

DELHI METRO RAIL CORPORATION LIMITED

MASS RAPID TRANSPORT SYSTEM – PHASE III

**DESIGN, MANUFACTURE, SUPPLY, TESTING AND COMMISSIONING OF 80
No. BROAD GAUGE CARS COMPATIBLE WITH EXISTING 'RS1' TYPE
TRAINS SUPPLIED BY MRM CONSORTIUM**

TENDER 'RS15'

(VOLUME 3)

- **EMPLOYER'S REQUIREMENTS – GENERAL SPECIFICATIONS**
- **EMPLOYER'S REQUIREMENTS – TECHNICAL SPECIFICATIONS**

DELHI METRO RAIL CORPORATION LIMITED

MASS RAPID TRANSPORT SYSTEM – PHASE III

**DESIGN, MANUFACTURE, SUPPLY, TESTING AND COMMISSIONING OF
80 No. BROAD GAUGE CARS COMPATIBLE WITH EXISTING 'RS1' TYPE
TRAINS SUPPLIED BY MRM CONSORTIUM**

TENDER 'RS15'

(VOLUME 3)

- EMPLOYER'S REQUIREMENTS – GENERAL SPECIFICATIONS
WITH APPENDICES**

EMPLOYER'S REQUIREMENTS – GENERAL SPECIFICATIONS

CONTENTS

EMPLOYER'S REQUIREMENTS – GENERAL SPECIFICATIONS	1
CONTENTS.....	1
CHAPTER 1	4
1.1 General.....	4
1.2 Technology Transfer of Complete Train Sets (Deleted).....	5
1.3 Power Supply	5
1.4 Climatic Conditions	5
1.5 Environmental Conditions in Tunnel.....	6
1.6 Standards and Codes	6
1.7 Units.....	6
1.8 Warranty (Defect Liability)	6
1.9 Optional Items.....	7
CHAPTER 2	8
2.1 General.....	9
2.2 Project Management Plan	10
2.3 Interface Management Plan	11
2.4 Work Plan (Works Programme And Design Submission Programme).....	13
2.5 Quality Assurance Plan.....	14
2.6 Quality Plan	14
2.7 System Safety Assurance Plan.....	15
2.8 Reliability, Availability And Maintainability Assurance Plan	15
2.9 Site Safety Plan	15
2.10 Software Quality Assurance Plan	15
2.11 Environmental Plan.....	15
2.12 Inspection, Testing And Commissioning Plan.....	16
CHAPTER 3	18
3.1 General.....	18
3.2 Dedicated Co-Ordination Team.....	19
CHAPTER 4	21
4.1 Works Programme Submission Requirements	21
4.2 Part One-Submission By Tenderers.....	21
4.3 Part Two-Submission By Contractor	22
4.4 Review Periods For Contractor's Submissions	23
4.5 Failure to Make Submissions.....	23
4.6 Programme Revision.....	23
4.7 Planning and Programming Staff.....	23
4.8 Project Calendar.....	24
CHAPTER 5	26
5.1 General.....	26
5.2 Review of Data	26
5.3 Format of Deliverables	26
5.4 Number of Copies	26
5.5 Design Submission Programme.....	27
5.6 Design Process	27
5.8 Pre-Final Design	28
5.9 Final Design.....	28
5.10 Design Submission And Review Procedure	28

5.11	Engineer's Review	29
5.12	Final Design Document Delivery	29
5.13	As-Built Drawings And Documents	30
5.14	Manufacturing Drawings	30
5.15	Post Acceptance Changes	30
CHAPTER 6		32
6.1	Prescriptive Framework	32
6.2	Software Framework.....	32
6.3	Software Management Control	32
6.4	Auditing	32
6.5	Software Acceptance	32
6.6	Availability of Complete Documentation And Development Tools	33
6.7	Re-Use of Existing Software	34
6.8	Re-Engineered Software	34
6.9	Test Software	34
6.10	Software Rights.....	34
CHAPTER 7		36
7.1	General.....	36
7.2	Sequence of Tests	36
CHAPTER 8		39
8.1	General.....	39
8.2	Unit Exchange Spares	39
8.3	Consumable Spares.....	39
8.4	Mandatory spares	40
8.5	Recommended spares (Deleted)	40
8.6	Overhauling Spares (Deleted).....	40
8.7	Special Tools, Testing and Diagnostic equipments: (Deleted).....	40
8.8	Special Jigs, Fixtures and Gauges (Deleted).....	40
8.9	Manufacture, Delivery and Warranty	40
8.10	Purchase of Spares from Vendors.....	41
8.11	Commissioning And DLP Spares	41
8.12	List of Spares	41
CHAPTER 9 -		44
9.1	Training Requirements.....	44
9.2	Training Objectives: Train Operating Staff	44
9.3	Training Objectives: Maintenance Staff	45
9.4	Training Methods.....	45
9.5	Training Manual.....	46
9.6	Transfer of Training Aids	46
9.7	Training Location and Facilities	46
9.8	Administration	46
CHAPTER 10		48
10.1	Access to Site	48
10.2	Site Facilities.....	48
10.3	Site Management	49
10.4	Site Safety	50
CHAPTER 11		52
11.1	General.....	52
11.2	Transportation to Site.....	52
CHAPTER 12		54
12.1	General.....	54

12.2	Operation Manuals.....	54
12.3	Maintenance Manuals	54
12.4	Electronic Manuals	55
CHAPTER 13	57
13.1	General.....	57
CHAPTER 14	60
14.1	General.....	60
14.2	Progress Photographs.....	60

CHAPTER 1**SCOPE OF THE GENERAL SPECIFICATION****1.1 General**

1.1.1 This Specification covers the general aspects of the tender viz., description of the Works, submittal requirements of Design & Drawings, Management Plans, Project Planning and Progress Monitoring, Site Management, Draughting and CAD Standards, and Contractor's obligations for safety and health etc. This General Specification shall be read in conjunction with the General Conditions of Contract (GCC), Special Conditions of Contract (SCC), Technical Specification, and Instructions to Tenderers. The abbreviations used in this General Specifications are given in Appendix 8 to this Specification.

1.1.2 General Description of the Works

The Table 1A below shows approximate route length of those corridors which are relevant to tender RS15. These corridors are on broad gauge. Table 1A shows the type of corridors i.e. at grade, underground or elevated.

Table 1A: Phase III of Delhi MRTS for RS15 Tender (BG)

S N	Corridors	Length (km) (Broad Gauge)		
		Underground (KM)	At Grade/Elevated (KM)	TOTAL (KM)
	NEW CORRIDORS			
(i)	LINE 1: Rithala - Bawana-Narela	0	21.725	21.725
(ii)	LINE 1: Dilshad Garden to Ghaziabad Bus Adda	0	9.41	9.41
(iii)	LINE 3: Noida City Centre to Sector 62 Noida	0	6.675	6.675
	EXISTING CORRIDORS			
(i)	LINE 1: Dilshad Garden – Rithala	0	25.09	25.09
(ii)	LINE 2: Huda City Centre – Samaypur Badli	23.70	25.72	49.42
(iii)	LINE 3: Dwarka Sec 21 – Noida City Centre.	3.13	36.81	39.94
(iv)	LINE 4: Yamuna Bank - Vaishali	0	8.74	8.74
TOTAL		26.83	134.17	161.00

The above corridors may be modified to some extent. The contractor shall be advised of such modifications, as applicable.

Shastri Park Depot on Line 1, Khyber Pass and Sultanpur Depot on Line 2 and Najafgarh and Yamuna Bank Depot on Line 3 and Line 4 are the associated Depots. The delivery priorities for the cars for the different lines may also vary slightly. Contractor shall have to make suitable changes in the delivery plan at the nominated depot at no extra cost to employer.

1.1.3 Rolling Stock supply targets for these shall be governed as per the specified key date schedule.

1.1.4 The scope work comprises design, manufacture, supply, testing and commissioning of passenger rolling stock comprising of 80 no. Broad Gauge cars as indicated in the appendix 'FT-1' to the 'Form of Tender' (Electrical Multiple Unit). The cars required for the corridors shall be compatible with and suitable for integration with the existing Broad Gauge 'RS1', 'RS6' and 'RS13' type cars of DMRC supplied by Consortium of 'M/s Mitsubishi Corporation, M/s Hyundai Rotem, M/s Mitsubishi Electric and M/s BEML. They shall be of modern design,

light weight made of stainless steel, with 3 phase AC drive having V.V.V.F. control, regenerative braking and compatible to work with ATP, ATC, ATO etc. provided by other designated contractors. The cars for underground / Elevated and at Grade Corridors shall operate on 25 KV ac single phase 50 Hz rigid / flexible Overhead Catenary System (OCS) and shall be same for all the corridors. The cars shall be provided with Propulsion and Control Systems supplied by M/s. Mitsubishi Electric Corporation (MELCO), Japan identical to the system provided in existing Rolling Stock of Line #1, 2, 3&4 (supplied under 'RS1','RS6' & 'RS13' Contracts). The suppliers of other Major sub-systems are detailed in Employer's Requirements –Technical Specification. The scope of work also includes the integration of 40 trains of existing 4/6 cars to 6/8 cars by integrating the new 'T + M' unit similar to the existing system. The contractor to include the same vendor for the system integration as referred in the APPENDIX TG of ERTS.

1.1.5 For the corridors mentioned, the Rolling Stock requirements is mentioned in Table 1B below :

Table 1B: Requirements of Cars

S N	ITEM	No.	No. Of Cars
1	'T+M' car unit suitable for extending existing RS1 type 4/6 car train to 6/8 car train.	40	80
Total			80

1.1.6 The 'T+M' car units being procured to convert the existing 4/6 Car Broad Gauge Trains procured under RS1,,RS6 & RS13 contracts to 6/8 cars trains. The cars to be supplied under this tender thus shall be compatible with and suitable for integration with the existing RS1, RS6 & RS13 Broad Gauge type trains of DMRC supplied by MRM consortium and M/s BEML (RS6 & RS13 cars).

1.1.7 The Tenderer are advised to survey manufacturing facilities already existing in India and make use of the same, if considered useful by them.

1.1.8 Deleted.

1.2 Technology Transfer of Complete Train Sets (Deleted)

1.3 Power Supply

1.3.1 25 kV ac 50 Hz single phase traction power supply shall consist of Overhead Rigid Catenary system fed throughout the Underground, and conventional Overhead Catenary System (OCS) in the elevated, at-grade section and Depot. The power system shall be suitable for regenerative braking of trains.

1.4 Climatic Conditions

1.4.1 The climatic conditions, which need to be taken into account by the Contractor for designing the Rolling Stock and the equipment provided therein, are furnished in Clause-3.10 of the Employer's Requirements - Technical Specification.

1.4.2 All underground stations will be fully air-conditioned.

- 1.4.3 Above ground stations will have air-conditioning for certain designated rooms only.
- 1.4.4 While designing and selection of the equipment and components, special care shall be taken for protecting these items against dust. As per the experience of DMRC, high level of IP protection is required in order to ensure equipment reliability under severe dust conditions prevalent in Delhi and the same shall therefore be suitably considered during design.

1.5 Environmental Conditions in Tunnel

- 1.5.1 Tunnel ventilation is achieved primarily by the movement of vehicles inside the tunnel under normal working conditions. The relief of the piston effect generated by the train is achieved by means of draft relief shafts. Tunnel ventilation fans installed at each end of each station will be used to provide supplementary ventilation at times of high temperature, and under congested traffic or emergency conditions. These fans will provide reversible airflow and will intake from, and exhaust to the outside through ventilation shafts. The maximum design temperature inside the tunnel is expected to be 46°C under normal as well as congested conditions.

Under emergency conditions of tunnel fire, the tunnel ventilation system will be used for smoke extraction by operating tunnel fans in push-pull mode. The allowable maximum temperature inside the tunnel during such smoke extraction will be below 60°C.

- 1.5.2 Track-way exhaust systems will be provided to extract a portion of train-generated heat while the train is within the bounds of a station. During normal conditions, under-platform exhaust as well as over-track-way exhaust fans will operate. In addition, control of these fans shall be possible during congested and emergency conditions for the purpose of aiding tunnel ventilation and providing additional smoke removal capability for the station and tunnel. During emergency fire conditions within a station, the station air handling system will be operated to supplement smoke removal.
- 1.5.3 Tunnel walls may be wet and seepage water will normally be present in the invert. Rolling Stock supplied must therefore be capable of withstanding the effects of seepage and continue to operate in such wet and humid conditions.

1.6 Standards and Codes

- 1.6.1 Rolling Stock equipment and software shall be in accordance with the requirements of the standards and codes specified in the Employer's Requirements - Technical Specification. The Contractor may propose an alternative equivalent international standard during the design stage. The acceptance of the alternative standard will however be subject to review by Engineer. When a Standard or Code is referred to, it shall be assumed that the latest revision is applicable, unless specifically approved by the Engineer.
- 1.6.2 Where no standard is identifiable, the Contractor shall make a proposal, based on the best International practice, which shall be subject to review by the Engineer.
- 1.6.3 During the preliminary design phase, the Contractor 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 the Engineer.
- 1.6.4 Deleted
- 1.6.5 Deleted

1.7 Units

- 1.7.1 All drawings and design calculations submitted with the tender, or in accordance with the requirements of the Contract, shall use SI units.

1.8 Warranty (Defect Liability)

- 1.8.1 Warranty (Defect Liability) period shall start from taking over of each train set/ 'T+M' unit up to **18 months**.
- 1.8.2 The Contractor shall be responsible for any defect or failure attributable to defective design, material or workmanship during the Warranty period.

- 1.8.3 The warranty period of spares or any other item / equipment delivered shall be:
- Either 24 months from the date of acceptance or
 - Up to expiry of the defect liability period of last train set/'T+M' unit (clause 1.8.1), whichever is later.
- 1.8.4 The repair and or replacement of failed components and equipment and installation of repaired/replaced components/equipment shall be undertaken by the Contractor free of charge at Site. The Contractor 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 component or equipment as a consequence of failure analysis, the minimum period of warranty i.e 18 months shall recommence from the date when the modified part is commissioned into service and modification shall be carried out free of charge. In all such cases, warranty will be applicable on complete sub - assembly; even when only component has been modified/replaced/repared due to design change.
- 1.8.5 All replacement and repairs under the warranty shall be carried out by the Contractor promptly and to the complete satisfaction of the Engineer on notification of the defect by the Employer so that no car is unfit for revenue service for more than 48 hours, which shall exclude time taken for withdrawal/induction of trains from/to revenue services and preparation time (placement of train in workshop, inspection bay etc) for making the defects good. In case any train remains out of revenue operation beyond duration specified above due to reasons attributable to contractor or the failure repeats within a week time, Employer may at his sole discretion impose a penalty on the contractor, commensurate with the revenue and opportunity loss to the employer. Decision of Employer shall be final and binding.
- 1.8.6 For each case of deboarding of commuters on account of reasons attributable to the contractor, Employer may at his sole discretion impose a penalty of Rs 200,000 (two hundred thousand). Decision of Employer shall be final and binding.

1.9 Optional Items

Employer at his sole discretion will have the option to include/delete supply of unit exchange spares and mandatory spares as detailed in Chapter '8'.

This page is left blank intentionally.

CHAPTER 2**MANAGEMENT PLANS****2.1 General**

- 2.1.1 In order to ensure satisfactory execution of the Contract, completion of works within specified targets, and quality in design, manufacturing and execution of work, a series of Management Plans shall be developed. The following Plans, unless otherwise waived off by Engineer, shall be developed and submitted by the Contractor for Engineer's review:
- (i) Project Management Plan
 - (ii) Interface Management Plan and Interface Documents - as approved by DMRC for Contract 'RS1' (as applicable) along with any updation/changes as may be required to be followed.
 - (iii) Work Plan (Work Programme and Design Submission Programme)
 - (iv) Quality Assurance Plan.
 - (v) Quality Plan.
 - (vi) System Safety Assurance Plan
 - (vii) Reliability, Availability and Maintainability Assurance Plan
 - (viii) Site Safety Plan
 - (ix) Software Quality Assurance Plan.
 - (x) Environmental Plan-as approved.
 - (xi) Inspection, Test and Commissioning Plan
- 2.1.2 The plans and documents shall be co-ordinated with each other and shall collectively define, describe and encompass the Contractor's proposed methods, procedures, processes, organisation, sequencing of activities to meet the requirements of the Technical Specification in respect of the subjects listed.
- 2.1.3 The respective Plans shall be submitted as per the submission schedule furnished in table 2A.

Table 2A: Submission of Plans

S.N.	Plan	To be submitted within
1	Project Management Plan	15 days of Commencement Date
2	Interface Management Plan and Interface Documents	30 days of notification from the Engineer of the identity of each Designated Contractor
3	Work Plan : (Work Programme and Design Submission Programme)	30 days of Commencement Date
4	Quality Assurance Plan	30 days of Commencement Date
5	Quality Plan	60 days of Commencement Date
6	System Safety Assurance Plan	30 days of Commencement Date
7	Reliability, Availability and Maintainability Assurance Plan.	90 days of Commencement Date
8	Site Safety Plan	120 days of Commencement Date
9	Software Quality Assurance Plan	75 days of Commencement Date
10	Environmental Plan	60 days of Commencement Date
11	Inspection, Test and Commissioning Plan	120 days of Commencement Date

2.2 Project Management Plan

2.2.1 The Project Management Plan shall provide a clear over-view of the Contractor's organisation, the management system and methods to be used for completion of the works. The organisation resources for the design, procurement, manufacture, installation, testing and commissioning, and setting to work, shall be clearly defined.

2.2.2 The Tenderer shall submit a Project Management Plan as a part of the Tender, which shall provide the following information.

(i) A diagram showing the organisational 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 organisations and sub-contractors and show clearly the individuals and lines of responsibility linking the various groups. It shall also identify the persons designated as contacts with the Engineer.

(ii) The names, qualifications, positions and current resumes of key executive, supervisory and engineering staff to be employed full-time for the works, separately for principals and sub-contractors.

(iii) A narrative describing the sequence, nature and inter-relationship of the main Contract activities including timing for exchange of information.

(iv) Procedure for documentation control.

(v) The Contractor 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 such Applicant based on whose experience and strength, the tenderer has qualified majority of the requirements for qualification criteria mentioned in Sl.No. 1 and 2 of IFEC: Filter of Applicants-Checklist.

The tenderer shall submit relevant CV of the Project Manager at the time of tendering for the Tenderer / Joint Venture/Consortium shall be furnished in the format provided in "Form of Tender FT-19" of "Form of Tender – Appendix FT-19". This will be a part of technical evaluation.

The nominee shall be subject to acceptance of the Engineer, who shall have the right to demand his replacement at any time after the work commences, should the Engineer consider this to be in the best interest of the Project.

(vi) The Contractor shall also nominate a senior engineer to co-ordinate activities of the design offices and manufacturing works. The engineer shall be responsible to the Project Manager for all works executed outside India and in India for ensuring that effective co-ordination is maintained with the various manufacturing units of the Contractor, Sub-Contractors and Suppliers and that contract delivery schedules are met.

(vii) The Project Manager shall be continuously on site in New Delhi and devote himself full-time to the Project, commencing not later than Thirty (30) calendar days from the date of the Commencement Date and shall continue up to the end of Defects Liability Period.

(viii) To fulfil the Contractor's obligations during the Testing and Commissioning and the Defect Liability Period, the Contractor shall nominate experienced maintenance engineers and organise deployment after obtaining Engineer's approval before undertaking testing and commissioning in depots. Separate maintenance engineer shall be positioned in each depot and they shall be supported by a dedicated team of testing / commissioning and maintenance personnel. The deployed maintenance engineer of the Contractor and supporting maintenance team in each depot shall continue up to the end of Defect Liability Period. They shall be responsible for all works arising in the supplied rolling stock based in the respective depot.

(ix) The work of the maintenance engineers of all the depots shall be coordinated by Contractor's Chief Maintenance Engineer who shall be nominated at least 90 days before, and shall be positioned (after obtaining approval of the Engineer) at least 30 days before the start of testing and commissioning of the prototype train-set.

(x) The Chief Maintenance Engineer and maintenance engineers shall coordinate with the Engineer's nominated representative in each depot and provide guidance as may be required to carry out the scheduled and un-scheduled maintenance activities from time to time. The work shall include, but not limited to, finalisation of detailed maintenance plans covering maintenance work instructions, requirements and specifications of tools, plants and test benches, test check sheets, etc.

(xi) Suitable replacement after obtaining approval of Engineer shall be provided by the Contractor in case of absence of the Chief Maintenance Engineer and maintenance engineers from the site for a continuous period exceeding 15 calendar days, for whatever reason. In case of cumulative absence of the Chief Maintenance Engineer and / or maintenance engineers for 30 days in a calendar year, the Engineer may at his sole discretion recover a reasonable amount from the due payments to the Contractor.

(xii) Timely deployment of the Chief Maintenance Engineer and maintenance engineers shall be a prerequisite for accomplishing the relevant key dates of testing and commissioning of the first train sets in the respective depots.

2.2.3 The Contractor will submit a Project Management Plan within the specified schedule. The Engineer will review the Contractor's Project Management Plan and shall have the right to require the Contractor to make amendments as deemed necessary by the Engineer. The Contractor shall submit a detailed revised plan within 10 days of the review of the Engineer.

2.2.4 The Contractor is required to maintain maintenance staff at not more than one DMRC depot in each line to maximum two numbers DMRC depots before arrival of first 'T+M' unit / train at any time during currency of Contract.

2.3 Interface Management Plan

2.3.1 The 'T+M' units procured under this tender 'RS15' shall operate on the different corridors of DMRC phase-I, Phase-II and Phase-III networks i.e. Line 1, 2, 3 and 4 as detailed in ERGS chapter 1. The Contractor shall interface and liaise with Designated and other Contractors in accordance with the requirements of Chapter 3 of the Employer's Requirement's General Specification.

2.3.2 The Contractor shall develop and submit to the Engineer within the specified schedule, an Interface Management Plan, which is mutually acceptable to both the Contractors and the Designated Contractors. The Contractor shall appoint an experienced Engineer as Interface Manager after approval of the Engineer. The Interface Manager shall be positioned at Delhi site starting from not later than three months from commencement date and atleast till commissioning of all trains and satisfactory resolution of all interface issues. Non mobilization of the IM within the stipulated three months would attract penalty (to be solely finalized by the Engineer) for delay of each month or part thereof. The CV of the proposed IM shall be submitted to the Engineer for approval not later than the one (01) months from the commencement date. The proposed IM should have minimum five (05) years of metro Rolling sStock project experience and should have worked on metro Rolling Stock project as a member of interface design and testing team involving design, supply & commissioning of trains.

The Interface Management Plan shall:

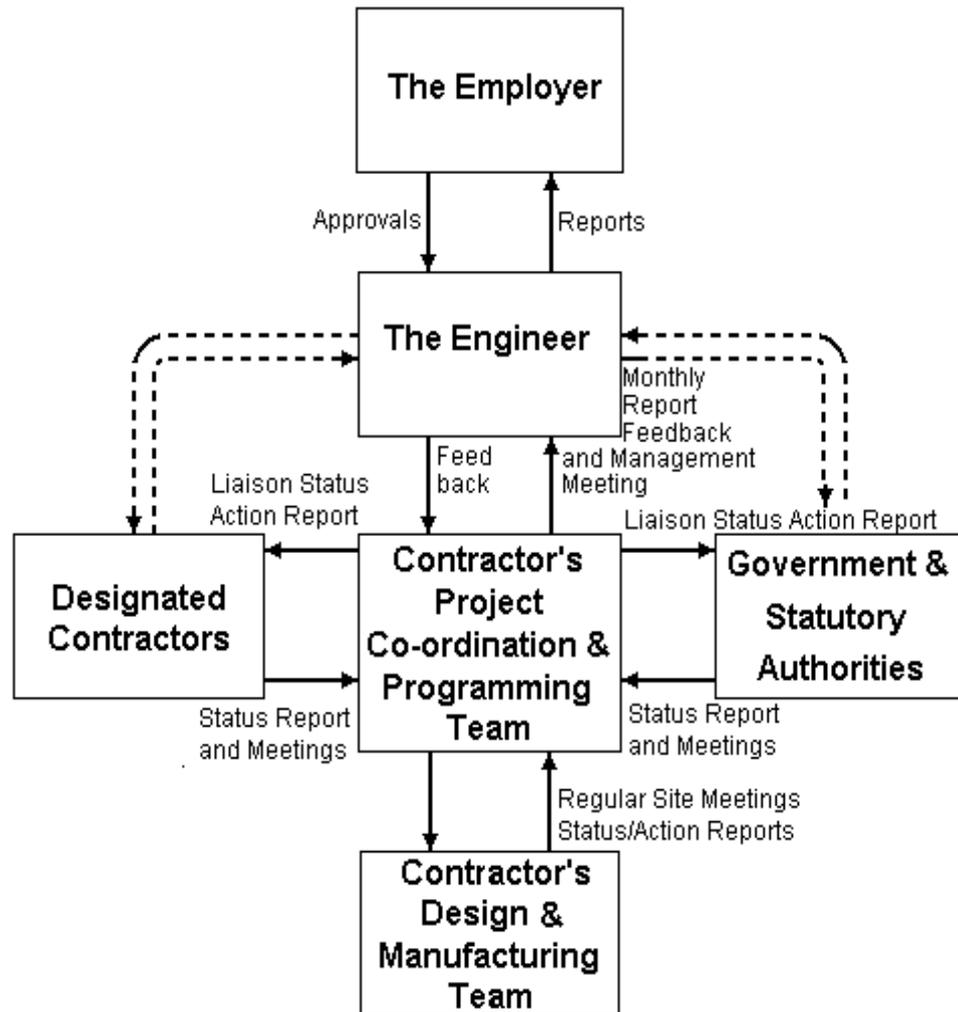
(i) identify the sub-systems as well as the civil works and facilities with interfacing requirements;

(ii) define the authority and responsibility of the Contractor's and Designated Contractors' (and any relevant sub-contractors') staff involved in interface management and development;

(iii) identify the information to be exchanged, precise division of responsibility between the Contractor and Designated Contractors and integrated tests to be performed at each phase of the Contractor's and Designated Contractors' works.

(iv) address the works programme of the Contract to meet the key dates of each Contractor and highlight any programme risks requiring management's attention

(v) after the review of Interface Management Plan with no objections by Engineer, the Contractor shall execute the works in accordance with the Plan.



ORGANISATION CHART (Proposed Interfacing)

2.4 Work Plan (Works Programme And Design Submission Programme).

- 2.4.1 The Tenderer shall submit a Work Plan as a part of the tender which shall contain the following :
- (i) proposed Works Programme.
 - (ii) proposed Design Submission Programme (unless specifically waived off by the Employer)
- 2.4.2 The Tenderer's proposed Works Programme shall indicate how the tenderer intends to organise and carry out the Works and achieve stages and complete the whole of the Works by the appropriate Key Dates. The Works Programme shall be prepared in terms of weeks from the Date of Commencement of Works.
- 2.4.3 The Tenderer's Design Submission Programme shall cover the Design phase and include a schedule identifying, describing, cross-referencing and explaining the Design Packages and submissions, which he intends to submit.
- 2.4.4 The Design Submission Programme should take due account of the design co-ordination interface periods with other Designated Contractors and be consistent with the Works Programme.
- 2.4.5 The Works Programme and Design Submission Programme shall include details as stipulated in Chapter 4 and 5 of this Employer's Requirements – General Specification, for review by the Engineer.

2.5 Quality Assurance Plan

- 2.5.1 The Tenderer shall submit an Outline Quality plan, illustrating the intended means of compliance with Chapter 2 of the Employer's Requirements - Technical Specification, and setting out in summary form an adequate basis for the development of the more detailed document. The outline Quality Plan shall contain sufficient information to demonstrate clearly the proposed method of achieving the Tenderer's quality objectives with regard to the requirements of the Contract.
- 2.5.2 The Plan shall be based on acceptable international standards. The Quality Assurance Plan shall embrace all activities of contractors, sub-contractors of any tiers including its suppliers and design consultants, if any. The Quality Assurance Plan shall indicate the approach and structure that the detailed plan will take and shall include the following:
- (i) a summary of the Project requirements including all proposed quality activities;
 - (ii) all quality assurance and quality control procedures proposed by the Contractor for his use in the execution of the Works;
 - (iii) a list of all the Codes of Practice, Standards and Specifications that the Contractor proposes to apply to his work;
 - (iv) the Contractor's proposals for internal and sub-contractor quality assurance audits;
 - (v) a statement detailing the records that the Contractor proposes to keep, the time during which they will be prepared and the subsequent period and manner in which they will be stored;
 - (vi) inspection and test plans for every activity requiring inspection. The plans shall identify the level of inspection required, Quality Control Points and Quality Hold Points.
 - (vii) procedure for maintenance of records of inspection/tests.
- 2.5.3 The Quality Assurance System shall be applied without prejudice to, or without in any way limiting, any Quality Assurance System that the Contractor already maintains.

2.6 Quality Plan

- 2.6.1 The Contractor shall provide the Engineer with a detailed Quality Plan taking into account any directions or requirements from the Engineer on the Quality Assurance Plan. The detailed plan shall be updated as necessary from time to time to incorporate, to the Engineer's satisfaction, all changes to the Contractor's procedures. The Quality Plan shall comprise :
- (i) A Management Quality Plan for control of management related activities;
 - (ii) A Design Quality Plan for control of design related activities; and
 - (iii) A Manufacturing (including Inspection and Testing) Quality Plan for the control of related activities.
 - (iv) Testing and Commissioning (including Integrated Testing and Commissioning) Quality Plan.
- 2.6.2 Quality Organisation
- The Contractor shall submit a detailed organisation chart identifying the responsibilities, authority and inter-relation of all personnel who manage, perform and verify work involving quality in respect of all Quality Plans. The organisation chart shall be specific to this Contract. The chart shall identify the Quality Management Representative who shall act as the Quality Co-ordinator for the Contractor in all dealings with the Engineer.
- 2.6.3 Quality Audit
- The Contractor shall audit all the activities in each Quality Plan at quarterly intervals or at other such intervals as the Engineer may require, to ensure continuing suitability and effectiveness of the quality management system. The Contractor shall make available upon request any document, which relates to his recent internal audits.

The Engineer may require compliance audits of the Contractor's quality system to be conducted. Not less than two weeks notice will be given by the Engineer. During audits, the Contractor shall provide suitably qualified staff to accompany the auditor.

- 2.6.4 Responsibility of quality control during manufacture, testing & commissioning, DLP shall solely rest with the member of consortium based on which the consortium/JV got qualified.

2.7 System Safety Assurance Plan

- 2.7.1 The Tenderer shall submit, as part of its Tender, an Outline Safety Plan, which shall contain sufficient information to demonstrate clearly the Tenderer's proposals for achieving effective and efficient safety procedures in the design, manufacture, testing and commissioning of the Rolling Stock. The Outline Safety Plan should include an outline of the safety procedures and regulations to be developed and the mechanisms by which they will be implemented for ensuring safety including Hazard Analysis, Fire control, EMC/EMI control, RAM (Reliability, Availability and Maintainability) requirements, site safety, transportation of rolling stock etc.
- 2.7.2 The Outline Safety Plan shall be headed with a formal statement of policy in relation to safety and shall be sufficiently informative to define the Tenderer's Safety Plan and set out in summary an adequate basis for the development of the site safety and safety in transport.
- 2.7.3 The Contractor shall submit for review by the Engineer, a System Safety Assurance Plan in accordance with the requirements of Chapter 2 of the Employer's Requirements - Technical Specification. The Plan shall include Hazard Analysis Plan, Fire Control Plan and EMC/EMI Control Plan.
- 2.7.4 The Hazard Analysis Plan shall evaluate and ensure that all the hazards are identified and satisfactorily resolved.
- 2.7.5 The Fire Control Plan shall evaluate and ensure *inter alia* that the fire loadings of material proposed to be used, and the fire withstand ratings etc are as per the requirements specified in the Employer's Requirements - Technical Specification and also are compatible with currently accepted international practices.
- 2.7.6 The EMC/EMI Control Plan shall evaluate and ensure that the requirements for electromagnetic compatibility and interference as specified in the Employer's Requirements - Technical Specification for all elements of the system are met.

2.8 Reliability, Availability And Maintainability Assurance Plan

- 2.8.1 The Contractor shall submit for review by the Engineer, a Reliability, Availability and Maintainability Assurance Plan in accordance with the requirements of Chapter 2 of the Employer's Requirements - Technical Specification.
- 2.8.2 The Contractor shall describe procedures required to perform the specific tasks necessary to achieve RAM requirements in the Reliability, Availability and Maintainability Plan.

2.9 Site Safety Plan

- 2.9.1 The Contractor shall also submit Site Safety Plan and a plan for safe transport of rolling stock to the depot as per requirements of Chapters 10 and 11 of this Employers Requirement, General Specification.

2.10 Software Quality Assurance Plan

- 2.10.1 The Contractor shall submit a Software Quality Assurance Plan in accordance with the Employers' Requirements: General Specifications and Technical Specifications.

2.11 Environmental Plan

- 2.11.1 The Tenderer shall submit as part of this Tender an Outline Environmental Plan illustrating the intended means of compliance with the Employer's Environmental Quality Management Manual. Outline Environmental Plan shall also contain sufficient information to demonstrate clearly the proposed method of achieving the Environmental objectives with particular

reference to Noise, Vibration, EMC/EMI etc. to meet the stipulations of Chapter 2 of Employer's Requirements -Technical Specification.

- 2.11.2 The Contractor shall submit the Environmental Plan, in accordance with the requirements of Chapter 2 of the Technical Specification with particular reference to Noise, Vibration, EMC/EMI etc. The Environmental Plan shall include Noise and Vibration Plan and Environmental EMC Control Plan as per details furnished in Chapter 2 of Employer's Requirements -Technical Specification.

2.12 Inspection, Testing And Commissioning Plan

- 2.12.1 The Contractor shall submit an Inspection, Testing and Commissioning Plan in accordance with Chapter 7 of this Employer's Requirements-General Specification and Chapter 15 of 'Employers' Requirements: Technical Specification.

This page is left blank intentionally.

CHAPTER 3

CO-ORDINATION WITH DESIGNATED AND OTHER CONTRACTORS

3.1 General

3.1.1 The 'T+M' units procured under this tender 'RS15' shall operate on the different corridors of DMRC Phase-I, Phase-II and Phase-III networks i.e. Line 1, 2, 3 and 4 as detailed in Chapter 1 of ERGS. The Contractor is responsible for detailed co-ordination of his design and manufacturing activities with those of the System-wide Contractors, Civil Contractors, Consultants and other Contractors whether or not specifically mentioned in the contract, who may be working on or adjacent to the site for the purpose of the Project.

Supplied product should be compatible with the installed systems under Phase-I, Phase-II and Phase-III projects of DMRC. It is expected that the 'RS15' Contractor shall adopt the existing interfaces for Line #1, #2 and #3 and #4 and not seek any modifications to the equipment, sub-system and systems supplied by the existing Phase-I and Phase-II contractors ie. RS1, RS2, Signalling and Train Control Contractor and the Telecommunications Contractor, as applicable. All the costs, including design identification and implementation costs, to adopt the existing interfaces shall be borne by the 'RS' contractor. For example, RS15 shall bear any such costs to make the trains/cars compatible with Signalling and Train Control and the Telecommunications systems, as applicable, or RS2 Stock for coupling during rescue.

3.1.2 All of the above parties are referred to as Designated Contractors. A list of some of the main Designated Contractors and some of the identified major interfaces are given in **Appendix 7**. The Contractor shall note that there are other contractors, consultants, agencies etc, which the Employer may engage from time to time, and with whom the Contractor shall have to similarly co-ordinate. Such co-ordination responsibilities of the contractor shall include the following, but not limited to:

(i) To provide all information reasonably required by the Designated Contractors in a timely and professional manner to allow them to proceed with their Design, Manufacturing, Construction activities, and to meet their milestones and key dates.

(ii) To ensure that the Contractor's requirements are provided to all other Designated Contractors, in a timely and reasonable manner.

(iii) To obtain from the Designated Contractors information reasonably required, to enable the Contractor to meet his own design submission dates.

(iv) To ensure very close co-ordination with Signalling & Communication Contractor, in respect of provision of Signal and Communication equipment in the cars, and finalising the interface between the Rolling Stock and Signalling & Communication equipment.

(v) Where the execution of the work of the Designated Contractors depends upon the site management or information to be given by the Contractor, the Contractor shall provide to such Designated Contractors the services, or the correct and accurate information required, to enable them to meet their own programme or construct their own works.

(vi) To ensure that there is no interference with the works of Designated Contractors.

(vii) To attend regular co-ordination meetings convened by the Designated Contractors and the Engineer. The Contractor shall conduct separate meetings with the Designated Contractors as necessary to clarify particular aspects of the Designated requirements of the Works. A record of the decisions taken in each such meeting shall be furnished to the Engineer. The party who convenes the meeting shall prepare minutes recording all matters discussed and agreed at the meeting

(viii) To ensure that all correspondence, drawings, meeting minutes, programmes, etc. relating to the Contractor's co-ordination with the Designated Contractors are issued to all concerned parties and four copies issued to the Engineer no later than seven calendar days from the date of such correspondence and meetings.

3.1.3 The Contractor shall in carrying out his co-ordination responsibilities raise in good time and provide sufficient information for the Engineer to decide on any disagreement between the

Contractor and the Designated Contractors as to the extent of services or information required to pass between them.

- 3.1.4 If such disagreement cannot be resolved by the Contractor despite having made all reasonable efforts, then the decision of the Engineer shall be final and binding on the Contractor.
- 3.1.5 Where a Designated Contract is yet to be awarded, the Contractor shall proceed with the co-ordination activities with the Engineer until such time as the Designated Contractor is available. The Contractor shall provide the Designated Contractor with all information necessary to enable the Designated Contractor to follow-on and proceed with their co-ordination.
- 3.1.6 Any claim of additional costs by the Designated Contractors as a result of the Contractor's failure to keep to specified dates shall be borne by the Contractor. The Contractor shall note that the information exchange is an iterative process requiring the exchange and up dating of information at the earliest opportunity and shall be carried out on a regular and progressive basis in order for the process to be completed for each design stage by the specified dates. Employer shall have full right to impose liquidity damages on the contractor should there be an impact of these delays in achieving the key dates. Decision of Employer shall be final and binding.

3.2 Dedicated Co-Ordination Team

- 3.2.1 The Contractor shall establish a dedicated co-ordination team, led by a Co-ordinator reporting to the Contractor's Project Manager. The primary function of the team is to provide a vital link between the Contractor's design and manufacturing teams and the Designated Contractors. The Contractor shall provide the Engineer with particulars of the Co-ordinator. The Engineer shall have the right to require the replacement of the Co-ordinator if in his opinion the Co-ordinator is unable to meet the co-ordination requirements of the Contract. The Contractor's attention is drawn to the need for the Co-ordinator to establish effective dialogues and communication links with the Designated Contractors. The Contractor's co-ordination team shall comprise a mix of personnel with experience in both design and manufacture of rolling stock necessary for effective co-ordination.
- 3.2.2 The Co-ordinator shall assess the progress of co-ordination with Designated Contractors by establishing lines of communications and promoting regular exchange and updating of information so as to maintain the Contractor's programme.
- 3.2.3 The complexity of the project and the importance of ensuring that work is executed within time limitations require detailed programming and monitoring of progress so that early programme adjustments can be made in order to minimise the effects of potential delays.
- 3.2.4 The Co-ordinator in conjunction with the Designated Contractors shall identify necessary provisions in the Works for plant, equipment and facilities of the Designated Contractors. These provisions shall be allowed by the Contractor in his design of the Works.
- 3.2.5 During the course of the contract, information will be obtained in a number of ways, including direct inspection, regular site meetings, the obtaining of progress reports and the use of turn round documents to obtain design and programme data. Turn round documents shall be issued to the Designated Contractors to be returned giving the current positions on their programme.

This page is left blank intentionally.

CHAPTER 4

PLANNING, PROGRAMME AND PROGRESS MONITORING

4.1 Works Programme Submission Requirements

- 4.1.1 The Works Programme submission requirements are organised into two parts. Part One is a requirement for all Tenderers and shall be submitted as part of their Tender. Part Two describes a series of reports to be submitted by the Contractor during the execution of the Contract.
- 4.1.2 In compiling its Works Programme, and in all subsequent up-dating and reporting, the Contractor shall make provision for the time required for co-ordinating and completing the design, testing, commissioning, and integrated testing of the Works, including *inter alia*, design co-ordination periods, during which the Contractor shall co-ordinate its design with those of Designated Contractors, the review procedures determining and complying with the requirements of Government Departments and all others whose consent, permission, authority or licence is required prior to the execution of any work. The Works Programme shall take full account of the Design Submission Programme.
- 4.1.3 The computerised Critical Path Method (CPM) using the Precedence Diagramming Method (PDM) shall be employed by the Tenderer in preparing their Part One submissions, and the Contractor in his Part Two submissions as well as all other programme submissions required during execution of the Contract.
- 4.1.4 Programming software shall be Primavera Project Planner for Windows Version 2.0b or latest, obtainable from Primavera Systems Inc.
- 4.1.5 Should the Tenderer wish to propose an alternative programming software, he shall demonstrate in his Tender submission the proposed software's capability for direct data exchange with Primavera Project Planner for Windows Version 2.0b or later. Such data exchange compatibility shall include, but not be limited to activity and resource coding. Full electronic data transfer to Primavera is required. The various levels of reporting and coding capabilities shall be at least equivalent to Primavera. Comparable performance between Primavera and the Contractor's proposed system shall be demonstrated. Scheduling Software and relevant instruction manuals, licensed for use in connection with the Contract, shall be provided by the Contractor.
- 4.1.6 Should the Engineer accept the Tenderer's proposed software, he shall upon ward of the Contract supply the Authority with an original copy, including manuals and approved training, of the software and any subsequent versions thereof at no extra cost.
- 4.1.7 All terminology, definitions and conventions shall be in accordance with BS 4335 (Glossary of terms used in Project Network Techniques) or the Associated General Contractor's (AGC) manual entitled "The use of CPM in Construction".
- 4.1.8 All submissions shall be in seven (7) paper copies and shall be in A0, A1, A3 or A4 size, as appropriate except as may otherwise be agreed by the Engineer. In addition, the submissions shall also be made in electronic format in a medium acceptable to the Engineer.
- 4.1.9 All programme submissions shall, unless otherwise specified, conform to the format and level of detail specified in Appendix 1.

4.2 Part One-Submission By Tenderers

- 4.2.1 The Tenderer shall clearly demonstrate in his tender submission the following;
- (i) The scheduling approach to the design, manufacture, testing and commissioning, integrated tests, and instrumentation tests, oscillation trials and any other required tests for the prototype rake, and service trials and their inter-relationships in the form of technically logical activity networks and also in bar chart format. These shall contain sufficient detail to assure the feasibility of the Tenderer's approach to meeting the contractual obligations. The programme shall be developed as a critical path network.
- (ii) The Tenderer's capability to manage the Execution of the Works to meet the specified

Key Dates. Details are given in Appendix 3.

(iii) A means to show the dates and periods relating to the Interfaces and Works of Designated Contractors. An Assumption Report accompanying the network should clearly indicate key dates, specific activities of other contracts, if any, which precede the commencement of activities listed in the Tender Submission.

(iv) Show submission for review and review period for all major documentation required by the Contract.

(v) Clearly identify the critical path in the programme and fully described in the accompanying narrative.

4.2.2 The Works Programme in the Tender shall be accompanied by a narrative statement that shall describe Programme activities, assumptions and logic, and highlight the Tenderer's perception of the major constraints and critical areas of concern in the design, organisation, manufacture, supply, testing, commissioning and completion of the Works. This narrative statement shall also indicate which elements of the Works the Tenderer intends to carry out off-shore and/or in India, with details of the proposed locations of where any such work is to be carried out, the facilities available and any third party undertaking the Tenderer may have in this regard. In particular the Tenderer must state the assumptions made in respect of the interfaces with the Employer, Engineer, other contractors and third parties both in detail and time, and any requirements for information on matters, which would affect his works.

4.2.3 Not Used

4.3 Part Two-Submission By Contractor

4.3.1 Work Programme Plan

The Contractor shall prepare a plan, illustrated by sample schedules, charts, tables, etc., detailing his proposals for staff and their responsibilities to support the programming functions, for submission of works programmes for the Execution of the Works, for the design, manufacture, supply, testing and commissioning, in accordance with the key dates for co-ordinating his programmes with those of the System-wide and Civil Contractors, for measuring, monitoring and reporting progress, for revisions to the programmes to ensure completion of the Works within the specified times.

The Contractor shall submit the works programme plan as per the Employer's requirement mentioned in chapter-2 of this GS for review of Engineer. Based on the review, the Contractor shall promptly make all amendments as required by the Engineer for his acceptance of the plan.

4.3.2 Preliminary Programme

(i) The Contractor shall make a preliminary Works Programme submission in accordance with the principles set out in his accepted plan. Such submissions may make use of the tender submissions, suitably amended, to the requirements of the Engineer. The submission shall be made in accordance with the respective plans as indicated in table 2-A.

(ii) The Contractor shall note that at the time of submission of his preliminary networks and bar charts, it may be that such Programmes have yet to be co-ordinated with the System-wide and Civil Contractors. These shall not prevent the Contractor from submission of detailed preliminary programmes using approximate dates for work of the System-wide and Civil Contractors (where such dates are not available), which has impact on the Contractor's programmes. Such programmes shall be amended subsequently to take into account the actual schedules of the System-wide and Civil Contractors. It is the Contractor's responsibility to ensure timely co-ordination with the System-wide and Civil Contractors to finalise his preliminary programmes so as not to affect the progress of the Works or those of the System-wide and Civil Contractors.

4.3.3 Baseline Programme

Following the Contractor's preliminary programme, submissions, no later than 90 days from the date of Notice to Proceed, the Contractor shall make re-submissions of these programmes suitably amended to take into account the programmes of the System-wide and Civil

Contractors. It is the Contractor's responsibility to ensure timely co-ordination with the System-wide and Civil Contractors to review, revise and finalise his preliminary programmes so as not to affect the progress of the Works and those of the System-wide and Civil Contractors.

The resubmitted programmes when accepted by the Engineer shall form the Baseline Programme against which actual progress of the Works is measured.

As the Works progresses, it may be necessary for the Contractor to update the Baseline Programme but such updating shall only be carried out with the prior approval of the Engineer or when directed by the Employer.

4.3.4 Precedence Diagramming Method Logic Network

The Contractor shall submit Precedence Diagramming Method logic network when requested by the Engineer from time to time to assist him in the analysis of the Contractor's Programmes.

4.3.5 Baseline Schedule Report

(i) The Contractor shall submit a Baseline Schedule Report in accordance with the approved format, which will quantitatively document the Baseline network and bar charts submitted. The activities in the report shall be grouped into the various phases e.g. design, manufacturing, delivery, commissioning etc.

(ii) Also required with the submission of the Baseline Schedule Report is a narrative sufficient to explain the basis of the Contractor's determination of duration and to describe the Contractor's approach to meeting specified key dates. The reasons for the main logic links and outline method statements shall be provided.

(iii) The Baseline Schedule Report and narrative shall be submitted together with the preliminary programme.

(iv) Notwithstanding the above, the Engineer may at any time during the course of the Contract require the Contractor to reproduce the computer-generated Baseline Schedule Report to reflect actual activity dates and generate schedules based upon "what if" statements.

4.3.6 Progress Reports

Progress reports, as detailed in Appendix 2, shall be regularly submitted by the Contractor, on a monthly basis.

4.4 Review Periods For Contractor's Submissions

4.4.1 The Engineer shall review those Contractor's programme submissions which require his acceptance and shall signify his acceptance or otherwise within 30 days. The Contractor shall, when required by the Engineer, re-submit his programmes within 14 days of receipt of the Engineer's comments.

The Engineer will endeavour to review and respond to the Contractor on the adequacy and acceptability of the Contractor's submissions and re-submissions as soon as reasonably possible but the Contractor should always allow for a 30 day review period.

4.4.2 Unless otherwise specified, the Contractor shall allow in his programme a 30-day review period for all submissions to the Engineer.

4.5 Failure to Make Submissions

4.5.1 Failure of the Contractor to submit any programme, or any required revisions thereto within the time limits stated shall be sufficient reason for certification that the Contractor is not performing the work required in a timely manner. The Engineer may certify retention of payment under the Milestone-related Schedule of Payments proposed for the Contractor, until his programmes are accepted by the Engineer, and may also cause imposition of Liquidated Damages.

4.6 Programme Revision

4.6.1 The Contractor shall revise his programmes whenever necessary, with the consent of, or as required by the Engineer to ensure completion of the Works within the times for completion prescribed in the Contract

4.7 Planning and Programming Staff

- 4.7.1 The Contractor shall employ sufficient number of planning and programming staff competent in the use of the programming software and with a good knowledge of the type of work required to be performed by the Contractor under the Contract.

The Engineer shall have the discretion to require the Contractor to replace his planning and programming staff if the Engineer considers that they do not have the training or skill required for this very specialised nature of work.

4.8 Project Calendar

- 4.8.1 Project Weeks shall commence on a Monday. A day shall be deemed to commence at 0001 hours on the morning of the day in question. Where reference is made to the completion of an activity or Milestone by a particular week, this shall mean by midnight on the Sunday of that week.
- 4.8.2 Requirements for the computation of Key Dates are given in Appendix 3 to the Employer's Requirements
- 4.8.3 A 7-day week calendar shall be adopted for various Work Programme Schedules for scheduling purposes.
- 4.8.4 For Project purposes, the presentation shall be in "Week" units.

This page is left blank intentionally

CHAPTER 5

DESIGN SUBMISSION REQUIREMENT

5.1 General

- 5.1.1 The objective of the design submission process is to ensure that the proposed resulting works comply with the specifications, are capable of being produced consistently to exacting quality standards, achieve low life cycle costs and can be operated safely to the satisfaction of the Engineer.
- 5.1.2 The design submissions include Design Calculations, Design Reports and Design Drawings, unless specifically waived off by the Employer. All design submissions shall include a 'clause by clause' compliance status to all applicable contract clauses of ERTS.
- 5.1.3 In the event that a statutory body (e.g. Government of India Ministry of Railways, RDSO, Commissioner of Metro Railway Safety, etc.) requires design information in a particular format, it shall be incumbent upon the Contractor to provide the same, as directed by the Engineer.

5.2 Review of Data

- 5.2.1 As soon as practicable after Contract Award, the Contractor shall review all applicable data, criteria, standards, directives and information provided to him as the basis for design. Any apparent inconsistencies or erroneous information shall be brought to the attention of the Engineer. Such information shall not alleviate the Contractor from his responsibilities under the Contract.

5.3 Format of Deliverables

- 5.3.1 Drawings and CAD data shall comply with the requirements of Appendix 4 of this General Specification: Drawing and CAD Standards. Reports, calculations, specifications, technical data and similar documents shall be provided in A4 format, and one of the copies shall be ring bound to facilitate photocopying. A3 size drawings included in documents shall be folded to A4 size.

5.3.2 Drawing and CAD Data Format

Within 30 days of Notice to Proceed, the Contractor shall have prepared and submitted the drawing and CAD procedures together with sample drawings and corresponding CAD data to demonstrate his understanding and compliance with Appendix 4 of this General Specification : Drawing and CAD Standards.

5.4 Number of Copies

- 5.4.1 The following quantities of drawings and other documents shall be submitted to the Engineer, including preliminary, pre-final, and final design submissions, the final contract document, and all other submissions. These drawings and documents are in addition to those required for the exchange of information between Designated Contractors and other submissions to statutory, governmental and local authorities. The submissions shall be in A0, A1, A3 or A4 size, as appropriate except as may otherwise be agreed by the Engineer. In addition, the submissions shall also be made in electronic format in a medium acceptable to the Engineer.

A. Hard copies

- i. 3 full-size sets of paper drawings (folded and collated)
- ii. 3 sets of design documents and calculations.
- iii. 2 copies of Design Status Report and Design Statement.
- iv. 3 sets of all other submissions.

B. Soft Copies:

Contractor shall handover and maintain at DMRC office 3 nos. of external hard disks of sufficient storage capacity for Engineer's office as directed by the Engineer, containing all the details and documents specified at para A (i) to (iv) above, including Presentations made by Contractor and other related agencies. The stored information shall be updated on daily basis

during working hours by the contractor till issuance of Performance Certificate by the Employer as per contract conditions.

All the above mentioned submissions shall be in editable format (except catalogues and test certificates) as well as well in PDF format.

5.5 Design Submission Programme

5.5.1 The Contractor shall prepare the Design Submission Programme (unless specifically waived off by the Employer) which is to set out fully the Contractor's anticipated programme for the preparation, submission and review of the Design Packages, the Final Design Submission and the Installation and Manufacturing Drawing Submissions and for the Issue of Notices in relation thereto.

5.5.2 The Design Submission Programme shall:

be consistent with and its principal features integrated into the Works Programme, and show all relevant Milestones and Key Dates;

identify dates and subjects by which the Engineer's decisions should be made;

make adequate allowance for periods of time for review by the Engineer and other review bodies;

indicate the Design Interface and Co-ordination periods for each Designated Contractor.

include list of requisite design details for each and every component or equipment of all sub-systems and systems.

Submission of design documentation shall be suitably staggered.

The Contractor shall update the Design Submission Programme suitably if Engineer observes any deviation

5.5.3 For System, sub-system and components the Contractor shall submit documents and drawings describing function description, product description, interface requirement description, RAM requirement description, Life cycle calculations, Type & routine test specifications, list and details of spares, related calculations etc. The Design Submission Programme shall also include listing of various Plans, processes and other submissions.

5.5.4 The Contractor shall submit the Design Submission Programme to the Engineer as indicated in Chapter 2 of this Employer's Requirements - General Specification, and thereafter up-dated versions thereof at intervals of not more than one month throughout the Design Phase.

5.6 Design Process

5.6.1 The Contractor shall deploy Design staff having sufficient experience in Delhi at all times to maintain liaison with the Engineer. The principal requirement of the Design Phase is to undertake the design during this phase in three stages:

- (i) The preparation of the Preliminary Design;
- (ii) The preparation of the Pre-final Design; and
- (iii) The preparation of the Final Design.

5.7 Preliminary Design

5.7.1 The purposes of the Preliminary Design submission are as follows:

- (i) State the design criteria;
- (ii) Design the overall system, and propose the system configuration;
- (iii) Identify the functions of each system, sub-system, equipment or other element within the overall design, and specify the relationships and interfaces between elements of the system;
- (iv) Identify the functions of each system, sub-system, equipment or other element within the overall design, and identify the relationships and interfaces between elements of the Contractor's system and those of other Designated Contractors; and

- (v) Verify the tender designs and calculations. In case of simulations, the inputs, relevant formulae, principles, assumptions, algorithm and logic followed shall be submitted with a sample calculation for each case. It shall be obligatory on the Contractor to submit any further details as required by the Engineer to approve the results. Any spreadsheet if submitted shall be supported with the linked formulae and calculations.
- (vi) Incorporate the engineer's suggestions and changes based on the Technical Specification and/or operational requirements.

5.8 Pre-Final Design

- 5.8.1 In the Pre-final Design stage the conceptual designs (including interfaces with those of Designated Contractors of the Employer, and of the Contractor's vendors) are required to be fully developed. In this stage, each element of the system will be considered and preliminary specifications with supporting calculations developed. Preliminary electrical and control schematics shall be developed to illustrate how various operational and functional requirements are achieved. Software design and development shall also be carried out at this stage.
- 5.8.2 Manufacturing units will be allowed to commence production only after receiving 'no objection' advice from the Engineer. This submission shall include sufficient detail from prospective suppliers to demonstrate that they have adequate understanding of the requirements. It will include either evidence of or proposals for design verification. Interfaces with other Designated Contractors shall be finalised by this stage.

5.9 Final Design

- 5.9.1 The purpose of the Final Design submission is to agree with the Engineer that the equipment is satisfactory, compliant with the specification, fit for purpose and safe. The Final Design shall be the level of design developed to the stage where all manufacturing drawings (including those received from Designated Contractors of the Employer, and vendors of the Contractor) are fully defined and specified and in particular :
 - (i) calculations and analyses are complete;
 - (ii) all main and other significant elements are delineated;
 - (iii) all other work, including studies, investigations and reports are complete

5.10 Design Submission And Review Procedure

- 5.10.1 All design submissions from the Contractor shall be made under a Design Review Certificate Application (DRCA) notice. The following DRCA numbering system shall be used to identify all submissions:
 <Contract No.>/<Subject Code>/<Stage Code>/<Sequence No.>/<Revision No.>
- 5.10.2 The contract number shall be limited to no more than four digits and reflect the contract number only e.g. BS03, BD01 etc.
- 5.10.3 The stage code and subject codes should be developed in conjunction with the Engineer to help identify particular types of submissions, e.g., type of service or equipment. A schedule of subject codes for each contract should be submitted to the Engineer for acceptance.
- 5.10.4 The contractor shall ensure that all submissions are correctly numbered in accordance with the schedule. The sequence code shall be a unique sequential number for each submission for each particular subject. Revision numbers shall be used when a re-submission is required, i.e. a DRCA was awarded "Not Accepted". For the initial submission the revision code of DRCA number shall be left blank.
- 5.10.5 Upon receipt of design submissions from the Contractor, a copy of the DRCA will be signed, dated and returned by the Engineer.
- 5.10.6 The Engineer shall issue Design Certificate Consent (DCC) Sheet properly dated and

numbered to Contractor for each of the DRCA. The DCC will carry status as Notices of "No Objection", "Notices of No Objection, subject to...." and decisions made by the Engineer in response to a Design Review Certificate Application made by the Contractor shall be transmitted to the Contractor on a Design Certificate Consent (DCC) Sheet properly dated and numbered. The consent sheet number shall be the same as the Design Review Certificate Application number except that the letters "DRCA" are replaced by "DCC".

- 5.10.7 When significant comments are noted by the Engineer on the design submission, the "DRCA" shall be returned "Not Accepted", and signed by the Engineer. One copy of the "DRCA" shall be returned to the Contractor together with the comments on why the submission was rejected.
- 5.10.8 When minor comments are noted by the Engineer on the design submission and it is "No Objection, but Subject to Comments" the "DRCA" will have the appropriate decision indicated upon it and be signed by the Engineer. One copy of the DCC, together with comments, will be returned to the Contractor.
- 5.10.9 A submission will be rejected automatically if not signed by the Contractor's Authorised Design Representative.
- 5.10.10 Upon receipt of a decision sheet from the Engineer, the "DCC" will be signed, dated by the Contractor, and returned to the Engineer.

5.11 Engineer's Review

- 5.11.1 The Engineer will complete his review of the submission within 30 calendar days), after which the review comments in writing or on marked up drawings and specifications will be furnished to the Contractor. The Contractor shall then meet with the Engineer to discuss the review comments. Within two weeks of the receipt of the Engineer's comments the Contractor shall submit his proposals for implementation in the next submission. Where the comments are minor, such proposals may be clarified by calculations, part prints, etc. acceptable to the Engineer and included in the Contractor's next submission. Should the Engineer deem the submission to be unacceptable, the Contractor shall revise and re-submit the entire submission within two weeks, unless otherwise agreed with the Engineer.
- 5.11.2 After Engineer's review of the design submissions, the Contractor shall update the documentation incorporating Engineer's observations and also other design requirements. For all subsequent submissions, the Contractor shall demonstrate that all the previous comments by Engineer has been incorporated. The Comments previously issued by Engineer shall also become part of the submission. All re-submissions by the Contractor to the Engineer shall invariably include an item-wise 'Reply sheet' to Engineer's comments on previous submission/minutes of meeting.
- 5.11.3 It is Employer's understanding that the contractor will need to depute a team of its design engineers for interaction with Employer's experts at New Delhi. Employer at his discretion may also consider deputing a team of engineers (around six) to Contractors design office or at Sub vendor's office for requisite duration with a view to expedite finalization of designs. In such case, Contractor shall provide office facilities and bear full expenditure towards out of pocket allowance, travel expense (as per entitlement), boarding, lodging etc. Such visit(s) as described above shall not be considered as part of inspection activity.

5.12 Final Design Document Delivery

- 5.12.1 To achieve agreement with the Engineer on the completion of the design and to allow the formal submission of the Final Design, the Contractor shall submit a list of all accepted Design Submissions to the Engineer for review along with self-adhesive stickers signed by the Contractor's Representative (CR). If there is no objection by the Engineer, he shall then sign and return the self-adhesive stickers to the Contractor for affixing to the amended Final Design Drawings (original) prior to their submission under the Final Design Document Delivery.
- 5.12.2 Based on the Engineer's review of the Final Design Submission, the Contractor shall then re-submit the entire Final Design Submission together with the following documents:
 - (i) Joint statements of completed design interface with the Designated Contractors of the Employer;

(ii) A signed statement confirming that he has incorporated all comments of the Engineer.

(iii) A Design Certificate duly endorsed, as shown in Appendix 5.

This above jointly will be known as "Final Design Document Delivery"

5.12.3 The soft copy of approved Final Design Submission should be submitted both in PDF and Word/Excel/Auto-Cad duly hyperlinked with index in a hard disk of suitable capacity.

5.13 As-Built Drawings and Documents

5.13.1 As-built drawings are intended to show the works exactly as constructed. These are prepared by amending the manufacturing drawings to take into account changes necessitated by manufacturing methodology. These drawings shall be completed on a regular basis as the works progress, and not left until the completion of the Defect Liability Period.

5.13.2 At least 1 months but not more than 3 months prior to the anticipated date of delivery of the prototype 'T+M' Unit, the Contractor shall compile and submit to the Engineer for recording purposes all those documents and drawings which in the opinion of the Contractor, constitute the complete record of the design and manufacture of the Works.

5.13.3 The updated compilation of the complete record of the design and manufacture of the Works shall be submitted at the end of the Defect Liability Period.

5.13.4 Final As-Built Drawings after approval by Employer before completion of DLP are to be submitted both in Auto-CAD & PDF format duly hyperlinked with index along with 3 sets of hard copies in A3 size papers in a hard disk of suitable capacity.

5.14 Manufacturing Drawings

5.14.1 Detailed manufacturing drawings will not normally be required for acceptance but shall be submitted for comment if the Engineer so requires.

5.15 Post Acceptance Changes

5.15.1 Changes to accepted drawings, whether they are initiated by the Contractor or the Engineer, shall be submitted through the DRCA system. The same process of submission, review and acceptance as described above shall be adopted. Upon acceptance of the post acceptance change, the Engineer shall issue a DCC to this effect. Submission as a result of a post acceptance change shall use a new DRCA number, i.e. not a previously used one.

5.15.2 The Contractor may propose a alternative procedure for implementing post acceptance changes (hardware and software) for review of the Engineer.

5.15.3 For requesting any change to the accepted design the Contractor shall submit the relevant design details for review of Engineer. The Contractor shall not implement any change without receiving 'No objection' from the Engineer.

5.15.4 At the end of DLP period, Contractor shall submit all the latest approved HECPs / SECPs of train system / sub-system done during DLP period in soft copy (PDF / word / auto-cad) duly hyperlinked with index in a hard disk.

This page is left intentionally blank.

CHAPTER 6

SOFTWARE MANAGEMENT AND CONTROL

6.1 Prescriptive Framework

- 6.1.1 The Contractor shall, within 30 days of Notice to Proceed, submit a Software Assurance Plan for review by the Engineer unless specifically waived off by the Employer.
- 6.1.2 All software to be developed or modified (re-engineered software) shall follow the standardisation requirements of EN 50128 (Railway Applications: Software of Railway Control and Protection Systems). The contractor shall define within the Software Quality Assurance Plan what techniques and measures are to be applied for software development.
- 6.1.3 The Plan shall require the Contractor to provide all changes, bug fixes, up-dates, modifications, amendments and new versions of the programmes, as required by the Engineer. Engineer may also direct to provide the copy of previous version of software till such time the new version of software is proven.
- 1.8.4 The Contractor shall provide all tools, Laptop computers or any special device to upload / download the software, TIMS data, equipment, manuals and training necessary for the Employer and Engineer to maintain and re-configure all software provided under this Contract. The documentation of software may be supplied after the expiry of the warranty period, under terms and conditions to be mutually agreed at Contract pre-award stage.
- 6.1.5 When a fault is discovered in delivered software, or an error in the associated documentation, the Contractor shall take the necessary steps to rectify such faults and errors at the earliest opportunity. The Contractor shall supply to the Engineer, full details, in writing, as to the nature of the corrective action proposed or taken. These changes shall be documented in the form of Software Engineering Change Proposal (SECP), which shall be got approved from Engineer. The documentation of software may be supplied after the expiry of the warranty period, under terms and conditions to be mutually agreed at Contract pre-award stage. Updated documentation shall be submitted before issuance of Performance Certificate.
- 6.1.6 It will be incumbent upon the Contractor to take responsibility for any changes required to software.

6.2 Software Framework

- 6.2.1 As defined in EN 50128, all software produced or supplied for the Project shall be subject to a defined quality framework. ISO 9000-3 shall be considered appropriate for low criticality software (safety integrity level 0 or 1) whilst the application of a more stringent framework shall be required for higher criticality software (safety integrity level 2 or above). The quality framework requirements for safety integrity level 2 and above are supplementary to the requirements of EN 50128.
- 6.2.2 SIL level of all softwares used in different sub-systems shall be defined and certified.

6.3 Software Management Control

- 6.3.1 The Contractor shall ensure a full time Software Project Manager and Software Quality Manager are appointed for software development, if software development or modifications are required under the Contract.

6.4 Auditing

- 6.4.1 The Engineer shall carry out an audit of the Software. Further external independent audits may also be arranged at the Engineer's discretion.

6.5 Software Acceptance

- 6.5.1 The Contractor also shall submit an Operational Safety Report (Software) for software acceptance by the Engineer.

The Operational Safety Report (Software) shall include, as a minimum

- (i) OSR(S) - Introduction

Shall describe the nature of software sufficiently to ensure that the Engineer is given a comprehensive overview of primary characteristics such as structure, functions, criticality, volume and language.

(ii) OSR(S) - Evidence of Quality Management

Shall provide evidence to demonstrate that the software development has been subject to acceptable quality assurance.

(iii) OSR(S) - Evidence of Safety Management

Shall provide evidence to demonstrate that the software development has been subject to acceptable safety management.

(iv) OSR(S) - Technical Report

Shall describe how software integrity has been achieved.

(v) OSR(S) Operation and Maintenance Report

Shall describe the Software operation and maintenance characteristics.

(vi) OSR(S) - Restrictions for Use

Shall define what restrictions are applied to the use of the software.

6.6 Availability of Complete Documentation And Development Tools

- 6.6.1 With the exception of commercial, "Off The Shelf" Software, the Engineer shall be provided with full access to application software(s) and any other software /hardware tools which may be specifically required for the intended purpose specified in this specification. For commercial software the Contractor shall provide all available documentation for the application and maintenance of that software. In case any commercially available software has been modified for being used in the train, the same shall be supplied to all depots.

Complete documentation along with the software to be supplied by the Contractor shall comprise of Signal flow diagram, flow charts, functional blocks, details of signals, interpretations so as to enable engineer to debug and implement vehicle/train level modifications based on DMRC's experience, operational & maintenance requirements. Full access to the application software shall be provided for this purpose.

It shall be possible for DMRC to modify/change various parameters used in the software. Complete set of parameters along with necessary changes that may be required to be made in the supplied software shall be furnished so that different makes of equipments if need be, can be integrated. It shall also be possible for engineer to connect/interface additional peripheral equipment as required by DMRC with vehicle/train software or TIMS, as the case may be, and implement system integration for the same. Contractor shall demonstrate to entire satisfaction of the Engineer that DMRC will be able to integrate peripheral equipments of makes other than that have been used by contractor in the train. Any hardware tool required for this purpose shall also be supplied.

DMRC engineers shall be fully trained to the entire satisfaction of Engineer and made conversant with the software and other related issues as found necessary during the contract execution. The documentation of software shall be supplied at the time of testing and commissioning of prototype train set and this shall be considered as a pre-requisite for accomplishment of Key Date no. '3'. The final document including all changes that may be done during the currency of the contract shall be supplied after the expiry of the warranty period and this shall be considered as a pre-requisite for issue of Performance Certificate.

- 6.6.2 After loading, and the satisfactory functioning of the software, the Contractor shall supply two back-up copies of the software, including any new versions adopted. The documentation of software shall be supplied before the expiry of the warranty period. The final documentation of softwares including all changes that may be done during the currency of the contract shall be supplied at the expiry of the warranty period and this shall be considered as a pre-requisite for issue of Performance Certificate. Employer at his discretion may affect suitable changes considered either desirable or essential during the post warranty Period. Employer shall be

solely responsible for any such changes that are made without specific written approval of the Contractor

- 6.6.3 All software(s), irrespective of contractor's own software or of sub-suppliers, shall be compatible with latest version of Windows Operating software and shall also have upward compatibility. In case, the compatibility of installed software(s) with latest version of Windows is not available, the contractor shall replace the installed software(s) that are compatible with latest version of Windows O.S. without downgrading the train performance. Contractor shall commit to support and supply free of cost any special hardware/software required for ensuring compatibility with new version of Windows for at least a period of 5 years beyond DLP of the last train.

Beyond this period, in case of obsolescence suitable alternatives solutions shall be implemented (at mutually agreed terms and conditions) and full support shall be provided by the contractor so as to ensure that train performance are not affected adversely.

Diagnostic tools to be provided as per the contract shall include all hardware/software required for the purpose of

- (i) Uploading/downloading of all software's used in the train/system/sub-systems,
- (ii) Downloading of faults and any other information required for trouble shooting and diagnostic purpose.
- (iii) Data analysis and Investigation tools for real-time downloads on the nominated server.

6.7 Re-Use of Existing Software

- 6.7.1 Where existing software (defined to module level) is to be re-used without modification, the Contractor shall provide acceptable evidence to the Engineer as to why that software is suitable for use in the proposed application. This evidence may be historical (certified evidence of previous satisfactory use in a similar environment and application), or it may be sought as cross acceptance from another railway authority or statutory body. Software re-use shall not be acceptable, without detailed review, where the proposed application is of the same or lower safety integrity level than the current application.

6.8 Re-Engineered Software

- 6.8.1 Re-engineered software may be used for applications at all safety integrity levels where the proposed application is of the same or lower safety integrity level than the current application. However, this shall be subject to quality assurance testing as defined above.

6.9 Test Software

- 6.9.1 All test software, with the exclusion of built-in test software, shall be produced in accordance with a quality system controlled under the requirements of accepted international standards. Test software shall be developed and documented using structured techniques and shall be designed to be maintainable throughout the duration of the Contract. All test software shall be documented to be supportive of maintenance. Any test software, which is to be delivered to the Employer (for long term testing use), shall be fully documented to allow the Employer to maintain the software for the life of the supported system.

6.10 Software Rights

- 6.10.1 The Contractor shall ensure that the Employer is granted all necessary rights to use Software embodied in the equipment and there are no restrictions attached to the use of any information supplied by the Contractor which might later prevent or hinder the Employer from modifying or adopting or extending the system. The Contractor shall indemnify the Employer against claim of any party, sub-contractor for the unauthorised possession or use of the software supplied.

This page is left blank intentionally.

CHAPTER 7

INSPECTION, TESTING AND COMMISSIONING

7.1 General

- 7.1.1 The Contractor shall submit Inspection, Testing and Commissioning Plan for Engineer's review as per schedule furnished in table 2-A. The Inspection, Testing and Commissioning Plan shall be prepared in accordance with the requirements of Chapter 15 of the Employer's Requirements – Technical Specification. This plan shall also include Integrated Testing and Commissioning of Trains in the Section, integration with existing RS1, RS6& RS13 'Broad Gauge' trains of DMRC and Service Trials before introduction in Revenue Service. The Plan shall contain, but not limited to, the following topics:
- (i) the Contractor's methodology for inspection, testing and commissioning;
 - (ii) all Inspections and Quality Hold Points;
 - (iii) the interdependency and inter-relationship with Designated Contractors and their commissioning programme;
 - (iv) the objectives of each test and criteria for successful tests;
 - (v) organisation chart and CV of key personnel in the Testing and Commissioning team;
 - (vi) documentation for conducting tests and submission of Testing and Commissioning procedures.
- 7.1.2 The Engineer will then check the plans to see whether, it meets the requirements. The Engineer shall inform the Contractor in writing within a reasonable period after receipt of the above information;
- (i) that the Contractor's proposed methods of inspection, testing and commissioning (including Integrated Testing and Commissioning) have the consent of the Engineer; or
 - (ii) in what respects, in the opinion of the Engineer the Contractor's proposed methods etc
 - (iii) fail to comply with the Employer's Requirements and/or the Final Design Document;
 - (iv) would be detrimental to the Works and/or to the other works comprising the Project;
 - (v) do not comply with the other requirements of the Contract; or
 - (vi) as to the further documents or information which are required to enable the Engineer to properly assess the proposed methods of inspections, etc.
- 7.1.3 In the event that the Engineer does not give his consent, the Contractor shall take such steps or make such changes in the said methods or supply such further documents or information as may be necessary to meet the Engineer's requirements and to obtain his consent. The Contractor shall not change the methods of inspection, testing and commissioning (including Integrated Testing and Commissioning) which have received the Engineer's consent without further review and consent in writing of the Engineer.
- 7.1.4 Notwithstanding the foregoing provisions of this Clause, or that certain of the Contractor's proposed methods of inspection etc. may be the subject of the consent of the Engineer, the Contractor shall not be relieved of any liability or obligation under the Contract.

7.2 Sequence of Tests

- 7.2.1 The sequence of tests shall be:
- (i) Routine and type tests of equipment and sub-systems in accordance with relevant standard and specifications in Contractor/Sub-contractor's factories.
 - (ii) Factory and Site Tests of complete cars in accordance with IEC 61133.
 - (iii) Testing and Commissioning of cars/trains in Depot in accordance with IEC 61133.

- (iv) Integration Tests in conjunction with all Designated Contractors.
- (v) Instrumentation, and Oscillation Trials on Prototype train set/'T+M' only, if required.
- (vi) Service Trials.

This page is left blank intentionally

CHAPTER 8

SUPPLY OF SPARES, SPECIAL TOOLS AND TESTING EQUIPMENT**8.1 General**

8.1.1 The Contractor 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 (Deleted)
- (v) Overhauling Spares (Deleted)
- (vi) Special Tools, Testing and Diagnostic equipments (Deleted)
- (vii) Special Jigs, Fixtures and Gauges (Deleted)

8.1.2 The relevant list of the spares mentioned above shall be submitted in the technical bids after blanking the prices, where applicable. The financial bid shall have the price details.

8.2 Unit Exchange Spares

8.2.1 The contractor shall supply the unit exchange spares for as listed in the Appendix 6 of this Employer's requirements- General specification. The unit exchange spare shall be supplied in the depot nominated by the Engineer. The delivery requirements of different lots are mentioned in the Appendix -6. These shall be delivered as per defined key dates.

8.3 Consumable Spares

8.3.1 The consumable spares shall include lubricants, oils, greases, sealants, brake blocks, filter media, gaskets, lamps, wearable parts like pantograph strips etc. and any other item, **whose declared life is less than one year.**

8.3.2 The consumable spares shall be stored at respective depots of the corridors.

8.3.3 The Tenderer shall provide a recommended list of consumable spares as noted above for maintenance, repairs and overhaul of trains. Any consumable item if required but not included in the above recommended list by the tenderer will be deemed to have been included and shall be supplied as per the provisions of this contract without any extra financial implication to the Employer. Contractor will be required to supply the requisite quantity of spares, as required irrespective of the quantities indicated by the contractor in the recommended list. Employer's decision in determining any particular item(s) as consumable in line with 8.3.1 above will be final and binding. In case any changes are required in the supply of consumables on account of changes at design stage, the contractor shall have to supply the required consumables within the quoted cost. No increase/decrease in quoted cost shall be made due to any change in the list of consumables arising due to change/modification of design.

8.3.4 Unpriced list of consumable spares shall be furnished in the Technical Package. List of consumable spares shall contain following information as a minimum:

Names, addresses, telephone numbers and other particulars of manufacturers and their local representatives;

Models and part numbers,

Full description of spares including a note whether it is sealed unit or an assembly or sub-assembly which can be broken down into component parts;

Quantity installed in the system;

Expected consumption rates;

Overall dimensions and weight including minimum packing (if any) for shelf space purposes;

Interchangeability or otherwise with similar parts
 Normal manufacturing and shipment lead times; and
 Shelf life.

Area of usage of consumable items.

- 8.3.5 It shall be the responsibility of the contractor to maintain sufficient stock of consumable spares at respective depots of different lines.
- 8.3.6 Recommended list shall be furnished by the contractor as part of design submission for respective systems and subsystems.

8.4 Mandatory spares

8.4.1 The Contractor shall supply the Mandatory Spares as listed in the **Appendix 6** of this Employer's Requirements - General Specification. The Spares shall be supplied in the Depot nominated by the Engineer. The items and quantity required are mentioned in the list in Appendix 6. The price of these spares shall be quoted at actual.

8.4.2 No change in quoted cost of any spare will be allowed even when there is change in design of any equipment/sub-system during execution of the contract.

8.4.3 Contractor will furnish complete details during contract execution (detailed design stage) as noted below for the listed spares;

Names, addresses, telephone numbers and other particulars of manufacturers and their local representatives;

Models and part numbers

Full description of spares including a note whether it is sealed unit or an assembly or sub-assembly, which can be broken down into component parts;

Quantity installed in the system;

Overall dimensions and weight including minimum packing (if any) for shelf space purposes;

Designed and shelf life;

Interchangeability or otherwise with similar parts;

Normal manufacturing and shipment lead times;

Procurement Technical Specification with relevant drawings of all major system equipments

8.5 Recommended spares (Deleted)

8.6 Overhauling Spares (Deleted)

8.7 Special Tools, Testing and Diagnostic equipments: (Deleted)

8.8 Special Jigs, Fixtures and Gauges (Deleted)

8.9 Manufacture, Delivery and Warranty

8.9.1 The major spare parts ordered under the Contract shall be manufactured, works tested and inspected in accordance with the relevant quality system, suitably packed and labelled in accordance with Chapter-13 of this Employer's Requirements General Specification "Storage, Packing, Crating and Marking" and delivered by the Contractor to the depot as directed by Engineer. All spares shall be subject to inspection by the Engineer. In the event that any item is known to be going out of production, then the Contractor shall give advance notice to the Engineer.

8.9.2 The warranty period of spares or any other item / equipment delivered shall be:

(a) either 24 months from the date of acceptance or

(b) upto expiry of the defect liability period of trains (clause 1.8.1), whichever is later.

8.10 Purchase of Spares from Vendors

- 8.10.1 The Contractor shall furnish an undertaking that he has no objection whatsoever to and shall not in any way deter or obstruct the Employer, its licensee or its representative from dealing directly with the Contractor's Vendors for the purchase of the spares during the Contract period. The spares purchased shall be subject to inspection by the Engineer.
- 8.10.2 Contractor shall obtain an undertaking from vendors, OEMs etc. at detailed design submission stage that they will deal directly with Employer for supply of spares, equipments and/or sub-systems.

8.11 Commissioning And DLP Spares

- 8.11.1 The Contractor during shall submit to the Engineer for review a list of minimum spare parts that he intends to make available during the installation, erection, commissioning and defect liability periods.
- 8.11.2 The Contractor shall keep on Site, at his own cost, throughout the installation, erection, commissioning and defect liability periods, stocks of spare parts, as per the list to enable rapid replacement of any item found to be defective or in any way in non-conformance with the Specification.
- 8.11.3 The Contractor shall not be entitled to use any of the Employer's spare parts during the installation, erection and commissioning periods or during the Defects Liability Period.
- 8.11.4 Contractor shall not be permitted to remove any working/healthy equipment / components / sub-systems / systems from any of the train available at any of the depot for any reason whatsoever without specific approval in writing from DMRC's depot incharge / Engineer's authorised representative.
- 8.11.5 Spares as per the agreed list shall be supplied at least three months before receipt of first train. Stocks of such spares as available in Contractor stores will be jointly checked with Engineer every three months. Certificate by Engineer confirming availability of the spares in contractor stores in Depots as per agreed list will be a pre-requisite for release of interim payments of the Contractor. However, this condition will not be applicable for six months before the expected expiry of the DLP period of the last 'T+M' unit / 'DT+M' unit/ 'Train'.

8.12 List of Spares

- 8.12.1 The Contractor shall ensure availability of spare parts for a period of ten year from the last date of taking over of whole of Works. The Tenderer shall furnish an unpriced list of spares for maintenance, overhaul and repair of cars separately (if there are difference in items) for a period of ten years from the date of taking over of the last trains in the Technical Package. The spares shall be in kit form. The Tenderer shall also quote unit prices for the kit of spare at the Depot along with escalation clause in the Financial Package. The Employer at his discretion, during a period of ten years from the date of taking over of the whole works, purchase as many kits of spare parts as required by him, at the rates indicated in this schedule.
- 8.12.2 If during the period of ten years, the Contractor intends to discontinue the manufacture of spare or replacement parts for the Rolling Stock, the Contractor shall immediately give notice to the Employer of such intention. The Employer shall be given the opportunity of ordering at reasonable prices such quantities of such spare or replacement parts as the Employer shall reasonably require in relation to the anticipated life of the Rolling Stock.
- 8.12.3 In the event of Contractor failing to supply the spare parts in accordance with this Clause, he shall in respect of each item of spare, furnish free of cost to the Employer, the drawings, specifications, patterns and other information to enable the Employer to make or have made such spare parts. The Employer shall be entitled to retain the aforesaid drawings etc., for such time only as is necessary for the exercise by the Employer of his rights under this clause and the drawings, if the Contractor so requires, shall be returned by the Employer to the Contractor in good order and condition (fair wear and tear excepted).
- 8.12.4 Under such circumstances, the Contractor shall also grant to the Employer, without payment of any royalty or charge, full right and liberty to make or have made spare or replacement parts as aforesaid and for such purposes only to use, make and have made copies of all drawings, patterns, specifications and other information supplied by the Contractor to the Employer pursuant to the Contract.

- 8.12.5 The Contractor will so far as it is reasonably able to bind his sub-contractors to conform with the requirements of this Clause and shall, prior to entry into any sub-contracts, provide the Employer with full details of any sub-contractor who will not so conform in which event the Employer may direct the Contractor to seek an alternative sub-contractor.
- 8.12.6 If the Contractor fails to provide spare or replacement parts as described in this Sub-clause and these are available from the Contractor's sub-contractor, the Employer shall have the right to obtain such spare and replacement parts from the sub-contractor or any other supplier and any additional cost incurred by the Employer shall be recoverable from the Contractor.
- 8.12.7 In case the Contractor is unable to supply spares in accordance with Clause above, he shall furnish, free of cost to the Employer, the drawings, specifications, and other technical details, to enable the Employer to manufacture parts, or have them manufactured. Such drawings and technical data shall be provided free of any charge or royalty, on the understanding that the Employer will use such data and drawings, only for the manufacture of parts for his own use.

The foregoing shall hold equally good for the Contractor, any or all of his sub-contractors, and vendors.

In the event that technological progress results in improved versions of spares and replacement parts, the latest version shall have the same plug compatibility, and spatial needs of its predecessor, to avoid modifications being required, to accept the up-graded version of the part.

8.13 Optional Item(s)- Deleted.

This page is left blank intentionally

CHAPTER 9

TRAINING

9.1 Training Requirements

- 9.1.1 The Training is optional and the price quoted under this shall not be considered for evaluation. The employer at his sole discretion may opt for exercise of the activities under this cost centre in part or full. The Tenderer shall include and price in his tender submission a Training proposal to meet the following requirements:

(Deleted)

Training of Employer's maintenance personnel (05 man months) in Contractors / sub-contractor's Works and MRTS off-shore.

Provision of Contractor's Driving Instructors (0.5 man months) for Training of Employer's operating personnel in India.

Provision of OEM's Experts / Instructors (05-man month) for Training of Employer's maintenance personnel in India.

Submission of Training Manuals (Original plus two hard copies) and in Electronic format.

- 9.1.2. The Tenderer shall list the cost for each component module of the Training in terms of man-months in Financial Package. The travel, boarding and lodging expenses for the Employer's trainees will be borne by the Employer. The Employer may at its absolute discretion delete any or all of the training modules while accepting the tender.
- 9.1.3 Facilities such as classrooms, overhead projectors, VCRs and video monitors will be made available for imparting training in Employer's depots in India free of cost to the Contractor. However, for training in the Contractor's works, such facilities shall be arranged by the contractor's at his own cost. The Contractor is however, required to provide at his own cost all other necessary training aids such as written and printed notes, video programmes, transparencies, slides, films, models and drawings, and other training aids etc.
- 9.1.4 The Employer's personnel required to undergo training will be qualified electrical, mechanical and electronics engineers, technicians, supervisors or instructors, with relevant practical experience. The training syllabus should therefore concentrate on familiarisation with particular systems and equipment of the cars and technologies outside of their experience.
- 9.1.5 Training Instructors provided by the Contractor shall be fully qualified and experienced electrical, mechanical and electronics engineers and experts in the relevant field with experience in training of engineering graduates and technicians to the level of competency essential for operation and maintenance of Metro trains of similar specifications. The Instructors shall be preferably English speaking. If any interpreter is required, it shall be arranged by the contractor at his cost. The appointment of Instructors shall be confirmed only after his detailed *curriculum vitae* have been accepted by the Engineer. In the event that an Instructor is subsequently deemed not to be competent, he shall be replaced forthwith.
- 9.1.6 The Contractor shall submit a detailed Training proposal in the Technical package to meet the above requirements.

9.2 Training Objectives: Train Operating Staff

- 9.2.1 The objective of training of train operating staff is that the batches of drivers and instructors who will operate the trains should be able to run the trains safely under all operating conditions. The training should also enable them to acquire full capability for identification and trouble shooting of the faults in the specified duration. In order to achieve the above objective, the Operating Staff and instructors should be trained on a cab simulator of a mass transit railway and on a Test Track. It will be preferred that after classroom instructions, which include mock-ups of cab equipment, the staff are trained in actual operation of cars in a Mass Rapid Transit System or on a test track, having similar cars, to acquire the required confidence.
- 9.2.2 The Contractor's Instructors deployed for training of operating Staff in India shall provide training in classroom, as well as actual driving of trains during and after commissioning of trains in India. The instructors shall also train the operating staff in trouble shooting of the

faults and emergency procedures.

9.3 Training Objectives: Maintenance Staff

- 9.3.1 The training should enable the engineers, inspectors and staff to achieve the following broad objectives:

Full understanding of all aspects of the system design and functions of all the equipment including proprietary and third party equipment, software etc.

Full understanding of all aspects of programmed maintenance and overhaul requirements of cars and equipment.

Procedures to be followed for unscheduled maintenance and repair of cars and equipment.

Identification of failed components and sub-systems in electronic equipment by use of special test equipment, as necessary.

Modification in the software to extend or modify the control and monitoring functions.

Maintenance Management Information System and documentation.

Monitoring and scheduling trains in the Progress Planning and Investigation Organisation.

Stores inventory planning and control.

- 9.3.2 The training of employer's personnel off shore shall include direct exposure to engineers, technicians, inspectors and staff in actual repair, maintenance and overhaul of similar cars in the Depots and Workshops of an operational Mass Rapid Transit System.

- 9.3.3 The Contractor's Instructors deputed to train Employer's personnel in India shall impart theoretical as well as practical training so as to enable them to develop skill and expertise necessary for satisfactory maintenance, repairs and overhaul of cars.

9.4 Training Methods

- 9.4.1 As a general guide, training shall be based upon a "two-stage" concept:

Stage one shall consist of training in the basic concepts and principles. These shall include system configuration and specification, operation and control of all equipments installed in the cars, preventive maintenance procedures, overhaul and repair concepts, fault diagnostic and trouble shooting and emergency procedures. The training shall consist of class room (theory) training; computer based inter-active training and mock-up training.

Stage two shall consist of "hand-on" site-based practical training on preventive and corrective maintenance and operating procedures.

The contractor shall also include the training of the staff in the correct procedures of maintenance and repair of different equipment based on the Training Manual supplied against the contract.

Contractor shall arrange the experts from the OEMs of the systems to impart the "hands on" training at site for the agreed durations during the contract execution.

Training evaluation shall be carried out at regular intervals to monitor the progress and suitability of the training programme, and of the trainees.

The performance of Contractor's Instructors shall also be evaluated by the Engineer at regular intervals.

- 9.4.2 Contractor shall provide training for maintenance and overhauling of the equipments, which shall cover, as a minimum of following work areas:

Deleted.

Bogie, Brake

Car body including furnishing

Doors and associated drives

Lifting of car, assembly/disassembly of equipment

Traction Motors

Converter/Inverter and associated controls
Auxiliary Supply Equipments
Transformers
TIMS / Control Electronics
Software handling
Air-conditioning
Stores Management
Any other area requiring specialist service.

9.5 Training Manual

9.5.1 The Contractor shall provide one original, Two coloured copies and one soft copy of the Training Manual for use by the Employer for conducting in-house training. The Manuals shall cover all requirements specified in this chapter.

9.6 Transfer of Training Aids

9.6.1 After completion of the training, training aids and materials used shall become the property of Employer to enable and further training to take place.

9.7 Training Location and Facilities

9.7.1 Training shall be carried out at such locations as will provide the maximum benefit to the trainees. Such locations may be in India, or abroad, at places of manufacture, assembly or testing, or at other locations as may be necessary. All locations proposed for training shall be subject to the consent of the Engineer. Details of the facilities proposed to be provided, shall be included within the detailed Training Proposal submitted by the Contractor.

9.8 Administration

9.8.1 The Contractor shall be responsible for the reception, office facilities etc. for the trainees, when in countries other than India.

9.8.2 The Contractor shall be responsible for the general welfare, health and safety of trainees under his control.

This page is left intentionally blank.

CHAPTER 10**SITE AND SITE MANAGEMENT****10.1 Access to Site**

10.1.1 The Contractor will be given access to the Site in accordance with Clause 2.2 of the General Conditions of Contract.

10.2 Site Facilities

10.2.1 The Contractor can be provided subject to availability, approximately 100 sq mtrs of total built up space at nominated depots for working on the vehicles, for setting up of the contractors' site offices and stores at the prevailing market rates as decided by Employer. The site office shall be handed over to Employer after the completion of the defect liability period.

10.2.2 The contractor shall arrange its furnishing, security etc. Charges for the electricity consumption shall be payable by the contractor at the prescribed rates.

10.2.3 (Deleted)

10.2.4 (Deleted)

10.2.5 (Deleted)

10.2.6 The Contractor shall also arrange for the constant and hygienic disposal of all effluent, sewage and rubbish from the buildings.

10.2.7 All buildings shall be supplied with electricity 240V 50Hz that shall be distributed to each room in accordance with the Regulations. Lighting and electrical power points shall be provided to each room.

10.2.8 Fire fighting equipment shall be provided in accordance with the recommendations of the Delhi City Fire Brigade.

10.2.9 The Contractor shall provide, erect and maintain appropriate name boards as specified for each of the offices.

10.2.10 Traction power at 25kV a.c. will be made available to Contractor free of charge for testing and commissioning. The Contractor shall liaise with Designated Contractors for availing of the power and assuring compliance of all safety procedures. The Employer shall provide his own EMU train drivers for Testing, Commissioning and Service Trials. A test track is installed in each of the depot. It will be available for the testing of first prototype unit. The Contractor will be allowed use of the test track free of charge.

10.2.11 The Contractor shall provide his own lifting facilities for unloading of EMU trains and any heavy equipment, at the port of arrival, transshipment point and depot. The Contractor shall however, be allowed to use any necessary Depot facilities free of charge for assembly, commissioning, inspection, repairs to EMU cars and equipment, subject to availability. The Employer shall, however, not be responsible for adequacy, reliability and safety of the facilities provided to the Contractor.

10.2.12 Reasonably lit access to the areas and to rail sidings will be provided by others. If Lighting are not provided in the specific areas allocated to the Contractor, he should make his own arrangements. The Contractor shall be solely responsible for the security and housekeeping of the area, plant and possessions allocated to him. The Contractor shall provide and maintain all facilities required by him in the area allocated for his exclusive use and all other work required to allow the Contractor to fulfil his obligations under the Contract.

10.2.13 The Contractor shall arrange at his own cost all Site services necessary and appropriate for the assembly, testing and commissioning of trains, which shall include, but not necessarily be limited to:

(i) Electricity at site area (other than traction and inside the shed);

(ii) Compressed air other than the depot inspection shed;

(iii) Communication facilities; and

(iv) Instrumentation.

10.2.14 The Contractor shall be responsible for making applications or requests to the concerned Authorities for availing of the above facilities. In the event that electricity or water supplies are arranged by another Designated Contractor in the Depot area, the Contractor may avail himself of those supplies from the Designated Contractor, either directly on agreed terms and conditions. The Contractor shall comply with all regulations of the utility companies and Government departments concerned.

10.2.15 The Contractor shall allocate at his Works, and those of his major sub-contractors, adequate office space, furniture and equipment for the use of the Employer's Representative's Inspection Engineers. Such accommodation shall include secure filing for Contractual and other sensitive documents, and secure telephone and facsimile facilities. Such facilities shall apply equally to the overseas and the local building phases of the Works.

10.3 Site Management

10.3.1 The particular use to which the Site is put shall be submitted to the Engineer for review within 120 days of the Date of Notice to Proceed. The Contractor shall:

- (i) confine his use of the areas of the Site to purposes having been reviewed without objection by the Engineer who reserves the right to extend, amend or restrict the uses to which areas of the Site will be put;
- (ii) where required under the Contract, provide and maintain fencing and lighting around and within the areas of the Site when or where necessary for the safety and convenience of the public or others or as directed;
- (iii) refrain from depositing rubbish or causing nuisance or permitting nuisance to be caused and, except where reviewed without objection by the Engineer, depositing earth on or removing earth from areas of the Site;
- (iv) refrain from felling trees, other than those specifically identified in the Contract to be felled, and refrain from depositing earth around the trunks of trees and protect all trees remaining on Site to the satisfaction of the Engineer.
- (v) except where otherwise provided, not permit any person to reside on the Site.
unless otherwise stated, pay all rates and charges of any nature whatsoever arising out of his use of the Site and all work areas provided therein under the Contract.
- (vii) not use any part of the Site or Works for advertising purposes except with the acceptance of the Engineer.

10.3.2 The Site shall be maintained in a clean and tidy condition. Materials, including those required for Temporary Works, shall be stored in an orderly manner. The Contractor shall, throughout the period of the Contract, provide a central collection point on Site, as reviewed without objection by the Engineer, for collecting all empty cans, drums, packing and other receptacles capable of holding water. The Contractor shall ensure the regular collection and removal of such debris from the Site. After every shift of works, all work areas shall be cleaned and made tidy to the satisfaction of the Engineer.

10.3.3 The Contractor shall ensure that gases, fuels, explosives and other dangerous goods are stored and handled in a safe manner and in accordance with the Statutory Regulations pertaining to their storage and handling. The Contractor shall be responsible for obtaining the requisite licences at his own cost.

10.3.4 The Contractor shall provide all necessary protective clothing, safety equipment, hand tools, ladders, trestles, power supply, and replacement equipment for the staff engaged on Site maintenance.

10.3.5 Because of the multi-disciplinary nature of the Project, several different parties may require access to the same portion of the Site during the construction phase, for the installation, erection and testing of the Works.

10.3.6 To facilitate the organisation and co-ordination of access and occupation requirements, the Contractor shall maintain a close liaison with other Contractors.

10.3.7 As soon as any or all of the Contractor's installations are no longer required for the execution

of the Works, the Contractor shall remove those facilities and ensure that the area is left free of debris, excess materials, and obstructions.

10.3.8 Deleted.

10.3.9 Deleted.

10.4 Site Safety

10.4.1 The Engineer will issue to the Contractor with the latest edition of the Employer's Project Safety Manual. The Contractor shall, as a minimum, comply with the Safety Manual. However, this shall not relieve the Contractor of any of his statutory duties, obligations or responsibilities under the Contract. The Engineer reserves the right to order the immediate removal and replacement of any item of Contractor's equipment, which is deemed to be in an unsafe condition.

10.4.2 The Contractor shall submit, as part of his Safety Plan, a Site Safety Plan, and also designate a member of his staff as Safety Officer.

10.4.3 The Contractor shall establish and maintain and staff at all times when personnel are on site, a First Aid Post. Portable First Aid Boxes shall be maintained in a fully equipped state at each site work centre. The Contractor shall ensure that at least one employee on every working shift, is a trained First Aider, capable of administering First Aid competently until the arrival of professional help, in an accident situation.

10.4.4 The Contractor shall be fully responsible for the safety of the Works, his personnel, his sub-contractors' personnel, the public, and any persons directly or indirectly associated with the Works, or on or in the vicinity of the depot site. The Contractor shall treat safety measures as high priorities in all his activities throughout the execution of the work.

10.4.5 The Contractor shall submit to the Engineer, regular Site Safety Reports, and shall notify immediately the occurrence of an accident involving his staff or that of his sub-Contractors, or to any person within the area of the depot for which the Contractor is responsible.

This page is left intentionally blank.

CHAPTER 11**TRAFFIC, ROAD & APPURTENANCES****11.1 General**

- 11.1.1 The Contractor shall conform to the applicable requirements of the Motor Vehicle Act - 1988. The Contractor shall ensure compliance with the requirements regarding the licensing of drivers and the registration of vehicles. Vehicle size and load limitations shall be in accordance with all statutory requirements.

11.2 Transportation to Site

- 11.2.1 The Contractor shall make all arrangements and assume full responsibility for transportation to the site at nominated depots of the passenger rolling stock, and all plant, equipment, materials and supplies needed for the proper execution of the Works. Procedures for access to and from the Site shall be co-ordinated with the relevant Authorities.
- 11.2.2 A loading / unloading line is constructed at Shastri Park (SP) depot and Khyber Pass (KP) depot where the coaches brought by road can be lifted using road cranes/ loaded on road trailer for further movement on road. Road transportation of coaches from SP depot to other Depots is possible using road trailers. Transportation from Line#2 to Line#3 is also possible through DMRC network. Coaches can be transported to other depots directly by road. The Contractor shall undertake survey of the site and determined the most suitable means for transportation of coaches.
- 11.2.3 The Contractor shall use such routes and rights of entry to the Site as may be decided by the Engineer from time to time. Routes for 'very large' or 'very heavy' loads shall be discussed with the Engineer in advance and all arrangements thereafter shall be submitted to the Engineer. In this context, the definition of the terms "very large" and "very heavy" refer to articles that cannot be transported by normal road vehicles or be handled by readily available methods. Where doubt exists, it shall be the responsibility of the Contractor to notify and discuss the nature of the load in question with the Engineer in accordance with Paragraph 11.2.2.
- 11.2.4 The Contractor shall be responsible for obtaining permission from the Traffic Police and other relevant authorities to move "very large" and "very heavy" loads and for arranging police escorts if required. The Contractor shall ensure that all roads and pavements, etc. leading to and around the Site are kept free from obstructions and shall not cause inconvenience or hindrance to traffic or persons either by its vehicle or its workmen, scaffolding, plant, materials, equipment, etc. All Workmen working on the road shall wear approved reflective safety vests at all times.
- 11.2.5 The Contractor shall repair damage caused to existing roads, footpaths, steps, cables, sewers, drains, etc. and shall reinstate the same at his own expense to the satisfaction of the relevant authorities.

This page is left blank intentionally.

CHAPTER 12

OPERATION AND MAINTENANCE MANUALS

12.1 General

- 12.1.1 The Contractor shall provide Operation and Maintenance manuals, wherever design changes with respect to existing stock are envisaged, for use by supervisory, operating and technical staff of DMRC, in English. The cost of supply of such operation and maintenance manuals covered under this chapter shall be deemed to be included in quoted lump sum price. No additional cost whatsoever shall be payable to the contractor on this account.
- 12.1.2 Thirty days before the date of commencement of test running of the first 'T+M' Units, the Contractor shall deliver the originals and 3 coloured copies each of the final Operation and Maintenance manuals. These manuals shall have been submitted for proof reading and training purposes prior to delivery. It is accepted that further amendments may subsequently be required.
- 12.1.3 Each and every manual shall be divided into indexed sections explaining the subject matter in logical steps. Most manuals shall consist of A4-size printed sheets bound in stiff-cover wear-resistant binders clearly and uniformly marked with the subject matter and reference number. Where alternative sizes are proposed, (e.g. A5/A6 pocket books of schematic wiring diagrams) these shall be for review and acceptance. The binding shall allow for all subsequent changes and additions to be readily effected.
- 12.1.4 Information shall be provided in pictorial form wherever whenever possible and shall include step-by-step instructions and views of the particular equipment including exploded views. Programmable equipment shall be supplied with sufficient flow charts and fully documented programmes to enable faults to be quickly identified and system modification to be undertaken at any time.
- 12.1.5 The Contractor shall provide clarifications and amendments to the Operation and Maintenance manuals as necessary during the execution of contract. Updates shall be provided for the originals and all copies.

12.2 Operation Manuals

- 12.2.1 The Contractor shall provide operation manuals explaining the purpose and operation of the complete system together with its component subsidiary systems and individual item of equipment. The characteristics, ratings and any necessary operating limits of the Equipment and Sub-systems shall be provided.

12.3 Maintenance Manuals

- 12.3.1 The Contractor shall provide maintenance manuals showing details of all the various systems and sub-systems from a maintenance and fault finding standpoint, with particulars of operating parameters, tools for dismantling and testing, methods of assembly and disassembly, tolerances, repair techniques and all other information necessary to set up a repair and servicing programme.
- 12.3.2 The Contractor shall provide documentation for all hardware and software for computer systems and other associated electronic equipment to meet the following requirements. Such documents shall include but not be limited to:
- (i) manufacturers' documentation supplied as standard with the equipment;
 - (ii) hardware configuration with details of expansion capabilities and options;
 - (iii) programme loading instructions, including runtime environment configuration;
 - (iv) Deleted.
 - (v) flow charts, data flow diagrams and state diagrams as appropriate;
 - (vi) description of software modules including purpose, linkage with other modules, error routines and any special considerations;
 - (vii) memory maps for both internal and peripheral memory showing description of all

- programmes, data files, overlay areas, memory available for expansion and the like;
- (viii) loading and operating instructions for diagnostic programmes and specifically developed debugging tools; and
 - (ix) programming manuals relevant to operating systems, languages, development tools, etc.
- 12.3.3 The documentation of software may be supplied after the expiry of the warranty period, under terms and conditions to be mutually agreed at Contract pre-award stage. The manual shall also include inspection/overhaul procedure and periodicity of various inspection/overhaul schedules in detail including the tools, special tools/plants, and facilities required. The manual shall be subject to review by the Engineer.
- 12.3.4 A preliminary maintenance schedule specifying the frequency of inspections and the scope of work during such inspections, including facilities, manpower and down-time required shall be included within the Tender.
- 12.3.5 The maintenance manual shall also include an illustrated parts catalogue of all equipment & components supplied and shall contain sufficient information to identify and requisition the appropriate part by maintenance staff. The catalogue shall comprise 3 sub-sections.

The first sub-section shall be an alphanumeric parts list, which shall include the following information:

- (i) Part number
- (ii) Description
- (iii) Name of manufacturer
- (iv) Quantity and Unit
- (v) Part number of next higher assembly (usually a line replaceable unit).
- (vi) Cross-reference to figure number.
- (vii) Category : e.g. consumable, line replaceable unit, repairable.
- (viii) Life-expected life, Mean time between failure or mean distance between failure where available.
- (ix) General or specific purpose
- (x) Purchase and technical specification

The second sub-section is a series of illustrations to indicate the location of each replaceable item, which shall be clear and progressive with exploded views to enable parts to be identified easily by cross-reference with the alpha-numeric list.

And the third sub-section, an indicative price list which shall list in alpha-numeric sequence the part number with the price, lead time and vendor.

12.4 Electronic Manuals

- 12.4.1 The Contractor shall provide manuals in electronic format. This is in addition to the submission of manuals in hard-copies.
- 12.4.2 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.
- 12.4.3 The contractor shall develop a complete Database Management System (DBMS) consisting of a publishing engine and a browser engine. The Design Data including As-Built drawings and Final Design documents, Spare Parts Catalogue, the Maintenance Schedule, the Maintenance Instructions Manuals, Engineering Changes details etc. shall be the main modules of DBMS and shall allow for links between different modules. The DBMS and Language used shall be subject to Engineer's review and approval. The contractor shall handover the complete package of DBMS for use by DMRC after Defect Liability Period (DLP). Till expiry of DLP, DBMS will be provided as an internet access web service to DMRC and the Contractor shall ensure sufficient training of DMRC personnel in the DBMS during this period.

This page is left blank intentionally

CHAPTER 13

STORAGE, PACKING, CRATING AND MARKING

13.1 General

- 13.1.1 The Contractor shall be fully responsible for the provision and maintenance of acceptable storage facilities for the Plant and any materials or equipment he intends to use for the carrying out of the Works.
- 13.1.2 The Contractor 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.
- 13.1.3 The Contractor shall provide all packing, crating and markings. In so doing he shall comply with the following requirements:
- (i) All packing procedures shall be subject to acceptance by the Engineer.
 - (ii) Spare parts shall be tropicalised in their packing for prolonged storage in accordance with BS 1133 or equivalent and shall be suitably labelled to indicate :
 - Ownership (DMRC)
 - Shelf life.
 - Type of storage.
 - Description of item and relevant part number.
 - Serial number, if applicable.
 - Inspection Certificate number and batch number, that is, the number allocated by the Contractor's Inspector at the time of manufacture or packing.
 - (iii) Protection requirements shall include but not be limited to:
 - (a) Electrical and other delicate items or equipment shall be properly protected to the Engineer acceptance.
 - (b) Tube ends, cable ends, cable entry points into equipment and other similar terminations and openings shall be blanked off to prevent ingress of dirt, moisture, vermin or insects and to provide protection against damage.
 - (c) Flanged ends shall be protected by adhesive tape or jointing material covered by a properly secured wooden blank not smaller than the flange itself. Plain tube ends shall be closed off with bungs or plugs or suitable materials firmly fixed in position.
 - (d) Particular care shall be taken to prevent damage to or corrosion of shafts and journals where they rest on timber or other supports, which may contain moisture. At such points, wrappings impregnated with anti-rusting composition shall be used. Wrapping shall be of sufficient strength to resist chafing under the pressures and movements likely to occur in transit.
 - (e) Spare ball and roller bearings and similarly protected items shall not be removed from the manufacturer's wrappings or packing.
 - (iv) Each case, crate or package shall be legibly and indelibly marked in large letters with the name (DMRC), address, Contract Number, "right way up", opening points and other markings as necessary to permit materials and Plant to be readily identified and handled during transit and when received at Site.
 - (v) Each case, crate or package shall contain a comprehensive packing list showing the number, mark, size weight and contents together with any relevant drawings. A second copy of the packing list shall be enclosed in a watertight enclosure on the outside of each case.

(vi) All items heavier than 100 kg shall be marked on the outside of the case to show the gross and net weights, the points for slinging, and where the weight is bearing.

(vii) Care shall be taken to prevent movement of equipment within cases, crates or packages by the provision of bracings, straps and securing bolts as necessary. Bags of loose items shall be packed in cases and shall be clearly identified by well-secured labels on which the quantity and name of the part and its index or catalogue number have been stamped.

In order to reduce fire risk and prevent obstruction, all empty cases, crates, or packages whether or not returnable shall be removed from the Site as soon as possible. If this requirement is not complied with, after due notice, the Engineer will instruct the Civil Contractor or others to remove them and the Employer will back-charge the Contractor the costs incurred together with handling charges.

- 13.1.4 If sea transportation of trains from manufacturer's works to site at New Delhi is required, seaworthy packing/ treatment of Trains shall be carried out for the safe transportation of trains. It shall apply to sea transportation of spares and other materials also.

This page is left blank intentionally

This page is left blank intentionally.

DELHI METRO RAIL CORPORATION LIMITED

MASS RAPID TRANSPORT SYSTEM – PHASE III

**DESIGN, MANUFACTURE, SUPPLY, TESTING AND COMMISSIONING OF
80 No. BROAD GAUGE CARS COMPATIBLE WITH EXISTING 'RS1' TYPE
TRAINS SUPPLIED BY MRM CONSORTIUM**

TENDER 'RS15'

(VOLUME 3)

• APPENDICES TO GENERAL SPECIFICATIONS

APPENDICES TO EMPLOYER’S REQUIREMENTS – GENERAL SPECIFICATIONS**CONTENTS:**

APPENDICES TO Employer’s requirements – general specifications.....	1
Contents:	1
APPENDIX 1	4
PROGRAMME.....	4
1 Time-Scaled Network/Bar Chart	4
2 Time Scaled Network/Bar Chart Details	5
The network/chart shall indicate tests, measurements and interface tests required to be carried out to verify system performance and readiness for revenue service	5
APPENDIX 2.....	6
MONTHLY PROGRESS REPORT	6
1 Contract Stages	6
2 Financial Status	6
3 Physical Progress	6
4 Programme Update (For Entire Project)	6
5 Milestones Status	7
6 Three Month Rolling Programme	7
7 Planning And Co-Ordination	7
8 Procurement Report	7
9 Production And Testing	7
10. Safety	7
11 Environmental.....	8
APPENDIX 3.....	10
APPENDIX 4.....	12
DRAUGHTING AND CAD STANDARDS.....	12
1. Introduction.....	12
2. General Requirements.....	13
2.1 General.....	13
2.2 Drawing Numbering System.....	13
2.3 Types of Drawing	13
3 Computer Aided Design & Draughting (CAD) Standards	14
3.1 Introduction.....	14
3.2 Objectives	14
3.3 General.....	14
3.4 Terminology & Associated Standards / Guidelines.....	14
3.5 Paper Drawings.....	15
3.6 CAD Data Creation, Content & Presentation	15
3.7 CAD Quality Control Checks	15
3.8 CAD Data Transfer Media and Format	15
3.9 CAD Media Receipt & Transmittal	16
3.10 Revisions.....	16
3.11 Block Libraries, Blocks, & Block Names.....	17
3.12 CAD Dimensioning	17
3.13 CAD Layering.....	17
3.14 Global origin, Location & Orientation on the Alignment Drawing.....	17
3.15 Line Thickness and Colour	17
3.16 CAD Utilisation of 2D & 3D Files	17
3.17 CAD File Numbering.....	18

3.18	CAD File Naming Convention - General	18
	APPENDIX 5	20
	DESIGN CERTIFICATE	20
	Contractor’s Statement.....	21
	Contractor’s Certification	22
	APPENDIX - 6	23
	SPARES.....	23
6.1	Unit Exchange Spares	23
6.1.1	For details, refer to ‘Annexure-G1’ in ‘Instructions to Tenderers, Annexure ITT-2B, Pricing document’. Prices of spares shall be actual prices and not apportioned prices. The spares shall be delivered at the nominated depots by the Employer. The delivery is linked to the key dates indicated in the notes under Cost Centre ‘G’ of ‘Instructions to Tenderers, Annexure ITT-2B, Pricing document’	23
6.2	Mandatory Spares:	23
6.2.1	For details, refer to ‘Annexure-G2’ in ‘Instructions to Tenderers, Annexure ITT-2B, Pricing document’. Prices of spares shall be actual prices and not apportioned prices. The spares shall be delivered at the nominated depots by the Employer. The delivery is linked to the key dates indicated in the notes under Cost Centre ‘G’ of ‘Instructions to Tenderers, Annexure ITT-2B, Pricing document’	23
	APPENDIX 7.....	25
	DESIGN AND MANUFACTURE INTERFACES	25
1	INTERFACES	25
1.1	General.....	25
1.2	Signalling and Communications Contract:	25
1.3	Railway Electrification, Power Supply Contract	25
1.4	Track Contract	25
1.5	Other Contracts:	25
2	Interface Responsibilities.....	26
3	Scope of Work of Integrated Management Plan.....	27
4	Interfaces between RS15 and BS01 & BS03, BS14 Contracts.....	27
5	Interfaces between RS15 and Rigid OCS Contract.	27
6	Interfaces between RS15 and Flexible OCS Contract	27
7	Interface specification of RS15 and Track Contract.....	27
8	Interface specification between RS15 and Other Contracts.	27
9	Interface between RS15 contractor and existing ‘RS1, RS6, RS13’ Broad gauge supplier “MRM Consortium and M/s BEML/India”	27
	Annexure (I).....	28
	INTERFACE FOR RIGID OCS:.....	28
	Annexure (II)	29
	INTERFACE BETWEEN RS15 AND FLEXIBLE OCS CONTRACT	29
	Annexure (III)	30
	INTERFACE BETWEEN RS15 AND TRACK CONTRACT	30
	Annexure (IV).....	31
	INTERFACE BETWEEN RS15 AND DESIGNATED CONTRACTORS:.....	31
	APPENDIX 8.....	33
	ABBREVIATIONS	33
	APPENDIX 9.....	34
	SUBMITTALS REQUIRED:	34
1.1	Submittals:	34

APPENDIX 1**PROGRAMME****1 Time-Scaled Network/Bar Chart**

- 1.1 All programmes shall be developed by computerised Critical Path Method (CPM) using the Precedence Diagramming Method (PDM) and shall be presented in either bar chart or time-scaled network diagram format, suitably coloured to enable easy reading. All duration for the purpose of programming shall be in calendar days. All reference to network shall mean time-scaled network unless otherwise specified.
- 1.2 Not Used.
- 1.3 The coding structure shall be such that the activities can be summarised to the various levels. Each level shall be summarised and collapsed to the next level using the programming software. The Contractor shall propose essential codes and activity codes to be used for review of the Engineer. The Engineer may require additional activity codes subject only to restrictions imposed by the programming software. Additional codes where necessary may be created by the Contractor with the approval of the Engineer. Each activity in the network shall be coded, as a minimum, with the following:
- (i) Contract number, activity type, and unique identification numbers.
 - (ii) Activity codes to indicate Unit, Segment, Stage or Phase, for e.g. design, manufacturing, delivery, installation, etc.
 - (iii) The Contractor shall note that breakdown of system into sub-systems is essential and shall be carried out not through further coding but through activity descriptions in a consistent manner such as to allow storing. However, the Engineer shall have the right to require the Contractor to code sub-systems, using codes approved by him, if necessary.
 - (iv) Area, location and location details under Activity Code – Unit.
 - (v) Cost and resources
 - (vi) Cost and resources codes shall be submitted for the approval of the Engineer. For tender purposes, the Tenderer shall use his own codes.
- 1.4 All logical and necessary relationships between activities shall be shown.
- 1.5 All key dates indicated in the Contract shall be shown. In addition to the key dates, the Contractor may require certain events that are critical to his work to be reflected in his programmes. These shall be reflected as "milestones". Appropriate activity codes shall be used to distinguish "milestones" from the key dates.
- 1.6 The level of programme development, information and detail shall be sufficient to permit the Engineer to have a good appreciation of the Contractor's project management plan especially with regard to the co-ordination and timing of his work in relation to the work of the other Designated contractors and the obtaining of necessary approvals from the relevant local authorities. It shall demonstrate ability to meet specified key dates through a logical work sequence that has taken account of the Project constraints.
- 1.7 Activities pertaining to review/acceptance by the Engineer and local authorities shall be identified. Where duration for review of the Contractor's submissions are specified elsewhere in the Contract, they shall be used. Where they are not specified, a duration of 30 days for review of each submission shall be used.
- 1.8 Activities outside the scope of the Contract that may affect the Contractor's progress shall be shown.
- 1.9 The activity network shall be organised so that major work sections are carefully co-ordinated with the Civil Contractor and the System-wide Contractors to allow opportunity for all to work with as minimal disruption as possible.

- 1.10 Critical paths shall be identified.
- 1.11 Activity descriptions shall be brief (<48 characters) and shall convey the nature and scope of the work. Uncommon abbreviations shall be explained in the legend. Float time shall be distinguished from schedule performance.
- 1.12 The CPM Network Diagram shall be developed to permit modification to the schedule and allow for impacts on the schedule to be analysed by introduction of "what if" statements into the input data.

2 Time Scaled Network/Bar Chart Details

2.1 Design

The Design network/bar chart shall detail the various design, submission and acceptance stages including approval by local authorities and the Engineer, preparation, submission and approval of drawings, manuals and all other activities related to the design.

2.2 Manufacturing

The manufacturing network chart shall indicate the relationship and duration of the activities necessary to procure, fabricate manufacture, assemble equipment/complete car tests, ship and deliver Rolling Stock in time to support the activities at site. It shall establish milestones for monitoring the progress of the manufacturing process. Major areas of work shall be shown as separate and distinct activities. The network shall also cover activities of Sub-Contractor as appropriate, including testing.

2.3 Testing and Commissioning

The Factory and On Site Testing and Commissioning network/bar chart shall present the relationship and duration of those items relating to Commissioning tests including those related to other Designated Contractors. The network/bar chart shall present testing approach to be used, the deployment of resources in accordance with train delivery dates.

2.4 Instrumentation Tests for Prototype Rake

Instrumentation Tests network/bar chart shall indicate that activities related to Instrumentation Tests, including Oscillation Trials, followed by Statutory approval, on the Prototype Rake including those related to Designated Contractors.

2.5 Integrated Testing

The Integrated Testing network/bar chart shall indicate the activities required to verify the functioning of the Rolling Stock in conjunction with activities of the System-wide and Civil Contractors.

2.6 Service Trials

After completion of Commissioning, the Contractor shall be required to carry out service trials.

The network/chart shall indicate tests, measurements and interface tests required to be carried out to verify system performance and readiness for revenue service

APPENDIX 2**MONTHLY PROGRESS REPORT****1 Contract Stages****1.1 General**

The Contractor shall submit to the Engineer, a Monthly Progress Report. This Report shall be submitted by the end of each calendar month and shall account for all work actually performed from 26th day of the last month and up to and including the twenty-fifth (25th) day of the month of the submission. It shall be submitted in a format to which the Engineer shall have given his consent and shall contain sections/sub-sections for, but not be limited to, the topics listed in clauses 2 to 10 below.

2 Financial Status

- 2.1 A narrative review of all significant financial matters, and actions proposed or taken in respect to any outstanding matters.
- 2.2 A spread sheet summarising each Cost Centre, the budget, costs incurred during the period, costs to date, costs to go, cost forecast (total of costs to date and costs to go) and cost variance (difference between cost forecast and budget).
- 2.3 A spread sheet indicating the status of all payments due and made.
- 2.4 A report on of the status of any outstanding claims. The report shall in particular provide interim updated accounts of continuing claims.

3 Physical Progress

- 3.1 It shall describe the status of work performed, significant accomplishments, including critical items and problem areas, corrective actions taken or planned and other pertinent activities, and shall, in particular, address interface issues, problems and resolutions.
- 3.2 It shall include a simplified representation of progress measured in percentage terms compared with percentage planned as derived from the Works Programme.

4 Programme Update (For Entire Project)**4.1 Programme updating shall include :**

(vii) The monthly Programme Update which shall be prepared by recording actual activity completion dates and percentage of activities completed up to the twenty-fifth (25th) of the month together with estimates of remaining duration and expected activity completion based on current progress. The Programme Update shall be accompanied by an Activity Report and a Narrative Statement. The Narrative Statement shall explain the basis of the Contractor's submittal:

(a) Early Work and Baseline Submittals – explains determination of activity duration and describes the Contractor's approach for meeting required Key Dates as specified in the Contract.

(b) Updated Detail Programme Submittals – state in narrative the Works actually completed and reflected along Critical Path in terms of days ahead or behind allowable dates. Specific requirements of narrative are:

If the Updated Detailed Work Programme indicates an actual or potential delay to Contract Completion date or Key Dates, identify causes of delays and provide explanation of Work affected and proposed corrective action to meet Key Dates or mitigate potential delays. Identify deviation from previous month's critical path.

Identify by activity number and description, activities in progress and activities scheduled to be completed.

Discuss Variation Order Work Items, if any.

(viii) the Programme Status which shall :

- (a) show Works Programme status up to and including the current report period, display Cumulative progress to date and a forecast of remaining work.
- (b) be presented as a bar-chart size A3 or A4 and as a time-related logic network diagram on an A1 media, including activity listings;
- (ix) the Activity Variance Analysis which shall analyse activities planned to start prior to or during the report period but not started at the end of the report period as well as activities started and/or completed in advance of the Works Programme.

5 Milestones Status

- 5.1 A report on the status of all Milestones due to have been achieved during the month and forecasts of achievement of any missed Milestones, and those due in the next month.

6 Three Month Rolling Programme

- 6.1 The monthly issue of the Three Month Rolling Programme.

7 Planning And Co-Ordination

- 7.1 A summary of all planning/co-ordination activities during the month and details of outstanding actions.
- 7.2 A schedule of all submissions and consents/approvals obtained/outstanding.

8 Procurement Report

- 8.1 A summary of all significant procurement activities during the month, including action taken to overcome problems.
- 8.2 A report listing major items of plant and materials, which will be incorporated into the Works. The items shall be segregated by type as listed in the Specifications and the report should show as a minimum the following activities:
 - (i) purchase Order Date - Scheduled/Actual,
 - (ii) manufacturer/Supplier and Origin,
 - (iii) letter of Credit Issued date,
 - (iv) manufacturer/Supplier Ship Date - Scheduled/Actual,
 - (v) method of shipment,
 - (vi) arrival date in India- Scheduled/Actual.

9 Production And Testing

- 9.1 A review of all production and manufacturing activities during the month.
- 9.2 Summaries of all production and manufacturing outputs during the month together with forecasts for the next month.
- 9.3 Review of all testing activities (both at site or at the manufacture's premises) during the month

10. Safety

- 10.1 A review of all safety aspects during the month including reports on all accidents and actions proposed to prevent further occurrence.

11 Environmental

- 11.1 A review of all the environmental issues during the past month to include all monitoring reports, mitigation measures undertaken, and activities to control environmental impacts.

This page is left blank intentionally.

APPENDIX 3

TENDER 'RS15': KEY DATE SCHEDULE

Refer Attachment to Appendix FT-1 of Form of Tender

This page is left blank intentionally.

APPENDIX 4**DRAUGHTING AND CAD STANDARDS****1. Introduction**

- 1.1 The purpose of this document is to define the minimum Draughting and CAD standard to be achieved by the Contractor for all drawings produced by the Contractor for the purpose of the Works.
- 1.2 By defining a common format for the presentations of drawings and CAD files, the exchange of drawn information is improved and will maximise the use of CAD in the co-ordination process.
- 1.3 All submissions shall be made to the Employer's Requirement in a format reviewed without objection by the Employer's Requirement and in accordance with the requirements in:
- (i) The Contract;
- (ii) The Document Submittal Instructions to Consultants and Contractors.
- 1.4 Paper and drawing sizes shall be "A" series sheets as specified in BS 3429.
- 1.5 The following software compatible for use with Intel-Windows based computers shall be used, unless otherwise stated, for the various electronic submissions required:

<u>Document Type</u>	<u>Electronic Document Format</u>
Text Documents	MS office 2007 Professional version
Spread Sheets	MS office 2007 Professional version
Data Base Files	MS office 2007 Professional version
Presentation Files	MS office 2007 Professional version
Programmes Ver 2.0a	Primavera for Windows, Ver. 2.0b, Suretrack
AutoCAD Graphics	AutoCAD 2011
Photographic	Adobe Photoshop, Ver.4.0
Desktop Publishing	Page Maker 6.5,5
CADD Drawings	AutoCAD 2011

The latest versions of the above mentioned Document formats shall be applicable.

- 1.6 Media for Electronic File Submission
One copy shall be submitted unless otherwise stated in CD-ROM.
- 1.7 Internet File Formats/Standards
- (i) The following guidelines shall be followed when the Contractor uses the Internet browser as the communication media to share information with the Employer.
- (ii) All the data formats or standards must be supported by Microsoft Internet Explorer version 3 or above running on Windows NT and Windows 7 and/or upgraded version.
- (iii) The following lists the file types and the corresponding data formats to be used on the Internet. The Contractor shall comply with them unless prior consent is obtained from the Employer's Requirement for a different Data format :

File Type	Data Format
Photo Image	Joint Photographic Experts Group (JPEG)
Image other than Photo	GIF or JPEG
Computer Aid Design files (CAD)	Computer Graphics Metafile (CGM)
Video	Window video (.avi)
Sound	Wave file (.wav)

- 1.8 The following states the standards to be used on Internet when connecting to database(s). The Contractor shall comply with them unless prior consent is obtained from the Employer's Requirement for a different standard :

Function to be Implemented	Standard to be Complied With
Database connectivity	Open Database Connectivity (ODBC)
Publishing hypertext language on the World Wide Web	Hypertext Markup Language (HTML)

The hard copy of all documents shall be the contractual copy.

2. General Requirements

2.1 General

- 2.1.1 The Contractor shall adopt a title block similar to that used in the Drawings for all drawings prepared under the Contract.
- 2.1.2 Each drawing shall be uniquely referenced by a drawing number and shall define both the current status and revision of the drawing.
- 2.1.3 The current status of each drawing shall be clearly defined by the use of a single letter code as follows:
- (i) P - Preliminary Design Drawing
 - (ii) D - Definitive Design Drawing
 - (iii) C - Construction Reference Drawing
 - (iv) W - Working Drawing
 - (v) B - As-Built Drawing
 - (vi) M - As Manufactured Drawing
 - (vii) E - Employer's Drawing

2.2 Drawing Numbering System

- 2.2.1 A suitable drawing numbering systems shall be evolved by the contractor and submitted to Engineer for his review. It shall present unique numbers and take care of revisions.

2.3 Types of Drawing

- 2.3.1 'Design drawings' mean all drawings except shop drawings and as-built drawings.
- 2.3.2 'Working drawings' are design drawings of sufficient detail to fully describe the Works and adequate to use for construction or installation.
- 2.3.3 Site drawings and sketches' are drawings, often in sketch form, prepared on site to describe modifications of the Working drawings where site conditions warrant changes that do not invalidate the design.
- 2.3.4 'Shop drawings' are special drawings prepared by the manufacturer or fabricator of various items within the Works to facilitate manufacture or fabrication.
- 2.3.5 'As-built drawings' show the Works exactly as constructed or installed. They are usually prepared by amending the working drawings to take into account changes necessitated by site conditions and described in Site drawings. These drawings shall be completed on a regular basis as the works progress, and shall not be left

until completion of the entire works.

3 Computer Aided Design & Draughting (CAD) Standards

3.1 Introduction

3.1.1 Scope of Use

Data input procedures between the Engineer and contractors must be co-ordinated, and the key parameters used to form CAD data files must be standardised. The production of all CAD data files shall comply with the following requirements.

3.2 Objectives

3.2.1 The main objectives of the CAD standards are as follows:

- (i) To ensure that the CAD data files produced for Project are co-ordinated and referenced in a consistent manner.
- (ii) To provide the information and procedures necessary for a CAD user from one discipline or external organisation to access (and use as background reference), information from a CAD data file prepared by another discipline or external organisation.
- (iii) To standardise the information contained within CAD data files which may be common to more than one discipline such as drawing borders, title boxes, grid lines etc.
- (iv) To establish procedures for the management of CAD data files.
- (v) To ensure all contractors use 'Model space' and 'Paper space' in the production of their CAD files'.

3.3 General

- 3.3.1 To facilitate co-ordination between contractors, it is a requirement that all drawings issued by contractors for co-ordination or record purposes shall be produced using CAD methods. Drawings shall be issued in digital format in addition to the paper copies.
- 3.3.2 The intent of the issue of digital information is to aid the related design by others. The definitive version of all drawings shall always be the paper or polyester film copies which have been issued by the contractor or organisation originating the drawing.
- 3.3.3 Drawings and drawing packages issued for co-ordination, record purposes or for acceptance shall be accompanied by a complete set of the corresponding CAD data files.
- 3.3.4 Any contractor or organisation making use of the CAD data from others shall be responsible for satisfying himself that such data is producing an accurate representation of the information on the corresponding paper drawing which is satisfactory for the purpose for which he is using it. Provided the general principles of this section have been achieved by the originator of the CAD data, contractors making use of the CAD data from others shall not be entitled to require alterations in the manner in which such CAD data is being presented to them.
- 3.3.5 In particular, automatic determination of physical dimensions from the data file shall always be verified against the figured dimensions on the paper or polyester drawings. Figured dimensions shall always be taken as correct where discrepancies occur.

3.4 Terminology & Associated Standards / Guidelines

- 3.4.1 Any terminology used within this section that is ambiguous to the user shall be clarified with the Employer's Requirement. British Standard BS1192 is used in principle as a guide for drawing practice, convention, CAD data structure and

translation.

3.5 Paper Drawings

- 3.5.1 For the Project “Paper” drawings are considered to be the main vehicle for the receipt and transmittal of design and production information, typically plans, elevations and sections.
- 3.5.2 The Project wide accepted media for the receipt and transmittal of “Paper” drawings will be paper and polyester film of various standard ISO ‘A’ sizes. The composition of this information shall be derived from a CAD “Model”.
- 3.5.3 The CAD derived “Paper” drawing composition will reflect a window of information contained within a CAD “Model Space” file together with a selection of information contained within the associated CAD “Paper Space” file.

3.6 CAD Data Creation, Content & Presentation

- 3.6.1 A consistent method of CAD data creation, together with content and presentation is essential. The method of CAD “Model Space and Paper Space” creation is as follows:

(i) Model Space Files

Typically CAD “Model Space” files are required for general arrangement and location plans and will consist of a series of other “Model Space” referenced CAD files covering the total design extents at a defined building level (the number of referenced files should be kept to an absolute minimum). Data contained within a CAD “Model Space” files is drawn at full size (1:1) and located at the correct global position and orientation on the Project Grid / or defined reference points.

Each CAD “Model Space” file will relate to an individual discipline. Drawing border / text, match / section lines or detailed notation shall NOT be included within a CAD “Model Space” file. Dimensions shall be included within a CAD “Model Space” but located on a dedicated layer. Elevations, Long Sections and Cross Sections shall also be presented in CAD “Model Space” as defined above, but do not need to be positioned and orientated on the Project Grid.

(ii) Paper Space CAD Files

Paper Space” CAD files are utilised to aid the process of plotting “Paper” drawings and are primarily a window of the CAD “Model Space” file. A “Paper Space” CAD file will typically contain drawing borders, text, match or section lines & detailed notation. Once these files are initially set up and positioned, the majority of “Paper Drawing” plots at various approved scales are efficiently and consistently generated by displaying different combinations of element layers and symbology contained within the “Paper Space” file and the referenced “Model Space” files.

The purpose is to ensure that total co-ordination is achieved between the CAD “Model Space” file and the “Paper Drawing” output during the revision cycle of the design and production process. Duplicated data in “Model and Paper Space” files will not be acceptable unless an automatic update link exists between the two data sets. “Paper Space” files are not typically required as part of the CAD Media Receipt from contractors, unless specifically requested.

3.7 CAD Quality Control Checks

- 3.7.1 Random CAD Quality Control Audits will be carried out by Engineer on all CAD media received and transmitted.
- 3.7.2 These checks DO NOT verify the technical content of the CAD data received or transmitted (as this is the responsibility of the originating organisation), however compliance with Project CAD and Draughting Standards shall be checked.
- 3.7.3 In addition, all contractors who transmit and receive CAD data from the Project shall have CAD quality control procedures in place. A typical quality control procedure shall contain CAD data quality checking routines coupled with standards for CAD data transmittal and archiving.

3.8 CAD Data Transfer Media and Format

- 3.8.1 When CAD data is received & transmittal between Engineer and the Contractor, the media shall be as follows:
- (i) Data Exchange Format - Autocad Release 14 (.DWG).
 - (ii) Operating System - / Window NT 3.51 /Windows 7 and/or upgraded version.
 - (iii) Data Transfer Media : DVDs/Hard disc/better
 - (iv) All media shall be submitted with a completed Form (CAD Disk/Tape Sheet).
 - (v) The Contractor must ensure the supplied media is free from virus.
 - (vi) Sub-directories on tapes or disks are not permitted. If CAD Data is created using UNIX, archive commands must be unrooted.

3.9 CAD Media Receipt & Transmittal

- 3.9.1 CAD Media Transmittal (from the Contractor to Engineer) - this will consist of the following:
- (i) CAD Digital Media (disk(s), CD's or tape (s)) shall typically contain CAD "Model Space" and "Paper Space" files.
 - (ii) CAD data sheet
 - (iii) CAD issue / revision sheet
 - (iv) CAD Quality Checklist confirming compliance.
 - (v) Plot of each "Model Space" file issued on an A1 drawing sheet (to best fit).
- 3.9.2 The above CAD media will be collectively known as "CAD Media Transmittal Set". The CAD data file transmittal format required by Engineer from all contractors shall be in AutoCAD.
- 3.9.3 All CAD media received from contractors will be retained by Engineer except for SCSI disk (if used) as an audit trail / archive of a specific contractor's design evolution.
- 3.9.4 CAD Media Receipt (from Engineer to the Contractor)
- (i) CAD media should normally be obtained from the respective Designated contractor(s), but should Engineer issue CAD media it will consist of the following:
 - (a) CAD Digital Media (disk (s) or tape (s)) typically contain only CAD "Model Space" files.
 - (b) CAD data sheet.
 - (c) CAD issue / revision sheet
 - (ii) The above CAD media will be collectively known as the "CAD Media Receipt Set". The CAD data file transmittal format used by Engineer to all contractors will be in AutoCAD version as stated in clause 1.5.
 - (iii) Each CAD transmittal disk / tape will be labelled with proper disk label as approved by the Engineer. Any CAD data transmitted without this label is assumed to be provisional information not to have been quality checked and therefore not formally issued.

3.10 Revisions

- 3.10.1 All 'Revisions', 'In Abeyance' and 'Deletions' shall be located on a common layer. This layer can be turned on or off for plotting purposes.
- 3.10.2 The following example text indicates the current CAD file revision, i.e. 'Revision [A]'. This shall be allocated to a defined layer on all CAD "Model Space" files, in text of a size that will be readable when the CAD "Model Space" file is fitted to the screen, with all levels on.

3.11 Block Libraries, Blocks, & Block Names

- 3.11.1 All Construction Industry symbols produced as CAD Cells shall typically conform to British Standard BS1192 - part 3.
- 3.11.2 All Blocks created shall be Primitive (i.e. NOT Complex) and shall be placed Absolute (i.e. NOT Relative).
- 3.11.3 The Contractor's specific block libraries shall be transmitted to Engineer together with an associated block library list containing the filename (max. 6 characters) and block description. The Contractor shall ensure that the library is regularly updated and circulated to all other users, together with the associated library listing.
- 3.11.4 All Blocks of a common type, symbols or details should initially be created within a CAD "Model Space File" specifically utilised for that purpose. These files will be made available on request by Engineer.
- 3.11.5 All Blocks created will typically be 2D unless 3D is specifically requested. In both instances they shall have an origin at a logical point located within the extents of each Block's masked area or volume.

3.12 CAD Dimensioning

- 3.12.1 Automatic CAD Dimensioning will be used at all times. Any dimensional change must involve the necessary revision to the model space file. If the CAD Quality Control Checks find that the revisions have not been correctly carried out, the rejection of the entire CAD submission will result.

3.13 CAD Layering

- 3.13.1 All CAD elements shall be placed on the layers allocated for each different discipline. The layer naming convention to be adopted by the Contractor shall be submitted for acceptance and inclusion within these standards.

3.14 Global origin, Location & Orientation on the Alignment Drawing.

- 3.14.1 Location or Plan information in "Model Space" files shall coincide with the correct location and orientation on the Project grid for each specific contract.
- 3.14.2 Location plans shall have at least three setting out points shown on each CAD "Model Space" file. Each setting out point shall be indicated by a simple cross hair together with related Easting and Northings co-ordinates. The Civil Contractor(s) will establish the three setting out co-ordinates for their respective works, which will then be used by all other contractors including the Contractor.

3.15 Line Thickness and Colour

- 3.15.1 To assist plotting by other users, the following colour codes will be assigned to the following line thickness / pen sizes.

Colour	Code No.	Line Thickness
Red	10	0.18
White	7	0.25
Yellow	2	0.35
Brown	34	0.5
Blue	130	0.7
Orange	30	1.0
Green	3	1.4
Grey	253	2.0

3.16 CAD Utilisation of 2D & 3D Files

- 3.16.1 Although the project standard is 2D CAD files, certain disciplines and contractors may use 3D CAD files for specific applications or where the isolated use of 3D aids the design and visualisation process (i.e. Architecture, Survey and Utilities). In these specific instances 3D CAD data will only be transmitted if all other users can use this data. If this is not the case, a 3D to 2D translation shall be processed by the creator prior to issue.

3.17 CAD File Numbering

3.17.1 Contractors CAD File Numbering shall be described in 2.2 above.

3.17.2 Employer CAD File Numbering Unlike most of the contractors, Employer will not be required to produce numerous CAD files. This will follow the numbering system Except that the status of the drawing in 2.1(3) shall be "E".

3.18 CAD File Naming Convention - General

3.18.1 CAD "Model Space" files shall be named in accordance with general drawing conventions.

This page is left blank intentionally.

APPENDIX 5

DESIGN CERTIFICATE

This Design Certificate refers to Submission No. which comprises:

[description of the Works to which the submission refers]

The contents of this submission are scheduled in Section A below.

Section A : Submission No. comprises the following :

Drawings : *(Title, drawing number and revision)*

Other : *(Title, reference number and revision)*

(i)

(ii).

(iii)

(iv)

etc.

The documents scheduled in Section B below, for which a Notice of No Objection has been issued, are of relevance to this submission.

Section B : Documents for which a Notice of No Objection has been issued and which are of relevance to this Submission No.

Item Reference: *(Title, reference number and revision)*

(i)

(ii).

(iii)

(iv)

etc.

Contractor’s Statement

We certify that :

(a) the design of the Works, as illustrated and described in the documents scheduled in Section A above, complies with the Employer’s Requirements General /Technical Specification

Clause.....

Covering.....
.....
.....

(b) an in-house check has been undertaken and completed to confirm the completeness, adequacy and validity of the design of the Permanent Works as illustrated and described in the documents scheduled in Section A below;

(c) all necessary and required approvals relating to the design of the Works, as illustrated and described in the documents scheduled in Section A, above have been obtained and copies of such approvals are annexed in Section C below;

(d) all effects of the design comprising the submission on the design of adjacent or other parts of the Works have been fully taken into account in the design of those parts.

Name.....

Position/ Designation.....

Date.....

Signed by Contractor’s Authorised Representative

Contractor’s Certification

This Certifies that all design has been performed utilizing the skill and care to be expected of a professionally qualified and competent designer, experienced in work of similar nature and scope. This further certifies that all works relating to the preparation, review, checking and certification of design has been verified by us.

	Name
	(for Contractor)
	Position/Designation
Signed by ‘Authorized Representative’	Date

Note 1

The Contractor shall insert one of the following, as applicable :

- (i) the Contractor’s Technical Proposals

- (ii) the Contractor’s Technical Proposals and Design Packages Nos. for which a Notice of No Objection has been issued.

- (iii) Design Packages Nos. for which a Notice of No Objection has been issued if such Design Packages develop and amplify the Contractor’s Technical Proposals.

- (iv) The Definitive Design

Section C

[Contractor to attach copies of necessary and required approvals]

- (i)
- (ii).
- (iii)
- (iv)
- etc.

APPENDIX - 6

SPARES

6.1 Unit Exchange Spares

6.1.1 For details, refer to 'Annexure-G1' in 'Instructions to Tenderers, Annexure ITT-2B, Pricing document'. Prices of spares shall be actual prices and not apportioned prices. The spares shall be delivered at the nominated depots by the Employer. The delivery is linked to the key dates indicated in the notes under Cost Centre 'G' of 'Instructions to Tenderers, Annexure ITT-2B, Pricing document'.

6.2 Mandatory Spares:

6.2.1 For details, refer to 'Annexure-G2' in 'Instructions to Tenderers, Annexure ITT-2B, Pricing document'. Prices of spares shall be actual prices and not apportioned prices. The spares shall be delivered at the nominated depots by the Employer. The delivery is linked to the key dates indicated in the notes under Cost Centre 'G' of 'Instructions to Tenderers, Annexure ITT-2B, Pricing document'.

This page is left blank intentionally.

APPENDIX 7

DESIGN AND MANUFACTURE INTERFACES

1 INTERFACES

1.1 General

1.1.1 The Contractor shall interface the design, manufacture, supply covering with that of other contractors, principally the Contractors for the Designated Contracts as defined in the General Conditions of Contract. The Contractor shall keep the Engineer fully informed in respect of such interfaces, such information being given to the Engineer in a manner and form and at such intervals as stated in the Contract or as required by the Engineer.

Major Designated Contractors for the RS15 Contract are mentioned below.

1.2 Signalling and Communications Contract:

1.2.1 For Phase-II (BG) of DMRTS the work of providing signalling and train control systems and telecommunications systems for different lines, relevant to Contract RS15 will be done under the following contracts:

- (i) BS01 & BS03 : For Signalling and Communications works train control for Line # 2 (Huda City Center – Jahangir Puri) and Jahangir Puri - Badli, Line # 3 (Dwarka 21 to Noida City Center) and Line # 4 (Yamuna Bank Depot – Vaishali)
- (ii) BS14: For Train Radio works for Phase-III Telecommunications for entire system for Phase-III of Delhi MRTS.
- (iii) GS01: For Signalling and Communications works train control systems Line#1 (Rithala – Ghaziabad New Bus Adda).
- (iv) CS10: For Signalling and Communications works train control systems Line#3 (Dwarka Sector-21 to Noida Sector–62).

1.3 Railway Electrification, Power Supply Contract

1.3.1 For the two corridors on BG, for flexible overhead 25 kV ac 50 Hz traction power, receiving, traction & auxiliary substation equipment, AC switchgear, transformers, auxiliary power equipment, power cables and SCADA are planned to be under one contract.

1.3.2 For rigid overhead 25 kV ac 50 Hz traction power, AC switchgear, transformers, auxiliary power equipment and power cables for under ground another contract is planned.

1.3.3 A detailed design consultant may also be engaged by DMRC for the design of works.

1.3.4 The details of these contracts and contractors shall be made available during the execution of the contract RS15.

1.4 Track Contract

1.4.1 For these corridors on BG, detailed design consultants, if any, and construction contractors for the tracks works for the elevated corridor and under ground corridor shall be advised during the execution of the contract RS15.

1.4.2 DMRC may also procure the Head Hardened Rails and Fastenings and a contractor may be engaged for design and supply turnouts and Rail Expansion Joints (REJ).

1.5 Other Contracts:

1.5.1 Besides above there are several designated contractors who would need the information regarding the design features and other parameters of the Rolling Stock. Their contracts shall have the provisions to interface directly with RS15 Contractor for the exchange of information. A list of contractors and contracts is

provided in the tender documents at **appendix-7**. It is not exhaustive and many more contractors shall be added. RS15 contractor shall do the required interface with them as and when required.

2 Interface Responsibilities

- 2.1 The responsibility for specification and provision of the requirements for the works that interface with Designated Contractors' equipment are tabulated in this appendix.
- 2.2 This Appendix describes the interface requirements between Designated Contractors with Contract RS15.
- 2.3 This Appendix shall be read in conjunction with the relevant clauses of the Employer's Requirements including the General Specifications and Technical Specifications. The RS15 Contractor shall be responsible for ensuring that all requirements of the specifications pertaining to interfaces are satisfied.
- 2.4 The requirements specified herein are by no means exhaustive and it remains the Contractors' responsibilities to develop and execute jointly an Interface Plan after the commencement of the works and throughout the execution of works, to ensure that:
 - (i) all interfacing issues between the two Contracts are satisfactorily resolved;
 - (ii) supply, installation and testing of equipment and software are fully co-ordinated; and
 - (iii) that all equipment supplied under the Contracts are fully compatible with each other, whilst meeting the requirements of the respective Specifications.
- 2.5 Notwithstanding the requirements described elsewhere in the Contract regarding document precedence the provisions contained in the drawings and elsewhere in the Employer's Requirements shall prevail over the provisions contained in this Appendix.
- 2.6 This Appendix outlines the interfacing requirements during the execution of the Works. However the requirements herein specified are by no means exhaustive and it remains the RS15 Contractor's responsibility to develop, update and execute jointly an Interface Management Plan after the commencement of the Works and throughout the execution of the Works to ensure that:
 - (i) all interface issues between RS15 and the Designated Contractors are satisfactorily identified and resolved; and
 - (ii) all the construction tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points.
- 2.7 Where details of the RS15 design are required to enable the Designated Contractor to implement interface works, the RS15 Contractor shall provide the Designated Contractors with the necessary information including, but not necessarily limited to, those described in the summary table appended to this requirement. The level of information provided shall be in sufficient detail to enable the Designated Contractors to design and / or construct the required interface work.
- 2.8 The RS15 Contractor shall take a lead in developing the Interface Management Plan. (IMP), which will be prepared in conjunction with the Designated Contractors to cover all aspects of the implementation of the interface works required. The Plan will define the interface works necessary to complete all the works in this contract and may not be limited to those listed in the summary table attached.
- 2.9 The IMP shall be fully conforming with the Works Programme and shall, in respect of the Contractor and each of the Designated Contractors, show and be

in logical agreement with Key Dates and Handover Dates for Rolling Stock. The IMP shall indicate dates for the commencement and completion of each principal activity by each contractor, and delivery and installation of principal items of equipment.

- 2.10 The IMP shall be submitted by the Contractor to the Engineer, in a preliminary form, as per schedule furnished in table 2-A. Thereafter, the IMP shall be updated by the Contractor at regular intervals, not exceeding twenty eight days, agreed with Designated Contractors and submitted to the Engineer. Should it appear to the Engineer that the progress of the Works, Works Programme or the Three Month Rolling Programme does not conform with the IMP, the Contractor shall be required to revise all such programmes and plans such that they do reflect that are progress of the Works is mutually consistent and conforms to other provisions of the Contract.
- 2.11 The RS15 Contractor shall review the details of interface works and notify the Engineer of any amendments to the summary table required in the process of his works. Unless such requests are reviewed without objection by the Engineer, the RS15 Contractor shall design and construct the RS15 works in accordance with the provisions outlined in this Appendix and the attached summary table.

3 Scope of Work of Integrated Management Plan

- 3.1 The information and scope of works to be provided by the RS15 Contractor include but may not necessarily be limited to those outlined in the attached summary table. This table only defines those tasks at the interface point and is not a complete itemisation of the Scope of Work.
- 3.2 The Designated Contractors shall liaison with the RS15 Contractor in the design, installation, testing and acceptance of the RS15 Works.
- 3.3 The RS15 Contractor shall provide all access and attendance necessary in accordance with the Contract requirements to enable the Designated Contractors to complete those activities defined under the summary table attached to this interface specification in a timely manner.
- 3.4 Where RS15 Contractor works are identified as failing to meet the requirements of the Contract and which will impact the Designated Contractor's works, the RS15 Contractor shall submit the proposed remedial measures to the Engineer's Representative for review and shall copy the same to the Designated Contractors.

4 Interfaces between RS15 and GS01, CS10, BS01 & BS03, BS14 Contracts.

This has been defined in the Appendix-TD of Employer's Requirements - Technical Specification.

5 Interfaces between RS15 and Rigid OCS Contract.

This has been defined in the annexure-(i)

6 Interfaces between RS15 and Flexible OCS Contract

This has been defined in the annexure-(ii)

7 Interface specification of RS15 and Track Contract

This has been defined in the annexure-(iii)

8 Interface specification between RS15 and Other Contracts.

This has been defined in the annexure-(iv).

9 Interface between RS15 contractor and existing 'RS1, RS6, RS13' Broad gauge supplier "MRM Consortium and M/s BEML/India"

The 'RS15' contractor has to interface with existing 'RS1, RS6 & RS13' Broad gauge train supplier "MRM Consortium and M/s BEML/India" and comply the ERTS clause 1.1.8 , 1.1.9 and 2.2.7.

ANNEXURE (I)

INTERFACE FOR RIGID OCS:

Interface between Rolling Stock Contractor RS15 & Rigid OCS, Power Supply Designer and Construct Contractor for under ground Corridor

- 1 These shall include the following but not limited to:

Item No.	Subject	RS15 Responsibilities	OCS and Power Supply Contractor's Responsibilities
1	Size and types of conductor wires	to incorporate into the design of the Pantograph	shall provide information to RS15 Contractor.
2	Contact wire tension	to incorporate into the design of the Pantograph	shall provide information to RS15 Contractor.
3	Arrangement of the Overhead Line System and sectioning	to incorporate into the design of the Pantograph	shall provide information to RS15 Contractor.
4	Detailed drawings of pantograph and pantograph head	shall provide information to designated Contractor.	to incorporate into the design of the OHE System
5	Material of pantograph contact strip	shall provide information to designated Contractor	to incorporate into the design of the OHE System
6	Detailed masses, springing and damping of pantograph	shall provide information to designated Contractor	to incorporate into the design of the OHE System
7	Pantograph sway calculations	shall provide information to designated Contractor	to incorporate into the design of the OHE System
8	Details of harmonic contents of rolling stock power supply	shall provide information to designated Contractor	to incorporate into the design of the OHE System
9	Maximum traction return	shall provide information to designated Contractor	to incorporate into the design of the OHE System
10	Harmonic Limitations of power supply.	to incorporate into the design of the Pantograph	shall provide information to RS15 Contractor.

ANNEXURE (II)**INTERFACE BETWEEN RS15 AND FLEXIBLE OCS CONTRACTOR****Interface between Rolling Stock Contractor RS15 and Flexible OCS, Power Supply Construct Contractor for At-grade and Elevated Corridors**

1 These shall include the following but not limited to:

Item No.	Subject	RS15 responsibilities	Flexible OCS Contractor's Responsibilities
1	Size and types of conductor wires	to incorporate into the design of the Pantograph	shall provide information to RS15 Contractor.
2	Contact wire tension	to incorporate into the design of the Pantograph	shall provide information to RS15 Contractor.
3	Arrangement of the Overhead Line System and sectioning	to incorporate into the design of the Pantograph	shall provide information to RS15 Contractor.
4	Detailed drawings of pantograph and pantograph head	shall provide information to designated Contractor.	to incorporate into the design of the OCS System
5	Material of pantograph contact strip	shall provide information to designated Contractor	to incorporate into the design of the OHE System
6	Detailed masses, springing and damping of pantograph	shall provide information to designated Contractor	to incorporate into the design of the OCS System
7	Pantograph sway calculations	shall provide information to designated Contractor	to incorporate into the design of the OCS System
8	Details of harmonic contents of rolling stock power supply	shall provide information to designated Contractor	to incorporate into the design of the OCS System
9	Maximum traction return	shall provide information to designated Contractor	to incorporate into the design of the OCS System
10	Harmonic Limitations of power supply.	to incorporate into the design of the Pantograph	shall provide information to RS15 Contractor.

ANNEXURE (III)

INTERFACE BETWEEN RS15 AND TRACK CONTRACTOR

Interface between Rolling Stock Contractor RS15 and Track Turnout Designer and Construct Contractor:

1 These shall include the following but not limited to:

Item No	Subject	RS15 Responsibilities	Designated Contractor's Responsibilities
1	Kinematic Envelope	RS15 shall incorporate in his design.	RS15 Contractor shall provide the Designated Contractor with the RS Kinematic Envelope.
2	Track Alignment drawings	RS15 shall use the information for his design and train running simulation.	Designated Contractor shall provide the RS15 Contractor, with the detailed Track alignment drawings.

2 If a DDC is engaged for the design of the track, RS15 contractor shall interface with the DDC.

ANNEXURE (IV)

INTERFACE BETWEEN RS15 AND DESIGNATED CONTRACTORS:

- i. These shall include the following but not limited to:

Item No	Subject	RS15 Responsibilities	Other Contractors
1	Rolling Stock Details	RS15 shall provide the relevant details of Rolling Stock as per his design.	Other contractors shall design their systems compatible to the Rolling Stock parameters provided to them.

2 Interface with Detailed Design Contractor(s) for Depot(s)

Engineer with experience and help of DDC will design the facilities in depots and workshops. This interface is to improve it further to meet the requirements.

Item	Subject	RS15 responsibilities	Engineer / Depot Design Contractor's Responsibilities
1	Requirement for commissioning and testing of cars	Review the planning by Engineer and DDC and define the minimum facilities required for commissioning and testing the cars in the depot.	Based on Engineer's broad design and review of RS15, DDC shall design the infrastructure facilities for commissioning and testing of cars in nominated Depot(s).
2	EMU Maintenance requirement	Shall furnish the maintenance schedules and equipment requirement for complete cars, assemblies and subassemblies systems and sub systems.	DDC shall design the Depot maintenance facilities including all depot buildings, to suit RS15 requirement
3	Plant and Machinery, test panels, tools and instruments etc.	Supply all special tools/test panels suitable for the rolling stock to be supplied.	Engineer shall design and develop specification for supply and commissioning of General-purpose plant and machinery, tools and instruments at Depot.
4	Store facilities for important items of Rolling Stock.	Shall furnish the special requirements for storage and the quantities for storage.	DDC shall design the store facilities for assemblies, sub assemblies, capital spares etc. at Depot.

3 Interface with Designated Depot Construct Contractor (s)

Item	Subject	RS15 responsibilities	Depot Construction Contractor's
------	---------	-----------------------	---------------------------------

No.			Responsibilities
1	Requirement for commissioning and testing of cars	Define the minimum facilities required for commissioning and testing the cars in the depot.	Shall construct the facilities for commissioning and testing of cars in nominated Depot to meet the commissioning schedule of RS15.
2	EMU Maintenance requirement	Shall furnish the maintenance schedules and equipment requirement for complete cars, assemblies and subassemblies systems and sub systems.	Shall construct the facilities (except certain maintenance equipments) needed to meet the maintenance needs as advised by RS15.
3	Plant and Machinery, test panels, tools and instruments etc.	Supply all special tools/test panels suitable for the rolling stock to be supplied.	Incorporate structural provision and Electrical and mechanical provisions for all Machinery and Plant. Supply and installation of machinery and plant.
4	Store facilities for important items of Rolling Stock.	Shall furnish the special requirements for storage and the quantities for storage.	Shall construct the store facilities

In order to perform the work, the contractor will be required to communicate directly with Engineer. The contractor will record the details of all these meetings, and provide a copy to Engineer. The contractor will also give the notice for meetings with sufficient time to enable Engineer to attend these meetings.

Engineer will provide the contractor with authorization; assistance and the support of its own personnel should the contractor request Engineer to intervene on its behalf with such meetings.

APPENDIX 8**ABBREVIATIONS**

Sl. No.	Abbreviation	Description
1	A0, A6	International Document Paper Sizes
2	a.c.	Alternating Current
3	AGC	Associated General Contractors
4	ATO	Automatic Train Operation
5	ATP	Automatic Train Protection
6	BS	British Standard (s) (Institution)
7	CAD	Computer Aided Design and Draughting
8	CPM	Critical Path Method
9	CR	Contractor Representative
10	DC	Direct Current
11	DCA	Design Certificate Application
12	DCC	Design Certificate (of) Consent (Sheet)
13	DLP	Defect Liability Period
14	DRCA	Design Review Certificate Application
15	EMC	Electro-Magnetic Compatibility
16	EMU	Electric Multiple Unit
17	EN	European Standards (Organization)
18	GCC	General Condition of Contract
19	Hz	Hertz(Frequency)
20	ISBT	Inter –State with Bus Terminus
21	ISO	International Standards Organization (Standard)
22	MRTS	Metro Rail Transport System
23	NTP	Notice To Proceed
24	OCS	Over-head Catenary system
25	OEM	Original Equipment Manufacturer
26	OSR (S)	Operational Safety Report (Software)
27	PDM	Precedence Diagramming Method
28	RAM	Reliability availability and maintainability
29	RDSO	Research, Design and Standard Organization
30	RS	Rolling Stock (Passenger Cars)
31	SECP	Software Engineering Change Proposal
32	SCC	Special Condition of Contract
33	SI	International System (of Metrication)
34	SI	Static Inverter
35	V	Volts
36	VCB	Vacuum Circuit Breaker
37	VCR	Video Cassette Recorder
38	VVVF	Variable voltage variable frequency

APPENDIX 9

SUBMITTALS REQUIRED:

1.1 Submittals:

Following plans & other details as required by Employer's Requirements: General Specifications, shall be submitted by the tenderers along with the bids.

Table 9A: Submissions

Sl no.	Description	GS Clause reference
1	Project Management Plan	2.2.2
2	Works Plan: a. Works programme b. Design submission programme	2.4.1
3	Outline Quality Plan	2.5.1
4	Outline Safety Plan	2.7.1
5	Environmental Plan	2.11.1
6	Scheduling approach to the design, manufacture, testing and commissioning, integrated tests	4.2.1
7	Works Programme in the Tender shall be accompanied by a narrative statement	4.2.2
8	Recommended list of consumable spares	8.3.3
9	Deleted	
10	Deleted	
11	Deleted	
12	Deleted	
13	List of commissioning and DLP spares	8.11.1
14	Deleted	

DELHI METRO RAIL CORPORATION LIMITED

MASS RAPID TRANSPORT SYSTEM – PHASE III

**DESIGN, MANUFACTURE, SUPPLY, TESTING AND COMMISSIONING OF
80 No. BROAD GAUGE CARS COMPATIBLE WITH EXISTING 'RS1' TYPE
TRAINS SUPPLIED BY MRM CONSORTIUM**

TENDER 'RS15'

(VOLUME 3)

• EMPLOYER'S REQUIREMENTS- TECHNICAL SPECIFICATIONS

EMPLOYER'S REQUIREMENTS: TECHNICAL SPECIFICATION

CONTENTS

CHAPTER 1	10
1.1 Scope.....	11
1.2 Prototype Train/Unit	12
CHAPTER 2	15
2.1 General.....	16
2.2 Interface Activities.....	16
2.3 Quality Assurance	17
2.4 System Safety Assurance	17
2.5 Hazard Analysis.....	17
2.6 Fail Safe Design.....	19
2.7 Reliability, Availability and Maintainability: General	20
2.8 Reliability Requirements	21
2.9 Reliability Demonstration.....	23
2.10 Availability Requirements.....	24
2.11 Availability Demonstration	25
2.12 Maintainability Requirements	25
2.13 Maintainability Demonstration	28
2.14 Maintenance.....	28
2.15 Electro-Magnetic Compatibility: General	29
2.16 Intra-system EMC	30
2.17 Inter-system EMC	30
2.18 Safety-related Systems Interference	30
2.19 Non-Safety-Related System Interference.....	31
2.20 Environmental EMC.....	31
2.21 Installation and Mitigation Guidelines	31
2.22 Noise and Vibration	31

2.23	Fire Performance	34
2.24	Life Cycle Cost.....	35
CHAPTER 3		37
3.1	Scope	38
3.2	Proven Design.....	38
3.3	Basic Design Philosophy & Requirements	38
3.4	Design Management and Control.....	39
3.5	System Integration Process	40
3.6	Interface Management.....	40
3.7	Design Submission Requirements	40
3.8	Design Review.....	40
3.9	Employer's Design Audit.....	41
3.10	Climatic and Environmental Conditions	41
3.11	Flood Proofing	42
3.12	Tunnel Diameter.....	42
3.13	Line Profile.....	42
3.14	Track Structure Parameters.....	42
3.15	Track Tolerances.....	44
3.16	Interface.....	44
3.17	Current Collection System.....	45
3.18	Signalling System	45
3.19	Telecommunication System	45
3.20	Kinematic Envelope	45
3.21	Train Performance	46
3.22	Car Weights And Passenger Capacity	47
3.23	Train Resistance.....	47
3.24	Wheel Diameters	48
3.25	Performance Requirements	48
3.26	Emergency Operating Condition	50
3.27	Specific Energy Consumption	50

3.28	Ride Performance	50
3.29	Ride Index	50
CHAPTER 4		<u>53</u>
4.1	General	54
4.2	Mock-ups - General	54
4.3	Static Vehicle Profile (Kinematic Envelope).....	54
4.4	Materials.....	55
4.5	Car Weight and Passenger Capacity	55
4.6	Car Body Strength.....	55
4.7	Equipment and Equipment Mounting.....	56
4.8	Crashworthiness	56
4.9	Under Floor Equipment Mounting	57
4.10	Couplers and Draft-gear	57
4.11	Car Exterior	58
4.12	Cab Front End Exterior.....	59
4.13	Driver's Cab.....	59
4.14	Saloon Interior.....	60
4.15	Inter-Car Gangways	63
4.16	Car Roof and Roof Mounted Equipment	65
CHAPTER 5		<u>67</u>
5.1	General Requirements and Features.....	68
5.2	Dynamic Requirements	68
5.3	Bogie Construction: Bogie Frame	69
5.4	Bogie Construction: Primary and Secondary Suspension.....	69
5.5	Bogie Construction: Bogie to Body Connection	70
5.6	Bogie Strength	70
5.7	Body to Bogie Connection	71
5.8	Bogie Mounted Equipment	71
5.9	Finite Element Analysis.....	72
5.10	Motor Suspension	72

5.11	Gearbox and Coupling	72
5.12	Wheels, Axles and Axle-boxes	72
5.13	Bogie Brake Equipment	73
5.14	Automatic Train Control (ATC) Equipment Mounting.....	73
5.15	Wheel Flange Lubrication Equipment	73
5.16	Maintainability.....	74
CHAPTER 6		76
6.1	Overview.....	77
6.2	Air Compressor and Drive.....	77
6.3	Auxiliary Compressor.....	78
6.4	Air Dryer and Filtration.....	78
6.5	Reservoirs	79
6.6	Pressure Governors and Switches	79
6.7	Pipe System	79
6.8	Pressure Gauges	80
6.9	Air Suspension Equipment.....	80
6.10	Automatic Coupling Actuating Equipment.....	80
6.11	Ancillary Pneumatic Devices.....	80
6.12	Isolation of Defective Equipments	80
6.13	Brake System	81
6.14	Electric Brake	82
6.15	Electric/Pneumatic Brake Blending	82
6.16	Parking Brake.....	82
6.17	Emergency Braking	82
6.18	Brake Control System	83
6.19	Jerk Limitation for Service Brake	83
6.20	Brake Operating Timing.....	83
6.21	Brake Pipe (BP) Controlled Back-up Brake System.....	84
6.22	Failure Management	84
6.23	Wheel Slide Protection	84

6.24	Monitoring.....	84
CHAPTER 7		86
7.1	General	87
7.2	Passenger Saloon Door.....	87
7.3	Cab Side Doors.....	91
7.6	Door Leaf Construction.....	92
CHAPTER 8		94
8.1	Propulsion Configuration.....	95
8.2	HV Power Collection	95
8.3	HV Protection & Distribution.....	95
8.4	Lightning Arrestor	96
8.5	25 kV Potential Transformer	96
8.6	AC Current Transformer	96
8.7	Main Transformer.....	96
8.8	25 kV Cable with HV Bushing and T-connector	97
8.9	Power Converter - Inverter.....	97
8.10	AC Traction Motor	97
8.11	Neutral Section Detector.....	98
CHAPTER 9		100
9.1	Auxiliary Supply System.....	101
9.2	Back-up Batteries.....	102
9.3	Battery Charger	103
9.4	Battery Box	103
CHAPTER 10		105
10.1	General.....	106
10.2	TIMS Architecture.....	106
10.3	Microprocessor Control and Diagnostic System	106
10.4	Driving Console.....	107
10.5	User Interface	108
10.6	TIMS Software	108

10.7	TIMS Labelling.....	108
10.8	Energy Measurement	108
CHAPTER 11		1110
11.1	General	111
11.2	Design Criteria – Cooling and Heating Capacity of the Unit.....	111
11.3	Heating System.....	113
11.4	Roof Mounted Package Units	113
11.5	Air Ducts and Diffusers	114
11.6	HVAC Unit Compressor.....	114
11.7	Condenser and Evaporator Coil.....	115
11.8	Piping.....	115
11.9	Electrical control cubicle.....	115
11.10	Control Equipment	115
11.11	Emergency Inverter	115
11.12	Operator's Cab Air-conditioning.....	116
CHAPTER 12		13718
12.1	General	119
12.2	Train Control and Operational Principles	119
12.3	Trainline Electrical Connections	119
12.4	Control equipment	120
12.5	Wires and Cables	120
12.6	Indication Circuit.....	121
12.7	Circuit Protection and Earthing System.....	121
12.8	Lighting System.....	123
12.9	Interior Illumination System	124
12.10	Cab Equipments.....	127
12.11	Auxiliary Machines and Drives.....	127
12.12	Safety Devices.....	127
12.13	Speedometer	128
12.14	Automatic Train Control	128

CHAPTER 13	1370
13.1 Train Communication Equipment.....	131
13.2 OCC to Driver and Passenger P.A. Communication Link	131
13.3 Passenger Alarm	131
13.4 On-train Public Address	132
13.5 Cab to Cab Mode	133
13.6 Automatic Voice Announcement System.....	133
13.7 Passenger Information System.....	133
13.8 Passenger Saloon Surveillance System.....	135
13.10 Interface.....	135
CHAPTER 14	137
14.1 General	138
14.2 Materials	138
14.3 Welding	138
14.4 Corrosion	139
14.5 Fasteners	139
14.6 Enclosures.....	139
14.7 Wires and Cables	140
14.8 Terminals and Cable Termination	141
14.9 Electrical Creepage and Clearance	142
14.10 Protection & Earthing.....	142
14.11 Circuit Design.....	143
14.12 Electronic Equipment	143
14.13 Microprocessors and Software-based Equipment	143
14.14 Software.....	143
14.15 Printed Circuit Board and Connectors.....	144
14.16 Integrated Circuits	144
14.17 Labels.....	145
14.18 Lubricants.....	145
14.19 Painting.....	145

14.20	Rubber Items.....	145
CHAPTER 15		137
15.1	General	148
15.2	Test Planning and Procedures	150
15.3	Special Tests	151
15.4	Vehicle Body Shell	151
15.5	Bogie Tests.....	151
15.6	Saloon Passenger Door Type Tests.....	152
15.7	Saloon Passenger Door Routine Tests	152
15.8	Cab Front End Emergency Exit Door Type Tests.....	152
15.9	Compressor and Motor Test.....	152
15.10	Brake Equipment Type Tests	153
15.11	Complete Brake System Type Tests.....	154
15.12	Complete Brake System Routine Tests.....	154
15.13	Electrical Type Tests	154
15.14	Roof Mounted Air Conditioning Package Unit Type Tests	154
15.15	Complete Car Air Conditioning System Type Tests	155
15.16	Complete Car Air Conditioning System Routine Tests	156
15.17	Emergency Operation.....	156
15.18	Noise and Vibration Verification	156
15.19	Fire Performance Verification	156
15.20	EMC Testing.....	156
INTERNATIONAL STANDARDS		159
TA1	General.....	159
APPENDIX TC: ABBREVIATIONS		1721
TC1	General.....	172
TD1	INTRODUCTION	175
TD1.1	Definitions and Scope.....	175
TD1.2	Rolling Stock Characteristics to be used by Signalling and Train Control and Telecommunication Contractors.	175

TD1.3	Signalling and Telecommunication Details to be used by RS15 Contractor.....	176
TD2	TRAIN OPERATING MODES.....	176
TD2.1	General System Description	176
TD2.2	ATO Mode.....	176
TD2.3	ATP (or Coded Manual) Mode	177
TD2.4	Restricted Manual (or Yard) Mode (RM)	178
TD2.5	Cut-out (or By-pass) Mode	178
TD2.6	Identification: Train Operating Mode, Train Description and Next Station Information	178
Td3	Interface Requirements between Signalling and Train Control and Telecommunications and RS15 Contractors	178
TD3.1	General	178
TD3.2	ATC and Radio Equipment Cubicles.....	180
TD3.3	Antennae... ..	180
TD3.4	Speed Measurement Devices	180
TD3.5	Driver's Display	181
TD3.6	Interface Between TIMS and Train	182
TD3.7	Power Supply and Earthing Arrangements	182
TD3.8	Telecommunications	182
TD3.9	Factory Installation and Testing	183
TD3.10	EMC/EMI Interface	183
TD4	SCOPE OF INTERFACE	183
TD4.1	Division of Responsibility.....	183
	Communications Equipment and Systems.....	184
	Environmental Issues.....	185
	Annex 1/TD Rolling Stock Characteristics.....	186
	APPENDIX TE List of Drawings.....	19387
	APPENDIX TF Submittals.....	1932
TF1	General	193
	APPENDIX TG Details Regarding Vendors/Sub-Vendors in Existing 'RS1', 'RS6' Type Stocks vis-a-vis those Proposed in RS15 Tender.....	1968
	EMPLOYERS REQUIREMENTS	199

EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 1

INTRODUCTION

CHAPTER 1: INTRODUCTION**1.1 Scope**

1.1.1 This specification establishes requirements for the design, development, manufacture, supply, testing, delivery, commissioning and integrated testing of light weight fully furnished modern passenger cars with microprocessor controlled 3-phase induction motor drive, for Line#1, Line#2, Line#3 and Line#4 of the Delhi Mass Rapid Transit System. The underground and elevated sections have ballastless track, and at-grade sections have ballasted track. The cars shall be designed to meet the performance requirement given in Chapter 3 of this specification. The track gauges for elevated, at grade and underground corridors shall be 1673 mm.

1.1.2 The cars shall be delivered and commissioned at the nominated Train Maintenance Depot of DMRC. The contractor shall base his Testing and Commissioning organisation at the nominated Depots.

1.1.3 The scope shall also include the following:

- (i) Provision of all the documentation and support material associated with the operation and maintenance of the cars as specified herein.
- (ii) Ongoing technical support and Defects Liability coverage until the completion of the warranty period, and making good defects.
- (iii) Interfacing with other Designated Contractors who have either physical, functional or design interfaces with this contract.
- (iv) Deleted.
- (v) Initial supply and installation of all consumables and materials required for testing, commissioning and operation.
- (vi) Provision of final drawings, design calculations and other documents including operations and maintenance manuals for review and acceptance by the Engineer.
- (vii) Deleted.
- (viii) Supply of spares as mentioned in ERGS: Chapter 8.
- (ix) Deleted.
- (x) Deleted.
- (xi) Liaison with the appropriate statutory authorities.

1.1.4 The complete network will be electrified at 25 kV a.c. single phase, 50Hz with auto-tensioned catenary and contact wire in the elevated and at-grade sections, and overhead rigid catenary in the underground section.

1.1.5 It is proposed to have three types of car viz. Motor car (M), Driving Trailer car (DT) and non-driving Trailer car (T). The unit formation shall generally be as follows:

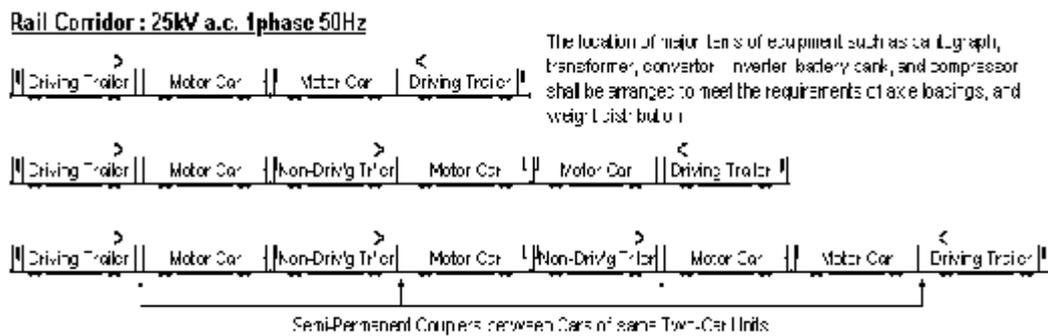


Fig. 1 Consist Configurations for Rail and Metro Corridors

Couplers:

The outer ends of each two-car unit shall be fitted with automatic couplers having mechanical, electrical and pneumatic coupling except for the Cab end of the DT cars, which shall not have electrical coupling head. Semi-permanent coupler shall be provided between cars of the same unit.

1.1.6 For each corridor, all DT, M and T cars shall be totally interchangeable with all other DT, M and T cars, respectively, without modification.

1.1.7 The scope of supply shall include all the equipment for meeting the performance requirements and trouble free and efficient operation of trains irrespective of whether such equipments are specifically included in the specification or not.

1.1.8 The 'RS15' type Rolling Stock shall conform to the Employer's Requirements – Technical and General Specifications and shall conform to all approved/would be approved variations, modifications and Hardware/Software Engineering Change Proposals against the contracts 'RS1', 'RS6' and 'RS13' in line with ERTS. In case of any contradiction between ERTS and approved/would be approved modifications (Hardware/Software Engineering Change Proposals) against the contracts 'RS1', 'RS6' and 'RS13', the later will prevail.

1.2 Prototype Train/Unit

1.2.1 The prototype Trainset/'T+M' unit shall be supplied as per the delivery schedule.

1.2.2 Clearance for dispatch of the prototype Trainset/'T+M' unit will be granted, only after successful completion of tests at the nominated place by the manufacturer, to the entire satisfaction of the Employer. Should any modification/ alteration based on results of the tests on the prototype be required, contractor will be obliged to carry out necessary modifications at no additional charge on all trains.

1.2.3 The Contractor shall manufacture and supply one complete Trainset/'T+M' unit duly equipped with test and measuring equipment and sensors for carrying out the following tests, in addition to those specified in IEC 61133 or an accepted International Standard, on respective lines.

- (i) Oscillation test to prove the riding and stability performance of the cars (refer clause 15.5 for detail test) for confirming fitness of the Trainset/'T+M' unit and vehicle for introduction into revenue service, if required.
- (ii) Performance requirement test including test of energy consumption.

- (iii) Emergency braking distance trials for AW0 and AW3 under both dry and wet conditions to prove the braking capability of the car.
- (iv) Tests to determine the levels of interference with traction power supply and signal and telecommunication train control equipments and facilities, to prove that these are within acceptable limits.
- (v) Any other test considered necessary for safe running of rolling stock.
- (vi) WSP Test under reduced adhesion conditions.

1.2.4 Clearance for despatch of the above trainset/'T+M' unit will be granted, only after completion of tests in accordance with IEC 61133, and on the strict understanding that the Contractor will carry out necessary modifications in India, as required by the results of the above tests (including prototype tests), at no additional charge.

1.2.5 Clearance for despatch of the balance of the trains/units built overseas and in India will be given by the Engineer after successful completion of tests in accordance with IEC 61133, and all agreed modifications having been completed at no additional charge.

This page is left blank intentionally

**EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATION**

CHAPTER 2

GENERAL REQUIREMENTS

CHAPTER 2: GENERAL REQUIREMENTS

2.1 General

2.1.1 This Chapter covers the following requirements:

- (i) Interface Activities
- (ii) Quality Assurance
- (iii) System Safety Assurance
- (iv) Hazard Analysis
- (v) Reliability
- (vi) Availability
- (vii) Maintainability
- (viii) Electromagnetic Compatibility
- (ix) Noise and Vibration
- (x) Fire and Toxicity Standards
- (xi) Life Cycle Costing

2.2 Interface Activities

2.2.1 Interfaces exist between the Rolling Stock Contractor and other designated contractors for systems, where the systems are mutually dependent, or interactive for satisfactory and safe operation. The Rolling Stock Contractor shall maintain close coordination / interface during design, manufacturing and, testing and commissioning phase with the designated Contractors, various other contractors and consultants who may be working in the Project, whether or not specially mentioned in the Contract. The Rolling Stock Contractor shall perform all design duties and provide all materials, equipment and labour to ensure the satisfactory accomplishment of interface of the systems for which the Rolling Stock Contractor is responsible.

2.2.2 The Rolling Stock Contractor shall submit and maintain an agreed Interface Management Plan. At all stages of the work, all interfaces shall be discussed and agreed upon, through the Engineer between the Rolling Stock Contractor and other designated contractors. Interface should essentially be with Signalling, Communications, Power Supply, Civil Engineering, Track-work, Depot Contractors and other Contractors advised by the Engineer. Refer to the Employer's Requirements - General Specification for requirements of the Interface Management Plan, its scope and other related details.

2.2.3 In certain cases, the Engineer may direct the Contractor to liaise with Designated and other contractors directly to discuss and agree on interfaces. However, the Rolling Stock Contractor shall keep the Engineer apprised in writing of all such discussions, agreements and conclusions.

2.2.4 It will be the responsibility of the Contractor that interface requirements be finalised as early as possible. Contractual delays and consequential implications as a result of delay in such liaisons on account of reasons attributable to the Contractor, as concluded by Engineer, shall be the sole responsibility of the Contractor.

2.2.5 It would be the responsibility of the Contractor to settle all disagreements with the Designated Contractors. If such disagreement cannot be resolved by the Contractor, despite having made all reasonable efforts, then the Contractor shall refer the matter to the Engineer for resolution with complete details with supporting documents and any other information as may be required by the Engineer. The decision of the Employer shall be final and binding on the Contractor(s).

As part of MPR (Monthly Progress Review), the Contractor shall submit the details of all interface meetings held in corresponding month in tabular form enclosing MOM of each interface meeting. Additionally, the schedule of interface meetings planned for next month along with the agenda (major issues to be discussed) for the same shall also be submitted as part of MPR submissions.

2.2.6 A Document titled "Interfaces between Rolling Stock, Signalling and Telecommunications Contractors" detailing the interfacing requirements and division of responsibility between the identified Designated Contractors is enclosed as 'Appendix TD' to this Specification.

2.2.7 Rolling stock being supplied under this contract shall be fully compatible with the existing Signaling and Telecommunication contracts. It will be the responsibility of the Rolling Stock Contractor 'RS15' to interact with all sub system suppliers of DMRC existing 'RS1', 'RS6' & 'RS13' Contracts and Signaling and Telecommunications contractors. In case of any specific interface requirement with any of the designated contractors, the entire cost of interface including that of the designated contractors shall be borne by the RS15 contractor and shall resolve all issues pertaining to integration of their sub system stabilization in existing 'RS1', 'RS6' & 'RS13' stocks.

2.2.8 The Contractor, as a part of its Management team shall mobilize at site an Interface Manager as laid down in General Specifications Chapter 2.

2.3 Quality Assurance

2.3.1 The Contractor shall submit 'Quality Assurance Plan' for review and acceptance by the Employer as specified in the Employer's Requirements: General Specification.

2.3.2 The Contractor shall develop a 'Quality Assurance Programme' (QAP), structured in accordance with acceptable international standards. Adequate records of quality assurance controls shall be maintained as per QAP and in a manner to facilitate performance audits by the Engineer.

2.3.3 The Contractor shall be solely responsible for all the Quality Assurance functions required by the Contract. All work and material shall be produced and control in accordance with an Internationally recognised and accepted quality standard.

2.3.4 The Contractor shall propose a Configuration Management System in accordance with latest relevant international standards. All deliverable items of equipment shall be of the same configuration and be totally interchangeable. Any modifications performed on later deliveries shall be applied retrospectively to equipment already installed.

2.4 System Safety Assurance

2.4.1 The Contractor shall submit 'System Safety Assurance Plan' for review and acceptance by the Engineer as specified in the Employer's Requirements: General Specification

2.4.2 The System Safety Assurance Plan shall cover design, manufacture, testing, commissioning and integrated testing, and minimising the magnitude and seriousness of events or malfunctions, which could result in injury to patrons or staff and damage to equipment or property, but cannot be completely eliminated.

2.5 Hazard Analysis

2.5.1 The Contractor shall take lead role in the interface Hazard Analysis for train borne equipment provided by other contractors.

2.5.2 The Contractor shall produce the Hazard Analysis Schedule for the complete train including all train borne systems and shall interface principally with the Signalling, Communication, Power Supply, Civil and Depot Contractor as well as any other Designated Contractors to obtain the information necessary, from their hazard analysis, to complete the analysis.

2.5.3 The Contractor shall, as part of the safety analysis, prepare analysis to identify Hazards and ensure their satisfactory resolution. The following analysis shall be prepared and submitted by the Contractor for the Engineer's acceptance.

- (i) Preliminary hazard analysis
- (ii) Interface hazard analysis (excluding EMI)
- (iii) Subsystem hazard analysis
- (iv) Operating hazard analysis including maintenance
- (v) Quantitative fault tree analysis
- (vi) Failure modes effects and criticality analysis (FMECA)

2.5.4 The Hazard Analysis shall be carried out in accordance with EN50126 as the primary standard, or any other internationally accepted equivalent standard, in areas not adequately addressed by the former standard.

2.5.5 The Contractor shall compile a list of critical and catastrophic items identified as a result of hazard analysis, FMECA or by other means. The Contractor shall carryout the Hazard and FMECA for the following equipment / sub-systems / systems:

Bogie and Suspension
 Vehicle Body
 Transmission Drive System
 Gangways
 Coupler
 Brake System
 Door System
 HVAC System
 Pneumatic System
 Communication System
 HV and Propulsion System
 Auxiliary Power System
 Control equipment
 TIMS

2.5.6 All hazard resolution by procedural control shall be cross-referenced from the Critical and Catastrophic Items List to the appropriate manuals.

2.5.7 The qualitative measures of hazard severity are defined as follows:

(i) Hazard Category I – Catastrophic: Operating conditions such that personnel errors, environment, design deficiencies, subsystem or component failure or procedural deficiencies may cause death or system loss. The safety target shall be based on internationally accepted standards.

(ii) Hazard Category II – Critical: Operating conditions such that personnel errors, environment, design deficiencies, subsystem or component failure or procedural deficiencies may cause severe injury to personnel, severe occupational illness or major system damage.

The safety target for the occurrence of all Category II hazards summed together shall again be based on

internationally accepted standards.

- (iii) Hazard Category III – Marginal: Operating conditions such that personnel errors, environment, design deficiencies, subsystem or component failure or procedural deficiencies, may cause minor injury to personnel, minor occupational illness or minor system damage.
- (iv) Hazard Category IV – Negligible: Operating conditions such that personnel errors, environment, design deficiencies, subsystem or component failure or procedural deficiencies will not result in injury to personnel occupational illness or damage to the system.
- (v) The Contractor shall submit a Schedule for Hazard Analysis Submissions within 30 days of Commencement Date (CD) and the Preliminary Hazard Analysis shall be submitted within 6 months of Commencement Date. This draft shall include a comprehensive assessment of potential equipment failure modes during normal operating and overload conditions and assess the performance of the equipment for a range of hazard conditions. The final draft shall be submitted by the completion date of final design.

2.5.8 The Contractor shall prepare a Fire Safety Design Report for review and acceptance by the Engineer. This shall be submitted within 2 months of Commencement Date and revised and updated for the completion of the preliminary, pre-final and final design stages. Materials used in the cars shall conform to fire safety requirements of EN 45545, latest editions, or the latest edition of other equivalent international standards, subject to the acceptance of the Engineer.

N.B. Whichever Standard is selected for meeting the Fire Safety Criteria, that standard shall be declared, and once accepted by the Engineer its requirements shall be met consistently throughout.

2.5.9 The procedures for Operation, Maintenance, Training and the Contractor's Quality Assurance manuals shall incorporate resolution of hazards so identified from this hazard analysis. Proper cross-referencing to the hazards and resolution measures shall be provided in all these aforementioned documents.

2.5.10 The following targets norms shall be employed for the Fault Tree Analysis. These norms are subject to review by the Engineer during the detailed design stage, and mutually agreed upon.

- (i) No single point failure shall lead to fatality.
- (ii) No combination of undetected failure and double point failures shall result in fatality.
- (iii) No combination of undetected failure and single point failure shall result in major injury.

2.5.11 Source of all failure rates employed to be indicated in the Hazard Analysis.

2.5.12 All hazard analyses submitted to the Engineer are to be standardised by the Contractor such that format and forms employed by all sub-contractors are the same.

2.6 Fail Safe Design

2.6.1 All equipment and systems, including software, affecting train safety and the safety of train crew and passengers, and/or identified as being "vital", shall be designed according to the following principles (couplers, door system, brakes, propulsion power removal, PEA shall be included, as a minimum):

Only components having a high reliability and predictable failure modes and that have operated in similar service conditions to those in Delhi shall be used.

Components must be utilized in such a manner that ensures that a restrictive, rather than a permissive

condition will result from a component failure. (For example: brakes will apply, rather than release; train will decelerate, rather than accelerate.)

Circuits shall be designed such that when a normally energized electric circuit is interrupted or de-energized, it will cause the controlled function to assume its most restrictive condition. (Broken wires, damaged or dirty contacts, a relay failing to respond when energized, etc., shall not result in an unsafe condition.)

System safety equipment design must be such that any single independent component or subsystem failure results in a restrictive condition. Failures that are not independent, those failures which, in turn, always cause others, must be considered in combination as a single failure and must not cause a permissive condition.

2.6.2 During the Design Review process, the Contractor shall submit analyses for Engineer's review and approval, which demonstrate compliance with these safety principles. These analyses shall address the following issues:

- (i) Circuit design
- (ii) Hardware design (Failure Modes, Effect and Criticality Analysis)
- (iii) Electrical interference
- (iv) Software errors
- (v) System failures

2.7 Reliability, Availability and Maintainability: General

2.7.1 Reliability, Availability and Maintainability (RAM) requirements and goals shall be developed in terms of Mean Distance Between Failures (MDBF), percentage Availability and Mean Time to Repair (MTTR). The Contractor shall perform RAM analysis up to the point of interface with other contractor's systems.

2.7.2 The Contractor shall comply with the guidelines of IEC 60300-1, IEC 60300-2 and IEC 60571 for electronic equipment, and IEC 60300-3-5 or any other internationally accepted equivalent standard in meeting the reliability, availability and maintainability requirements of equipment.

2.7.3 The Contractor shall submit Reliability, Availability and Maintainability Plan as specified in the Employer's Requirements: General Specification. The Contractor shall verify, after system design have been completed, that the reliability, availability and maintainability requirement will be met.

2.7.4 Delhi Metro Rail Corporation attaches the greatest importance to the attainment of the highest possible Reliability during service of all the equipment and systems supplied and installed under this contract. The design, manufacture, installation and commissioning of the equipment as also the training of the operating and maintenance staff shall be such as to ensure near Zero Failure performance in the initial stages and that the few defects and deficiencies that may be exposed during the Service Trial and the initial reliability growth period of one year are totally eliminated in the bulk supply.

2.7.5 The Contractor shall demonstrate by quantitative methods achievement of the specified levels of reliability for the train and specific individual items of equipment.

2.7.6 An evolving reliability model consisting of reliability block diagrams and probability of success equations shall be developed and submitted to the Engineer for acceptance. This model shall show the relationships required for system and equipment to operate successfully. The reliability block diagrams shall include all elements essential to the successful performance of the system and the interrelationships and interface of these elements.

2.7.7 Reliability apportionment and prediction analysis shall be in accordance with established techniques or standards, which will be submitted for acceptance by the Engineer. The analysis shall provide predictions for each major equipment and sub-system. Predictions shall be based on actual revenue service results for identical

equipment operating under service conditions and duty cycles equivalent to DMRTS, or more severe. The analysis shall be carried out in parallel with the design of the train. The relevant apportionment and prediction figures shall be part of the design submission documents for the individual equipment, sub-system and system.

2.7.8 Reliability Apportionment and Prediction Report shall be completed prior to build commencing and reports shall be submitted at this stage for acceptance by the Engineer, who reserves the right to require the Contractor to carry out field data collection to verify the reliability model.

2.8 Reliability Requirements

Reliability demonstration against this contract shall correspond to the performance of the rolling stock supplied against this contract. Failure of the components/ sub-assemblies in the stock not supplied against this contract shall not be considered for proving out the reliability requirements of stock supplied against this contract.

2.8.1 Definitions:

- (i) Relevant Failure: A relevant failure of an item is an independent failure which results in a loss of function of that item caused by any of the following:

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

- (ii) Non-relevant Failure: Any failure of an item not included in the definition of relevant failure, such as the following:

A failure caused by malfunction of other equipment or subsystem that are not supplied by the Contractor;

A failure caused by human error, except as noted in Relevant Failure above;

A failure caused by accidents not associated with the normal operation of the item. Such as collision or striking a foreign object on the right of way;

A failure caused by operating the equipment or sub-system outside of design or environmental specification limits.

- (iii) 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 predeparture check;

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.

The discretion of declaring a train as Not-available to start revenue service after successful completion of pre-departure checkout or withdrawing a train from revenue service on account of any relevant failure rests solely with the Employer and shall be final.

- (iv) 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 decision of the Engineer shall be final.

- (v) Mean Distance Between Failure (MDBF): The MDBF is the ratio of the total operating distance accumulated by the total available fleet of the trains to the total number of Service Failures
- (vi) Mean Distance Between Component Failures (MDBCF): The MDBCF of a system is the ratio of the total operating distance accumulated by the total population of identical items in the available fleet of the trains to the total number of Relevant failures.
- (vii) Since integration of 'T+M' units may be required to be done with existing train sets, allocation of failures attributable to the Stock supplied against this contract shall be considered for reliability demonstration targets specified herein.

2.8.2 Reliability Targets:

- (i) Reliability shall be monitored for the respective fleet under reliability Demonstration period (RDP). The RDP shall be always at par with the Defect Liability period (DLP). Any extension in RDP shall lead to extension of DLP by the same period.
- (ii) The fleet average levels of MDBF, as specified in table 2.1, shall be achieved.

Table 2.1: Reliability Targets

Duration	Minimum fleet average MDBF
	Train set/'T+M' unit
After 6 months of start of revenue service	80,000

Any unit/train shall be counted as available for reliability calculations only after a stabilization period of 6 months after putting the unit/train into revenue service.

- (iii) The achieved level of MDBCF of major systems shall be as proposed by the Contractor in the bid. The Tenderer shall submit MDBCF of the major systems as listed in table 2.2 along with the bid.

Table 2.2 : MDBCF of major systems

S.N	System / Equipment	MDBCF (km)
(i)	Propulsion System	
	a) Pantograph	
	b) VCB and Earthing switch	
	c) Main Transformer	
	d) Power Converter – Inverter	
	e) Traction Motor	
	f) Neutral Section Detector	

(ii)	Auxiliary Supply System	
	a) Auxiliary Converter	
	b) Battery Charger	
	c) Back-up Batteries	
(iii)	Air Supply and Friction Brake Equipment	
(iv)	Door System and Controls	
(v)	HVAC System	
(vi)	Communication System	
(vii)	Couplers and Draft Gear	
	a) Automatic couplers	
	b) Semi permanent couplers	
(viii)	Bogies	
	a) Drive gear and coupling	
	b) Primary suspension	
	c) Secondary suspension	
(ix)	Lighting System	
(x)	TIMS	

2.8.3 Whatever definitions, targets that have been mentioned in clause 2.8 referring to trains, fleets pertain to the individual 'T+M' units supplied against the contract and integrated with the existing trains. Separate trains, if any supplied under the present contract shall also get covered under clause 2.8.

2.9 Reliability Demonstration

2.9.1 The Contractor shall be required to establish a personal computer based Failure Reporting and Corrective Action (FRACAS) System to demonstrate compliance with specified train and equipment reliability. The reliability demonstration period (RDP) of each supplied 'T+M' unit or trainset, if any shall start after six months of that unit/trainset in revenue service and shall continue till the end of the defects liability period. Reliability of the trainset and of the identified major systems shall be demonstrated on the supplied 'T+M' units/ trainset , if any.

2.9.2 The Employer shall collect and maintain data on every Service Failure along with the TIMS data indicating the probable failure. MDBF and MDBCf shall be calculated throughout the monitoring period. The Contractor shall collect all the relevant details from the Engineer and submit monthly Reliability Demonstration Reports covering all units /trains under DLP during the month .

2.9.3 In case the Contractor is not able to achieve specified/provided reliability target of MDBF/MDBCf, the Contractor shall take necessary corrective measures either by way of change of design of the relevant equipment/ component or software modification. In case of the MDBF for the rolling stock under DLP being lower than the target MDBF in any particular month, the RDP as well as DLP of all the stock that is under DLP in

that month shall get extended by one month.

2.9.4 The Contractor shall analyze each and every failure/defect of components of various equipments to determine the cause of failure and to propose corrective measures, which would be reviewed by the Engineer.

2.9.5 A record shall be maintained for each and every defect/failure in accordance with FRACAS as stated in Clause 2.9.1 to be submitted by the Contractor and approved by the Engineer.

2.9.6 Reliability shall be monitored during revenue service operation of the trains. The Contractor shall collect and collate data on each and every deficiency and failure observed by both himself and the Engineer, from handing over the first train to the end of the Defect Liability Period. Each and every failure, whether of component, sub-system or system, during this period shall be subject to a failure analysis to determine the cause of failure. The Contractor shall submit investigation reports for review of the Engineer.

2.9.7 Correction shall be made to components or subsystems that either fail to attain predicted reliability levels or show Pattern Failure, at no additional cost to the Employer.

2.10 Availability Requirements

Availability shall be assessed by the following measure:

$$\text{Percentage Availability} = \left\{ 1 - \frac{\text{DT(OPM)} + \text{DT (CM)}}{\text{Total Time}} \right\} \times 100$$

where:

- (i) Total Time is the time in hours in the assessment period multiplied by the number of trains commissioned under the Contract.
- (ii) DT (OPM), or Down Time due to Other Preventive Maintenance, is the total down time in hours due to Preventive Maintenance other than service checks, summed overall sessions carried out on all trains commissioned under the Contract during the assessment period. The trains shall not be due for major overhauls at the time of demonstration and shall therefore be excluded from the assessment.
- (iii) DT (CM), or Down Time due to Corrective Maintenance, is the total down time in hours due to corrective maintenance, summed over all sessions carried out on the trains commissioned under the Contract during the assessment period. Any unreasonable delay in handing-over the train for repairs for reasons not attributable to contractor shall be excluded. Time spent on train integrity inspections after train reformations arising from corrective maintenance work shall be included. Time segregation between the existing trains vis-a-vis the new integrated units shall be with the approval of the Engineer where corrective maintenance is attributable to the integrated 'T+M' unit.
- (iv) The down time DT (OPM) shall be counted starting from the moment when the train becomes unfit for service or work is physically started on a train, whichever is earlier, and shall end when the train is restored to service condition. If the train is withdrawn from revenue service specially for preventive maintenance, time spent on withdrawing the train and sending back the train to revenue service, if any, shall also be included.
- (v) Down time DT (CM) shall be counted starting from the moment when the train becomes unfit for service or work is physically started on a train, whichever is earlier, and shall end when the train is restored to service condition. If the train is sent to revenue service after the corrective maintenance, the time spent on sending back the train to revenue service, if any, shall also be included.

The down times DT (OPM) and DT (CM) shall also cover the full content of the maintenance work concerned, including safety precautions, inspections, servicing, replacement of equipment, defect detection and rectification, testing and restoration to service condition.

2.10.2 Availability Target

The 'T+M' unit/trainset if any shall achieve a minimum availability of 96.5%.

2.11 Availability Demonstration

2.11.1 Deleted.

2.11.2 The average availability of the 'T+M' unit/trains if any shall be assessed after 8 months from the start of revenue operation with the first 'T+M' unit/ train if any , supplied under the contract, in a specified train Maintenance Depot. The total maintenance down times on account of the integrated 'T+M' units/trains if any, shall be collected by the Engineer on monthly basis, and the average availability during the preceding six months, shall be worked out from the above formula.

2.11.3 In the event that the availability target is not achieved, the determination of availability achievement in the preceding six month period shall be continued at monthly intervals until the target is achieved.

2.11.4 In the event that the availability target is not achieved, the Contractor shall, at his own expense, take whatever action is deemed necessary to meet the availability requirement.

2.12 Maintainability Requirements

2.12.1 Simplicity of maintenance, operation and emergency procedures, ease of repair of damaged cars and equipment, are most important. These together with ease of exterior and interior cleaning will be taken into account throughout the development of the design.

2.12.2 Particular attention shall be paid during the design of the cars to ensure that scheduled maintenance tasks are achieved in minimum time and using minimum manpower.

2.12.3 Those components, systems and assemblies which require routine maintenance, frequent attention or unit replacement, shall be easily accessible for in situ maintenance.

2.12.4 The Contractor shall develop a comprehensive maintenance programme for the trains.

2.12.5 The maintenance regime proposed for the train shall be developed during the design process. A Failure Mode Effect Analysis (FMEA) will be required, based on function and derived from the specification at conceptual design stage.

2.12.6 At pre-final design stage the Contractor will develop this FMEA to include required maintenance derived from each failure mode. Any other maintenance required for the train should be indicated at this stage.

2.12.7 The vehicle shall incorporate design, which reduces maintenance, substantially improving service intervals and component replacement. The design shall also minimize mean time to repair (MTTR) and costs throughout design life. MTTR is defined as :

$$\text{MTTR} = \frac{\text{Cumulative time for repair (including the access time expended during a time interval)}}{\text{Total number of relevant failures}}$$

2.12.8 The objective of the maintainability program including corrective and preventive maintenance shall provide for:

- (i) Enhancement of Vehicle availability.
- (ii) Minimisation of maintenance cost.
- (iii) Minimisation of vehicle down time.

2.12.9 During the design stage, the Contractor shall furnish a list of Least Replaceable Units (LRU's) for the equipments, Sub-system and Systems supplied, which should not take more than 30 minutes for replacement. Specific exceptions, if any, whose replacement is not achievable in 30 minutes shall be indicated by the tenderers in their offer. In order to achieve this requirement, quick release connections such as plugs and adaptor shall be provided between LRU's and the equipment.

2.12.10 The Tenderer shall submit the expected MTTR of the identified key systems as listed in table 2.3, alongwith the bid.

Table 2.3 : MTTR of major systems

S.N	System / Equipment	MTTR (hours)
(i)	Propulsion System	
	a) Pantograph	
	b) VCB and Earthing switch	
	c) Main Transformer	
	d) Power Converter – Inverter	
	e) Traction Motor	
	f) Neutral Section Detector	
(ii)	Auxiliary Supply System	
	a) Auxiliary Converter	
	b) Battery Charger	
	c) Back-up Batteries	
(iii)	Air Supply and Friction Brake Equipment	
(iv)	Door System and Controls	
(v)	HVAC System	
(vi)	Communication System	
(vii)	Couplers and Draft Gear	
	a) Automatic couplers	
	b) Semi permanent couplers	
(viii)	Bogies	

	a) Drive gear and coupling	
	b) Primary suspension	
	c) Secondary suspension	
(ix)	Lighting System	
(x)	TIMS	

2.12.11 During the design stage, the Contractor shall submit periodicity, downtime and manpower requirements for the maintenance inspections and service checks considered necessary for maintaining the trains under normal operational conditions as per table 2.4. The service check sessions shall include all routine maintenance activities including inspections, cleaning, washing, pest and rodent control etc. and shall not impact availability of trains for more than 1.5% averaged over annual basis.

Table 2.4 : Service checks

Session	Interval (Minimum)	Manpower and downtime requirements (Maximum)	
		Downtime	Expected staff
Service Check 1			
Service Check 2, if any			
Service Check 3, if any			
.....			
Service Check n, if any			

2.12.12 The Contractor shall also submit periodicity, downtime and manpower requirements for the maintenance activities as listed in table 2.5, for maintaining the trains under normal operational conditions, during the design stage. In table 2.5, some of the values against identified activities are furnished. The contractor shall either meet or provide better performance for these activities.

Table 2.5 : Maintenance Activities

Session	Interval (Minimum)	Manpower and downtime requirements (Maximum)	
		Downtime	Expected staff
Intermediate Overhaul	4,20,000 km (3.5 years)	10 days	-
LRU Replacement	-	30 mins	-
Corrective Maintenance operations that do not require car lifting	-	4 hours	-
Corrective Maintenance operations that require car lifting, excluding time required for shunting	-	6 hours	-

Note: The Corrective Maintenance time as indicated above shall include defect identification, replacement of defective LRUs and restoration to service condition

2.13 Maintainability Demonstration

2.13.1 The Contractor shall carry out tests to demonstrate that all maintainability predictions provided vide Clauses 2.12.10, 2.12.11 and 2.12.12 are met. All such tests shall be completed within six months after the delivery of first train. In the event that any maintainability target is not achieved, the Contractor shall at his own expense take whatever action is deemed necessary to meet the maintainability targets.

2.13.2 The Contractor shall ensure that all the required information including the related Maintenance Work Instructions (MWI) etc. are available before the commissioning of the first train into revenue service to enable him to demonstrate the maintainability targets.

2.14 Maintenance

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

2.14.2 Special tools shall be avoided wherever possible. If they are required, they shall be supplied by the Contractor in sufficient quantities to meet the maintenance requirements.

2.14.3 Equipment design shall be modular to minimise down time following failures of equipment and components. Provision for mechanical handling devices shall be provided for any single piece of equipment weighing more than 35kg. Equipment covers shall be provided with secure, visible, latching arrangements easily inspectable from the side of trains.

2.14.4 All underframe equipment which cannot be handled manually shall be configured such that it can be removed and replaced from track level using fork lift trucks or lift tables, with recognition being given to the confined environment of the pit and the rail level and underframe dimensions.

All underframe equipment shall be arranged such that it is capable of being removed and replaced without disturbing any other equipment.

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

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

2.14.7 Bogies shall be capable of being disconnected and reconnected to vehicle bodies with a minimum of operations. All connections must be easily and safely accessible to personnel located in pits or alongside the bogie at rail level. It shall be easy to inspect for correct reconnection, from alongside the bogie where possible.

Preference will be given to a design which permits release of the bogie to permit the raising of the car body, without the need for a pit in the Lifting Berth.

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

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

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

2.14.11 Should the electronic equipment be found to be faulty, the equipment shall enable fault finding to be carried out at module level.

2.14.12 Off vehicle test equipment shall be used in the depot repair centre. This equipment shall allow fault finding down to the smallest replaceable item of equipment.

2.14.13 The unit shall have equipment cases and modules that are connected to the main vehicle wiring via connectors which are proven in equivalent service duties to achieve high reliability and are easily removable in the event of equipment replacement.

2.14.14 Equipment to which access will be required for faultfinding shall be conveniently located. A list of such equipments and their location shall be supplied.

2.14.15 The unit shall have provision for the isolation and where applicable, earthing of all electrical sub-systems to facilitate safe and systematic maintenance and fault diagnosis.

2.14.16 It shall be physically impossible for plug and socket connections and connections on safety-critical circuits to be mismatched.

2.14.17 The unit shall have standard test points on pneumatic systems. There shall be unrestricted access to facilitate checks during routine maintenance and fault diagnosis.

2.14.18 The abovementioned features shall be suitable reflected in the respective design documents, as applicable, during the design stage.

2.15 Electro-Magnetic Compatibility: General

2.15.1 An EMC Control Plan shall be submitted by the Contractor within 30 days of the Notice to Proceed for acceptance by the Employer's Representative.

2.15.2 The EMC Control Plan shall include measures to reduce conducted, induced and radiated emissions to acceptable levels as specified by the relevant international standards. The plan shall specify measures to increase immunity of the train and all its subsystems.

2.15.3 The plan shall specify basic protective measures proposed for all electrical and electronic subsystems and components and specific measures to be adopted for selected subsystems and components.

2.15.4 The plan shall analyse EMI and EMC impacts on the design of the train, all other train-borne equipment and track-side equipment as well as the general environment. Particular attention should also be paid to additional requirements in grounding bonding, shielding, filtering and cabling arrangements.

2.15.5 The Contractor is required to conduct full EMI tests on one train at locations adjacent to television and radio transmission stations, airport, and other transmitting commercial stations to be agreed with the Employer's Representative. These tests shall include simulated fault conditions.

2.15.6 The Contractor is required to conduct type tests as well as full EMC tests on a complete train. Tests to be conducted shall include but not be limited to satisfying the latest versions of the following standards or equivalent :

- (i) Overall compliance: EN50121-1
- EN50121-2
- EN50121-3

(ii) Specific standards:

Immunity	
Electrostatic discharge	IEC 61000-4-2
Radio frequency fields	IEC 61000-4-3
Electrical fast transient/burst	IEC 61000-4-4
Surge	IEC 61000-4-5
Conducted RE	IEC 61000-4-6
Power frequency magnetic field	IEC 61000-4-8
Pulse magnetic field	IEC 61000-4-9
Damped oscillatory magnetic field	IEC 61000-4-10
Voltage dips, short interruptions	IEC 61000-4-11
Oscillatory waves	IEC 61000-4-12
Emission	
Radiated emission	EN50121 - 2
CISPR16/RIA18	
Conducted emission	EN50121-3-1

The conducted emission must also satisfy special requirements for ATO.

2.16 Intra-system EMC

2.16.1 The Contractor must ensure that all intra-system EMI are taken care of through proper design and other special measures. All major subsystems must be tested for emissions and immunities in accordance with the appropriate international standards for equipment operating in railway or similar industrial environment.

2.17 Inter-system EMC

2.17.1 The Contractor shall ensure that all train equipment is designed and constructed in accordance with the latest issues or version of internationally recognised EMC standards, including but not limited to CISPR, EN50082, EN50121, EN50123, EN50155, IEC60571-1, IEC61000, RIA12, RIA13, RIA18, RIA22, or equivalents, to ensure proper functioning.

2.18 Safety-related Systems Interference

2.18.1 Special attention must be given to the interference with safety-related operations and equipment such as the signalling systems. Special tests must be designed to ensure that the full range of emissions, whether conducted, induced, or radiated, individually or in combination with one another, conform with the specific requirements of these safety-related systems. Adequate safety margins must be ensured between the immunity levels of these safety-related systems and the emission levels of the rolling stock specified by prevailing international standards.

2.18.2 The subsystems and components which could possibly give rise to the level of emissions under both normal and fault conditions (conducted, induced or radiated) that may affect the safety-related systems must be identified. The quantified risk assessment must be carried out as part of the Hazard Analysis to determine the probabilities and effects of such interference. Measures must be taken to reduce such emissions. The reliability of subsystems and components as well as the additional measures, e.g., filter, must be investigated.

These shall include both long and short-term reliability and shall conform to guidelines given in, but not limited to :-

- (i) IEC60571-3 Electronic Equipment Used on Rail Vehicles,
- (ii) IEC60300-1 Dependability Programme Management,
- (iii) IEC60319 Presentation of Reliability Data on Electronic Components (or Parts) and

- (iv) IEC60300-3-2 Dependability Management – Pt. 3 Application Guide Sect. 2 Collection of Dependability Data from the Field.

The probabilities of various conditions which could lead to an unsafe operation must be determined. An appropriate technical construction file suitable for safety audit must be developed to demonstrate EMC compliance to the Employer's Representative.

2.18.3 The Signalling Contractor shall be responsible for determining the limits of interference for the Signalling equipment, to ensure safe operation of the trains. It will be incumbent upon the Employer's Representative to ensure liaison between the Rolling Stock and Signalling Contractors in this regard.

2.19 Non-Safety-Related System Interference

2.19.1 The Contractor shall take appropriate measures to ensure that EMC is achieved between the rolling stock and all other train-borne and track-side equipment. Particular attention must be given to:

- (i) Communications Equipment

The train-borne electrical and electronic equipment shall not produce significant interference affecting proper operation of telephone, public address system, train to OCC and passenger information systems due to influence arising from radiation, conduction, inductive, capacitive or electrostatic-coupling. The limits in CCITT (The Consultative Committee on International Telegraphy and Telephony) directives must be complied with at all times.

- (ii) Supervisory & Control Equipment

The Contractor must ensure that electromagnetic compatibility is achieved with the supervisory & control equipment. These shall include induced or radiated coupling to sensors and in-built test equipment including VDU and computer systems, low-frequency induced and high-frequency radiated coupling through common-mode, differential-mode, or ground-loop mechanisms.

2.20 Environmental EMC

2.20.1 The train-borne electronic and electrical equipment shall not produce significant interference with radio, television, tape recorders or players, heart pace-makers, radar, computer systems, magnetic media, portable and cellular telephones, pagers, etc., in the passenger saloon or externally. This includes action by static electricity, magnetic fields and electric fields.

2.20.2 Effect of emission on explosive or volatile/flammable material must be considered. BS6656 (Prevention of Inadvertent Ignition of Flammable Atmospheres by Radio-Frequency Radiation) and other related standards shall be adhered to.

2.20.3 Effect of the low-frequency magnetic field produced by traction on Delhi MRTS grounding system as well as electrolytic weakening of underground structures should be considered wherever applicable.

2.21 Installation and Mitigation Guidelines

2.21.1 IEC61000-5 Installation and Mitigation Guidelines must be observed wherever applicable.

2.22 Noise and Vibration

2.22.1 General

- (i) The Contractor shall ensure that the cars and equipment are designed and built so that specified noise and vibration limits are not exceeded. Particular attention shall be given to the design of all equipment

to minimise generation of noise and vibration. The design of the vehicle shall have adequate attenuation of airborne and structural-borne vibration along potential paths from the sources to passenger saloon and to wayside receptors.

- (ii) Exterior and individual systems and equipment noise measurements are to be made in accordance with ISO 3095, and interior noise measurements are to be made in accordance with ISO Standard 3381, except where otherwise specified. For evaluation, the noise level measurements shall be as per the specified criteria below.
- (iii) Ride quality vibration measurements shall be carried out in accordance with ISO 2631 (1985).
- (iv) Unless otherwise stated, noise means sound pressure level as defined in the latest revision to ANSI S1.4. All noise levels listed are in decibels referred to $20\mu\text{Pa}$ as measure with "A" weighting network of a standard Type 1 sound level meter with time weighting F. All noise values indicated in dBA, herein after are the L_{pA5} values in a window of 20sec. After applying time and frequency weighing, the sampled measurement data (atleast 10000 readings with 500Hz from one microphone) shall be divided into classes corresponding to each level (say 10 classes per dB). For each class the frequency over the measurement time shall be calculated. A histogram of frequency of each L_{pAF} level over the measurement time is made. This shall be converted to a graph over cumulative relative frequency. The value for 95% of the time is L_{pA5} Level i.e. the A-weighted sound pressure level exceeded for 5% of the measurement time period as defined in ISO 1996-1
- (v) For all tests, the levels of all sounds or vibrations other than those being evaluated shall be not less than 10dB below the levels of sound being evaluated, when measure with the same weighting network of (1/3) octave bands as that being used for the test.
- (vi) Wayside noise measurements shall be performed in an essentially free field environment with no nearby structures or reflective surfaces, which could influence the measurements, by more than 2dB, other than the standard track structure and the adjacent flat, clear ground.
- (vii) Interior noise criteria apply to measurement within an empty full fitted car. All noise level limits specified for car interior shall also apply to interior of gangway as far as practical. The noise level shall be measured at any point along the longitudinal centreline of the gangway and at a height of 1400mm above the gangway foot-plate.
- (viii) The pad stiffness used in DMRC ballastless track is generally 29MN/m and the same shall be used for design. The noise tests during running condition shall be done in the section after six months of train operation. The tenderer may suggest change in pad stiffness if it can help in further reducing the noise level.
- (ix) All specified noise measurements shall be revalidated 6 months before the end of DLP on a representative train selected by the engineer. In case of non compliance, the Contractor shall take necessary action to correct the defect and revalidate.

Provision shall be made to use wheel noise dampers, if required. The floor, door panels and ceiling shall essentially use honey comb or better panels for noise reduction.

Contractor shall use noise simulation software tools to predict the noise compliance to specified values. Detail simulation report shall be submitted. The report shall be submitted at first stage of design approval. References of the projects where the simulation tool has been used and actual arrived values (Corresponding to the measurement procedure specified herein) shall be submitted.

2.22.2 Noise and Vibration Assurance Plan

- (i) The Contractor shall submit a Noise and Vibration Assurance Plan as specified in the Employer's Requirements: General Specification for review by the Engineer.

- (ii) The Noise and Vibration Assurance Plan shall include:
- Expected total car noise levels, and sub-system noise levels for all equipment and systems.
 - Expected vibration levels for equipment, system and measurement locations specified herein.
 - Expected dynamic characteristics of the primary and secondary suspension.
 - Details of proposed approach to determining noise and vibration of the cars.
 - All codes and standards to be used during the design and verification of the cars.
 - Plan for noise and vibration design reviews.
 - Details of proposed sub-system testing to be carried out during the design and manufacture of the cars.
 - Details of proposed rake testing to demonstrate specification compliance.
- (iii) The Plan shall be updated at each Design Stage by the Contractor and be submitted to the Engineer for review. In the Design Reviews, the Contractor shall submit noise level and vibration prediction, calculations, design information, material property information, test results and other relevant data.

2.22.3 Interior Noise Level shall not be more than those specified in table 2.6.

Table 2.6 : Interior Noise Levels ($L_{PAeq20sec}$)

Location (Section)	Interior Noise Measurements in Maximum dBA		
	Stationary		Running (Elevated and At grade)
	Elevated	Underground	75 kmph
All cars except in driving cab (Elevated and At grade)	68	75	75
Driving Cab (Elevated and At grade)	68	72	70

where:

- (i) During Stationary condition the specified limits shall be met with all auxiliary equipment operating simultaneously at maximum capacity.
- (ii) For running conditions the specified limits at specified speeds shall be met in elevated two track section including acceleration and deceleration) with all equipment operating simultaneously.
- (iii) All measurements to be made along the car centre-line 1400mm above the floor and not less than 600mm from the end of the vehicle.

2.22.4 Door Operation Noise produced by simultaneous operation of all saloon doors on one side of the car shall not exceed 75 dBA during the sliding operation and 78 dBA for the locking/unlocking, measured on the fast meter scale. This should be measured at all points in the car from the 300 mm from the doors and 1000mm above the floor level.

2.22.5 Exterior Noise Levels for elevated (measured in two track section) and at-grade sections shall not be more than those specified in table 2.7.

Table 2.7 : Exterior Noise Levels ($L_{PAeq20sec}$)

Maximum Level of Exterior Noise in dBA @ 7.5 m from center of track on either sides	
Stationary	Running at 75 kmph
67	82

where:

- (i) Exterior Noise level measurement to be done at a location 7.5 m horizontally from the track centreline on a horizontal plane passing through the axle centreline at any point along the length of the vehicle on either side.
- (ii) During Stationary condition the specified limits shall be met with all auxiliary equipment operating simultaneously at maximum capacity.
- (iii) For running conditions the specified limits shall be met for the entire speed range upto 75 kmph (including acceleration and deceleration) with all equipment operating simultaneously.

2.22.6 Noise levels obtained in underground tunnels and platforms shall be measured by the Contractor under the same conditions (as far as possible). These shall be submitted to the Engineer for reference purposes.

2.22.7 Vibration

- (i) The measured vibration on any portion of the car floor, walls, ceiling panels, stanchions, handholds or seat frames shall not exceed the values specified in ISO 2631-1(1985) for 24 hrs exposure time and not higher than 0.315m/sec^2 (Not-Uncomfortable) as specified in ISO 2631-1997.
- (ii) All equipments, sub-assemblies and components shall be capable of withstanding shock and vibrations of the Rolling Stock satisfactorily such that they do not fail prematurely on this account earlier to the designed life. To establish this requirement, all of equipments, sub-assemblies and components shall be subjected to shock and vibration test to IEC 61373 or other relevant standard.

2.23 Fire Performance

2.23.1 General

- (i) Each train shall be designed to minimise the risk of a fire starting, as far as is practically possible.
- (ii) Materials used in the construction of each train shall be selected to reduce to the maximum extent practical the heat load, rate of heat release, propensity to ignite, rate of flame spread, smoke emission and toxicity of combustion gases.
- (iii) The train shall be designed to prevent fire propagation through the use of fire barriers in the floor, and in walls at the sides and ends and fire resistant equipment housings. Flammable materials shall be well contained and protected.
- (iv) The Contractor shall submit a plan to the Engineer for review which shall describe the process that will be used to systematically identify and eliminate fire hazards, to avoid the use of combustible materials whenever practical and to reduce to the extent practical the energy content and heat release rates of the combustible material that are used.

- (v) The plan shall include the Standards to be followed and the tests to be completed and shall be submitted for review by the Engineer.

2.23.2 Material Properties

Materials used in the cars shall meet the Flammability, Smoke Emission and Toxicity requirements of the chosen Specification. (See 2.5.8)

2.23.3 The contractor shall minimize the total fire load of potentially flammable materials on a vehicle as far as is practicable, but in any case it shall not exceed the following:

Above floor level : 28000 MJ

Below floor level : 28000 MJ

Contractor shall furnish the relevant data.

2.24 Fire and Smoke Detection System

2.24.1 Fire and smoke detection system shall be provided which would give audio-visual alarm to the driver (Train Operator) in case of fire/smoke detected in saloon.

2.24.2 Fire and smoke detection system shall consist of smoke/heat detectors, fire detection and control unit (FDCU), sounders, displays & software apart from small items like cables, connectors etc. Minimum 4 no. of Smoke & Heat detectors (multi-sensors) shall be installed in passenger area of each car. The sensitivity of smoke detector has to fulfill the requirements of ARGE guidelines. The actuating temperature of heat detector shall be settable according to the international norms and standards. The FDCU shall interface with TCMS.

In case of fire, the entire air conditioning on the train must be switched off in order to prevent any transfer of smoke to other train parts. Ventilation shall be provided depending on Whether the fire/smoke has been detected inside or outside of the passenger saloon area.

2.24.3 The system is designed to fulfill relevant standard and technical guidelines of EN 30155; EN 45545; EN 50126; EN54-5,7; EN50128, ISO 9001 & ARGE guidelines for fire detection in Rolling Stock.

2.24.4 Detail scheme of above system will be finalized during design stage with the approval of the Engineer.

2.25 Life Cycle Cost

2.25.1 The Contractor shall develop a life cycle cost plan in accordance with IEC 300-3-3 with an aim to minimize the overall life cycle cost whilst meeting the safety, quality and reliability requirement of this particular specification.

This page is left blank intentionally

EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 3

DESIGN AND PERFORMANCE REQUIREMENTS

CHAPTER 3: DESIGN AND PERFORMANCE REQUIREMENTS**3.1 Scope**

3.1.1 This chapter outlines the broad design and performance requirements of the rolling stock, details of track structure, power supply system, climatic and environmental conditions, and signalling & telecommunication systems.

3.2 Proven Design

3.2.1 The Contractor shall develop the design based on this specification and on sound proven and reliable engineering practices. The design details shall be submitted with technical data and calculations to the Engineer for review and acceptance.

3.2.2 The rolling stock, including all sub-systems and equipment shall be of proven design. Sub-systems and equipment offered in this tender shall have been in use and have established their performance reliability on a mass rapid transit system or suburban e.m.u.'s in revenue service over a period of two years or more. Where similar equipment or sub-systems of a different rating are already proven in service, then the design shall be based on such equipments. In case this stipulation is not fulfilled the tenderer shall furnish sufficient information to prove the basic soundness and reliability of the offered subsystem.

3.2.3 Propulsion system is the heart of Rolling Stock and the performance of rolling stock largely depend upon reliable performance of propulsion system. Technology for three phase drive using VVVF control IGBTs is fairly new and has made rapid strides in its development. To ensure that a reliable system is offered, it is necessary that the manufacturer of this system has got atleast 10 years experience in this field with atleast 5 years outside his home country. To support this requirement, the Tenderer shall furnish names of various railway systems to which the technology has been applied, the total service logged and certificates from the user on reliability of the equipment.

3.2.4 Vendors for important sub-system/equipments in the existing 'RS1', 'RS6' and 'RS13' type fleet have been listed in Appendix TG. The contractor is expected to comply to the list to the extent possible. The vendor in the present tender have to be necessarily the same for the critical system/equipments as indicated in the 'proposed vendor/sub vendor' column of Appendix TG. For the others, the contractor could include the names of alternative vendors in the same column. However these new vendors can only be considered with prior approval of the Engineer. Appendix TG duly filled shall be submitted with the bid.

3.2.5 The overall performance of the tenderer (all members in case of JV/Consortium separately) shall be examined for all the ongoing Rolling Stock Works awarded by DMRC/ any other Metro Organization (100% owned by Govt.) of value more than 40% of NIT cost of work and also for all the completed Rolling Stock Works awarded by DMRC / any other Metro Organization (100% owned by Govt.) within last one year (from the last day of the previous month of tender submission), of value more than 40% of NIT cost of work executed either individually or in a JV/Consortium. The tenderer shall provide list of all such works in the prescribed Performa given in Appendix FT-18 of the Form of Tender. The tenderer (all members in case of JV/Consortium separately) may either submit satisfactory performance certificate issued by the Client / Employer for the works or give an undertaking regarding satisfactory performance of the work with respect to completion of work/execution of work (ongoing works) failing which their tender submission shall not be evaluated and the tenderer shall be considered non-responsive and non-compliant to the tender conditions. In case of non-submission of either satisfactory performance certificate from client / employer or undertaking of satisfactory performance of any of the above work, the performance of such work shall be treated as unsatisfactory while evaluating the overall performance of tenderer in terms of Note (b) of Appendix FT-18. In case of performance certificate issued by the client, same should not be older than three month (from the last day of the previous month of tender submission for the ongoing works.

3.3 Basic Design Philosophy & Requirements

3.3.1 The design philosophy should meet the following criteria:

- (i) Application of state-of-the-art technology
- (ii) Lightweight integral car body
- (iii) Service proven design
- (iv) Design life 35 years
- (v) Crashworthiness
- (vi) Minimum life cycle cost
- (vii) Low maintenance and overhaul cost
- (viii) Use of interchangeable, modular components.
- (ix) Extensive and prominent labelling of parts and wires.
- (x) Use of unique serial numbers for traceability of components
- (xi) High reliability
- (xii) Low energy consumption
- (xiii) System safety
- (xiv) Adequate redundancy in system
- (xv) Fire and smoke protection
- (xvi) Use of fire retardant materials
- (xvii) High passenger comfort including low noise level
- (xviii) Environmentally friendly
- (xix) Adherence to operational performance requirements
- (xx) Safe passenger evacuation in emergency
- (xxi) Maximum possible commonality of structure, components, equipments, and sub-systems amongst cars.
- (xxii) Maximum utilisation of indigenous materials and skills, subject to performance requirements and quality standards.

3.3.2 Adequate margin shall be built into the design particularly to take care of the higher ambient temperatures, dusty conditions, and high humidity, etc. prevailing in Delhi.

3.3.3 Specified temperature rise of equipment shall be calculated after taking into account atleast 25% choking of air filters and/or radiator fins etc.

3.4 Design Management and Control

3.4.1 In order to ensure that the requirements of this Technical Specification are met, the Contractor shall establish and maintain documented procedures using ISO 9001 to control and verify the design of the train and all its equipment. These procedures shall be subject to review by the Engineer.

3.4.2 The Contractor shall establish and maintain a systematic, documented, comprehensive, and verifiable system integration process throughout the execution of the Contract. This process shall ensure that interfaces

and interaction between cars, infrastructure, subsystems, software, and operating and maintenance requirements have been identified and engineered to function together as a system.

3.5 System Integration Process

3.5.1 The Contractor shall systematically identify and formally document all design, manufacturing and operational interfaces between equipment within the train, and between the train and external systems, facilities, operations and the environment likely to affect or be affected by the train.

3.5.2 A mechanism and assigned project responsibility for interface management and control shall be provided, such that every identified interface has a defined resolution process that can be monitored.

3.5.3 The Contractor shall define methods to confirm compatibility between train equipment and carrying out integration tests at different stages of the design and interface management process to demonstrate that all equipment functions perform properly, both individually and as part of the complete train.

3.5.4 The Contractor shall ensure that performance, availability and safety requirements are addressed in the design process and that the reliability and maintainability of all equipment will enable the service performance to be met. The system integration process shall be capable of audit by the Engineer.

3.6 Interface Management

3.6.1 The Contractor shall submit to the Engineer for review an Interface Management Plan (IMP) and Detail Interface Documents, in accordance with the General Specification, which defines how the Contractor shall systematically identify and document technical interfaces.

3.7 Design Submission Requirements

3.7.1 The Contractor shall perform his designs for the Contract in accordance with the General Specification. The Contractor shall submit to the Engineer for his review, relevant design information as identified under each stage. Such submissions shall incorporate the relevant international standards applicable.

The design submission requirements are detailed in the Employer's requirements- General Specification.

3.8 Design Review

3.8.1 At appropriate stages in the design process, formal documented reviews of the design and related issues shall be planned and conducted. This shall be performed at fleet, train, car, system and subsystem levels, as appropriate, to verify and demonstrate:

- (i) Safety for manufacture, testing, operation and maintenance.
- (ii) Compliance with the relevant codes, specifications, the General Specification and this Technical Specification.
- (iii) Fitness for purpose, fulfilling the necessary operational functionality and performance.
- (iv) Integration and interfacing within the project and to external elements.

3.8.2 The Contractor shall submit for the Engineer's review a Design Review Schedule, in accordance with the General Specifications, which shall define the scope and timing of design reviews.

3.8.3 The Engineer reserves the right to attend any or all design reviews.

3.8.4 The Contractor shall ensure that participation in design reviews includes representatives of all functions, disciplines and entities concerned with the equipment and the stage being reviewed.

3.8.5 The Contractor shall at least 15 days prior to the date of each design review submit in-progress design documents of the elements to be addressed at the design review meeting.

3.8.6 The Contractor shall within 15 days after the date of each design review submit for review Design Review Minutes, detailing all issues raised during the review, their resolution or ongoing design status and due date for resolution.

3.9 Employer's Design Audit

3.9.1 The Engineer will carry out design audits of the Contractor periodically throughout the Contract as deemed necessary for validation of the design.

Such design audits will generally cover issues related to performance, integration, co-ordination and operation and detailed design issues so far as they are considered necessary by the Engineer.

3.9.2 The Contractor shall provide all documentation and personnel participation reasonably requested by the Engineer to enable design audits to be carried out.

3.9.3 The Contractor shall within 15 days of the date of each design audit submit for review Design Audit Minutes detailing all issues raised during the audit, their resolution or ongoing design status and due date for resolution.

3.10 Climatic and Environmental Conditions

3.10.1 Extreme climatic conditions are given below :

Table 3.10.1 : Climatic & Environmental Conditions

Description	Limiting Values
Maximum ambient temperature (See note below)	47°C
Minimum temperature	3°C
Humidity	100% saturation during rainy season
Rainfall	Rain occurs generally from June to September. Average annual rainfall is approximately 650 mm. Maximum rainfall in any 24h period is 50mm.
Atmosphere during hot season	Extremely dusty
Maximum wind Load	150 kg/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 IEC 61373.
SO ₂	80 – 120 mg/m ³
Suspended particulate matter	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 70°C.

3.11 Flood Proofing

3.11.1 The traction equipments mounted on the under-frame will be designed to permit propulsion of the train at 10km/h through water up to a depth of 75mm above rail level. Traction equipment shall be made splash proof in accordance with International Standards.

3.12 Tunnel Diameter

3.12.1 The tunnel diameter for the Metro Section will be nominally 5400mm.

3.13 Line Profile

3.13.1 The drawings showing the line profiles of

(i) Line 1

- (a) Rithala to New Bus Adda
- (b) Rithala to Bawana (New Corridor)

(ii) Line 2

- (a) Samaypur Badli to Huda city centre

(iii) Line 3

- (a) Dwarka Sec 21 to Noida Electronic City

(iv) Line 4

- (a) Yamuna Bank to Vaishali

All the above drawings are to be found in Volume 4. Some of them are currently under review. The permanent speed restrictions on both corridors are shown in the line profiles.

3.14 Track Structure Parameters

3.14.1 The Track Structure Parameters for both the Rail and Metro Corridors are set out in Table 3.14.1.

Table 3.14.1: Track Structure Parameters

Description	Elevated and At-Grade Corridor		Underground Corridor
	Ballasted	Ballastless (DFF)	Direct Fixation Fastener (DFF)
Gauge	1673mm	1673mm	1673mm
Rail Type Main Line	UIC 860/0 - 60 kg/m	UIC 860/0 - 60 kg/m	UIC 860/0 60 kg/m
Rail Profile	UIC 861-3	UIC 861-3	UIC 861-3
Rail Type Depot	IRS 52 kg/m	IRS 52kg/m	IRS 52 kg/m
Inclination Of Rail (BG)	1 in 20	1 in 20	1 in 20

1673mm)			
Sleeper Spacing Main Line	600mm ± 20mm	600mm ± 10mm	600 ± 10mm
Sleeper Spacing Depot	750mm ± 20mm		
Ballast Cushion Depth Main Line	300 mm		
Ballast Cushion Depth Depot	200mm		
Standard Rail Length	13m and 18m	13m and 18m	13m and 18m
Rail Panel Lengths	39m long welded	26m long welded	26m long welded
Minimum Radius of Curvature	300m – main line 200m – depot	300m - main line	300m - main line
Minimum Turn Out Rad. Main Line (BG)	220m	220m	220m
Minimum Turn Out Depot (BG)	1 in 8.1/2	-	-
Maximum Cant Permissible (BG)	150mm @ 1673mm gauge	150mm @ 1673mm gauge	150mm @ 1673mm gauge
Maximum Cant Desirable (BG)	125mm @ 1673mm gauge	125mm @ 1673mm gauge	125mm @ 1673mm gauge
Maximum Cant Deficiency Permissible	100mm @ 1673mm gauge	100mm @ 1673mm gauge	100mm @ 1673mm gauge
Maximum Cant Deficiency Desirable	75mm @ 1673mm gauge	75mm @ 1673mm gauge	75mm @ 1673mm gauge
Maximum Permissible Cant Gradient	1 in 440	1 in 440	1 in 440

Table 3.14.1 : Track Structure Parameters (continued)

DESCRIPTI ON	Rail Corridor		Metro Corridor
	Ballasted	Ballastless (DFF)	Direct Fixation Fastener (DFF)
Minimum Turn-out Speed : Turn-out	50km/h	50km/h	50km/h
Minimum Turn-out Speed : Scissors	40km/h	40km/h	40km/h
Minimum Turn-out Speed : In Depots	25km/h	25km/h	25km/h
Maximum Gradient Main Line	3%	3%	3%
Maximum Gradient Depot Connection	4%	4%	4%
Minimum vertical radius of curvature	2500m	2500m	1500m

3.15 Track Tolerances

The Track tolerances for both the elevated/at-grade and underground corridors are set out in Table 3.15.1 :

Table 3.15.1 Track Tolerances

Description	Ballasted	Ballastless (Direct Fixation Fastener)
Laying Tolerance of Vertical Alignment measured by 10m chord (Designed level)	±4mm	±2mm
Alignment (Laying) (Base 10m)	±4mm	±2mm
Cross Level Laying Tolerance (Designed)	±2mm	±2mm
Twist	1mm/600mm	1mm/1000mm
Cross Level Difference	12mm	4mm
Gauge measured at a point 14mm below crown of rail (laying)	+0mm -3mm	+0mm -3mm
Sleeper to sleeper variation of gauge	±2mm	±2mm
Unevenness (Maintenance) (Base 10m)	±12mm	±5mm
Alignment (Maintenance) (Base 10m)	±6mm	±2mm
Gauge variation (sleeper to sleeper)	±2mm	±2mm
Gauge (Maintenance) - Tangent	+10mm -3mm	+10mm -3mm
Gauge (Maintenance) - >500m radius	+10mm -3mm	+10mm -3mm
Gauge (Maintenance) - <500m radius	+19mm -3mm	+19mm -3mm
Gauge Face Wear	10mm	10mm

3.16 Interface

- (i) Length : 185 m
- (ii) Width: Island type : 10.0m
Side type : 6.5m
- (iii) Height above rail level : Ballasted Track 1080mm ± 5mm
:Ballastless Track (DFF) 1090mm ± 5mm
- (iv) Floor height of the rolling stock: 1130mm
- (v) Distance between track centre and platform edge : 1675mm maximum. The minimum possible shall be attained. Internationally accepted standards followed on other metro systems shall be taken into account in respect of the platform gap.
- (vi) Minimum horizontal curvature at platform : 1000m

3.17 Current Collection System

3.17.1 The principal details of the Current Collection Systems for the two Corridors are set out in Table 3.17.1, below:

Table 3.17.1 Current Collection System

System Particulars	Elevated/At-grade Corridor	Underground Corridor	Depots
Supply Voltage System	25 kV ac single phase 50Hz	25 kV ac single phase 50Hz	As main line
Type of OHE	Flexible Catenary	Rigid Catenary	Flexible Catenary
Current Collection	Through Pantograph	Through Pantograph	Through Pantograph
Height of Contact Wire from rail level	4800mm min. 5000mm max.	4150 mm min.	5000mm maximum for MC and 5500 mm maximum for RC
Stagger	±200/300mm	± 200 mm	±300mm

3.18 Signalling System

3.18.1 Principal details of the Signalling and Train Control System are set out in Table 3.18.1 below. For details see Chapter 8, and Appendix TD.

Table 3.18.1 Signalling System

Item	Elevated/At-grade Corridor	Underground Corridor
Train control system	Cab signal and Automatic Train Protection system (ATP)	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)
Train control mode	i) Coded manual mode ii) Restricted manual mode	i) Automatic mode ii) Coded manual modes iii) Restricted manual mode

3.19 Telecommunication System

3.19.1 The communications links are required to be provided, for both the Rail and Metro Corridors, as appropriate. For full details, and division of responsibilities, see Chapter 13.

3.20 Kinematic Envelope

3.20.1 A Kinematic Envelope on tangent level track is shown in Sketches E1 to E6 in Appendix TE. No part of any car shall infringe the Kinematic Envelope, under any circumstance, on either the Metro Corridor or Rail Corridor.

3.20.2 The tenderer shall develop and furnish a Kinematic Envelope of the proposed car, separately for Metro Corridor and Rail Corridor, taking into account all car displacements resulting from the simultaneous occurrence of all normal conditions specified in clauses (i) to (ix) inclusive, and any one abnormal condition specified in clauses 3.20.4, (x) to (xii) inclusive. Track tolerance shall be taken as specified in clause 3.15.

3.20.3 The tenderer shall also furnish a static vehicle profile along with Kinematic Envelope.

3.20.4 The tenderer shall furnish detailed calculations based on which Kinematic Envelope has been developed, showing lateral and vertical shifts due to each factor separately, based on which Kinematic Envelope has been developed.

Normal Conditions:

- (i) All vehicle speeds between 0 and 90km/h.
- (ii) All vehicle loads between tare and fully loaded (based on 8 passengers per square metres).
- (iii) Any degree of vehicle wheel wear between new and fully worn.
- (iv) Any degree of vehicle suspension, wear or adjustment from new to fully worn, including all service tolerances and potential variations in setting.
- (v) Maximum cant deficiency.
- (vi) Maximum cant excess.
- (vii) Vehicle lateral and rolling movements due to wind forces with a wind speed of 60km/h on the Rail Corridor.
- (viii) Vehicle yaw and vertical movements.
- (ix) Track tolerances as detailed in clause 3.15.

Abnormal Conditions

- (x) Any combination of bogie air spring deflated.
- (xi) Vehicle lateral and rolling movements due to wind forces with a wind speed of 115km/h on the Rail Corridor.
- (xii) Account shall be taken of over-inflated air springs in calculating the vertical lift of the car body under abnormal conditions.

Tenderers are required to develop the Kinematic Envelope for curved track parameters as set out in clauses 3.14 and 3.15.

3.20.5 Draft Schedule of Dimension for DMRC have been prepared in line with the International practice and are under finalisation. The Contractor shall ensure that the cars conform to the Schedule of Dimension.

3.21 Train Performance

3.21.1 General

The following data shall be used for all normal and emergency performance requirements. The performance shall be guaranteed at 22.5kV a.c. for both Metro and Rail Corridor.

3.21.2 Traction Electrical Supply Systems

The maximum and minimum voltages anticipated within the traction supply systems for the Metro and Rail Corridors are set out in table 3.21.2

Table 3.21.2 Traction Electric Supply Systems

Item	Corridor
Nominal voltage	25.0 kV a.c.
Minimum voltage	19.0 kV a.c.
Maximum voltage	27.5 kV a.c.
Instantaneous minimum voltage	17.5 kV a.c.
Occasional maximum voltage	31.0 kV a.c.
Voltage for guaranteed performance	22.5 kV a.c.
Variation in frequency	48-52 Hz

3.22 Car Weights and Passenger Capacity

3.22.1 To minimise energy costs, great importance will be placed on achieving practical designs of minimum car weight whilst meeting specified structural and performance requirements.

3.22.2 The minimum number of passengers required to be carried, including approximately 50 of whom will be seated, is as follows :

Motor Car	:	380
Driving Trailer Car	:	360
Trailer Car	:	380

3.22.3 The number of passengers are estimated on the basis of standees at the rate of 8 persons per square metre. The weight of each passenger may be taken as 65 kg. The tare weights of the cars should not exceed the following

Type of Car	Metro Corridor	Rail Corridor
Driving Trailer Cars & Trailer Cars	42 tonnes	42 tonnes
Motor Car	42 tonnes	42 tonnes

The limiting car weights are for Broad Gauge. Tare weights in respect of each car and each 4 car train for the Rail Corridor shall not exceed 42T and 168T respectively for Broad Gauge.

The tare weight of Driving Trailer/ Trailer Cars and Motor Cars may vary from the specified values above provided the total weight of a 2-car unit does not exceed the following values. However, this shall not affect the performance requirements specified in clause 3.25.1

Metro Corridor: 84 tonne

Rail Corridor : 84 tonne

3.22.4 The weight distribution shall be as defined in IEC 61133.

3.22.5 Total gross axle load of DT/T/M car should not exceed 17 tonnes.

3.23 Train Resistance

3.23.1 The tenderer shall furnish the formulae which have been used to determine train resistance for all alignments, for both Rail and Metro Corridors.

The following train resistance formulae have been used for determining the performance requirement in this

document.

For elevated/at-grade Corridor:

$$R=1.43+0.027V+0.000195V^2 \text{ kg/tonne, Where } V= \text{Speed in km/h}$$

For underground Corridor:

$$R=1.1(4.83906+0.06156V+0.001875V^2) \text{ kg/tonne, where } V= \text{Speed in km/h}$$

The curve resistance may be taken as $500/R$ kg per tonne, Where R = radius of curvature in metres.

The Tenderers shall use these formulae for all alignments for Rail and Metro Corridors for giving performance details. Moreover the Tenderers may also submit performance details using their own formulae, which shall be quoted in full and shall guarantee such declared performance.

3.24 Wheel Diameters

3.24.1 Wheel diameter shall be taken as: -

(i)	New	860 mm
(ii)	Half worn	820 mm
(iii)	Fully worn	780 mm

3.24.2 Train performance calculations shall be based on half worn wheels except where otherwise stated.

3.25 Performance Requirements

3.25.1 The performance requirements are given in Table 3.25.1

Table 3.25.1 Performance Requirements

Item	All Corridors
Maximum design speed	90km/h
Maximum operational speed	80 km/h
Round trip schedule speed with 30s station stops & 8% coasting, excluding terminal station turn round time with fully loaded train .	34 km/h
Acceleration from 0km/h to 30km/h for fully loaded train on level tangent track (Notional)	0.82 m/s/s \pm 5%
Service braking rate from 80km/h to standstill up to fully loaded train on level tangent track	1.0 m/s/s \pm 5%
Emergency braking rate from 80km/h to 0 km/h up to fully loaded train on level tangent track	1.3 m/s/s
Jerk rate (maximum)	0.75 m/s/s/s
Expected running adhesion but not limited to	18 %

3.25.2 Not used.

3.25.3 The proposed methodology of train running will be as under:

3.25.4 For the given track profile determine the speed-time curve of a fully loaded train under the specified voltage and wheel condition shall be determined between the various stations on all corridors in both the directions, in the following modes:

- (i) Normal Mode:
1. Accelerate the train using the designed speed-TE characteristic of the rolling stock.
 2. Coast to the extent it is possible to achieve the specified schedule speed or if the maximum speed is reached.
 3. Apply regenerative braking using the designed speed braking effort characteristic of the rolling stock up to a pre-determined speed so as to achieve the specified scheduled speed.
 4. Apply blended brakes thereafter so as to achieve the average service level of retardation of 1m/s^2 until standstill.

The above steps should be taken in a manner such that prescribed scheduled speed is achieved and energy consumption is minimised. The scheduled speeds are to be obtained with a dwell time of 30 seconds at each station.

- (ii) All-out Mode: This will be the same as normal mode excepting that there will be no coasting and regenerative blended braking will be to achieve a retardation of 1m/sec^2 from top speed till stop.
- (iii) Normal mode will be used for regular running of trains and time tabling.
- (iv) All-out mode will be used when trains, running late, can make up time to achieve the scheduled timings.
- (v) When the train is worked under ATO, it will receive commands as:
Run under Normal mode; or
Run under all-out mode.
- (vi) The control system should be such that the train will achieve the speed time curves arrived at sub-clause (i) above subject to keeping the loading of the traction system within the boundary limits of design.

3.25.5 The Tenderer should furnish the speed-time characteristics arrived at above, and also with the following:

- (i) Inter-station running time for each corridor, each way
- (ii) Actual schedule speed with a dwell time of 30 seconds at each station
- (iii) % coasting achieved in terms of time and distance, if any.
- (iv) Pre-determined speed up to which only regenerative braking was applied in the normal mode.
- (v) Total traction energy consumed
- (vi) Total auxiliary energy consumed
- (vii) Total regenerative energy fed back into the system
- (viii) Net energy consumption; and
- (ix) RMS current loading

The Tenderer should also furnish the inter-station running time for a fully loaded train, under the 3 emergency conditions of running, for each corridor, each way for:

- (i) 8-car train with 25% of motors cut out
- (ii) 6-car train with 33-1/3% of motor cut out; and
- (iii) 4-car train with 50% of motors cut out.

- 3.25.6 The continuous thermal rating of the traction system shall meet all the conditions of normal working. During emergency conditions operation as per Clause 3.25.5, the rake starting after a continuous working, one hour thermal rating should not be exceeded for one full trip, either way, in each corridor.
- 3.25.7 The Contractor shall hand over the software package employed by him for the above studies to the Employer.
- 3.26 Emergency Operating Condition
- 3.26.1 Deleted.
- 3.27 Specific Energy Consumption
- 3.27.1 The estimated specific energy consumption figures will be submitted by the Tenderer for each section based on the train resistance formula, curve resistance formula, track profile given in the tender document on the 'normal mode' of train operation. The Tenderer should also furnish the break-up of the estimated specific energy consumption as follows:
- (i) Specific energy consumption in traction
 - (ii) Specific energy regenerated and fed back to the system
 - (iii) Specific energy consumption by each auxiliary power consumption point
 - (iv) Efficiency of each auxiliary power consumption point

During dynamometer tests and combined bed tests, the speed-TE characteristic, speed regenerative braking effort characteristic and speed-traction efficiency characteristic will be evaluated. Using the above details, a computer simulation will be done to evaluate the traction energy consumption using the same train resistance formula curve resistance formula and track profile.

On the test bed during manufacturing stage at works, the average efficiency of all auxiliary machines and power supply equipment will be evaluated. The Auxiliary component of specific energy consumption will then be arrived at using the energy consumption and efficiency figures quoted in the tender and the actual efficiency figures obtained.

The actual specific energy consumption will then be arrived at adding the traction portion and auxiliary portion and compared with the figures quoted by the Tenderer.

Energy consumption on air-conditioning will be excluded from the above appreciation. However, these figures should be separately given.

If the actual specific energy consumption exceeds the estimated specific energy consumption quoted by the Tenderer by more than 5%, the Contractor shall carry out rectification work on the train, within a reasonable time as agreed with the Engineer. In case the Contractor fails, the recovery shall be made for the excess energy consumption over and above 1.05 times the estimated specific energy consumption for the entire life of the cars.

3.28 Ride Performance

- 3.28.1 All vehicles shall be dynamically stable throughout the speed range up to 90km/h under all loading conditions, even in the event of partial or complete deflation of the secondary air suspension, throughout the service life of the cars.

3.29 Ride Index

- 3.29.1 The maximum Sperling ride index shall not exceed 2.50 in new and worn wheel profile condition, both in the vertical and lateral planes, under tare and fully loaded conditions up to 90km/h, for all different

types of vehicle of a train set. The tests will be performed using the standard new profile, and the fully worn profile. Drawings will be provided later. The sketch for fully worn profile for the Broad Gauge wheels shall be provided by the Contractor.

This page is left blank intentionally

EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 4

VEHICLE BODY

CHAPTER 4: VEHICLE BODY**4.1 General**

4.1.1. Modern lightweight integrally structured rail passenger cars are required, using modular construction techniques for major components, such as roof, sides, floor and end modules.

Full details of the technique/technology employed for joining the modular elements of shells shall be furnished, alongwith details of quantity and service records of vehicles assembled using such techniques.

4.1.2 The cars shall be designed and constructed for a service life of at least 35 years of normal usage without major rebuilding, strengthening and repair.

4.1.3 The car body structure shall be constructed so that fixed or mobile jacks can be used to lift the car body, with or without bogies.

4.1.4 Additionally, arrangements shall be made to permit the use of portable jacks in a restricted space to re-rail a car after derailment.

4.1.5 Full details shall be provided of the arrangements made to provide seating for jacks and body stands, both for normal and emergency applications.

4.2 Mock-ups - General

4.2.1 Deleted.

4.2.2 Deleted.

4.2.3 Deleted.

4.2.4 Deleted.

4.2.5 The Contractor shall prepare and handover to the Engineer, 10 numbers of approximately 1:50 size true models of the DT car (non-working), with pedestal and casings.

4.3 Static Vehicle Profile (Kinematic Envelope)

4.3.1 The tenderer shall furnish a static vehicle profile together with a Kinematic Envelope as required by Clause 3.20.

4.3.2 The notional leading particulars of the driving trailer car, trailer car, and motor car are set out in Table 4.3.2.

4.3.3 It is preferred that a common body shell structure be adopted for all types of car as far as possible.

N.B. The vehicle shall remain within the Kinematic Envelope under all conditions.

Table 4.3.2 Principal Notional Vehicle Dimensions

Description	Dimension
Gauge	1673mm
Length over Body (T and M). DT car may be marginally longer	21 340mm
Maximum Width over Body	3 200mm

Minimum Passenger Saloon Headroom	2 050mm
Dropped down pantograph height for 25 kV a.c. cars from TOR at Car Centre Line	4250mm maximum
Height of floor from TOR	1130mm
Bogie wheel base (approximately)	2 400mm
Distance between bogie centres (approximately)	15 000mm
Wheel diameter (new)	860mm
Wheel diameter (fully worn)	780mm

4.4 Materials

4.4.1 The car body shall be constructed of austenitic stainless steel of grade SUS301L to JIS G4305 or any other internationally accepted equivalent standard. The Contractor shall bring to the notice of and take approval of the Engineer, if any of the components of the car body is intended to be of different material.

4.4.2 Throughout the design life of 35 years, the car body material shall not corrode or be etched by the environmental conditions (See also Clause 3.10.1) that exist in Delhi area and its tunnels to the extent that the original appearance of the car cannot be restored by normal washing. In particular, the cars shall withstand contamination from water dripping within the tunnel environment.

4.4.3 The exterior appearance of the car body shall be smooth (not corrugated) unpainted metal without the use of filler or other similar material, such that the maximum variation from the required car profile, over any one metre length, shall not exceed 1.0 mm. Any fluting, if offered, shall be shown to have advantages, and shall be subject to review by the Engineer. The roof, excluding the cantrail, may be either corrugated or smooth.

4.4.4 The finish texture shall be subject to approval by the Engineer, whether applied by machine or hand.

4.4.5 In the case of stainless steel cladding materials below 6mm in thickness, the side and end wall sections and underframe shall be manufactured from rolled sections, folded or pressed plates, or plain sheets.

4.5 Car Weight and Passenger Capacity

4.5.1 The tare weight of the cars, passenger capacity and weight of passengers are detailed in Chapter 3.

4.6 Car Body Strength

4.6.1 The mechanical strength of the car body structure shall comply with the requirements of UIC 566 except for the compressive load, which shall be 1200kN applied at the end of the car body at the centreline of the coupler, and shall be compatible in respect of crashworthiness. The tensile force shall be reduced in the same ratio as the compressive force in UIC 566.

4.6.2 The vehicle shall withstand an evenly distributed downward vertical load equal to 1.1 x the weight of the vehicle complete with all its equipment and supplies, but no passengers, with the body supported at the lifting points provided by the Contractor close to the ends of the body bolsters in the underframe.

4.6.3 The number of passengers seated shall be taken as one per seat and standing as ten per square metre. The weight of each passenger shall be taken as 65kg, for the purpose of strength analysis.

4.6.4 The camber on the coach body under fully loaded condition shall be such that the structure shall not sag below the horizontal plane throughout the vehicle's 35 year life.

4.6.5 Vertical deflection of the car body structure, up to the fully laden condition, shall not hinder the normal operation of the passenger doors and cab-side doors.

4.6.6 The carbody, and any equipment mounted on, beneath or within it shall be designed to withstand the fatigue loads that the car body structure will encounter over a period of 35 years in service, in accordance with the criteria described herein. The fatigue life assessment of body structure shall be carried out using recognised techniques and shall be submitted by the Contractor for review by the Engineer.

4.7 Equipment and Equipment Mounting

4.7.1 All equipment, mountings and fasteners of components shall withstand the forces and impacts as specified in UIC 566 without any part of the equipment becoming detached, and without any permanent deformation to the car-body.

4.7.2 The roof structure shall be designed to support the air conditioning apparatus, pantographs, VCB/HSCB, surge arrestor, ducts, conduit, lighting fixtures, headlining, stanchions and other equipment, and shall, in addition, have sufficient strength to support, without permanent deformation, concentrated loads of 1000N, applied by personnel working on the roof at increments of 750mm apart.

4.7.3 The Contractor shall carry out a stress analysis of the carbody (including torsion mode) as well as for important structural components that affect safety or availability, using the Finite Element Method. Separate analyses shall be demonstrated and submitted for car bodies having different basic structures. The analysis shall demonstrate that all static and fatigue strength requirements of the carbody and equipment mounting are met.

4.7.4 Calculations of the moments of inertia of the carbody about its longitudinal and transverse axes shall be furnished, together with those of the carbody bending frequency.

4.8 Crashworthiness

4.8.1 The car structure and its supplemental energy absorption devices shall be designed to minimise accelerations transmitted to passengers, by absorbing collision energy, whilst not permitting one vehicle to over-ride another, nor to telescope one into another.

4.8.2 The car body design shall be suitable for an eight-car, six-car or four-car train and shall be such that it is capable of absorbing collision energy in a manner so as to localise structural deformation at low energy levels.

4.8.3 At high energy levels it shall ensure that collision energy is absorbed by progressive deformation of the vehicle end structure, thereby protecting the passengers and passenger area in the car. There shall be no structural deformation between the body bolsters.

A suitable proven energy absorption feature with associated collapse features shall be incorporated into the coupler draft gear. The coupler shall sustain no permanent damage when a fully loaded eight-car train collides with an impact speed up to 10km/h.

4.8.5 Of particular concern is the cab front structure, which is required to protect the driver, and vital control and communications equipment in the event of a collision. The centre section of the cab is to be used as an emergency escape route, from cab to track.

The Tenderer shall submit his proposal as to the structural arrangement of the cab front and sides, and the manner in which members tie in with the underframe and roof structure.

4.8.6 The Tenderer shall submit predicted values for the following in respect of fully loaded cars. The Contractor shall submit a detailed technical proposal and analysis to specify the following in respect of the fully loaded vehicle :

- (i) The maximum collision speed at which there is no structural damage to the car body and the coupler.

- (ii) The minimum collision speed at which the coupler energy absorption device fails.
- (iii) The maximum speed at which the cab structural collapse features deform completely, without damage to the main car body structure.
- (iv) The minimum speed at which actual structural damage commences.

4.8.7 The detailed proposal shall also specify the measures taken in the design to achieve the above objectives and the proposed verification to satisfy the effectiveness of the design.

4.9 Under Floor Equipment Mounting

4.9.1 Equipment shall be mounted in accordance with IEC 61133 regarding weight distribution.

4.9.2 Routine maintenance and inspection will be carried out from the sides and underneath of the car. The Contractor may mount propulsion and auxiliary equipment using an optimum number of pre-wired, piped and tested modules, to ensure ease of access to equipment.

4.9.3 Equipment box covers shall be provided with simple secure locking devices, with easily visible markings to indicate locked position. The size and weight of the cover shall permit removal and manipulation by one person.

4.9.4 Covers shall be so designed that in the event of failure of a locking device in service, covers shall remain captured and shall not infringe the Kinematic Envelope. Otherwise, cover retention catches shall be provided to prevent covers from accidentally falling off. Covers shall open in a manner that will prevent injury by contact with sharp edges or live electrical contacts.

Similarly, pneumatic and brake equipment shall be provided in a brake panel for easy access from the side.

4.9.5 The under-floor mounted equipment cases shall be constructed using materials requiring no corrosion protection throughout the life of the car.

4.9.6 All under-floor-mounted rotating machinery shall be fitted with resilient mountings to eliminate transmission of mechanical vibrations to the car body. Rotating parts should also be adequately guarded and protected against ejection under failure conditions.

4.9.7 All equipment mountings must be designed such that in the event of maloperation or failure, equipment will remain secure and within K.E.

4.10 Couplers and Draft-gear

4.10.1 General

The outer ends of the cars of each two-car unit shall be fitted with automatic couplers allowing automatic mechanical, electrical and pneumatic coupling and uncoupling of units. The inner ends of the unit shall be provided with semi-permanent couplers.

4.10.2 Coupling Requirement

The automatic coupler shall, in conjunction with the draft-gear automatically effect mechanical, electrical and pneumatic coupling. It shall also permit separation of units either manually from the track side or remotely from the cab. The coupler shall provide adequate support to the gangway with passengers. Alternative gangway support systems may be proposed. Full details shall be provided.

The coupler and draft-gear shall, in conjunction with the inter-car gangway, be capable of gathering, engaging and coupling units on all track conditions detailed in Chapter 3, Clause 3.14. and Table 3.14. Under these track

conditions, coupling shall be achieved with the most adverse mismatch of car heights, caused by wheel wear, passenger loading, air spring deflection, and service tolerances.

The automatic coupler shall be equipped with a self-centring device to prevent the coupler from swinging transversely when uncoupled.

However, the gathering range of the mechanical coupler shall be suitable for horizontal curves of 200m radius and vertical curves of 2500m radius.

4.10.3 Automatic Couplers : Protection

When uncoupled, auto-couplers shall be arranged so that electrical contacts and pneumatic connections shall be automatically protected from the ingress of water and extraneous foreign matter.

Auto-couplers shall also incorporate provision for the selective isolation of air and electrical connections whilst remaining mechanically coupled.

The electromagnetic valves used for actuation of coupling / uncoupling action shall have IP protection of IP 65 and shall be proven in EMU metro operation for atleast 2 years.

4.10.4 Semi-Permanent Couplers and Draft-gear

Means shall be provided for vertically aligning the couplers, at the intermediate ends, to facilitate coupling. After coupling, such means shall not limit normal operating movement of the coupler. This arrangement shall accommodate the full range of height variation between adjacent vehicles when being coupled. The pneumatic connection between the cars of a unit shall be through the semi-permanent coupler.

Electrical end connections shall be semi-permanent. Uncoupling or re-coupling shall not damage these connections. It shall not be necessary to give preventative maintenance attention to these connections between vehicle overhauls.

4.10.5 Draft-gear Design and Energy Absorption Requirements

The draft-gear shall meet the requirements specified in Clause 4.8.

4.10.6 The coupler shall be maintained horizontal by means of easily adjustable supports, which shall take care of loss of coupler height within the car body.

4.10.7 The weakest portion for parting shall be at the junction of the two coupler heads, interrupting electrical and pneumatic connections, and thus causing an instant emergency brake application.

4.11 Car Exterior

4.11.1 The appearance of the car exterior must be of a modern and aesthetically pleasing profile. The car exterior finish shall not require paint for protection.

4.11.2 Proposals for measures that will maintain the original appearance of the car exterior from undue deterioration, staining or streaking, including appropriate chemical cleaners shall be submitted.

4.11.3 The DMRC/MRTS logo (to be advised after contract award) shall be applied on both sides of the car at both ends at a location to be advised later. The car number shall be applied on both sides of each car at both ends, both externally and internally and also inside the cab to be easily visible to the train driver.

4.11.4 A longitudinal colour band or other branding image shall be provided along each side of each car. The colour scheme shall be agreed upon during the design review of the cars.

4.11.5 On each side of every car, at an appropriate location close to mid point of the vehicle but beyond the sweep of the passenger saloon doors, a Train Identification Indicator (ESD) shall be provided (See Chapter 13). The device shall be flush mounted with the exterior of the car body.

4.11.6 The cars shall be completely watertight and be able to withstand an agreed water test, simulating a train travelling at speed under severe climatic conditions of Delhi as well as passage through automatic wash plants.

4.11.7 The design of the car exterior shall generally be aesthetically pleasing, and shall minimise the build up of dirt.

4.12 Cab Front End Exterior

4.12.1 The cab front end is required to house the following features and devices :

- (i) Front end centrally Emergency Door (See chapter 7)
- (ii) Windscreens for the driving position, and at the non- driving side (See 4.13.2), with windscreen wiper blades and windscreen washer nozzles, the washing medium being contained in reservoirs accessible from within the cab.
- (iii) Train Identification Number indicators shall be located inside the non-driving side windscreen, and be visible from 20m ahead of the train. Full details of the proposed system shall be provided.
- (iv) Head Light and Tail Light- See chapter 12.
- (v) The destination indicator shall be clearly visible at the top of the non-driving side windscreen. Alternatively, the destination indicator may be placed centrally above the emergency door/ramp, if the door/ramp mechanism allows it.
- (vi) A pneuphonic horn, operable from the driver's console shall be provided. See Clause 6.10.2.
- (vii) Windscreen wipers shall be provided on both side screens operable from the driver's console.

4.12.2 The steps provided in the skirt portion of mask for entraining and detraining of train operators shall have anti slip surface. The material used should last at least for interval between major overhauls of car body.

4.12.3 The cab grab rail shall be brush finished with sufficient hand clearance for ease in holding.

4.13 Driver's Cab

4.13.1 Cab Layout

The Driver's Cab shall be the full width of the car, with the Driving side on the left in the forward direction of travel. It is required to house the Driver's console, including direct access to all the necessary telecommunications links, instrumentation, power and braking controls, and indirect access to miniature circuit breakers, fault indicator lights, sealed switches, etc.

The driving console shall include, arranged ergonomically, all necessary devices, incorporating a fore-and-aft quadrant power-brake controller with integral "dead-man" device. The proposed layout shall be incorporated into a mock-up. See Appendix TB.

4.13.2 Windscreens

Windows in the driving cab shall be constructed of laminated safety glass, and shall comply with the requirements of UIC 651.

The windscreen shall be sufficiently strong to comply with UIC 566, in addition to UIC 651.

4.13.3 Cab Front Non-Driving Side Cupboard

An emergency equipment cupboard shall be provided at the cab front, beneath the non-driving side windscreen, to house the portable bridging device, emergency door stowage devices, First Aid box, and safety equipment including fire extinguishers.

4.13.4 Destination Indicator

The train destination indicator shall be located at the top of, and immediately behind the non-driving side windscreen. A modern high resolution display in both Hindi and English is required. Full details of the data to be incorporated will be provided to the Contractor. Data input shall be from the driver's console as part of the setting up procedures. Access for maintenance and adjustment shall be from within the cab.

4.13.5 Driving Console Lighting

Lighting of the driver's console shall meet the requirements of UIC 651 OR which stipulates a minimum of 60 lumens/m² measured at the driving control desk (see chapter 12).

4.13.6 Driver's Seat

The driver's seat shall be cushioned, using non-flammable materials and filling, and fully adjustable in the longitudinal and vertical directions. The seat back may be made integral with the back wall. The seat squab shall be arranged to flip up, when weight is removed from it, providing a narrow lateral passageway between the centre of the cab and the side door.

4.13.7 Cab Side Doors

See Chapter 7.

4.13.8 Saloon-to-Cab Door

See Chapter 7.

4.13.9 Cab Air Conditioning and Ventilation

The driver's cab shall be provided with a dedicated air conditioning unit. (See Chapter 11).

4.13.10 Cab Floor

The cab floor shall be clear of all discontinuities, and shall not incorporate access panels to underfloor mounted equipment, junction boxes and cable ducts. It shall be possible to undertake water washing of the cab floor without damage to the floor or equipment.

4.13.11 Cab Lighting

The cab shall be provided with a ceiling lights, providing 200lux at 1m above floor level. It shall be operated automatically by the opening of either cab door, and extinguished manually from within the cab (see chapter 12).

4.14 Saloon Interior

4.14.1 General Considerations

- (i) The Contractor shall propose vehicle interior layouts which incorporate a modern aesthetic approach with considerations to optimise passenger comfort, safety and security as well as to minimise noise in the saloon.

- (ii) It shall incorporate wide double leaf automatic doors along each side, longitudinal seating, enclosed by stand-back areas and draught screens, grab-poles and rails, LED lighting, air conditioning outlet grilles, passenger information displays, public address loud speakers, and passenger alarm devices to permit passengers to make the driver aware of problems.
- (iii) External panelling, including the under surface of the car roof and all interior surfaces of car body side panels shall be coated with suitable anti-drumming compound, except where corrugated materials are used.

The body side and roof outer skin shall have a suitable thickness of approved acoustic insulating material bonded to their interior surfaces.

The design of interior fittings shall be safe under all conditions of passenger impact, during emergency braking and buffing under fully loaded condition.
- (vi) All non-metallic materials shall satisfy the requirements of flammability and smoke emission limitations.
- (vii) All interior surfaces must be finished with good blending and good slow ageing properties to provide a pleasant, high-quality interior and for ease of cleaning and maintenance.
- (viii) All internal panel surfaces shall be smooth finished with modern low flammability, low smoke emission, and low toxicity materials. All internal panels shall be resistant to graffiti, scuffing, vandalism, and cleaning agents. Rounded corners or covings shall be provided wherever mutually perpendicular flat plane surfaces abut. Metal kicking strips of 150mm depth with radiused coving are required on all exposed vertical surfaces above floor level.
- (ix) As far as possible, fastening devices, fixings and securing screws shall not be visible from within the saloon.
- (x) Gaps between all interior lining panels, kick strips, seat shell, etc. shall be minimised. The effects of thermal expansion shall be taken into account and all unsealed gaps shall not exceed 1mm in depth where feasible. Suitable cushioning at panel joints shall be provided to suppress noise.
- (xi) The area between top of body side windows and the ceiling shall be utilised for advertising displays.
- (xii) The tenderer shall propose arrangements for map and advertisement holders in the saloon. He may also propose alternative and additional display systems which satisfy the above intentions.
- (xiii) Equipment cupboards for housing equipment for which access from the saloon is necessary, may be provided at the carbody ends.
- (xiv) Two 10kg fire extinguishers with dial type pressure gauge of the dry powder type shall be installed in each saloon, readily accessible, and notionally located beneath diagonally opposite seats.
- (xv) A dedicated space shall be provided in the Driving Trailer car, to accommodate a wheelchair, complete with its occupant. Detailed proposals, including the need for a doorway flap or ramp shall be submitted and may be reflected in the appropriate mock-up.
- (xvi) Each Saloon shall have at least one 230V, 5A socket and 2 fast charging USB ports on both ends. The sockets and USB shall be used for mobile & laptop charging.

4.14.2 Windows

- (i) Saloon windows shall be provided and be flush mounted with the exterior of the car body.
- (ii) All windows, including those in Passenger Saloon Doors (See 4.14.3 below) shall comprise double

glazed, toughened, laminated glass separated by an air gap, permanently sealed against ingress of moisture. The inner pane need not be laminated.

- (iii) All windows shall be designed to minimise solar gain and provide a level of thermal insulation consistent with the requirements of the air conditioning system.
- (iv) Window units shall be modular units, and shall be replaceable with minimum disturbance to the rest of the vehicle.
- (v) Large window openings are preferred to permit standing passengers a wider view. The size of the windows shall be subject to review by the Engineer.
- (vi) Each window, including glazing shall have sufficient strength to resist penetration into the car in compliance with UIC 566.
- (vii) All side windows shall transmit less than 5% of the incident ultra violet radiation. All windows shall transmit between 50% and 55% of incident visible light.
- (viii) Deflection at window and door openings under a compressive load of 1200kN and a tensile load of 1000kN shall not damage the window or door.
- (ix) Window seals shall be designed to prevent ingress of water to the inside of walls.

4.14.3 Passenger Saloon Doors

For details, see chapter 7.

4.14.4 Not Used

4.14.5 Seats

- (i) Longitudinal banks of seats shall be provided along the body-side between doorway draught-screens, and between draught-screens and body ends.
- (ii) The seats shall provide an adequate level of comfort, have a good appearance and be scuff and vandal resistant and their mountings shall be capable of withstanding the loads arising in service conditions.
- (iii) The seats shall provide some resistance to passenger movement longitudinally along the vehicle during acceleration and braking of the consist.
- (iv) Seats shall not be upholstered and shall not have sharp edges or protrusions that could cause injury to passengers or staff.
- (v) Seat modules in similar situations in a vehicle shall be interchangeable. It is preferable that only one style of module be used throughout the train.
- (vi) It is preferred that the seats be cantilevered out from the side wall, to provide a clear unobstructed car width floor, for ease and speed of cleaning.

4.14.6 Draught Screens

- (i) Beside all passenger access body-side doorways, shall be provided a longitudinal space, providing a "stand-back" position for passengers to manoeuvre themselves into position when nearing their station.
- (ii) Beyond the stand back area and at the end of the adjacent longitudinal seat a draught screen shall be

installed. The draught screens shall be formed from tubular metal grab poles, fitted with clear safety toughened glass, in such a way as to provide uninhibited hand holds to passengers within reach of the tubular metal sections.

- (iii) The strength of the draught screens shall be such that passenger loadings shall not produce any permanent deformation, damage or displacement.

4.14.7 Grab Poles and Rails

- (i) Stainless steel grab poles and rails shall be provided in the standing areas of the saloon for the comfort and safety of standing passengers.
- (ii) Grab poles shall also be an intrinsic feature of the inner edges of all draught screens.
- (iii) The grab poles and rails shall suffer no permanent deformation when subject to loading conditions arising in service, in accordance with UIC 566
- (iv) Grab poles and rails shall be positioned such that 95% of Indian passengers can always access a pole or rail without having to reach more than 300 mm.

4.14.8 Interior Lighting

For details, See Chapter 12.

4.14.9 Floor

- (i) The non-skid floor structure shall be designed to minimise the life cycle cost of the floor over 35 years.
- (ii) The floor, and its mounting structure, shall be designed to withstand any loads that may be applied over 35 years in normal operation of the consist.
- (iii) The floor structure shall provide a high resistance barrier to fire and to noise generated beneath the vehicle. At all door openings, the floor shall make a weather-tight connection. No opening in the sub-floor is permitted.
- (iv) The floor covering shall be anti-slip, waterproofed and sealed, non-skid, resistant to wear and staining, shall not trap dust, and shall be easily cleaned using conventional floor cleaning machines/methods and media.
- (v) The floor design shall allow the floor covering to be removed without damage to the floor sub-structure.
- (vi) The total floor structure shall provide an effective fire barrier for a minimum of 30 minutes as per EN 45545, Latest Editions. The tenderer shall provide, as an option an increase of this period to 45 minutes, highlighting any implications this may have. Fire resistance characteristics shall conform to international standards.
- (vii) The sub-floor shall be insulated for anti-drumming and noise suppression.
- (viii) Contractor shall demonstrate through design that no floor swelling or undulations shall occur during the design life.

4.15 Inter-Car Gangways

4.15.1 Exterior

- (i) The gangways, when coupled shall be completely weatherproof and draught proof.
- (ii) The gap between the station platform edge and the exterior of the inter-car gangway shall be minimised.
- (iii) For cars coupled by auto-couplers the alignment and engaging of the gangway shall be actuated simultaneously with the action of the auto-coupler.
- (iv) The gangway structure shall lock securely at top and bottom. Locking and unlocking shall be by manual means.
- (v) The means of uncoupling a semi-permanently coupled pair of cars, in workshop conditions shall be described by the tenderer.
- (vi) All inter-car gangway structures shall be totally interchangeable with one another.
- (vii) To protect the interior of the vehicles when stabled as units, (i.e. not as a complete 4, 6, or 8 car rake), from inclement weather, temporary gangway end covers shall be provided. The covers shall be sufficiently robust to provide good protection, but sufficiently light weight to permit fitting and removal by one person.

The covers shall be lockable in position to withstand high wind conditions. The tenderer shall include in his price for **twelve** such covers.

4.15.2 Interior

- (i) The inter-car gangways shall be arranged so that litter left in the gangway cannot accumulate, and is readily removable, without having to disconnect gangways or remove access covers.
- (ii) The headroom in the inter-car gangway area shall be at least 1900mm, and the clear width through at least 1400mm.
- (iii) The interior design shall be fitted with smooth and aesthetically pleasing panelling and shall ensure that no potential finger or dirt traps exist.
- (iv) It shall not be possible for a person to move apart parts of the gangway interior cladding in such a way as to gain access to the exterior of the vehicle between components of the gangway, under any circumstances

4.15.3 Gangway Floor

- (i) The floor through the inter-car gangway shall be maintained as nearly as possible at the same height as the rest of the car floor. The height difference shall be kept to a minimum, and at no point shall it exceed 20mm difference from the remainder of the floor. Height changes shall be ramped so as not to cause inconvenience to passengers.
- (ii) Vertical gaps between the hinged moving tread-plates of the inter-car gangway and the general floor level of the car shall not exceed 5mm. The means shall be provided to minimise wear of the floor by the sliding action of each moving tread plate.
- (iii) The design of the floor shall be such that the relative movement between adjacent vehicle ends does not cause sliding floor plates to lift in such a way as could cause injury, in particular to sandal-clad or bare feet.

- (iv) Heat and sound insulation measures sufficient to meet internal noise levels and air conditioning requirements of the car body shall be provided.
- (v) Sealing of the gangway shall eliminate leakage of water into the saloon area.
- (vi) The elements of the gangway shall give a service life of fifteen years excepting those susceptible to deterioration, such as gangway flexible elements, which shall give a service life of 7.5 years.

4.15.4 Gangway Strength

- (i) The gangway floor shall be designed to meet the same strength requirements as the rest of the car floor.
- (ii) The gangway shall withstand without permanent deformation the following loads:
- (iii) A differential pressure between inside and outside of the gangway of $\pm 2.5\text{kN/m}^2$.
- (iv) A concentrated perpendicular load, acting from within the gangway, of 1000N applied over an area of 0.1m² anywhere on the surface of the side walls.

4.16 Car Roof and Roof Mounted Equipment

4.16.1 Roof Structure

Every effort shall be made to make the structure of all cars, as nearly as possible identical. To this end, tenderers shall indicate what economies may accrue from making all car roofs to one standard design, having a recess capable of accommodating a pantograph, even though no pantograph will be fitted on the Motor Cars. Tenderers may offer what alternatives they consider appropriate.

4.16.2 Air Conditioning Equipment

Package air-conditioning units shall be mounted at each end of the car roof, housed in suitable watertight wells in the car roof structure. The wells shall be provided with adequate, double sealed connections to the main conditioned air ducting, electrical supply and condensate drains. Conditioned air shall be fed into thermally insulated ducting. The duct shall be split diagonally from end to end to distribute air evenly throughout the length of the car, even in the event of the failure of one air conditioning unit (see chapter 11).

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.

4.16.4 Roof Drainage

The Contractor shall ensure adequate water drainage from the roof, such that no water shall be discharged into the vicinity of the passenger doorways.

The drainage shall be so designed to eliminate the requirement for unblocking of leaves and other debris. The drainage arrangement shall be suitable for use with, and not cause damage to the brushes of automatic train wash plants.

This page is left blank intentionally

**EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATION**

CHAPTER 5

BOGIES

CHAPTER 5: BOGIES

5.1 General Requirements and Features

5.1.1 The bogie shall be of a design which has worked satisfactorily in service on a metro or suburban railway, of similar traffic density for at least three years, irrespective of gauge.

5.1.2 It shall be constructed to continue in service, under normal operating conditions for at least 35 years, assuming normal wear and tear, and maintenance. During that period, there shall be no major rebuild, repair or strengthening of any bogie structural members.

5.1.3 The bogies shall be of the two axle bolsterless type incorporating a steel-and-rubber primary suspension system, and a secondary pneumatic suspension system, and with axle bearings outboard of the wheels. The use of helical coil steel springs will not be permitted. Calculations supporting the selection of axles and bearings shall be submitted for review by the Employer's Representative.

5.1.4 The bogies shall be identical. Driving trailer car bogies, trailer car bogies and motor car bogies shall have interchangeable components to the maximum extent possible.

5.1.5 Carbody and bogie construction tolerances and distortions shall be compensated by the incorporation of shims, welded into position, and which shall become a permanent fixture on the carbody and bogie respectively.

5.1.6 The design shall provide means for easy compensation for wheel wear and loss of height in the bogie resulting from other causes.

5.1.7 The bogie and bogie mounted equipments shall be designed to minimise unsprung mass.

5.1.8 The bogies offered shall permit the cars to negotiate curves on plain track and through turnouts as shown below :-

Table 5.1.8 Bogie Performance on Curves

Track Gauge	Min. Rad. of Curvature Plain Track	Turnout Type	Min. Rad. of Curvature Turnout	Track Speed
1676mm	175m	1 in 8.1/2	175m	<25km/h
1676mm		1 in 12	350m	<40km/h

The bogies shall also be able to operate on a gradient of 3% without speed restriction, and on a gradient of 4% with speed restriction in depot, and on specified cant deficiencies and at specified speeds.

5.2 Dynamic Requirements

5.2.1 Suspension characteristics shall be selected so as to avoid resonance between the various elements of the vehicle system including the carbody. Bogie and body frequencies shall be suitably separated.

5.2.2 All vehicles shall be dynamically stable, and so designed that no part of the car shall infringe the Kinematic Envelope at any speed up to 90km/h.

5.2.3 The vehicle shall remain dynamically stable throughout the full speed range of the train under all loading conditions in the event of either complete or partial deflation of the secondary suspension, the car shall operate safely up to the maximum design speed.

5.2.4 The bogie suspension, in conjunction with the carbody, shall be designed to enable cars to operate satisfactorily on track with the maximum specified track twist. The maximum off loading of any wheel shall not exceed 50% of nominal wheel load.

5.2.5 The axle yaw stiffness, and the rotational resistance of the complete bogie shall be such that lateral flange forces generated when negotiating the track alignments for the route specified are not so high as to lead to excessive rail wear and wheel flange wear, but shall be sufficient to obviate bogie or wheelset hunting.

5.2.6 The Contractor shall submit calculations to confirm that the derailment quotient Y/Q shall not exceed 1.0 under the most adverse conditions, where Y & Q are the instantaneous lateral force on the wheel flange and the instantaneous vertical load on that wheel tread respectively.

5.3 Bogie Construction: Bogie Frame

5.3.1 The bogie frames shall as a minimum be of fabricated, robust construction, using weather resistant high tensile carbon steel to an approved international standard, capable of withstanding heavy duty, the design incorporating adequate safety margins. The bogie frame construction shall be consistent with good mechanical design, be as light as possible.

5.3.2 The Contractor shall submit for review detailed calculations, including a finite element analysis under different boundary conditions, to demonstrate that the strength of the bogie frame is adequate for the specified loading.

5.3.3 The bogie frames for all the cars shall be identical unless justified otherwise.

5.3.4 The Contractor shall undertake full fatigue strain gauge and suitable non-destructive tests on a pre-production bogie frame and submit the report. The strain gauge fixing locations and the application of forces for static as well as for fatigue testing shall be in place at the time of testing.

5.3.5 All fasteners for bogie mounted equipment or components shall be positively locked. The use of self-locking nuts alone is not acceptable.

5.3.6 Adequate corrosion protection shall be provided. Details shall be submitted. A corrosion protection control programme for the bogie shall be submitted.

5.4 Bogie Construction: Primary and Secondary Suspension

5.4.1 The Contractor shall submit a proposal for the primary suspension using steel-and-rubber springs, and shall declare the estimated mean service life for operation in the Delhi environment. The service life shall be not less than 6 years, and shall be warranted for 5 years.

5.4.2 Secondary air suspension shall be installed to provide automatic vehicle body to bogie height adjustment, functional for all vehicle loading conditions.

5.4.3 Vehicle height variation due to wheel wear and re-profiling shall be adjusted by packing. This shall be made possible without disconnection or removal of the carbody from the bogie.

The maximum floor height reduction on this account shall be for review by the Employer's Representative.

The minimum clearance of bogie mounted equipment from rail level for a fully loaded static car including full

wheel wear on diameter shall not be less than 75mm.

5.4.4 Secondary suspension emergency springs, which shall become operative in the event of full deflation of air springs, shall be fitted. The car shall be capable of safe operation up to the specified maximum speed with deflation of any or all of the air springs. In the event of one air spring becoming wholly or partially deflated, the complete air spring system of that bogie shall be correspondingly exhausted to ensure that the carbody remains level laterally, and can continue to operate safely.

5.4.5 Hydraulic dampers shall be provided as necessary to control and limit the vertical and horizontal oscillation of the carbody.

5.4.6 The air spring pressure shall also be used to provide an average signal input to the load weighing equipment for load compensation of the propulsion, brakes and air-conditioning systems. If the load signal fails, the system shall default to the maximum laden condition.

5.4.7 The lateral stop shall be cushioned using a properly designed stiffness value.

5.5 Bogie Construction: Bogie to Body Connection

5.5.1 The carbody centre pivot shall be capable of permitting the full range of bogie movements without excessive restraint.

5.5.2 The bogie shall be attached to the carbody in such a way as to permit lifting of carbody and bogies as a complete unit. The Contractor shall indicate the minimum safety factor used, taking account of the yield stress for all support members.

5.5.3 Traction linkage(s) shall be provided, and located such that the ride characteristic of the vehicle is devoid of any pronounced fore- and-aft and pitching motion.

5.5.4 Arrangements shall be made to exchange wheelsets with the minimum dismantling of bogie components being required.

5.5.5 The carbody shall be easily detached and lifted from the bogie. It is preferred that the Contractor may consider offering a design to permit access to one or more easily located fasteners, accessible from the side of the vehicle without the necessity for a pit between the rails.

5.5.6 The arrangement should allow the bogie to be mechanically disconnected, permitting the body to be lifted sufficiently far to provide access between body and bogie to disconnect traction motor cables, brake system flexible pipe connectors, and secondary suspension levelling valve linkages, etc.

5.5.7 The bogie frame shall have a suitable arrangement for lifting the bogie frame from the wheels and for lifting the complete bogie during maintenance in the workshop.

5.5.8 Body to bogie connection shall be easily accessible to facilitate exchange of bogies. An effective system of guiding shall be provided to assist the exchange of bogies following repair.

The target interval between major bogie overhauls shall be not less than 0.8 million kilometres of service operation. The Contractor shall propose how this requirement will be achieved.

5.6 Bogie Strength

5.6.1 The mechanical strength of the bogie frame shall comply with the requirements of UIC 615-4 and UIC 515-4 or latest version for static test under exceptional loads and fatigue tests. The maximum stress developed under static load shall not exceed 85% of the yield strength of the material. The dynamic effects due to the inertia of the motors and transmission shall also be simulated along with traction and braking forces.

5.6.2 The bogie frames shall be able to withstand a longitudinal shock load of **5g** without failure. This shall be taken as occurring simultaneously with the fully laden vertical load.

5.6.3 The axle shall be designed in accordance with UIC 515-3 or latest version.

5.6.4 The number of seated passengers shall be taken as one per seat, and standing passengers as $10/m^2$ for all the above-mentioned strength analyses. The passenger weight for this calculation shall be taken as **65kg/person**.

5.7 Body to Bogie Connection

5.7.1 The carbody to bogie connection shall withstand the following loads without permanent deformation:

- (i) A vertical load of 0.75 times the fully loaded weight of the carbody (excluding bogies)
- (ii) A lateral load of half fully loaded body weight subjected to an acceleration of **$\pm 1.1g$** .
- (iii) A longitudinal load equivalent to the bogie mass subjected to an acceleration of **$\pm 3.0g$** .

5.8 Bogie Mounted Equipment

5.8.1 Equipment mounted on the bogie frame shall withstand without permanent deformation the loads associated with the following accelerations acting on the mass of the item of equipment :

(i)	vertically	10g
(ii)	transversally	3g
(iii)	longitudinally	5g

5.8.2 Equipment mounted on the bogie frame shall have a fatigue life of not less than 10^7 cycles under loads associated with the following accelerations acting on the mass of the item of equipment :

(i)	vertically	$\pm 5.0g$
(ii)	transversally	$\pm 1.5g$
(iii)	longitudinally	$\pm 0.2g$

5.8.3 Equipment mounted on the axlebox shall withstand without permanent deformation the loads associated with the following accelerations acting on the mass of the item of equipment :

(i)	vertically	25g
(ii)	transverse	5g
(iii)	longitudinal	5g

5.8.4 Equipment mounted on the axlebox shall have a fatigue life of not less than 10^7 cycles under loads associated with the following accelerations acting on the mass of the item of equipment :

- | | | |
|-------|----------------|---------|
| (i) | vertically | ± 10.0g |
| (ii) | transversally | ± 3.0g |
| (iii) | longitudinally | ± 0.5g |

5.8.5 The acceleration level specified in paragraphs 5.8.1 and 5.8.2, will be reviewed by the Employer's Representative, based upon International Standards or Norms followed by reputed metro railways.

5.9 Finite Element Analysis

5.9.1 Finite element analysis shall be demonstrated using validated software, and detailed calculations submitted for the above mentioned strengths (including static and fatigue).

5.10 Motor Suspension

5.10.1 The traction motor shall be bogie frame mounted, complete with suitable drive and suspension.

5.10.2 Traction motors and drives shall be easily removable in a workshop, after disconnection of cables and fixings without the need to disturb the axle.

5.10.3 Contractors are invited to offer as an alternative, a motor suspension arrangement which will permit a traction motor to be lowered onto a drop table from beneath a car elevated on a raised track or on jacks. The Contractor should indicate the extent of his past experience with such an arrangement.

5.10.4 Calculations indicating the natural frequency of the motor suspension system shall be submitted, and shall clearly indicate that resonance with the bogie frame is avoided.

5.11 Gearbox and Coupling

5.11.1 Contractor shall provide flexible coupling between traction motor and drive gear.

5.11.2 The gearbox shall be compatible with the flexible coupling. Gearbox movement shall be restrained by a torque reaction link between the gearbox and bogie frame.

A safety device shall be incorporated to restrain gearbox rotation should the link fail in service. The gears including bearings shall not require overhaul at least earlier than 0.8 million kms.

5.11.3 The gears shall be splash oil lubricated and a sight glass shall be provided in the gear case for inspection. It shall not be necessary to change the oil earlier than 200,000 km.

5.11.4 The gearbox shall be subjected to a test based on the actual duty cycle on a specified Corridor with the specified torque and speed conditions. Testing shall start with gearbox at temperature of at least 30°C and temperature shall be continuously monitored. The temperature shall not exceed the manufacturer's recommendations consistent with life between oil changes. Test shall be carried out in both the directions. Noise and vibration test shall also be performed along with this test. The Contractor shall submit a Test Procedure based on international practice for approval by the Engineer.

5.12 Wheels, Axles and Axle-boxes

5.12.1 The wheels shall be monobloc forged steel, complying with the requirements of EN 13262, grade ER8 Category 2. The type test (carried out according to table F1 of EN 13262) certificate shall be provided with the prototype deliveries.

5.12.2 The powered axles shall comply with EN 13104 or UIC Code 811-1 or any other internationally accepted equivalent standard. Manufacturing of axles shall be as per EN 13261. The type test (carried out in

accordance with table J1 of EN 13261) certificate shall be provided with the prototype deliveries.

5.12.3 The non-powered axles shall comply with EN 13103 or UIC Code 811-1 or any other internationally accepted equivalent standard. Manufacturing shall as per EN 13261. The type test (carried out in accordance with table J1 of EN 13261) certificate shall be provided with the prototype deliveries.

5.12.4 Wheels, axles, drive gears and axle bearings shall be assembled on axles by an interference fit method. Oil injection grooves shall be provided as appropriate.

5.12.5 The wheel tread shall be of the wear adapted wheel profile in accordance with RDSO Sketch No. 91146 (Alteration 2) for a track gauge of 1676mm (See Appendix TE).

The extreme maintenance limits for broad gauge wheels are as given below:

- (i) Minimum thickness of flange measured from wheel gauge face at 13mm from outer edge of the flange = 16mm
- (ii) Maximum projection for flange of worn wheel measures from the tread at 63.5mm from the wheel gauge face = 35mm
- (iii) Back-to-back wheel gauge distance = 1600mm $-1\text{mm} + 2\text{mm}$
- (iv) Maximum clearance between flange and new rail = 22mm

5.12.6 Axle bearings shall be of a proven type. The roller bearings shall have a minimum life rating of 3 million kilometres when computed in accordance with the method given in ISO 281/1. The passenger load as described in Clause 5.6.4 shall be taken for the design of the wheels, axles and axle bearings. Bearings shall be arranged not to carry any traction return current.

5.12.7 Natural frequencies of the wheels, axles, axle boxes and other unsprung equipment shall have sufficient separation between natural frequencies with the track structure to avoid resonance.

5.12.8 The Contractor will be required to provide recommended lubricants which shall have been proven in similar railway service for the axle bearings.

An alternative lubricant, manufactured in India shall also be identified by the Contractor, in conjunction with the bearing manufacturer, and the lubricant manufacturing industry.

5.13 Bogie Brake Equipment

5.13.1 Full details of the braking scheme are to be found in Chapter 6.

5.14 Automatic Train Control (ATC) Equipment Mounting

5.14.1 Full details of the Automatic Train Control System interface issues are given in Chapter 12 and Appendix TD.

5.15 Wheel Flange Lubrication Equipment

5.15.1 Dry type Wheel flange lubricators of a proven design in EMU metro application shall be provided in 25% of axles of each car. A suitable mechanism shall be provided to ensure that lubricators operate only in the leading position on the train. The functionality of the wheel flange lubrication mechanism shall be submitted for review of the Engineer.

5.16 Maintainability

5.16.1 Arrangements shall be made to exchange wheel sets with the minimum dismantling of bogie components being required. The procedure for dismantling shall be furnished.

5.16.2 The arrangement should allow the bogie to be mechanically disconnected, permitting the body to be lifted sufficiently far to provide access between body and bogie to disconnect traction motor cables, brake system flexible pipe connectors, and secondary suspension leveling valve linkages, etc.

5.16.3 The bogie frame shall have a suitable arrangement for lifting the bogie frame from the wheels and for lifting the complete bogie during maintenance in the workshop.

5.16.4 Body to bogie connection shall be easily accessible to facilitate exchange of bogies.

5.16.5 The target interval between major bogie overhauls shall be not less than 0.8 million kilometers of service operation. The Contractor shall furnish inspection, maintenance and operational schedule of the bogies along with the intervals.

5.16.6 The bogie shall provide easy and safe access for all maintenance, including access for train operator to operate the isolating cocks for bogie-mounted equipment and parking brake manual release.

5.16.7 The contractor shall submit the detail of ultrasonic testing of powered & non- powered axles. The detail shall include the testing procedure and pattern used as reference for this test, which shall be used by Employer's maintenance staff/personal.

This page is left blank intentionally

**EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATION**

CHAPTER 6

PNEUMATICS, AIR SUPPLY AND BRAKE SYSTEM

CHAPTER 6 : PNEUMATICS, AIR SUPPLY AND BRAKE SYSTEM

6.1 Overview

6.1.1 Each two-car unit shall be fitted with a complete "stand-alone" compressed air supply system.

6.1.2 The Pneumatic and Air Supply System (See Clauses 6.2 to 6.11 inclusive) shall consist of, but need not be limited to, the following :

- (i) Air compressor unit and drive motor
- (ii) Auxiliary Compressor and 110V DC motor drive
- (iii) Air drier and filtration components
- (iv) Reservoirs
- (v) Pressure governors and switches
- (vi) Pipe system
- (vii) Air suspension equipment
- (viii) Automatic coupling actuating equipment.
- (ix) Pantograph actuating equipment
- (x) Ancillary pneumatically driven devices.

6.1.3 The Brake System (See Clauses 6.12 to 6.22 inclusive) design shall be subject to review, and shall consist of, but need not be limited to, the following :

- (i) Brake system
- (ii) Electric brake
- (iii) Electric/pneumatic brake blending
- (iv) Parking brake
- (v) Emergency brake
- (vi) Brake control system
- (vii) Wheel spin and slide protection

6.2 Air Compressor and Drive

6.2.1 The compressor and associated pneumatic equipment shall be so positioned as to facilitate access for maintenance and ensure freedom from noise, vibration and discomfort to passengers and train crew.

6.2.2 A proven air compressor operating from a 415V 3-phase 50 Hz power supply with an adequate free air

delivery capacity for 2-cars shall be provided. One compressor shall have sufficient capacity to charge a completely empty 2-car unit within 7 minutes. Full air suspension inflation shall be achieved in a further five minutes. The average duty cycle of each compressor without electric braking shall not exceed 50% during operation.

6.2.3 In the event of total failure of electric brakes and one air compressor on a fully loaded 4-car train, the remaining air compressor on the train shall have sufficient capacity to enable the train to remain in service for at least 3 hours.

6.2.4 While the quietness of the proven type of compressor is of importance, considerable emphasis is also placed upon reliability. The Contractor is therefore required to show that the reliability and maintainability of the compressor offered, has been established in actual EMU metro service. The Contractor should, *inter-alia*, submit letters from actual users indicating experience with the compressors on their system.

6.2.5 The motor compressor unit shall be resiliently mounted to minimise the levels of vibration transmitted to the car body.

6.2.6 The intake air shall be directed through a properly designed filter, suitable for the dusty atmospheric conditions prevailing in Delhi.

6.2.7 The compressor should preferably be splash lubricated to avoid the need for oil pump, filter, valve, etc.

6.2.8 A pressure switch shall control the cutting in and out of the compressor. A time relay shall be provided to monitor the state of health of the compressor and air delivery system.

6.2.9 A non-return valve shall be provided between the compressor and the main reservoir supply line.

6.2.10 The compressor shall not be made to start against back pressure. If need be, a soft start feature shall be provided.

6.2.11 A safety valve shall be provided to protect the compressor against excess pressure.

6.2.12 The Contractor shall submit calculations to show that the compressor will meet the above conditions.

6.3 Auxiliary Compressor

6.3.1 A proven 110V d.c. operated compressor shall be provided for operation of pantograph and VCB during start-up of the train. The compressor shall work satisfactorily within voltage range of 77V to 138V d.c.. Minimum protection class should be IP 55.

6.4 Air Dryer and Filtration

6.4.1 The air delivered to the pneumatic system shall be clean and dry. Detailed proposals on the method and standards achievable for exclusion of water vapour, oil and water mist and particles, prior to delivery of air to the main reservoir, and the means of combatting the extremely hot, humid and dusty conditions prevailing in Delhi, shall be submitted.

6.4.2 The grade of filtration at rated pressure shall be minimally as follows:

(i)	Particles removal down to	:	1 micron
(ii)	Maximum remaining oil content	:	0.01 mg/m ³ at 21°C
(iii)	Liquid water removal	:	> 95%
(iv)	Dew point depression	:	40°C

Under the ambient conditions prevailing in Delhi, no condensation shall take place.

6.4.3 A proven regenerative type of air dryer with suitable capacity shall be provided between the air compressor and the main reservoir. The air dryer shall be preceded by an automatic drain valve, preferably of the swirl type, which collects and discharges the bulk of the moisture in the compressed air, before it enters the air dryer.

6.4.4 Use of a desiccant that would improve the filtering standards of the above is preferred. Suitable means of oil separation, prior to the air dryer shall be provided if a desiccant drying agent is proposed. An inter-cooler and after-cooler of liberal capacity shall be supplied to ensure efficient operation of the air dryer. Full technical details of the proposed air dryer shall be furnished by the Contractor for review by the Employer's Representative.

6.4.5 All failures of the air dryer shall be displayed in the driver's cab.

6.5 Reservoirs

6.5.1 A main reservoir with a capacity adequate for a 4-car train shall be provided on each two-car unit. The reservoir shall incorporate a safety valve and an automatic drain valve. The Contractor shall provide calculations to substantiate correct sizing of the reservoirs.

6.5.2 The brake service reservoir shall have sufficient capacity for three consecutive full service brake applications with a train speed of 80km/h fully loaded. This shall be achieved without electric brake supplement and without air replenishment from the main reservoir.

6.5.3 Not Used

6.5.4 Reservoirs shall be manufactured from stainless steel. All reservoirs shall have a device for venting and draining of the contents of reservoirs.

6.5.5 A separate air suspension system reservoir of suitable capacity shall be provided.

6.6 Pressure Governors and Switches

6.6.1 Pressure governors and switches proven in railway rolling stock applications shall be provided for various control and monitoring functions.

6.7 Pipe System

6.7.1 All piping shall be of stainless steel conforming to the requirements of SUS 316L to JISG 3459 or any other internationally accepted equivalent standard with flare less double compression fittings. The pipe fittings shall conform to the requirements of DIN 2353.

6.7.2 A main reservoir pipe shall run continuously throughout the train.

6.7.3 All piping shall be of stainless steel with flareless compression fittings. The use of pipe fittings with rubber 'O' rings or similar types of seal is not acceptable.

6.7.4 It is preferable that sizes of pipes are limited to a minimum. Sharp bends shall be avoided and standard connections shall be used as far as possible.

6.7.5 All branches from the main reservoir pipe or control system shall be fed via cut-out cocks which may or may not be vented as appropriate. Strainers, reducing valves and check valves shall be incorporated as required.

6.7.6 Quick release coupling test points made of stainless steel, with blanking plugs shall be provided. They

shall be located in easily accessible positions.

6.7.7 Flexible hoses shall be kept to a minimum, and be proven in railway rolling stock service. The Contractor shall submit proposals to increase the integrity of the air supply system against rupturing of inter-car flexible hoses. Burst hose protection shall be provided for hoses to each actuator.

6.7.8 Foreign matter shall be removed from all pipes prior to installation.

6.7.9 Suitable colour coding shall be applied to all pipework for identification.

6.8 Pressure Gauges

6.8.1 All driving cabs shall be fitted with a pressure gauge which indicates:

- (i) The pressure in the main reservoir pipe.
- (ii) The pressure in the brake actuators of the vehicle to which the gauge is fitted.
- (iii) Pressure in the brake reservoir.

6.8.2 On all cars, test points, onto which test gauges may be connected, shall be provided in the vehicle brake and air supply system. It shall be possible to check the operational pressure of each brake actuator. The location of the test points shall be submitted to the Employer's Representative for review.

6.9 Air Suspension Equipment

6.9.1 A levelling control system shall be provided to ensure longitudinal and transversal control of body height under all conditions of load. In each bogie, one levelling system shall be provided to adjust air pressure in the air springs. In the case of failure of one air spring, the other should quickly bleed out so that the carbody is lowered to its stable position. The air supply for the levelling system shall be taken from the main reservoir pipe.

6.10 Automatic Coupling Actuating Equipment

6.10.1 Control of the auto coupler operation shall be provided by air supplied from the main reservoir via an isolating cock, protection choke and solenoid operated valves.

6.11 Ancillary Pneumatic Devices

6.11.1 Pantograph actuating equipment shall be fed by air supplied from an auxiliary reservoir, suitably located in each unit together with a battery operated motor driven compressor, for the purpose of initial raising of the pantograph and closing of the vacuum circuit breaker.

6.11.2 A pneuphonic horn, operable from the driver's console shall be provided, located at the front end of the cab, facing forwards. It shall be in accordance with the requirements of UIC 644 or latest international standards. Details of the loudness, tone and pitch shall be subject to review by the Employer's Representative.

6.12 Isolation of Defective Equipments

6.12.1 Isolating valves and switches shall be provided to enable parts of the system to be isolated.

6.12.2 All isolating valves that require operations by train crew in normal operation or in emergencies shall be easily accessible either from within the car or from track level as appropriate.

6.12.3 Isolating cock handles shall lie parallel to the pipe in which it is installed, in the normal operational (Open) position, and perpendicular to the pipe in the isolated (Closed) position, and shall operate in the horizontal plane only. Cable ties shall provide a ready means of identification of a cock which has been operated.

6.13 Brake System

6.13.1 The train braking performance shall be as specified in Chapter 3, Clause 3.25.1.

6.13.2 The brake system shall be complete in each two-car unit, and shall consist of :

- (i) An electro-pneumatic (EP) service friction brake.
- (ii) A fail safe, pneumatic friction emergency brake.
- (iii) An spring applied air-release parking brake.
- (iv) An electric regenerative service brake.
- (v) Provision of smooth and continuous blending of EP and regenerative braking.

6.13.3 The EP brake is to be so designed that its control function can be taken over by the pneumatic control units even in the case of failure of individual electronic or electrical control elements.

6.13.4 Friction braking shall be achieved by bogie mounted brake actuator units operating on the EP system. The EP service and emergency brakes shall operate the same brake actuators. The brake actuator shall operate a tread brake.

Parking brakes shall be incorporated on 50% of tread brake actuators. Parking brakes shall be capable of holding a fully loaded stationary train on a 4% gradient under all track conditions, indefinitely.

6.13.5 The friction brake system shall be proven and capable of achieving all performance requirements for a continuous round trip with maximum speed of 55 Kmph without the aid of electric braking.

6.13.6 With the train at standstill on a rising gradient, the brake application shall be retained (up to e.g. 6 km/h) while traction power is being applied, with a force sufficient to prevent the train from rolling backwards.

6.13.7 At station stops, the friction brake application shall continue at a level sufficient to prevent the train from moving. The brake shall be released only when a power command is given to start the train.

6.13.8 It shall be possible to isolate the friction brake system individually on each bogie. The isolation device shall be located on the underframe adjacent to the bogie and be readily accessible. The isolation shall be readily discernible to operations and maintenance staff.

6.13.9 All devices capable of isolating a portion of the brake system shall be located and protected to avoid inadvertent or malicious operation.

6.13.10 Brake friction materials shall not contaminate the wheels or rails adversely so as to affect train detection by the Signalling System.

6.13.11 Composite tread brake blocks shall contain no asbestos material. Heating by the brake block shall in no case cause the wheel to exceed its permissible temperature above which incipient thermal surface cracks appear.

6.13.12 Friction characteristics of the brake block material as tested on the Contractor's brake dynamometer, in both dry and wet conditions in the range of 0-110km/h under various designed brake forces and pressures shall be submitted.

6.13.13 The calculation for emergency braking distances under dry and wet conditions shall be submitted.

6.13.14 Braking distances for normal service braking with electric brake blending shall also be submitted.

6.13.15 All the pneumatic control equipment and valves for one car shall be mounted on modular panels or frames to minimise pipe lengths.

6.14 Electric Brake

6.14.1 Priority shall be given to the electric brake whenever a brake command is initiated. The electric brake shall also be load weighed to ensure consistent performance. The use of electric brakes shall be maximised in all service braking modes, and shall make full use of the adhesive weight on all motor car axles.

6.14.2 The Contractor shall state the lowest possible electric brake application speed before instability occurs.

6.14.3 Deleted

6.14.4 In the event of failure of the electric brake, the friction brake shall be capable of carrying out full braking duty.

6.14.5 The tenderer shall submit brake effort v. speed characteristics showing the contribution of regenerative braking and electropneumatic braking separately over the entire speed range.

6.15 Electric/Pneumatic Brake Blending

6.15.1 The brake blending system shall ensure the priority of electric braking over pneumatic braking. If the demand declaration is not achievable solely by the motor cars' electric brakes, the pneumatic brake system on the trailer cars shall provide supplementary brake effort. The Contractor shall submit full proposals for review. Electric brake fade out shall not occur above 5km/h.

6.16 Parking Brake

6.16.1 The parking brakes shall be applied in the event of loss of the main compressed air supply. The parking brakes shall be capable of release from within the cab when the compressed air supply is present. With no compressed air supply available, it shall be possible to release individual parking brake actuators manually from track level. Application of parking brakes shall also be controllable from the cab. (See also 6.12.4).

6.16.2 The design shall be such that the parking brakes will take effect prior to fade off of service brake and shall ensure that the combined brake effect of the pneumatic brake and parking brake is never less than the full brake effort of the parking brake alone.

6.16.3 Status of train parking brake shall be displayed in the active cab.

6.17 Emergency Braking

6.17.1 The Contractor shall furnish emergency braking distances to standstill, for a fully loaded train from speeds, starting from 10km/h to 90km/h in increments of 10km/h.

6.17.2 The friction brake system shall be rated to, and have sufficient thermal capacity to safely complete three successive acceleration and emergency brake cycles, with no interval between each cycle. Each cycle shall comprise a full acceleration from standstill to 80km/h followed by the application of emergency brake to standstill. On the completion of the five cycles, the brake system shall show no abnormalities.

6.17.3 Wheel slide protection shall be used during emergency braking. Any failure in the wheel slide protection in emergency braking shall result in the application of full brake force and deactivation of the spin/slide system.

6.17.4 The electric brake shall be isolated during emergency braking.

6.17.5 Two emergency brake push-buttons shall be installed in each cab in the train. Activation of the buttons shall apply the emergency brakes under all conditions, including in-active cabs.

6.17.6 Unintended parting of the train shall result in an emergency brake application on both halves of the train.

6.17.7 Activation of the emergency brake by any means shall result in the propulsion system being disabled in a safe critical manner. The propulsion system shall not be re-enabled until the train is at zero speed and the emergency condition has been reset.

6.18 Brake Control System

6.18.1 A high integrity fast response closed loop digital brake control system shall be provided, with the brake regulation rate at $\pm 5\%$ of the deceleration demanded. The Contractor shall ensure that the brake system is so designed that failure of any single control component shall not result in loss of braking effort on more than one car. All circuits and controls essential for braking equipment shall have high integrity 'hard wire' feeds and inputs. These feeds and inputs shall be duplicated. A microprocessor based brake control system, shall be offered.

6.18.2 A Deadman device shall be incorporated into the Master Controller Handle.

6.18.3 A Load Weighing Signal, proportional to the passenger load shall be applied to the control systems for the rates of acceleration and braking, and for ensuring correct adjustment of the car body by the secondary air springs.

6.19 Jerk Limitation for Service Brake

6.19.1 The build-up of pneumatic brake force shall be jerk limited (for changes in brake demand) to increase passenger comfort. The jerk limitation shall be as per chapter 3, table 3.25.1. This limit shall be respected at the time of final stoppage also.

6.19.2 Jerk rate control shall be applicable to braking as well as propulsion.

6.20 Brake Operating Timing

6.20.1 The following maximum brake operating timing shall be achieved on all cars of a train. The maximum time for a brake application from full release to 90% of full Brake Cylinder Pressure (BCP) and for brake release from full Brake Cylinder pressure to 10% shall not exceed the following:

(i)	Service Brake Application	:	2.0s
(ii)	Emergency Brake Application	:	1.5s (max.)
(iii)	Service and Emergency Brake Release	:	2.5 s.

6.20.2 A malfunction of the brake control system shall result in an emergency brake application. At restart, the train shall be able to be controlled by normal brake operation system.

6.20.3 Brake Assurance Time (the time from initiation of the brake application signal, to achievement of the retardation rate requested), shall be provided. Full details shall be given. This feature will require close liaison with the Signalling Contractor.

6.21 Brake Pipe (BP) Controlled Back-up Brake System

6.21.1 A BP controlled back-up system including a separate pneumatic control unit shall be provided in order to take over the control function in case of failure of electronic or electric control elements in the brake system. In case of such failure, the operator can continue to control braking by using the back-up brake. This system shall also be used to control brake system of dead train during rescue by a healthy train, transit of cars and shunting operation.

6.21.2 The back-up brake control unit shall be ergonomically placed on operator's console and shall have three positions for application, charging and lap modes.

6.21.3 During the operation of this mode, the dynamic brakes shall be isolated and the pneumatic brake application shall be resorted to.

6.22 Failure Management

6.22.1 It shall be possible to recover a dead train (i.e. one having no traction power and no means of generating further compressed air, but with the air brake system intact) using only an air connection from the rescue train or locomotive. The emergency brake application of the dead train shall be possible by its operator. The detailed scheme shall be subject to the Employer's Representative's review.

6.23 Wheel Slide Protection

6.23.1 Digital wheel slide protection with gradual slide correction shall be provided in all braking modes, on all cars. Slide detection shall be on a per axle basis with correction on a per bogie basis. The slide protection scheme provided shall be capable of detecting the severity of the slide and provide the appropriate level of slide correction.

6.23.2 Automatic wheel wear compensation shall be incorporated in the wheel slide protection scheme. The wheel slide system shall detect the onset of slide by either (a) an axle deceleration exceeding a pre-set parameter, or (b) detection of a difference between the relative speeds of the axles of any one bogie. Wheel slide indication shall be made available in the driving cab. The Tenderer shall submit full details of wheel slide protection scheme and equipment.

6.24 Monitoring

6.24.1 The performance of brake system shall be monitored by the train integrated anagement system (TIMS) and displayed in the driver's cab.

6.24.2 All components of the pneumatic system shall be tested in accordance with IEC 60077 or any other internationally accepted equivalent standard as set out in Chapter 15.

6.25 Brake Electronic Control Unit (BECU) Cards

6.25.1 Improved BECU cards with highest reliability shall be used to reduce failures of these cards being experienced by DMRC in the existing fleets.

6.25.2 The contractor shall propose the improvements carried out in BECU cards during design stage for Enginners review.

This page is left blank intentionally

**EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATION**

CHAPTER 7

DOOR AND DOOR CONTROL SYSTEM

CHAPTER 7 : DOOR AND DOOR CONTROL SYSTEM

7.1 General

7.1.1 The train shall have following type of doors:

- (i) Passenger Saloon Door
- (ii) Cab Side Door
- (iii) Passenger Saloon to Cab Door
- (iv) Front end central Emergency Door

7.2 Passenger Saloon Door

7.2.1 General

- (i) Each car shall have eight pairs of externally hung, sliding bi-parting doors, four per side. The clear door opening width of each door pair shall be 1400mm or 1500mm. The doors shall be electrically driven.
- (ii) The inner and outer skin of the door leaf shall be formed in such a way as to be lightweight, of adequate strength, and internally reinforced and formed into an integral unit, in such a way as to prevent injury to passengers or staff.
- (iii) Sheet metal shall be of ample gauge to provide adequate strength and rigidity. Joints and edges shall be thoroughly sealed against ingress of moisture with drain holes located at the bottom of the doors to allow drainage of condensate.
- (iv) Doors shall be vibration free and insulated against heat and sound transmission. Exterior and interior surfaces of the door leaves shall be finished to match the adjacent surfaces of car. The doors shall be free from dimples, warping, spot welding depressions and any other blemish.
- (v) When closed, door leaves shall be capable of withstanding forces in compliance with UIC 566 or latest international standards.
- (vi) The door leaf design shall enable any portion of the door leaf or the car body visible to passengers to be cleaned.
- (vii) Each door leaf shall have a window of flat, double glazed toughened, laminated safety glass separated by an air gap, permanently sealed against ingress of moisture, positioned to avoid stress points resulting from any change in angle of the body side.
- (viii) In respect of solar gain, thermal insulation, replacement criteria, strength, resistance to pressure, and the transmission of light, and solar heat gain, these windows shall be identical with those of the saloon windows. (See 4.13.2 (viii) above).
- (ix) Door windows shall be replaceable without removal of the door leaf.
- (x) No single defect or failure of any part of any door system shall produce a situation capable of causing injury to any door user.
- (xi) Door guides and supports shall be mounted within the section of doorway protected by the door seals and shall not allow ingress of dirt, debris, or any other foreign matter likely to result in excessive wear or incorrect operation of the door equipment.
- (xii) The materials used for the door track rollers and seals shall take into account of hygroscopic effects in high humidity tropical environments.
- (xiii) Sealing arrangements on external sliding door leaf shall meet the following requirements:

- (xiv) The doors shall be sealed against draughts, water and noise. In the event of ingress of water or dirt with the doors in the open position provision shall be made to ensure that rapid draining takes place and that no surrounding equipment or systems are affected in any way.
- (xv) Positive sealing along entire saloon door opening and door leaf inner surfaces to eliminate in-rush of tunnel air due to the piston effect.
- (xvi) Door sealing shall also be such that the saloon interior noise specification is satisfied when measured at doorways.
- (xvii) Door sealing arrangement shall be adequate to prevent water ingress due to torrential rain and car washing through automatic wash plant.
- (xviii) The sealing arrangement shall take into consideration of car body manufacturing tolerance and deflections under fully loaded conditions.
- (xix) The tenderer shall indicate the amount of time required to replace a door leaf on the car, adjust it, and test it.

7.2.3 Door Mechanism

Doors shall be electrically operated from 110V dc supply through train line. The door operating mechanism shall be of a proven design in service.

The door system shall continue to operate correctly with the car battery voltage supply range between 77V to 132V dc.

The door operating mechanism shall be housed within the saloon above the doorway lintels. The design shall provide ease of access for maintenance. The complete mechanism shall be modular and mounted on a rigid frame so that it can be adjusted *in situ* for alignment and be removed as an integral unit from the car.

7.2.4 Passenger Door Opening and Closing Times

- (i) Opening and closing time of the passenger doors shall be adjustable in the range of 1.5 to 4.5 seconds.
- (ii) The end of the closing stroke (say 100mm) shall be damped or cushioned to reduce impact and minimise possible injury to passengers.
- (iii) All doors on the train shall fully open within 2.0 to 2.5 seconds from initiation of the open door command.
- (iv) All doors on the train shall fully close within 2.5 to 3.5 seconds from the initiation of the close door command.
- (v) An automatic feature shall be provided to detect and release obstructions with the gap between door leaf edges between 300mm and 50mm. With the gap greater than 300mm, if an obstruction is detected, the door shall continue to attempt to close.
- (vi) Between 300mm and 50mm gap, on sensing an obstruction, the door shall stop. The closing force of the obstructed door shall be removed. After a delay of 2s, the door shall attempt to close again. If an obstruction persists, each door leaf shall either open 25mm or the closing force of the obstructed door shall be removed. After a further delay of 2s, the door shall attempt to close again. Failure to do so shall be reason for the driver to arrange to isolate and lock the door closed, and take it out of action.
- (vii) On successfully closing, electrical interlocks prove the closed position of each door leaf, and a mechanical

lock is caused to operate. Only then can traction enabling circuits be energised.

- (viii) The push back feature shall be operative after the door leaves have been locked, and a spring loaded device to permit extraction of entrapped clothing or other articles, as specified in Clause (viii) below.
- (ix) It shall be possible to manually push back each closed door leaf to enable entrapped objects to be withdrawn, even after the mechanical lock has engaged. The force required to push back each door leaf shall be not less than 80N nor more than 120N.
- (x) The above gaps and timings are notional, and shall be capable of being adjusted after experience in service has been gained. The initial settings shall be determined from an investigatory trial undertaken using the door mock-up, or the door test rig.

7.2.5 Passenger Door Operational Criteria

(i) Reliability and Safety

The reliability and intrinsic safety of the doors of all high capacity metro trains are of paramount importance. One door failure often has the effect of disrupting the service, and usually by more than a two minute delay. It is of the utmost importance therefore that the door scheme shall be designed with all necessary safeguards against potential failure.

(ii) Emergency Release of Doors

Two means of operating doors by staff, shall however be provided for emergency situations, operable from outside the vehicle from platform level or track-side.

On each side of every car, a mechanism shall be provided, close to the mid-point of the vehicle but beyond the sweep of the door leaf. This mechanism shall release the "locking" mechanism, on the adjacent door only.

The manual emergency release mechanism shall be unobtrusive, flush with, or recessed into, the car side, but readily available in an emergency. Once the door is opened, it shall be indicated to the train operator as an open door.

A second device shall be provided on diagonally opposite end panels of each car, to release the "locking" mechanisms on all the doors on that side of the car. Where not all of a train has been able to enter a station, this device will allow the orderly de-trainment of passengers from those cars at the platform.

Passenger saloon doors on both sides near drivers cab in case of 'DT+M' car/ Train shall be used for emergency egress for passengers & train crew. The contractor shall develop & implement suitable design to ensure safe and secure emergency egress to the walkway/platform at any location on the elevated, at grade and underground sections duly considering the curves and strictly in accordance with the relevant international standards.

(iii) Door Failure

Each saloon door shall be fitted with the means of isolating and locking both door leaves. The isolation shall require the use of a key at a location normally accessible from the platform. The keyhole location shall be subject to review by the Engineer.

When the isolation is activated, the door shall be mechanically locked in the closed position. Manually isolated doors shall be enunciated on the driver's cab visual display unit (VDU).

The door leaves will need to be provided with the appropriate means of applying a locking device. Full details of the Tenderer's proposal shall be provided.

In Door By Pass/Cut Out mode, in case Train Operator forgets to close the door i. e. forgets to push the relevant push button for closing of doors, the system should automatically generate door closing command and traction shall get enabled only after lapse of sufficient time (variable and operator settable) to ensure that doors are closed before the train achieves motion. Contractor shall submit the proposal for Engineers's review during design stage.

(iv) Interlocking

No spurious electrical signals shall cause any door to be released or opened. The Contractor will be required to provide a comprehensive Safety Audit to prove this point to the satisfaction of the Engineer.

There shall be no single point failure of equipment or wiring, or two point failure with one failure undetected, which would cause a door to open without being commanded.

Irrespective of the operating mode, the train shall not be able to move unless all the saloon doors and cab side doors are proved closed and locked. A sealed cut out switch accessible to the driver in each cab, shall be provided to bypass the interlock, to enable a train to be taken to the next station prior to being taken out of service, to attend to the defective door. Operation shall be recorded by the Train Integrated Management System (TIMS).

(v) Door Controls : Driver's Controls

All door control panels in the driver's cab shall have an identical layout and shall be physically interchangeable.

All door control panels shall be located conveniently for operation of the doors that side of the train. The control devices located on each side of the cab shall only operate the doors on that side of the consist.

The doors shall be arranged for cab control operation. The control circuit shall be hardwired so that all the doors on either side may be operated automatically by either ATO command or manually. All door control panels in the operator's cab shall have an identical layout and shall be physically interchangeable.

The door control push buttons shall be illuminated with distinct colour light. The details and schematic shall be provided for the review of the Engineer.

The opening and closing of the door shall only be possible from an operative cab. The door controls shall be located on the operator's console and also near cab side door.

The cab side door control panels shall be located conveniently for operation of doors of that side of the train. The control devices located on each side of the cab shall only operate the doors on that side of the consist.

A switch shall be provided, preferably at the back wall of the driving side of the cab. In ATO mode, the automatic door open command may be overridden by operating this switch. Operation of this switch shall be monitored by TIMS.

In case of unavailability/failure of door authorization signal from ATP system, adequate safeguard shall be provided and also incorporated in the control circuit to minimise the probability of error of opening of doors on wrong side (other than platform side) during revenue service.

The following additional control device is required :

(vi) A chime shall sound over the PA system as the doors are opening, as a signal to the visually impaired. The chime shall stop when the doors are fully open.

(vii) A door close announcement followed by a chime shall be triggered each time the "Door Close

Announcement" button is pressed. The door close chime shall continue to play till the Doors achieve locked position. The chime shall warn the passengers inside the train as well as those on the platform about the door operation. Selection of the type and adjustment of volume of the chime shall be independent of the volume of the announcements.

(vii) While chime is played over the PA system, any existing auto announcement shall be aborted.

7.3 Cab Side Doors

7.3.1 There shall be a cab side door on both sides of the cab. The doors shall be manually operated doors. It shall be possible to lock, unlock, open and close the cab side doors from track level.

7.3.2 The cab side doors shall be lockable from inside without the use of a key.

7.3.3 The cab side door shall be positively retained in the closed position under all operating conditions.

7.3.4 The assembly of the cab side door, including the mounting tracks, door retaining mechanism, cushioning bumper, stopper, etc., shall be of a robust design that can withstand rough handling including slam-open and slam-close by operation and maintenance personnel.

7.3.5 The doors shall be sealed against draughts, noise and water.

7.3.6 The door shall be positioned such that access to the cab is free from obstructions.
The clear door opening width shall be 650mm \pm 50mm.

7.3.7 Heavy duty locks with proven record in metro applications shall only be used.

7.3.8 The open/close and lock/unlock status of the cab side doors shall be monitored using reliable & suitable sensors. The train control logic shall be designed so that the train shall not be able to move unless all the saloon doors and cab side doors are proved, closed and locked.

7.3.9 The open/close and lock/unlock status of the cab side doors shall also be used to provide the status to TIMS and also to actuate the cab lights.

7.3.10 Each cab side door shall contain a fixed window, which shall be flat and positioned to avoid stress points resulting from any change in angle of the body side.

7.4 Saloon-to-Cab Door

7.4.1 There shall be a solid door between the saloon and the cab. The clear door opening shall not be less than 1100 mm wide. In normal operation opening the door from the saloon shall require the use of a special key.

7.4.2 Opening the door from the cab shall only require the train operator to operate a handle. No key shall be required.

7.4.3 The door shall not be possible to be locked, bolted or wedged from either side of the door to prevent opening.

7.4.4 In emergency, it shall be possible for a passenger to gain access to the locking device, to permit access to the cab, for operation of the emergency end door.

7.4.6 A visual and audible alarm shall be activated in the event that the saloon-to-cab door in the unoccupied cab is opened.

7.5 Front End Central Emergency Door:

Between the front end windows, the front of the cab shall be fitted with a dual-purpose central door, flush with the exterior panels, to provide an aesthetically pleasing exterior, to provide emergency egress for train crews and passengers. It shall be arranged to provide either :

- (i) Deleted
- (ii) Train to Track Mode

To move train crew and passengers from a defective train onto the track, it shall be arranged that the front door be released at the top, but leaving in position a hinge arrangement at the bottom, allowing the door to be pushed outwards unfolding into a two-section ramp, approximately 1100mm wide tread, the surface of which is faced with a high friction material, and the outside edges marked with fluorescent guide lines.

The assembly shall be complete with all necessary guide straps, which will enable the walkway to be lowered onto the track, while restraining the ramp from hitting the track bed and thereafter giving support to those negotiating the ramp.

Full details of the arrangement shall be given. The equipment necessary to return the door to its normally stowed position shall be provided. All necessary ancillary equipment to enable the train to be moved after emergency de-trainment shall be provided as parts of the scope of equipment under this clause.

For either of the above modes, simplicity of operation is imperative. Instructions shall be displayed to enable passengers, unfamiliar with the equipment to operate the emergency door, in either mode, when the driver is incapacitated.

- (iii) Side Walkway

It should be noted that a side walkway nominally 800mm below the car floor level in the Rail Corridor, and within 50mm of the floor level in the Metro Corridor will be provided. This may play a part in emergency disembarkation of passengers. Tenderers may offer an alternative arrangement. Full details shall be provided.

7.6 Door Leaf Construction

7.6.1 All exterior doors shall have the same durability as the vehicle body. The interior finish shall be compliant with the visual design and withstand severe wear and tear. It shall not be possible for a door to become detached from the vehicle under any operating conditions, including heavy side load from standing passengers or sudden pressure transients.

7.6.2 The construction of the door shall be such that it is able to resist without deformation or damage a load equivalent to that which could occur on a crush loaded train. The door shall be as light and rigid as possible.

7.6.3 The door leaf edges shall be such that when the doors are closed they form a weather tight seal extending the full height of the door.

7.6.4 Any seal shall not require regular cleaning. Seals and sensitive edges (if used) shall be effective under all operating conditions from tare to crush loading and particularly shall be resistant to atmospheric and chemical deterioration and to vandalism.

This page is left blank intentionally

EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 8

HV AND PROPULSION EQUIPMENTS

CHAPTER 8: HV AND PROPULSION EQUIPMENTS

8.1 Propulsion Configuration

8.1.1 The Propulsion System shall be suitable for operation at 25 kV ac single phase on the entire network. The tenderer may adopt 1800V as the nominal d.c. link voltage for the 25 kV system. The equipments, d.c. link, inverter and traction motors shall be common.

8.2 HV Power Collection

8.2.1 Power shall be drawn from the overhead line by pantographs. The pantograph for the 25 kV 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.

8.2.2 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.

8.2.3 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.

8.2.4 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.

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

8.2.6 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 as well as to the strips themselves. The tenderer shall furnish the frequencies of replacement of strips in terms of kilometres earned by the car.

8.3 HV Protection & Distribution

8.3.1 A roof-mounted vacuum circuit breaker (VCB) of proven design shall be provided for the 25 kV ac system vehicles, located close to the pantograph. The VCB shall be of the single bottle type having a short circuit rating of 250MVA, and conforming to IEC 60056, in conjunction with IEC 60077 or any other internationally accepted equivalent standard.

8.3.2 A switch shall be provided, operable from inside the car, enabling each high voltage (HV) circuit to be earthed during maintenance. This switch shall be interlocked with the pantograph to prevent the pantograph being raised while the HV circuit is earthed and to prevent the HV circuit from being earthed while the pantograph is raised. It shall be possible to apply padlocks in the isolated and earthed position.

8.3.3 A suitably rated high voltage cable, shall connect the vacuum circuit breaker to the main transformer. The cable insulation and sheathing materials shall be halogen free, flame-retardant, and having low smoke emission as per the requirements of EN 45545, latest editions. The enclosure and termination of the cable shall be protected against flexure and wear. In the event of the breakdown of the cable insulation or the termination, there shall be no risk of electrocution, or other hazards, to persons inside, or close to the outside of the car.

8.3.4 Deleted.

8.3.5 On the Rail Corridor a suitable arrangement shall be made to switch off the VCB automatically before a neutral section, resulting in the traction control equipment returning to OFF with no driver intervention. The VCB shall automatically re-close after the neutral section, causing traction control equipment to switch on again in the same operating mode, as before the switching off operation, without driver intervention.

8.3.6 The RS15 Contractor shall provide both the required way side/track-side equipment for one number of neutral section and trainborne equipment. The trackside equipment shall be installed by the RS15 Contractor in consultation with the Track Contractor, the OCS contractor and the cost to be borne by RS15 Contractor. The trainborne equipment shall be installed by RS15 Contractor. The Contractors shall liaise with one another for exchange of technical data and regarding testing and system integration.

8.4 Lightning Arrestor

8.4.1 Gapless type lightning arrestors of proven design in accordance with specification IEC 60099-4 shall be provided on the roof located as close to the pantograph as possible, for protection against line voltage transients caused by lightning or system switching.

8.4.2 The voltage and current ratings of lightning arrestors for 25 kV a.c. system shall be as follows:

Description	25 kV ac
Rated Voltage	42kV r.m.s.
Rated Current	10kA@8/20 μ s

8.5 25 kV Potential Transformer

8.5.1 A 25 kV Potential Transformer, to be mounted, on the roof, meeting the requirements of IEC 60044-2, for protection / measurement shall be supplied.

8.5.2 The Potential Transformer should be of Anti Burst Type of proven design and MCB protected.

8.6 AC Current Transformer

8.6.1 An AC Current Transformer, to be mounted along with 25 kV cable for protection and measurement, meeting the requirements of IEC-60044-1, shall be supplied.

8.7 Main Transformer

8.7.1 The main transformer shall have a service life of at least 35 years, demonstrable through design calculations to the satisfaction of the Employer's Representative.

8.7.2 The overall harmonic current level at the pantograph shall be restricted so that EMI with other equipments as well as Train Control & Signalling system Track Circuit frequencies are within the specified limits. The Contractor shall submit the harmonic current spectrum and overall harmonic current at pantograph level during design stage, which will be subjected to review by Employer's Representatives. The kVA rating of the transformers shall be specified at a line voltage of 22.5kV and shall be designed to deliver the power corresponding to the continuously rated traction motor currents, after accounting for the efficiency and the power factor of the traction motor, converter, inverter and auxiliary inverter.

8.7.3 The transformer shall be designed to conform to IEC 60310 and the temperature rise limits of windings and oil shall correspond to IEC 60310 limits.

8.7.4 The transformer shall be modular in construction, complete with oil pump, oil pump motor, radiator, conservator and protection equipment (e.g. Buchholz Relay) all assembled as a single module.

8.7.5 The transformer shall be silicon oil immersed, to ensure the minimum acceptable standard for fire load. Alternative coolants offering enhanced fire safety may be offered.

8.7.6 The transformer shall be under-slung and the mounting arrangement shall be described in detail by the tenderer.

8.7.7 Measures shall be included to monitor for, and protect against, traction transformer failure and leakage. The design shall minimise the fire load of the transformer.

8.8 25 kV Cable with HV Bushing and T-connector

8.8.1 Copper cable of adequate voltage rating and diameter shall connect the vacuum circuit breaker to the main transformer. The cable shall be laid in a stainless steel pipe. The cable insulation and sheathing shall be halogen free, flame retardant, and having low smoke emission in compliance with EN 45545, Latest Editions. The details for roof end and the transformer end terminations shall be provided for the Engineer's review.

8.9 Power Converter - Inverter

8.9.1 There shall be two converters and one inverter in each motor car. The power converter - inverter shall be a proven, four quadrant Revolution Intelligent Power Module (RIPM) based unit, with pulse width modulation control to ensure that the power factor is always lagging near unity at all speeds. The equipment shall conform to IEC 61287-1 or latest internationally accepted equivalent standard. Natural or forced air cooling may be offered, however natural cooling is preferred. However, if forced air cooling is deemed necessary, complete details of the arrangement, including the method of filtration shall be furnished.

8.9.2 The system shall be designed to minimise switching losses, switching noise, and weight, and improve heat dissipation.

8.9.3 The current rating of the RIPM should be such that the junction temperature has the minimum thermal margin of 10°C in the worst loading conditions taking into account the ambient conditions. The design calculations to establish the above margins in junction temperature, as well as margins available in voltage rating, shall be furnished.

8.9.4 The converter/inverter system and transformer shall be capable of withstanding the maximum short circuit under fault conditions.

8.9.5 The continuous rating of the converter shall be based on the continuous rating of the traction motor, inverter and rating of auxiliary converter after accounting for the efficiency and power factor of the traction motor.

8.9.6 24 V DC LED based lighting arrangement shall be provided in the CI box for maintainence purpose. Its fail safe interlocking with the box cover to be ensured. Contractor shall submit the detail document for Engineers' review during design stage.

8.9.7 Latest generation Gate Control Unit with individual Traction Motor Current and Temperature monitoring shall be provided with the Converter- Inverter.

8.9.8 Deleted

8.9.9 For maintenance purpose, there shall be additional by pass ground switch in CI box duely interlocked with safety locks. Contractor shall submit the proposal for Engineers's review during design stage.

8.10 AC Traction Motor

8.10.1 Three phase asynchronous traction motors, suitable for RIPM converter/inverter operation shall be offered. The motor shall have adequate built in margin to cater to the environmental conditions given in the

specification. The motor shall be designed to suit ripples and harmonics from the inverter and shall have a high degree of reliability in service during motoring as well as regeneration. The traction motor shall be self ventilated, and shall comply with the requirements of IEC 60349 or latest internationally accepted equivalent standard and parts thereof.

8.10.2 Evaluation of the insulation system for sealing against moisture shall be made in accordance with IEEE 429 or latest internationally accepted equivalent standard. The insulation system shall be evaluated for thermal endurance in accordance with the requirements of IEC 60505 (1975) or latest internationally accepted equivalent standard, its draft supplement and IEEE 304.

8.10.3 Various ageing parameters viz., thermal and electrical stresses, ambient temperature, humidity, dust and mechanical stresses, vibration etc., should be used in the evaluation and the temperature index of the insulation system corresponding to an extrapolated life of 20 000 hours shall be established.

8.10.4 The temperature rise limit for the stator winding shall be the maximum temperature index of the insulation minus 70°C.

8.10.5 The traction motor shall be suitably rated to meet the most severe service requirements as specified in Clauses 3.25 and 3.26.

The motor bearing maintenance inspection interval (excluding lubrication if required) shall exceed 0.8 million kilometres and the bearing shall have a design life of 1.6 to 2.0 million kilometres. Lubrication of motor and gearbox bearings shall be accessible without the need of equipment removal. Calculations supporting the choice of bearings shall be submitted for review.

The motor shall be mounted on the bogie frame via flexible coupling and gear unit, which shall be totally enclosed and free from lubricant leakage.

8.11 Neutral Section Detector

8.11.1 A suitable arrangement shall be made to switch off the VCB automatically before a neutral section, resulting in the traction control equipment switching OFF without train operator's intervention. The VCB shall automatically re-close after the neutral section, causing traction control equipment to switch ON again in the same operating mode, as before the switching OFF operation, without train operator's intervention. The sequence of VCB closure shall be so planned that minimum numbers of cars in a train are affected. Sequential opening and closing of VCB shall be ensured to minimize the power loss. Back up operation (Both open and close) of VCBs of each unit shall be affected based on distance from previous station.

8.11.2 The control logic for the neutral section detector shall ensure that the power demand smoothly reduces on approach to overhead line neutral sections and smoothly increases the power demand immediately after the neutral section. Power ramping characteristics shall be submitted for review by the Engineer, and shall be validated by test.

8.11.3 Adequate redundancy shall be built in so that no single point failure can cause disruption. The status as well as failures of vital components shall be logged by TIMS.

This page is left blank intentionally

**EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATION**

CHAPTER 9

AUXILIARY SUPPLY EQUIPMENTS

CHAPTER 9: AUXILIARY SUPPLY EQUIPMENTS**9.1 Auxiliary Supply System**

9.1.1 The auxiliary power supply shall consist of a static inverter -converter together with back-up batteries and battery charger. The auxiliary static inverter - converter will receive its power from from a separate winding in the traction transformer. The auxiliary converter shall be Silicon Carbide switching Device based with microprocessor and pulse width modulation control. The three output voltage shall be as follows:

- (i) Output 1: 415V 50Hz 3 ϕ 3 wire
- (ii) Output 2: 230V 50Hz 1 ϕ
- (iii) Output 3: 110V d.c.

None of the above shall be accessible by passengers.

Industrial 415V 50Hz 3 socket outlets with spring loaded covers, capable of accepting a shore supply shall be provided on each vehicle at sole-bar level, on both sides. Each shall be accompanied by a red lamp, to warn of live sockets, when a shore supply is plugged in.

Internal 230V 50Hz 1 socket outlets for vacuum cleaners, and scarifiers shall be provided in each car.. Each Saloon shall have at least one 230V, 5A socket and 2 fast charging USB ports on both ends. The sockets and USB shall be used for mobile & laptop charging.

9.1.2 The output circuits are galvanically isolated from the input and each other. The auxiliary converter shall provide power supply to all auxiliaries including ventilation blower motor, air-conditioning units, air compressor, doors, light equipments, control units and low voltage loads.

9.1.3 The supply shall be regulated within $\pm 5\%$ of the nominal voltage and total harmonic disturbance shall be limited to 8% under all operating conditions. The converter shall otherwise comply with the provisions of IEC 61287-1 or latest internationally accepted equivalent standard. The control shall ensure that the converter power factor is always lagging near unity at all loads.

9.1.4 The auxiliary converter shall be continuously rated to provide full auxiliary load on one unit (1M+1T). Full auxiliary load shall include charging a discharged battery to 80% full charge within 4 hours.

9.1.5 Protection against single phasing and short circuiting shall be incorporated into the auxiliary converter feeding 415V, 50Hz auxiliary drives.

Control circuit logic shall permit testing and monitoring of the operation of the auxiliary power supply system when running. Appropriate test equipment shall be supplied.

The auxiliary power control system shall carry out self-tests to ensure the integrity of the equipment. Sufficiently detailed status, fault and diagnostic information shall be transmitted to the train integration management system (TIMS), to enable protective or corrective action to be taken immediately, when necessary.

The train operator from the cab shall be able to isolate any defective auxiliary power supply equipment.

All auxiliary power equipment shall be easily accessible for inspection, testing and maintenance. Contactors shall be rated for maximum current capacity and overload interruption capability.

9.1.6 The SIV box shall be of Painted Aluminium with rivetting. Contractor shall submit detail document during design stage for Engineers' review. Necessary type/routine tests shall be performed in accordance with the latest accepted international norms.

9.1.7 For maintenance purpose, there shall be separate by pass ground switch in SIV box duely interlocked with safety locks. Contractor shall submit the proposal for Engineers's review during design stage.

9.2 Back-up Batteries

9.2.1 Batteries having a nominal voltage of 110V comprising of cells of nickel cadmium type with cell casings of stainless steel or other alternative robust flame- retardant material. They shall meet the requirements of IEC 60623 and IEC 60993 respectively or latest internationally accepted equivalent standard.

9.2.2 The back up battery shall be adequately rated be provided to:

- (i) maintain full d.c. 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 in case of failure of battery charger or its supply with the battery charged to 80% of its full capacity. Non-essential load shall be shed after 30 seconds of failure of battery charge supply.

9.2.3 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, emergency help points, surveillance system and train radio.
- (v) Propulsion and brake controls.
- (vi) Door controls.
- (vii) TIMS.
- (viii) Cab console indicators, lighting and interlocking.
- (ix) ATP train borne equipment.
- (x) Data recorder.
- (xi) Safety proving circuit.

9.2.4 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.

9.2.5 Battery electrolyte capacity shall be such that the batteries will not require to have distilled water added more than once in every 90 days. 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.

9.2.6 Two sets of battery electrolyte automatic topping up devices shall be provided. 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. The Contractor shall submit details of this device for acceptance.

9.2.7 The control elements taking power from the battery shall be capable of operating between 77V and 137.5V d.c.

9.3 Battery Charger

9.3.1 The battery shall be charged from the local (two-car unit) static battery charger. The battery charger with automatic control shall be capable of providing a high rate float charge compatible with the characteristic of the Ni-Cd batteries. The battery charger voltage and current output shall be monitored for diagnosis and generation of fault with respect to auxiliary power system output availability.

9.4 Battery Box

9.4.1 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.

9.4.2 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.

9.4.3 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.

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

This page is left blank intentionally

EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 10

TRAIN INTEGRATED MANAGEMENT SYSTEM

CHAPTER 10: TRAIN INTEGRATED MANAGEMENT SYSTEM

10.1 GENERAL

10.1.1 The Train Integrated Management System (TIMS) shall be of latest version (in case of 'DT+M' car) complete, integrated system for the control and monitoring of train functions, systems and subsystems. The system shall provide for real-time distributed control and modular processing of subsystems in a redundant manner with high reliability and availability in the adverse operating environment of a railway.

It would be desirable for the train control data bus and the control processor to be duplicated.

10.1.2 The design shall consider the train as a complete system. The train shall monitor all its sub-systems' operation and fault status, fault data logging, incident investigation and reporting. Real-time diagnostic information shall be accessible on the console display to assist drivers to operate the train safely, quickly, efficiently, and to rectify faults or failures that are resettable.

A proven train data communication link, which is immune to EMI and harmonics generated by traction equipments, will be provided between the cars. The tenderer shall list the subsystems that are to be monitored or controlled by the TIMS with their interface details.

10.1.3 The scheme proposed shall differentiate between faults which are not potentially life threatening, (e.g. air conditioning failure), and other system faults which could be life threatening (e.g. failure of the brake system).

10.2 TIMS Architecture

10.2.1 The system shall be made up of subsystem processing nodes interconnected through a train data communication link. Both subsystems processing nodes shall be redundant to increase system reliability and availability.

Diagnostic capability incorporated in the system shall detect node or line section failure rapidly to ensure no impairment of normal control and monitoring functions. The tenderer shall submit proposed system architecture.

10.2.2 The TIMS shall be of a fault tolerant distributed control system architecture.

10.2.3 The TIMS shall be modular in functional design at all levels with at least 10% spare capacity for expansion.

10.2.4 The TIMS unit shall incorporate built-in self-test diagnostic functions.

10.2.5 The hardware system shall conform to IEC 60571

10.2.6 Data protocols and standards should be to international and railway industry standards. The Tenderer shall advise the standards he intends to apply, for review.

10.3 Microprocessor Control and Diagnostic System

10.3.1 A Microprocessor/Micro-Controller based control system shall be adopted to cover control, protection, fault diagnostic display and data acquisition requirements.

10.3.2 A suitable physical bus interface, to ensure error-free and high speed data transmission shall be provided. It is desirable that the majority of control and monitoring functions are implemented by software, so as to reduce hardware and cables.

10.3.3 The microprocessor should perform the task of fault diagnostics and display, in addition to performing the control task. The microprocessor should be capable of monitoring the status of the equipments continuously and occurrence of faults. The microprocessor should also cause appropriate action to be taken, and wherever necessary shut down equipments.

10.3.4 The fault data reading system shall be connected to the Train Integrated Management System (TIMS) via the Car Data Bus and Inter-Car Data Bus.

Fault data shall be displayed in the "live" driving console on a VDU.

10.3.5 Fault occurrences should also be stored in the memory of the microprocessor and it should be possible to transmit the output by means of a serial interface to a printer or a personal computer. The various important parameters of the equipments at the time of occurrence of faults should also be recorded with a view to enabling proper fault analysis. Adequate redundancy should be built into the microprocessor.

10.3.6 The tenderer shall furnish detailed technical features of the control system including control methods and strategy adopted in the design.

10.3.7 The monitoring functions, control functions and the fault diagnostics rules of TIMS shall be subjected to the review & change by Engineer upto the defect liability period. Since supplier of TIMS for 'RS15' has been specified same as that of 'RS1'/'RS6'/'RS13' as defined in Annexure TG of this Technical Specifications, all modifications and changes as advised by Engineer for 'RS1'/'RS6'/'RS13' and 'RS15' TIMS within the available hardware capacities shall be carried out at no extra cost upto the defect liability period. RS15 TIMS shall have reverse compatibility with 'RS1'/'RS6'/'RS13' TIMS.

Necessary onshore training shall be imparted to Engineer's representatives upto the full satisfaction of Engineer, to utilise the available capacity of TIMS and the required modification of the TIMS software.

10.4 Driving Console

10.4.1 Each Driving Console shall be provided with a VDU to display real time information to the driver. The display screen shall be of the liquid crystal display (LCD) type. The VDU shall display information of equipment operating status, faults and failure of both auxiliary and control functions. The VDU shall also display recommended remedial actions in the event of alarms or faults occurring on the train.

10.4.2 A communication port on each car to interface with a notebook computer shall be provided and all information on the VDU shall be accessible on the notebook computer. In addition, other diagnostic access by maintenance staff via the notebook computer shall also be provided.

A minimum of Five laptop (notebook) computers, together with all associated accessories and software necessary for all diagnostic functions for all train-borne equipment shall be provided. Two copies in approved non-volatile memory of all the softwares uploaded in the notebook computers shall also be provided separately.

10.4.3 The notebook computer shall provide full testing of and interaction with the on-board TIMS at both train and car level.

10.4.4 The following minimum capabilities shall be provided:

- (i) System monitoring, fault data retrieval and analysis.
- (ii) Viewing and processing of logged TIMS data.
- (iii) Uploading facilities for new operating software and parameters.
- (iv) Uploading facilities for new train configuration data (e.g. wheel diameters, etc.).
- (v) Downloading of fault and usage information in Depot.
- (vi) Exercising and checking of digital inputs and outputs.

- (vii) Checking of train and subsystem serial links.
- (viii) Checking of train data bus set-up and configuration.
- (ix) Retrieval of equipment identification numbers.
- (x) Initiating function testing of onboard equipment.

10.4.5 A seven-digit odometer display shall be incorporated into the VDU display on each driving console. It shall record cumulative distance run, irrespective of direction, and shall be non-resettable.

10.5 User Interface

10.5.1 A high-speed suitable communication port on each car to interface with a notebook computer shall be provided and all information on the TIMS shall be accessible on the notebook computer. It shall be possible to download the desired data for the entire train including data logged in its sub-systems through any one of these ports.

10.5.2 In addition, other diagnostic access by maintenance staff via the notebook computer shall also be provided.

10.5.3 The level of access to distinct functionalities shall be controlled for the maintenance personnel. At least three levels shall be defined which shall be user name and password protected. The details shall be reviewed by the Engineer.

10.6 TIMS Software

10.6.1 The software and communication protocols used throughout the TIMS and the interfaces to subsystems shall be to a common standard or standards.

10.7 TIMS Labelling

10.7.1 The type, location and identification of all hardware, software interconnections, cabling and terminals shall be determined on a coherent hierarchical system basis. Labelling or identification shall use appropriate English language based mnemonics or abbreviations. The Contractor shall submit proposal for review.

10.8 Energy Measurement

10.8.1 Energy meter shall be provided with facility to display energy consumption for each journey as well as cumulative in each motor car. Facility shall be available to key in the driver and train identification number.

10.8.2 The control system shall be designed to ensure accurate energy measurements. The integrity of measurements with the unit & train shall be ensured, recorded and retrievable. The employer intends to use the data for getting carbon credits. The measurements shall include both during traction, coasting and regeneration at pantograph, converter and aux converter level. The system shall ensure the followings:

Net energy drawn at panto with both the components viz. motoring (including coasting) & regeneration with time & kilometers travelled stamp shall be displayed on HMI when required. The integrated & cumulative values at any time shall be available and recorded with date, time stamp & net kilometers travelled.

All energy measurements shall have accuracy within $\pm 3\%$. This shall be validated during type tests.

Further details shall be discussed and finalized during design. The contractor shall also provide suitable analytical tools to screen and analyze the data for optimization of energy regeneration, coasting, right manner/energy saving manner of driving, educating train operators and indentifying the areas where energy can be saved etc. Contractor shall submit the proposal for Engineers's review during design stage.

This page is left blank intentionally

**EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATION**

CHAPTER 11

HEATING, VENTILATION AND AIR-CONDITIONING

CHAPTER 11: HEATING, VENTILATION AND AIR-CONDITIONING

11.1 General

11.1.1 The Heating, Ventilation and Air-conditioning (HVAC) System shall be installed on each car to provide full control of interior temperatures automatically, over the full range of heat loads associated with passengers, miscellaneous electrical equipment, lighting, heat transmission and solar gain.

11.1.2 HVAC units shall be roof mounted package type. Two identical units per car shall be suitably located to achieve specified conditions.

The Contractor shall submit proposals relating to measures to be incorporated to prevent unloading of air-conditioning units under the conditions of stoppage of train at the platforms and inside the tunnels due to high condenser temperature.

11.1.3 The units shall continue to operate at maximum capacity at condenser inlet temperatures up to 50°C and derated capacity up to 58°C.

11.1.4 The refrigerant used in the air-conditioning system shall be in accordance with the requirements of the Montreal Protocol. Environment-friendly R407C/R134 refrigerant shall be used.

11.1.5 The proposed HVAC system shall be service proven in a rail-borne application, and shall achieve a reasonable degree of comfort for minimum weight and life cycle cost.

11.1.6 The estimated weight, power requirements and heat load calculations giving the parameters adopted, shall be submitted by the Contractor. The specific measures taken to minimise energy consumption of the HVAC unit shall be detailed in the tender.

11.1.7 Deleted.

11.2 Design Criteria – Cooling and Heating Capacity of the Unit

11.2.1 The HVAC unit shall be designed to achieve internal conditions as listed in table 11.2 for the indicated external conditions

Table 11.2 external/internal conditions for HVAC

Weather Conditions	External temperatures	Internal Conditions
Summer	44°C Dry Bulb, 33% RH	25°C Dry Bulb, 60% RH
Monsoon	35°C Dry Bulb, 65% RH	25°C Dry Bulb, 60% RH
Winter	4°C	18°C

11.2.2 The fresh air intake may be taken as 2.3 litre/sec. for 380 passengers should give CO₂ level of below 2600 PPM inside saloon at ambient CO₂ of around 450 PPM.

11.2.3 Heat gains to be considered for each car shall be mainly as follows:

- (i) Car lighting and electrical loads (including evaporator fan motors).
- (ii) Passenger loading @ 380 passengers/T and M car and 360 passenger for DT car.
- (iii) Carbody heat transmission with an assumed 10 kmph relative exterior velocity.
- (iv) Fresh air heat load.

- (v) A solar load representing direct and diffused radiation, convection and radiation from window surfaces, and absorbed heat gain from the glazing and carbody structure.

11.2.4 The system shall automatically control the temperature and relative humidity throughout the passenger area up to 25°C and relative humidity of 60%RH respectively, for ambient temperatures of 35°C 65% RH and 44°C 33% RH.

11.2.5 Failure of one of the HVAC units on a car shall not adversely affect operation of the other unit. The Contractor shall submit calculations for the inside conditions with one HVAC unit out of operation.

11.2.6 The HVAC system shall be designed to achieve the following:

- (i) Air Discharge Velocities: The air discharge velocities at any outlet grille shall not exceed 4m/s. The air velocities at specified points in the car, as proposed by contractor and reviewed by Engineer, shall not exceed those set out in EN13129/EN14750. The air velocity at any point in the car shall not exceed 0.75 m/s. The air velocity within ducts shall not exceed 8m/s, shall not cause noise or air movement discomfort to passengers, and shall generally follow internationally accepted practices. The air intake velocity at the re-circulation and exhaust grilles shall not exceed 3m/s. Details of the Contractor's proposals shall be submitted.
- (ii) Temperature Distribution: Temperature difference among all points in the same horizontal plane over full car length shall commensurate with best international practices. The Contractor shall submit proposal for review of the Engineer.
- (iii) Saloon Pressure: The ventilation shall pressurize the car with all doors closed and car stationary. The proposed value of pressure shall be submitted.

11.2.7 In the event of the failure of both HVAC on a car, an emergency ventilation system shall operate automatically to admit fresh air directly into car to maintain the required oxygen level in the fully laden car, in accordance with ASHRAE. The outside fresh air shall not be less than 18m³/h/person, under fully loaded train conditions. Contractor shall submit minimum fresh air required as per ASHARE. The emergency ventilation fans in the saloon shall be fed from the 110V d.c. supply in the event of non availability of 415V ac supply from their individual inverters.

11.2.8 Fresh air should be filtered for human comfort and safety, in accordance with internationally accepted norms. The filter element shall be provided before the fresh air damper and fixed in a metallic frame and shall be easily replaceable from inside the car. Even with extremely dusty and humid environment prevailing in Delhi, the cleaning of the filters shall not be required before 5000 kms of train run. The filter shall have sufficient efficiency to ensure that dust deposition in the air duct is bare minimum and cleaning of duct is not required in between major overhaul. Cleaning of the duct shall be simple and contractor shall suggest necessary equipment required for dust removal and sanitization against fungal growth etc. The method for cleaning the filters and expected life of filter shall be furnished during detail design stage. Minimum expected life of filter provided shall be 100,000 kms. Better alternatives may be suggested during design.

Tenderers shall indicate the type of filters proposed to be used by them in the bid. The expected pressure drop across the filter shall be furnished. Details of suitable tools, used for measurement of pressure drop shall be provided in the bid. Two sets of such tools shall be supplied by the contractor in each depot. Each type/ size of filter shall be interchangeable with the RS1/RS6 or RS13 fleet.

11.2.9 Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the saloon, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn into the vehicle. Full details of the system proposed shall be given.

11.2.10 Provision of reheating may be provided for dehumidification as required to achieve the specified humidity conditions. The Contractor shall give technical write-up explaining as to how they will control the

humidity inside the car giving details with respect to psychometric charts and type of arrangement envisaged.

11.2.11 The HVAC units fed by one Auxiliary Power Supply Equipment shall have staggered starting in a sequence to reduce the inrush current load due to simultaneous starting of air-con motors. This may be achieved through Programmable Logical Controller of the units and TIMS.

11.2.12 The HVAC unit shall have optimized capacity control depending on the number of commuters inside the car.

11.2.13 Employer expects that energy efficient system comparable with the best available in the market shall be provided. Contractor shall furnish energy efficiency ratio (EER) for the offered system. In cooling mode the Coefficient of performance (COP) of HVAC shall not be less than 2.5 for both summer and monsoon outdoor and indoor conditions specified in table 11.2. Energy Efficiency Ratio (EER) of minimum 2.5 is to be proved during Type Test (if there is any design change) for summer and monsoon conditions with fresh air damper open. Cooling capacity test has to be done as per latest version of IS 8148 or any equivalent ASHRAE or international standard. The contractor shall submit the record of proven system already functional in metros with the specified COP.

11.2.14 Deleted.

11.2.15 In case of grounding in any HVAC unit, it shall be possible to isolate the defective HVAC unit without affecting the static inverter operation. Contractor shall submit the proposal for Engineers's review during design stage.

11.3 Heating System

11.3.1 The car shall be electrically heated by a Thermostatic Control System using evaporator fan / heater unit. The system shall be designed to provide an inside temperature of 18°C with an external ambient temperature of 4°C.

11.3.2 The heater shall be installed in the evaporator unit, downstream of the evaporator coils, to condition the fresh air intake and for reheating to control humidity under partial cooling operation of the cooling equipment.

11.3.3 The control circuit shall not allow the heaters to be powered unless the evaporator blowers are operating. Heater element over temperature protection shall be provided. Self-resetting thermostats shall be installed adjacent to the heaters to open the contactors when excessive temperatures are detected. A positive interlock shall be provided to open heater contactors in the event of failure of the Auxiliary Power Supply Equipment.

11.4 Roof Mounted Package Units

11.4.1 Two package type HVAC units, with all equipments required for satisfactory functioning of the system, shall be provided on each car.

11.4.2 Each unit shall be arranged on an integral stainless steel frame with bottom plate of SUS 316L and SUS 304L body, removable from the car as a single complete module. The integral frame housing of the unit shall be constructed such that to avoid any corrosion in service on any account and the box shall last for the lifetime of the HVAC unit without needing any attention. HVAC frame/cover shall be suitable for free movement of maintenance personnel without any consequential damage to covers/equipment. The finish of the frame shall match and will be in harmony with the car body finish. The HVAC unit supplied with RS15 stocks shall be completely interchangeable with existing HVAC of RS1/RS6/RS13 stocks.

11.4.3 The complete operation to remove and replace a unit should be simple. The Contractor shall declare the weight of the complete unit including specialized mechanical handling equipment.

All electrical connections shall be fitted with quick disconnection fittings, at easily accessible locations.

11.4.4 The frame housing shall be designed and constructed so that access for inspection and routine maintenance is from roof hatches, hinged at one side, secured by captive bolts on the other, and provided with stops to retain them securely in the lifted position when opened.

11.4.5 The carbody roof walls for accommodating the overhead air-conditioning units shall be a compartment in the car roof structure. Each well shall provide a continuous watertight and weatherproof area complete with adequate water drains to prevent rain, condensate or washing water leakage into the car.

11.4.6 Fresh and return air shall be filtered before being passed over the evaporator coil. It shall be possible to remove and replace air filters from inside the cars conveniently without the need for removal of any cable connection.

11.4.7 Air-conditioned unit shall have noise less compressor & condenser.

11.4.8 The design shall ensure the easy cleaning of the drains, evaporator coil, and condenser coil without lifting of HVAC unit from the roof.

11.5 Air Ducts and Diffusers

11.5.1 Conditioned air from each unit shall be directly introduced into a duct running the full length of the car and be discharged into the car through ceiling outlets.

11.5.2 The duct shall be constructed from stainless steel or anodised aluminum and diagonally split so that each unit feeds one side of the car. The duct shall be fully lagged with non-combustible insulation material to prevent the formation of condensation. The Duct shall be suitably designed to ensure that no short circuit between the two ducts shall be possible. The design shall ensure that in the event of failure of cab end HVAC, the bleed of cool air is always available in the cab. The Contractor shall take into consideration the requirement of maintenance access for duct cleaning as and when required.

11.5.3 Two rows of air diffusers shall be mounted on each side of ceiling panel, blending well with the car interior design. It shall be possible to adjust the air quantity from the diffusers during testing and commissioning, to achieve uniform distribution of air, to the extent possible. The details of the diffusers shall be submitted.

11.5.4 The design of duct shall take account of the possible need to provide a recess in the roofs of cars, to accommodate the support for the pantograph base arrangement.

11.5.5 A model of the proposed duct made of plywood or any other suitable material shall be prepared to evaluate the design parameters, including air velocity from the outlets and air distribution inside the car.

11.5.6 Adequate sized duct from adjacent AC to the cab shall be routed to the driving cab, control cabinets and driving console. Air turbulator shall be provided in the driving console, signaling cubicles and electrical cabinets to achieve uniform cooling.

11.6 HVAC Unit Compressor

11.6.1 The Contractor shall provide twin hermetic scroll compressors proven for sufficiently long time in Metro service. Scroll compressor shall be suitable for operation at high ambient temperatures upto 50⁰C. The details of the drive for the compressor shall be provided. Full details of the compressor and its experience in Metro application, particularly in high temperature, dusty and humid environment shall be furnished. Unloading of compressor shall be linked with HP setting.

11.7 Condenser and Evaporator Coil

11.7.1 The condenser and evaporator coils shall be of copper with copper fins . Condenser fins spacing shall be no closer than 3mm to prevent dirt/dust build up. The coil assembly shall be mounted in a stainless steel / copper alloy frame. Cleaning of condenser and evaporator coils should not be required earlier than 1.5 lakhs KM running. The frequency of cleaning of coils in Delhi climate shall be furnished.

11.7.2 The condenser and evaporator fan motor shall work at 415V, 3 phase, 50Hz. However, in case of auxiliary supply failure, the evaporator fan motor shall be fed from the inverter. Dual speed condenser fan motor may be used. The fan motors shall have IP 56 protection as per IEC 60529.

11.7.3 A condensate drain stainless steel pan shall be provided beneath the evaporator coil. Baffles shall be provided in the pan to prevent spillage. Adequate big size drain pipe shall be provided for drainage of condensate from drip tray to the rain gutters. Suitable means shall be incorporated for cleaning of drainage system.

The design of rain gutter shall ensure smooth passage of drainage and muck.

11.7.4 Quality of HVAC copper tubing and joints shall be of a very high order so as to minimize chances of refrigerant leakage. It the experience to the employer that these may have to provided with suitable coating to insulate against environment pollution.

11.8 Piping

11.8.1 The refrigerant piping shall be of copper with suitable non-ferrous fittings. All connections between the piping and equipment shall be made using either capillary fittings or brazed joints. There may be relative movement between the terminals of the compressor, condenser and evaporator coils resulting from vibration. The pipe layout shall take this aspect into consideration.

11.9 Electrical control cubicle

11.9.1 An electrical switchgear and control equipment for the system shall be located in a sealed cubicle, which shall be an integral part of the package. The electric switches, contactors and relays etc. should be proven in Metro application. The cables shall be halogen free compliant to EN 45545, Latest Editions in respect of flammability, smoke emission and toxicity requirements.

11.10 Control Equipment

11.10.1 Each HVAC unit shall be associated with its microprocessor control panel which shall be easily accessible from within the car. The micro-processor based system, proven in railway service shall be provided with loading, scheduling, diagnostic and operational data interfaced with TIMS.

11.10.2 The microprocessor shall have extendable memory permitting logging of faults and system events in its memory for sufficiently long durations. The microprocessor shall have suitable interface with TIMS for data communication and display. Suitable communication shall be provided to permit logged events to be downloaded to a laptop computer.

11.11 Emergency Inverter

11.11.1 An Inverter of adequate capacity shall be provided in each to supply 415 Volt power from 110 Volt d.c. battery to power the ventilator fan motors of the car during emergency mode, when cooling is off, for supplying emergency fresh air. Inverter shall be IGBT based and tested in accordance with IEC 61287. The current rating of IGBT shall be such that the junction temperature has a minimum margin of 10 °C in the worst loading

conditions. The inverter shall be located in evaporator section of the HVAC unit.

11.12 Operator's Cab Air-conditioning

11.12.1 The driving cab shall have a special package HVAC unit capable of maintaining inside conditions at less than 25°C, 60% RH. The fresh air supply shall be not less than $0.04\text{m}^3/\text{s}$ ($144\text{m}^3/\text{h}$). The temperature shall be easily adjusted by the operator.

11.12.2 In case of the failure of cab air-conditioning, it shall be possible for car cooling air to be supplied to the cab.

11.12.3 A suitable diffuser, adjustable in both vertical and horizontal directions shall be provided.

11.12.4 Manual On-off and two-speed controls shall be provided for fan operation.

11.12.5 Deleted.

11.12.6 The HVAC unit of cab supplied with RS15 stocks shall be completely interchangeable with existing HVACs of RS1/RS6/RS13 stocks.

This page is left blank intentionally

EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 12

ELECTRICAL AND CONTROL EQUIPMENTS

CHAPTER 12: ELECTRICAL AND CONTROL EQUIPMENTS

12.1 General

12.1.1 On-train electrical equipment and control circuits, other than those for the propulsion system, shall use one or more of the following power sources:

- (i) 415V ac, 50 Hz, 3 ϕ , 3 wire
- (ii) 230V ac, 50Hz, 1 ϕ
- (iii) 110V d.c.
- (iv) 24 V d.c.

12.1.2 AC single phase levels at the load end shall be within $230 \pm 6\%$ V and $50 \pm 3\%$ Hz.

12.2 Train Control and Operational Principles

12.2.1 A modern ergonomically designed console located between the train operator's seat and the cab front end structure shall be equipped with vital train operation controls mainly master controller, back-up brake control, door controls, gauges, indicators, push buttons etc as approved by the Engineer. In addition to the above direct controls, an indirect access to miniature circuit breakers, fault indicator lights, sealed switches shall also be provided. The console shall also be provided with TIMS, VDU and ATP/ATO displays besides the identified gauges and indications. Suitable ventilation shall be provided by the Contractor for the backside area of the console.

12.2.2 The control and operation shall be based on the optimized combination of the following principles:

- (i) Maximum safety
- (ii) Maximum reliability and availability
- (iii) Operator convenience and ergonomic design
- (iv) Adequate redundancy
- (v) Energy efficiency
- (vi) Maintenance support

12.2.3 The control logic shall ensure that the vital train control functions (such as Couplers, door system, brakes, propulsion power removal, PEA etc.) are executed using conventional relay control and dedicated hardwired train line signals. All vital circuits not totally within the system apparatus enclosure, shall be double wire, double break, with the exception of connections to non-vital circuits. The identified safety critical signals shall be carried using redundant train line pairs.

12.2.4 Warnings and indications that are necessary for safe operation of train shall be indicated by means of LED lamps and shall also use hardwire system.

12.2.5 TIMS link shall be used to execute non-vital commands and controls of the train.

12.2.6 In addition, TIMS link shall be used for the identified non-vital control functions through VDU interface. TIMS link shall also be designed to provide back-up signals of certain identified vital commands.

12.2.7 The Contractor shall develop overall control logic for review of the Engineer. The proposed equipment shall be service proven and reliable.

12.3 Trainline Electrical Connections

12.3.1 Electrical contact blocks, mounted on the semi-permanent or automatic coupler shall be provided. When the automatic couplers are mechanically coupled, automatic pneumatic and electrical coupling shall be effected between the mating couplers. When the automatic couplers are uncoupled, the electrical contact blocks shall be automatically retracted and protected by covers with adequate weather protections. Electrical

connectors for the semi-permanent couplers shall be mechanically secured together.

12.3.2 The Contractor shall submit details for inter-car and inter-unit connections to meet the necessary train operation requirement. Adequate number of spare connection pins shall also be provided.

12.3.3 The free end of the cabling from the electrical connector shall be terminated in a multi-pin plug (s) with compatible socket(s) at the interface with the car wiring.

12.3.4 All exposed cables at the exterior including the inter car jumper cables, if any shall have suitable mechanical protection.

12.4 Control equipment

12.4.1 The control equipment relays and switches and such other devices shall be of proven technology established under the most severe operating conditions with particular regard to reliability.

12.4.2 Wherever considered necessary by the Contractor, contacts shall be duplicated to provide redundancy. Inter-vehicular control couplers and data transmission pairs shall be duplicated to ensure reliability of operation.

12.4.3 Interlocks and auxiliary contacts connected with important protective, operation, control, auxiliary and safety circuits will be housed in enclosures.

12.4.4 The voltage range of all relays and contactors will be 77 to 138 V dc (110V d.c. -30%, +25%, in accordance with IEC requirements). These devices will work within this voltage range properly under their rated temperatures and contact pressures. The contact pressure will be adequate to ensure satisfactory operation under most severe working conditions.

12.5 Wires and Cables

12.5.1 All wires and cables shall be adequately protected for the maximum design and fault currents, and designed for minimum voltage drop.

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 latest editions. 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.

12.5.3 Fire resistant cables shall be proposed for circuits, which should survive for long periods during fire, as per applicable international standards. As a minimum, the cables and wires for Public Address System shall be fire resistant cables.

12.5.4 The system adopted to rate cable shall be fully specified for review. All de-rating factors shall be applied, together with the maximum permissible conductor temperature for the particular insulation type. In no case shall the conductor continuous temperature exceed 90°C. The maximum short circuit temperature shall not exceed 250°C. The cable insulation shall be capable of withstanding these temperatures.

12.5.5 The minimum cross sectional area of control cables for connections between equipment shall preferably be 1.5 mm². Smaller cable sizes may be used inside equipment cases. Any deviation from this requirement, in exceptional cases, will be subject to approval by Engineer in design stage.

12.5.6 The proposed cables shall be proven on metro Rolling Stock. The Contractor shall submit the voltage grade, size and type of cable for different applications alongwith the proposed specification for the cables for review by the Engineer.

12.6 Indication Circuit

12.6.1 All hardware indications shall be with LED type. Failure of a single LED shall not cause incorrect indication. Individual cars shall have local indication of the operating status of the equipment, being remotely indicated in the VDU display, through TIMS.

12.6.2 Indication on DT Car

Backup LED indication for critical function shall also be provided in the DT Car. In addition to VDU display the indications provided shall be for train and car level. All indications shall be provided either on the driver's console or on the panel behind and adjacent to the driving position. The tenderer shall furnish a list of indicators including function, control and display format for review.

12.6.3 Train Lines for Indication Circuit

The tenderer shall submit proposal for train lines utilised for the indication circuits.

12.6.4 Trainline Electrical Connections

- (i) Electrical contact blocks, mounted on the semi-permanent or automatic coupler shall be provided. When the automatic couplers are mechanically coupled, automatic electrical coupling shall be affected between the mating couplers. When the automatic couplers are uncoupled, the electrical contact blocks shall be automatically retracted and protected by covers with adequate weather protections. Electrical connectors for the semi-permanent couplers shall be mechanically secured together.
- (ii) The tenderer shall submit details for inter-car and inter-train connections to meet the necessary train operation requirement. Adequate number of spare connection pins shall also be provided.
- (iii) The free end of the cabling from the electrical connector shall be terminated in a multi-pin plug (s) with compatible socket(s) at the interface with the car wiring.

12.7 Circuit Protection and Earthing System

12.7.1 All electrical circuits shall be protected by fast acting, 10kA fault current rated MCB's. The Contractor shall propose a protection scheme for review. The Contractor shall submit a detailed protection scheme including calculations to demonstrate proper segregation and discrimination between the cables, fuses and the traction substation circuit breakers. Calculations shall be submitted to verify proper discrimination between different levels of the protection system.

12.7.2 All equipments will be adequately earthed, insulated, screened or enclosed and provided with essential interlocks and keys as may be appropriate to ensure the protection of the equipments and safety of those concerned with its operation and maintenance.

12.7.3 All equipments on the vehicles, except the battery boxes shall be safety grounded to the carbody structure. The safety grounding shall be distinct from power return grounding. Safety grounding points shall be of tinned copper, clean, free from paint, and of a sufficient area to ensure proper electrical contact for the grounding cable fasteners. Untinned bronze grounding points and austenitic grade stainless steel grounding points are also considered acceptable.

12.7.4 The area of any weld joining the grounding pad to a surface shall be at least equal to the cross sectional area of the grounding cable. Grounding points will have either a tapped hole or, preferably, a clearance hole (with access to both sides) suitably sized for the lug attachment fasteners. Minimum grounding cable size will be 6mm².

12.7.5 An earth fault detection system shall be proposed by the Contractor for review. Protective devices shall

also prevent fires resulting from short circuits, or other electrical defect.

12.7.6 The Earth Concept shall such that requirement in audio frequencies used in signaling track circuits is met.

12.7.7 All electrical circuits shall be fully insulated from the superstructure on both the positive and negative sides and the super-structure shall not be used as any portion of an earth return circuit.

12.7.8 Earth fault protection shall be provided on control, auxiliary and traction power circuits, so that it shall be possible to continue operation for a limited period even where there is one earth fault on the circuit. For this purpose the earthing of the circuits may be provided through the coils of earth fault detection relays and the supply battery.

12.7.9 All electrical and electronic equipment shall be protected against surge or transient voltages caused by switching (internal or external to the rolling stock), lightning discharges and line voltage disturbances by the provision of suitable filters or surge suppressors.

12.8 Lighting System

12.8.1 Exterior Lighting

- (i) Exterior lights lens assemblies shall be sufficiently robust to resist the impacts of flying ballast.
- (ii) The IP protection shall be IP65, when fitted on the carbody.
- (iii) Deleted
- (iv) Individual power LED clusters used as exterior lights shall be able to be replaced easily from track level. Replacement of individual cluster shall be possible in depot without disturbing the functioning of the light. In case, the change of cluster require readjustment of complete light or component, facility for the same shall be provided in each depot.
- (v) Access for cleaning and the replacement and adjustment shall be possible.
- (vi) All LEDs shall conform to the minimum requirements as specified in ERTS 12.9 and its sub- clauses.
- (vii) Complete lighting system(s), their components shall generally conform to relevant ENs/IECs applicable for railway applications and shall be type tested.

12.8.2 Head and Tail Lights

- (i) Power LED based Head- and tail-lights in watertight sealed, vermin-and-insect proof integrated housings placed at approximately 3m centres and 1.5m above top of rail datum, beneath the windscreens. The units shall be "handed", left and right, so that the taillights are outboard of the headlights.

The two power LED based white light, with provision for dipper shall be mounted at the front of the driving end of the DT Car, to provide even illumination of the tunnel bore, track bed and track side signal posts. It shall be possible to read the number plates provided on the OCS masts and other boards like pantograph lower / raised boards. The illumination level of the head light shall be as per the international norms. Replacement of individual cluster shall be possible in depot without disturbing the functioning of the light. In case, the change of cluster require readjustment of complete light or component, facility for the same shall be provided in each depot.

- (ii) Each beam shall be separately adjustable both horizontally and vertically. The On/Off and Beam controls shall be switched from the train operator's console.
- (iii) Two bi- colour power LED based marker lights (tail lights) shall be provided which may be lit in both active and non-active cab. The taillights shall be LED type. Each LED shall be dual colour of white and red which shall be selectable from cab. Alternatively white & red LEDs may be provided within the same block/fitting and be used accordingly. In active cab the marker lights shall be white and in non-active cab it should be of red colour. During the normal train operation, white front lights shall glow and rear shall be red. However in case of a stationary train in siding or depot , both front and rear lights shall be red.
- (iv) The taillights shall be sufficiently large and bright, to enable the lamp to be seen and acted upon by a train operator within the stopping distance of the consist travelling at maximum speed.
- (v) When a driving cab is activated by a Train Operator, in the occupied cab either the head lights shall be lit and the tail lights shall be switched off or only tail lights (white colour) shall be lit; while in the non-active cab the head lights shall be switched off and tail lights (red colour) shall be lit.
- (vi) The headlights and taillights shall not be switched off when the train is passing through a neutral section.

- (vii) The Contractor shall propose to suitably indicate the front end of the train while parked at depot, or stabling sidings, by illuminating two white lights either by using dimmer position of head light or using dual colour LEDs in the tail light or by other appropriate means.

12.8.3 Flasher Light

In order to attract the attention of the train operator of the following train or a train approaching from the opposite direction, in emergency, a 'powerful flashing amber light in addition to the tail lamps shall be provided in the front panel of each driving car. This light shall be switched ON by the train operator in case of emergency and shall not be switched OFF even while negotiating neutral sections.

Flasher light when lit and flashing shall be able to attract attention at a distance of 300 meters under clear sunny day light.

12.8.4 Door Indicator Lights

An amber indication lamp (power LED based) shall be located at an appropriate location both outside and inside near each door.

The lamp shall remain extinguished when respective door is fully closed and locked.

The lamp shall be illuminated when the door is in fully open condition, or when the locking mechanism has failed to register, preventing traction circuits from picking up or when the door is closed, locked and isolated.

The lamp shall flash whenever door is opening or closing; for example when close announcement button from the active cab is pressed. It shall continue to flash till such time the door is closed.

12.8.5 Call-On Light Switch

A Call-On Switch shall be provided in the train operator's cab, to cater for Emergency Push-Out situations. Operation of the switch on a failed train, with the Mode Selector in OFF, shall cause the tail lights at the rear of the failed train to flash on and off, indicating to the train operator of the rescuing train that he may proceed to affect coupling.

12.9 Interior Illumination System

- (1) The lighting system shall generally conform to EN13272. The system shall be based on power LEDs and should meet following requirements in general:
- (2) The guaranteed life of the LEDs with their control system and optics/luminary shall not be less than 60000 burning hours.
- (3) The specified illumination level shall be met till at the end of the life of 60,000 hours when the illumination is not less than 70% of their original illumination level.
- (4) The colour of LED shall be similar to the existing light. It shall be ensured that all LEDs are selected from the same bin to avoid any difference in colour and performance. Approval of Engineer will be required before installation.
- (5) The design of the heat dissipation arrangement shall be submitted in details with simulated results. Colour rendering index shall not be less than 70.
- (6) Complete light and energy simulation calculations shall be provided during design to prove validity of the proposed solution.
- (7) The system shall be designed to limit glare and ensure no glare by night time reflections in windows.

- Luminaries shall be designed to conform relevant international standards.
- (8) The change of chromaticity over the lifetime of the product shall be within 0.007 on CIE 1976 (u',v') diagram or equivalent.
 - (9) Luminaire efficiency inclusive of LEDs/control gears & optics etc. shall not be less than 100 lm/W at the working junction temperature; higher values shall be preferred.
 - (10) Design layout of LEDs & their strings/blocks should be such that the failure of one LED should not cause isolation of complete string/block. Similarly failure of one controller on one string/block should not adversely affect other strings/blocks. Details shall be finalized during design stage.
 - (11) Coaches may remain unpowered in open sun and internal temperature may go upto 70°C (ERTS 3.10). Suitable protection measures shall be taken to ensure that this does not adversely affect the performance, reliability or efficiency of the lighting system and its components. Verification/validation to the above shall be proposed by the contractor during design.
 - (12) Illumination within saloon with LED luminaires shall be designed so as to ensure that the desired maximum illumination level is achieved with LEDs operating at approximately 50% of its rated capacity. However, driver/control unit/optics etc. shall be designed for full rating of the LEDs.
 - (13) All luminaires shall be of LED type and fitting shall be protected and diffused. No exposed light sources will be accepted.
 - (14) LED luminaires and control gears shall be sealed to IP 52 and IP 54, BS EN 60529:1992, respectively to prevent the ingress of dirt and foreign objects.
 - (15) After one year, two year and 60,000 operation hours, the colour temperature s all be within $\pm 5\%$, $\pm 8\%$ and $\pm 10\%$ of the initial value respectively.
 - (16) LED luminaries shall be designed to withstand switch cycles of 1,00,000 and tests shall be conducted to prove the compliance.
 - (17) The contractor shall replace all the LED lighting with a newly improved LED lighting if
 - a. The total cumulative failure rate of the LED luminaries and controlgears within DLP exceeds 5% with 20% of LEDs failed in a LED luminaire is constituted as a failure of the LED luminaire; or
 - b. The illumination level at floor level of any five trains drops below 90% of the initial values at the end of two—year operation of each train, by assuming 15 hours daily operation and 365 days of operations.
 - (18) Since LED technology is fast evolving and the rolling stock supply is a long drawn process , sub-supplier shall commit to supply new generation of improved LEDs progressively and which should be compatible with the luminaries already supplied and installed. The contractor shall regularly update the engineer on this aspect during the manufacture.
 - (19) Noise generated by the energised LED lighting, fixtures and ballast/control gear installed in a car shall not exceed 50 dbA when measured 1m from the equipment.
 - (20) LEDs manufactured by reputed manufacturers shall only be used after taking the prior approval of the Engineer during Design Review.
 - (21) LED(s) shall have lumen rating as 100 lumen/LED or above.

- (22) Maximum number of LEDs which a driver/power supply can feed shall not exceed 60 LEDs.
- (23) During commissioning and subsequently, it may be desirable to adjust the lux level to 250/200 in the saloon. Provision shall be made for adjustment of the lux level within saloon. At least three levels of adjustments i.e. 200 lux/250 lux/300 lux shall be provided in the saloon illumination design as a minimum. Details shall be discussed during design review.

The selection of vendor shall be made so as to optimize the design criteria as above

12.9.1 Saloon Illumination

- (i) Energy efficient, power LED based lights, in luminaries meeting flame, smoke and toxicity requirements shall be recessed into the ceiling panelling. The light fittings shall be simple, and arranged not to trap dirt, moisture and insects. Suitable sealing protection shall be incorporated to prevent ingress of dust etc from AC ducts. The luminaries shall ensure to minimise the glare.
- (ii) All the saloon lights shall work on 110V d.c.
- (iii) The size and number of light fittings with diffuser shall be sufficient to provide a sensibly constant level of illumination of 300lux at a height of 1.0 m above floor level, along the entire length of saloon.
- (iv) Separately protected lighting circuits shall be used, such that in the event of one tripping, the others provide evenly distributed lighting throughout the saloon.
- (v) 100% of lamps, evenly distributed over the saloon area, shall remain illuminated, energized even when the train/car passes through neutral section.
- (vi) The control logic shall ensure automatic selection, with manual over-ride, of the saloon light circuit(s) to maximize utilization of the natural light and maintain the desired illumination level. During day time, the interior lights shall be controlled automatically through dimmer(s) so as to maintain illumination level within acceptable level and reduce the energy consumption. The Contractor shall submit details for review by the Engineer.
- (vii) The contractor shall submit service life of LED lamp during the design stage which shall be as per the best international practices
- (viii) The contractor shall submit layout of fittings and control circuit for review by the Employer.
- (ix) It shall be possible to replace defective LEDs/ block of LEDs with ease and minimum need for readjustments or otherwise. Any special toll required for the purpose shall be supplied as two sets to each depot.

12.9.2 Cab Illumination

- (i) The cab shall be provided with a ceiling lights, providing a sensibly constant level of illumination of 200lux at 1m above floor level. It shall be operated automatically by the opening of either cab door, and extinguished manually from within the cab.
- (ii) Separate lighting of the train operator's console shall meet the requirements of UIC 651 OR which stipulates a minimum of 60 lumens/m² measured at the driving control desk. Driving console light shall be operated manually from within the cab.

12.9.3 Cubicle Lighting

All cubicles shall have sufficient lighting arrangement for facilitating their maintenance related works.

12.10 Cab Equipments

12.10.1 Master Controller

A Master Controller shall be provided on the driver's console. The Master Controller shall be a fore and aft longitudinal shift type. A deadman's device shall be provided on the Master Controller Handle. Driving mode will be achieved by moving handle away from the operator. The tenderer shall propose number of notches in powering and braking mode for review.

12.10.2 Mode Selector

A Mode Selector Switch shall be provided on the driver's console and selection of mode shall be by longitudinal, fore and aft movement. The Mode Selector shall be mechanically and electrically interlocked with the Master Controller.

12.11 Auxiliary Machines and Drives

- (i) With the exception of the auxiliary (pantograph, etc.) compressor, which shall be suitable for a supply at 110V d.c., all other drive machines shall be suitable for a (non-sinusoidal) supply from an auxiliary convertor, which will have harmonics.
- (ii) All auxiliary motors, including that of the auxiliary compressor, shall conform to the requirements of IEC 60349-2.
- (iii) The temperature rise limits of all auxiliary motors shall be to the maximum temperature index, minus 70°C. The temperature rise test of the auxiliary converter shall be carried out with auxiliary convertor supplying all auxiliary motors simultaneously

12.12 Safety Devices

12.12.1 Fuse Protection

- (i) Adequate fuse protection for all electrical circuits shall be provided. The Contractor shall propose a protection scheme for review. The Contractor shall submit a detailed protection scheme including calculations to demonstrate proper segregation and discrimination between the cables, fuses and the traction substation circuit breakers. Calculations shall be submitted to verify proper discrimination between different levels of the protection system.

12.12.2 Earthing System

- (i) All equipments will be adequately earthed, insulated, screened or enclosed and provided with essential interlocks and keys as may be appropriate to ensure the protection of the equipments and safety of those concerned with its operation and maintenance
- (ii) An earth fault detection system shall be proposed by the Contractor for review. Protective devices shall also prevent fires resulting from short circuits, or other electrical defect.
- (iii) All electrical circuits shall be fully insulated from the superstructure on both the positive and negative sides and the super-structure shall not be used as any portion of an earth return circuit.
- (iv) DT/T cars shall be provided with a manually operated two position earthing switch. The operation of the switch shall enable earthing of the power circuit of the motor cars. The HT equipment shall be

safeguarded by a system of interlocked keys in a receptacle associated with the earthing switch. (Annett's or Castell Key or similar).

- (v) Earth fault protection shall be provided on control, auxiliary and traction power circuits, so that it shall be possible to continue operation for a limited period even where there is one earth fault on the circuit. For this purpose the earthing of the circuits may be provided through the coils of earth fault detection relays and the supply battery.

12.12.3 All electrical and electronic equipment shall be protected against surge or transient voltages caused by switching (internal or external to the rolling stock), lightning discharges and line voltage disturbances by the provision of suitable filters or surge suppressors.

12.13 Speedometer

A speed indicating and recording equipment shall be provided in each DT car which shall also record the distance travelled by the train.

12.14 Automatic Train Control

12.14.1 The Automatic Train Control system, is supplied by Signalling and Train Control Contractor.

12.14.2 Full details of the interface issues, and the responsibilities of the RS15, and Signalling and Train Control Contractors are set out in Appendix TD to this Specification, entitled: Interfaces between Rolling Stock, and Signalling and Telecommunications Contractors.

This page is left blank intentionally

**EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATION**

CHAPTER 13

COMMUNICATION SYSTEM

CHAPTER13: COMMUNICATION SYSTEM

13.1 Train Communication Equipment

13.1.1 The following on-train communications requirements shall be provided :

- (i) Two-way Communication between the Operations Control Centre (OCC) or Back-up Control Centre (BCC), and driver, via train radio equipment (Supplied by Signalling and Train Control and Telecommunications Contractors).
- (ii) Emergency passenger announcements on the train by OCC or BCC via train radio system
- (iii) Means for the driver to address passengers throughout the train from the driving cab.
- (iv) Facilities to permit simplex conversation between a passenger who has operated a passenger alarm device, and the driver.
- (v) Deleted.
- (vi) An automatic voice announcement system
- (vii) A passenger information system
- (viii) Passenger saloon surveillance system using CCTV

13.2 OCC to Driver and Passenger Address Communication Link

13.2.1 A Train-to-OCC (and Train-to-BCC) radio communications link (Supplied by Signalling and Train Control and Telecommunications Contractors). shall be provided to enable :

- (i) Voice communication between the OCC/BCC and passengers, and between the OCC/BCC and the driver.
- (ii) Vehicle health data communication from TIMS to OCC at designated times and locations. The data required to be transferred from the train to the OCC shall be finalised by the Contractor at the detailed design stage and submitted for review by the Engineer.
- (iii) The interface between the radio link and TIMS shall be provided by RS15 Contractor.
- (iv) Voice shall have priority over data communication.
- (v) When the OCC or BCC to passenger communication occurs, any other system set at that time shall be overridden.
- (vi) A radio control head, which shall be integrated with the driving console, shall be supplied by Telecommunications Contractors.

13.2.2 A suitable interface shall be provided by the RS15 Contractor to enable the OCC/BCC-to-Passengers communication link to be transmitted over the train public address system.

13.3 Passenger Alarm

13.3.1 When a passenger alarm device is operated, a warning sonic device shall sound in the cab, an indication shall be given to the driver of the location of the operated device, and a visual indication on the

exterior of the car shall advise station staff which is the affected car.

The driver shall acknowledge the alarm by operation of an override device, which shall terminate the cab sonic alarm, and simultaneously cause an indicator to illuminate at the emergency device location.

Passenger communication shall be driver initiated. This will render the local microphone and loudspeaker adjacent to the activated emergency device active, thereby enabling bi-directional inter-communication between the train driver and the passenger.

If more than one emergency device has been operated, each demand shall be independently acknowledged, and alarms shall be stored, displayed and answered sequentially.

Full details shall be submitted for review by the Engineer

13.3.2 Whilst the communications system is in the passenger alarm mode it shall be possible for the driver to move between passenger alarm, OCC, PA and cab-to-cab communication.

In the event that the driver fails to acknowledge a passenger alarm call, within a specified time, the call shall be logged by TIMS.

Once the doors have been opened, it shall not be possible to restart the train until all the passenger alarms have been reset. Once this has occurred the system shall revert to its normal form of operation.

13.3.3 Under no circumstances shall cab-to-cab conversation or driver to OCC conversation be relayed to any passenger.

13.4 On-train Public Address

13.4.1 An integrated communications panel shall be supplied by RS15 Contractor, and shall control the public address functions, cab-to-cab communications, and passenger alarm communications.

13.4.2 On-train public address shall be capable of being initiated from the OCC, the driving cab or the automatic voice announcement system. The Automatic Voice System shall be the default public address mode (default mode).

13.4.3 The Public Address System together with its main components shall comply with internationally accepted standards.

13.4.4 Power amplifiers are required for the p.a. system and shall cater for the requirements of an eight car train.

13.4.5 Each power amplifier shall ensure that messages are broadcast evenly throughout the train in the event of a single power amplifier failure.

13.4.6 The PA system shall have automatic continuous variable volume control, based on saloon background noise level. A sound level adjustable between 6dB(A) and 10dB(A) above background noise level is required throughout the train. The Contractor may however, propose alternative suitable settings.

13.4.7 The PA system shall exhibit no oscillation, acoustical feedback or other instabilities at any combination of input level, gain or speaker volume control settings under all test and operational conditions.

13.4.8 The public address amplifiers shall be protected against short circuit at the outputs of the amplifier.

13.4.9 The through line cable inside the car shall be suitably insulated, screened, armoured and overall outer sheathed. The cable shall be of the fire survival type.

13.5 Cab to Cab Mode

13.5.1 In the cab-to-cab mode, the train driver shall be able to communicate with a person at the other end of the train.

13.5.2 The cab-to-cab communication system shall be able to operate independently of, and simultaneously with, automatic announcements and with the passenger alarm system operative.

13.5.3 Simplex mode operation between two trains while in proximity, shall be possible, via OCC on the radio communication system.

13.6 Automatic Voice Announcement System

13.6.1 An automatic pre-recorded message announcing system shall be provided in each cab by the RS15 Contractor. Functions and features of this system shall be as follows:

- (i) The device shall be operable from the driver's cab.
- (ii) To be fully integrated with the train PA system.
- (iii) To be triggered by ATP/ATO to make an announcement of pre-determined messages. Close liaison is required between the RS15 and Signalling and Train Control and Telecommunications Contractors in this regard.
- (iv) A monitor repeater in each cab.
- (v) All interfaces between the automatic voice announcement system and the ATP/ATO system shall be provided by the RS15 Contractor.
- (vi) Messages shall be digitally stored, and announcements shall be in the Hindi and English languages.
- (vii) The comprehensive details of message and special messages (their format, frequency, use etc.) shall be subject to review by the Engineer.

13.7 Passenger Information System

13.7.1 General

- (i) The Passenger Information System shall include a high resolution multicolour graphic display, suitable for the remote displaying of moving messages, in Hindi and English, on board the train.
- (ii) The location and number of the display units shall be proposed by the Contractor taking into consideration the need for all-round good visibility by passengers within the saloon. The Contractor shall submit his proposal, including diagrammatic representation of the angle of visibility of the display units.
- (iii) There shall be a Destination Indicator on each side of every car, at an appropriate location close to mid point of the vehicle but beyond the sweep of the passenger saloon doors. The Destination Indicator shall display the destination name to the passengers standing on the platform. It shall be capable of displaying the requisite information in single line alternating between in Hindi and English language. The device shall be flush mounted with the exterior of the car body. The display shall automatically

change as per short loop operation as the case may be. The Contractor shall submit proposal for Engineers's review.

(iv) Programmable Digital Route Maps (DRM):

Four programmable coloured LCD based route maps for the designated lines shall be provided above alternate saloon doors and shall have following provisions as minimum (details shall be decided during design stage):

- (1) Display of real time destination station, present station, approaching station, distance for reaching next stations, clock and door indications etc. Necessary interface shall be ensured by the Contractor.
- (2) Route-map of respective interchange lines in specified colours, point of inter-change.
- (3) The size of the letter on LCD with LED backlit displays panel and resolution shall be programmable and have adequate clarity and visibility for a seating passenger. Further details shall be decided during design.
- (4) Direction of movement of displays, positioning of destination station on DRM shall match with the geographical direction of destination station/train direction.
- (5) The station names shall be displayed in multi-languages (regional language(s) and English and/or Hindi) alternatively.
- (6) DRM display size has to be much longer to give comfortable view of the complete line(s) and additional information as already described above. DRM display shall fully use the available space in the door coving where the same shall be mounted.
- (7) Detail specification shall be drawn and screens shall be got approved during design. Additional changes if required during design shall be incorporated during upto defect liability period.
- (8) Door indication on DRM shall be finalised during the design stage. Details shall be submitted for review by the engineer.
- (9) Routes map, arrows, lines etc. shall be dynamically updated based on the train location.

(v) The Train Number, Destination Indicator, Train Identification Indicator and Dynamic Route Maps shall be able to be set via the route setting control. The route setting control shall be either through the manual control on the TIMS or be automatically set by the Automatic Train Control (ATP /ATO) system as given in Appendix TD.

(vi) Train Number, Destination Indicator and Train Identification Indicator shall have a view angle of not less than 120 degrees in the horizontal plane and shall be legible under direct sunlight, artificial light and darkness. Light sensors shall be equipped to vary the intensity of the LEDs based on the level of ambient light

13.7.2 Automatic Operation of Passenger Information System

- (i) The system shall be capable of automatic operation throughout. At train set up, the train running number shall automatically initialise the passenger information system by selecting the appropriate information from the train equipment and transmitting it to speakers and displays.
- (ii) The system shall update the journey information by accessing the train location information from the ATO/ATP equipment.
- (iii) The system shall be capable of receiving real time information from the control centre (via the train radio) relating to delays and other relevant information. The system shall be capable of automatically updating the information being presented at the time to include the real time information received.

13.7.3 Manual System

- (i) In addition to automatic operation, visual and audio information shall be capable of being originated from the driver's cab.
- (ii) The system shall be capable at being operated in a manually updated or non-updated mode, in the event that the ATO/ATP positional information is not available.

13.8 Passenger Saloon Surveillance System

13.8.1 The Passenger Saloon Surveillance System (PSSS) shall comprise of a close circuit television (CCTV) network using surveillance cameras, recorder, routers and cables and other accessories for each individual cars. The fully expended system shall be designed for minimum 25 fps or more. The picture quality will be level E as minimum at 100% Rotakin measured according to EN50132-7. The design shall be finalized during design stage.

13.8.2. Each car shall be provided with at least four surveillance camera devices (one additional in cab in case of DT cars) at appropriate location to cover the maximum passenger saloon area for surveillance. It shall be possible to increase number of cameras by atleast 2 per car by simple plug in to the system. Any hardware/software tool required for expanding the system shall be provided to enable the Employer to plug in additional cameras if so required in future. Employer's Engineers shall be trained for interfacing and commission the same with no extra cost.

The camera shall be suitably selected in respect of best HD resolution, clarity of images, illumination conditions, iris control, Wide Dynamic Range (WDR) etc. for on-train applications and shall be of proven design. The design of camera shall be finalized during design stage. Mounting of camera shall be unobtrusive, flushed with, or recessed into the interior panel. Screen shall have facility to enable multiple views of the platform simultaneously. The system shall be based on open environment/protocol like Ethernet for ensuring interchangeability of cameras. The system shall have self-diagnostics and communicate the same suitably to the maintainer.

13.8.3 The visual images from each camera shall be recorded in non-volatile solid state drive memory in a video recorder without any limitation of repetitive writing of the data. The capacity of the recorder shall be of at least 15 days and shall have the provision of First in First out (FIFO). The memory shall be expandable by simple plug in of commercially available memory media. The records shall be easily downloadable. The Contractor shall provide equipment and means for the same.

13.9 Details of storage module used for PA/PIS & PSSS and its capacity, limitation (if any) shall be submitted for review and approval by the Engineer. Storage module used shall be of latest version & latest art of technology.

13.10 Interface

13.10 See Appendix TD for full details of the division of responsibility between the RS15 and Signalling and Train Control and Telecommunications Contractors.

This page is left blank intentionally

EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATIONS

CHAPTER 14

MATERIAL AND WORKMANSHIP

Chapter 14: Material and Workmanship

14.1 General

14.1.1 All equipment shall be constructed in a sufficiently robust manner, and arranged so as not to suffer deterioration, wear, or damage due to vibration or shock loads encountered in traction service.

14.1.2 Equipment shall be arranged into groups, where practicable. The items of any one group shall be mounted on a common frame or equivalent, complete with wiring, piping, etc.

14.1.3 All such equipment shall be protected against damage caused by dirt, dust, moisture, etc.

14.2 Materials

14.2.1 Metals shall be supplied in compliance with the following material standards or equivalent, unless otherwise specified:

- (i) Steel Castings - BS 3100 (592) latest version.
- (ii) Stainless Steel - chromium content not less than 17%, carbon content not more than 0.03 % - JIS 4305 latest version.
- (iii) Steel used in welded structures – BS 4360 (WR-50 or WP-50B) latest version.

14.2.2 Glass fibre reinforced plastics may be used for non-structural parts, and applications as accepted by the Engineer. They shall be manufactured to an approved process and satisfy the flammability, toxicity and smoke generation limitations of EN 45545, Latest Editions, or the latest equivalent internationally accepted standard. See also Clause 2.5.8.

14.2.3 Natural rubber shall not be used for any components exposed to sunlight or lubricants during operation or maintenance.

14.2.4 Soft metals subject to creep (aluminium, zinc, etc.), shall not be used in applications requiring them to carry current, stress or operate in high temperatures. In exceptional cases, such applications shall be submitted to the Engineer for review.

4.2.5 Where copper components require to be annealed or brazed during manufacture, special precautions shall be taken to obviate hydrogen embrittlement.

14.3 Welding

14.3.1 All welding procedures shall be documented by the Contractor. Approval of the welding procedure shall be as required by BS EN 288-3 : Specification of Approval Testing of Welding Procedures, or equivalent.

14.3.2 Approval of the welder shall be as required by BS EN 287-1 : Specification for Approval Testing of Welders Working to Approved Welding Procedures, or equivalent.

14.3.3 Arc welding shall be performed by the MIG process and in all cases complete and adequate fusion with the base material shall be ensured.

14.3.4 The Contractor shall provide details of all preparatory and post-welding procedures to be undertaken during the process of spot welding. Spot welding of components which carry structural loads shall be performed using equipment fitted with time, current and pressure control.

14.3.5 The Engineer or Inspector reserves the right to verify the quality of welds, particularly in critically stressed areas, by appropriate non-destructive testing methods (NDT).

14.4 Corrosion

14.4.1 Protection of materials against all types of corrosion shall be appropriate for the environment of Delhi and the operating conditions of the cars.

14.4.2 Corrosion protection methods for metallic components and equipment cases shall be submitted. Where feasible, such corrosion protection measures shall not require to be repeated throughout the life of the vehicle.

14.5 Fasteners

14.5.1 Screw threads shall be of ISO metric sizes.

14.5.2 ISO Metric fine threads shall be used in applications where the fastener is subjected to alternating transverse loads. In other cases, the coarse series of threads shall generally be used, except where precluded by size. The use of studs shall be avoided wherever possible.

14.5.3 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.

14.5.4 Fixings shall be locked adequately to prevent loosening in service. Fixings shall withstand any shock loads the equipment is likely to encounter.

14.5.5 In critical areas the locking of all nuts, bolts and fixings shall be of a positive form, which prevents mechanical rotation of the nut relative to the bolt, irrespective of source vibration.

14.5.6 Stainless steel parts shall be attached by stainless steel screws or fasteners except in locations where high tensile strength is needed.

14.5.7 Whenever possible tapped holes shall be drilled and tapped to the full thickness of the material. Blind holes shall be used only where this is unavoidable. All such blind holes shall provide at least 3mm clearance between the end of the screws and the bottom of the tapped hole.

14.5.8 Tapped holes shall be provided with suitable thread inserts where necessary, and shall always be used in aluminium or copper.

14.5.9 The use of loose nuts and bolts will only be accepted where it is possible for staff to easily reach both parts of the fixing simultaneously.

14.5.10 Fixings for covers which may have to be removed for maintenance, shall be captive.

14.5.11 Items of electrical equipment shall be fitted to panels so that all fixings can be made from the front only, except where specified otherwise.

14.5.12 All steel fasteners used in electrical equipment and/or exterior applications shall be of stainless steel duly coated with double layer of Geomat or superior.

14.6 Enclosures

14.6.1 Wherever required equipment shall be mounted in sealed enclosures. Where this is not possible, and cooling is essential, the enclosure shall be pressure ventilated using filtered, clean air. Such enclosures may be treated as mounted in clean conditions, as specified in IEC 60077: Specification for Electric Traction Equipment, or equivalent.

14.6.2 Filters shall be of the dry type and shall preferably not require cleaning more frequently than at three monthly intervals. Cleaning shall preferably be by suction cleaning, knocking or blowing off dirt from the filter. If washing of the filters is required this shall be no more frequently than six monthly.

An exception to the above requirement applies only to the vehicle air conditioning unit filters, which will be unit replaced for cleaning at 5000 kilometers intervals.

14.6.3 Air inlets, outlets and vents shall be designed so that ingress of rain, dust or rubbish is prevented, irrespective of whether the car is moving or stationary, and independent of the direction of the wind or the car movement.

14.6.4 Enclosure doors and covers shall be securely attached, and wherever possible with quick release latches. These shall include safety devices and keyed access to prevent accidental unlatching.

14.6.5 Enclosure interiors shall have smooth easily cleaned self coloured surfaces to assist in maintenance.

14.6.6 Apparatus using two stages of insulation shall also be enclosed completely, either in an earthed metal case or in a case made from insulating material.

14.6.7 Enclosures in which heat or arcs may be generated shall be lined with barriers of insulating material.

14.6.8 All enclosure covers shall be designed to be handled by one person in an ergonomic manner.

14.6.9 Signage shall be provided at appropriate positions for clear indication and warning of the potential hazards relating to the equipment or component inside enclosures.

14.7 Wires and Cables

14.7.1 All wires and cables shall be adequately protected for the maximum design and fault currents, and designed for minimum voltage drop.

14.7.2 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 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.

14.7.3 The system adopted to rate cable shall be fully specified for review. All de-rating factors shall be applied, together with the maximum permissible conductor temperature for the particular insulation type. In no case shall the conductor continuous temperature exceed 90°C. The maximum short circuit temperature shall not exceed 250°C. The cable insulation shall be capable of withstanding these temperatures.

14.7.4 All cables and pipes shall be cleated at frequent intervals to avoid vibration leading to abrasion or fracture. All holes through which cables pass shall be fluted, or bushed, to prevent chafing and damage to insulation.

14.7.5 High and low voltage cables shall, wherever possible be kept separate. Where cables carrying voltages of greater than 200V between conductors are carried in the same jumper as other cables, they shall be run together only as far as the nearest junction box. Any such arrangement shall be submitted to the Engineer for review.

14.7.6 All cable runs in exposed locations, such as on the bogies or underframe, and therefore potentially vulnerable to damage shall be in conduits of stainless steel. Where such exposure is not a problem, cables shall be run in enclosed waterproof and dust-proof ducting.

14.7.7 All cables of voltage less than 50V shall be kept separated from high and low voltage cables.

14.7.8 Wherever cables carrying heavy current, e.g. in traction circuits, pass close to metal structures, adequate clearances shall be provided to obviate inductive heating of the structural members. Temperature rises in the adjacent steel structure shall not exceed 5°C in the steady state condition, with all cables in the

vicinity carrying normal working current. Such temperature rise shall be taken into account in selecting the cable ratings.

14.7.9 It shall not be necessary to remove cables from their cleats to gain access to equipment for inspection or maintenance. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.7.10 The minimum bend radius in cables shall not be less than twice that required in breakdown tests used in the applicable cable standards. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.7.11 The minimum cross sectional area of control and auxiliary power cables for connections between equipment shall be 3mm^2 . Smaller cable sizes may be used inside equipment cases. External sockets to such cables shall be suitable for 3mm^2 cables. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.8 Terminals and Cable Termination

14.8.1 Except for electronic equipment, all cable terminations shall be of the crimped type in accordance with BS 4579 : Part 1 : 1988, Compression Joints in Copper Conductors, or other service proven type. Soldered connections will not be accepted.

14.8.2 Crimping standards shall conform with current international practice. The Engineer may require that crimped lugs be subjected to random testing before acceptance.

14.8.3 Bolted terminations for all high voltage d.c. and return cables shall be torque loaded to a defined torque value.

14.8.4 Low voltage cables up to 6.0 mm^2 conductor cross sectional area shall preferably be fitted with terminals conforming to BS 4579 Pt.1 or equivalent. Alternatives shall be submitted for review.

14.8.5 High voltage cables, of conductor sizes up to 6.0 mm^2 shall be crimped using a lug which grips both the insulation and the conductor. An alternative suitable arrangement intended to prevent excessive flexing of the core where it emerges from the lug may be offered.

14.8.6 Terminals shall be of the steel screwed post type, securely moulded into an insulation base. All power terminations on one stud shall be assembled together without the use of intervening nuts, washers etc. Studs or bolts shall not be used to carry current. Alternative types of terminal may be offered but their acceptance will be subject to review by the Engineer in design stage.

14.8.7 Control cable terminations assembled on one stud in pre-wired removable enclosures shall be separated such that all outgoing connections may be removed without disturbing internal connections.

14.8.8 Terminals and terminal boxes shall be so arranged that if water collects in ducts and conduits this cannot reach live components or parts. Measures shall be taken to avoid the accumulation of water in such enclosures.

14.8.9 Terminals for circuits of different voltage shall be arranged in separate groups. Negative and neutral terminals shall also be grouped separately. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.8.10 All equipment enclosures and shock mounted equipment shall be grounded using flexible 'strap' type, grounding leads bolted to a designated carbody grounding pad. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.8.11 Alternative terminations may be offered for review by the Engineer.

14.8.12 All cable sockets and busbar contact faces shall be tinned. In printed circuit boards contact faces of connectors shall be gold plated. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.9 Electrical Creepage and Clearance

14.9.1 Surface creepage and clearance distances between voltage potentials and carbody earth shall be as defined in IEC 60077 Specification for Electric Traction Equipment, for all electrical circuits, equipment and associated cabling. Voltages less than 250V shall be treated as 250V.

14.9.2 Creepage or clearance where arcs are present, or along the outside or clearance where arcs are present, or along the outside of a cable sheath, shall be 200% of that defined in IEC 60077 : Specification for Electric Traction Equipment. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.9.3 Terminal boards and panel surfaces between terminals and live posts shall as far as possible be vertical to minimise the build up of tracking paths.

14.10 Protection & Earthing

14.10.1 Except as specifically required otherwise, d.c. and single-phase a.c. circuits shall be such that one pole of each device shall be connected directly to the negative or neutral line, i.e. without switches, fuses or contacts on the negative or earthy side.

14.10.2 High voltage traction circuits shall be protected in accordance with the requirements of IEC 60077 : Rules for Electric Traction Equipment, by an approved fault interrupting device.

14.10.3 In all cases, the fault discriminating characteristics of the system shall be submitted for review.

14.10.4 Low voltage fuses and associated fuse carriers shall comply with IEC 60269-1 : Low Voltage Fuses. Protection and isolation of low voltage circuits shall be in accordance with IEC 60947-2 : Low Voltage Switch Gear and Control Gear : Pt.2 Circuit Breakers or approved equivalent.

14.10.5 Grounding connections shall be made through copper or bronze pads of adequate area, to the carbody. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.10.6 High voltage circuits and low voltage circuits should not be earthed together and separate earthing shall be arranged. All earthing pads shall be readily visible and accessible for inspection and trouble-shooting.

14.10.7 The Contractor shall produce a complete earthing scheme, which shall prevent traction return current passing through motor and axle bearings, gearboxes, bogie centre bearings, couplers, or any path other than the designed path. The earthing scheme shall be submitted to the Engineer for review.

14.10.8 Miniature circuit breakers (MCB's) shall be used only for the protection and isolation of the d.c. control voltage and a.c. auxiliary circuits. MCB's shall be of a robust design suitable for use in the railway environment as detailed in IEC 61133.

14.10.9 All grounding and bonding jumpers and straps shall be sized to handle fault currents and lightning discharge currents, for which the voltage drop shall not exceed 25V.

The bonding method employed shall not produce a d.c. resistance in excess of 0.0025 Ω ; or more than 0.025 Ω at 150kHz for any applied a.c. voltage.

14.10.10 Electrical equipments like capacitors and transformers which can develop internal faults shall be provided with effective devices to isolate at once the defective equipment from the source of power such that there is no fire or explosion at any time.

14.10.11 Liquid di-electric materials used in capacitors, transformers and similar equipment shall be of the non-inflammable type.

14.11 Circuit Design

14.11.1 Circuit diagrams shall be clear and easy to interpret, and shall comply with IEC 60617-1 to 13 as applicable.

14.11.2 Apparatus coding, and cable and wire designations shall be submitted to the Engineer.

14.12 Electronic Equipment

14.12.1 As a minimum, all electronic equipment shall comply with IEC 60571 : Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased against an internationally recognised quality assurance and reliability certification procedure. However, the dry heat test temperature shall be 80°C as against 70°C specified in IEC.

14.12.2 Variable resistors shall be avoided wherever possible.

14.12.3 Circuit boards in safety control systems shall be connected through a safety circuit to disable the train if a circuit board is removed, unless the control system is proven safe and tolerant of such circumstances.

14.12.4 Electronic components shall only be purchased from suppliers having as a minimum, ISO 9001/2 certification.

14.12.5 Electronic equipment shall not be damaged, nor shall malfunction when subjected to direct spikes and surges on the supply and indirect burst transients as defined in IEC 60571: Electronic Equipment used on Rail Vehicles.

14.12.6 Deleted

14.13 Microprocessors and Software-based Equipment

14.13.1 Where microprocessor systems incorporate technology such as surface mounted components, multi-layer circuit boards, or flexible PCBs, the Contractor shall demonstrate that he has operational experience of the successful use of these technologies in a similar railway environment.

14.13.2 All microprocessor based systems shall have watchdog circuits to ensure correct software operation. When the watchdog circuit detects a fault it shall trigger hardware forcing all system outputs into a safe state before resetting the system and entering a self-test mode. Normal operation shall only be resumed if all self-test checks are satisfactory.

14.13.3 Microprocessor systems shall incorporate self-test and diagnostic facilities to locate and indicate faults within the system. The system shall have sufficient built-in diagnostic capabilities to automatically identify all system faults.

14.13.4 Where microprocessor electronics systems require additional test equipment this shall be portable for use on the car. It shall derive its power supply from that of the system under test.

14.13.5 LED's shall be used to indicate faulty modules, to allow rapid fault diagnosis and maintenance.

14.13.6 Faults occurring during system operation shall be logged, the information being stored in a non-volatile memory.

14.13.7 Deleted

14.14 Software

14.14.1 Software shall be written in a structured manner and fully documented during all stages of its design and development, with at least two levels of documentation above the source code level.

14.14.2 This shall meet the requirements of EN 50126-2: Dependability for Guided Transport Systems - Part 2 : Safety, EN 50128 : Railway Applications : Software for Railway Control and Protection Systems, and EN 50129 : Safety-related Electronic Railway Control and Protection Systems. Any deviation from this requirement will be subject to review by Engineer in design stage.

14.14.3 The Contractor shall submit his Software Quality Plan for review by the Engineer before work commences on software design. The software quality plan shall clearly state the controls and practices used in the software life cycle from specification through to in-service operation.

14.14.4 Independent review, verification and testing, using real and synthetic data, shall be performed at the software module and system level. The Engineer may audit the Contractor against the Software Quality Plan at any stage in the Contract. The Contractor shall ensure that all software is fully de-bugged prior to final review by the Engineer.

14.14.5 Sufficient software documentation shall be provided to give the Engineer a full understanding of the software function and operation. Documentation shall be complete, yet clear and concise, and include all modifications up to final acceptance. Documentation shall include software block diagrams showing signal flow, logic, and hardware interfaces. A top level flow diagram and description of detailed operation shall be provided.

14.15 Printed Circuit Board and Connectors

14.15.1 PCB's shall be of glass epoxy with components mounted on one side only.

14.15.2 The minimum thickness of PCB's shall be not less than 1.6mm. PCB's shall generally comply with IEC 60326-3 : 1991 Printed Boards – Part 3 : Design and Use of Printed Boards.

14.15.3 Soldering of electronic components shall comply with the latest internationally accepted practice. Tenderers shall indicate the standard with which they are compliant.

14.15.4 PCBs shall be connected to the case or rack wiring using multi-pin connectors, which shall have a successful service history in rail applications. Details shall be provided.

14.15.5 In any electronic rack system, the failure of any one module or individual circuit board shall neither cause loss of the electronics power supply within the rack, nor cause subsequent failure of circuits on other PCB's or modules.

14.15.6 Printed circuit board extenders shall be provided for test purposes. The Contractor shall provide detailed maintenance and troubleshooting procedures, including wave-forms at critical locations of the circuitry.

14.15.7 PCB's shall have mechanical polarisation to prevent insertion into a wrong socket. The use of PCB edge connectors is not permitted unless reviewed by the Engineer, on a case by case basis. PCB's and modules shall be positively retained in the rack or case by a fastener or spring loaded locking pin.

14.15.8 All PCB contact faces of connectors shall be gold plated.

14.15.9 PCB's shall be held in place by screwed fasteners to prevent vibration causing wear on terminal contacts. Circuit boards shall be mounted vertically to minimise the accumulation of dust on the boards. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.16 Integrated Circuits

14.16.1 All integrated circuits and semiconductor devices shall be standard devices available from at least two manufacturers. Proprietary devices shall be submitted to the Engineer for review.

14.16.2 All integrated circuits shall be burned in and screened for defects to a level equivalent to relevant international standards.

14.17 Labels

14.17.1 All items shall be labelled with the maker's name and the 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.

14.17.2 Rotating machines shall carry a rating plate indicating current and voltage ratings and speed at rated current, and maximum speed. In addition a connection diagram shall be provided inside or adjacent to the terminal box wherever provided.

14.17.3 Unidirectional rotating machines shall carry an arrow showing the correct direction of rotation, and in the case of axial fans, of the airflow.

14.17.4 The labels shall be clearly stamped, cast or engraved and securely attached to the equipment. Where appropriate, equipment shall be labelled with warnings of high temperature and electric shock risk. Warning labels shall be written in both Hindi and English.

14.17.5 All cables and busbars shall be provided with durable and legible cable identification markers at each end, corresponding exactly with those on circuit diagrams. The cable identification numbers should remain intact for the entire service life of cable.

14.18 Lubricants

14.18.1 The Contractor is expected to utilise, as far as possible, lubricants manufactured in India. With this in mind, he shall furnish a list of grades of lubricants and greases manufactured or available in India, which are considered equivalent to those used by him. The technical particulars of the RS1 Contractor's lubricants (from the manufacturer's country of origin) shall be furnished to the Engineer.

14.19 Painting

14.19.1 All painting processes shall be proven in a railway application.

14.19.2 All painting processes shall be proven in railway applications, and suitable for the climate of this project, and shall be subject to review. Such processes shall include surface preparation suitable for the material, corrosion preventative priming and high durability finish. Exterior stainless steel, aluminium or their alloys shall not be painted. Bogies shall be treated with primer and an internationally accepted finishing paint. All steel which will be hidden, except stainless steel, shall be treated with primer and an accepted rust preventative before being concealed. The treatment of copper bearing structural steel shall be subject to acceptance by the Engineer.

14.20 Rubber Items

14.20.1 All rubber hoses, connecting pipes etc used in pneumatic circuit shall not be required to be replaced before 5 years or major overhaul whichever ever later. The rubber/ rubber- metal components used in suspensions shall not be replaced before major overhaul of the equipment.

This page is left blank intentionally

EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 15

INSPECTIONS, TESTS AND TRIALS

CHAPTER 15: INSPECTIONS, TESTS AND TRIALS

15.1 General

15.1.1 Individual cars and complete trains, shall be type and routine tested in accordance with IEC 61133, and as specified below. Such tests may be performed either at the Contractor's works, or on site, as appropriate, and as agreed with the Engineer.

15.1.2 The individual equipments, systems and sub-systems, shall be type- and routine-tested in accordance with the IEC Publications or other appropriate international standards listed in Appendix TA, special tests specified in this Chapter, and the test programme drawn up by the Contractor, and agreed by the Engineer. Type test specifications shall be got approved from the Engineer.

In addition to 'mandatory tests' as prescribed in IECs, the Engineer may also require any of the prescribed 'optional tests' to be carried out.

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

15.1.4 Wherever any equipment, system or sub-system is not specifically covered by an internationally recognised specification or test procedure, or where the type and routine tests prescribed by IEC or other international standard do not adequately cover the requirement, tests which are acceptable both to the Contractor and to the Engineer, shall be devised.

15.1.5 Type tests for certain equipment may be waived if these were carried out earlier on equipments of identical design, witnessed by a reputed organisation, and the service performance of such equipments was found to be reliable. The Contractor shall submit a proposal in this regard to the Engineer for review. The waiver of Type Test is entirely at the discretion of the Engineer.

15.1.6 Without prejudice to any other provisions of the Contract, the Employer reserves the right to witness any or all of the tests, and to require submission of any or all test specifications and reports. The Employer reserves the right to reasonably call for additional tests as are considered necessary, including the quality of welds particularly in highly stressed areas, by non destructive testing methods. Prototype tests may be required to verify the suitability of the process or the materials proposed. Engineer may if considered necessary may call for conducting optional tests as per relevant standards without any additional cost to the Employer. In case of repetition of tests, as decided by engineer, entire cost including that of engineer's representative(s) shall be borne by the contractor.

15.1.7 The results of all tests shall be submitted to the Employer's Representative, who will record his conclusions as to whether or not the equipment being tested has passed satisfactorily.

15.1.8 Instrumentation Test

Engineer at his sole discretion (if required) at an appropriate time can initiate testing of one complete four-car train/unit integrated with 4/6 car train (as the case may be) as specified in Clause 1.2.3, mainly to verify and establish operational performance, capacity and safety. The Contractor shall provide full instrumentation to conduct these tests and carry out modifications as required, to ensure that the cars will meet the safety requirements. These tests shall be conducted both at full load, and tare conditions, under both new and fully worn wheel profiles and with both fully inflated and fully deflated secondary suspension air springs. The performance of each type of car will be separately evaluated.

The Contractor shall prepare a report after completion of these tests, which shall be submitted to the competent authority, through the Commissioner of Railway Safety, for statutory approval of the Rolling Stock for revenue operations.

Brief details of the tests to be evaluated during the Oscillation Tests will include, but need not be limited to:

Table 15.1.8

Terms	Definition	Condition	Acceptable Value
Derailment Coefficient	The ratio of the instantaneous lateral force at the axle-box level, to the instantaneous vertical load of the wheel.	Average value over a 2 meter length of track	≤ 1 (unity)
Maximum Vertical Acceleration		Measured at the Centre Pivot. Measured for a time period of 1/20s	$\leq 0.3g$
Maximum Transversal Acceleration		Measured at the Centre Pivot. Measured for a time period of 1/20s	$\leq 0.3g$

The Sperling Ride Index shall however not exceed 2.5, as specified in Clause 3.29

15.1.9 Integrated Testing and Commissioning

On completion of testing and commissioning of the Contractor's own system to the satisfaction of the Engineer, the Contractor shall carry out all tests necessary to verify the functioning of his system with those of other Designated Contractors. Tests and test procedures shall be submitted by the Contractor for acceptance by the Engineer or as required by him. All defects and shortfalls in the Contractor's system, discovered in the course of Integrated Testing and Commissioning, shall be made good and re-tested to the satisfaction of the Engineer before the commencement of service trials.

On completion of the integrated testing and Commissioning, to the satisfaction of the Engineer the Contractor shall confirm in writing to the Engineer that the rolling stock provided by him is suitable for the purpose of service trials.

15.1.10 Service Trials

The prototype and other trains shall be subjected to pre-revenue service trials. Service trials are intended to prove not only the satisfactory running performance of the cars, but also to enable practical evaluation of their reliability in service, ease of maintenance and operation, in parallel with the work of other Designated Contractors, and adequacy of the cars and equipment for all performance requirements envisaged in the specification. The Contractor shall make all necessary arrangements including temporary provisions in his system to ensure safety during service trial period. The Contractor and designated contractors will run trains subject to constraint of the newly established railway system.

Upon completion of Service trials the Contractor shall submit a statement confirming that the rolling stock is safe and ready for commencement of revenue service.

15.2 Test Planning and Procedures

15.2.1 The Contractor shall submit within 120 days after date of Notice to Proceed, a Test Plan for review and acceptance by the Engineer.

15.2.2 The plan shall include the following information :

- (i) Relevant specification applicable to each of the tests.
- (ii) Type, routine and special tests to be carried out.
- (iii) Description of the tests, scheduled dates, and locations of the tests.
- (iv) Test parameters to be measured.
- (v) Constraints to be applied during the test.
- (vi) Defined pass/fail criteria
- (vii) Facilities, equipment, and test and measurement tools.

15.2.3 The Employer reserves the right to reasonably call for additional tests if considered necessary.

15.2.4 The Contractor shall produce a test report, in three copies, and in an approved format, within an agreed period following the test, for acceptance by the Engineer.

15.3 Special Tests

15.3.1 The following clauses specify tests which are either not covered by standard specifications, or require the provisions of the standard specification to be modified to some extent.

15.4 Vehicle Body Shell

15.4.1 A static compressive end-load test, and a lifting test shall be performed in accordance with UIC 566, under a simulated load as specified in Chapter 4, as a type test.

15.4.2 Crashworthiness shall be proved by submission of detailed calculations and demonstration by means of finite element analysis.

15.4.3 The strength of the saloon side wall windows and of those in the doors shall be performed in accordance with UIC 566, as a type test.

15.4.4 The strength of the cab windscreen shall be tested in accordance with the requirements of both UIC 651 and UIC 566, also as a type test.

15.4.5 The strength of couplers and draught gear shall be carried out in accordance with international practice, also as a type test.

15.4.6 The carbody shall also be subjected to a vertical deflection test. All side doors, including the cab side doors, on one side of the car shall be installed, complete with drive mechanisms, and all sealing and weather-stripping.

At each increment of test load the doors shall be opened and closed by means of the door controls. Any failure to operate at the prescribed speed profile, or any indication of binding, shall require corrective action to be taken by the Contractor, to the car structure, to the door arrangement, or both.

15.5 Bogie Tests

15.5.1 The bogie shall be subject to static as well as fatigue tests in accordance with UIC 615-4, with the payload as specified in Chapter 5. This shall be a type test.

15.5.2 Tests for clearances in the bogie, and between bogie and body shall be carried out on straight track as a routine test.

15.5.3 Tests for clearances in the bogie, and between bogie and body shall also be carried out by rotating the bogie to simulate a 150m radius curve. This shall be a type test.

15.5.4 The Contractor shall perform a wheel unloading test to verify the calculations submitted. The test shall be conducted in the most disadvantageous combination of unloading and suspension conditions.

15.5.5 A load deflection test and accelerated ageing tests shall be performed to demonstrate that the spring rate of the primary suspension system and the creep rate for the

materials used are within the design limits.

These tests shall prove that the primary suspension system behaves as predicted and will not result in excessive deflection or a decrease in bogie clearance above top of rail to less than the minimum specified herein.

15.6 Saloon Passenger Door Type Tests

15.6.1 The body side doors shall be tested for strength in accordance to UIC 566. See also Chapter 4 for relevant parameters which are required to be met.

15.6.2 The following type test shall be carried out on a complete double leaf door and operating assembly equipment with its control gear.

(i) Endurance

One million operations. A record of the velocity profile shall be taken at the beginning and the end of the test. It should also be demonstrated that no undue wear or compression of seals has occurred. This test shall be performed under representative dry and wet conditions.

(ii) Vibration Tests

Vibration test shall be carried out as defined in IEC 61373.

Cab doors shall also be subjected to an endurance test of 100 thousand operations, during which test it shall be demonstrated that no component fails.

15.7 Saloon Passenger Door Routine Tests

15.7.1 These will comprise functional test to verify that performance is consistent with accepted type test results, and shall include tests to IEC 60077 for the electrical portion.

15.8 Cab Front End Emergency Exit Door Type Tests

15.8.1 The Contractor shall demonstrate, to the satisfaction of Engineer, that the emergency door is entirely fit for the purposes for which it is intended to form a ramp between cab floor and track

15.8.2 The Contractor shall demonstrate to the satisfaction of the Engineer, that the emergency door is entirely fit for the purpose together with the emergency portable bridging device.

15.9 Compressor and Motor Test

15.9.1 Type Test

i) Starting Test

The motor shall undergo type- and routine-tests in accordance with IEC 60349-2, Electric Traction. Rotating Electrical Machines for Rail and Road Vehicles, Part 2-Electronic Converter Fed Alternating Current Motors.

The compressor shall undergo type- and routine-tests in accordance with ISO 1217: 1996 and BS 1571 : Pt.2 : 1984 Methods for Simplified Acceptance Testing of Air Compressors and Exhausters.

In addition to the above, starting tests shall be performed, five times at the maximum permissible rated voltage, and five times at the minimum rated voltage, the ten tests being performed in succession, at two minute intervals, at the specified reservoir pressure. The machine shall not exhibit a temperature rise higher than the specified maximum permissible.

(ii) Voltage Interruption Test

The supply shall be interrupted and restored, at intervals of one second, five times in succession, allowing the normal load conditions to be re-established between successive interruptions, the motor operating at its maximum voltage and rated load. The motor shall withstand the test without mechanical deterioration.

(iii) Heat Run

The set shall be tested at its rated voltage against the specified pressure for six hours, to show that the motor temperature rise does not exceed the specified limit, based on the class of insulation, and that the permissible temperature rise of the compressor is not exceeded.

15.10 Brake Equipment Type Tests

15.10.1 Tread Brake Unit

(i) Following Tests shall be carried out on Tread Brake Unit:

- (a) Functional checks such as working stroke, slack adjuster operation and parking brake action.
- (b) Recording of the relationship of brake block force to cylinder pressure over the full working range.
- (c) Plotting of brake force against pressure curves in all conditions of operation of main cylinder and parking brake.
- (d) Vibration test as defined in IEC 61373.
- (e) Air leakage test.

15.10.2 Brake Blocks

The Contractor shall carry out testing of brake blocks in respect of coefficient of friction with respect to the wheel material under dry and wet conditions, maximum temperature attained during braking, rate of wear etc..

15.10.3 Brake Control Equipment

Individual items of electro-pneumatic equipment shall be type tested as follows:

- (i) Mechanical Operation and Endurance as defined in IEC 60077
- (ii) Vibration and Shock as defined in IEC 61373.
- (iii) Air Tightness generally as in IEC 60077.
- (iv) Electrical Test, generally as in IEC 60077.
- (v) Characteristic Tests
- (vi) Each item of equipment having a pilot or transducing function, shall be tested to confirm compliance with the Contractor's design data. Oscillograms shall be produced in support.

(vii) Type Tests on Electronic Equipment

The electronic equipment used in brake system shall be tested as laid down in IEC 60571: "Electronics Equipment Used in Rail Vehicles".

15.11 Complete Brake System Type Tests

15.11.1 A complete set of brake equipment comprising all items of equipment forming the Brake

System shall be assembled. These shall include the Brake Controller and interface with

ATO equipment and a transceiver to measure force at the push rod of Tread Brake unit. A

complete series of tests shall be carried out on this rig under all service conditions to

demonstrate the function of the brake system as a whole, both in manual and auto

modes. The Contractor may combine the test of individual items with the system test if agreed by the Engineer.

15.12 Complete Brake System Routine Tests

15.12.1 All reservoirs shall be tested to an appropriate international pressure vessel standard and necessary test certificates shall be provided from a recognised test agency.

15.13 Electrical Type Tests

15.13.1 The Contractor shall, in addition to type tests carried out individually on all electrical equipment, in accordance with internationally accepted specifications, shall undertake combined propulsion, braking and TIMS test, using simulated loads on the traction motors. The testing shall reflect, as far as practicable, the layout of equipment on the car. Combined propulsion system testing shall be in accordance with IEC 61287-1 and IEC 61377.

15.13.2 Testing shall include simulated service operation, fault handling, including wheel slip/wheel slide control, braking and load weigh interfaces and abnormal operation and failure condition operation.

The Contractor shall perform tests on the TIMS system to verify designed capacity of the systems, functional requirements and correct interfaces as described in Chapter 7. The real interface hardware and software should be used where possible.

15.13.3 Testing shall be carried out to demonstrate the ability of the auxiliary power system to provide the required level of standby power under the normal and emergency conditions specified in Clause 9.2.

15.14 Roof Mounted Air Conditioning Package Unit Type Tests

15.14.1 The following tests shall be carried out at the manufacture's works or a reputed testing laboratory on the prototype unit in the presence of the Engineer.

(i) Dimensional and visual inspection.

(ii) Conditioned air delivery test

(a) This test shall be conducted by adjusting static head at 25 mm WG over conditioned room air.

(b) Air velocity measurements shall be recorded at both return air filters. Both fresh air filters shall be closed.

(iii) Fresh Air Quantity Test

Measurements of fresh air quantity shall be made with fresh air openings in (a) fully opened and (b) in the minimally opened condition to assess maximum and minimum air quantities.

(iv) Cooling Capacity Test

The package unit shall be tested in a climate laboratory capable of simulating the ambient environment and applicable heat loads. This test shall be made in the following conditions keeping static head of supply air at 25mm WG:

Table 15.14.1: HVAC Unit Test Criteria

Test Conditions	Condition of Hot Chamber	Condition of Cold Chamber
Summer	44°C Dry Bulb, 33% RH	25°C Dry Bulb, 60% RH
Monsoon	35°C Dry Bulb, 65% RH	25°C Dry Bulb, 60% RH
Winter	4°C	18°C

Cooling capacity shall be calculated both on the condenser and the evaporator side.

15.14.2 The power input to the module, as well as to each of the motors shall be recorded.

15.14.3 Insulation Resistance Test

Insulation resistance tests under all weather conditions shall be undertaken on all equipment, using a 1kV d.c. Megger tester. The resistance reading shall in no case be less than 100MΩ.

15.14.4 Dielectric Test

The equipment shall withstand a high potential difference of 2kV for a duration of one minute.

15.14.5 Vibration and Shock Tests

This test shall be done as per IEC 61373.

15.14.6 All rotating electrical machines shall be tested in accordance with IEC 60349-2: Electric Traction – Rotating Electrical Machines for Rail and Road Vehicles Part 2-Electronic Converter Fed Alternating Current Motors.

15.15 Complete Car Air Conditioning System Type Tests

15.15.1 One car body equipped with all interior finish and all underframe mounted equipment, shall be tested to demonstrate the effectiveness of the equipment in meeting the specified temperature and humidity conditions inside the car. Heating and humidifying equipment shall be provided in the car for test purposes.

15.15.2 The extent of such test shall be decided by the Engineer, but shall include, as a minimum, the following :

(i) Air Flow Test

Air flow will be checked at the fresh air inlet to the unit, and at the return air inlet.

(ii) Air Distribution Tests

Saloon air ducts shall be checked to ensure even distribution of air along each duct.

15.16 Complete Car Air Conditioning System Routine Tests

15.16.1 Every roof mounted AC package unit shall be subjected to routine test at the manufacturer's works as given below:

- (i) Dimensional & Visual inspection
- (ii) Conditioned air-delivery test
- (iii) Fresh air quantity test
- (iv) Measurement of power
- (v) Electrical test.

15.17 Emergency Operation

15.17.1 After delivery of two trains, the ability of one healthy train to rescue a disabled train in section as specified in Clause 3.26.1 (i) shall be tested.

15.18 Noise and Vibration Verification

15.18.1 The Contractor shall perform noise and vibration tests on at least one complete 8-car consist or 'T+M' unit on both the Rail and Metro Corridors, to demonstrate compliance with Clause 2.18. All test procedures, data and results shall be submitted to the Engineer for acceptance.

15.19 Fire Performance Verification

15.19.1 Type tests according to the relevant ASTM, NFPA or EN 45545, Latest Editions shall be undertaken to establish fire ratings for all materials proposed. However, test certificates from any Testing Agency of international repute may be accepted in lieu by the Engineer at his sole discretion.

15.20 EMC Testing

15.20.1 The Contractor shall perform measurements to demonstrate EMC requirements specified in Chapter 2. have been achieved. Demonstration of EMC compliance shall be considered a type test requirement.

This page is left blank intentionally

EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

APPENDIX TA

**INTERNATIONAL
STANDARDS**

APPENDIX TA.**INTERNATIONAL STANDARDS**

TA1 General

TA1.1 Standards are set out in alphabetical order of the Standards Organization (in English) in tables TA1.1 to TA1.17. Many of the standards included in the listing are suggested as guidance only.

Table TA1.1: American Society for Testing and Materials Standards

Standard Organization	Standard Reference Number	Title or Description of the Standard
ASTM	A 480	Standard specification for general requirements for flat rolled stainless and heat resisting steel plates

Table TA1.2: British Standards Institution

Standard Organization	Standard Reference Number	Title or Description of the Standard
BS	88	Cartridge Fuses for Voltages up to and including 1000V a.c. and 1500V d.c.
BS	476-7	Flame Spread Requirements for Paint
BS	476-15 : 1993 ISO 5660-1 : 1993	Fire Test on Building Materials and Structures : Method of Measuring the Rate of Heat Release of Products
BS	857:1990	Specification for Safety Glass for Land Transport
BS	1571 : Pt. 2 1984	Methods for Simplified Acceptance Testing of Air Compressors and Exhausters : Part 2 : Simplified testing of reciprocating and rotating types, including permissible deviations pressure and temperature measurements and arrangement of tests, form of test report and gives adjustment of test result to guarantee conditions.
BS	1725 Pt. 1	
BS	3100:1991	Specification for Steel Castings for General Engineering Purposes. Chemical Composition Heat treatment and Mechanical Properties of Cast Steels.
BS	3682 Pt.1: 1994	Specification for Compressed Air Brake Hose
BS	3900:1980	Methods of Test for Paint.
BS	4066	Cable Tests in Fire Conditions
BS	4360 :	Steel Used in Welded Structures
BS	4579: Pt.1 1970	Compression Joints in Copper Conductors.

		Covers requirements for the performance of general application compression joints for use with copper and copper alloy conductors up to 1000mm ² cross sectional area operating below 85°C.
BS	4743	Specification for Safety Requirements for Electronic Measurement Apparatus
BS	4870	Specification for Approval Testing of Welding Procedures.

Table TA1.2 British Standards Institution (Continued)

Standard Organisation	Standard Reference Number	Title or Description of the Standard
BS	4870 : Pt.3 1985	Arc Welding of Tube to Tube-Plate Joints in Metallic Materials. Welding procedure tests, approval & its extent , test joints, examination and testing, results.
BS	4870 : Pt.4 1988	Specification for Automatic Fusion Welding of Metallic Materials including Welding Operator Approval. Approval testing of procedures, programmes, systems, and operators for automatic or robotic welding. Items in welding procedure test, changes affecting approval, extent of approval, examination and testing.
BS	5135:1984	Specification of Arc Welding of Carbon and Carbon Manganese Steels. Parent metals , welding consumables, butt and fillet weld details, preparation and assembly, procedures to avoid cracking, welding procedure details, approval of welders, inspection and testing. Appendices on design, typical weld details, avoidance of hydrogen cracking, solidification cracking, lamellar tearing and guidance on acceptance levels.
BS	6656	Prevention of inadvertent ignition of flammable atmospheres by radio frequency radiation
BS	7371 Pt. 10 : 1994	Specification for Organic Coatings (The Deltaseal Process)

Table TA1.3: British Standards Institution/Euro Normes

Standard Organisation	Standard Reference Number	Title or Description of the Standard
BS-EN	3	Portable Fire Extinguishers
BS-EN	286-3:1995	Simple Pressure Vessels designed for Air Braking and Auxiliary Pneumatic Equip-ment for Railway Rolling Stock.

BS-EN	286-4:1995	Simple Unfired Pressure Vessels Designed to Contain Air or Nitrogen. Aluminium Alloy Pressure Vessels for Air Braking Equipment and Auxiliary Equipment for Rolling Stock.
BS-EN	287-1 : 1992	Specification of Approval Testing of Welders Working to Approved Welding Procedures : Pt. 1 Fusion Welding of Steel

Table TA1.3: British Standards Institution/Euro Normes (Continued)

Standard Organization	Standard Reference Number	Title or Description of the Standard
BS-EN	288-3 : 1993	Fusion Welding of Steel
BS-EN	10025	Hot Rolled Products of Non-Alloy Structural Steels. Technical delivery conditions. Requirements for long and flat products.
BS-EN	10210	Hot Finished Structural Hollow Sections of Non-Alloy and Finer Grain Structural Steels.
BS-EN	24014 : 1992	Hexagon Head Bolts. Product grades A, B
BS-EN	24017 : 1992	Hexagon Head Machine Screws. Product grades A and B
BS-EN	30042 : 1994	Arc Welded Joints in Aluminium and its Weldable Alloys. Guidance on quality levels for imperfections.
BS-EN	50081	Electromagnetic Compatibility. Generic emission standard.
BS-EN	60529 :1992	Specification for Degrees of Protection Provided by Enclosures (IP Code). Gives uniformity in methods of describing protection provided by enclosures and in tests to prove protection. Provides an optional extension of the IP code by an additional letter A – D, if the actual protection of persons against access to hazardous parts is higher than that indicated by the first characteristic numeral.

Table TA1.4: CISPR

Standard Organisation	Standard Reference Number	Title or Description of the Standard
CISPR	16 am1 (1997-08)	Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods : 1 Radio Disturbance and Immunity Measuring Apparatus

Table TA1.5: Defence Standards

Standard Organisation	Standard Reference Number	Title or Description of the Standard
DEF-STD-	00-56	Hazard Analysis

Table TA1.6: German Standards / Deutshes Institut fur Normung

Standard Organisation	Standard Reference Number	Title or Description of the Standard
DIN	2353 : 1998	Compression fittings and couplings

Table TA1.7: Euro Normes

Standard Organisation	Standard Reference Number	Title or Description of the Standard
EN	10155	Structural Steels with improved atmospheric Corrosion
EN	50082	EMC
ENV	50121	Railway Application – Electro-Magnetic Compatibility – Rolling Stock
EN	50121-1 : 1996	Railway Application – Electro-Magnetic Compatibility Part 1. General
ENV (DD)	50121-2 : 1996	Railway Application – Electro-Magnetic Compatibility Part 2. Emission of the Whole Railway System to the Outside World.
EN	50121-3	Railway Application – Electro-Magnetic Compatibility – Rolling Stock
EN	50264	Railway Application- Railway Rolling Stock cables having special fire performance
EN	50126	Railway Application – Specification and Demonstration of RAMS
EN V	50121-3-1	Railway Application – Electro-Magnetic Compatibility – Rolling Stock Pt. 3–1 : Train and Complete Vehicle. traction stock, train sets and independent hauled stock. Covers the frequency range d.c. to 400GHz.
EN	50121-3-2	Railway Application – Electro-Magnetic Compatibility – Pt. 3–2 : Rolling Stock Apparatus. Specifies emission and immunity requirements for electrical and electronic apparatus for use on rolling stock. Covers the frequency range d.c. to 400GHz.
EN	50124-1	Electrical Enclosures
EN	50126-2	Railway Applications – Dependability for Guided Transport System - Pt. 2 : Safety
EN	50128	Railway Applications : Software for Railway Control and Protection Systems
EN	50129	Safety Related Electronic Railway Control and Protection Systems
EN	50155	EMC
EN	50163	Lightning Arrestors

EN	50207	Power Converters for Rolling Stock
ENV		Software for Railway Control and Protection Systems

Table TA1.8: International Electro-technical Commission

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IEC	60034-1 : (1996-12) 60034-1 : am1 (1997-06)	Rotating Auxiliary Machines : Pt. 1 Rating and Performance Amendment No.1
IEC	60034-7	Rotating Auxiliary Machines : Pt. 7 Rating and Performance
IEC	60056 (1987-03) 60056 am3 (1996-10)	High Voltage Alternating Current Circuit Breakers Amendment No.3

Table TA1.8: International Electro-technical Commission (Continued.)

IEC	60068-2	Environmental Testing
IEC	60076	Power Transformers
IEC	60077 (1968-01)	Specification for Electric Traction Equipment. Motive power units of 600-3000V d.c. or high-voltage a.c. or independent power source, also for control trailers or multiple unit trains. Can be applied to d.c. rolling stock at voltages below 600V.
IEC	60099-4 (1991-11)	Surge Arrestors – Pt.4 Metal Oxide, without Gaps for A.C. Systems
IEC	60115-1	Smaller Resistors
IEC	60228	Cables
IEC	60268-1 (1985-01) 60268-1 60268-1 (1988-01)	Sound System Equipment : Pt. 1 General Amendment 1 Amendment 1
IEC	60268-16 Part 16	The Objective Rating of Speech Intelligibility in Auditoria by the "RASTI" Method
IEC	60269-1 1998-12	Low Voltage Fuses Pt. 1 : General Requirements
IEC	60269-2 am1 (1995-11)	Low Voltage Fuses Pt. 2 : Supplementary Requirements for Fuses for Use by Authorised Persons (Fuses mainly for Industrial Applications)
IEC	60300-1 (1993-04)	Dependability Management – Pt. 1 Dependability Programme Management
IEC	60300-2 (1995-12)	Dependability Management – Pt. 2 Dependability Programme Elements and Tasks
IEC	60300-3-1 (1991-11)	Dependability Management – Pt. 3 Application Guide Sect. 1 Analysis Techniques for Dependability. Guide on Methodology
IEC	60300-3-2 (1993-10)	Dependability Management – Pt. 3 Application Guide Sect. 2 Collection of Dependability Data from the Field.
IEC	60300-3-3 (1996-09)	Dependability Management – Pt. 3 Application Guide Sect. 3 Life Cycle Costing
IEC	60310 1991-11)	Traction Transformers and Inductors

IEC	60319 1978-01	Presentation of Reliability Data on Electronic Components (or Parts)
IEC	60326-3 : 1991 BS 6221 : Pt.3 : 1991	Guide for the design and use of printed wiring boards. Design and application of printed boards, irrespective of their method of manufacture. Recommends design, specification, and application.
IEC	60332-1 1993-04	Tests on Electric Cables under Fire Conditions – Pt.1 :Test on a Single Vertical Insulated Wire or Cable
IEC	60332-3 1992-03	Tests on Electric Cables under Fire Conditions – Pt.3 : Tests on Bunched Wires or Cables
IEC	60349 1991-12	Electric Traction. Rotating Electrical Machines for Rail and Road Vehicles
IEC	60349-1	Electric Traction – Rotating Electrical Machines for Rail and Road Cars
IEC	60349-2 1993-04	Electric Traction – Rotating Electrical Machines for Rail and Road Vehicles Pt. 2 Electronic Convertor-fed A.C. Motors
IEC	60349-2 1993-04	Electric Traction – Rotating Electrical Machines for Rail and Road Vehicles Pt. 2 Electronic Convertor-fed Alternating Current Motors
IEC/TR2	60349-3 1995-08	Electric Traction – Rotating Electrical Machines for Rail and Road Vehicles Pt. 3 Determination of the Total Losses of Convertor-fed Alternating Current Motors by Summation of the Component Losses
IEC	60384-1	Electrolytic Capacitors
IEC	60384-4	Electrolytic Capacitors
IEC/TR	60411-2 (1978-01)	Power Convertors for Electric Traction Pt. 2 Additional Technical Information
IEC	60494 1974-01	Rules for Pantographs of Electric Rolling Stock
IEC	60502	High Voltage Cables
IEC/TR	60505 1975-01	Guide for the Evaluation and Identification of Insulation Systems of Electrical Equipment
IEC	60529	IP Codes, etc.
IEC	60563	Permissible Limiting Temperatures in Service for Components of Electrical Equipment of Traction Vehicles
IEC	60571 1998-02	Electronic Equipment Used on Rail Vehicles
IEC	60571-1	Electronic Equipment Used on Rail Vehicles
IEC	60571-2	Electronic Equipment Used on Rail Vehicles
IEC	60571-3	Electronic Equipment Used on Rail Vehicles
IEC	60605	Reliability and maintainability Requirements in Equipment
IEC	60617	Graphical Symbols For Diagrams
IEC	60617-1 (1985-01)	Graphical Symbols For Diagrams : Pt. 1 General Information, General Index. Cross Reference Tables
IEC	60617-2 (1996-05)	Graphical Symbols For Diagrams : Pt. 2 Symbol Elements, Qualifying Symbols and Other Symbols Having General Application
IEC	60617-3 (1996-05)	Graphical Symbols For Diagrams : Pt. 3 Conductors and Connecting Devices
IEC	60617-4	Graphical Symbols For Diagrams :

	(1996-06)	Pt. 4 Passive Components
IEC	60617-5 (1996-06)	Graphical Symbols For Diagrams : Pt. 5 Semiconductors and Electron Tubes
IEC	60617-6 (1996-05)	Graphical Symbols For Diagrams : Pt. 6 Production & Conversion of Electrical Energy
IEC	60617-7 (1996-05)	Graphical Symbols For Diagrams : Pt. 7 Switch gear, Control gear, and Protective Devices
IEC	60617-8 (1996-05)	Graphical Symbols For Diagrams : Pt. 8 Measuring Instruments, Lamps and Signalling Devices
IEC	60617-9 (1996-05)	Graphical Symbols For Diagrams : Pt. 9 Telecommunications Switching & Peripheral Equipment
IEC	60617-10 (1996-05)	Graphical Symbols For Diagrams : Pt. 10 Telecommunications Transmission
IEC	60623 1990-03 60623 am1 1992-04	Vented Nickel Cadmium Prismatic Rechargeable Single Cells Amendment No. 1
	60623 am2 1992-07	Amendment No. 2
IEC	60631	Electro-dynamic Braking
IEC	60664	Surface Creepage and Electrical Clearance
IEC	60747-6	Electrical Type Test
IEC	60749	Mechanical and Climatic Test Methods
IEC	60754-1 1994-01	Tests on Gases Evolved During Combustion of Materials from Cables Pt. 1 : Determination of Amount of Halogen Acid Gas
IEC	60754-2 1991-08	Tests on Gases Evolved During Combustion of Materials from Cables Pt. 2 : Determination of Amount of Halogen Acid Gas
	60754-2 1997-04	Amendment No. 1
IEC	60850 (1988-03)	Supply Voltages for Traction Systems
IEC	60871-1 (1997-10)	Shunt Capacitor for A.C. Power Systems having a Rated Voltage above 1000V – Pt. 1 General Performance, Testing and Rating – Safety Requirements – Guide for Installation and Operation
IEC	60913 (1988-12)	Electric Traction Overhead Lines
IEC	60947-1 (1998-11)	Low Voltage Switch Gear and Control Gear Pt.1 General Rules
IEC	60947-2 (1998-03)	Low Voltage Switch Gear and Control Gear Pt.2 Circuit Breakers
IEC	60947-3	Circuit Breakers
IEC	60947-4	Circuit Breakers
IEC	60993 (1989-08)	Electrolyte for Vented Nickel-Cadmium Cells
IEC/TR3	61000-1-1 (1992-05)	Electro-magnetic Compatibility (EMC) Pt. 1 : General
IEC	61000-4-2 (1995-01) 61000-4-2 am1(1998-01)	Testing and Measurement Techniques Pt. 4, Sct. 2 : Electrostatic Discharge Immunity Test Amendment No. 1

IEC	61000-4-3 (1995-03) 61000-4-3 am1(98-06)	Testing and Measurement Techniques Pt.4 Sct 3 : Radiated Radio Frequency Electromagnetic Field Immunity Tests Amendment No. 1
IEC	61000-4-4 (1995-01)	Testing and Measurement Techniques Pt.4 Sct. 4 : Electrical Fast Transient/Burst Immunity Test
IEC	61000-4-5 (1995-03)	Testing and Measurement Techniques Pt.4 Sct. 5 : Surge Immunity Test
IEC	61000-4-6 (1996-04)	Testing and Measurement Techniques Pt.4 Sct. 6 : Immunity to Conducted Disturbances Induced by Radio Frequency Fields
IEC	61000-4-8 (1993-06)	Testing and Measurement Techniques Pt.4 Sct.8 : Power Frequency Magnetic Field Immunity Test
IEC	61000-4-9 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 9 : Pulse Magnetic Field Immunity Test
IEC	61000-4-10 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 10 : Damping Oscillatory Magnetic Field Immunity Test
IEC	61000-4-11 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 11: Voltage Dips, Short Interruptions and Voltage Variations Immunity Test
IEC	61000-4-12 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 12 : Oscillatory Waves Immunity Test
IEC	61000-5-1 (1996-12)	EMC Pt. 5 :Installation and Mitigation Guidelines Sct. 1 General Considerations
IEC	61000-5-2 (1996-12)	EMC Pt. 5 :Installation and Mitigation Guidelines Sct. 2 Earthing and Cabling
IEC	61034	Cables
IEC	61071-1	Power Electronic Capacitors
IEC	61133 (1992-11)	Electric Traction – Rolling Stock – Test Methods for Electric and Thermal/ Electric Rolling Stock on Completion of Construction and Before Entry into Service
IEC	61287-1 (1995-07)	Power Converters Installed on Board Rolling Stock – Pt. 1 Characteristics and Test Methods
IEC	61373	Requirements for Vibration and Shock Testing of Equipment for Railway Cars
IEC	61377 (1996-05)	Electric Traction – Rolling Stock –Combined Testing of Inverter Fed Alternating Current Motors and their Control
IEC	61508-1 1998-12	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems : Part 1. General Requirements.
IEC	61508-3 1998-12	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems : Part 3. Software Requirements.
IEC	61881	Power Electronic Capacitors used on Rolling Stock

Table TA1.9: Institution of Electrical and Electronics Engineers

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IEEE	304	Thermal Endurance of Insulation
IEEE	429	Sealing Against Moisture

Table TA1.10: Indian Railways Standards

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IRS	R16	Unpowered Axles for Broad Gauge Vehicles
IRS	R19	Wheels for Broad Gauge Vehicles
IRS	R43	Powered Axles for Broad Gauge Vehicles

Table TA1.11: International Standards Organisation

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ISO	281/1	Steel for Railway Wheels
ISO	1553	Methods of the Determination of Copper, Lead, Iron, Aluminium and Nickel in Copper Alloys
ISO	1554	
ISO	1810	
ISO	2631 (1985)	Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole Body Vibration
ISO	3095	Acoustics – Measurement of Noise Emitted by Railbound Vehicles 1 st . Edition
ISO	3381	Acoustics – Measurement of Noise Inside Railbound Vehicles 1 st Edition.
ISO		Fire Tests – Reaction to Fire – Pt.1

Table TA1.12: International Standards Organisation

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ISO	9000	Design Management and Control. Quality Systems : Model for Quality Assurance in Design, Development, Production, Installation and Servicing
ISO	9001	
ISO	9002	
ISO	9662	Information Processing – Volume and File Structure of CD-ROM for Information Exchange

Table TA1.13: Japan Industrial Standards

Standard Organisation	Standard Reference Number	Title or Description of the Standard
JIS	G 3114	Hot rolled atmospheric corrosion resisting steels for welded structure
JIS	G 3459	Stainless steel pipes

Table TA1.14: Military Standards

Standard Organisation	Standard Reference Number	Title or Description of the Standard
MIL-HDBK-	454 (1)	General Guidelines for Electronic Equipment
MIL-I-	46058	Insulating Compound (for Coating Printed Circuit Assemblies)
MIL-STD-	882 C	Hazard Analysis
MIL-STD-	883 E (1)	Test Methods Standard Microcircuits
MIL-STD-	889 B (3)	Dissimilar Metals

Table TA1.15: French Standards (Normes Françaises)

Standard Organisation	Standard Reference Number	Title or Description of the Standard
NF-F	63-808	Halogen Free Cables for Low Voltage Applications
NF-F	63-826	Halogen Free Cables for High Voltage Applications

Table TA1.16: Research and Study Organisation (ORE)

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ORE	C116/RP8	DB WZ Ride Index : Frequency Weighting Curves

Table TA1.17: International Railway Union

Standard Organisation	Standard Reference Number	Title or Description of the Standard
UIC	410 O	Composition and Calculation of the Weight and Braking of Passenger Trains
UIC	515-3 OR	Rolling Stock – Bogies – Running gear – Axle design calculation method
UIC	515-4 O	Passenger rolling Stock – Trailer bogies – Running gear – Axle design calculation method
UIC	518 OR	Testing and Approval of railway Vehicles from the Point of View of their Dynamic Behaviour, Safety, Track fatigue and Ride Quality
UIC	534 OR	Signal lamps and signal lamp brackets for locomotives, railcars and all tractive and self propelled stock
UIC	541-5 O	Brakes – Electropneumatic brakes for passenger trains and freight trains
UIC	541-6 O	Brakes – Electropneumatic brakes test programmes for passenger trains and freight trains
UIC	555 OR	Electric lighting in passenger rolling stock
UIC	555-1 OR	Transistorised inverters for supplying fluorescent

		lamps (1)
UIC	560 OR	Doors of coaches and luggage vans
UIC	564-2 OR	Regulations Relating to Fire Protection and Fire Fighting Measures in Passenger Carrying Railway Vehicles
UIC	566 OR	Loadings of coach bodies and their components
UIC	615-1 OR	Tractive units – Bogies and running gear – General conditions applicable to component parts
UIC	615-4 OR	Motive power units - Bogies and running gear – Bogie frame structure strength test
UIC	651	Layout of driver's cabs in locomotives, railcars, multiple unit trains and driving trailers.
UIC	811-1 OR	Technical Specification for the Supply of Axles for Tractive and Trailing Stock
UIC	812-2 OR	Solid Wheels for Tractive and Trailing Stock Tolerances (1)
UIC	812-3	Technical Specification for the Supply of Solid Wheels for Trailing Stock
UIC	813 O	Technical Specification for the Supply of Wheelsets for Tractive and Trailing Stock : Tolerances and Assembly

1. All sub-systems including major equipments, assemblies and complete car/train must comply with the latest international standards.
2. The above list is for guidance only. Wherever updated standard is released, the same shall be applicable.
3. The contractor shall provide the relevant Standard in soft copy to DMRC for reference.

**EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATION**

APPENDIX TB

CAR BODY MOCK UPS- Deleted.

EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

APPENDIX TC

ABBREVIATIONS

APPENDIX TC: ABBREVIATIONS

TC1 General

TC1.1 Various abbreviations used in this document are set out in alphabetical order in table TC1.1

Table TC1.1 Abbreviations.

Abbreviation	Description in Full
ASHRAE	American Society for Heating , Refrigeration and Air-conditioning Engineers
ASIC	Application Specific Integrated Circuits
ATC	Automatic Train Control (System)
ATO	Automatic Train Operation (System)
ATP	Automatic Train Protection (System)
ATS	Automatic Train Supervision (System)
BCC	Back-up Control Centre
BCP	Brake Cylinder Pressure
BP	Brake Pipe
CATC	Continuous Automatic Train Control
CCTV	Close Circuit Television
CCITT	Consultative Committee on International Telegraphy and Telephony
CD	Commencement date
CI	Converter Inverter
CM	Coded Manual (Driving Mode)
DFF	Direct Fixation Fastener
DIN	German Industrial Standards
DLP	Defect Liability Period
DT	Driving Trailer Car
DMRC	Delhi Metro Rail Corporation
DMRTS	Delhi Mass Rapid Transport System
EER	Energy Efficiency Ratio
EMC	Electro-magnetic Compatibility
EMI	Electro-magnetic Interference
EMU	Electric Multiple Unit Train
EP	Electro-Pneumatic
FFT	Fast Fourier Transform
FMEA	Failure Modes Effects Analysis
FMECA	Failure Modes Effects and Criticality Analysis
FRACAS	Failure Reporting And Corrective Action System
GS	Employer's Requirements : General Specification
HSCB	High Speed Circuit Breaker
HVAC	Heat, Ventilation and Air Conditioning
IC	Integrated Circuit
IEC	International Electro-technical Commission
IGBT	Insulated Gate Bi-Polar Transistor
IMP	Interface Management Plan
ISO	International Standards Organisation
kmph	kilometer per hour
LCD	Liquid Crystal Display
LED	Light Emitting Diode

LRU	Least Replaceable Unit
M	Motor Car
MCB	Miniature Circuit Breaker
MRTS	Mass Rapid Transit System
MDBF	Mean Distance Between Failures
MDBCF	Mean Distance Between Component Failures
MTBF	Mean Time Between Failure
MRTS	Metro Rail Transit System
MSS	Maximum permissible Safe Speed
MTTR	Mean Time To Repair
MWI	Maintenance Works Instruction
NFPA	National Fire Protection Association
OCC	Operations Control Centre
OCS	Over-head Catenary System
OEM	Original Equipment Manufacturer
OHE	Over Head Electric (System)
OHL	Over Head Line
O & M	Operation and Maintenance
PA	Public Address (System)
PCB	Printed Circuit Board
PEA	Passenger Emergency Alarm
PLC	Programmable Logic Control
PSSS	Passenger Saloon Surveillance System
PWM	Pulse Width Modulation
RAM	Reliability, Availability and Maintainability
RDSO	Research Design and Standards Organisation (Ministry of Railways)
RH	Relative Humidity
RI	Ride Index
RM	Restricted Manual (Driving Mode)
SBD	Safe Braking Distance
SCS	Safety Cut-out Switch
SMD	Surface Mounted Devices
T	Non Driving Trailer Car
TIMS	Train Integrated Management System
TR	Train Radio
Train ID	Train Identification Number
TS	Employer's Requirements : Technical Specification
VCB	Vacuum Circuit Breaker
VDU	Video Display Unit
VVVF	Variable Voltage Variable Frequency
ZVR	Zero Velocity Relay

**EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATION**

APPENDIX TD

**INTERFACES BETWEEN ROLLING
STOCK, SIGNALLING AND TELECOMMUNICATIONS CONTRACTORS**

TD1 INTRODUCTION

TD1.1 Definitions and Scope

TD1.1.1 This Appendix describes the interface requirements between Signalling and Train Control and Telecommunications contracts and Contract RS15.

TD1.1.2 The Signalling and Train Control and Telecommunications contracts and Contract RS15 shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.

TD1.1.3 The requirements specified herein are by no means exhaustive and it remains the responsibility of Signalling and Train Control and Telecommunications contracts and Contract RS15 to develop and execute an interface plan during execution of the work to ensure that :

- (i) All interface issues between the two contracts are satisfactorily resolved
- (ii) Supply, installation and testing of equipment and software are fully co-ordinated
- (iii) All equipments supplied in the contracts are fully compatible with each other.

TD1.1.4 The Automatic train Protection (ATP) system shall issue the braking commands to the Rolling Stock when safety limits are exceeded or when over-speed is detected. The removal of traction power and the correct application of brakes shall be the responsibility of RS15 Contractor. The ATP system shall be responsible for monitoring of speed and the issuing of braking commands when safety limits are exceeded.

TD1.1.5 Parking brakes shall be provided by the RS15 Contractor. The parking brakes shall be capable of holding a fully loaded stationary train on a 4% gradient under all track conditions, indefinitely.

TD1.2 Rolling Stock Characteristics to be used by Signalling and Train Control and Telecommunication Contractors.

TD1.2.1 The size and location of track circuits for determining the ATP blocks shall be designed to meet the headway requirements of 4-car, 6-car and 8-car consists, based on the characteristics of the vehicles to be furnished (Annexure I) and the track geometry. The back-up (line-side) signalling (in cut out mode) shall use the same track circuits as designed for the ATP working. The signal designer must co-ordinate with the rolling stock supplier to fine-tune the block design based on the traction and braking characteristics of the actual vehicles furnished. Acceptance tests of the signal system will use the actual vehicles supplied.

TD1.2.2 When operating in ATP Mode, a delay of 2s (programmable) shall be provided for the train driver to acknowledge a reduction in speed and begin to apply the brakes.

TD1.2.3 The model for calculating the safe braking distance (SBD) shall identify and take into account various systems' response times and drivers' reaction times. The design of ATP blocks shall also take into account the effect of track geometry on the traction and braking characteristics. The RS15 Contractor shall furnish the assured braking rate at the normal braking efficiency, and at the lowest braking efficiency permitted in service, including brake deterioration, to the Signalling and Train Control and Telecommunication Contractors. RS15 Contractor shall provide the speed/acceleration and speed/tractive effort curves, for all loading conditions.

TD1.2.4 The RS15 Contractor shall furnish as a minimum the rolling stock parameters to be used by the Signalling and Train Control and Telecommunications contractors for designing the target distance based ATP system, as set out in the attached Table.

For any other information required by the Signalling and Train Control and Telecommunications contractors, they shall co-ordinate with the RS15 Contractor.

TD1.3 Signalling and Telecommunication Details to be used by RS15 Contractor**TD1.3.1 The following data shall be provided :**

- (i) The maximum power consumed by the Signalling and Train Control and Telecommunications Contractor's equipment from the 110V d.c. supply under all specified operating conditions.
- (ii) The number of train wires required, and the function of each.
- (iii) All control logic outputs.
- (iv) Electrical characteristics of the interconnection cabling and wiring.
- (v) Sensitivity levels, and frequencies which must be avoided.
- (vi) The specific heat load for air conditioning purposes.
- (vii) The limiting value of psophometric current, to obviate interference in the operation of telecommunication equipment
- (viii) Details of the provisions required to enable the transference of data from the train to the OCC.

TD2 TRAIN OPERATING MODES**TD2.1 General System Description**

TD2.1.1 The train-borne Automatic Train Control (ATC) system will consist of an Automatic Train Protection (ATP) system and an Automatic Train Operation (ATO) system.

TD2.1.2 The rolling stock required for the Metro Corridor shall be fitted with redundant ATO and ATP systems, complete in all respects, whereas rolling stock for the Rail Corridor shall be provided with a redundant ATP system only.

TD2.1.3 The Automatic Train Control (ATC) System will be supplied by the Signalling and Train Control and Telecommunications Contractors, who will be required to liaise closely with the RS15 Contractor, in regard to the installation, testing and commissioning of the Signalling and Train Control Equipment.

TD2.2 ATO Mode

TD2.2.1 The onboard equipment shall provide for Automatic Train Operation (ATO) on the Metro Corridor. In this mode, the train's speed, motoring, coasting and braking within the parameters dictated by the ATP system will be performed by the on-board equipment without the driver's intervention. This operation shall include:

- (i) Automatic operation of trains between stations.
- (ii) Receipt of coasting request and passing of request to traction power equipment and also provide for acceleration and deceleration of the train.
- (iii) Automatic stopping of trains at platforms within a tolerance of $\pm 300\text{mm}$ for 99.5% of station stops, and $\pm 500\text{mm}$ for 99.98% of station stops.
- (iv) Automatic opening of doors on the appropriate platform side(s) when the train is berthed.
- (v) Prevent the train from starting if train doors are detected "not closed".

- (vi) Receipt and implementation of control to skip one or more stations.

It shall be possible for the train driver to transfer from ATO to ATP modes on the Metro Corridor, at any time. Transfer from ATP to ATO shall only be possible at standstill at a station stopping point.

TD2.3 ATP (or Coded Manual) Mode

TD2.3.1 The onboard equipment shall provide Automatic Train Protection (ATP) on both corridors. In this mode, the control of the train speed and braking within the parameters dictated by the ATP system, shall be performed by the Train Operator.

TD2.3.2 The ATP mode shall include:

- (i) Identification and enforcement of maximum safe speed at which the train may operate, as deduced from the most restricting ATP condition.
- (ii) Identification and display of actual speed, target speed, target distance, and the maximum safe speed.
- (iii) Identification and audible and visual warning when train is operating at a speed higher than the maximum safe speed. The equipment to provide audible and visible warnings shall be provided by Signalling and Train Control and Telecommunications contractors.
- (iv) Provision of an audible and visual warning to the driver, when the system identifies that the train is operating at a speed in excess of the maximum safe speed; recognition of a delay of 2s for the train driver to react, and a service brake application should the driver fail to reduce the speed below the maximum safe speed in a specified time. In the event of the service braking rate being inadequate, an irrevocable Emergency Brake application shall be made, automatically.
- (v) Identifying the platform side of the train with the train berthed at a station. The system shall then enable the doors to be opened on that side.
- (vi) Receipt of a door closed signal indicating that all doors are closed and locked before the train may start. Loss of this signal shall cause the ATP system to initiate a brake application.

TD2.4 Restricted Manual (or Yard) Mode (RM)

TD2.4.1 In this mode, principally for use in depots, the maximum train speed shall be controlled by the on-board ATP, to a limit adjustable between 15km/h and 25km/h. This mode shall be available only when the on-board ATP equipment is operational.

TD2.5 Cut-out (or By-pass) Mode

TD2.5.1 By-pass Mode shall be provided for use in the event of failure of the ATP system. In this mode, the train speed shall be controlled entirely by the driver, to a limit adjustable between 15km/h and 25km/h. The RS15 Contractor shall provide equipment that limits speed to the above limit when the Cut-out Mode is in effect.

The ATP By-pass Mode shall be initiated by the train driver operating a sealed Safety Circuit Switch (SCS) and simultaneously breaking its seal. The operation shall be recorded by the on-board digital counter and TIMS. The SCS shall be provided by RS15 Contractor. The on-board digital counter shall be provided by the Signalling and Train Control and Telecommunications contractors. In this mode the train doors shall only be enabled and controlled manually.

TD2.6 Identification: Train Operating Mode, Train Description and Next Station Information

TD2.6.1 The Signalling and Train Control and Telecommunications contractors shall provide electrical signals to the RS15 Contractor identifying which mode is in effect. The levels and form of these signals shall be coordinated between the two Contractors.

TD2.6.2 The RS15 Contractor shall log each time the mode is changed using the onboard TIMS equipment.

TD2.6.3 In By-pass or Cut-out Mode, the external indication light shall flash or occult.

TD2.6.4 The Signalling and Train Control and Telecommunications contractors shall provide the necessary input signals (next station information code, triggering signal, etc.) to RS15 for displaying and making next station announcements to passengers on-board. RS15 Contractor shall provide the necessary hardware. Levels and protocols shall be agreed between the two Contractors.

TD3 INTERFACE REQUIREMENTS BETWEEN SIGNALLING AND TRAIN CONTROL AND TELECOMMUNICATIONS AND RS15 CONTRACTORS

TD3.1 General

TD3.1.1 The Signalling and Train Control and Telecommunications contractors shall provide the RS15 Contractor with the final sizes and weights of the ATO/ATP and radio on-board cab equipment and antennae to be mounted on the rolling stock.

TD3.1.2 The Signalling and Train Control and Telecommunications contractors shall deliver to the RS15 Contractor’s factories, all trainborne ATC and radio equipment and data to enable fitting and testing.

The predicted quantities of Signalling and Train Control and Telecommunications contractors supplied equipment per cab indicated below are subject to change :

Item		Item	
ATC Cubicle	1 set	Tacho-generator (Speed	2 sets

ATO Antenna	2 sets	Sensor)	
ATO System	2 sets	Train Radio Antenna	1 set
ATP Antenna	2 sets	Train Radio Driver Control	1 set
ATP System	2 sets	Panel	
Axle Mounted Speed Sensors	2 sets	Train Radio Transceiver	1 set
Emergency Brake Relay	2 sets	Train to Wayside Antenna	1 set
Speedometer	2 set	Zero Velocity Relay	1 set

TD3.1.3 The Signalling and Train Control and Telecommunications contractors shall supply at RS15 Contractor's factory pre-wired equipment racks with appropriate connectors for all wiring terminating inside ATC and train radio enclosures, including wiring between ATC racks. The Signalling and Train Control and Telecommunications contractors shall supply the Train Radio Driver Control Panel

TD3.1.4 Interfacing wiring for each module provided by the Signalling and Train Control and Telecommunications contractors shall terminate in a quick disconnect robust plug connector suitable for traction applications, with direct cable connection as far as possible. All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colours for identification of e.g. safety function cables.

TD3.1.5 For all relay contact interfaces the Signalling and Train Control and Telecommunications contractors shall provide auto-contact jam detection and contact bounce elimination function to ensure proper operation of the system. Relays for safety functions shall comply with the appropriate internationally accepted standard specification.

TD3.1.6 The Signalling and Train Control and Telecommunications contractors shall provide the RS15 Contractor with the number of wires required between cars of a married pair and between married pairs to transmit signals from one end of the rake to the other end through an automatic electrical coupler.

TD3.1.7 For compatibility, the rolling stock and the train detection system (track circuits), shall conform to EN 50238.

TD3.2 ATC and Radio Equipment Cubicles

TD3.2.1 The RS15 Contractor shall supply the ATC and Train Radio equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, etc. required for mounting the cubicle and its equipment shall be properly co-ordinated between the Signalling and Train Control and Telecommunications contracts to ensure secure mounting, and access. The cubicle(s) shall be resiliently mounted.

TD3.2.2 To achieve the ATC control functions, the Signalling and Train Control and Telecommunications contractors shall identify any interfacing circuits specifically required for ATC operation and liaise with the RS15 Contractor. These include but not be limited to start, door control, motoring, coasting, braking and emergency brake commands.

TD3.2.3 For train control circuits the Signalling and Train Control and Telecommunications contractors shall identify the voltage free contacts to be provided by the RS15 Contractor, including the number and type of electrical signals required between the ATP/ATO equipment and the equipment provided by the RS15 Contractor. The two Contractors shall co-ordinate to agree on levels and protocols for each such signal.

TD3.3 Antennae

TD3.3.1 The Signalling and Train Control and Telecommunications contractors shall identify roof-, bogie-, and underframe-mounted antennae, and associated disconnection box mounting brackets and location requirements to identify cable and conduit routes required to antennae.

TD3.3.2 The Signalling and Train Control and Telecommunications contractors shall supply the necessary disconnection boxes, terminal blocks, cables and adaptation mounting brackets, flexible conduit assemblies complete with connectors and cables from antennae to the junction boxes.

TD3.3.3 The RS15 Contractor will provide the antenna mounting brackets, conduits, support or clamping arrangements to ensure security and reliability.

TD3.3.4 The antenna system shall not contravene the kinematic envelope and fully meet the radio coverage requirements both for normal and reverse directions of train working.

TD3.4 Speed Measurement Devices

TD3.4.1 For each ATC equipment set (per driving cab), the Signalling and Train Control and Telecommunications contractors shall supply to the RS15 Contractor for installation, two sets of axle mounting speed measurement devices and couplings, to be configured, and the data from them processed in such a way as to achieve the objectives of D3.4.2 below.

TD3.4.2 The Signalling and Train Control and Telecommunications contractors shall ensure that the speed measurement devices produce a signal which reflects the true speed of the train (within ± 1.0 km/hr) under any operational, weather and track conditions including gradient, curvature, wheel spin/slide and error in the speed measurement due to wear in wheel diameter.

TD3.4.3 The Signalling and Train Control and Telecommunications contractors shall supply the necessary disconnection and terminal blocks, device mounting brackets and plates, flexible conduit assemblies complete with connectors and cables from speed measurement devices to the junction boxes.

TD3.4.4 The RS15 Contractor shall provide for each speed measurement device mounting brackets, support or clamping arrangements to ensure security and reliability.

TD3.4.5 The Signalling and Train Control and Telecommunications contractors shall furnish the zero velocity detection apparatus (ZVR relay).

TD3.4.6 Deleted.

TD3.4.7 The Signalling and Train Control and Telecommunications contractors shall furnish the RS15 Contractor with full mounting details, apertures, fixing holes, etc.

TD3.5 Driver's Display

TD3.5.1 Indications to the driver shall be displayed on the ATC Cab Display supplied by the Signalling and Train Control and Telecommunications contractors. It shall incorporate as a minimum, but need not be limited to the following information :

- (i) Train description, (ID) including crew identification
- (ii) Target Distance
- (iii) Target Speed
- (iv) Service and Emergency Brake Initiation
- (v) Train docked
- (vi) Train hold status
- (vii) Station dwell time available
- (viii) Departure order
- (ix) In ATP zone or not
- (x) ATP/ATO failure indications
- (xi) Skip Stop indication
- (xii) DOOR OPEN Indication

- (xiii) Maximum Permissible Safe Speed (MSS) in ATP and ATO Modes
- (xiv) Train stopped outside of expected stopping window
- (xv) Depot indication, when the train is identified as being in a depot
- (xvi) Axle locked indication, for axles on which ATC speed sensors
- (xvii) Door release available; indicating on which side(s) of the train the doors may be opened.
- (xviii) Operating Mode

TD3.6 Interface Between TIMS and Train

TD3.6.1 The RS15 Contractor shall provide an on-board Train Information Management System (TIMS), to log the information from the ATO and ATP equipments supplied by Signalling and Train Control and Telecommunications contractors, in addition to the information shown in the RS15 specification.

All the vital commands by the on-board ATP and ATO systems, to Rolling Stock equipment and the responses of the rolling stock equipment to these commands, shall be recorded in TIMS. Data stored in the TIMS shall be password protected. Levels and protocols shall be agreed between the two Contractors.

TD3.6.2 The signals to be supplied from the TIMS to the equipment of Signalling and Train Control and Telecommunications contractors shall be decided jointly.

TD3.6.3 The TIMS shall be able to communicate data to the wayside, the OCC or BCC, using a data link supplied by Signalling and Train Control and Telecommunications contractors.

TD3.7 Power Supply and Earthing Arrangements

TD3.7.1 Two independent power supply circuits, including positive and negative poles, one for ATC and one for Train Radio Equipment will be provided by the RS15 Contractor and there shall be no physical or electrical links between these power supply circuits. Both Contractors shall co-ordinate to agree the power supply voltages.

TD3.7.2 The RS15 Contractor shall provide dedicated earthing arrangements for the train borne ATC and radio equipment. The Signalling and Train Control and Telecommunications contractors shall specify the earth impedance required.

TD3.7.3 The power supply cable between the train power supply and the ATC and radio train borne equipment power equipment shall be segregated, as short as possible and directly connected to the supply without any intermediate connection.

TD3.8 Telecommunications

TD3.8.1 The Signalling and Train Control and Telecommunications contractors shall furnish the RS15 Contractor with the interface required between the train radio system and the on-board public address system to allow on-board announcements to be made from the OCC.

The complete on-board public address system, and interface hardware, including the transmission link, and a communication panel shall be furnished by the RS15 Contractor. Levels and protocols shall be agreed between the two Contractors.

TD3.8.2 The Signalling and Train Control and Telecommunications contractors shall furnish the RS15 Contractor with the interface required between the train radio system and the on-board TIMS for recording the initiation, termination, and success or failure of emergency calls initiated by the train driver and/or OCC or BCC on the

radio. The hardware interface shall be furnished and installed by the RS15 Contractor. Levels and protocols shall be agreed between the two Contractors.

TD3.9 Factory Installation and Testing

TD3.9.1 All the special equipment associated with the train borne ATC and radio system shall be designed and supplied by the Signalling and Train Control and Telecommunications contractors to the RS15 Contractor's factory. Each contractor shall be aware of the locations of manufacturing plants, which could concurrently be manufacturing cars.

TD3.9.2 The Signalling and Train Control and Telecommunications contractors shall be responsible for providing all data and training of RS15 Contractor's staff in all aspects of ATC and train radio installation and testing where applicable. The first set of ATC equipment shall be installed by the RS15 Contractor, under the supervision of the Signalling and Train Control and Telecommunications contractors Contractor's representative.

TD3.9.3 The RS15 Contractor will be responsible for installing wiring and equipment, and its testing on each car to the functioning standard agreed with the Signalling and Train Control and Telecommunications contractors

TD3.9.4 Testing of each car shall comply with the accepted international standards agreed between the two Contractors as agreed with the Employer's Representative. Initial integration tests (static and dynamic) shall be done at the rolling stock factory and carried out by the test personnel of both Contractors jointly. Further main line integration tests will be required to be carried out to ensure all train control functions and telecommunications between OCC and Train which will be required to be done jointly by the two contractors, RS15 & Signalling and Train Control and Telecommunications contractors at site in Delhi. The test certificate for on board signaling equipment will be issued jointly by both RS15 & Signalling and Train Control and Telecommunications contractors.

TD3.9.5 The RS15 Contractor shall provide facilities including test track for comprehensive static, dynamic, and interface tests between the Rolling Stock, Signalling and Telecommunications systems at his premises. The Signalling and Train Control and Telecommunications contractors shall be responsible for the provision of special test equipment and instrumentation.

TD3.10 EMC/EMI Interface

TD3.10.1 Regarding electromagnetic interference, the Signalling and Train Control and Telecommunications contractors shall provide a list of frequencies and other sensitive requirements to the RS1 Contractor, to enable him to avoid such frequency bands in his design, and to provide devices to isolate the source of emission wherever required.

The two Contractors shall also jointly develop a test plan detailing how the electromagnetic compatibility of traction and signalling and telecommunications systems will be verified. The two Contractors shall work together to assure that all electronic and electrical equipment on the rolling stock works properly without interfering with signalling, or telecommunications sub-systems.

TD4 SCOPE OF INTERFACE

TD4.1 Division of Responsibility

TD4.1.1 The Signalling and Train Control and Telecommunication contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to :

Item	Signalling and Train Control and Telecommunication Contractors	RS15
1. On board ATP equipment 2. On board ATO equipment (Metro Corridor only) 3. On board radio equipment 4. Antennae for train radio, ATP, ATS and TWC 5. Speed measuring sensors and speedometer. 6. ATC Cab Displays (Drivers MMI).	To supply the equipment to the RS15 Contractor's Works	To provide space in the vehicle design for fixing and installation at the manufacturer's facility, by the RS15 Contractor, under the supervision of the Signalling and train Control and Telecommunication Contractors. The speedometer to be supplied by SYS1 AND 3SO3.
7. Power supply and earthing for on board ATP/ATO and train radio equipments.	Furnish required voltage values and earthing requirements to RS15 Contractor.	To provide the required voltages and earthing
8. Logging of on-board information from ATP/ATO	Signalling and Train Control and Telecommunication Contractors to co-ordinate with RS15 for signal levels and protocols.	Provide the on board data logger TIMS.
9. Interface between ATP/ATO with train braking and propulsion systems for automatic braking, acceleration and deceleration.	ZVR & EBR relays to be supplied by the Signalling and Train Control and Telecommunication Contractors	RS15 shall co-ordinate with the Signalling and Train Control and Telecommunication Contractors to agree on levels and protocols for interface signals.
Item	Signalling and Train Control and Telecommunication Contractors	RS15
10. On board next station information to the passengers 11. On board announcement from	Shall provide necessary signals on-board to RS15.	Shall provide for necessary hardware interface, display for on-board P.A.

Communications Equipment and Systems

OCC.		system inside the cars.
12.Data transmission link from one end of the rake to another.		RS15 Contractor shall provide car/train lines and auto-coupler spare pins

Environmental Issues

Item	Signalling and Train Control and Telecommunication Contractors	RS15
13 Climatic requirements for on board ATP/ ATO and radio cab equipments.	Signalling and Train Control and Telecommunication Contractors to specify at an early date, the total heat load wattage, and maximum permitted temperature	RS15 Contractor to provide, incorporated with Cab Air Conditioning installation.
14 EMI/EMC interface between the RS15 and Signalling and Train Control and Telecommunication Contractors	Signalling and Train Control and Telecommunication Contractors Contractor shall advise EMI/EMC plan for ATP/ATO & radio equipments to RS15 Contractor at early date.	RS15 Contractor shall ensure the compliance of the requirements of Signalling and Train Control and Telecommunication Contractors for on board ATP/ATO and radio equipments.

Annex 1/TD Rolling Stock Characteristics

Acceleration on Tangent Track at Peak Load	0.82 m/s ² ± 5%
Deceleration with full service brake	1.0 m/s ²
Guaranteed emergency braking rate	1.3 m/s ²
Jerk rate (maximum)	0.75 m/s ³
*Service Brake Response Time	2.0s
*Emergency Brake Response Time	1.5s max
*Service and Emergency Brake Release Time	2.5s
* Brake Assurance Time	
Length of car over couplers	22.1 m approximately
Maximum Vehicle Overhang	3625mm ± 125mm approximately
Maximum wheel diameter	860mm
Minimum wheel diameter	780mm
Maximum train design speed	90km/h
Maximum train service speed	80km/h
Tare weight Motor Car	42 tonne maximum.
Tare weight Trailer Car Rail Corridor	42 tonne maximum.
Tare weight Trailer Car Metro Corridor	42 tonne maximum.
Axle Load	17 tonne maximum.
Train length – 4 Car Train	89m approximately
Train length – 6 Car Train	134m approximately
Train length – 8 Car Train	178.5m approximately

Note : 1. All of the data in the above table are notional, and should be confirmed between the Contractors. The above data is not exhaustive, and full co-operation between Contractors is required.

2. For the four items marked *, the timings are for a brake application from full release to 90% of full brake cylinder pressure, and for brake release from full brake cylinder pressure to 10%.

**EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATION**

APPENDIX TE

DRAWINGS

APPENDIX TE**LIST OF DRAWINGS**

Sequence. No.	Description	Drawing No.
1	General Alignment Drawings : Shahdra to Tis Hazari Section of Rail Corridor	DMRC/RC/ENGG/1998/9 Sheets 1 to 9 inclusive
2	General Alignment Drawings : Tis Hazari to Tri Nagar Section of Rail Corridor	RC/C/TN/Alignment
3	Alignment plan and Profile for Vishwa Vidyalaya to Central Secretariat of Metro Corridor	MC/C1A/GENL/PP/001 Sheets 1 to 18 inclusive
4	Shastri Park Depot cum Workshop Conceptual Layout Plan for Rail Corridor	RC/Depot-cum-Workshop Layout 001
5	Khyber Pass Depot cum Workshop Conceptual Layout Plan for Metro Corridor	MC/Depot-cum-Workshop Layout 001
6	Trinagar – Barwala Corridor Longitudinal Section	GGM/C/UT/PTB/L Section
7	Shahadra – Nangloi Corridor Longitudinal Sectional	8830/RC/C/L Section/93
8*	Kinematic Envelope on Level Tangent Ballasted Track Broad Gauge	A3 Sketch No. RS/99/001
9*	Kinematic Envelope on Level Tangent DFF Track of Metro (Inside Tunnel) (Broad Gauge)	A3 Sketch No. RS/99/002
10*	Kinematic Envelope on Level Tangent Ballasted Track (Standard Gauge)	A3 Sketch No. RS/99/004

11*	Kinematic Envelope on Level Tangent DFF Track of Metro (Inside Tunnel) Standard Gauge – 1500V d.c.	A3 Sketch No. RS/99/005
12*	Kinematic Envelope on Level Tangent Ballastless Track (Standard Gauge) 25 kV a.c. System	A3 Sketch No. RS/99/007
13*	Kinematic Envelope on Level Tangent DFF Track (Ballastless) – 25 kV a.c. System	A3 Sketch No. RS/99/008
14*	Worn Wheel Profile	A4 RDSO Sketch No. 91146

Note : Drawings marked * (Nos. 8 – 14 inclusive) are enclosed within the Employer's Requirements : Technical Specification

APPENDIX TE

Volume	Page, Clause, etc.	Location	Amendments
Volume 3 TS Appendix TE	Sketch No. RS/99/002	Note No.**3	Replace Note No. **3 with the following sentence: "75mm is minimum clearance allowed for bogie mounted equipment from rail level for fully loaded static coach with fully worn wheel on diameter for a width of 1220mm on either side of centre of Broad Gauge track with the exception of wheels and its attachments from a distance of 51mm inside to 216mm outside of the gauge face of the wheel.
Volume 3 TS Appendix TE	Sketch No. RS/99/005	Note No.**3	Replace Note No. **3 with the following sentence: "75mm is minimum clearance allowed for bogie mounted equipment from rail level for fully loaded static coach with fully worn wheel on diameter for a width of 1100mm on either side of centre of Standard Gauge track with the exception of wheels and its attachments from a distance of 51mm inside to 216mm outside of the gauge face of the wheel.
Volume 3 TS Appendix TE	Sketch No. RS/99/001, RS/99/008	Note No.**2	Replace Note No. **2 with the following sentence: "75mm is minimum clearance allowed for bogie mounted equipment from rail level for fully loaded static coach with fully worn wheel on diameter for a width of 1220mm on either side of centre of Broad Gauge track with the exception of wheels and its attachments from a distance of 51mm inside to 216mm outside of the gauge face of the wheel.
Volume 3 TS Appendix TE	Sketch No. RS/99/004, RS/99/007	Note No.**2	Replace Note No. **2 with the following sentence: "75mm is minimum clearance allowed for bogie mounted equipment from rail level for fully loaded static coach with fully worn wheel on diameter for a width of 1100mm on either side of centre of Standard Gauge track with the exception of wheels and its attachments from a

			distance of 51mm inside to 216mm outside of the gauge face of the wheel.
Volume 3 TS Appendix TE	Sketch No. RS/99/001, RS/99/004, RS/99/008.	Underlined Note i.e. before "1.TRACK ALIGNMENT..."	Delete " REDUCED" & delete "FOR DFF TRACK ON METRO"

EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

APPENDIX TF

SUBMITTALS

APPENDIX TF.**SUBMITTALS**

TF1 General

TF1.1 As per various clauses of this Employer's Requirements: Technical Specification, the Tenderers are expected to submit relevant information. A list of the required documents / information is given in table TF.1 along with the respective clause reference.

Table TF.1 Submittals with tender

S.N.	Description	TS Clause reference
1	Expected MDBCf for major systems	2.8.2
2	Specific exceptions for LRU's, whose replacement is not achievable in 30 minutes	2.12.9
3	Expected MTTR for major systems	2.12.10
4	Confirmation of provenness of equipment / sub-system / system and exceptions thereof	3.2.2
5	Confirmation of provenness of propulsion equipment	3.2.3
6	Kinematic Envelope	3.20
7	Train Resistance formulae	3.21.5
8	Performance Characteristics	3.22
9	Estimated Specific Energy Consumption	3.24.1
10	Quality specification of the regenerated energy including its harmonic analysis	3.24.4
11	Details on technique of joining modular elements of shell	4.1.1
12	Proposal on structural arrangement	4.8.5
13	Predicted values towards crashworthiness of cars.	4.8.6
14	Means of uncoupling a semi-permanently coupled pair of cars.	4.15.1
15	Details on provenness of bogie alongwith performance certificates from end user	5.1.1
16	Brief description of the proposed disc brake system alongwith expected life of brake pads and discs on the wheels	6.13.13
17	Time required for replacement of door leaf	7.2.1
18	Details of locking device for door leaves	7.2.4.3
19	Mounting details of transformer	8.7.5
20	TIMS system architecture	10.2.1
21	The proposed standards on Data protocols	10.2.6
22	Specific measures taken to minimise energy consumption for HVAC	11.1.6
23	Details on latest internationally accepted practice for Soldering of electronic components	14.15.3

TF1.2 The Tenderers shall include the above information / documents in their bid, as a minimum. Notwithstanding the above, the Tenderers shall submit all the required documents / information as specified in various clauses even if the same do not figure in table TF.1.

**EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATION**

APPENDIX TG

APPENDIX TG: Details Regarding Vendors/Sub-Vendors in Existing 'RS1', 'RS6' Type Stocks vis-a-vis those Proposed in RS15 Tender.

S.No.	Item	Existing Vendor/Sub-Vendor	Proposed Vendors/Sub-Vendors in RS15
A	Bogie	Rotem/Korea BEML/India	Compatible.
	Primary Suspension	TOKAI	Compatible.
B	Gangway Systems	M/s Dellner	M/s Dellner
C	Coupler		
1	Automatic Coupler, Intermediate Automatic Coupler, Semi Permanent Coupler	Voith Turbo Scharfenberg Gmbh, Co.KG, Germany	Voith Turbo Scharfenberg Gmbh, Co.KG, Germany
D	Brake System & Pneumatic	Knorr Bremse	Knorr Bremse
E	Door System	IFE	IFE
F	Communication System		
	PA/PIS	AAL	AAL
G	HV and Propulsion System		
1	Traction Motor	Mitsubishi Electric Corporation Ltd. Japan	Mitsubishi Electric Corporation Ltd. Japan

2	Converter Inverter	Mitsubishi Electric Corporation Ltd. Japan	Mitsubishi Electric Corporation Ltd. Japan
3	Transformer	Mitsubishi Electric Corporation Ltd. Japan	Mitsubishi Electric Corporation Ltd. Japan
4	VCB	Schneider Electric Infrastructure Limited India (AREVA T&D India Ltd.)	Compatible.
5	Anti Burst type Potential transformer (PT)	RITZ	Compatible.
6	AC Current Transformer	Mitsubishi Electric Corporation Ltd. Japan	Compatible.
7	Surge Arrestor	OTOWA Electric Industrial Co. Ltd. Japan, Tridelta	Compatible.
F	Auxiliary Power System	Mitsubishi Electric Corporation Ltd. Japan	Mitsubishi Electric Corporation Ltd. Japan
G	TIMS	Mitsubishi Electric Corporation Ltd. Japan	Mitsubishi Electric Corporation Ltd. Japan
H	HVAC	Sidwal	Compatible.

EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

APPENDIX TH

APPENDIX TH

EMPLOYERS REQUIREMENTS

TECHNICAL SPECIFICATION FOR RS1 TYPE STOCK - ERTS – RS15

The 'RS15' type Rolling Stock shall conform to the Employer's Requirements – Technical and general specifications of contract 'RS1, RS6 & RS13' along with all approved/would be approved variations, modifications and Hardware/Software Engineering Change Proposals that may be implemented in contract 'RS1, RS6 & RS13' cars in line with ERTS. In case of any contradiction between ERTS and approved/would be approved modifications (Hardware/Software Engineering Change Proposals) against the contracts 'RS1, RS6 & RS13', the later will prevail.

This page is left intentionally blank.