DMRC RS-15 Project for Delhi Metro Rail Corporation Limited (DMRC).

BEML shall carry out all required works and activities as contractor for DMRC RS-15 project while the subcontractor shall be responsible for all works required in this PTS with regard to supply of Pantograph system and shall be responsible for supporting the BEML activities as contractor for DMRC RS-13 Project. The supplies must be compatible with RS1, RS4, RS6 and RS13 rolling stock with modifications/improvements required as per ERTS of RS15 contract.

The configuration of train formation is as follows.

- T-M - (Intermediate cars)
- DT-M-T-M-M-DT - (6 car formation)
- DT-M-T-M-T-M-M-DT - (8 car formation)

DT : Driving Trailer Car, M : Motor Car, T : Trailer Car.

The scope of work also includes the integration of existing 4/6 cars Broad Gauge Trains to 6/8 cars by integrating the new 'T + M' unit similar to the existing system.

1.2 Climatic Condition

The DMRC RS-15 Car shall operate reliably and safely under Delhi climatic conditions shown in Table.

Description	Limiting Values
Maximum ambient temperature	47°C(Refer note below)
Minimum temperature	3°C
Humidity	100% saturation during rainy season
Rainfall	Rain occurs generally from June to September. Average annual rainfall is approximately 650mm. Maximum rainfall in any 24h period is 50mm.
Atmosphere during hot season	Extremely dusty

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Maximum wind load	150kg/m ²
Vibration & Shocks	The equipment, sub-systems & their mounting arrangements shall be designed to withstand satisfactorily the vibration and shocks encountered in service as specified in IEC61373 and IEC60571
S0 ₂ level in atmosphere	80— 120 mg/ m ³
Suspended particulate matter in atmosphere	360 — 540 mg/m ³

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 70⁰C.

1.3 Operating Environments

The proposed DMRC RS-15 cars will operate with the track geometry shown in Table.

Track Gauge	1673 mm
Min. radius, on revenue track (Main line)	300 m
Min. radius in depot	200 m
Radius (equivalent) of min. vertical curve (convex or concave) mainline	1500 m
Max. gradient (Mainline)	3%
Max. gradient (Depot)	4%
Maximum design speed	90 KMPH
Maximum operational speed	80 KMPH
Round trip schedule speed with 30s station stops & 8% coasting, excluding terminal station turn round time with fully loaded train	34 KMPH
Service acceleration rate	0.78 m/s ² ± 5%
Service deceleration rate	1.0 m/s ² ± 5%
Emergency deceleration rate	1.3 m/s ²
Jerk rate (maximum)	0.75 m/s ³
Expected running adhesion but not limited to	18%
Wheel diameter (new/worn)	860/780 mm

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Bogie wheel base (approximately)	Min 2,400 mm
Average travel per year	1,50,000 Km

1.4 Current Collection System

System particulars	Rail Corridor	Metro Corridor	Depots
Supply Voltage System	25kV ac Single phase 50Hz	25kV ac Single phase 50Hz	As main line
Type of OHE	Flexible Catenary	Rigid Catenary	Flexible Catenary
Current Collector	Through Pantograph	Through Pantograph	Through Pantograph
Height of Contact wire from rail level	4800mm min 5000mm max	4150mm min	5000mm max for MC and 5500mm max for RC
Stagger	±200/300mm	±200 mm	±300 mm
Nominal Voltage	25kV ac		
Minimum Voltage	19kV ac		
Maximum Voltage	27.5kV ac		
Instantaneous min Voltage	17.5kV ac		
Occasional max Voltage	31.0kV ac		
Voltage for guaranteed performance	22.5kV ac		
Variation in frequency	48-52 Hz		

2. Definition:

The following definitions and abbreviations are applicable to the PTS.

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

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

“BEML” means the Customer to procure the Pantograph system for DMRC RS-15 Project.

“Subcontractor” means the subcontractor of Pantograph system to BEML for DMRC RS-15 Project.

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“GS” means Employer’s Requirements-General Specification of DMRC RS-15 contract for DMRC RS-15 Project

“TS” means Employer’s Requirements-Technical Specification of DMRC RS-15 contract for DMRC RS-15 Project

“PTS” means BEML’s Procurement Technical Specification.

“NA” means Not Applicable

“GTC” means General Terms and Conditions

3. Precedence of Documents

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

To the extent that any provision of the PTS is inconsistent with any provision of the Commercial Specification, the provisions of the General Terms and Conditions (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. Indigenization (ERGS Clause 1.1.8)

The subcontractor shall make efforts to source maximum number of equipment and materials from India, as specified in the Table 1.C recommended items for indigenization of ERGS 1.1.8, pantograph system to be indigenized to meet the required performance requirements and quality standards and facilitate ease in maintenance and easy availability of spares.

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5. Scope of Supply

5.1 Hardware

The Pantograph system shall fully meet the requirement of TS & GS of RS15 and shall be **compatible** with and **suitable** for integration with the existing DMRC RS1 trains and RS4 & RS6 units with all the necessary modifications/ improvements as per RS15 contract to form 6 car and 8 car train formation. The subcontractor shall be responsible for providing all the equipments for Pantograph system to comply with GS & TS of RS15.

The Scope of Supply for one set of Pantograph equipment comprises of the items listed in Table-1 as below, The list of items are indicative

SI No.	Item	Qty/ T Car
1	PANTOGRAPH (25KV)	1 No
2	FOOT INSULATOR (25KV)	1 set
3	AIR FEED INSULATOR(25KV)/ INSULATED AIR PIPING	1 set
4	PANTO CONTROL PANEL	1 No

Table-I: Scope of supply


Note: Sl. No. 1 to 4 constitute one complete assembly for scope of supply.

One set of Pantograph consists of the following but not limited to:


- (1) Pantograph Assembly
- (2) Maximum extension device (MED)
- (3) Base Frame including required insulators
- (4) Air feed insulator (If required)
- (5) Pneumatic Control Panel including the following pneumatic components.

In addition the following components are required for smooth functioning of the pantograph system and any other component required for smooth operation of Pantograph shall also be provided,

- a) Pressure switch

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- b) Magnetic valve (holding and releasing) including suppression Diode or varistor, reducing valve, throttle valve, safety valve, stop valve, etc.
 - c) Terminal
 - d) Off pressure test point and blanking plug for test fitting
 - e) Air filter
 - f) Panel
- (6) Any other Mechanism for operation of Pantograph Assembly
- (7) All items needed for functioning of Pantograph shall be supplied and listed before contract by the subcontractor.
- (8) The sub contractor shall incorporate all the changes / modifications carried out in the RS1/RS4/RS6/RS13 cars of Pantographs for RS15 supplies as required in TS Appendix-TH. HEC/DMRC/SPD/ELECT/01 shall be implemented by subcontractor wherein all the controls are relocated inside the car (Applicable for BW Pantographs).
- (9) The sub contractor shall provide valid type test certificates/documents and routine test certificates for the Pantograph system & aggregates.
- (10) The sub contractor shall be fully responsible for integrated type testing and commissioning of the Pantograph system at BEML works and at DMRC Depot & Mainline. **The subcontractor shall perform current collection test (Type test) at DMRC Mainline including Arc test, Sway test & Video recording.**
- (11) The sub contractor shall be responsible for interfacing with all other aggregate suppliers for integrating the system / aggregates with on-board TIMS.
- (12) As per ERTS 4.16.3, In Delhi area, incidences of stray wire being dropped by birds etc are quite frequent. In many cases this has fallen on OCS and roof equipment mounted on the body. These resulted not only in interrupting train running and power supply system but also withdrawal of rakes from revenue service and also puncturing of roof sheets. To obviate these problems, suitable design arrangements for provision of suitable insulation (for 25 kv single phase) of all live parts on the roof (excepting pantograph pan) shall be provided. **In this regard, sub contractor shall provide suitable solution for insulating metallic part of Pantograph system to avoid above issues. Subcontractor shall provide suitable proposal along with technical offer for evaluation.**
- (13) The sub contractor shall be responsible to maintain the DLP and commissioning spares at DMRC Depot. The list of DLP and

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commissioning spares shall be furnished by the sub contractor for review and approval by DMRC.

- (14) The sub contractor shall provide following documents and shall also provide any other documents required by DMRC.
- Design documents for approval by DMRC including operation performance documents.
 - Description of Pantograph system aggregates with drawings.
 - Quality assurance plan (QAP)
 - Test procedure for the pantograph system and aggregates
 - Type test and Routine test reports
 - Operation and maintenance manual
 - DLP Spares List.
 - Spare parts catalogs.
- (15) The supplier shall maintain the Pantograph system aggregates and supply of spares for at least 10 years from the date of completion of the contract.
- (16) **The sub contractor shall provide training in operation and maintenance to BEML and DMRC staff at Bangalore & Depots at Delhi.**

5.1.1 Submittals – Technical Offer

The subcontractor shall provide the following as part of technical offer.

- Complete Technical offer for Pantograph system.
- Clause wise compliance against,
 - PTS - Doc no. GR/TD/3006.
 - Relevant Clauses of RS15 ERGS (See Section 5.2 for relevant clauses).
 - Relevant Clauses of RS15 ERTS (See Section 5.2 for relevant clauses).
 - GCC 5.8.
- Confirmation to TS Appendix-TH along with the List of all the variations, modifications, HECPs of RS1, RS4, RS6, RS13 cars for incorporation in the RS15 supplies for submission to DMRC. The vendor shall resolve & implement solutions for all NCR's, RSOI's and EIR's raised by DMRC. (Applicable for BW Pantographs).
- Confirmation to the List of all the variations, modifications, HECPs of RS3,

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RS6 & RS13 cars for incorporation in the RS15 supplies for submission to DMRC. The vendor shall resolve & implement solutions for all NCR's, RSOI's and EIR's raised by DMRC.

- e) List of DLP and commissioning spares.

5.2 Software

Not Applicable

5.3 Interface Responsibilities

The location of mounting points and the design of equipment installation comprising of Pantograph assembly shall be defined by the Subcontractor and approved by BEML in order to avoid the mechanical interference with other equipment for the vehicle & Kinematic envelope. The Subcontractor shall be responsible for the equipment and material to be supplied and recommended installation method and procedures.

BEML shall be responsible for defining the technical requirements and the design constraints.

The Subcontractor shall be responsible for the design of the Pantograph system and the submission of design information and the performance of testing activities and the supply, installation and commissioning of Pantograph system and the maintenance and rectification of the Pantograph system during the defects liability period, etc. (Refer GS and TS).

The Subcontractor shall be responsible for the hardware interface required by BEML.

The Subcontractor shall be responsible for complying with the control circuit to be arranged by BEML in order to fulfill the requirement of TMS interface. If the subcontractor thinks that the control circuit designed by BEML is not suitable for Pantograph operating, the subcontractor shall discuss it and clarify it before starting production.

5.4 Design Information

The Subcontractor shall provide BEML with all necessary documents, drawings, software, reports, calculations, technical data and similar documents of design, system assurance, quality assurance, manufacturing and testing with respect to PTS according to the time schedule defined by BEML.

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The drawings and documents shall be written in English with data format of respectively, latest AUTOCAD, CATIA release.(Document – MS word, Spread sheet – MS excel, Data base files – MS Access, Presentation file – MS Power point).

Three sets of all drawings, test procedures, manuals 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 hard copies and soft copy. The subcontractor shall comply with the requirements specified in GS & TS.

5.5 Testing

The Subcontractor shall perform, as a minimum, the following tests for Pantograph,

- (1) Type tests and Routine tests of complete equipment and sub-systems.
- (2) Type Commissioning test for Pantograph of the first train-set & T+M unit of RS15 project.
- (3) Integration Tests in conjunction with all Designated Contractors.

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

- (1) Routine complete vehicle tests for Pantograph of each Corridor
- (2) Routine commissioning test for pantograph of each Corridor
- (3) Service Trials

The detailed requirements are specified in the section 8.

The Supplier will provide technical assistance where required for interface testing, but will not accept responsibility for instrumentation or testing authority for interface testing which is classed as combined testing and the responsibility of the vehicle supplier.

5.6 Operation and Maintenance Manuals and Spare Parts Catalogues

The Subcontractor shall provide the operation/maintenance/ spare parts manuals and spare parts catalogues for the pantograph system aggregates both in the hard copies and electronic format as required in RS15 TS & GS. The subcontractor shall provide the following O & M manual:

- a) Volume 1 – Technical Manual
- b) Volume 2 – Operation Manual
- c) Volume 3 – Maintenance Manual
- d) Volume 4 – Fault Diagnostics Manual
- e) Volume 5 – Spare Parts Manual

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- f) Volume 6 – Software Manual
- g) Volume 7 – Special Tools & Test Equipment Manual

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

5.7 Spares, Special Tools and Testing Equipment

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 Pantograph system and supply of spares for at least 10 years from the date of completion of the contract.**

The subcontractor shall supply the following items of spares

- (1) Unit Exchange Spares.
- (2) Consumable spares for maintenance for all trains during commissioning, service trials and upto completion of warranty period.
- (3) Mandatory Spares.
- (4) Special tools, Testing and Diagnostic equipment.
- (5) Special jigs, Fixtures & Gauges required for maintenance, repair and overhaul of the trains.
- (6) Recommended list of consumable spares including lubricants required for maintenance, repairs and overhaul of trains.
- (7) Recommended list of Special Tools, Testing and Diagnostic Equipment separately for maintenance and diagnostics of various equipments.
- (8) Recommended list of Special Jigs, Fixture and Gauges for maintenance and diagnostics of various equipments.
- (9) The drawings, manuals and full operating instructions.
- (10) The means and instructions which describe the parameters of each item of Special tools, Testing and Diagnostic Equipment.

The delivery of unit exchange spares, consumables spares, special tools, testing and diagnostic equipment and Special jigs, fixtures & gauges shall be supplied along with the first supplies of the Pantograph system.

The drawings, manuals and full operating instructions shall be supplied along with the first two trains for Corridor.

The detailed requirements are specified in GS8 .

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5.8 Storage, Packing Crating and Marking

The subcontractor shall provide all packing. Crating and markings in accordance with the requirements specified in GS. When handing over, hand over the complete Pantograph and the spare parts, special tools and testing equipment

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 Pantograph.

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. For detail information see GS13.

5.9 Warranty

The subcontractor shall be responsible for any defect or failure of equipments provided in the cars, due to defective design, material or workmanship during warranty period.

The warranty period of special tools, test and diagnostic equipment, maintenance and unit exchange spares shall be as per GS of RS15 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 (BEML' works/ DMRC depots).

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 18 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.

Also Refer General Terms and Conditions (GTC) of the tender.

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6. Technical Requirements

6.1 General

The subcontractor shall be responsible for meeting all the general and technical requirements of the Pantograph system as specified in GS & TS. The General Requirements (TS 2) comprising:

1. Interface Activities
2. Quality Assurance
3. System Safety Assurance
4. Hazard Analysis
5. Fail safe design
6. Reliability, Availability & Maintainability
6. Electromagnetic Compatibility
7. Noise and Vibration
8. Fire performance and Toxicity Standards

6.2 Technical requirements of Pantograph system

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

- | | |
|---------------|---|
| (1) TS 2 | General Requirements |
| (2) TS 3 | Design and Performance Requirements |
| (3) TS 4.3 | Static Vehicle Profile (Kinematic Envelope) |
| (4) TS 8.1 | High Voltages and Propulsion Configuration |
| (5) TS 8.2 | HV Power Collection |
| (6) TS 12 | Electrical and Control Equipments |
| (7) TS 14 | Material and workmanship |
| (8) TS 14.3 | Welding |
| (9) TS 14.4 | Corrosion |
| (10) TS 14.17 | Labels |
| (11) TS 14.18 | Lubricants |
| (12) TS 14.19 | Painting |
| (13) TS 15 | Inspection, Tests and Trials |
| (14) | Appendix TA International Standards |
| (15) | Appendix TB Car body Mock-ups |
| (16) | GS Appendix- 7: Designs and Manufacture Interface |
| (17) GS 2 | |
| (18) GS 5 | |
| (19) GS 7 | |
| (20) GS 8 | |
| (21) GS 9.1 | |

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(22) GS 13

The vendor shall submit the clause by clause compliance for the above clauses of ERTS & ERGS along with the technical offer as specified at section 4.1.1 of this document.

The pantograph shall meet at least the following technical specifications

- 1) Pantograph shall be suitable for current collection both from rigid as well as flexible over head systems.
- 2) The Panto control like settings, test fittings etc., shall be provided inside the car so that any parameter shall be settable from the saloon of the car.
- 3) The Panto control panel shall at least have the following
 - a) Air flow restrictor to set the pantograph extension speed.
 - b) Pressure regulator to adjust the static force value.
 - c) Air flow restrictor to set the pantograph lowering speed.
 - d) Solenoid valve to raise/ lower the Pantograph.
 - e) Pressure switch to detect actuation of maximum extension detection.
 - f) Pressure switch to know the status of pressure applied to raise or lower the pantograph.
 - g) Insulated air supply pipes fitted on the vehicle roof.
- 4) The static force of the pantograph should be a settable one and it shall have setting range from 50N and 120N.
- 5) The subcontractor shall specify the air consumption during raising and lowering in their technical offer.
- 6) The power consumption of the pantograph shall be less than 6 W.
- 7) The time required for raising and lowering of the pantograph shall be settable one and same shall be provided in the technical offer.

6.3 Noise

Not applicable.

6.4 Weight

6.4.1 Target Weight Limit

The subcontractor shall specify the following equipment weight limit.

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The weight of each component of Pantograph shall be verified and controlled by the subcontractor in accordance with the requirements defined by BEML to comply with the requirements specified in TS 3.22.

The Subcontractor shall comply with all weight reductions judged by necessary by BEML. Any unit exceeding the permissible weight shall be rejected. Overweight tolerance is not permitted.

The subcontractor shall submit the list which describes the exact weights of all equipment. The subcontractor shall maintain and publish a weight control document. The weight control document shall list the weight and center of gravity of all components with tolerances.

Weight of the Pantograph shall not exceed the following:

Total weight of the Pantograph assembly with
foot insulators and Air feed Insulator : **208kg**

Total weight of the Pantograph control box : **12kg**

Note: Weights shall be equal or less than RS1/RS4/RS6/RS13 supplies

6.4.2 Subcontractor Weight Control Activity

(1) Experience equipment actual weight report.


The subcontractor shall provide the actual weight and basic specification of all equipment within two weeks after contracting that subcontractor has already manufactured for mass production in last five projects.

(2) 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.

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.

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(3) Equipment Weighing Test

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

6.5 RAMS Requirements

The sub-contractor shall meet RAMS (Reliability, Availability, Maintainability and Safety) requirements given in the Technical Specification (TS) and the General Specification. 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:

6.5.1 Reliability Analysis

The reliability data shall be based on actual operating information for the equipment. If the equipment in question has no previous operating experience, operational data from a similar piece of equipment shall be used. In this case, the reliability data shall be taken from equipment having approximately the same electrical and mechanical characteristics and operating under similar conditions. Under these circumstances, sub-contractor will use this data and must be approved by BEML.

In the case where there is no operating experience with similar equipment, reliability data shall be estimated and provided in accordance with the latest revision of reliability data-book such as MIL-HDBK-217, NPRD, EPRD, PRISM or similar.

In addition, the sub-contractor shall submit a list of typical train withdrawal scenarios for review and acceptance by the BEML. The list shall include all anticipated failure scenarios, which can affect safety, punctuality and passenger comfort. 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 developed and submitted to the 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 sub-contractor 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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6.5.2 Reliability Target

The MDBCF (Mean Distance Between Component Failure) per 4 car train-set of Pantograph shall meet the following table,

	MDBCF (train-km) Train set/'T+M' unit
After 2 months of start of revenue service	7,900,000 train-km

The reliability performance shall be assessed by the following measure:

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

Where, Mean Distance Between Component Failure (MDBCF): The MDBCF of 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.

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:

Unavailability of the train to start revenue service after successful completion of pre-departure Checkout;

- Withdrawal of the train from revenue services;
- A delay equivalent to or exceeding 3 minutes from the Schedule / Time table as noted at the destination station for the one way trip.

6.5.3 Maintainability Requirements

6.5.3.1 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.

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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 TS 2.12.

6.5.3.2 Maintainability Target

- 1) The LRU replacement should be less than 30 minutes
- 2) The mean time to repair (MTTR) of Pantograph should be less than 1 hour
- 3) Corrective Maintenance Operation that do not require a car lifting shall be less than 4hours.
- 4) Corrective Maintenance Operation that do require a car lifting shall be less than 6 hours.

6.5.3.3 Master Maintenance schedule

The maintenance schedules will be provided stating the parts needing attention at the basic service period and for major overhauls.

The sub-contractor shall submit work instructions for all scheduled maintenance activities, fault finding, and corrective maintenance of all faults likely to be found during maintenance and servicing.

6.5.4 Life Cycle Costs

The sub-contractor shall provide equipment that has minimum total Life Cycle Cost. The subcontractor shall submit all information for Life Cycle Cost calculation in accordance with RAMS Guideline to be provided by BEML.

6.5.5 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. Provided the target is a legitimately realistic value.

The sub-contractor shall provide an active support for high availability. The procedure for this as shown in figure. Therefore, the sub-contractor should be complied with BEML's procedure. If some failure needs the sub-

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contractor 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.

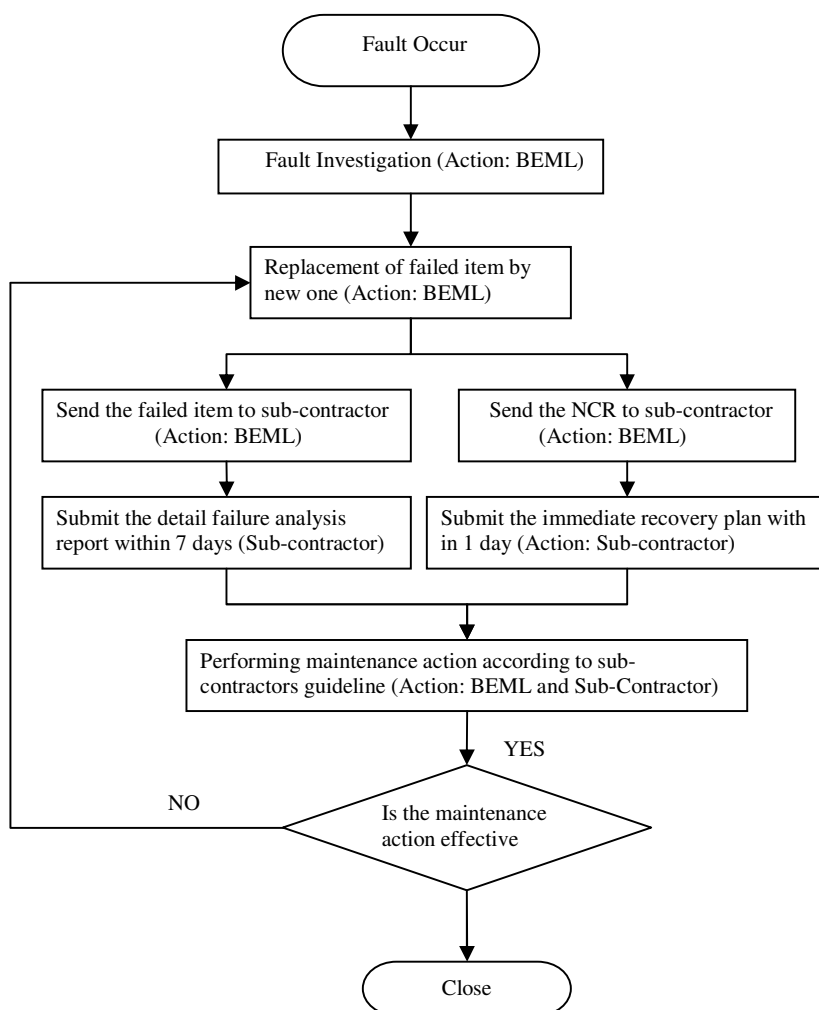


Fig – 1

6.5.6 Safety Requirements

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 As Low As Reasonably Practicable (ALARP).

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

- 1) Hazard Analysis including Subsystem Hazard Analysis, Operating and Support Hazard Analysis and Interface Hazard Analysis
- 2) FMECA (Failure Mode, Effects and Criticality Analysis)

The Guideline for preparing the safety related documentations will be provided in the RAMS Guideline at early design stage.

The sub-contractor shall submit the safety related documentations in fully compliance with RAMS Guideline (especially format and methodology) to be provided by BEML.


6.5.7 RAMS Deliverables

The sub-contractor shall submit the following RAMS Deliverables in accordance with RAMS Guideline (especially format and methodology) to be provided by BEML.

- Product Breakdown Structure during Preliminary Design Stage
- Reliability Analysis including a list of typical train withdrawal scenarios, Reliability Block Diagram and Reliability Prediction during both Pre-final Design Stage and Final design Stage
- Preventive and Corrective Maintenance Analysis during both Pre-final Design Stage and Final design Stage
- Hazard Analysis including Subsystem Hazard Analysis, Operating and Support Hazard Analysis and Interface Hazard Analysis during both Pre-final Design Stage and Final design Stage
- Life Cycle Cost Analysis during Final design Stage
- FMECA (Failure Mode, Effects and Criticality Analysis) during both Pre-final Design Stage and Final design Stage
-

6.6 Fire

The Fire Safety requirements shall be met, but not be limited to, the requirement of EN 45545, latest editions :

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6.6.1 Fire Performance Test Procedure and Criteria

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

All the components of Pantograph including paint and cables of Panto control unit should comply to EN 45545, latest editions requirements.

6.6.2 Wires and Cables:

All wires & Cables shall comply to ERTS Clause – 12.5. The insulation of all wires and cables including those used within equipment/subsystem shall be halogen-free flame retardant and formulated to minimize generation of smoke, noxious emissions and corrosive fumes, in the case of overheating or fire in compliance with EN 45545 latest editions. All cables shall comply NF F 63-808 (for low voltage, 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 (ERTS 12.5.2).

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.

6.7 EMC requirements

The sub-contractor shall not cause interference with signaling and other public services, e.g. communication and navigational services, including broadcasting of all kinds, television, radar, and other services. As a minimum, the subsystem shall comply with EU. EMC Directives such as 'EN50121-3-2: Rolling stock-Apparatus'. A technically competent independent body shall certify the compliance. The subsystem shall as a minimum conform to the requirements of GM/RC 1500. Relevant test specification, report and certificates shall be approved by BEML Company before equipment delivery not applicable to scope of supply.

6.8 Operation & Maintenance Manual

6.8.1 General Requirement

The Subcontractor shall prepare the Operation Manual, the Maintenance Manual, and the Illustrated Parts Catalogue for the Pantograph system.

Standard off-the-shelf documentation shall be reviewed for acceptance providing the documentation contains the required information as outlined in

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this section and its subsections. All manuals and catalogues shall be in English.

BEML/DMRC reserves the right to make any future presentation refinements at the detail level, which would result in minimum cost impact. All materials shall be subject to the DMRC final approval.


The Subcontractor, no later than 8 months prior to the test running date, shall submit to BEML/DMRC for review and approval, three preliminary color hard copies and the electronic copy of the Operations and Maintenance Manuals for all the Systems, sub-systems, equipment, and components supplied under the Subcontract. For the final revisions of the Operations and Maintenance Manuals, the Subcontractor shall submit to BEML/DMRC for review and approval. These manuals shall provide comprehensive operating instructions, maintenance instructions, maintenance drawings, and illustrated parts lists for the entire Subcontractor's System such that every item of the System's equipment can be properly operated and maintained. The information provided in the manuals shall be comprehensive and adequate to accomplish the required tasks and scopes of works.

The instructions contained in the Operations and Maintenance Manuals shall be in sufficient detail to enable the DMRC and/or BEML to operate, maintain, and repair each part of the System.

Information contained in the Operations and Maintenance Manuals shall be in pictorial form whenever possible and shall include step-by-step instructions, detailed descriptions, block diagrams, exploded views, photographs, illustrated parts breakdowns, and schematic drawings to sub-systems, systems, etc.

The content of the Operations and Maintenance Manuals shall be thorough, clear, and complete, and shall be presented in language free of vague and ambiguous terms, using the simplest of words and phrases that shall convey the intended meaning. Sentences shall be short and concise. Punctuation shall be used in a manner that aids in reading and prevents misreading.

Programmable equipment and Systems shall be supplied with sufficient flow charts and fully documented programmes to enable faults to be quickly identified and modifications to be undertaken at any time.

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6.8.2 Operation Manuals

The Subcontractor shall prepare and submit to BEML/DMRC for review and approval, the Operations Manual for the System. The Operations Manual shall be provided as a stand-alone manual. The Operations Manual shall include, but not be limited to, the following System related content:

(a) Introduction and general information including, but not limited to, the following items:

- Explanation of the manual's purpose,
- The scope of the manual
- A brief description of the System and its sub-systems and components
- The features of the System
- The location of the System's controls
- The characteristics and physical makeup of the System with illustrations and exploded views

(b) The theory of operation

(c) The detailed operating procedures including, but not limited to, the following items:

- Adequate operation instructions of the System for a complete Start to stop cycle including safety precautions to be observed, preliminary adjustments, alignments, and positioning required, and warm-up procedures
- The means of connection between equipment components within the System and to other systems
- The step-by-step procedures to operate the System under normal operating conditions and the list of controls and indicators for the System and the explanation of the function of each

(d) The detailed operation planning instructions (i.e., all of the steps required to prepare the basic System for function checks, all necessary steps to perform functional checks, etc.)

(e) The troubleshooting procedures and trouble recognition symptoms

(f) The safety precautions

(g) The functional relationship with other equipment, sub-systems, or systems

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- (h) The operational limits and restrictions
- (i) Illustrations depicting control layout or other pertinent features required to supplement the description of the operational procedures and instructions.
- (j) Any other information necessary for proper and efficient operation.


6.8.3 Maintenance Manuals

The Subcontractor shall prepare and submit to BEML/DMRC for review and approval, the Maintenance Manual for the System. The Maintenance Manual shall include, but not be limited to the following sections:

- (a) Introduction — an introduction to the System and its components.
- (b) Functional Description — detailed description and operation, including theory of operation of the System and its components.
- (c) Troubleshooting — troubleshooting procedures in a tabular form with headings of Trouble, Probable Cause, and Possible Remedy. All adjustment and alignment procedures shall include tolerances and limits, where applicable.
- (d) Inspection and Maintenance — procedures for preventative maintenance, including but not limited to cleaning, lubrication, and adjustment. Inspection requirements shall include procedures and intervals. Schedules shall be in tabular form with headings for Component, Procedure, and Interval. The inspection interval can be expressed in distance or time or both. All text procedures shall be supported by line drawing illustrations. Photographs shall be acceptable for conditions, such as bearing wear, which cannot be clearly illustrated by line drawing illustrations.
- (e) Removal and installation: Disassembly and Assembly — procedures for component replacement. Line drawing illustrations shall be used to illustrate the procedures. Procedures for disassembly and assembly of all repairable electrical, electronic, pneumatic, and mechanical components, including the overhaul periods, inspection criteria for the disassembled parts shall also be provided.

The Maintenance Manual shall include, but not be limited to, the following inspection and maintenance sections:

- (1) Corrective Maintenance (fault finding and diagnostics)

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- (2) Preventative Maintenance
- (3) Spare Parts List
- (4) Standards
- (5) Special Tools and Test Equipment


The Corrective Maintenance section shall detail all unscheduled servicing actions performed, as a result of a System failure, to restore the System to a specified condition. The corrective maintenance cycle shall include, but not be limited to, failure, localization and isolation, disassembly, item removal and replacement or repair, re-assembly, checkout, and condition verification. This section shall contain sufficient information, drawings and schematics to allow a suitably qualified person to identify the cause of faults, and shall describe the steps necessary to rectify the fault.

The Corrective Maintenance section shall also specify test procedures required to be carried out after corrective maintenance action on any part of the System in order to verify that the System's integrity has not been compromised.

The Preventative Maintenance section shall describe all preventative maintenance activities required to achieve the specified performance levels for the life of the System. Preventative maintenance shall include, but not be limited to, all scheduled servicing actions performed to retain the System in a specified condition. Scheduled servicing shall include the accomplishment of periodic inspections, condition monitoring, critical item Replacements, overhaul, adjustment, and calibration. In addition, servicing requirements (for example, lubrication, cleaning, housekeeping, etc.) may be included under the general category of scheduled servicing. The Preventative Maintenance section shall be ordered such that for each level of maintenance the complete instructions to perform that maintenance are included such that each section of the manual is effectively stand-alone. In addition the Preventative Maintenance section shall specify the following:

- (a) All preventative maintenance inspections, including limits, settings and tolerances
- (b) All lubrication and cleaning required, including frequency, methods, materials and location
- (c) All routine component replacements, including frequency, replacement criteria and methods
- (d) All routine reconditioning or overhaul of components including frequency, replacement and methods

The Spare Parts List section shall provide an Illustrated Parts Catalog for the System supplied and shall contain sufficient information to identify and

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requisition the appropriate part by maintenance personnel. The Spare Parts List section shall include, but not be limited to, the provision of the following part descriptions:

- (1) An alpha-numeric parts list including for each part, as a minimum, the part number, the part description, the part number of the next higher assembly (usually an LRU), a cross-reference to a figure or drawing number, the part category (consumable, LRU, repairable, etc.). and the part life data (expected part life, guaranteed MTBF, MTTR, etc.)
- (2) Illustrations to indicate the location of each replaceable item (clear and progressive with exploded views to enable parts to be easily identified from the drawing cross-reference in the alpha-numeric parts list)
- (3) A parts price list, in alpha-numeric sequence, that includes, as a minimum, the part price, the lead time, and the part vendor

The Special Tools and Test Equipment section (including gauges) shall identify all special tools, test equipment, gauges, and any other resources required to perform the tasks detailed in the Maintenance Manual.

Operating procedures for Special Tools and Test Equipment shall be provided by the Subcontractor.

Preservation and storage procedures for repaired / overhauled components shall be provided. Testing procedures including test parameters shall be provided.

In general, all test procedures shall be supported by line drawing illustrations.


6.8.4 Illustrated Parts Catalogue

The Illustrated Parts Catalogue shall contain exploded views, if applicable, for each assembly, subassembly, and sub-subassembly with a full parts list. All parts shown on the illustrations shall be identified by an item number and leader lines. Engineering drawings and photographs shall not be acceptable, unless specifically approved by the DMRC.

The list shall include all parts attached by means other than welding or riveting, unless welded or riveted parts are considered normally replaceable by the manufacturer.

The figures and text listings shall have the same orientation (i.e., both landscape or both portraits).

The column headings shall provide the following information (starting with the left hand column):

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- (a) Figure and item number,
- (b) Part number (either the original equipment manufacturers or the Subcontractors) and part description
- (c) Original equipment manufacturers code
- (d) Provision for entry of customer stock code.

For standard electrical, electronic, pneumatic, and / or hydraulic hardware components such as nuts, bolts, resistors, lamps, valves, etc., the description shall provide sufficient detail to facilitate procurement from a generic supplier.

6.8.5 Submissions

The Subcontractor shall submit the draft of all manuals to BEML. After submission of draft maintenance manual, the final maintenance manual shall be provided within schedule approved by BEML.

6.9 Training

6.9.1 General :

The subcontractor shall provide the training for Employer's operating staff and maintenance staff according to the requirements specified in GS 9.

The detail requirements for training schedule including the number of times will be informed later.

6.9.2 Training Requirements :

The sub-contractor shall provide training to BEML/DMRC staff at Factory and DMRC site. The subcontractor shall submit a training proposal to BEML.

Training shall be carried out such locations as will provide the maximum benefit to the trainees. Such locations may be at places of manufacture, assembly or testing or other locations shall be furnished by sub-contractor.

The detailed requirements are specified in GS 9.1.

6.9.3 Training Manual

The subcontractor shall provide one original and five colored copies and electronic copies of the training manual for use by the Employer for conducting in-house training. The Manuals shall cover all requirements specified in GS 9.

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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. Quality Assurance Program

The Supplier shall comply with the requirements of QAP (Quality Assurance Program), which is to assure the quality of products supplied from the subcontractor to BEML. If necessary, details of QAP need to be discussed with BEML's Quality Control Team.

The Supplier shall provide the following information about Capital Spare Parts, Warranty Spare Parts and Consumable Parts in full compliance with the Technical Specification.


7.1 Organizations

The organization of the Contractor's Quality Assurance (QA) Program shall have sufficient, well-defined responsibility and organization. It shall report directly to the General Manager of the Contractor's facility or the Contractor'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 nonconforming 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 Contractor's high level management starting with the General Manager or equivalent.

7.2 Certification of Personnel

The Contractor's 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 (Non-destructive tests), etc. shall be certified for such work. Records of personnel certifications shall be maintained and monitored by the Contractor's Quality Assurance personnel. These records shall be made available to the Engineer of BEML for review.

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7.3 Evidence of Compliance

The Contractor'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.

7.4 Certificates of Compliance


The Contractor 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 software is installed to the product), Barcode number of the product(if barcode system is specified in the specification of product), Project name, Contractor'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 Contractor, 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 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 Contractor.

7.5 Calibrations

The Contractor 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

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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.

7.6 Procedure Documents

The Contractor 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 subcontractors, 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.

7.7 Quality Assurance Activities

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

7.7.1 Procurement

The Contractor 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 Contractor shall require each supplier to be responsible for maintaining and retaining records. Furthermore, the Contractor shall require each supplier, as a minimum, to submit with each shipment appropriate

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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 subcontractors.

7.7.2 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 Contractor's Inspection and Test Plan (ITP) upon review of the Contractor'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.

7.7.3 Production Conformance Testing


The Contractor'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.

7.7.4 Receiving Inspection

The Contractor's receiving inspection activity 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 Contractor 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.

7.7.5 Shipping Inspection

The Contractor'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

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shall be prepared as required to preclude damage during shipment. The inspections and preparation for shipment shall be verified by the Contractor's QA/QC personnel.

7.7.6 Changes

The Contractor shall ensure that inspection and tests are based on the latest approved revision or change to drawings and specifications. The Contractor 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.

7.7.7 Identification of Status

The Contractor 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 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.

7.7.8 Handling

The Contractor'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.

7.7.9 Nonconformance Control

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

The contractor 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 Contractor or

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Contractor's sub-suppliers, the Contractor shall establish nonconformity control procedure and include 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.

7.7.10 Quality Audit

The Contractor 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 Contractor's QAP. If any Nonconformity is detected while the audit, Corrective Action request will be issued to the Contractor. For the Corrective Action Request, the Contractor shall prepare and submit appropriate action plan within 10 (ten) days, perform the action plan and reply the result to BEML QC team.

7.8 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.

- (1) 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:
 - (a) Introduction of ITP (purpose, application scope and etc)

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- (b) Description of Symbols, Abbreviations and Definitions
- (c) Sampling Procedure if it is necessary
- (d) Inspection/Test Notification procedure
- (e) General Inspection/Test process/flow
- (f) Manufacturing and Inspection/Test flow (block diagram) which describes manufacturing flows and inspection/test points.
- (g) Description of Inspection and test activity and item
- (h) Kinds of Inspection and Test such as Design Qualification verification test (), FAI, Routine inspection/test
- (i) Inspection/Test Level such as 100%, Sampling, 1/Lot and etc
- (j) References of the inspection/test such as specification, procedure, etc
- (k) Responsible entity of the inspections and tests
- (l) Places of the Inspection and test
- (m) Witness/hold points of BEML and/or the Customer of BEML
- (n) Description of Reports /checklists required and the Submission
 - A table format is recommended to describe the Items (g) & (n).

(2) Witness/Hold point of Inspection/Test

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

- 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 Contractor. The contractor can proceed 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 Contractor to BEML. In case of hold point, Contractor 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) are designated as the Hold Point.

(3) Inspection/Test Notification of Witness/Hold point

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

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8. Design Information

8.1 General

The subcontractor shall submit, not limit to, the following general information in accordance with the schedule.

Document/Deliverables	Reference/ Description
Testing plan	GS2, TS15
Schedule of Tests	GS2, TS15
Test procedure of; Type and routine of equipment, Type test of complete vehicles, Commissioning test of complete vehicles	GS2, TS15
List of spares, special tools and testing and diagnostic equipment	GS8
All relevant drawings, manuals and full operation instructions for the special tools, testing and diagnostic equipment	GS8
Training proposal	GS9
Training Course	GS9
Training manual	GS9
Operation and Maintenance manuals and spare part catalogues	GS13
As built drawings	GS5
All tools, equipment and manuals necessary for the maintenance	GS8.4
The requirements for the completion of project management plan, interface management plan, work plan, quality assurance plan, safety assurance plan and site safety plan, environmental plan, inspection, test and commissioning plan	GS2

8.2 Design

8.2.1 General

The design of Pantograph shall basically comply with TS 3.17, TS 4.3, TS 8 and relevant specification of GS and TS. Please provide these documents for SW review.

When designs the pantograph, Subcontractor shall take into the interface with other Designated Contractor and BEML's carbody design. The design

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submission shall be submitted to BEML according to the following three stages;


(1) Preliminary design submission stage (refer to GS 5.7)

(2) Pre-final design submission stage (GS5.8)

(3) Final design submission stage (GS5.9)

The subcontractor shall submit, not limit to, the following design information in accordance with the schedule

Submission Stage	Document / Deliverables
Preliminary Design Submission	(1) System description Pantograph system(Rate, Control Mechanism, Part list, Auto-drop function, etc) (2) Detailed specifications and drawings of all equipment {Pantograph assembly(Contact strip, Insulator, etc.), Control unit, Control mechanism, etc } (3) Schematic diagram (Air piping diagram/ Electrical diagram) (4) Calculations; Temperature of Pantograph at rated current. (5) Full proposals of; Pantograph head profile, Installation method, Raising time, Lowering time, Contact pressure, (6) Full technical details of; Paint spec, Material of air hose, Part list of the control panel equipment, Air hose connection method, etc. (7) Service history of Pantograph Assembly, Control panel, Auto-drop function, etc. (8) Reliability and maintainability proven data and letters of pantograph and control panel. (9) Explanation: Auto-drop function. (10) Pantograph sway Calculations (11) Static Uplift force of Pantograph and maximum aerodynamic force. (12) Frequency of replacement: Carbon strips. (13) Material of pantograph contact strip (14) Detail masses spring and damping of pantograph. (15) Information of magnetic valve
Pre-final Design Submission	(1) Upgraded System description; At this stage, the information described at the preliminary stage shall be fixed and finalized. (2) The evidence of or proposals for design verification (3) Test specification of Pantograph The detailed requirements will be specified later by BEML.
Final Design Submission	(1) Completed calculations and analysis, studies, investigations and reports (2) The detailed requirements will be specified later by BEML.

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The subcontractor shall submit all data for each design submission to BEML as soon as possible so that they can be confirmed by BEML by at latest the defined time schedule. BEML will furnish the review comments about the submission to the subcontractor. The subcontractor shall meet with BEML to discuss the review comments. Should BEML deem the submission to be unacceptable, the subcontractor shall revise and re-submit the submission as soon as possible.

8.2.2 Requirement of Pantograph

The design of Pantograph shall comply with the requirement TS & GS (please provide for review), IEC 60494-2 and Kinematics Envelop gauge (please Provide for review). The Pantograph, at least, shall meet the following requirements.

- (1) Power shall be drawn from the overhead line by pantographs. The pantograph for the 25kV ac system shall be suitable for flexible auto-tensioned OCS consisting of catenary and contact wire on elevated/at grade sections as well as rigid catenary system provided in the tunnel section, for flexible OHE in the depot and in the event that the Metro routes may later be extended above ground.
- (2) The pantograph shall be capable of sustained operation and satisfactory current collection from 100mm above the collapsed pantograph level up to the full range of contact wire height, and at all operating speeds as specified.
- (3) A pantograph auto-drop function which shall drop the pantograph automatically when excessive height is detected shall be provided. An indication shall be provided to the train operator when this function has operated.
- (4) Pantograph controls shall be configured in the cab car such that any one pantograph, or all pantographs can be raised or lowered. When all pantographs are raised, there shall be a time delay function such that the instantaneous line current demand peak and inrush current characteristic are reduced to less than the operating limit of the traction power and OHL system.
- (5) Pantograph spacing shall, as nearly as is possible, be a minimum of two car lengths of all trains.
- (6) The contact wearing strips to be used on the pantograph shall be of carbon of proven design, arranged to cause least wear on the contact wire

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as well as to the strips themselves. The renderer shall furnish the frequencies of replacement of strips in terms of kilometers earned by the car.

(7) A pantograph auto-drop function, which shall drop the pantograph automatically when excessive height is detected, shall be provided. Art indication shall be provided to the train operator when this function has operated

(8) Pantograph controls shall be configured in the cab such that any one pantograph or all pantographs can be raised or lowered.


(9) Pantograph spacing shall, as nearly as is possible, be a minimum of two car lengths of all trains.

(10) The pan-head shall be designed with metalized carbon strips with a view to achieve minimum dynamic mass. The Contractor shall furnish the expected frequency for replacement of strip in terms of kilometers earned by the car.

(11) The width and profile of the pantograph shall be such that the Kinematic Envelope of the car is within specified limit in accordance with the Clause. The contact wire, under the worst conditions of the sway on the Car and stagger shall be within the carbon strip portion of the pantograph. The electrical clearance between the live portion of the pantograph and the roof shall not be less than 290mm. The minimum mechanical clearance from fixed structures at any time should not be less than 100mm.

(12) The pantograph shall be a single arm, direct air operated type with two strip pan-head arrangement and compliant to IEC 60494-2. The pantograph shall be of a proven design for both flexible and rigid catenary system. in case, the pantograph has not been used on both types of catenary, the supplier shall establish the suitability of the offered design on theoretical basis, which shall be validated by service trials. The pantograph shall be complete with air control equipment including air filter and pressure regulator. In case Air is supplied to pantograph via an air-feed insulator. The creepage length of the insulators shall not be less than 900mm.

(13) Pneumatic pipe, other fittings and equipments provided on the pantograph frame shall be insulated from the frame to avoid any damage to pipes due to flow of fault current on account of earthing of the frame from any stray wire accidentally thrown by birds etc. on the roof. The insulation shall be suitable for 25kv AC system. Note the only way this can be achieved

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is to remove the actuator from the pantograph and operate the articulation with an insulated rod.

8.3 SEM (System Engineering Management)

The Subcontractor shall submit, not limit to, the following design information within the defined schedule:

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 in accordance with the schedule


Classification	Document/ Deliverables
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

9 Testing

9.1 General

9.1.1 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 GS 7.1 and TS 15.2

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The Pantograph of individual cars and complete train-set, for RS 15 project operational line shall be type- and routine-tested in accordance with IEC 61133 in accordance with the requirement specified in TS 15.

The Pantograph shall be type and routine tested in accordance with the IEC Publications or other appropriate international standards in accordance with the requirements specified in TS15.1.2.

The type tests for the Pantograph system at both the component level and complete train level, for RS15 project Operational line, shall be re-performed by the Subcontractor under BEML and DMRC participation, if DMRC want to witness the tests even though the tests were accepted by BEML.

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.


Type tests for Pantograph system may be waived if these were carried out earlier on equipments of identical design, witnessed by a reputed organization, and the service performance of such equipments was found to be reliable. The subcontractor submits a proposal in this regard to the BEML and DMRC for review. The waiver of Type test is entirely at the discretion of the BEML and DMRC.

BEML and DMRC reserve the right to witness any or all of the tests, and to require submission of any or all test specifications and reports. BEML and DMRC reserves the right to reasonably call for additional tests (eg. fire performance) if considered necessary in accordance requirements specified in TS 15.

All defects and shortfalls in the subcontractor's system, discovered during all tests, made good and re-tested to the satisfaction of BEML and DMRC. The subcontractor shall provide full instrumentation to conduct all tests and carry modifications as required.

All test procedures, reports including all maintenance activities and check lists 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.

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The subcontractor shall produce a test report, in three copies, and in an approved format, and defined period following the test, for acceptance by BEML and DMRC.

9.1.2 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 requirements specified in GS.

9.1.3 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 GS.

9.1.4 Test Procedure

Following items shall be complied.

- (1) All test equipment shall carry an appropriate and valid calibration label.
- (2) The subcontractor shall sign all reports of Tests
- (3) The subcontractor shall present a comprehensive Testing and Commissioning Program.
- (4) 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.
- (5) 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 GS.

9.1.5 Sequence of Tests

- (1) Routine and type test of equipment and sub-systems in
Accordance with relevant standard and specifications in

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Contractor/Sub-contractor's factories.

- (2) Factory and Site Tests of complete cars in accordance with IEC 61133.
- (3) Testing and Commissioning of cars trains in Depot in accordance with IEC 61133
- (4) Integration Tests in conjunction with all Designated Contractors.
- (5) Instrumentation and Dynamometer Tests, and Oscillation Trials on Prototype Rakes only (Not applicable for this PTS).
- (6) Service Trials

9.2 Routine and type tests of equipment and sub-systems

The Pantograph shall comply with the requirement TS & GS and IEC 60494-2.

9.2.1 Type Test, Pantograph

This test is required to verify that the Pantograph operates in accordance with the approved Design Data. Type test of each component shall be performed by the Subcontractor under BEML, and DMRC participation in accordance with the requirements specified in TS 15.1.2.

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.

The subcontractor shall perform as a minimum, the following test in accordance with the requirements specified in TS 15;

- (1) Transverse Rigidity Test
- (2) Structural Strength Test
- (3) Operation Test (raising & lowering Time)
- (4) Contact force measurement (static force & total force)
- (5) Water Tightness Test
- (6) Visual Inspection
- (7) Dimensional Inspection
- (8) Auto-drop function Test
- (9) Dielectric test.
- (10) Mechanical endurance tests
- (11) Air-tightness tests
- (12) Measurement of degrees of freedom of pantograph head
- (13) Measurement of retaining force in lowered or rest position
- (14) Heating tests

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- (15) Tests for Withstanding Shock and Vibration.
- (16) Current collection tests for Arc and Sway test with Video recording.
- (17) Others, if any.

The subcontractor shall submit valid Type test report for the complete Pantograph system.

Note: However, that item (16) will be covered by submission of previous test reports, and item (9) is a combined test to be carried out on installed equipment and therefore the vehicle builder's responsibility.

9.2.2 Routine Test, Pantograph

This test is required to verify that the Pantograph 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 function test, visual inspection and dimensional inspection but not be limited. The subcontractor shall perform, as a minimum, the following test in accordance with the requirements specified in TS 15;

- (1) Operation Tests
- (2) Auto-drop Test
- (3) Visual Inspection
- (4) Dimensional Inspection
- (5) Air-rightness tests.
- (6) Dielectric tests.
- (7) Contact force measurement (static force)

9.2.3 Fire Performance Test

The sub-contractor shall perform the fire performance tests of Pantograph in accordance with the requirements specified in TS 2.5.8, 2.23 and 15.19.

Appropriate test certificates will be submitted wherever relevant.

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9.2.4 Withstanding Vibration and Shock

The sub-contractor shall perform the Withstanding Vibration and Shock test of Pantograph in accordance with the requirements specified in a relevant international standard.

BEML will perform the noise performance test on the completed car, unit and train. So the subcontractor shall be responsible to assist for BEML to achieve the noise criteria.

9.3 Factory and Site Tests of complete cars

9.3.1 Type Test, Completed car, unit and Train Tests

The individual cars and complete trains for RS13 project shall be type tested at Delhi, India by BEML and under Subcontractor's responsibility for Pantograph in accordance with IEC 61133.

The Subcontractor, Design Engineer, shall also participate in this testing to ensure that Pantograph meet the performance requirements specified at the contract and do not introduce any adverse effects into the train.

9.3.2 Routine Test, Completed car, unit and Train Tests

The individual cars and complete trains for RS-13 project shall be routine tested at Delhi, India by BEML and under Subcontractor's responsibility for Pantograph test in accordance with IEC 61133. The Subcontractor shall be responsible for correcting any interfacing defects. These tests will be a subset of those tests performed at Type Test, complete vehicle to demonstrate that the principal features of the Pantograph are compliant with the GS and TS. This test shall include but not be limited to a test of all safety system.

9.4 Testing and Commissioning of cars/ trains in Depot (India)

9.4.1 Type Commissioning Tests

On the first train or trains delivered to Delhi, BEML will undertake Type Test for Pantograph of Commissioning Tests to adequately demonstrate that the requirements of GS, TS for Pantograph have been satisfied under the Subcontractor's responsibility. The commissioning shall include tests on the train in accordance with IEC 61133.

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The subcontractor shall perform current collection test (Type test) at DMRC Mainline including Arc test, Sway test & Video recording.

The Subcontractor's design engineer shall also participate in this testing to ensure that Pantograph meet the performance requirements specified at the contract and do not introduce any adverse effects into the railway and its environment.

9.4.2 Routine Commissioning Tests

Following delivery of the trains to the Site train will be commissioned by BEML and at an appropriate time the Engineer will witness certain of these tests to satisfy himself that the Pantograph are acceptable for operating in passenger service. The commissioning shall include tests on the train in accordance with IEC 61133.

This test for Pantograph shall be performed by BEML in India under Subcontractor's responsibility. The Subcontractor shall be responsible for correcting any interfacing defects. These tests will be a subset of those tests performed at Type Commissioning Test to demonstrate that the principal features of the Pantograph are compliant with the OS and TS. This test shall include but not be limited to a test of all safety system.

9.5 Integration Test


BEML will perform the integration test with the assistance of sub-contractor according to GS 7 and TS 15 at site.

The sub contractor shall be fully responsible for integrated type testing and commissioning of the Pantograph system at BEML works and at DMRC Depot & Mainline. The subcontractor shall perform current collection test (Type test) at DMRC Mainline including Arc & Sway test & Video recording.

The subcontractor shall submit all information for the integration test to BEML. If needed, the concerned engineer from subcontractor shall participate in the test.

9.6 Service Trials

BEML will perform the service trial and the sub-contractor shall supply the sufficient information and assistance if necessary according to GS 7 and TS 15.1.10.

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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.

10. List of Documents and Drawings Supplied

- (a) ERGS
- (b) ERTS
- (c) Extract of GCC 5.8
