INDIAN RAILWAYS

सत्यमेव जयते

R.D.S.O.
Ministry of Railways

POWER SUPPLY & EMU DIRECTORATE

TECHNICAL SPECIFICATION
FOR
AC EMUs WITH THREE PHASE ELECTRICS
FOR
MRVC/MUTP-II

No. RDSO/PE/SPEC/EMU/0096–2008 (Rev.4)
(DECEMBER 2009)

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GENERAL DESCRIPTION AND SUPPLIER'S RESPONSIBILITIES

CHAPTER 1

GENERAL DESCRIPTION AND SUPPLIER'S RESPONSIBILITIES

1.1 INTRODUCTION

1.1.1 The EMU suburban services on Central & Western Railway at Mumbai are presently operated at 1500V DC and 25 kV AC OHE voltage. The new AC/DC EMU rakes equipped with IGBT based dual voltage electrics of Siemens are being manufactured at ICF, Chennai. 159 such rakes shall be manufactured in phased manner. Existing fleet of DC EMUs shall be replaced gradually with newly built AC/DC EMU rakes. These EMUs are working with a formation of 12 cars comprising of 4 motor coaches and corresponding Trailer coaches. Four basic units (two 'End basic units' & two 'Middle basic units') make a 12 car rake. Each 'End basic unit' comprises of one Driving Trailer coach, one Motor coach and one Trailer coach. The 'Middle basic unit' comprises of Non Driving Trailer coach instead of a Driving Trailer coach, one Motor coach and one Trailer coach. The general formation of the 12 car rake in Central & Western Railway is enclosed at annexure – VIII. A list of drawings for bogie, suspension & brake arrangement is enclosed at annexure XII.

1.1.2 The 1500 V DC Traction is being gradually converted to 25 KV AC Traction on the suburban section of Central and Western Railway, Mumbai under the conversion programme of IR. In the transition phase, Dual Voltage 1500 V DC/25KV AC equipments have been fitted to the EMU stock. The system has been so designed that the redundancy of the equipment is bare minimum if the EMUs are used on 25 KV AC traction supply system only as against initial use on dual voltage system i.e. 25 KV AC and 1500 V DC.

1.1.2.1 25 KV AC EMUs are to be provided with 3-phase asynchronous induction motors with associated IGBT based, micro-processor controlled converter-inverter, auxiliary converter and filters etc. Three phase drive equipment shall be based on the latest technology and shall be suitable for regeneration. Drive system shall be through self ventilated, nose suspended, axle hung with roller bearings traction motors capable of being mounted on the existing motor coach bogies with bare minimum changes/modifications to be done on existing bogies, axles and structure.

The Motor Coach, Driving Trailer Coach and Trailer Coach shall be manufactured at ICF, Chennai/RCF, Kapurthala/any other manufacturing unit as decided by Indian Railways as per the existing mechanical design with electrics, associated equipment and other accessories supplied by the supplier at works of coach manufacturer i.e. ICF, Chennai/RCF, Kapurthala/any other manufacturing unit as decided by Indian Railways. The bogies shall be provided with pneumatic suspension in secondary and coil suspension in primary by Indian Railways. As such no bogie suspension item shall be supplied by the supplier. The brake system and battery, as existing, shall be provided by the purchaser.

1.1.2.2 In developing the detailed design, the Bidder will acquaint himself and take note of the passenger loading especially during the peak time, the route conditions and environmental operating conditions under heavy monsoon & track flooding conditions, saline, humid and dusty atmosphere etc. It shall be advisable for the Bidder to visit the Mumbai suburban area to assess the actual site conditions. Some of the salient features of Mumbai suburban section can be referred in Annexure VII.

1.1.3 Each Basic Unit shall generally consist of one motor coach (MC) with a Pantograph located above the High Tension Compartment and with an emergency Driving Cab, one driving trailer coach (DTC) and one trailer coach (TC). The coupling of two or more Basic Units to form trains (rakes) shall be possible, a train normally consisting of not less than three and not more than six Basic Units. In the rake formation, the inner DTCs shall be replaced by plain trailer coaches. The emergency cab shall be provided with driver console duly mounted with the safety related equipment & instruments and combined master / brake controller.

1.1.4 General Design Requirements:-

i) 3-phase drive equipments should be capable of being mounted in the H.T. compartment of the motor coaches, which shall not exceed 3.5 m in length along the track. Fitment of various equipments will be so decided that the weight is properly distributed with least possible weight unbalancing during tare condition. Mounting of converter/inverter panels on the roof or under frame is not permitted. The traction transformer, and compressor shall be mounted in the under carriage/under frame.

ii) The stock fitted with the supplied equipment shall meet the operating/service conditions and performance requirements specified in Chapter 2 and Chapter 3 of this specification respectively and shall be suitable for varying loading conditions occurring in the Mumbai Suburban Section as defined in Clause 2.1.

iii) Notwithstanding the contents of this specification, the supplier shall ensure that the equipment supplied by them is complete in all respect so as to enable the desired operation of the EMU fitted with their equipment.

iv) The equipment design shall incorporate all essential features necessary to yield high traffic use, low maintenance requirements, easy maintainability, high reliability in operation and high efficiency with low Specific Energy Consumption (SEC).

v) **Deleted**

vi) The entire equipment shall be designed to ensure satisfactory and safe operation under the running conditions specified in Chapter 2 and especially under sudden variations of load and electric pressure as may arise under working conditions due to faulty operation and short circuits. The design shall also facilitate erection, inspection, maintenance and replacement of the various units comprising the equipment.

vii) All working parts of the control and auxiliary circuit specifically electronics and PCBs, shall be suitably covered to keep them free from moisture and dust. The protection level shall be furnished by the supplier during design approval.

viii) All the electrical equipments shall comply with the latest edition of IEC specifications unless otherwise specified. The temperature rise shall be measured according to the procedure stipulated by IEC and shall comply with the limits specified and the ambient conditions defined in this specification. Specified temperature rise of equipment shall be calculated after taking into account at least 25 % choking of air filters and radiator fins etc. The supplier shall give traction motor air duct design and co-ordinate with coach builder for interfacing.

ix) All equipments shall be adequately earthed, insulated, screened or enclosed. They shall be provided with essential interlocks and keys as may be adequate to ensure the protection of the equipment and the safety of those concerned with its operation and maintenance.

x) Supplier shall study the currently available lubricants/cooling oils in India and employ these as far as possible. Full lubrication scheme and schedule for the equipment shall be submitted. Wherever imported lubricants or cooling oil are used, Supplier shall study and furnish details of equivalent Indian lubricants/oil.

xi) The complete system shall be compatible with the Auxiliary Warning System already working in Mumbai area. The AWS System, Type ZUB –100, is being supplied by M/s. SIEMENS India Ltd. and shall be supplied and fitted by the IR. AWS shall remain completely isolated in rear driving cab.

IR may provide Automatic Train Protection (ATP) in Mumbai suburban area in future. The complete system as supplied against this tender shall be fully compatible with the ATP and should be fully functional by simple interface such that in future it should be possible to interface the same with the ATP by simple interface catering for 4 input and 4 output signals. The supplier shall furnish the details of the interface arrangement so as to make the system functional on mutually agreed terms and conditions with the purchaser during currency of the contract.

xii) The traction equipment shall be suitable for operation with 25 KV AC, 50 Hz supplied by overhead contact wires. The control equipment shall be suitable to permit multiple operation upto 18 (eighteen) coach formation of 06 (six) basic units where each basic unit shall comprise of 01 (one) motor coach and 02 (two) associated trailer coaches.

xiii) Trailer coaches of 3-phase drive equipment of same make shall be interchangeable from one rake to another rake in any position in the formation of rake and vice-versa.

xiv) The equipment shall be designed keeping in view that the EMUs in MUMBAI operate with doors and windows wide open.

xv) The design shall also facilitate easy erection by means of suitable tools and equipment, inspection, maintenance and replacement of the various units comprising the equipment.

xvi) Software shall be written in a structured manner and fully documented during all stages of its design and development. 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 need approval of RDSO in design stage.

xvii) Logic of the Software of various sub-systems shall be approved by RDSO in consultation with user railways at the design approval stage. The supplier shall submit the values of parameters, list of fault messages, their environmental data sets, hierarchy of fault display, fault categorization, trouble shooting of each fault, etc, for approval of RDSO. Changes in parameters shall be demonstrated with their effect on results.

xviii) The supplier shall submit software logic diagrams with detail explanation along with complete software packages to be loaded in train management system before the commissioning of the prototype rake. Parametric changes shall be possible in the software in order to meet future requirements, such as change in acceleration and deceleration, bogie and coach suspension, train configurations, OHE voltage and frequency, etc. While listing out the values of various parameters, the contractor must provide a range within which any change can be done without jeopardizing the functionality of the system.

xix) Software shall be fine tuned through simulations & real life working conditions based on the extensive trials, associating user railways before putting the rake into commercial services. As it requires, instrumentation and expertise of Software Design Professional, software expert (s) of supplier shall be based at the work place along with commissioning engineers so that all the software related issues are resolved before putting the rake into commercial service.

xx) Quality and efficacy of Trouble shooting manual, software tools and software documentation shall be validated during extensive field trials. Final version of these documents shall include the changes required based on the trials and experience of operating railways. This shall be approved by RDSO.

xxi) All the changes, thereafter, in software shall be approved by RDSO in consultation with user railways before actual implementation and the supplier must give software release which shall include brief description of the problem, logics , explanations, parametric changes, etc. to the satisfaction of Railways.

xxii) Software documentation shall be provided to give the full understanding of the software function and operation. Documentation shall be complete, clear and concise, and include all modifications up to final acceptance. Documentation shall include software block diagram showing signal flow, logic, and hardware interfaces. A top level flow diagram and description of detailed operation shall be provided.

xxiii) **Proven Equipment.**

The design of the equipment shall be based on sound, proven and reliable engineering practices. The equipment used in different sub systems shall be of proven technology and design. The equipment and the components used for various sub-systems not specifically covered under Section - III A of Qualification Criteria shall be such that they are manufactured in the manufacturing units that have furnished the same components/equipment for use on 60 coaches /locomotives that have been in satisfactory service for at least two years.

xxiv) Research Designs Standards Organization (RDSO) has been assigned the responsibility for technical evaluation of bid, approval of design and test specification. RDSO shall also be responsible for approving the prototype test procedures and coordinating, witnessing, and verifying prototype testing and results. In addition, RDSO shall be responsible for approval of modifications resulting in any changes in design and layout of the EMU's.

xxv) Bidder shall enclose basic details of their system design, weight particulars and its disposition, covering all major items viz. Transformer, converter, inverter, auxiliary converter, traction motor, auxiliary machines, basic software specification, control electronics, compressor, communication

protocols, display systems, possibility of system expandability and any other aspect/equipment which is within the scope of supply of the Bidder. Bidder shall refer Annexure II while enclosing such details.

1.1.5 FIRE PREVENTION

i) The equipments shall be designed to minimize the risk of any fire.

ii) Materials used in the manufacture of equipments shall be selected to reduce the heat load, rate of heat release, propensity to ignite, rate of flame spread, smoke emission and toxicity of combustion gases.

iii) The Supplier shall comply with specification NF F 16-101: (Railway Rolling Stock Fire behaviour "Choice of Material"), NF F 16-102: (Railway Rolling Stock Fire behaviour "Material choosing, application for electric system" category A2), BS 6853 – 1999 Category II or DIN 5510 or any other equivalent/superior international standard for fire safety plan in respect of their equipment. Whichever standard is selected for meeting the fire safety, the standard shall be declared and a copy shall be furnished to RDSO.

1.1.6 DEFINITIONS

Throughout this specification, the term

i) 'Bidder' means the firm or Company or Joint Venture who submits his offer for supply of the goods and services against the tender.

ii) 'Purchaser' means Mumbai Railway Vikas Corporation entering into the contract.

iii) R.D.S.O., means Research Designs & Standards Organization of Ministry of Railways

iv) 'Inspecting Officer' means the person nominated by purchaser/RDSO/IR to inspect the goods on their behalf.

v) 'Supplier' means the firm or Company or Joint venture with whom the order for supply of the goods and services has been placed.

vi) 'Sub-Supplier' means any firm or Company from whom the Supplier may obtain any material, service or fittings to be used for the goods.

vii) 'CR' & 'WR' means 'Central Railway' and 'Western Railway' respectively.

viii) ICF means Integral Coach Factory, Chennai, RCF means Rail Coach Factory, Kapurthala – IR's manufacturing units designated for assembly /manufacture of EMUs.

ix) 'Basic Unit' means one Motor Coach with its associated Driving trailer coach and trailer coach.

x) 'SDCL' means Super Dense Crush Load viz. Seating passengers plus standing passengers with density as 16 passengers/m^2 details can be referred in Chapter 2.

xi) 'OEM' means 'Original Equipment Manufacturer' of assemblies, sub assemblies and components.

1.2 SCOPE OF SUPPLY

1.2.1 The details of scope of supply have been defined in – Schedule of Requirement of the Bid Document and corresponding Schedules. The scope shall also include the followings:

The supply of complete documentation for approval of design, relevant drawings and calculations to the satisfaction of purchaser and RDSO and support documentation associated with the operation and maintenance of the equipment supplied against this specification. The documents shall include the details as defined in Clause 1.4 “Approval of Design” of this specification.

Supplier shall submit list of equipment and facilities required for maintenance and overhaul of equipment offered. Supplier shall also interact with the consultant appointed by the purchaser for finalising the layout design of construction/ modification of the existing facilities in respect of maintenance sheds/workshop.

1.3 SUPPLIER’S RESPONSIBILITIES

The Supplier’s responsibilities will extend to the followings:

1.3.1 The Supplier shall supply detailed instructions, drawings and relevant specifications for proper installation of the equipment in coaches to MRVC, ICF and RDSO or any other agency nominated by IR. For this purpose, the Supplier shall depute a team of engineers to ICF or any other manufacturer’s premises for supervision of installation and pre-commissioning of the equipment in the motor coaches and trailer coaches for two prototype rakes and subsequent all the (12 car) rakes. Commissioning of all series rakes will be carried out by the supplier at ICF or EMU maintenance shed/workshop of IR or any other manufacturer’s premises in India.

Installation of equipment, pre-commissioning and commissioning of EMUs shall be supervised by a trained engineer of supplier along with supporting staff to ensure that the each interface & equipment mounting / assembly is being performed as per design document.

1.3.2 The Supplier shall be responsible for commissioning, testing and service trials of the equipments in service and depute team of engineers to Western and Central Railway for first two (12 car) prototype rakes and commissioning of all (12-car) rakes.

1.3.3 The Supplier shall arrange required instrumentation and carry out detailed tests and service trials jointly with RDSO, Western, Central Railway & ICF/EMU maintenance shed/workshop/any other manufacturer nominated by IR as per Chapter 5 of this specification.

1.3.4 The Supplier shall be entirely responsible for the execution of the Contract in accordance with the requirements of this Specification. The Supplier shall comply with the provisions of the General Conditions and the Special Conditions of the Contract in scheduling, executing, and obtaining the RDSO’s approval of the design.

1.3.5 The Supplier shall submit a technical plan, giving details of overall system design, Project organization chart, project schedule clearly defining the start

& completion of activity through PERT/Bar chart and schedule of submission of design documents/drawings to the Purchaser and RDSO as specified in delivery schedule of contract.

The software required for trouble shooting and software tools for maintenance of equipment at module level at depot shall be supplied. Supplier shall demonstrate the procedure of trouble shooting through software.

Complete information on equipment testing and commissioning at site/on train, their interface and complete system testing shall also be provided. The relevant customized hardware, if any, required for the purpose as above shall also be supplied to RDSO and Central & Western Railways.

1.3.6 Supply of drawings, operating manuals, maintenance manuals, and software manuals of the supplied equipment.

1.3.7 Deleted

1.3.8 In addition to the equipment and services specified in this Specification, the Supplier shall supply handling tackle, special tools and appliances which may be necessary for the installation, testing and commissioning of the supplied equipment on the new manufacture EMUs, even though such material or work may not be specifically mentioned in this Specification.

1.3.9 The two prototype rakes (12 car), fitted with the supplied equipment after the successful completion of all tests and trials and RDSO clearance shall undergo service trials for four months. The balance equipments shall be supplied by the supplier only after successful prototype trials. However, the supply of equipments for the "work in progress" for the period of service trials can commence for the proven equipments and for the newly designed equipments as agreed by the supplier and purchaser so that the continuity of the production is not affected. During the prototype tests/service trials, if any problems arise or feedback information is obtained, which warrants a re-check of the design/manufacture/quality of the equipment and components, action will be taken as may be necessary by the Supplier to carry out the required investigations and to incorporate the modification considered most appropriate to reach compliance with the specification without any extra costs to the Purchaser and in a manner approved by the RDSO on equipment/components already supplied as well as those to be supplied later.

1.3.10 Before carrying out any modification, as found necessary on the basis of tests and trials, the drawings and execution plan shall be got approved from the RDSO.

1.3.11 CLAUSE BY CLAUSE COMMENTS:

The bidder shall furnish clause by clause comments on compliance of this specification. Complete details as required vide the respective clauses shall be furnished by the bidder.

The comments like 'noted' against the respective clauses shall be considered as 'not complied' for the specific clause. Therefore, the bidder shall clearly indicate the compliance or otherwise by writing 'Complied' or 'Not Complied'

1.4 APPROVAL OF DESIGN

1.4.1 The design shall be developed based on the requirements given in this specification and sound engineering practices with specific consideration to the specified passenger loading condition, route conditions and environmental conditions. The basic design for system and major equipments shall be supplied by the Supplier with required technical data and calculations to RDSO for approval. The manufacturing will commence after the approval of the design by RDSO.

Any calculation which is evaluated on the basis of software simulations shall be supported with sample calculations. One copy each of RDSO approved design shall be supplied to the purchaser, Western & Central Railways & ICF/EMU maintenance shed/workshop of IR or any other manufacturer nominated by IR.

1.4.2 After the contract is signed, the Supplier shall furnish to RDSO and the purchaser the detailed schedule programme for submission of design documents for approval which shall be suitably staggered, to enable RDSO to plan for expeditious clearance.

1.4.3 The Supplier shall deliver all necessary data, designs, calculations, drawings and specifications referred in their drawings or design documents in English language as required by RDSO for examination and shall provide explanation and clarification of the drawings for which approval is sought. The submission of design document for any equipment for approval by the supplier without the complete information as per the contract specification shall not be considered as submission of document. Approval or decision by RDSO shall normally be given within 3 weeks of submission of all clarifications by the Supplier to the satisfaction of the RDSO. For this purpose, the Supplier shall depute his technical experts to RDSO for design discussions and finalisation. After the final design is approved, the Supplier shall furnish complete set of applicable specifications as mentioned in the approved drawings & documents and shall also submit the list of equivalent Indian Standards wherever applicable.

Supplier shall submit technical details desired in annexure-IIA along with technical specification, functional specifications, block diagrams, schematic drawings, loading calculations, circuits, wiring diagrams, basic design of converter, inverter and other power and control equipment, train control networking, protocols used and the connected software details for carrying out modifications as permissible and weight balancing calculations, drawings and ratings of all sub-Supplier's deliveries. The loading of electronic equipment/components calculated under the ambient conditions as specified, ventilation design, component rating etc. shall be got approved from RDSO. While the aspects covered, as above, are not exhaustive, the Supplier shall supply/furnish complete technical details with respect to their system and equipment design and to the satisfaction of RDSO at the time of design approval. In this connection Annexure II A may be referred.

The design shall be developed in SI units.

1.4.4 The Supplier shall submit the technical specification of the components of sub-assemblies. The specification shall specifically be indicated on relevant drawings/documents.

1.4.5 Approval of design means approval of general design features. Notwithstanding the approval, the supplier shall wholly and completely be

responsible for the performance of the complete system and equipment supplied by him. RDSO will not be responsible for the correctness of the dimensions indicated on the drawings, the materials used or the strength of parts. The Supplier shall, when submitting proposals or designs for approval of RDSO, draw specific attention to any deviation or departure from the specification involved in his proposals or designs.

1.4.6 Deleted

1.4.7 The Supplier shall be responsible for carrying out improvements and modifications at his own expense on all the equipment supplied, provided such modifications/improvements are decided to be necessary jointly between Supplier and RDSO for meeting the requirements of reliability, performance & safety etc.

1.4.8 For the purpose of technical decisions on improvements/modifications etc. on equipment, the final authority from the purchaser's side will be RDSO.

1.4.9 Maintenance Manual, Spare Parts Catalogue & Material Specification

The detailed maintenance and service manual shall be prepared for the various equipments and 40 (forty) copies of the same shall be supplied free of charge. The draft contents of the manuals shall be submitted for approval of the RDSO.

Detailed spare parts catalogue listing all components manufactured or purchased by the supplier along with their rating, source & schematic position etc. (40 copies) each shall also be supplied free of charge. Supplier shall furnish purchase specification of the bought items as well.

The documentation shall be provided on compact discs (Blue Ray) along with relevant software and complete arrangements to read them or edit them in future to take prints in colour.

1.4.10 **As made drawings**

Six complete sets of 'as made' drawings shall be supplied by the Supplier to the purchaser/RDSO.

1.4.11 **Size of drawings**

The drawings of the following parts shall be to the sizes indicated below:

I	Equipment details	-	full size or half size
II	Motor Assemblies	-	1 : 5
III	General assemblies	-	1 : 10

The dimensions, weight, capacity, etc, shall be in SI units. All drawings shall be submitted on CDs along with complete setup for reading and taking prints. In case the format is not compatible with AUTOCAD necessary customized hardware and software shall be submitted.

1.4.12 Method of filing of drawings

To facilitate filing of drawings, it is essential that each drawing submitted for approval is marked so that it can be identified. The supplier is, therefore, required to ensure that all prints are marked legibly at the right hand bottom corner. The following information is required in respect of each drawing:

I. Supplier's drawing number.
II. Supplier's name and date of submission.
III. Contract no. given by the purchaser.
IV. Description of drawings.
V. Relevant Specifications

1.4.13 **Photographs:**

While the equipment is under manufacture, photographs shall be taken of the various assemblies and sub-assemblies in various stages of production. Photographs shall not be less than 380 x 255 mm in size and shall be taken on non-curl films. The negative and three prints of each shall be furnished to the purchaser and IR. The print should be mounted on sheets to form complete sets. Photographs on digital media and videos shall also be furnished.

1.4.14 **Binding**

Each set of tracings together with a set of photographs shall be suitably bound within a cover of superior quality durable materials with the title block printed on the outside of the cover.

1.4.15 **Marking of equipment**

All main assemblies of the equipment shall bear serial number for identification and initials of the purchaser. Where the sub-assemblies/components of the main assemblies are not inter-changeable, the sub-assemblies shall also be marked with the serial nos. of the main assembly of which they form a part.

1.4.16 **Rating plate**

All equipment/cubicles shall contain rating plates of anodized aluminum with embossed letters. The rating plate will give detailed rating specification and identification of equipment. The details of rating plate of each of the equipment shall be as approved by RDSO.

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CHAPTER 2

OPERATING AND SERVICE CONDITIONS, DESIGN CONSTRAINTS

CHAPTER 2

OPERATING AND SERVICE CONDITIONS, DESIGN CONSTRAINTS

2.0 LEADING PARTICULARS:

The leading particulars of the EMU stock, on which supplied equipments are to be fitted, shall be as follows:

i)	Track gauge	1676 mm
ii)	Coach length over body	20726 mm
iii)	Max. Width over body side	3660 mm
iv)	Inside Length of the existing HT compartment	3500 mm
v)	Inside width of the existing HT compartment	3300 mm
vi)	Maximum permissible axle load (motor coach)	20.32 tonnes
vii)	Maximum permissible axle load (trailer coach)	20.32 tonnes

The length and width of the HT compartment as indicated above is approximate.

2.1 PAYLOAD AND WEIGHT PARTICULARS :

2.1.1 The terms used for indicating various loading criteria in Mumbai area are as follows:

Normal (all seating), Crush (double the no. of seating passengers), Dense crush load (03 times the no. of seating passengers) and Super Dense Crush Load (sitting plus 16 Passengers/m^2 (standing). The EMUs in Mumbai area operate under conditions of very heavy passenger load. The maximum payload may be calculated as follows:

Max. payload = Seating capacity + Standing capacity

Where 'standing capacity may be calculated at the rate of 16 passengers / m^2 of free space; the free space shall include doorway area and the aisle, but shall not include the knee space of sitting passengers. Henceforth, such loading condition having loading equivalent to 16 standing passengers/m^2 shall be referred as SUPER DENSE CRUSH LOADING (SDCL). The total passenger loading in the motor coach, DTC& TC is approximated as 26.76, 28.0 & 34Tonnes respectively. The average weight per passenger has been taken as 60 Kg.

2.1.2 Weight Distribution

(i) The total weight of the existing electrics including complete traction equipment, roof equipment, battery with battery box, cables & compressor with its motor etc. is approx. 17.982 T. The weight of the existing cables is approx. 1000 Kgs., battery with battery box is approx. 700 Kgs & compressor (with motor & air dryer) is 250 Kgs. The equipment shall be so designed that the total overall axle load of the motor coach or TCs, fitted with the three phase electrics and other accessories does not exceed 20.32 Tonnes after taking into consideration the SDCL loading equivalent to 26.76, 28, 34 Tonnes in MC, DTC or TC respectively and unbalancing during tare conditions.

(ii) Axle load limitation shall be taken into account while finalising and designing the equipment layout giving due consideration to weight unbalancing during tare and SDCL loading conditions. Bidder shall submit weight disposition of each equipment in motor coach, DTC & TCs and shall submit calculation of overall centre of gravity with respect to bogie centers at the design stage. This shall also include calculation for unbalance of load under tare load and SDCL conditions on both the bogies.

(iii) Bidder shall distribute the power equipment viz. converter-inverter, traction motor & transformer etc. amongst motor and trailer coaches for optimized weight distribution and reduced axle load within the unit. The existing equipment layout of Motor coach & DTC is enclosed with annexure XII. It shall be noted that due to safety considerations, pantograph is essentially to be provided on the non passenger area i.e. HT compartment. However, supplier shall note that actual arrangement shall be of proven layout which has usually been adopted by the supplier in other rolling stocks and shall be in line with the basic guidelines as indicated above. As such the distribution of weight shall have to be compatible with the mechanical structure of the coaches which shall be manufactured at ICF as per the existing designs. The relevant mechanical drawings for the existing motor coach, driving trailer coach and plain trailer coach may be referred.

Bidder shall submit the relevant references where the proposed arrangement has already been supplied and is functioning satisfactorily for 3-phase drive systems (refer Annexure II)

(iv) The Bidder shall ensure that such weight disposition is proven arrangement for ensuring reduced axle loads. The inter-vehicular couplers for high-tension connections to traction motors, if used, shall be proven. Such couplers shall be exposed to vandalism activities including people riding on the mechanical couplers etc. As such the coupler shall be designed to cater for all such abnormalities. Details of the coupling arrangement shall be furnished.

2.1.3 Tare Weight particulars of the existing coaches are as under:
(Ref.:- ICF letter no. MD/D/Weights/119 dated 29.11.2007)

Type of coach	Weights (tonnes)
Motor Coach	53.868
Trailer Coach ‘C’ Type (TC)	36.775
Trailer Coach ‘D’ Type (DTC)	39.061
Trailer Coach ‘D(HC)” (NDTC)	37.937

2.2 GAUGE AND MOVING DIMENSIONS

Unless otherwise stated, the EMU coaches shall conform to the INDIAN Railways Schedule of Dimension – 1676 mm gauge of 1929 (reprinted 1973) with latest amendments, read with RDSO sketch-76180 and sketch–74176 MMD for AC & DC EMUs respectively placed at Annexure IX.

2.3 TRACK CONDITIONS:

(i) Gauge: Broad Gauge system of the Indian Railways: 1676 mm.

(ii) Track Structure: The track is to a minimum standard of 52 Kgs rails

(iii) Sharpest curve and turnout: 152.4 m radius. The EMU will also be checked for passage in both directions over standard BG 1 in 8 1/2 turnout.

(iv) The latest track recording on the suburban section between Churchgate and Borivali is enclosed as Annexure III A & B. The largest peak in each Km for unevenness, Twist, Gauge and Alignment is also indicated in the Annexure attached. The mounting of the equipment shall be designed to suit these worst cases as per the Annexure III so that their performance is not affected adversely. An update of the track measurements for Church Gate- Andheri section & Mumbai CST- Kasara section shall be furnished to the Supplier during design stage.

(v) The sample raw data for the track where these EMUs are likely to run, is given. However detailed track data as recorded and processed can be referred in Annexure III D.

2.4 SPEED, ACCELERATION AND DECELERATION

The equipment shall be designed for following operational parameters at maximum gross weight (SDCL).

2.4.1 Acceleration

Starting acceleration (average from 0 to 40 Km/h) : 0.54 m/s^2

2.4.2 Deceleration

Service braking deceleration
i) Average from 110 Kmph to 50 Km/h : 0.76 m/s^2
ii) Average from 50 Km/h to standstill : 0.84 m/s^2

2.4.3 Maximum Speed

i) Maximum service speed : 110 Km/h
ii) Minimum balancing speed on level track at any condition of wheel wear : 120 Km/h
iii) Maximum test speed : 120 Km/h

2.5 Traction Power Supply System

The equipment shall be suitable for operation on the electrical suburban sections of the Central and Western Railways. The general particulars are:

The operating voltage: **25KV AC power supply:**

i) Normal variation : 19 KV to 27.5KV
ii) Occasional maximum (cut off) : 30 KV
iii) Occasional minimum : 16.5 KV
iv) Cut off voltage : 16 KV
v) Frequency variation : 47 Hz to 53 Hz

The power supply system shall be 25 KV, 50Hz single phase AC, 25 KV being the nominal voltage of the system. The guaranteed performance shall

be based on voltage of 22.5 KV. However, the run time for all out run for 1.5 km section on level tangent track and SDCL loaded train shall not deteriorate more than 5% as compared to that specified at clause 3.1.3 within the variation of OHE supply in the range 21KV to 28.5 KV and frequency variation of 47Hz to 53Hz. Train operation shall be feasible at OHE voltage of 16.5KV, may be with restricted power. The system shall be capable of working even upto frequency variation of 50Hz +/- 8% with certain modifications, to be advised by the Bidder, if so required. Bidder shall indicate cost of modification separately.

2.6 OVERHEAD EQUIPMENT

2.6.1 25KV AC Traction: The overhead equipment is supplied through 3 phase grid system and step up/down transformers at the traction substations. Consecutive sections are not supplied from the same phase, therefore neutral sections are provided in between the traction feed from two adjacent substations. The length of the neutral section shall be about 9.5 m. The OHE shall be of regulated type.

2.6.2 Limit of second harmonic: The second harmonic current of each motor coach shall not exceed 0.5 Amps and shall be governed by international standard (IEEE 519-1992). This will supercede the limit of second harmonic stipulated in the Annexure VI A. The Supplier shall submit curves of harmonic currents vs load current per motor coach and per 12/15/18 car EMU rake.

2.7 CLIMATIC AND ENVIRONMENTAL CONDITIONS

i) **Relative Humidity**: upto 98% saturation during rainy season which may be as long as five (5) months.

ii) Ambient temp. max. : 50º C
min. : 0º C
Average annual ambient temperature shall be taken as 35°C.
Maximum temperature inside HT compartment of motor coach may reach 55º C.

iii) The temperature of stationary rake in sun may go as high as 70-75º C. The equipment in HT compartment shall not be adversely affected in any way due to exposure to such high temperatures. Bidder shall furnish the precautions taken in equipment/component selection in order to conform to this requirement. The Bidder will indicate the expected temperature rise in the machine room/HT compartment under the reference site conditions described above and shall submit the expected MTBF at such temperature.

iv) The area along both sides of the track is heavily populated. Bidder may assess the site conditions by visiting the Mumbai suburban area. The air discharge from the cubicles, if any, shall be suitably regulated so that dust blow during the run is bare minimum and does not cause any inconvenience to passengers.

v) **Altitude**: coastal area

vi) **Rainfall**: Very heavy and continuous (up to 2500mm during rainy season)

All under slung equipment shall be designed suitably to ensure its normal working even in adverse conditions as above.

vii) The equipment shall be so designed to run at 8 Km/h through water up to 203 mm above rail level, allowance to be made in addition for increase in the height of water level due to wave effect. Incase of flood level increasing more than 203mm, the EMU shall be made dead.

There are certain sections of the track that get flooded with water to standing depth of 760mm. The traction gear and other under slung equipment must be completely water proof to this height above rail level. During the peak flood condition water may reach up to floor level. The equipment shall not get damaged due to such flooding and it should be possible to rejuvenate the equipment with minor attention without any adverse effect on their performance.

viii) **Atmosphere during hot weather**: Extremely dusty, humid and salty. The EMU shall be working primarily in coastal area and thus shall be continuously exposed to highly corrosive, salty atmosphere along with industrial pollutants.

Special care shall be taken to ensure no damage to equipment due to deposition of atmospheric salts and industrial pollutants. Bidder shall enclose the details of specific measures adopted to ensure the satisfactory working of equipment against the deposition of salts & industrial pollution.

ix) **Vibrations**: Because of track irregularities, level of shocks and vibrations to which traction motors are exposed are far more than actually given in IEC for axle hung nose suspended TM mounting arrangement. Measured data of vibration levels at critical locations of TMs and its mounting / suspension arrangement of existing AC/DC EMUs with 40Hz/100Hz low pass filter, which is placed as Annexure XV, can be used for design and in case of any doubt, the tenderer must carry out instrumented trials on existing stock for measurement of shocks and vibrations in Mumbai sub-urban area in consultation with RDSO, at design stage, only. The suspension system and the mounting arrangement shall be so designed that the equipment's performance is not adversely affected due to such high vibrations and shocks. The Bidder shall refer the track parameter vide clause 2.3. Bidders are also strongly advised to check and verify the existing track conditions over the sections of the Railway where the EMU stock shall run.

2.8 SIGNAL AND TELECOMMUNICATION INSTALLATIONS:

The tracks over which the EMUs train will run will be equipped with 50 Hz AC track circuits, 83.33 Hz AC track circuits, digital axle counters, DC track circuits as well as track circuits at higher frequencies including audio frequency track circuits and Auxiliary Warning System (AWS). The design of the power electronics and control electronics provided on the EMU Train shall be such as not to cause unacceptable level of interference on these track circuit and on the installed S&T equipment. Acceptable level of interference and psophometric current limits for one EMU rake of 12 car (4M + 8T), 15 car (5M+10T) & 18 car (6M+12T) are given in Annexure VI-A. The overall limits as included in the Annexure shall be applicable to 9 car (3M + 6T) EMU as well.

Bidder shall note that the number of motor coaches in the formation may change as per the requirement of Railways but will not be more than 5 at present. It may be noted that acceptable limit are indicated for one motor coach and also for complete EMU rake. The Bidder shall ensure that even in worst possible combination in service conditions the overall limit prescribed per rake shall be adhered to. The bidder shall submit the simulation results of the likely value of harmonic currents of the SDCL loaded EMU train with the formation up to 18 car (including 9 car formation), and will also include the worst conditions of Motor coach isolation as above. The simulation of harmonic currents for 18 car EMU train shall be submitted during design stage.

IR prefers to measure the values of the currents for complete EMU rake under the worst possible conditions. The Supplier shall furnish detailed procedure, any special condition of measurements and specific instrumentation required for the purpose. It shall be the responsibility of the Supplier to arrange the instrumentation in order to conduct the measurements. The procedure shall be furnished by the Supplier and shall be finalized as agreed jointly with RDSO. The tests shall also include the cases of isolation of motor coaches during service. These tests shall be conducted on either of the prototype rakes.

On the communication network, control circuits, tele-printer circuits, as well as VHF/UHF and micro-wave circuits are employed. Broad details of such equipment used are given in Annexure VI-B.

The design of the power electronics and control electronics provided on the EMU train shall meet the requirements as above.

2.9 MAINTAINABILITY:

2.9.1 Bidder shall submit the basic maintenance schedules of the proposed equipment. Minimum interval between two maintenance schedules for the equipment supplied under the specification in the depot shall be 90 days except for the panto strips and 3 years for major works in workshop/major depot.

It may be noted that the periodicity of the present maintenance schedules are as under:-

I 'A'	45 days
I 'C'	180 days
POH	18 months

The maintenance programme prepared by Bidder shall have the following objectives ascertaining the above periodicity of maintenance schedules:

a) Enhancement of EMU availability
b) Minimization of maintenance costs
c) Minimization of coach downtime /MTTS (meantime to restore serviceability).

2.9.2 Based on the proposed maintenance schedules the Bidder will submit average downtime on account of scheduled maintenance for the equipments to be supplied excluding the time required for transfer of rake to and from the maintenance depot. Ineffective on this account should not

exceed Two percent. Bidder should also submit an estimate for the downtime for unscheduled maintenance in respect of equipments to be supplied. The Bidder shall assess and submit the figure for 'total percentage Ineffective', in terms of percentage of rakes expected to be ineffective/unserviceable due to schedule and unscheduled repairs/maintenance of equipment supplied (excluding the time taken for transfer of the rakes to and from maintenance depot) against the total number of rakes fitted with the equipment under his scope of supply. This ineffective figure shall not exceed FOUR percent in any week (Monday-Sunday) calculated on 24 hourly basis. If during the test and service trial period of prototype rakes it is experienced that downtime due to unscheduled repairs/scheduled maintenance of the equipment supplied is excessive, supplier shall be required to take suitable remedial measures to bring the ineffective figure within the limit submitted during the design approval stage."

2.9.3 Modular design principles shall be employed. Requirements for adjustments after module interchange shall be avoided except as required in the specification.

All systems, components and structural areas serviced as part of inspection or periodic preventive maintenance shall be readily accessible for service and inspection.

2.10 RELIABILITY:

In addition to meeting the performance requirements, the equipment, shall incorporate high standards of reliability to ensure that operating cost and operation performance are optimized.

The Bidder shall provide the achieved quantitative reliability data of major subsystem/equipment, expressed in Mean Time between Failures (MTBF) and/or Mean distance between Failure (MDBF), based on operations of proven coaches fitted with similar equipment for a minimum of 3 years and 450,000 kilometers per coach in revenue service, for purchaser's and IR's evaluation. The definition of MTBF & MDBF for this purpose may be considered as: MTBF = No. of equipments (Population) x Period (Time)/Total number of failures during that period. MDBF = No. of equipments (Population) x Kilometer run (Distance)/Total number of failures during that distance

The MTBF shall be submitted for the ambient temperatures of 45º C, 50º C, 55º C and at the temperature expected inside the HT compartment as per the Bidder's calculation.

A list of equipments for which the MTBF and/or MDBF values shall be submitted along with calculation (method) during the design approval stage is enclosed as annexure XIII. Bidder shall submit the list of equipments and confirmation at the bid stage.

Failure is defined as "An electrical multiple unit (on units) on a suburban service should be considered to have failed, when through some mechanical or electrical defect in the stock:-

a) either unit is unable to complete its booked working throughout the day
or
b) a delay of not less than 15 minutes is caused to any train included in the booked working of the day. Failures of all coaches, whether employed on traffic or departmental service, are to be included.

2.11 ADHESION LIMITS:

The equipment shall be so designed that the coefficient of adhesion requirement does not exceed 20% during powering and 16% during braking under all requirements of performance as specified in this specification.

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CHAPTER 3

PERFORMANCE REQUIREMENTS

CHAPTER 3

PERFORMANCE REQUIREMENTS

3.1 PERFORMANCE REQUIREMENTS

3.1.1 General Description

(i) The capacity of the traction motor and the other equipment shall be adequate to permit continuous operation of Super Dense Crush Loaded 12 coach train comprising of 4 units of total weight 884 tonnes and with the formation of 4 motor coaches and 8 trailer coaches so as to meet the performance requirements as described herein. The design shall permit the operation of EMU train with different formations as per Clause 1.1.4 (xii) under loaded conditions with the unit weight as above. All performance calculations shall be with respect to 12 car trains unless stated otherwise.

(ii) The three phase drive equipment shall be based on the latest technology and shall be suitable for regeneration. The traction equipment shall be suitable for operation with 25KV AC, 50 Hz traction system supplied by overhead contact wires. Three Phase asynchronous induction motors with associated IGBT based and micro-processor controls are to be provided against this specification.

(iii) Fitment of various equipments will be so decided that the weight is properly distributed. Mounting of converter/inverter & control electronics panels on the roof and under slung is not permitted.

(iv) The entire equipment shall be designed to ensure satisfactory and safe operation under the running conditions specified in Chapter I & 2, abnormal conditions such as sudden voltage variation, load variation, short circuits and track & weather conditions prevailing in Mumbai area. The design shall also facilitate erection, inspection, maintenance and replacement of the various units comprising the equipment.

(v) All working parts of the control and auxiliary circuit shall be suitably covered to keep them free from moisture and dust.

(vi) All the electrical equipments shall comply with the latest editions of IEC specifications unless otherwise specified. The temperature rise shall be measured according to the procedure stipulated by IEC and shall comply with limits specified in this specification.

(vii) The wheel dia of the new wheel is 952 mm. The performance shall be guaranteed with half worn wheel of 915 mm. Minimum clearances as specified in Clause 3.7 shall be ensured with the wheel dia of 877 mm.

The equipment design shall permit the train operation up to 850 mm if the purchaser decides to run the stock with reduced clearance in future.

3.1.2 The average acceleration requirements on level tangent track, according to stipulations of Clause 2.4 shall be fulfilled with an average OHE voltage of:

i) 22.5 KV under AC traction and
ii) 22.5 KV under AC traction with half worn wheels at SDCL load.

3.1.3 The typical run of 1.5 Km on level tangent track for all out running i.e. without coasting and with regeneration braking for a super dense crush loaded 12 car rake (SDCL) with average line voltage of 22.5 KV in AC traction and half worn wheels shall be completed in 106 seconds with braking rates as specified. The typical run shall be taken as traction cycle with reference to Clause 3.1.7. Bidder shall also ensure compliance to clause 2.5. However, the maximum current drawn from OHE at the average line voltages specified herein shall not be exceeded at lower voltages.

3.1.4 The speed of 12-car Super dense crush loaded train shall be as specified in the Clause 2.4

3.1.5 Bidder shall submit the RMS current values for 1.5 Km typical run as per Clause 3.1.3. The R.M.S. (root mean square) loading of the traction motor with regenerative braking in use for all out running for the typical run as indicated above shall not exceed the continuous rating of the traction motor.

3.1.6 Ratings of equipment

i) The continuous rating of the traction converter, inverter & the traction transformer shall be based on the continuous rating of the traction motor by taking into account the efficiency & power factor and maximum loading of the equipment. The procedure for calculation of ratings is enclosed at Annexure II.

ii) Bidder shall submit detailed calculations of maximum power loading of all major components of the traction system including the maximum r.m.s. currents, tractive effort and motor torque for motoring. Similar calculations for maximum power loading of all the major components of traction system including maximum r.m.s. current, braking effort and motor torque for braking shall be submitted. During traction mode, maximum auxiliary power shall be taken into account and during braking mode minimum loading of auxiliary power shall be considered. While deciding the ratings of equipment the Bidder shall ensure that the performance of the EMU shall conform to the conditions laid down in the Clause 2.5.

iii) Efficiency curves of each equipment and tractive effort/braking effort (in KN) for each motor coach shall be furnished along with overall system efficiency curves. The total auxiliary power shall be furnished as break up of power requirement for lights, fans and ventilation loads, auxiliary power required for propulsion system.

3.1.7 Calculations/simulation for temperature rise of the traction motor for repeated traction cycle as specified above at 3.1.3 (without considering stoppage time) and the specified conditions shall be furnished by the Bidder along with the offer. The temperature rise shall not exceed the permissible value specified in clause 4.4.7.5. All the temperatures calculated on the basis of repeated runs/continuous duty cycles shall be deemed as stabilized temperatures.

3.1.8 The super dense crush loaded 12-car rake with one motor coach isolated and already running continuously in CST – Thane section with half worn wheels shall be capable of starting on a gradient of 1 in 34 and clear this section of 1 Km. The temperature rise of the traction motor and other

equipment shall be within thermal rating of the respective equipment as specified in Chapter 4. The one hour rating of the Traction Motor shall be submitted. Average line voltage during the period shall be taken 22.5 KV AC under traction. The time, in which the section will be cleared and the maximum speed attainable shall be furnished by the Bidder. The temperature rise of propulsion equipment shall not exceed the stipulated values. Bidder shall submit the traction motor temperature rise under the above conditions as per the Annexure II.

3.1.9 For a SDCL loaded 12 car train with one motor coach cutout, starting after continuous working in the sections of Central & Western Railway as specified in clause 3.1.12, the specified thermal rating of traction motor and equipment shall not be exceeded for full one trip (maximum approx. 250 Km), either way starting from one end. Bidder shall also furnish temperature rise of traction motor and other equipment under such conditions and overall running time in Churchgate–Andheri and CST–Thane, CST -Kasara section. Bidder shall refer Annexure II for further details.

3.1.10 For the purpose of final acceptance tests for the temperature rise and energy consumption etc., the train schedule shall be 10 round trips between Churchgate and Andheri Section of Western Railway, Mumbai CST-Thane &/or Mumbai CST -Kasara section of Central Railway with 30 seconds stop at each intermediate station and 2 minutes lay over at terminals. The sections and number or round trips to validate temperature rise are tentative only and may be changed by the IR during design stage. The schedule shall be carried out with all out running without coasting on 12-car rake. These tests shall also be done with 'one motor coach' isolated condition for at least one round trip and preferably the last trip.

The validation of other design parameters, as described in this Clause 3.1.3, 3.1.4, 3.1.5, 3.1.7 & 3.1.8 may not be possible on site. As such, these design features shall be validated during the performance tests on the combined test bed. Clause 5.7 may kindly be referred for further details.

3.1.11 The inter-sectional timings for the complete round trip of the train schedule specified for Churchgate and Andheri Section of Western Railway, Mumbai CST-Thane, Mumbai CST-Kasara of Central Railway for obtaining minimum energy consumption and best overall schedule speed shall be furnished by the supplier after the design finalisation. For this purpose, the supplier shall furnish the curves of the energy consumption, RMS loading of the traction motor with regenerative braking in use and overall schedule speed. RMS loading for all out running for the round trip shall not exceed the declared continuous rating of the Traction Motor and the temperature rise shall not exceed the stipulated limits.

3.1.12 Bidder shall also furnish the performance of 12 - car EMU rake with all out run & with 10% coasting in time on both slow and fast corridors, variation of line current, speed, distance, inter-station timings, motoring energy consumption, regenerative energy and RMS loading of traction motor for complete round trip between Mumbai CST–Kasara &/or Mumbai CST–Thane section of Central Railway and for Church Gate–Andheri Section of Western Railway. Route profile with details of temporary speed restrictions is placed at annexure V. The performance shall be submitted in graphical and tabulated forms. All the performance values, as desired above, shall be submitted for maximum speeds of 110 Km/h, 100 km/h & 80Km/h

separately. For slow corridors, the train will stop at all stations and for fast corridors, the following stoppages are to be considered:-

Churchgate to Andheri & Back	**Churchgate to Mumbai Central:-** Stopping at all stations.
	Mumbai Central to Andheri:- Stopping at Dadar & Bandra stations.
Mumbai CST to Kasara & Back	**Mumbai CST to Kalyan:-** Stopping at Byculla, Dadar, Kurla, Ghatkopar, Thane, Diva stations.
	Kalyan to Kasara:- Stopping at all stations.
Mumbai CST to Thane & Back	**Mumbai CST to Thane:-** Stopping at Byculla, Dadar, Kurla & Ghatkopar stations.

3.1.13 The variation of power/TE & BE with the OHE voltage, from starting to maximum speed, at the interval of 20 Km/h in the range of (i)16 KV to 22.5 KV AC in the steps of 1.5KV shall be submitted during design stage. The effect of the reduced power on run time for Church Gate–Andheri & Mumbai CST to Thane section and on a representative section of 1.5 km shall be submitted in graphical and tabulated forms.

3.1.14 It should be possible to form the 9/12/15/18 car rakes. In each formation by addition of the unit(s), the train control should be possible only from one end of driving trailer coach occupied by motorman. The Bidder shall furnish performance parameters with the above combination of rake formation.

3.1.15 The equipments shall be so designed that the coefficient of adhesion does not exceed the optimized value during powering or braking. The Bidder shall furnish the optimized value of coefficient of adhesion and the reason thereof.

3.1.16 Specified temperature rise of equipment shall be calculated after taking into account at least 25 % choking of air filters and radiator fins.

3.1.17 **Regenerated Energy:** The regenerated energy for all out running for (Churchgate - Andheri) section stopping at all stations, round trip shall not be less than 30% of the energy consumed during powering at the specified voltage indicated in clause 3.1.2. Acceleration and braking rates shall be as defined in Clause 2.4 and full auxiliary load shall be taken into account except ventilation & emergency load. Duty cycle for the compressor and lights shall be taken as 50% and for the balance load 100% duty cycle shall be considered. The net energy consumed or regenerated at the pantograph shall be used for calculating percentage regeneration energy. The regenerated energy shall be utilized within the system by other trains in the same feeding zone.

3.1.18 **Specific Energy consumption:** The specific energy consumption calculated as KWH per 1000 Gross Tonnes Kms (KWH/1000 GTKm) shall not be more than 35 KWH/1000 GTKm for schedule speed (i.e. distance/(run time + stop time)) of 34 kmph (approx.) in slow corridor and 45 kmph (approx.) in fast corridor of Churchgate-Andheri-Churchgate section with total stop time of 14 minutes & 7 minutes respectively. The auxiliary power consumption shall be considered as defined in clause no. 3.1.17 above. Details of run for Churchgate-Andheri-Churchgate section are as under:

Total distance of Churchgate-Andheri-Churchgate section = 43.660 Km.

Type of Run	Run time (Sec.)	Dwelling time (Sec.)	Scheduled Speed (Kmph)
Slow	3780	840	34
Fast	3066	420	45

3.1.19 **Continuous Operating Equipment**:

The capacity of the traction motors and equipment shall be adequate to permit continuous and punctual operation of SDCL trains under the operating and service conditions specified.

3.1.20 Bidder shall submit the residual acceleration for the SDCL loaded train starting on a rising gradient of 1 in 34 along with the time and distance for attaining 110 kmph speed on straight and level tangent track.

3.2 POWER SUPPLY AND ENVIRONMENTAL CONDITIONS:

The details are specified in the Clause no 2.5, 2.6 & 2.7.

3.3 NEUTRAL SECTION:

(i) Neutral section is provided in the AC traction area. Suitable arrangement shall be provided by the supplier in every motor coach to ensure that the loss of main power for each motor coach, while traversing through neutral section, is restricted to bare minimum. The supplier shall also supply the design details & specifications of fixed equipment to be installed at each neutral section or alternatively shall ensure compatibility of their equipment with the track side equipment, if already installed by IR and are already in use at the neutral sections at the time of design finalization stage.

(ii) It shall be possible for the system to open or close the circuit breaker sequentially while approaching and leaving the neutral section respectively. The system shall have all necessary safety provisions.

3.4 INTERFERENCE TO SIGNAL AND TELECOMMUNICATION INSTALLATIONS

Interference to signal and telecommunication installation shall be as per the Clause no.2.8.

3.5 TRAIN RESISTANCE: Train Resistance of the existing EMU motor and Trailer Coaches is as under:

Motor coach:
R = 2.35 + (0.02922-0.00049xW)xV+(0.03722/W)xVxV Kg/t

Trailer/ Driving trailer Coach:
R = 1.347 + 0.00385xV + 0.000165xVxV Kg/t
where W is the gross wt in tonnes,
R is the resistance in Kg/tonnes, and
V is the speed in Km/hour.

Starting Train resistance: The starting train resistance for EMU motor and trailer coaches is 4 kg/t.

The performance calculations shall be done with the train resistance formulae as indicated herein.

3.6 EQUIPMENT LAYOUT

3.6.1 Traction Motor

The axle hung nose suspended traction motors are to be mounted on the existing motor coach bogies in similar manner as the existing motors are mounted in AC/DC EMUs running in Mumbai area. The motors shall be provided with roller bearing suspension suitable for mounting on the existing motor coach bogies. The modifications required for roller bearings on the existing axles shall be minimal and shall be advised by Bidder. The present dia of the axle at sleeve bearing zone is 180 mm. The inner diameter of the inner race shall be 196+ mm to be selected from the commercially available standard international sizes. The drawing for the finished machined axle shall be furnished by the Supplier for approval at design stage.

Finished machined axles to the approved drawing shall be supplied by Railways. Drawing of the rough axle is enclosed (refer annexure XII).

3.6.2 High Tension (HT) Compartment layout

(i) The Converter-Inverters, Auxiliary converter unit, Auxiliary compressor, Elecrical Control Cabinet (ECC) and Auxiliary Control Panel (ACP) etc. are presently mounted in the High Tension equipment compartment provided on board of motor coaches. 3-phase drive equipments should be capable of being mounted in the H.T. compartment of the driving motor coaches. The supplier will ensure that the size of the HT compartment is not required to be increased. Adjoining the HT Compartment, there is a driving compartment of same width and 0.936-metre length. It will be possible to utilize a part of this space as well, as only the master controller for traction control and the brake controller for the brake control by the driver are required to be provided in this area.

(ii) At present the central portion of this H.T. compartment is clear from the floor with vertical clearance of 2.85 metres over a width of about 3 metres. However, the available clear height is likely to be reduced by about 120mm in order to conform the coach profile to DC MMD (refer Clause 2.2) with the roof equipment as supplied by the Supplier suiting to 25 KV insulation system. Supplier shall design the equipment accordingly so that enough space is available for maintenance works. The dishing of roof, as above, shall not be extended to the passenger area and shall be restricted to the HT compartment roof as far as possible. Bidder shall submit the roof layout (plan & elevation) with the equipment mounted vis-à-vis DC MMD demarcating clearly the area where the dishing may be required. Details shall be worked out during design stage.

(iii) Presently, equipment mounting in the H.T. compartment is from the sides through hatch openings of 1.8 meters height and 1.3 meters width. However their height is likely to be changed due to dishing of the roof. It shall be possible to remove and take out the complete cubicles from the HT

compartment without disturbing any other cubicle. Each cubicle shall have enough working space in its top & front for easy working.

(iv) Fitment of various equipments will be so decided that the body weight is properly distributed so that the axle load is within permissible limits after taking into consideration unbalance during the tare and SDCL loading conditions.

(v) Control equipments for the driver will also be required to be provided in the leading driving trailer coach, which has clear cab space of 3.6 meters width and length varying from 1 meter at the ends to 1.2 meters at the middle. Height being common to the height available in the undished H.T. compartment.

(vi) H.T. compartment shall be pressurized to avoid the ingress of dust.

(vii) Layout drawing of existing AC-DC EMU motor coach and DTC may be referred annexure-XII.

3.7 MINIMUM CLEARANCE FROM RAIL LEVEL

Under fully worn wheels and SDCL condition of the coach, the minimum clearance of bogie-mounted equipment from rail level shall be more than 103 mm under worst conditions. The minimum clearance for the body mounted under slung equipment shall be 215 mm under tare condition with fully worn wheels.

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CHAPTER 4

ELECTRICAL REQUIREMENT

SCOPE OF SUPPLY & TECHNICAL SPECIFICATIONS

4.0 A) SCOPE OF SUPPLY

The scope under this tender covers design, development including simulation studies, manufacture, supply and erection, commissioning of complete set of 3-phase drive equipment for 25 KV, 50 Hz AC BG EMU Motor Coaches, Driving Trailer Coaches & trailer coaches as detailed in the 'Schedule of Requirements' in the Bid document and will include:

i) Traction transformer with required number of secondary traction windings along with protection equipments.

ii) Gapless lightning arrestors for 25KVAC.

iii) IGBT based PWM power converter-inverter

iv) DC link with 100 HZ resonance filter and/or any other equipment necessary to reduce the effect of other harmonics on S&T equipments.

v) Asynchronous traction motors compatible with IGBT power supply, with pinion and wheel gears, roller bearings, sensors and equipments necessary for provision of suspension roller bearings

vi) Microprocessor based traction control system including fault diagnosis and display system in the driving cab.

vii) Pre-charging resistors, braking resistor and associated power/control contactors.

viii) Auxiliary converter for auxiliary supplies, battery charging and to cater forced ventilation system.

ix) Auxiliary machines such as oil pump, oil cooling blowers for traction transformer, blowers for power converter-inverter, auxiliary converter, lights and fans for motor and trailer coaches etc.

x) Pneumatic system comprising of main air compressor, air dryer, filters and auxiliary compressor

xi) VCB for AC operation

xii) Pantograph & Earthing Switches for AC operation - Single pantograph suitable for 25 KV AC supply shall be used on each motor coach.

xiii) Train Management System, Multiplexing system for relevant Control & other Signals and any other equipment, cables, inter-vehicular couplers & terminal equipments. Inter-vehicular couplers shall be supplied in assembled form.

xiv) Power & control cables including terminal equipments.

xv) Complete pre-fabricated driver's and shunting desk. The cab shall include all the cab equipments e.g. combined master-cum-brake controller, instrument panel with back-lit instruments, gauges for pneumatic indications, control panels, driver's diagnostic display unit & driver's "log in" device, driver and guard seat etc., ergonomically designed driver'

desk/console, pre-wired and terminated on a terminal board and multi-pin plugs/sockets for inter-equipment connections. Cab-equipments shall also include pneumatic horns, electric motor driven wind screen wipers with redundancy & emergency manual control, sun-screens, auxiliary head light with tail light, safety related equipments like bell code system, flasher light and speedometer-cum-recorder.

xvi) Pressurization of H.T. compartment to avoid the ingress of dust.

xvii) Higher sweep Fans i.e. 450 mm and lighting system including coach lighting, headlight and marker light etc. Control switchgear shall also be supplied for these items.

xviii) Passenger information system including coach displays, head code, audio communication system and interface with the existing train monitoring system on Central and Western Railways and any equipment required for interfacing PIS with the Receiver-Equipment of existing train monitoring system on Central & Western Railways. Receiver Equipments of existing Train Monitoring System is in the scope of supply of the purchaser and is mounted in the driving cab. The specification shall be made available to the supplier at the design approval stage if required.

xix) Complete set of MCBs contactors, relays etc. for propulsion system, controls, auxiliaries etc.

xx) Parking brake equipments complete with controls, associated valves & wiring etc.

xxi) APC receiver compatible with existing track magnets

xxii) Brake Control Electronics complete system fulfilling the brake blending requirements.

xxiii) Weight Sensors with adequate redundancies.

xxiv) Any other equipment for power isolation and interlocking etc. and required for proper functioning of the traction equipments in AC operation.

xxv) Instrumentation required for commissioning and field-testing of the equipment.

xxvi) Special tools required for maintenance

xxvii) Maintenance spares for three years

xxviii) Complete forced ventilation system. The ducting arrangement for prototype units only.

B) TECHNICAL SPECIFICATIONS FOR 3-PHASE PROPULSION SYSTEM WITH SYSTEM AND ASSOCIATED EQUIPMENTS

The 3-phase drive equipments shall be based on the technology proven in successful service applications as identified by the Bidder in the Bid Data Sheets / Clause 1.1.4 (xxiii). The equipment shall be suitable for regeneration for full speed range. The broad specification of the various equipments is furnished below:

4.1 TRACTION TRANSFORMER

4.1.1 A fixed ratio transformer will be provided with multi traction windings suiting the requirements of IGBT based power converter-inverters to meet the load of three-phase propulsion equipments. The number of secondary traction windings should match the number of power converters duly phase shifted for the motor coach.

4.1.2 The KVA rating of the transformer shall be specified at a line voltage of 22.5 KV and shall be designed to deliver the power at a total current corresponding to the continuous rated traction motor currents after accounting for the efficiency & power factor of traction motor, converter-inverters, auxiliary converter for meeting the auxiliary load as specified in the specification clause 4.14.4. The guiding principle for calculation of rating shall be as per clause 3.1.6. Bidder shall note that the performance is required to be guaranteed for the range of voltage as per the clause 2.5. The transformer will be designed with overload capacity to permit full utilization of the traction motor capacity during starting as well as running.

4.1.3 The transformer will be designed to conform to IEC 60310 and temperature rise limits of the windings and oil shall correspond to IEC 60310 minus 20^0C under all conditions of operations.

4.1.4 The secondary windings shall have a very high magnetic de coupling.

4.1.5 The transformer shall be of modular construction. To maintain the overall dimensions as to existing size, improved insulation scheme shall be adopted to the extent possible. In case the change in the dimensions of the new transformer is inevitable, the change should be minimal. The transformer shall be complete with oil pump and radiator with blower, conservator and protection equipment assembled in single module. Means will be provided for letting out the oil from transformer to the underside of the coach in the event of any fault/electrical disturbance in the transformer causing oil to rush out. No part of the transformer shall protrude above floor level. Adequate care shall be taken in design in view of the high humidity for long duration (in coastal areas). The silica gel, if used, should not require attention in between the Schedule examination.

4.1.6 The cooling agent for the transformer shall be arc resistant and shall have high flash point.

4.1.7 The transformer shall be under slung and the mounting arrangement shall preferably be same as of existing transformer, otherwise it shall clearly be indicated by the Bidder. The lower portion of the tank shall be of adequate strength so as to protect against hitting by extraneous objects while on run.

4.1.8 Current transformer, potential transformer and matching overload relay shall be in the scope of supply.

4.2 LIGHTNING ARRESTOR

Gapless type lightning arrestors of well proven design for 25 KV AC shall be provided on the roof of the motor coach for protection against line voltage transients caused by lightning or system switching.
Additional gapless type arrester shall be provided immediately after 25KV AC circuit breaker.

4.3 POWER CONVERTER-INVERTER

4.3.1 The four quadrant power converter-inverter shall be of a design service proven in similar applications, IGBT based with PWM control to ensure regeneration and the power factor near to unity. The range of variation of power factor shall be submitted by the Bidder.

4.3.2 Cooling System

Power Converter-Inverter offered shall be forced air/water cooled.

4.3.3 The voltage rating of IGBT would be so chosen that at least 25 % margin is available after taking into consideration the DC link voltage and voltage jump on account of inductance and capacitors in the circuit. The current rating of IGBT shall be such that the junction temperature has minimum thermal margin of 10^0C in the worst loading conditions and under the ambient conditions as specified. Bidder shall submit the maximum junction temperature of the devices under worst operating conditions.

4.3.4 The catenary voltage fluctuates widely as indicted in the clause 2.6. The variation of frequency has also been indicated therein. The converter shall be provided with necessary control to provide the guaranteed performance under such fluctuations without exceeding the rated cut off current of IGBT and keeping minimum cut off time within limits.

4.3.5 In the vital units of power control circuit like power supplies etc., where any defect/failure of component would cause complete failure of the motor coach, suitable means for redundancy will be provided in order to avoid the motor coach failure or reduction in performance due to such defects. Bidder shall specifically submit details of the redundancy provided in the system to this effect.

4.3.6 Suitable margin shall be provided in the equipment rating such that under emergency condition with isolation of single traction unit such as converter, traction motor etc., there shall be no necessity to withdraw the rake from service and journey is completed satisfactorily. The one hour rating/thermal rating as specified herein of the equipment will not be exceeded under such operation. For such purpose, short time rating of the major electrical equipment such as main transformer, power converter, auxiliary converter/inverter and traction motor etc. will be furnished. Bidder may also refer clause 3.1.9.

4.3.7 Selective isolation of individual bogies i.e. two motors, shall be ensured by providing individual and independent inverter for each bogie of the motor coach. The propulsion equipment shall ensure the guaranteed performance for wheel diameter differences for at least up to 6 mm within any bogie and up to 13 mm between bogies without any adverse affect on any equipment. If the wheel diameter tolerances exceed the above limits then no damage shall occur to any equipment. Bidder shall also furnish the permissible diameter difference between the wheels of the same bogie and those on different bogies of the same coach as affected by the control of individual motors, individual bogies or of complete motor coach.

4.3.8 The protection/alarm/indication circuit will normally have self correcting features rather than cause tripping of the motor coach for reduction of the tractive effort. If the driver intervention is needed, sufficient indication will be given to the driver to enable corrective action to be taken in time. It shall be possible for the driver to take any protective action, or any other action as indicated to him through diagnostic display, on any of the motor coaches in the rake, if so desired, from the driving cab itself.

4.3.9 Freedom from dust and protection from surges will be ensured. Modular construction will be adopted wherever considered possible. The converter/inverter system and transformer will be capable of withstanding the maximum short circuit current under fault conditions and these will be established as well. As such in case of any dead short circuit across the outgoing terminals of converter/inverter systems, the system shall provide adequate protection so that no damage is reflected on the converter/inverter system.

Inverter and line converter modules shall preferably be of identical design in use, as far as possible, with identical components.

4.3.10 The propulsion system shall be suitable for operation on 25 KV AC. Bidder may adopt DC link voltage suitably and submit the details with justification along with the offer.

4.4 TRACTION MOTOR

4.4.1 Axle hung nose suspended 3-phase asynchronous type of traction motor suitable for IGBT converter/ inverter shall be used. Traction motor shall be suspended on the nose of the bogie and shall be axle hung by means of roller bearing and suspension tube.

4.4.2 The general design and manufacture of the motor will be done to the standard IEC 60349-2 in accordance with the modern traction practices. The design will include all those features which are known to have worked well in the tropical climatic conditions. The maximum working speed of traction motor corresponding to 110 kmph with full worn wheel of 877 mm diameter shall not exceed 3000 rpm. Traction motors with speed lower than the above will be preferred.

4.4.3 The motor will be rated as per the EMU performance requirements for the most severe service operation as defined in IEC 60563. It shall withstand safely with adequate design margins to work satisfactorily at maximum power operating point under motoring & regenerating. Calculations for maximum

power loading shall be furnished by the bidder taking into account gear efficiency.

4.4.4 The motor will be capable of withstanding transients such as line voltage fluctuations, switching surges caused by stalling and wheel-slips.

4.4.5 It should be possible to absorb the stresses resulting from short circuit so as to have sufficient safety against damage or loosening of electrical connections. The safety factors should be furnished during design review for approval. The Bidder shall also comment on the design adequacy of the construction of the motor for the maximum to continuous tractive effort ratio and the specified speed. The Bidder shall also submit a detailed note on the robustness of rotor bar construction with end rings, precautions against loosening of bar in slots, overheating etc. from the full life cycle point of view. IR has experienced the failure of brazing joints specially in the traction motor junction box. In view of this, additional measures shall be taken for ensuring the adequate strength of brazed joints. In this respect, the supplier shall furnish the detail note during the design and suitable test scheme for ensuring the efficacy of the design.

4.4.6 The following operational and environmental factor will be specially kept in view in the design of the motor:

4.4.6.1 Because of track irregularities, level of shocks and vibrations to which traction motors are exposed are far more than actually given in IEC for axle hung nose suspended TM mounting arrangement. Tenderer can obtain the data of vibration trial from IR and in case of any doubt; the tenderer must carry out instrumented trials on existing stock for measurement of shocks and vibrations in Mumbai sub-urban area in consultation with RDSO, at design stage, only.

4.4.6.2 Prevalence of high temperature and humidity for the most part of the year.

4.4.6.3 Operation of the EMU over a humid and salty terrain in which the climate varies from high rainfall for 4-5 months and extremely dusty atmosphere during rest of the year.

4.4.7 Insulation System:

4.4.7.1 The insulation system to be employed will be particularly designed to withstand the adverse environmental conditions. The materials comprising this system and the system itself shall have to be proven and of the highest reliability in traction applications. Imperviousness to moisture will be a special requirement.

4.4.7.2 The evaluation of the insulation system for thermal endurance will be made with fabricated test models by way of accelerated aging test as per the test programme drawn up in accordance with the norms specified in IEC: 60034-18 and IEC 60505/1999. Various aging parameters such as heat, vibration, mechanical / compressive stresses, special environmental effects of humidity with water immersion test, dust, metallic dust from bake shoes, etc. will be incorporated to simulate the actual working conditions as closely as possible.

(i) Evaluation of the insulation system for sealing against moisture will be done in accordance with IEEE 429. The temperature index of the insulation

system corresponding to the extrapolated life of 20,000 hours shall be established. In this connection, the bidder shall submit test certificates of the moterette test carried out on the insulation system of the similar traction motor along with the offer, followed by test on motorette manufactured with the insulation scheme and design of proposed traction motor.

4.4.7.3 In view of the extremely humid climatic and environmental conditions as specified in clause 2.9, the insulation system shall be tested against humidity and water immersion vide clause 4.4.4.5, 4.6 and 4.7 of IEEE 429-1994.

4.4.7.4 The motor will be designed such that the “hot spot” temperature under conditions such as one hour, short-time and continuous rating of loading in any winding (stator and rotor) does not exceed the average temperature of that winding measured by resistance method by more than 30° C.

4.4.7.5 Having regard to the system of insulation adopted and the environmental conditions the maximum temperature rise in the traction motors will be less than the temperature index minus 70°C under all operating conditions including emergency operations.

4.4.7.6 The mechanical design of traction motor, its mounting arrangement on the bogies , transmission system(pinions and gears, gear case etc.) shall be designed considering the measured data of shock and vibration , as mentioned in para 4.4.6. Various components of traction motors shall be manufactured with such tolerances so as to enable complete interchangeability of components from one motor to another of same design.

4.4.7.7 **Harmonic/Ripple Factor**: The traction motor will operate satisfactorily over the entire range of loading, with harmonic/ripples imposed on from the IGBT based supply system (comprising of the transformer and converter/inverter both during motoring and regeneration braking conditions). With the harmonics/ripples generated by the converter, temperature rise in traction motor shall be in accordance with that mentioned in Paras 4.4.7.4 and 4.4.7.5. With regard to the system of insulation adopted and the climatic and environmental conditions, the tenderer shall provide maximum margins in the temperature rise, for the prolonged life of the traction motors. The manufacturer shall conduct necessary tests on the traction motor to establish compliance with this requirement.

4.4.7.8 Criteria of selection of the traction motor bearings (equivalent dynamic and static loading of the system with respect to those of bearings, limiting speed, reference speed, etc.) and its lubrication system (thermal stability) should be brought out and all the calculations must be provided at the time of design stage.

The designed L10 life should be at least 2.5 million KM. If the insulated bearing is used, then the reason for the same should be specified in the offer. For calculation of L-10 life, calculation of equivalent dynamic loading for the proposed traction motor bearing shall be provided to IR for evaluation.

Traction motor bearings shall be rivet less and grease lubricated on both DE and NDE sides, independent from gear case lubricants. Intermixing of TM bearing and gear case lubricants is not allowed. The greasing interval & overhauling frequency of the bearing may be specified. Standard and proven

bearings with at least one year successful service experience in axle hung nose suspended arrangement shall only be used.

4.4.7.9 The armature shaft should be detachable from rotor. The rotor should be reusable/ repairable. Copper Rotor Cage in the traction motor is mandatory. No extended shaft (plugged in type) shall be used for pinion mounting.

4.4.7.10 The speed sensing device for control purposes, if necessary, shall be mounted on the traction motor itself.

4.4.7.11 If winding temperature probes are provided for control purposes, then it should be indicated in the offer. In any case, suitable provision shall be made to detect traction motor over temperature for ensuring timely protection to the traction motor before any damage occurs. Bidder shall substantiate the compliance.

4.4.7.12 Speed sensing device and the temperature probe should be made accessible from the pit and should also be replaceable. The mounting arrangement of the speed sensing device and temperature probe shall consider the protection of these sensors against breakages during the train operation. Their maintenance/ replacement shall not require lifting of the motor coach. The arrangement should correspond to the flood-proofing requirement. The connecting leads should be protected from mechanical damages and should be fastened to the motor at least at one point. The end shields shall be provided with suitable protection arrangement to protect the windings from any damage due to flying ballast during run.

4.4.7.13 Design shall provide for screened motor cables for control purpose. The screening should be grounded at the motor. The terminal markings should be legible permanently on the cables.

4.4.8 Traction Motor Tests: The traction motor shall be subjected to all the prototype & routine tests in line with IEC 60349-2. Prototype tests shall include continuous temperature rise test, short time rating tests, characteristics tests, over speed, power factor, efficiency, dielectric & torque measurement tests.

4.4.9 Special tests on traction motor:

The following special tests on traction motor shall be carried out along with those specified in IEC 60349-2:-

i) Flood proofing tests: Traction motor fitted with pinion & gear box running at 200 r.p.m (without gear, axle roller bearing housing & other attachment parts) to be immersed up to 760 mm from rail level for 24 hours. Following test parameters shall be recorded:

a) Insulation resistance before immersion test
b) Insulation resistance after immersion test
c) Visual inspection regarding seepage of water inside the gear box and motor

ii) Tests on speed/temperature sensors - in case of proven items, certified test reports shall be acceptable.

iii) Testing of insulation system as per IEEE 429-1994 at the relative humidity of 95-100% for a period of 48 hours and water immersion test for 30 minutes along with the voltage tests – as per further details specified in clause 4.4.4.5, 4.6 and 4.7 of IEEE 429-1994.

iv) Measurement of waveforms of the motor converter voltage, motor converter current, motor torque & space vector flux under different ranges of operation during heat run & characteristics test on converter supply.

v) Vibration test

vi) Traction motor roller bearing test

vii) Roller suspension bearing tests
The hot spot measurements shall be done during prototype tests on traction motor by embedding thermocouples in the stator winding.

4.4.10 TRACTION MOTOR DRIVE

i) The torque transmission arrangement from traction motor to axle shall be simple and suitable for both traction and braking forces. The tractive/braking effort shall be directly transferred from the traction motor pinion to the wheel gear. Lubrication system for gear/pinion shall be kept physically segregated from traction motor bearings and motor suspension unit bearings. Both the ends (drive and non-drive) of traction motor and motor suspension unit bearings shall be grease lubricated, only. The complete arrangement shall be of proven design for same or higher traction/braking torque transmission. However, special care shall be taken in design with respect to high track vibrations as mentioned in clause 2.3 and para 4.4.6. Bidder shall submit relevant details in this regard along with the special measures taken in view of the specified track data and environmental conditions.

(ii) Roller Suspension Bearing: The motor shall be axle hung nose suspended and with roller suspension bearing. The bearing should be selected to have L-10 life of 6 million Kms. For calculation of L-10 life, calculation of equivalent dynamic loading for the proposed motor suspension unit bearing shall be provided to IR for evaluation. Criteria of selection of the motor suspension unit bearings (equivalent dynamic and static loading of the system with respect to bearings, limiting speed, reference speed, etc.) and its lubrication system (thermal stability) should be brought out and all the calculations must be provided at the time of design stage.
Motor suspension unit bearings shall be grease lubricated on both DE and NDE sides, independent from gear case lubricants .The design of suspension shall ensure no leakage or ingress of gear case compound into the roller bearing under any circumstances. Standard and proven bearings with at least one year successful service experience in axle hung nose suspended arrangement shall only be used.
Details for the interference fit of bearings should be furnished during design approval. The suitability of the entire drive consisting of traction motor, gear and suspension including axle should be proved in a type test.

iii) Gear case shall be made of steel and shall have sufficient mechanical strength so as not to get damaged due to hitting by ballast or any other foreign objects. Aluminum shall not be used anywhere in the under frame. The design of gear case shall ensure minimum loss of lubricant during run. Cast steel gear case shall be preferred. The oil circulation in gear case should

be independent to the lubrication of bearings for the traction motor. The Use of helicals in the threaded holes for fastening of bolts shall not be permissible.

iv) **Traction gear:** All traction gears will be case hardened alloy steel of approved quality. The MTBF for the pinion should at least be 1 million Km and for the gear wheel at least 2 million Km. Pinion and gear wheel should be produced from case hardened alloy steel. The gear case design shall be furnished and finalized during design approval. Supplier shall submit proof of stability for gear tooth forming and total design, description of the gear tooth forming, provided materials, manufacturing and hardening procedures with corresponding specifications, Oil types and lubrication intervals.

4.5 MICROPROCESSOR CONTROL AND DIAGNOSTIC SYSTEM:

4.5.1 Microprocessor based control system will be used for converter control, DC link control, inverter control, traction control, braking control, auxiliary power control, slide and slip control, converter actuating, monitoring of commands to the control units and protection etc. The link between the microprocessor and the interfaced cards should be established by means of serial bus system. Suitable physical bus interface, to ensure error free and high speed data transmission should be provided. It is desirable that majority of control and monitoring functions are implemented by software so as to reduce hardware and cables. All electronic cards shall be suitably protected against dust and moisture. The protection level and the arrangement shall be furnished by the Bidder. The electronics shall be tested for its functionality in a dusty and humid environment. The electronics and other equipment shall be suitably protected against mould or fungus growth.

4.5.2 Microprocessor should perform the task of fault diagnostics and display in addition to control task. The microprocessor should be capable of monitoring the status of the equipment and continuity of jumper cables continuously and occurrence of faults. The microprocessor should also take appropriate action and where ever necessary shut down the equipment. The faults occurring in any of the motor or trailer coach shall be displayed in appropriate form in the driving cab. Coach wise faults shall be displayed with messages on LCD screen in driver's cab as per clause 4.8. It shall be possible for the driver to select and take appropriate action viz. isolation of specific equipment of any motor coach etc. from the cab itself, if so desired.

4.5.3 The faults should also be stored in the memory of the microprocessor and it should be possible to output the same by means of USB/serial interface to commercially available printer or personal computer. The various important parameters of the equipment as well as environmental data at the time of occurrence of the faults should also be recorded with a view to enable proper fault analysis. Application/diagnostic software tools as required for trouble shooting and analysis of equipment wise and motor coach wise faults and maintenance of the EMU and equipment shall be provided. Adequate redundancy should be built in the microprocessor.

4.5.4 It shall be possible to down load the major diagnostic messages of the rake from the DTCs. There shall be arrangement of online downloading of fault diagnostic messages through GSM or other suitable links from train to maintenance car sheds / depots. The communication link shall be responsibility of IR; however integration shall be responsibility of the supplier. It shall be possible to down load the faults of any defective motor coach from

this motor coach itself. The diagnostic messages of at least last 45 days shall be available in its memory.

4.5.5 It shall be possible to keep the EMU at the desired speed irrespective of track profile. The speed control shall work within the limits of maximum electrical performance. The selection of speed shall be possible by press of a switch. However, the system shall be inherently fail safe and shall immediately come out of this mode to normal mode on actuation of master/ brake controller, actuation of AWS or as required from safety considerations. In case preset/selected speed control is not used, the tractive effort control will enable the EMU to be driven on the basis of tractive effort readings.

4.5.6 It shall be possible to read and record the energy consumption figures for regeneration and traction for a particular time period for the individual motor coach and for the full rake, along with train no., the name of the driver, date, time journey details etc. as fed through suitable electronic device in the driver's cab, details to be worked out during design stage. These figures shall be available readily on the driver's display panel as and when required and shall be retrieved through PC.

4.5.7 Isolation of motor coach shall not affect the normal functioning of brake system. Under such conditions, the regenerative braking from other motor coaches shall not be affected adversely. The regenerative braking shall be independent for each bogie and faults on one bogie shall not affect regenerative braking performance on the other.

4.5.8 It shall be possible to test the software after uploading the same by means of simulation facility or by some other means. The downloading of the software, and detail diagnostics etc. shall be feasible through any motor coach or DTC in the rake. The configuration of the motor coaches for the purpose of interlacing etc. shall be automatic and without any manual interference in case of isolation of motor coaches during the service or change in the formation of the rake in the shed so as to ensure compliance to clause 2.8. Bidder may note that the control for the complete range of operating speeds for one basic unit (one DTC, one MC and one TC/NDTC) level shall also be preferred though the normal operation of the EMUs shall be in 12-car, 15-car or 18-car formation.

4.5.9 Acceleration and speed shall be clamped to a selectable value while opting for 'shunting' operation. The shunting operation shall be selectable and shall be recorded.

4.5.10 The microprocessor control and diagnostic system shall also provide for measurement and recording of speed of the EMU in the driver's cab with the provision of wheel diameter correction, distance travelled and time.

4.5.11 The system shall ensure normal working & with out any adverse effect on any equipment while traversing the neutral section.

4.5.12 It shall be possible to selectively operate the circuit breakers or pantographs if so required by the driver. Sequential operation of VCB as desired vide clause 3.3 shall be ensured.

4.5.13 It shall be possible for the IR to execute any modification through software by changing the variable data or otherwise, if so required in future in order to improve the operation of EMU. Supplier shall supply all necessary

software/hardware tools required for the purpose. However, in case the implementation of the modification calls for any provision of any specific equipment, the purchaser shall provide the same. The modifications shall be restricted to parametric changes as permissible within the design constraints, details shall be finalized at design stage.

4.5.14 The bidder shall submit separate lists of safety signals, control signals and priority signals etc.

4.6 PROPULSION CONTROL, PASSENGER INFORMATION & COMMUNICATION

4.6.1 The leading cab will be controlling the motor coaches in the rake formation. Necessary provision shall be made for acquisition and transmission of data required for leading cabs and the controlled equipment on other coaches. Necessary measures shall be taken to ensure that the control signals are not distorted by any type of interference.

4.6.2 Passenger Information & Communication System

Passenger Information & Communication System shall be a proven one based on GPS system and shall provide following facilities:

i) Driver-guard or cab–cab communication between two driver's cabs on the train.

ii) Public Address announcements or playing of taped information by the driver & connectivity of the public address system of the train with the announcements made by train controller through Train Monitoring System installed by respective user Railways. The details shall be collected by the bidder in association with the respective user railway and the control scheme finalized.

iii) Displays like type of service, class of coach destination, halts, name of the approaching station & platform direction etc. in the coaches on the LED (Multi-coloured) screens specifically designed against vandalism, water & dust ingression. Data input shall be from the driver's console as a part of setting up procedure from both driving trailer coaches (preferably by Guard but also possible by driver). Display panel for Passenger Information & Communication System shall be provided separately on driver's console than the display panel specified in clause 4.8.2. Coach displays will be both in Hindi, English and in one regional language as optional. The display should have two dimensional graphic LED matrix display for catering to display of advertisements in multicolor i.e more than two colors. Galvanic isolation and Video Display Processor (VDP) instead of Video Display Controller (VDC) may be used as per design requirements. The internal displays shall be IP 54 class.

There shall be two one sided and two double sided internal displays of approximate size 15 cm H × 60 cm W × 7.5 cm D (single sided for end walls fixing & double sided for middle fixing displays) per coach. The encapsulation class shall not be less than IP 54 with the suitable arrangement to avoid damage to display due to vandalism. The size, number, matrix & resolution of LEDs with L-70 life time shall be such that it shall be visible clearly from

distance of 20 meters minimum. The viewing angle for the internal displays shall be 60 degree for uniform intensity and 90 degree with slight reduction in intensity.

iv) Destination indicator (Head Code) shall be provided on the driving coach face. The head code box shall be behind the lookout glass & flushed with the driver cab interior. A modern high resolution LED display in both English and Hindi in amber colour shall be provided which should be visible clearly from the platform from the distance of 50 meters minimum (in day light) while the train is approaching the platform. Full details of the data to be incorporated will be furnished to the Supplier at the design stage. Data input shall be from the driver's console as a part of setting up procedure. The destination indicator shall have IP65 protection. Head code display shall include Destination, location of Handicapped coach, Rake formation, Slow/Fast etc. However, the appropriate class and overall dimensions according to the location shall be frozen during the design stage. There shall be provision of manual over ride feature for setting the Head Code display in the event of failure of Passenger Information System (PIS) electronics

The viewing angle for the destination indicators shall be 60 degree (+/- 30 degree from the centre line).

v) The microphone used by the driver shall be common for all voice modes and priority shall be allocated to various modes.

vi) The PA intercom system shall be controlled by the keys in the driver's dashboard. The driver shall have the facility of adjusting the volume level from a minimum to maximum level by suitable mode provided in driver's dashboard.

vii) The communication shall be in full duplex mode and multiplexed with suitable measures to prevent acoustic feedback. The priorities of different functions of the PA system shall be defined.

viii) In case of failure of one unit of PA system or a passenger communication unit in one car, there will be no failure of the whole system. The loudspeakers shall be separated into two groups, each audio line being supplied by it's own power amplifier. Suitable arrangement for ensuring the adjustment of the volume of loudspeakers against the varying ambient noise shall be provided. While designing the system, adequate care shall be taken to prevent damage of equipment due to vandalism, water and dust as the EMUs shall run with doors wide open. This shall also have bearing in selection of amplifiers of adequate capacity. Suitable tools for configuring the system shall be provided.

At least 8 speakers shall be provided in each motor/trailer coach respectively so as to ensure the optimum audio level uniformly distributed in the passenger compartment. The exact number shall be decided during design stage. System shall provide adequate redundancy and expendability to undertake future requirements of IR. Bidder shall enclose detailed comments on this subject. It shall also be possible for the driver/guard to manually adjust the amplification levels of the public address system. The complete integration of the system including the uploading of sound files, announcements and advertisements shall be the responsibility of the

supplier. Any modification e.g. in announcement and advertisement files shall be user friendly.

ix) All the communication and control cables shall be conforming to international standards for fire retardant, fire survival characteristics suitable for the EMU services.

4.7 MASTER CUM BRAKE CONTROLLER

4.7.1 A combined master cum brake controller, integrated into a single unit shall be used. This shall be of a proven design and shall be of step less type. Suitable provision shall be made to ensure unhindered operation in case of failure of master controller.

The master controller shall be provided with a dead man's device which shall have to be remained activated manually and consciously by the driver. In case of the driver gets incapacitated and the 'dead man' device is released, the emergency brakes shall apply through direct opening to atmosphere.

4.7.2 The master controller shall be suitable to ensure controlled speed. For the purpose of wheel slip and slide control, the 3-phase drive traction/braking control system shall supervise the following condition and take corrective action:-

-- Excessive acceleration
-- Differential speed between axles
-- Over-speed control

4.7.3 Suitable forward/reverse interlocks and interlocks with braking system shall be incorporated in the master controller. The traction shall be possible only from one cab at a time.

4.7.4 Maximum utilization of the regenerative braking is envisaged in the 3-phase drive system such that regenerative braking is available over full range of speed to be blended with the EP brakes.

4.8 DRIVER'S CAB

4.8.1 Layout of Driver's Cab

i) Supplier shall design the complete pre-fabricated driver's and shunting desk in line with the UIC 651 to the extent possible. The layout of the crew area and control system shall be ergonomically designed to allow crew to efficiently operate all controls for safe train operation either sitting or standing. The modification required to be implemented in the coach body viz. layout of pneumatic pipelines and adjustment to the cab depth etc. shall be implemented by the supplier in association with the manufacturer to the maximum possible extent.

The cab shall include all the cab equipments e.g. combined master-cum-brake controller, instrument panel with back-lit instruments, gauges for pneumatic indications, control panels, driver's diagnostic display unit & driver's "log in" device, driver and guard seat etc., ergonomically designed driver' desk/console, pre-wired and terminated on a terminal board and multi-pin plugs/sockets for inter-equipment connections. Cab-equipments shall also include pneumatic horns, electric motor driven wind screen wipers (wiper

should have wind screen washer & control as well) with redundancy & emergency manual control, sun-screens, auxiliary head light with tail light, safety related equipments like bell code system, flasher light and speedometer-cum-recorder. This shall also include suitable 'bell code exchange' system between the cabs of the EMU train. Destination indicator (Head Code) shall be provided behind the lookout glass & flushed with the driver cab interior.

ii) All crew workstation/driving desk and cab area controls must be robust, of industrial quality and resist physical abuse and vandalism. Moulded FRP or better material suitable for such application must be used. The color scheme of interior shall be frozen at the time of design approval.

iii) The top of the driver's control workstation must accommodate documents such as timetable or similar books without interfering with the operation of the controls. Suitable space for keeping crew bag/briefcase, fire extinguisher and skids shall be provided in the cab.

iv) The positioning of crew interface controls must be such that they are within the range of vision, touch and audibility requirements whilst the crew is in his/her normal operating positions under all operation conditions.

v) Crew cab, pipes and conduits
Equipments such as air pipes, conduits, ducts, cabling, terminals and connectors shall be hidden from the view and shall not interfere with the crew operations. The doors of such enclosures shall have proper locking arrangements with ease of handling

vi) Each functional position and/or range must be clearly marked by embossed or engraved letters. The labeling used must be by agreement.

vii) A circuit breaker listing must be included on the inside of any door or hatch that covers circuit breakers. The circuit breaker listing must relate the circuit breaker labeling to its function, and the equipment which it isolates.

viii) **Ergonomically Designed Driver's Desk:**

Ergonomically designed driver's desk/console taking into account necessary traction controls, safety controls and passenger amenities items etc. shall be a part of the complete driver's and shunting cab. The design of the console shall also take into account the positioning of various pneumatic gauges, brake controller, AWS equipments and any other equipment installed in the cab. The complete console shall be supplied pre-wired and terminated on the terminal board and multi-pin plugs/sockets for inter equipment connections. Lighting on the driver's console shall not be less than 60 lux measured at the console. The cab shall be provided with ceiling lights designed to provide 100 lux (approx.) at 1 metre above floor level. Supplier shall be responsible for its proper commissioning.

All the equipments viz indication and instruments, panels, switches, ventilation control system, lighting, driver and guard seat, sunscreens and gauges etc. required to be installed in the cab, shall be supplied by the supplier except for AWS equipments and Auto Brake Controller which shall be supplied by the purchaser. A list of the equipments which is normally installed in the cab is placed at Annexure-I. As such the supplier shall have

the complete responsibility of ergonomic design of driver's cab and supply, commissioning and interfacing of the complete cab equipment.

ix) The layout of the equipment on driver's desk shall be finalized during design approval stage to maintain uniformity with cab arrangement of a similar project of IR so that the cab layout remains same from driver's perspective to the extent possible. Based on the approved layout, a mock up of the complete driver's and shunting cab shall be made at ICF/nominated manufacturing works to finalize the finer details and freeze the design.

4.8.2 DISPLAY PANEL:

A suitable display (back lit) with high resolution, wide viewing angle, suitably designed against vandalism, high impact, rough handling, ingress of water & dust and IP 54 protected robust & heavy duty input/output system as per the available technology, shall be provided on driver's desk to display fault status, energy values & status of various important parameters as selected by driver/ maintenance staff or as required for the satisfactory system operation. The selection of the display panel shall be liberal and details shall be worked out during design stage. Bidder shall submit options available. The display system shall be protected against dust and moisture.

4.9 SAFETY MEASURES

4.9.1 All equipment will be adequately earthed, insulated, screened or enclosed and provided with essential interlocks and keys as may be appropriate to ensure the protection of equipment and safety of those concerned with operation and maintenance. An earth fault detection system shall be provided by the Bidder.

4.9.2 **Fire prevention measures for equipment design:** The design of equipment shall incorporate all measures to prevent fires and will be such that should any fire take place the effects shall be minimized and no spread of fire should take place. Materials which are not fire retardant shall not be used.

4.9.3 System shall provide foolproof safety against unauthorized person driving the train. The authorized person shall have to `log in' by means of suitable electronic device in the driver's cab and the details of the personnel and timing, journey details etc. shall be recorded in the memory. This shall be accessible as and when required. The details shall be worked out during design stage. .

4.9.4 Each driving cab shall be provided with speed indicating cum recording equipment as per the latest RDSO approved norms & specification no. MP.0.3700.07 (Rev. 04) of April'2007 or latest. The recording shall be on suitable media viz. CD or RAM cassette and thus should be readable in graphic and tabulated form. The capacity of the memory shall be such that it retains all data of at least one-month service period.

The speed indication cum recording equipment with electric drive will have a scale range of 0 – 120 Kmph. The equipment shall suitably interface with the controls to incorporate the wheel diameter correction and also take protective action in case of over speeding.

4.9.5 The existing safety provisions in the EMUs like passenger alarm systems and alarm system in the ladies compartment shall be provided by IR. These shall be suitably interfaced with the system by the supplier. The details shall be worked out during design stage.

4.10 CONTROL EQUIPMENT

The control equipments, relays and switches, and such other devices shall represent the latest and proven technology established under the most severe operating conditions defined in this specification with particular regard to reliability. Wherever considered necessary, the contacts should be duplicated to provide redundancy. The temperature of the equipment offered shall be governed by IEC minus 30^{o}C. The use of relays and contactors shall be to bare minimum. All control equipments, relays and contactors shall be mounted on suitable panels placed in dust proof enclosures and shall remain in the scope of supply of the bidder including harnessing thereof.

4.11 POWER AND CONTROL ELECTRONIC EQUIPMENT

The traction converter/inverter shall meet the requirements of IEC-61287 & the control electronic and PCBs shall conform to IEC-60571 including compliance to the optional tests. However, due to higher ambient temperature in India, the temperature for dry heat test shall be 80^{0} C. The electronic control equipments should be protected against unavoidable EMI in the machine compartment. The equipments shall be suitably mounted in properly designed cabinets for cooling requirements of the electronic equipments (with or without doors) and shall remain in the scope of supply of the bidder. The vibration and shock tests and endurance tests shall be done as per IEC 61373 as per the requirements of design.

4.12 BRAKE BLENDING

4.12.1 Full utilization of the regenerative braking is envisaged in the 3-phase drive system such that regenerative braking is available over full range of speed to be blended/interfaced with the existing EP brakes. The control system shall be designed that in the EP brake region, for any set braking effort demand, as decided by the position of the brake handle, maximum possible brake effort is obtained from the regenerative energy of the motor coaches and the EP brakes of the trailer coaches are applied mainly to supplement the difference between the demand and the regenerative braking effort achieved.

4.12.2 Normally, in the EP service braking zone, only regenerative braking is applied in the motor coaches where as the EP brakes are applied on the trailer coaches. However, if the regenerative braking becomes ineffective, the EP brakes shall come on the motor coaches. The Bidder shall furnish the time delay for such a change over. In case the power supply fails for EP system, automatic brakes shall be applied immediately.

4.12.3 The supplier shall modify at his own cost the existing brake equipment for proper functioning of the brake blending scheme, in case the design calls for such a change. The design change in brake system, if become imperative, shall be got approved by the supplier before implementation. The details of the existing brake system shall be provided by RDSO during design approval stage.

4.12.4 Bidder shall furnish details of the system adopted for ensuring safe and smooth changeover to EP brakes when regenerative brakes are rendered ineffective. In order to ensure smooth changeover from regenerative to EP brakes and vice versa, braking resistor shall be provided during the change over period. The bidder shall submit the respective distribution/proportion of electrical & mechanical brakes throughout the operational range of the EMU for achieving the specified rate of decelerations at clause 2.4.2.

4.12.5 Adequate redundancy shall be provided to ensure that the EP brakes do not become non functional in case of failure of power supplies, isolation of motor coach or failure of control electronics and pressure transducers etc. In case of isolation of any EP valve due to any defect, the brake electronics shall take adequate corrective action with least system isolation. System shall provide enough redundancy in the brake electronics and controls so that the isolation of motor coach does not lead to non-functioning of EP brakes of the motor coach.

Separate Brake Electronic Control Unit of proven design shall be provided to ensure redundancies and shall perform the functions as defined in sub-clauses of Clause No. 4.12. Brake system integration test shall be performed through simulation on test bed at manufacturer's works.

4.12.6 It shall be possible for the driver to know the mal functioning of brake system of a coach. Selective isolation of EP valves (coach wise) shall be possible. The bidder shall examine the present system mounted on the EMUs and shall accordingly propose the design to achieve the isolation. The control scheme shall be submitted by the bidder. A drawing of the EP brake unit is enclosed at s. no. (xxii) of annexure-XII. Any other associated components required to realize the above function shall remain in the scope of supply of the bidder. Details shall be worked out during design stage. However, IR may decide for their provision and implementation based on the ease of operation offered in the design by the bidder.

The friction braking system shall function as the ultimate braking system on the car, acting as a backup during normal service braking and as the primary braking system during emergency stops and while parking.

The bidder shall provide suitable interface for the brake system with the existing auxiliary warning system (AWS) provided on IR and on the existing EMUs. AWS shall remain operative as at present without any need for modification in AWS. AWS details are given in Annexure VI-C.

System shall provide for adequate safety measures against rolling back of EMU in case the train is to be started on a rising gradient.

4.12.7 Wheel Slip/Slide Protection & Anti Skid Controls

The Wheel slip/slide protection function & anti skid controls should be integrated/ interfaced with the Traction Control Wheel Spin and Protection function unit.

The wheel slip/slide protection system, to be installed on motor coach, shall make maximum use of the available adhesion between the wheels and rail to minimize slipping distances (and improve acceleration) in adverse rail conditions. The wheel slide protection system shall be active in all braking

(and acceleration) modes and shall detect and correct negative (and positive) wheel slip (slide/spin) that may be occurring randomly or synchronously between axles on the same bogie. The system shall be fail-safe such that any failure of the system shall render it ineffective. If a failure occurs in braking, the system shall not reduce the level of braking below the commanded level for more than 3 seconds. The wheel slide protection system shall monitor all axle speeds on the motor coach to determine if a slide (or spin) condition exists. If such a condition is detected, the system shall control negative (or positive) Tractive effort of each bogie individually to prevent the wheels on each bogie from sliding, locking or spinning. Bidder shall explicitly submit the complete control scheme with explanation to achieve the above requirements in their design.

4.12.8 PARKING BRAKE

i) A parking brake system shall be provided in each 3 car unit and shall be capable of holding it under SDCL loaded condition on a 1 in 100 gradient when there is no electrical power. A test scheme shall be submitted by the supplier to test the efficacy of parking brake system during the design stage. Detailed design calculation justifying the suitability of the offered system shall be submitted during design stage by the supplier. The system shall be tested for its satisfactory functioning in 12-car rake.

ii) Parking brake system working shall be optional and with the provision for isolation in case of mal-operation, if so desired, in emergency viz. bursting of air connection to parking brake cylinder etc.. System shall immediately detect any mal operation of the parking brake system before it causes any damage to wheels and other connected item and shall take suitable protective action.

iii) The parking brakes shall be applied in the event of loss of the main compressed air supply. The design shall be such that the parking brakes will take effect prior to fading off of the service brakes. The parking brakes shall be capable of release from within the driver's/shunting 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 driver's/shunting cab.

iv) Status of train parking brake shall be displayed in the active driver's/shunting & guard's cab. A suitable pressure gauge shall also be provided and shall be in the scope of supply of the bidder.

4.12.9 JERK LIMIT

Under all normal operating conditions, the rate of change of coach acceleration or deceleration shall not exceed 1.0 m/s^3. Failure of the jerk limiting system shall not limit braking effort. Emergency brake applications and any associated ramp out of propulsion shall not be jerk limited. Reduction of propulsion effort due to a power interruption need not be jerk limited.

4.12.10 LOAD WEIGHING SYSTEM

Load weighing system shall be used to meet the requirements of rates of acceleration, braking and for ventilation adjustments. The pneumatic signal for the load weigh system can be taken from the air suspension to be

provided by the purchaser on these EMUs. The load weighing compensation signals to the propulsion and braking systems shall be a continuous function available for all coach weights up to and including SDCL. Adequate redundancy shall be provided in the load weighing system and failure shall be recorded in the diagnostic. If there is a failure of this system, the coach shall respond as if it was loaded to an SDCL level. A detailed control scheme shall be submitted by the supplier along with the calculations for the achieved levels for the acceleration, deceleration values and for the ventilation control system adjustments. The proven schemes already in use by the supplier other similar rolling stock applications shall also be given in support of the calculations submitted by the supplier. The same shall be examined during the design approval and decision shall be taken by the purchaser considering the features offered for their reliability, maintainability and ease of operation offered. The extent of advantage achieved on this account duly simulated shall be submitted by the supplier. The same shall be verified during the proto type approval by the purchaser for its effectiveness and implementation.

4.13 HIGH VOLTAGE PROTECTION

Roof mounted single bottle Vacuum Circuit breaker of proven and approved type shall be provided on 25 KV AC system.

A suitably rated high voltage cable conforming to the external application for running on the roof under the ambient conditions as per the specification shall connect the VCB to the main transformer. The cable insulation and sheathing material shall be halogen free, flame retardant and shall have low smoke emission. The enclosure and termination of the cable shall be protected against rain water & wear. In the event of the breakdown of cable insulation or the termination, there shall not be any risk of electrocution, or other hazards to the persons inside or close to the outside of the coach. The supplier shall submit the cable layout schemes (preferably avoiding the passenger areas) during the design evaluation stage. All the safety measures must be listed along with the references of materials used by the bidder.

4.14 AUXILIARY SYSTEMS:

4.14.1 The Power supply for the auxiliaries will be through IGBT based converter/inverter suitable for AC traction supplies. The system shall be protected and devices shall be selected suitably to ensure that there is no damage on account of surges. The design of the snubber circuit shall be carefully done so that the components do not fail due to surges. This aspect shall be specifically checked during commissioning by actual measurements of the surges and will be complied accordingly.

4.14.2 The auxiliary system provided on each unit shall cater for the complete auxiliary load of the unit (3-cars) and additionally shall cater for lights & fans and any other emergency requirements of the adjoining 3-car unit which shall have to be fed in case of failure of auxiliary converter. The changeover shall be affected automatically and without any time delay through control electronics. The full power availability of the auxiliary converter shall be ensured throughout the voltage limits specified for traction system in clause 2.5 so that the loads connected to the auxiliary converter shall not have to be reduced/adjusted in the entire voltage variation from minimum to maximum as specified in clause 2.5. The variation in the output of the auxiliary converter unit, if any, shall be submitted by the bidder for the entire voltage range of

OHE as specified. However, auxiliary converter shall be capable to cater the full auxiliary (100%) load at input voltage range between 19 kV to 27.5 kV AC and shall perform up to 16.5 kV OHE voltage. Headlight shall not extinguish while traversing neutral section. However, control shall ensure that the battery does not get overloaded due to switching 'ON' of the headlight when overhead power is not available for long period. The power supply to headlights will be at 24V by using DC to DC converter with input voltage of 110V DC.

4.14.3 While traversing the neutral section or in the event of momentary non availability of OHE during the service, the lights and fans shall work normally.

4.14.4 While calculating the rating of the Auxiliary converter, a provision of 10% in the auxiliary converter capacity shall be kept for future use. The complete equipment and connected accessories shall be supplied by the supplier.

The auxiliary load requirement of existing lights, fans & battery charger etc. of a unit (1-MC & 2 TCs) is of the order of 25 KVA. This shall be re-assessed by the bidder in view of the stipulations of the clause 4.14.16 and also taking care of the other loads either to feed through auxiliary converter and battery. The responsibility of the system integration and provision of any cable or termination equipment for other loads like flasher light, auxiliary head light, tail light, auxiliary compressor, alarm bells etc. shall rest with the Bidder.

4.14.5 Separate inverter may be provided for supplying power to the compressor, independent of other loads like pumps, blower motors etc.

4.14.6 Only a few different types of motors will be used to ensure interchangeability. Coupling and mounting design requirements will be kept identical where applicable. Adequate redundancy shall be maintained while selecting the size of motors.

4.14.7 All the drive motors will be designed for three phase AC supply with suitable protection against single phasing and short circuits and over loads.

4.14.8 The standard low tension supply voltage for EMUs is 415 V, 3-phase, 50 Hz AC. The supply voltage for the auxiliary machines will be 415 V +/-. 10%, 3-phase, 50 Hz +/- 3% AC.

4.14.9 Totally enclosed fan cooled design is to be considered for auxiliary machines if the use of such machines is likely to result in freedom from dust and contamination and in general better performance. Internally ventilated auxiliary machines having encapsulated stator windings may also be considered for this application if considered to be advantageous over totally enclosed fan cooled design.

4.14.10 The temperature rise limits for auxiliary machines will be reduced compared to IEC limits to take care of the higher ambient in India.

Only insulation system of class H and higher will be acceptable. The permitted temperature rise for different classes will be:

Class H:- 80 degree C
Class C:-100 degree C

Vacuum pressure impregnation (VPI) of the stator winding must be done using solvent less varnish having thermal index above 200^0C. Any other method utilized in place of VPI may be considered provided its advantages are listed and provenness is ensured, for the environmental conditions existing in India, by the supplier at the design approval stage.

4.14.11 In the case of squirrel cage motors, aluminum alloy die cast rotor construction will be preferred.

4.14.12 L-10 life of bearings will not be generally less than 1,00,000 working hours when calculated as per ISO recommendation R-281. For motors higher than 15 KW, flange bearing housing units will be used. The bearing design will be such that no greasing or any intermediate attention may be required to be done for at least one and half year after each greasing/adopting maintenance schedule as recommended by manufacturer.

4.14.13 All auxiliary motors separately & combined equipment like motor blower sets will be subjected to prototype tests as per relevant IEC specification If the operating conditions of the auxiliary machines differ from the specified test conditions in relevant IEC publications additional tests will be carried out.

4.14.14 Auxiliary Compressor Set: A 110 V DC battery operated auxiliary compressor set having adequate capacity, will be provided in each unit for feeding the auxiliary air reservoir for operation of the pantograph and main circuit breaker during the preparation of the EMU for service. A governor device will also be included in the scope of supply of the bidder. Any modification in the existing pneumatic control circuit shall not normally be preferred. However, if it becomes inevitable due to any design up gradation of the equipment, it shall be the responsibility of the bidder.

4.14.15 Lights And Fans:

i) Lights and fans shall be fed through the Auxiliary converter. With the existing available fans (each of 60 Watts) and the lights (each of 36 Watts), the light & fans load of the 3-car unit is calculated approx. 8KW. The design shall be such that the output from the fans and lights is not appreciably affected during extension of feed from adjoining coach in view of the consequential voltage drop.

ii) Supply of energy efficient fluorescent lights and fans for complete basic unit (1MC +1DTC+1TC), suitable for inverter supply, shall be in the bidder's scope of supply. At present, there are approx. 16 to 22 nos. fluorescent lights and 29 to 34 nos. fans per coach (quantities differ for MC, DTC, TC and NDTC). Two number of DC fans shall be provided in each driver's cab. Each H.T. compartment shall also be provided with minimum one DC fan and two AC fans. The performance of the lights and fans as provided by the Bidder shall not be lower than that what is provided by Railways at present. Bidder shall rework and submit the lights and fans load requirement for assessing the Auxiliary converter load. The fan shall be designed for minimum delivery of 65 m^3 per minute under the worst conditions. The number and type of fans shall be decided on the basis of the ventilation requirements. Fans should be water jet washable, with sealed bearing & without any need of painting. All the fan switches shall also be the scope of supply of the bidder. Fan switches shall be flame retardant conforming to category V0, as per UL 94 suitable for

traction duty application. Endurance test to be conducted at rated load for 1,20,000 operations.

iii) Energy efficient, fluorescent lamps, in low flame and smoke luminaries, shall be recessed into the ceiling paneling. The light fittings shall be simple, open, without diffusers, and arranged not to trap dirt, moisture and insects. Purchaser shall make necessary arrangement for fitment of these fittings. The fluorescent lights should have stainless steel reflectors & suitable cover & should be water jet washable.

iv) The size and number of light fittings shall be sufficient to provide a sensibly constant level of average illumination of 300 lux at a height of 1.5 m above floor level, along the entire length of the coach irrespective of the emergency feed extension in case of failure of auxiliary power or failure of main power during traversing of neutral section etc. The compartment shall be illuminated by sufficient number of parallel rows of fluorescent lamps extending full length of the coach. The coach lights and fans shall be able to work normally during the non-availability of the OHE when the train is traversing through the neutral section. The changeover to the alternative supply under such conditions shall be automatic and immediate.

v) Separately protected lighting circuits shall be used, such that in the event of one tripping, the others provide evenly distributed lighting throughout the coach.

vi) At least 50% of lamps and fans, evenly distributed over the coach area, shall remain energized and provide sufficient light for safety of passengers, in the event of a main auxiliary power failure even from the adjacent unit.

vii) Coach wise indication of healthiness/working of lights and fans circuit shall be provided in the driving cab. In case it is required to changeover to emergency feed, same shall be possible from driver's cab. It shall be possible to isolate 50% lights of the rake from driver cab when the EMU is stabled in yards or shed.

viii) Emergency lights (at least 8 nos. per coach) shall be provided in each coach to be fed by battery in case of total failure of auxiliary supplies.

ix) Lighting on the driver's console shall not be less than 60 lux measured at the console. The cab shall be provided with ceiling lights designed to provide 100 lux at 1 metre above floor level.

x) The wirings, switch gears, relays and terminal equipment required for proper working of lights and fans shall be provided by the supplier.

4.14.16 Head, Tail & Flasher Lights

The front end of each driving trailer shall be provided with:

a) Head light - High intensity, long distance, halogen bulb or better, twin beam & with double filament (bright/dim)

b) Auxiliary head light cum tail light, 02 nos. on each side of DTC. Tail light LED based (blinking during the service in rear cab),

c) Flasher light LED based of proven design and shall be of international standards. The flasher light shall be designed to provide flashes at the rate of 30 flashes per minute.

Following shall also be provided and shall be in the scope of supply.

d) LED based step light with IP54 protection antitheft arrangement unbreakable cover along with switch.
e) The crew cab light and its control.
f) Indicator lights test switches.

These will work on the battery supply. The flashers will be used only in the emergencies arising from accidents to trains etc. Supplier shall ensure that a separate switch is provided in the driver's cab to switch ON/OFF the auxiliary head light independent of Head light and tail light (normal & blinking operation respectively).

4.14.17 Pneumatic system

Proven pneumatic system comprising of air compressor, compatible air dryer and filters shall be supplied so as to ensure delivery of the compressed air complying with air quality class specified in ISO-8573. The air compressor shall be supplied as a complete unit containing all equipment required to supply all air systems with cool dry and filtered air and shall be sized to fulfill all air requirements of each car under all operating conditions. The compressor shall be directly driven by the motor and shall deliver required air for suspension, brakes and other requirements.

4.14.17.1 Main Motor-Compressor Set

i) Suitable compressor with motor having capacity of the order of 900 lpm at 7 kg/cm^2 with duty cycle 50% to 70% shall be provided in each unit so as to meet compressed air requirement for brake system, control system and air suspension spring etc. The compressor shall be proven for satisfactory working in tropical and dusty conditions and shall require minimum attention/maintenance. Bidder shall quote for proven low noise compressor of suitable capacity to suit the requirements as above. The final capacity shall be worked out during design approval. Supplier shall be responsible to submit the complete calculations for the duty cycle of the offered compressor, maintenance schedules, its provenness on similar rolling stock applications and environmental conditions given in the specification. Supplier shall also organize for the verification of the duty cycle on the EMUs.

The motor shall be 3-phase AC motor suitable for working from 3-phase output of the auxiliary converter. The Bidder may offer soft start motor with VVVF control of motor compressor suitable for under slung mounting. In case Direct on Line (DOL) starting of compressor is adopted, bidder shall enclose a brief justification including the references and specific design feature, which take care of fluctuations due to the compressor duty cycle.

ii) The motor-compressor unit shall be resiliently mounted with a 4-point suspension for minimizing the level of vibrations transmitted to the car body.

iii) Bidder shall specifically ensure that the noise level of the compressor shall be as low as possible so as not to cause inconvenience to the commuters. The

compressor shall be splash lubricated so as to avoid need for supplementary equipment such as oil pump, filter or valve etc. Noise emission level shall be 68 dBA which shall be measured in accordance with ISO 3095:2001 norms satisfying the emission noise level for EMU as mentioned in UIC guideline for procurement of new rolling stock.

iv) The capacity of the compressor shall be selected after taking into account the frequent purging of air by the air dryer (due to high ambient humidity), which may affect the compressor duty cycle.

v) Bidder shall offer the compressor of proven design and ensure the provenness of such compressor in the dusty and humid climate as described in the Clause 2.7

vi) An air cooler that cools discharge air from the air dryer to within 10-15ºC of ambient air shall be provided.

4.14.17.2 AIR – DRYER AND AIR FILTER

i) Regenerative type air-dryer shall be provided at the outlet of the compressor to ensure that the dry air is available for controls and pneumatic operations. Due to heavy rainfall and high humidity as prevalent in most part of India, the air dryer shall be of heavy-duty type suitable for application in coastal areas and shall not require frequent attention & changing of the coalescing element and other chemicals. Bidder shall furnish the details in this regard. The mounting arrangement shall be such that the checking of the humidity indicator and changing of the chemicals shall not essentially require the pit.

ii) Air Dryer shall be provided with exhaust silencer so that the noise emanating out of the purging operation does not cause any discomfort to passengers or otherwise.

iii) The maximum relative humidity at the output of the air dryer shall be smaller than 35 %.

iv) Air shall be aspirated by the low-pressure cylinders and cleaned by a dry-type air-filter. The filter element shall be heavy-duty type and shall be specifically designed for high level of dust and debris as found in the vicinity of tracks in Mumbai. In any case, there should not be any need for cleaning the filter before the Schedule examination in the shed (refer clause 2.9.1). Bidder shall declare the time period after which the filter shall require cleaning. Suitable mechanism shall be provided to indicate the quality of the air.

v) Under the ambient conditions of Mumbai, no condensation shall take place. Minimum particle size of 1 micron shall be removed and maximum 0.01mg/m^3 oil content shall be permissible as remnant. At least 95% liquid water shall be removed even at the worst condition/efficiency of the filter.

vi) The dryer shall be proven regenerative type under similar coastal conditions and shall preferably preceded by an automatic drain valve to collect and discharge the bulk of moisture in the compressed air before it enters the air dryer. An intercooler and after cooler of liberal capacity shall be supplied.

vii) The working of the air dryer shall be monitored and displayed in the driver's cab. In case of any malfunctioning of the dryer requiring isolation of the dryer,

the system shall take suitable protective action without any interference from the driver.

4.14.18 FILTERS

All the filters as required by the supplier for satisfactory functioning of the equipment and complete system shall be supplied by him. IR has experienced that the cyclonic filters used in the existing rolling stock gets choked with the debris lying around the track making the filter arrangement ineffective. Air filters assemblies of suitable type shall be selected accordingly and should be heavy industrial duty type.

The filtering capability, flow rate capacity, and overall size shall be appropriate for the application and the ambient conditions like prevalence of heavy dust and debris in India. It shall be possible to gain access to the filter element for replacement purposes. The design of capacity requirements shall take into account at least 25% choking in air filters & radiator fins vide clause 1.1.4 (viii).

4.14.19 VENTILATION:

The implementation of the proposed modifications to the extent of mounting and ducting arrangements etc. shall be the responsibility of ICF/nominated manufacturing unit. However, interface of the electrical equipment with the system shall be done by the supplier.

(i) The ventilation design furnished by the supplier shall be adopted on the new built RDSO design EMU stock which shall be manufactured at ICF. The existing layout of ventilation shall be followed; however, any improvement in the layout proposed by the supplier shall be examined at the design stage.

(ii) In the existing EMU stock, already in service in Mumbai suburban services, during the peak rush hour i.e with SDCL loading condition of passengers, the natural ventilation gets retarded due to blocking of doors and windows by the passengers and CO_2 level in the coach goes to uncomfortable limits. This accumulation of CO_2 which may go beyond threshold limits, leads to highly uncomfortable conditions specially for standing passengers in the coach.

(iii) Bidder is advised to study the problems of ventilation in the existing EMU stock operating in Mumbai area. Based on the study the Bidder shall assess the CO_2 level inside the SDCL loaded coach and design the coach ventilation such that CO_2 level inside the SDCL loaded coach does not exceed the permissible threshold limit of the order of 700 PPM above the CO2 concentration in air outside. The bidder shall submit the fresh air requirement for the purpose as above without taking the effect of natural ventilation, As such the air flow of the order of 15,000 m^3/hr per coach shall be maintained. The ventilation design as proposed by the supplier shall be such that control of CO_2 level is through natural ventilation arrangement to maximum possible extent and may be supplemented by forced ventilation, if required, to achieve a desired comfort level. Supplier after the detailed study may suggest the modifications along with the complete drawings required in the existing design of ICF built stock to improve the natural ventilation without any major modification in the structure. It shall be the responsibility of the Supplier to ensure the ventilation level as desired. Ashrae standard shall be referred for any clarification.

(iv) The coach ventilation arrangements shall be so designed that in event of failure of forced ventilation, there is still reasonable level of comfort to passengers not necessitating immediate withdrawal of coach.

(v) Bidder shall furnish detailed calculation and design philosophy adopted and reason thereof. The energy consumption of arrangement shall also be furnished. Suitable test procedure shall be furnished by the Supplier during design stage to validate the ventilation design.

(vi) For forced ventilation, fresh & filtered air will be introduced into the cars via longitudinally arranged diffusers situated in the ceiling. As the ambient conditions in Mumbai are extremely humid, the design shall ensure automatic draining of condensate from the duct. The Supplier shall furnish detailed design drawings of the duct arrangement and any other such modification at the time of design approval stage.

(vii) Superstructure shall be provided with ducting arrangement for discharge / exhaust of air. It shall be ensured that water does not enter in such arrangement during rains or car washing. Complete duct for the forced ventilation system shall be provided in the prototype unit only for measurement of air flow in actual conditions. Special care shall be taken to ensure that there is no ingress of water at the worst conditions, when there is heavy rain striking at 45 degree opposite to the movement of the train running at 110 kmph. This shall be verified by simulating on the mockup at equipment manufacturer's works.

(viii) Suitable mechanism to adjust the air flow/speed of the ventilators, depending upon rush hours and seasonal requirements, shall be provided. Load weigh signal shall be used for adjustment of the ventilation in suitable steps. Alternative provision shall also be provided with the driver, which may be actuated if so desired during exigencies. The loading pattern varies during 24 hours due to typical traffic pattern in suburban systems. As a general guidance to the supplier for designing the ventilation system, the loading pattern of Mumbai suburban traffic is summarized as:

A) Average 500 passengers per coach (Max. 570 in TC) for 6 hours
B) Average 400 passengers per coach (Max. 450 in TC) for 8 hours.
C) Average 300 passengers per coach (Max. 350 in TC) for 6 hours.
D) Stabling period – 4 hours.

Bidder shall note that while the information as above may be used for design of energy efficient ventilation system, other requirements of the specification shall be as per the load specified at the respective clauses.

4.15 Flood proofing of the equipment:

The equipment shall be designed to run at 8 km/h through water up to 203 mm above rail level, allowance to be made in addition, for the increase in the height of the water level due to wave effect. Further, due to certain sections of the tracks becoming flooded with water to a standing depth of 760 mm, the traction gear and other under slung equipment must be made completely waterproof to this height above rail level. During peak flood conditions water may reach up to floor level. Under such conditions, it shall be possible to rejuvenate the equipment with minimal maintenance.

4.16 SELECTION OF INSULATING MATERIALS:

In selecting the materials of insulation, the moist tropical weather conditions and chemical pollution/corrosive atmosphere such as prevailing in Mumbai will be kept in view. In this regard the manufacturer will furnish information regarding the suitability of the selected materials under various climatic conditions referred to in the specification. Additional necessary tests, if any, for ensuring suitability of materials for Mumbai conditions as specified, will be conducted by the supplier in the presence of IR's representative in the same way as executed by IR in INDIA and the test result advised to the purchaser.

4.17 CABLES

(i) All power cables shall be electron beam irradiated, thin walled cables conforming to International standards using low smoke, low toxicity & halogen free materials suitable for EMU applications.

(ii) All the auxiliary, communication, control and safety cables shall be conforming to international standards for fire retardant, fire survival characteristics suitable for the EMU services.

(iii) The cables shall be de-rated to take care of the adverse ambient conditions. All de-rating factors shall be applied, together with the maximum permissible conductor temperature for the particular insulation type. In no case the conductor continuous temperature shall exceed 90^{o} C. The maximum short circuit temperature shall not exceed 250^{o} C. The cable insulation shall be capable of withstanding these temperatures.

(iv) The length of power cables will be kept to minimum and cable connections from transformer to power converter will be minimized.

(v) High voltage 3-phase AC and low voltage DC cables/connections will be physically separated from each other. Adequate number of standby vital spare control wires will be provided with adequate indications.

4.17.1 The following operational and environmental factor will be specially kept in view while selecting the cable:

- Excessive vibrations that are experienced because of prevalent track maintenance conditions in India.
- Prevalence of high temperature and humidity for the most part of the year.
- Operation of the EMU over a humid and salty terrain in which the climate varies from high rainfall for 4-5 months and extremely dusty atmosphere during rest of the year.

4.17.2 Wiring and Cabling:

(i) Optical fiber cables, if used for control signal purposes, shall be as per international practices & standards. Harnessed/optic fiber cables with end connectors shall be provided as 10% standby.

(ii) All connections shall be terminated on terminal bars of approved design, provided for the purpose. The terminal and cable ends shall be suitably marked to facilitate correct connections. All the end wall panels in suitable

enclosures as per the coach wiring requirements shall be the responsibility of the supplier.

(iii) Plugs/couplers and sockets will be used to connect pre assembled units and to facilitate maintenance & ensure a better layout.

(iv) No cable having conductor size of less than 2.5 sq. mm shall ordinarily be used.

(v) Smaller size cables for internal wiring of panels, control cubicles, consistent with the mechanical and electrical requirements, may be adopted.

(vi) The layout of the cable will be such that contamination by oil is avoided.

(vii) Loading of power cables will not be more than 75% of its capacity.

(viii) Cables for terminal connections will have only crimped joints.

(ix) The cables for wiring will use high grade electrolytic copper stranded conductors tinned as per approved international standards and practice.

(x) Suitable cable Layout to bring down EMI interference levels within acceptable limits.

(xi) EPDM based cable sealing arrangement to ensure air circulation shall be provided.

4.17.3 Train Management System

i) Train Management system shall be used for integrating and multiplexing of signals for control purpose and for monitoring of the complete train, its systems and sub-systems within the appropriate safety framework as per the extant international practices so as to minimize the inter-vehicular cables. While designing the multiplexing the bidder shall have to ensure fail safe working of the safety related signals and also indicate the use of such system elsewhere in the similar traction applications.

Bidder shall submit details of the arrangement proposed to be adopted, the standard followed and the reference where similar system is functioning, maximum number of vehicles which can be connected to the network without need of gateway or repeater and the extent of multiplexing leading to reduction of the cables. The TMS system shall be modular in design and shall cater for at least 10% capacity for expansion and future use. Necessary information, software & hardware tools as considered necessary shall be supplied to enable IR to interface compatible equipment with TMS if so required in future.

Adequate redundancy in the system design of TMS, as permissible vide the standard adopted, shall be ensured. A complete schematic of the scheme with the redundancies shall be submitted by the bidder.

ii) Communication Protocols

The communication protocols to be used by bidder for implementation of TMS and for data, message, signal exchange and communication within the coach and the train shall be an open protocol conforming to ISO's Open System Interconnection model. IEC 61375 may be one of the options.

Bidder shall submit details of the communication protocols used in their design at different levels clearly indicating how the above requirements are complied with. Further details along with any hardware/software tools required shall be submitted/ supplied during design stage so as to enable IR to implement permissible modifications and interface compatible equipment.

4.17.4 Train Line Cables, Inter Vehicular Electrical Couplers

i) The electrical coupler shall be capable of making all necessary electrical connections between adjacent cars to permit controls of all cars in a rake from the leading cab. On minimum radius curves, the covers shall not exceed the allowable clearance envelope of the car. Sufficient spare contacts (at least 15 %) shall be provided for catering to future needs of the IR. As such multiplexing of signal shall be adapted to the maximum extant possible in line with the current international practices.

ii) The outer cover of the electrical coupler shall be additionally strengthened to protect the coupler against ballast or external hitting.

iii) In order to secure the cables from external hitting, the cables connected with the coupler shall not hang lower than the lowermost face of the coupler and shall be suitably secured to arrest any dangling.

iv) Electric couplers shall use a configuration so that any end of the standard unit can couple to any end of any other standard-unit. Contacts shall preferably be spring loaded, of silver surfaced alloy, shall have sufficient capacity, shape and positive action to prevent fouling in coupling, shall maintain positive contact under all specified operating conditions and shall be capable to work even with the impacts to which the car coupler may be subjected in service.

v) The inter-vehicular coupler arrangement for both power and control system shall be proven and shall conform to international standards. However, special arrangement shall be made to ensure that it is not damaged due to external reasons like vandalism, ballast hitting and the flooding conditions. The layout shall be such that it is out of the reach of any passenger or common man.

vi) The design shall cater for relative movements between the coaches. It shall be that there is no disruption and sparking due to vehicle behaviour under worst conditions of operation.

vii) All end connection and fittings will be supplied by supplier. The jumper cables assemblies i.e. jumper cables along with the inter-vehicular couplers in assembled condition shall be supplied by the supplier. These assemblies shall be tested for endurance test for 20 million cycles on test rigs simulating the conditions of end of coach at level, curves & crossings.

viii) These assemblies shall be supplied by the supplier and be fitted on the newly manufactured coaches by ICF/manufacturing unit. The electrical couplers to

be used shall be designed for trouble free operation under all operating conditions.

ix) Couplers shall allow coupled coaches to negotiate curves of radius 152.4 metres and shall be capable of passage in either direction over standard 1 in 8 ½ turn outs and shall function satisfactorily with difference in head stock heights of adjacent coaches up to 75 mm. Bidder shall ensure that the jumper cable assemblies do not touch/rub the couplers under any circumstances.

x) The coupler system shall permit train operation up to 15 cars in normal service and 18 cars in future and shall enable one cab in a rake to control all other cars in a rake through the electric train lines.

xi) Coupling shall be capable of being accomplished by one person and shall be practicable with longitudinal axes misalignment between cars of eight degrees and 100 millimeters different in height.

xii) All train lines and inter vehicular couplers shall be so designed that they are not susceptible to any damage due to vandalism and external hitting during the run. Further, adequate safety measures shall be taken to safeguard against ballast hitting, vandalism, rains and flood water. The layout shall be such that they are accessible to maintenance staff only. Adequate measures shall be taken to reduce the number of train lines to bare minimum. Details of the arrangement shall be furnished during the design approval stage.

xiii) The supply of cables, termination equipment, couplers or any other material required for laying the cables in the rake shall be the responsibility of the supplier. This shall also include switch gears, relays, fittings and terminal equipment required for proper working of the equipment under supplier's scope.

4.18 PANTOGRAPH:

4.18.1 A single pantograph suitable for satisfactory operation up to 120 Km/h under 25 KV AC power supply systems as given in clause 2.5 and environmental conditions specified in clause 2.7 shall be provided.

4.18.2 The design of pantograph shall incorporate the following desired features:

(i) Pantograph shall be suitable for satisfactory working in dusty, humid and saline atmosphere with heavy rains during monsoon seasons. The IR has experienced the failure of nylon bushes, bolts, washers and plungers due to ingress of heavy dust. In view of this, their use shall not be acceptable. Auto drop function of the pantograph shall drop the pantograph automatically when excessive height is detected. An indication shall be provided to the driver when this function is operated.

(ii) The design shall provide for efficient damping arrangement for pan assembly and articulation assembly.

(iii) The minimization of the pan mass shall be preferred.

(iv) The adoption of proven "Air Raising Springs" for pans and hydraulic damping for articulation assembly shall be used.

(v) The limiting of aero dynamic effect from 3kgf to 5kgf for maximum speed by the use of aero foils shall be preferred.

(vi) Efficient current collection at all speed with least sparking while traversing the OHE shall be ensured. As a design criteria, the maximum limit of contact loss should be of the order of 0.2 percent in the regulated OHE. The current collection tests under the actual field conditions shall be the responsibility of the supplier. Simulated test results and performance of pantograph for the similar rolling stock and OHE system shall be preferred during the design stage.

(vii) The maximum electrical resistance between current collector and power take-off should be limited to 2 milli ohms.

(viii) The pantograph shall have the feature to protect itself in case there is any panto entanglement with OHE.

(ix) Supplier shall conduct on line current collection test with GPS supported location recording system. The output report in soft copy shall be supplied for continuous / selective viewing of location having abnormal behavior and in hard copy with exception report of spark image, location wise report in excel/ word format for complete section selected for trial in Western & Central Railway. One set of complete test equipment loaded with recording, analysis & reporting package in image and Microsoft word/excel format shall also be supplied to each EMU maintenance car sheds.

4.18.3 The insulation system of pantograph shall be suitably designed to ensure satisfactory operation under 25 KV AC systems without any need for attention other than the specified scheduled maintenance.

418.4 The pantograph shall be capable of sustained operation and satisfactory current collection from 100 mm above the collapsed pantograph level up to the full range of contact wire height, and at all operating speeds as specified.

4.18.5 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 OHE system.

4.19 TECHNICAL CREDENTIAL:

Bidder shall furnish the data of major electrical traction equipment manufactured & supplied by them to various Railways for EMU application & Bidder shall also furnish the no. of such equipment and date since when they are in service.

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CHAPTER 5

TESTS & TRIALS

CHAPTER 5

TESTS & TRIALS

5.1 General

5.1.1 The individual equipment, systems and sub systems shall be type and routine tested in accordance with the relevant IEC/UIC publications inclusive of the mandatory and optional tests along with the special tests as specified.

5.1.2 All type tests shall be carried out at the Supplier's cost where ever performed in presence of and to the satisfaction of RDSO, who reserves the right to witness any or all of the tests.

5.1.3 Wherever any equipment, system, sub system is not specifically covered by an international recognized specification or test procedure, the tests which are acceptable to both to Supplier and to the IR's representative shall be devised.

Without prejudice to any provisions of the contract, the purchaser reserves the right to witness any or all of the type tests and to require submission of any or all test specification and reports.

5.2 Mechanical tests

5.2.1 Oscillation trials (on prototype rake only)

After commissioning of the rakes fitted with the equipment supplied by the supplier, IR shall conduct oscillation trials in WR and/or CR. The supplier's representative shall be present in this trial to the extent of any problem related with the equipment under his scope of supply.

5.2.2 Braking Distance trial (on prototype rake only)

After the completion of satisfactory oscillation trial, the braking distance trails shall be conducted by IR for the rake formation upto 15/18 coach rake. The rake formation shall be finally decided during design stage. The supplier shall be associated with this test in respect of the items related to regenerative braking, brake blending and connected microprocessor controls.

5.2.3 Tests on Parking brakes (on prototype rake only)

Parking brakes shall be tested by applying the parking brakes fully and air brake released under the specified conditions as defined in the clause 4.12.8.

5.2.4 The dynamometer car tests shall be conducted by RDSO on the prototype to prove Tractive effort and braking effort Vs speed of the propulsion system. The detailed test scheme shall be finalized during design stage. The instrumentation required for measurement and recording of the relevant data shall be arranged by the supplier.

5.3 ELECTRICAL TESTS

5.3.1 Generally test procedures shall be followed as per the recent IECs. Equipment/Systems/Subsystems testing.

(i) Alongwith 'mandatory' tests as described in the IECs, including 'optional and investigative' tests shall also be conducted. Any other tests which become imperative due to the specific requirement of this specification and is categorically mentioned in this specification shall also be carried out.

(ii) RDSO may waive some of these tests in case of equipment/sub assemblies where the manufacturer can establish to the satisfaction of RDSO that such tests have already been carried out earlier or where the equipment have been proved in service. In such a case, manufacturer shall submit complete test reports alongwith necessary certification.

5.3.2 **Witness of tests**: Type tests on major electrical equipment like transformer, traction motor, converter & inverter, auxiliary converter, control electronics and TMS / TCN shall be witnessed by representative of RDSO. Any new design of equipment offered by the supplier and accepted during the design stage shall also be type tested and witnessed by the representative of RDSO.

5.3.3 **Raw material/Component and subsystem testing:** RDSO may also in addition, require test results on raw materials and components of critical nature, so as to ensure that they meet the performance and reliability stipulations. This may extend to components/raw materials not manufactured in the manufacturer's works, but purchased by him. For proven materials, which have been tested before, tests need not be conducted again. Certified test report shall be submitted if so required by RDSO.

Subsystems like PIS, TMS and control equipments etc. shall be supported with tests reports and certificates. However, in case such subsystems are required to meet any special requirement specified herein, the relevant tests shall be carried out by the supplier.

5.3.4 **Cables:** All cables shall be tested against the requirements as laid down in the relevant IEC/UIC specifications. Cables shall also be tested for ensuring its Fire retardant characteristics. Details shall be submitted by the supplier during the design stage.

5.3.5 **TRACTION MOTOR TESTS**: Details of the test requirements are as per Clause 4.4.

5.3.6 TESTS ON CONTROL ELECTRONICS and PCBs:

Control Electronics shall be tested as per IEC 60571/EN50155 and IEC 61373 including both compulsory and optional tests. Following tests shall be carried out on the electronics PCBs as per IEC 60571/EN 50155 and IEC 61373 with the modified parameters.

i) **Dry Heat test:** Dry Heat test shall be done at 80^0C.Alongwith the testing for the satisfactory performance, temperature stickers shall be put on the critical ICs, Controllers & capacitors etc. for monitoring the maximum temperature of these components during dry heat tests. It shall be confirmed that the temperature recorded during dry heat test as above does not exceed the specified operating /surface temperature of these components. For the

purpose, data sheets of such components shall be referred and submitted during testing.

ii) **Cyclic Humidity test:** The tests shall be done for 2 cycles of 24 hours each and components shall be examined for the performance tests and physical damage if any. The humidity cycle shall be as specified in IEC 60571.

iii) **Salt Mist Test:** The test duration shall be 48 hours and after the tests the performance test shall be done. There shall be no physical damage, rusting or deterioration of the varnish/lacquer coating.

iv) **Dust & Sand Test & Mould growth test:** The tests to determine the performance of the electronics in Sand and Dust ambient shall be carried out with the dust settlement rate of 6gm/m^2/day. The dust particle size shall not be larger than 100 μm. Further details shall be worked out at design stage. The reference IEC shall be IEC 68; test Dust and Sand and IEC721-2-5 test Dust and Sand. The component shall be protected against mould/fungal growth. The test scheme shall be finalized during design stage.

v) Further to the above, investigative tests for determining the limits the thermal limit of failure of the PCB and limit shocks and vibrations shall also be carried out.

5.3.7 **Power & Auxiliary converter/Inverter**: Tests shall be done as per IEC 61287.

5.3.8 AUXILIARY MACHINE

All auxiliary machines including the motor-compressor set shall be tested in accordance with the relevant IEC specifications. All auxiliary machines not covered in IEC shall be subjected to such tests as decided by RDSO during finalisation stage to ensure that it will meet the working conditions.

5.4 Complete train

Complete train shall be type & routine tested as per IEC 61133 and as per the test programme agreed by RDSO. After erection, the complete equipment shall satisfactorily withstand the dielectric voltages as specified in the IEC specification.

5.5 **Sequence test:** Connection shall be made to the 25 KV AC overhead contact system and all parts of the control and main power circuit shall be tested out to ensure correct sequence of operation, all interlock cut-out switches shall then be tested, and the pantograph shall be tested to prove the speed of raising and lowering.

5.6 Tests to determine levels of interference with Signal and Telecommunication equipment to prove that these are within the acceptable limits. Supplier shall arrange complete set of calibrated equipments/instruments for carrying-out these tests and trials.

5.7 Test on combined test bed:

(i) Bidders shall furnish details of the test facilities available at their works or at the test laboratory where the system performance tests of the complete equipment is proposed to be carried out as per IEC 61377.

(ii) The supplier shall be responsible to arrange the testing of propulsion equipment on the combined test bed at manufacturer's works as per the stipulations of IEC 61377. Both the type and investigative tests shall be done at all the specified loads including the full load and special loading conditions with reference to the maximum wheel diameter difference. This shall also include measurement of system efficiency and monitoring of system response in case of failure of control signals.

(iii) While the system performance tests shall be carried out as per IEC 61377 as mentioned in para (ii) above, the balance tests, as required to be carried out as per IEC 61133, shall be carried out within the facilities as available at the combined test bed. In case where the bidder has only restrictive facilities available at the test bed with reference to the balance tests and thus has not been able to demonstrate the satisfactory completion of these system tests at full load at 25 kV AC on test bed, all the balance tests as identified in IEC 61133, read with IEC 61377, shall be completed on the vehicle at full load after equipment mounting and commissioning and the inspection certificate to such supplier for prototype equipment shall be issued only after successful completion of these tests.

(iv) Final testing of the EMU train fitted with the supplied equipment shall be done at the site as per the approved test programme and IEC 61133.

5.8 Vibration and shock values: The equipment used in the cars shall conform to IEC 61373 for shocks and vibrations as specified on the basis of the location and mounting of the equipment. The tests shall also cover Endurance tests included herein.

5.9 Service trials

The prototype rakes fitted with the supplied equipment, shall be subjected to pre-revenue service trials (refer clause 1.3.9). Service trials are intended to prove the satisfactory running performance of the supplied EMU equipment and evaluate their reliability in service, ease of maintenance and operations. The performance of the equipment shall be assessed based on the experience gained during the service trials. Necessary modification as required and also as desired by the RDSO shall be implemented in the series production.

5.10 PERFORMANCE TEST (on prototype rake only)

The EMU's performance with regard to the supplied equipment shall be demonstrated in test runs and shall meet the target figures in Chapter 3.

5.10.1 Test Runs:

(i) Test runs shall be made on the Churchgate-Andheri and CST–Kasara or any other sections on which the stock is to operate with sufficient number of trains to ensure that the train equipment meets the operating conditions. The duration and location of stoppages shall be selected in accordance with the scheduled time table stoppages. The Supplier shall arrange instrumentation

and record speed, voltage, current, temperature rise of various equipments, energy consumption, tractive effort and any other relevant parameter shall be recorded. During the test run section distance may change subject to availability of sections.

(ii) The temperature of the various parts of the electrical equipment shall be recorded during the test as per the standard procedure specified. Trains formed by coupling three, four, five or six units shall then be run at the maximum speeds permitted and on the heaviest gradient in such a manner as to prove that the equipment meets the requirements of the specification. For further details refer Chapter 3.

(iii) The Supplier shall supervise and carry out the above tests both at his works on combined test bed and also at the site (Mumbai) and shall provide all equipment necessary for such tests and such special consumable stores as oil, grease etc, for the first filling and for trial runs. Special measuring instruments shall be provided by the Supplier.

(iv) During the tests acceleration, deceleration, speed on straight level track and the energy consumption for a round trip shall be measured. In all cases, 12-coach super dense crush loaded train formed by coupling four complete units shall be tested with an average line voltage of 22.5 KV AC.

5.11 ENERGY CONSUMPTION

(i) The required values of energy saving are as per Clause 3.1.17 The Bidder shall give guaranteed figures for a 12-car, SDCL, for round trip operation between Chruchgate and Andheri (WR), Mumbai CST- Kasara for all out running without coasting and with 10% coasting and on the basis of halting at all stations on the slow corridors for the following modes:

a) Traction energy consumption without electrical braking.

b) Regenerated energy through electrical braking.

c) Energy consumption by auxiliaries & efficiency of each power consumption point. For further details, refer Annexure II

(ii) The estimated specific energy consumption figures alongwith the break up as above in para (i) of this clause and clause 3.1.18, will be submitted by the Bidder for each section based on the train resistance formula and track profile & permanent speed restrictions, placed in Annexure V.

(iii) The validation of efficiency and energy consumption shall be done on combined test bed and at field as per the IEC 61377 and 61133. However, the measurement of the SEC, as specified in the contract, shall be carried out during performance tests as per IEC 61133. In case SEC is found to be higher by 5% or more than specified, the supplier would make required adjustments / modifications to the supplied equipment and software to improve SEC.

(iv) Acceleration: The acceleration will be calculated from the time taken to reach a speed of 40 km/h. The time taken shall be from the instant master controller is switched on to the instant speed of 40 Km/h is touched.

(v) Tests will be conducted to confirm acceleration performance according to values specified with tolerance of 3%.

(vi) Test results shall also be recorded for wet rail condition.

(vii) The permissible tolerance for achieving balancing speed of 110 Km/h shall be 3%.

(viii) Deceleration: The deceleration test shall be taken after preliminary runs of 200 miles (320 km) in order to bed in the brake blocks. Deceleration shall be calculated by dividing the initial velocity by the time taken from the instant the brake controller is moved to the instant the train comes to a complete halt. The initial velocity shall be determined from the reading indicated by the speedometer which shall be calibrated prior to test. The test shall be taken on dry rail and the average of three tests will be taken as the final figure for deceleration.

5.12 Pre-commissioning Tests at ICF / Chennai

Supplier shall list the tests that are to be carried out on the supplied equipment after it has been mounted on the EMUs at ICF/Chennai or at EMU maintenance shed/workshop of IR or at any other manufacturer's premises. The test procedure, instrumentation and tolerance shall be furnished.

The supplier shall supervise these tests on two prototypes and all series production of 12 car rakes and also train staff of ICF/EMU maintenance shed/workshop/any other manufacturer's works where the electrics supplied as per this specification shall be equipped in EMU coaches in carrying out the tests. ICF or EMU maintenance shed/workshop of IR or any other manufacturer's works shall provide qualified staff for carrying out above tests.

5.13 Commissioning of EMUs at Mumbai.

Each rake shall be commissioned at Mumbai by the supplier staff before putting into commercial service. The supplier will commission two prototype rakes and all series production of 12 car rakes. The supplier shall furnish a Commissioning Schedule for the supplied equipment and the system which shall also include the following:-

(i) Confirming satisfactory functioning of the all system.
(ii) Test run in for about 1500 km over 3 days to confirm specified operating parameters such as acceleration, deceleration, brake blending and energy consumption.
(iii) Rectification replacement of any malfunctioning equipment.
(iv) Check of all safety related items.

CHAPTER 6

EXISTING EQUIPMENT DETAILS

6. SYSTEM DETAILS

6.1 The existing 1500 V DC/25 KV AC (AC-DC) EMU coaches are built for a track gauge of 1676mm, take power at an average line voltage of 1400 Volts DC and 22.5 kV AC, varying under normal working conditions between 1200 volts and 1800 volts and 19 KV to 27.5KV respectively. The equipments also operates satisfactorily at instantaneous minimum line voltage of 800 volts DC and 16.5 kV AC, under the condition of a sub-station being temporarily out of action.

6.2 The train unit consists of a driving trailer coach, a motor coach and a non-driving trailer coach, in that order. The motor coach has a small emergency driving cab for shunting in yards. Three-coach units may be coupled together to form trains of nine/twelve/fifteen/eighteen coaches.

Loading particulars of the equipment are as follows :-

Nominal voltage DC	1500V
Nominal voltage AC	25 kV
Number of traction motors per motor coach	4
TRACTION MOTOR	
Continuous rating	240 kW @2000 rpm
- Torque	1147 Nm
- Fundamental current	200 A
One hour rating	270 kW @2000 rpm
- Torque	1290 Nm
- Fundamental current	211 A
Short time rating	300 kW @2000 rpm
- Torque	1434 Nm
- Fundamental current	223 A
TRACTION CONVERTER	
Continuous rating	
AC mode	
Input power per 4QC	620 kW
Out put power per PWMI	535 kW
Input current per 4QC	764 A
Output current per PWMI	322 A
DC mode	
Out put power per PWMI	535 kW
Output current per PWMI	400 A
Short time rating (2 min.)	
AC mode	
Input power per 4QC	720 kW
Out put power per PWMI	630 kW
Input current per 4QC	903 A
Output current per PWMI	371 A
DC mode	
Out put power per PWMI	630 kW
Output current per PWMI	446 A

AUXILIARY CONVERTER POWER	115 kVA
415 V, 3 phase output	87 kVA
110 V, AC single phase	20 kVA
110 V DC	09 kW
Wheel diameter (New)	952 mm
Wheel diameter (Fully worn)	877 mm (tyred)
Length over body	20,726 mm
Bogie wheel base	2,896 mm
Bogie centres	14,630 mm
Width over body	3,662 mm
Pantograph height (locked down position)	4,293 mm
Nominal voltage DC	1500V

6.3 Current is collected from the over head line by a dual voltage AC/DC pantograph. It is mounted on insulators which are themselves mounted on an insulated platform.

6.4 An Electrical Control Cabinet (Auxiliary power panel) containing SIBAS KLIP, DC earthing switch, MCB's and other switchgear equipments is mounted in the H.T. compartment of motor Coach (MC). Central Control Unit (CCU), MVB repeater and other switchgear equipments are housed in another cabinet i.e. Central Control Unit cabinet mounted in driver's cab in DTC.

6.5 The auxiliary Converter of 115 KVA capacity is used to supply auxiliary power from the input DC link voltage varying with respect to over head voltage as defined in chapter-II. It supplies to main compressor, auxiliary machines, battery charger, ventilation and other control equipments. A 50 cell lead acid battery of 90 AH capacity is used for emergency supply. An auxiliary compressor of 110 V DC, 10 amps rating is provided for raising pantograph at start.

During the AC mode, 2x950 V AC input is fed to traction converter (IGBT based) 4QC, which transforms the input voltage into controlled direct voltage for DC link circuit. DC link voltage is the input to Pulse Width Modulated Inverter (PWMI) which provides three phase voltage system for traction motors controlled by adjusting the frequency & voltage. Similarly, during the DC mode OHE voltage is directly fed to DC link circuit. There are two inverter modules, each feeding two traction motors connected in parallel.

Ventilating air for the traction motors is taken from the coach through individual dry fabric type filters via under frame ducting. Traction motors are provided with fan on rotor shaft at non-driving end of the motors. The existing traction motor draws cooling air from inside coach body through a duct. A leather bellow is used to connect the coach body duct & traction motor air inlet. Air outlet is in curved shape to prevent the water splashed by wheels from entering into motor.

6.6 An under frame mounted compressor of 940+6% LPM at 7Kg/cm^2, given by an integral 415V 3-phase AC motor supplies air for the electro-pneumatic brakes and control equipment. A speedometer cum recorder is fitted in the driving cab.

Following drawings for the existing system for ready reference are enclosed at Annexure X.

S. No.	Description	Drg. No.
1	Power schematic for dual voltage i.e. 25 kV AC and 1500 V DC BG EMUs	Fig. 1 (1 sheets)
2	Auxiliary converter circuit	Fig. 2 (1 sheet)
3	End wall coupler arrangement	Fig. 3
4	Layout of Driver's desk	Fig. 4

6.7 Indian Railways is executing a project with fitment of three phase electrics suitable for Dual voltage operation (1500V DC & 25 KV AC) on ICF built coaches. For reference, drawings pertaining to AC/DC EMU for Bogie, suspension and brake arrangement are enclosed with Annexure XII. Name of Drawings are indicated in Annexure XII.

LIST OF ENCLOSURES

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S. No.	Enclosure type	Description
1.	Annexure-I	List of equipments to be provided in driver's cab
2.	Annexure-II	Salient design details to be submitted along with the offer
3.	Annexure-II A	Design data calculations & drawings to be submitted by the supplier.
4.	Annexure-III A	Track data
	Annexure-III B	Track data
	Annexure-III D1	Track recording results (Western Railways)
	Annexure-III D2	Track recording results (Central Railways)
5.	Annexure-IV	List of specifications for testing of equipments
6.	Annexure-V	Route profile of CST-KASARA & Churchgate-Andheri Section
7.	Annexure-VIA	Limits of interference currents
	Annexure-VIB	Tele-communications cabling installation
	Annexure-VIC	AWS Specification
8.	Annexure-VII	Present Suburban Network
9.	Annexure-VIII	Formation of existing 12 car EMUs in Central & Western Railways.
10.	Annexure-IXA	AC MMD
	Annexure-IXB	DC MMD
11.	Annexure-X	Power schemes of existing EMUs, Aux. Converter circuit, END wall coupler arrangement & layout of driver's desk
12	Annexure-XI	Drawing sheet format Nos. PE/F/0007 to 0010 (4 sheets)
13.	Annexure-XII	AC/DC EMU ROLLING STOCK DRAWINGS FOR BOGIE, SUSPENSION & BRAKE ARRANGEMENT (supplied with the Bid Documents as Soft Copy on CD-1)
14.	Annexure-XIII	List of equipments for which MTBF/MDBF to be submitted
15.	Annexure-XIV	ICF's letter no. MD/D/Weights/119, dated 29.11.2007
16	Annexure-XV	Vibration levels at Critical Locations of Traction Motor & its Suspension, Mounting Arrangement of existing AC/DC EMU with 40/100 Hz low pass filter.