

EMPLOYER'S REQUIREMENTS: TECHNICAL SPECIFICATION

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EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 1

INTRODUCTION



CHAPTER 1: INTRODUCTION

1.1 Scope

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

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

1.1.3 The scope shall also include the following:

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

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

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



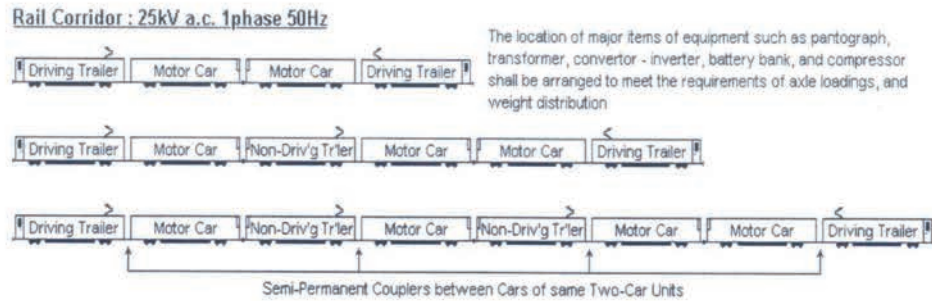


Fig. 1 Consist Configurations for Rail and Metro Corridors

Couplers:

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

- 1.1.6 For each corridor, all DT, M and T cars shall be totally interchangeable with all other DT, M and T cars, respectively, without modification.
- 1.1.7 The scope of supply shall include all the equipment for meeting the performance requirements and trouble free and efficient operation of trains irrespective of whether such equipments are specifically included in the specification or not.
- 1.1.8 The 'RS15' type Rolling Stock shall conform to the Employer's Requirements – Technical and General Specifications and shall conform to all approved/would be approved variations, modifications and Hardware/Software Engineering Change Proposals against the contracts 'RS1', 'RS6' and 'RS13' in line with ERTS. In case of any contradiction between ERTS and approved/would be approved modifications (Hardware/Software Engineering Change Proposals) against the contracts 'RS1', 'RS6' and 'RS13', the later will prevail.

1.2 Prototype Train/Unit

- 1.2.1 The prototype Trainset/'T+M' unit shall be supplied as per the delivery schedule.
- 1.2.2 Clearance for dispatch of the prototype Trainset/'T+M' unit will be granted, only after successful completion of tests at the nominated place by the manufacturer, to the entire satisfaction of the Employer. Should any modification/ alteration based on results of the tests on the prototype be required, contractor will be obliged to carry out necessary modifications at no additional charge on all trains.
- 1.2.3 The Contractor shall manufacture and supply one complete Trainset/'T+M' unit duly equipped with test and measuring equipment and sensors for carrying out the following tests, in addition to those specified in IEC 61133 or an accepted International Standard, on respective lines.
 - (i) Oscillation test to prove the riding and stability performance of the cars (refer clause 15.5 for detail test) for confirming fitness of the Trainset/'T+M' unit and vehicle for introduction into revenue service, if required.
 - (ii) Performance requirement test including test of energy consumption.
 - (iii) Emergency braking distance trials for AW0 and AW3 under both dry and wet conditions to prove the braking capability of the car.



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

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

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



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EMPLOYER'S REQUIREMENTS TECHNICAL SPECIFICATION

CHAPTER 2

GENERAL REQUIREMENTS



CHAPTER 2: GENERAL REQUIREMENTS

2.1 General

2.1.1 This Chapter covers the following requirements:

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

2.2 Interface Activities

- 2.2.1 Interfaces exist between the Rolling Stock Contractor and other designated contractors for systems, where the systems are mutually dependent, or interactive for satisfactory and safe operation. The Rolling Stock Contractor shall maintain close coordination / interface during design, manufacturing and, testing and commissioning phase with the designated Contractors, various other contractors and consultants who may be working in the Project, whether or not specially mentioned in the Contract. The Rolling Stock Contractor shall perform all design duties and provide all materials, equipment and labour to ensure the satisfactory accomplishment of interface of the systems for which the Rolling Stock Contractor is responsible.
- 2.2.2 The Rolling Stock Contractor shall submit and maintain an agreed Interface Management Plan. At all stages of the work, all interfaces shall be discussed and agreed upon, through the Engineer between the Rolling Stock Contractor and other designated contractors. Interface should essentially be with Signalling, Communications, Power Supply, Civil Engineering, Track-work, Depot Contractors and other Contractors advised by the Engineer. Refer to the Employer's Requirements - General Specification for requirements of the Interface Management Plan, its scope and other related details.
- 2.2.3 In certain cases, the Engineer may direct the Contractor to liaise with Designated and other contractors directly to discuss and agree on interfaces. However, the Rolling Stock Contractor shall keep the Engineer apprised in writing of all such discussions, agreements and conclusions.
- 2.2.4 It will be the responsibility of the Contractor that interface requirements be finalised as early as possible. Contractual delays and consequential implications as a result of delay in such liaisons on account of reasons attributable to the Contractor, as concluded by Engineer, shall be the sole responsibility of the Contractor.
- 2.2.5 It would be the responsibility of the Contractor to settle all disagreements with the Designated Contractors. If such disagreement cannot be resolved by the Contractor, despite having made



all reasonable efforts, then the Contractor shall refer the matter to the Engineer for resolution with complete details with supporting documents and any other information as may be required by the Engineer. The decision of the Employer shall be final and binding on the Contractor(s).

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

- 2.2.6 A Document titled "Interfaces between Rolling Stock, Signalling and Telecommunications Contractors" detailing the interfacing requirements and division of responsibility between the identified Designated Contractors is enclosed as 'Appendix TD' to this Specification.
- 2.2.7 Rolling stock being supplied under this contract shall be fully compatible with the existing Signaling and Telecommunication contracts. It will be the responsibility of the Rolling Stock Contractor 'RS15' to interact with all sub system suppliers of DMRC existing 'RS1', 'RS6' & 'RS13' Contracts and Signaling and Telecommunications contractors. In case of any specific interface requirement with any of the designated contractors, the entire cost of interface including that of the designated contractors shall be borne by the RS15 contractor and shall resolve all issues pertaining to integration of their sub system stabilization in existing 'RS1', 'RS6' & 'RS13' stocks.
- 2.2.8 The Contractor, as a part of its Management team shall mobilize at site an Interface Manager as laid down in General Specifications Chapter 2.

2.3 Quality Assurance

- 2.3.1 The Contractor shall submit 'Quality Assurance Plan' for review and acceptance by the Employer as specified in the Employer's Requirements: General Specification.
- 2.3.2 The Contractor shall develop a 'Quality Assurance Programme' (QAP), structured in accordance with acceptable international standards. Adequate records of quality assurance controls shall be maintained as per QAP and in a manner to facilitate performance audits by the Engineer.
- 2.3.3 The Contractor shall be solely responsible for all the Quality Assurance functions required by the Contract. All work and material shall be produced and control in accordance with an Internationally recognised and accepted quality standard.
- 2.3.4 The Contractor shall propose a Configuration Management System in accordance with latest relevant international standards. All deliverable items of equipment shall be of the same configuration and be totally interchangeable. Any modifications performed on later deliveries shall be applied retrospectively to equipment already installed.

2.4 System Safety Assurance

- 2.4.1 The Contractor shall submit 'System Safety Assurance Plan' for review and acceptance by the Engineer as specified in the Employer's Requirements: General Specification
- 2.4.2 The System Safety Assurance Plan shall cover design, manufacture, testing, commissioning and integrated testing, and minimising the magnitude and seriousness of events or malfunctions, which could result in injury to patrons or staff and damage to equipment or property, but cannot be completely eliminated.

2.5 Hazard Analysis

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



- 2.5.2 The Contractor shall produce the Hazard Analysis Schedule for the complete train including all train borne systems and shall interface principally with the Signalling, Communication, Power Supply, Civil and Depot Contractor as well as any other Designated Contractors to obtain the information necessary, from their hazard analysis, to complete the analysis.
- 2.5.3 The Contractor shall, as part of the safety analysis, prepare analysis to identify Hazards and ensure their satisfactory resolution. The following analysis shall be prepared and submitted by the Contractor for the Engineer's acceptance.
- (i) Preliminary hazard analysis
 - (ii) Interface hazard analysis (excluding EMI)
 - (iii) Subsystem hazard analysis
 - (iv) Operating hazard analysis including maintenance
 - (v) Quantitative fault tree analysis
 - (vi) Failure modes effects and criticality analysis (FMECA)
- 2.5.4 The Hazard Analysis shall be carried out in accordance with EN50126 as the primary standard, or any other internationally accepted equivalent standard, in areas not adequately addressed by the former standard.
- 2.5.5 The Contractor shall compile a list of critical and catastrophic items identified as a result of hazard analysis, FMECA or by other means. The Contractor shall carryout the Hazard and FMECA for the following equipment / sub-systems / systems:
- Bogie and Suspension
 - Vehicle Body
 - Transmission Drive System
 - Gangways
 - Coupler
 - Brake System
 - Door System
 - HVAC System
 - Pneumatic System
 - Communication System
 - HV and Propulsion System
 - Auxiliary Power System
 - Control equipment
 - TIMS
- 2.5.6 All hazard resolution by procedural control shall be cross-referenced from the Critical and Catastrophic Items List to the appropriate manuals.
- 2.5.7 The qualitative measures of hazard severity are defined as follows:
- (i) Hazard Category I – Catastrophic: Operating conditions such that personnel errors, environment, design deficiencies, subsystem or component failure or procedural deficiencies may cause death or system loss. The safety target shall be based on internationally accepted standards.
 - (ii) Hazard Category II – Critical: Operating conditions such that personnel errors, environment, design deficiencies, subsystem or component failure or procedural deficiencies may cause severe injury to personnel, severe occupational illness or major system damage. The safety target for the occurrence of all Category II hazards summed together shall again be based on internationally accepted standards.



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

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

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

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

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

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

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

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

2.6 Fail Safe Design

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

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

Components must be utilized in such a manner that ensures that a restrictive, rather than a permissive condition will result from a component failure. (For example: brakes will apply,



rather than release; train will decelerate, rather than accelerate.)

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

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

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

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

2.7 Reliability, Availability and Maintainability: General

- 2.7.1 Reliability, Availability and Maintainability (RAM) requirements and goals shall be developed in terms of Mean Distance Between Failures (MDBF), percentage Availability and Mean Time to Repair (MTTR). The Contractor shall perform RAM analysis up to the point of interface with other contractor's systems.
- 2.7.2 The Contractor shall comply with the guidelines of IEC 60300-1, IEC 60300-2 and IEC 60571 for electronic equipment, and IEC 60300-3-5 or any other internationally accepted equivalent standard in meeting the reliability, availability and maintainability requirements of equipment.
- 2.7.3 The Contractor shall submit Reliability, Availability and Maintainability Plan as specified in the Employer's Requirements: General Specification. The Contractor shall verify, after system design have been completed, that the reliability, availability and maintainability requirement will be met.
- 2.7.4 Delhi Metro Rail Corporation attaches the greatest importance to the attainment of the highest possible Reliability during service of all the equipment and systems supplied and installed under this contract. The design, manufacture, installation and commissioning of the equipment as also the training of the operating and maintenance staff shall be such as to ensure near Zero Failure performance in the initial stages and that the few defects and deficiencies that may be exposed during the Service Trial and the initial reliability growth period of one year are totally eliminated in the bulk supply.
- 2.7.5 The Contractor shall demonstrate by quantitative methods achievement of the specified levels of reliability for the train and specific individual items of equipment.
- 2.7.6 An evolving reliability model consisting of reliability block diagrams and probability of success equations shall be developed and submitted to the Engineer for acceptance. This model shall show the relationships required for system and equipment to operate successfully. The reliability block diagrams shall include all elements essential to the successful performance of the system and the interrelationships and interface of these elements.
- 2.7.7 Reliability apportionment and prediction analysis shall be in accordance with established techniques or standards, which will be submitted for acceptance by the Engineer. The analysis



shall provide predictions for each major equipment and sub-system. Predictions shall be based on actual revenue service results for identical equipment operating under service conditions and duty cycles equivalent to DMRTS, or more severe. The analysis shall be carried out in parallel with the design of the train. The relevant apportionment and prediction figures shall be part of the design submission documents for the individual equipment, sub-system and system.

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

2.8 Reliability Requirements

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

2.8.1 Definitions:

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

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

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

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

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

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

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

- (iii) Service Failure: Any relevant failure or combination of relevant failures during revenue service operations, simulated revenue operations, or during pre-departure equipment status checkouts to determine availability for revenue service, which results in one of the following:

Non availability of the train to start revenue service after successful completion of pre departure check;

Withdrawal of the train from revenue services;

A delay equivalent to or exceeding 3 minutes from the Schedule / Time table as noted at the destination station for the one way trip.

The discretion of declaring a train as Not-available to start revenue service after successful completion of pre-departure checkout or withdrawing a train from revenue



service on account of any relevant failure rests solely with the Employer and shall be final.

- (iv) **Pattern Failure:** Repeated occurrence of three or more relevant failures of the same replaceable part, item or equipment in same manner in identical or equivalent applications when they occur at a rate which is inconsistent with the predicted failure rate of the part, item or equipment. The decision of the Engineer shall be final.
- (v) **Mean Distance Between Failure (MDBF):** The MDBF is the ratio of the total operating distance accumulated by the total available fleet of the trains to the total number of Service Failures
- (vi) **Mean Distance Between Component Failures (MDBCF):** The MDBCF of a system is the ratio of the total operating distance accumulated by the total population of identical items in the available fleet of the trains to the total number of Relevant failures.
- (vii) Since integration of 'T+M' units may be required to be done with existing train sets, allocation of failures attributable to the Stock supplied against this contract shall be considered for reliability demonstration targets specified herein.

2.8.2 Reliability Targets:

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

Table 2.1: Reliability Targets

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

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

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

Table 2.2 : MDBCF of major systems

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



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

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

2.9 Reliability Demonstration

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

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

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



month, the RDP as well as DLP of all the stock that is under DLP in that month shall get extended by one month.

- 2.9.4 The Contractor shall analyze each and every failure/defect of components of various equipments to determine the cause of failure and to propose corrective measures, which would be reviewed by the Engineer.
- 2.9.5 A record shall be maintained for each and every defect/failure in accordance with FRACAS as stated in Clause 2.9.1 to be submitted by the Contractor and approved by the Engineer.
- 2.9.6 Reliability shall be monitored during revenue service operation of the trains. The Contractor shall collect and collate data on each and every deficiency and failure observed by both himself and the Engineer, from handing over the first train to the end of the Defect Liability Period. Each and every failure, whether of component, sub-system or system, during this period shall be subject to a failure analysis to determine the cause of failure. The Contractor shall submit investigation reports for review of the Engineer.
- 2.9.7 Correction shall be made to components or subsystems that either fail to attain predicted reliability levels or show Pattern Failure, at no additional cost to the Employer.

2.10 Availability Requirements

Availability shall be assessed by the following measure:

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

where:

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



maintenance, the time spent on sending back the train to revenue service, if any, shall also be included.

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

2.10.2 Availability Target

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

2.11 Availability Demonstration

2.11.1 Deleted.

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

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

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

2.12 Maintainability Requirements

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

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

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

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

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

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

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

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



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

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

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

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

Table 2.3 : MTTR of major systems

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



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

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

Table 2.4 : Service checks

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

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

Table 2.5 : Maintenance Activities

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

Note: The Corrective Maintenance time as indicated above shall include defect



identification, replacement of defective LRUs and restoration to service condition

2.13 Maintainability Demonstration

- 2.13.1 The Contractor shall carry out tests to demonstrate that all maintainability predictions provided vide Clauses 2.12.10, 2.12.11 and 2.12.12 are met. All such tests shall be completed within six months after the delivery of first train. In the event that any maintainability target is not achieved, the Contractor shall at his own expense take whatever action is deemed necessary to meet the maintainability targets.
- 2.13.2 The Contractor shall ensure that all the required information including the related Maintenance Work Instructions (MWI) etc. are available before the commissioning of the first train into revenue service to enable him to demonstrate the maintainability targets.

2.14 Maintenance

- 2.14.1 The trains shall operate with minimum attention between the specified inspection periods, and shall, under the operating conditions specified, operate between overhaul periods without requiring replacement of components other than those on the agreed list of consumable parts to be proposed by the Contractor and accepted by the Engineer.
- 2.14.2 Special tools shall be avoided wherever possible. If they are required, they shall be supplied by the Contractor in sufficient quantities to meet the maintenance requirements.
- 2.14.3 Equipment design shall be modular to minimise down time following failures of equipment and components. Provision for mechanical handling devices shall be provided for any single piece of equipment weighing more than 35kg. Equipment covers shall be provided with secure, visible, latching arrangements easily inspectable from the side of trains.
- 2.14.4 All underframe equipment which cannot be handled manually shall be configured such that it can be removed and replaced from track level using fork lift trucks or lift tables, with recognition being given to the confined environment of the pit and the rail level and underframe dimensions.
All underframe equipment shall be arranged such that it is capable of being removed and replaced without disturbing any other equipment.
- 2.14.5 If any equipment mounted above the ceiling requires the use of lifting equipment for its removal or refitting this shall be readily achievable without the risk of damage to the vehicle interior.
- 2.14.6 Removal and re-assembly of moving and wearing parts on bogies shall generally be carried out without the use of special tools.
- 2.14.7 Bogies shall be capable of being disconnected and reconnected to vehicle bodies with a minimum of operations. All connections must be easily and safely accessible to personnel located in pits or alongside the bogie at rail level. It shall be easy to inspect for correct reconnection, from alongside the bogie where possible.

Preference will be given to a design which permits release of the bogie to permit the raising of the car body, without the need for a pit in the Lifting Berth.
- 2.14.8 Each vehicle shall be capable of being lifted complete with bogies without the need to attach extra restraints or supports for the bogies or wheels.
- 2.14.9 Lubrication points shall have button head type grease nipples, and shall be easily accessible from rail level and shall, where possible, be grouped together.
- 2.14.10 On-vehicle test equipment shall be used on a vehicle to discriminate between a fault on the main equipment and a fault on the control electronic equipment.



- 2.14.11 Should the electronic equipment be found to be faulty, the equipment shall enable fault finding to be carried out at module level.
- 2.14.12 Off vehicle test equipment shall be used in the depot repair centre. This equipment shall allow fault finding down to the smallest replaceable item of equipment.
- 2.14.13 The unit shall have equipment cases and modules that are connected to the main vehicle wiring via connectors which are proven in equivalent service duties to achieve high reliability and are easily removable in the event of equipment replacement.
- 2.14.14 Equipment to which access will be required for faultfinding shall be conveniently located. A list of such equipments and their location shall be supplied.
- 2.14.15 The unit shall have provision for the isolation and where applicable, earthing of all electrical sub-systems to facilitate safe and systematic maintenance and fault diagnosis.
- 2.14.16 It shall be physically impossible for plug and socket connections and connections on safety-critical circuits to be mismatched.
- 2.14.17 The unit shall have standard test points on pneumatic systems. There shall be unrestricted access to facilitate checks during routine maintenance and fault diagnosis.
- 2.14.18 The abovementioned features shall be suitable reflected in the respective design documents, as applicable, during the design stage.

2.15 Electro-Magnetic Compatibility: General

- 2.15.1 An EMC Control Plan shall be submitted by the Contractor within 30 days of the Notice to Proceed for acceptance by the Employer's Representative.
- 2.15.2 The EMC Control Plan shall include measures to reduce conducted, induced and radiated emissions to acceptable levels as specified by the relevant international standards. The plan shall specify measures to increase immunity of the train and all its subsystems.
- 2.15.3 The plan shall specify basic protective measures proposed for all electrical and electronic subsystems and components and specific measures to be adopted for selected subsystems and components.
- 2.15.4 The plan shall analyse EMI and EMC impacts on the design of the train, all other train-borne equipment and track-side equipment as well as the general environment. Particular attention should also be paid to additional requirements in grounding bonding, shielding, filtering and cabling arrangements.
- 2.15.5 The Contractor is required to conduct full EMI tests on one train at locations adjacent to television and radio transmission stations, airport, and other transmitting commercial stations to be agreed with the Employer's Representative. These tests shall include simulated fault conditions.
- 2.15.6 The Contractor is required to conduct type tests as well as full EMC tests on a complete train. Tests to be conducted shall include but not be limited to satisfying the latest versions of the following standards or equivalent :
 - (i) Overall compliance: EN50121-1
 - EN50121-2
 - EN50121-3



(ii) Specific standards:

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

The conducted emission must also satisfy special requirements for ATO.

2.16 Intra-system EMC

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

2.17 Inter-system EMC

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

2.18 Safety-related Systems Interference

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

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

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

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



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

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

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

2.19 Non-Safety-Related System Interference

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

- (i) Communications Equipment

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

- (ii) Supervisory & Control Equipment

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

2.20 Environmental EMC

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

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

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

2.21 Installation and Mitigation Guidelines

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

2.22 Noise and Vibration

- 2.22.1 General



- (i) The Contractor shall ensure that the cars and equipment are designed and built so that specified noise and vibration limits are not exceeded. Particular attention shall be given to the design of all equipment to minimise generation of noise and vibration. The design of the vehicle shall have adequate attenuation of airborne and structural-borne vibration along potential paths from the sources to passenger saloon and to wayside receptors.
- (ii) Exterior and individual systems and equipment noise measurements are to be made in accordance with ISO 3095, and interior noise measurements are to be made in accordance with ISO Standard 3381, except where otherwise specified. For evaluation, the noise level measurements shall be as per the specified criteria below.
- (iii) Ride quality vibration measurements shall be carried out in accordance with ISO 2631 (1985).
- (iv) Unless otherwise stated, noise means sound pressure level as defined in the latest revision to ANSI S1.4. All noise levels listed are in decibels referred to $20\mu\text{Pa}$ as measure with "A" weighting net-work of a standard Type 1 sound level meter with time weighting F. All noise values indicated in dBA, herein after are the L_{PA5} values in a window of 20sec. After applying time and frequency weighing, the sampled measurement data (atleast 10000 readings with 500Hz from one microphone) shall be divided into classes corresponding to each level (say 10 classes per dB). For each class the frequency over the measurement time shall be calculated. A histogram of frequency of each L_{PAF} level over the measurement time is made. This shall be converted to a graph over cumulative relative frequency. The value for 95% of the time is L_{PA5} Level i.e. the A-weighted sound pressure level exceeded for 5% of the measurement time period as defined in ISO 1996-1
- (v) For all tests, the levels of all sounds or vibrations other than those being evaluated shall be not less than 10dB below the levels of sound being evaluated, when measure with the same weighting network of (1/3) octave bands as that being used for the test.
- (vi) Wayside noise measurements shall be performed in an essentially free field environment with no nearby structures or reflective surfaces, which could influence the measurements, by more than 2dB, other than the standard track structure and the adjacent flat, clear ground.
- (vii) Interior noise criteria apply to measurement within an empty full fitted car. All noise level limits specified for car interior shall also apply to interior of gangway as far as practical. The noise level shall be measured at any point along the longitudinal centreline of the gangway and at a height of 1400mm above the gangway foot-plate.
- (viii) The pad stiffness used in DMRC ballastless track is generally 29MN/m and the same shall be used for design. The noise tests during running condition shall be done in the section after six months of train operation. The tenderer may suggest change in pad stiffness if it can help in further reducing the noise level.
- (ix) All specified noise measurements shall be revalidated 6 months before the end of DLP on a representative train selected by the engineer. In case of non compliance, the Contractor shall take necessary action to correct the defect and revalidate.

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

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

2.22.2 Noise and Vibration Assurance Plan



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

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

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

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

where:

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

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

2.22.5 Exterior Noise Levels for elevated (measured in two track section) and at-grade sections shall



not be more than those specified in table 2.7.

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

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

where:

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

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

2.22.7 Vibration

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

2.23 Fire Performance

2.23.1 General

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



combustible materials whenever practical and to reduce to the extent practical the energy content and heat release rates of the combustible material that are used.

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

2.23.2 Material Properties

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

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

Above floor level : 28000 MJ
Below floor level : 28000 MJ

Contractor shall furnish the relevant data.

2.24 Fire and Smoke Detection System

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

- 2.24.2 Fire and smoke detection system shall be consist of smoke/heat detectors, fire detection and control unit (FDCU), sounders, displays & software appart from small items like cables, connectors etc. Minimum 4 no. of Smoke & Heat detectors (multi-sensors) shall be installed in passenger area of each car. The sensivity of smoke detector has to fulfill the requirements of ARGE guidelines. The actuating temperature of heat detector shall be settable according to the international norms and standards. The FDCU shall interface with TCMS.
In case of fire, the entire air conditioning on the train must be switched off in order to prevent any transfer of smoke to other train parts. Ventilation shall be provided depending on Whether the fire/smoke has been detected insdide or outside of the passenger saloon area.

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

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

2.25 Life Cycle Cost

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



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EMPLOYER'S REQUIREMENTS TECHNICAL SPECIFICATION

CHAPTER 3

DESIGN AND PERFORMANCE REQUIREMENTS



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

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

3.2 Proven Design

- 3.2.1 The Contractor shall develop the design based on this specification and on sound proven and reliable engineering practices. The design details shall be submitted with technical data and calculations to the Engineer for review and acceptance.
- 3.2.2 The rolling stock, including all sub-systems and equipment shall be of proven design. Sub-systems and equipment offered in this tender shall have been in use and have established their performance reliability on a mass rapid transit system or suburban e.m.u.'s in revenue service over a period of two years or more. Where similar equipment or sub-systems of a different rating are already proven in service, then the design shall be based on such equipments. In case this stipulation is not fulfilled the tenderer shall furnish sufficient information to prove the basic soundness and reliability of the offered subsystem.
- 3.2.3 Propulsion system is the heart of Rolling Stock and the performance of rolling stock largely depend upon reliable performance of propulsion system. Technology for three phase drive using VVVF control IGBTs is fairly new and has made rapid strides in its development. To ensure that a reliable system is offered, it is necessary that the manufacturer of this system has got atleast 10 years experience in this field with atleast 5 years outside his home country. To support this requirement, the Tenderer shall furnish names of various railway systems to which the technology has been applied, the total service logged and certificates from the user on reliability of the equipment.
- 3.2.4 Vendors for important sub-system/equipments in the existing 'RS1', 'RS6' and 'RS13' type fleet have been listed in Appendix TG. The contractor is expected to comply to the list to the extent possible. The vendor in the present tender have to be necessarily the same for the critical system/equipments as indicated in the 'proposed vendor/sub vendor' column of Appendix TG. For the others, the contractor could include the names of alternative vendors in the same column. However these new vendors can only be considered with prior approval of the Engineer. Appendix TG duly filled shall be submitted with the bid.
- 3.2.5 The overall performance of the tenderer (all members in case of JV/Consortium separately) shall be examined for all the ongoing Rolling Stock Works awarded by DMRC/ any other Metro Organization (100% owned by Govt.) of value more than 40% of NIT cost of work and also for all the completed Rolling Stock Works awarded by DMRC / any other Metro Organization (100% owned by Govt.) within last one year (from the last day of the previous month of tender submission), of value more than 40% of NIT cost of work executed either individually or in a JV/Consortium. The tenderer shall provide list of all such works in the prescribed Performa given in Appendix FT-18 of the Form of Tender. The tenderer (all members in case of JV/Consortium separately) may either submit satisfactory performance certificate issued by the Client / Employer for the works or give an undertaking regarding satisfactory performance of the work with respect to completion of work/execution of work (ongoing works) failing which their tender submission shall not be evaluated and the tenderer shall be considered non-responsive and non-compliant to the tender conditions. In case of non-submission of either satisfactory performance certificate from client / employer or undertaking of satisfactory performance of any of the above work, the performance of such work shall be treated as unsatisfactory while evaluating the overall performance of tenderer in terms of Note (b) of Appendix FT-18. In case of performance certificate issued by the client, same should not be older than three month (from the last day of the previous month of tender submission for the ongoing works).



3.3 Basic Design Philosophy & Requirements

3.3.1 The design philosophy should meet the following criteria:

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

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

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

3.4 Design Management and Control

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



- 3.4.2 The Contractor shall establish and maintain a systematic, documented, comprehensive, and verifiable system integration process throughout the execution of the Contract. This process shall ensure that interfaces and interaction between cars, infrastructure, subsystems, software, and operating and maintenance requirements have been identified and engineered to function together as a system.

3.5 System Integration Process

- 3.5.1 The Contractor shall systematically identify and formally document all design, manufacturing and operational interfaces between equipment within the train, and between the train and external systems, facilities, operations and the environment likely to affect or be affected by the train.
- 3.5.2 A mechanism and assigned project responsibility for interface management and control shall be provided, such that every identified interface has a defined resolution process that can be monitored.
- 3.5.3 The Contractor shall define methods to confirm compatibility between train equipment and carrying out integration tests at different stages of the design and interface management process to demonstrate that all equipment functions perform properly, both individually and as part of the complete train.
- 3.5.4 The Contractor shall ensure that performance, availability and safety requirements are addressed in the design process and that the reliability and maintainability of all equipment will enable the service performance to be met. The system integration process shall be capable of audit by the Engineer.

3.6 Interface Management

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

3.7 Design Submission Requirements

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

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

3.8 Design Review

- 3.8.1 At appropriate stages in the design process, formal documented reviews of the design and related issues shall be planned and conducted. This shall be performed at fleet, train, car, system and subsystem levels, as appropriate, to verify and demonstrate:
- (i) Safety for manufacture, testing, operation and maintenance.
 - (ii) Compliance with the relevant codes, specifications, the General Specification and this Technical Specification.
 - (iii) Fitness for purpose, fulfilling the necessary operational functionality and performance.
 - (iv) Integration and interfacing within the project and to external elements.
- 3.8.2 The Contractor shall submit for the Engineer's review a Design Review Schedule, in



accordance with the General Specifications, which shall define the scope and timing of design reviews.

- 3.8.3 The Engineer reserves the right to attend any or all design reviews.
- 3.8.4 The Contractor shall ensure that participation in design reviews includes representatives of all functions, disciplines and entities concerned with the equipment and the stage being reviewed.
- 3.8.5 The Contractor shall at least 15 days prior to the date of each design review submit in-progress design documents of the elements to be addressed at the design review meeting.
- 3.8.6 The Contractor shall within 15 days after the date of each design review submit for review Design Review Minutes, detailing all issues raised during the review, their resolution or ongoing design status and due date for resolution.

3.9 Employer's Design Audit

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

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

- 3.9.2 The Contractor shall provide all documentation and personnel participation reasonably requested by the Engineer to enable design audits to be carried out.
- 3.9.3 The Contractor shall within 15 days of the date of each design audit submit for review Design Audit Minutes detailing all issues raised during the audit, their resolution or ongoing design status and due date for resolution.

3.10 Climatic and Environmental Conditions

- 3.10.1 Extreme climatic conditions are given below :

Table 3.10.1 : Climatic & Environmental Conditions

Description	Limiting Values
Maximum ambient temperature (See note below)	47°C
Minimum temperature	3°C
Humidity	100% saturation during rainy season
Rainfall	Rain occurs generally from June to September. Average annual rainfall is approximately 650 mm. Maximum rainfall in any 24h period is 50mm.
Atmosphere during hot season	Extremely dusty
Maximum wind Load	150 kg/m ² .
Vibration & Shocks	The equipment, sub-systems & their mounting arrangements shall be designed to withstand satisfactorily the vibration and shocks encountered in



	service as specified in IEC 61373.
SO ₂	80 – 120 mg/m ³
Suspended particulate matter	360 – 540 mg/m ³

Note: The temperature of the metal surfaces of the vehicles when exposed directly to the sun, for long periods of time, may be assumed to rise to 70°C.

3.11 Flood Proofing

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

3.12 Tunnel Diameter

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

3.13 Line Profile

3.13.1 The drawings showing the line profiles of

(i) Line 1

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

(ii) Line 2

- (a) Samaypur Badli to Huda city centre

(iii) Line 3

- (a) Dwarka Sec 21 to Noida Electronic City

(iv) Line 4

- (a) Yamuna Bank to Vaishali

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

3.14 Track Structure Parameters

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

Table 3.14.1: Track Structure Parameters

Description	Elevated and At-Grade Corridor		Underground Corridor
	Ballasted	Ballastless (DFF)	Direct Fixation Fastener (DFF)
Gauge	1673mm	1673mm	1673mm
Rail Type	UIC 860/0	UIC 860/0	UIC 860/0
Main Line	- 60 kg/m	- 60 kg/m	60 kg/m



Rail Profile	UIC 861-3	UIC 861-3	UIC 861-3
Rail Type Depot	IRS 52 kg/m	IRS 52kg/m	IRS 52 kg/m
Inclination Of Rail (BG 1673mm)	1 in 20	1 in 20	1 in 20
Sleeper Spacing Main Line	600mm \pm 20mm	600mm \pm 10mm	600 \pm 10mm
Sleeper Spacing Depot	750mm \pm 20mm		
Ballast Cushion Depth Main Line	300 mm		
Ballast Cushion Depth Depot	200mm		
Standard Rail Length	13m and 18m	13m and 18m	13m and 18m
Rail Panel Lengths	39m long welded	26m long welded	26m long welded
Minimum Radius of Curvature	300m – main line 200m – depot	300m - main line	300m - main line
Minimum Turn Out Rad. Main Line (BG)	220m	220m	220m
Minimum Turn Out Depot (BG)	1 in 8.1/2	-	-
Maximum Cant Permissible (BG)	150mm @ 1673mm gauge	150mm @ 1673mm gauge	150mm @ 1673mm gauge
Maximum Cant Desirable (BG)	125mm @ 1673mm gauge	125mm @ 1673mm gauge	125mm @ 1673mm gauge
Maximum Cant Deficiency Permissible	100mm @ 1673mm gauge	100mm @ 1673mm gauge	100mm @ 1673mm gauge
Maximum Cant Deficiency Desirable	75mm @ 1673mm gauge	75mm @ 1673mm gauge	75mm @ 1673mm gauge
Maximum Permissible Cant Gradient	1 in 440	1 in 440	1 in 440

Table 3.14.1 : Track Structure Parameters (continued)

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



3.15 Track Tolerances

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

Table 3.15.1 Track Tolerances

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

3.16 Interface

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

3.17 Current Collection System

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



Table 3.17.1, below:

Table 3.17.1 Current Collection System

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

3.18 Signalling System

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

Table 3.18.1 Signalling System

Item	Elevated/At-grade Corridor	Underground Corridor
Train control system	Cab signal and Automatic Train Protection system (ATP)	On board Continuous Automatic Train Control system (CATC) consisting of i) Automatic Train Protection ii) Automatic Train Operation (ATO) iii) Automatic Train Super-vision (ATS)
Train control mode	i) Coded manual mode ii) Restricted manual mode	i) Automatic mode ii) Coded manual modes iii) Restricted manual mode

3.19 Telecommunication System

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

3.20 Kinematic Envelope

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

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

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



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

Normal Conditions:

All vehicle speeds between 0 and 90km/h.

All vehicle loads between tare and fully loaded (based on 8 passengers per square metres).

Any degree of vehicle wheel wear between new and fully worn.

Any degree of vehicle suspension, wear or adjustment from new to fully worn, including all service tolerances and potential variations in setting.

Maximum cant deficiency.

Maximum cant excess.

Vehicle lateral and rolling movements due to wind forces with a wind speed of 60km/h on the Rail Corridor.

Vehicle yaw and vertical movements.

Track tolerances as detailed in clause 3.15.

Abnormal Conditions

Any combination of bogie air spring deflated.

Vehicle lateral and rolling movements due to wind forces with a wind speed of 115km/h on the Rail Corridor.

Account shall be taken of over-inflated air springs in calculating the vertical lift of the car body under abnormal conditions.

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

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

3.21 Train Performance

3.21.1 General

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

3.21.2 Traction Electrical Supply Systems

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

Table 3.21.2 Traction Electric Supply Systems

Item	Corridor
Nominal voltage	25.0 kV a.c.
Minimum voltage	19.0 kV a.c.
Maximum voltage	27.5 kV a.c.
Instantaneous minimum voltage	17.5 kV a.c.



Occasional maximum voltage	31.0 kV a.c.
Voltage for guaranteed performance	22.5 kV a.c.
Variation in frequency	48-52 Hz

3.22 Car Weights and Passenger Capacity

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

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

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

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

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

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

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

Metro Corridor: 84 tonne

Rail Corridor : 84 tonne

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

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

3.23 Train Resistance

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

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

For elevated/at-grade Corridor:

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

For underground Corridor:

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

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



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

3.24 Wheel Diameters

3.24.1 Wheel diameter shall be taken as: -

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

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

3.25 Performance Requirements

3.25.1 The performance requirements are given in Table 3.25.1

Table 3.25.1 Performance Requirements

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

3.25.2 Not used.

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

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

(i) Normal Mode:

Accelerate the train using the designed speed-TE characteristic of the rolling stock.



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

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

- (ii) All-out Mode: This will be the same as normal mode excepting that there will be no coasting and regenerative blended braking will be to achieve a retardation of 1m/sec^2 from top speed till stop.

(iii) Normal mode will be used for regular running of trains and time tabling.

(iv) All-out mode will be used when trains, running late, can make up time to achieve the scheduled timings.

(v) When the train is worked under ATO, it will receive commands as:

Run under Normal mode; or
Run under all-out mode.

(vi) The control system should be such that the train will achieve the speed time curves arrived at sub-clause (i) above subject to keeping the loading of the traction system within the boundary limits of design.

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

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

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

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

- 3.25.6 The continuous thermal rating of the traction system shall meet all the conditions of normal working. During emergency conditions operation as per Clause 3.25.5, the rake starting after a continuous working, one hour thermal rating should not be exceeded for one full trip, either way, in each corridor.



- 3.25.7 The Contractor shall hand over the software package employed by him for the above studies to the Employer.

3.26 Emergency Operating Condition

- 3.26.1 The train shall in addition to the above be capable of meeting the following criteria

- (i) One serviceable fully loaded 8-car train shall be capable of pushing a fully loaded defective 8-car train without parking brake applied, on both the Metro Corridor and the Rail Corridor, including a section of 3% gradient up to the next station. therefore, the healthy train shall, after all the passengers have detrained at the station, continue to push the defective train up to the next terminal. There shall be no equipment damage or degradation, while maintaining safe operation.
A 4,6 or 8 car fully loaded train shall be capable of clearing the section, with the traction motors of one 2-car unit cut-out. The temperature rise of the traction motor and equipment shall be within one hour rating of traction motor and other equipments in the above condition.

3.27 Specific Energy Consumption

- 3.27.1 The estimated specific energy consumption figures will be submitted by the Tenderer for each section based on the train resistance formula, curve resistance formula, track profile given in the tender document on the 'normal mode' of train operation. The Tenderer should also furnish the break-up of the estimated specific energy consumption as follows:

- (i) Specific energy consumption in traction
- (ii) Specific energy regenerated and fed back to the system
- (iii) Specific energy consumption by each auxiliary power consumption point
- (iv) Efficiency of each auxiliary power consumption point

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

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

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

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

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

3.28 Ride Performance

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

