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GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

TECHNICAL SPECIFICATION

FOR

IGBT BASED 3-PHASE DRIVE ELECTRICS

FOR

WAG9 & WAP7 LOCOMOTIVES

Specification No. RDSO/2007/EL/SPEC/0048, Rev. '0'

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ELECTRICAL DIRECTORATE
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CHAPTER 1

GENERAL DESCRIPTION AND CONTRACTOR'S RESPONSIBILITIES

1.0 Introduction

1.1 Indian Railways (IR) is currently manufacturing electric locomotives employing 3-phase propulsion based on the GTO technology. In order to upgrade the existing technology to the state-of-the-art, it is proposed to develop and introduce electrics with three phase drive IGBT propulsion for fitment on WAG9 freight locomotives and WAP7 passenger locomotive.

1.2 This specification defines the technical requirements of design, development, manufacture, testing, supply, delivery and commissioning of IGBT based 3-phase drive electrics including Main Transformer, Traction Converter, Traction Motor, Auxiliary Converter and Hotel load Converter, along with associated control/electronics/ subsystems, cabling, spares, tools, documentation etc. for use in Indian Railways.

1.3 These equipment shall be provided in the bogie and body of WAG9 and WAP7 class of locomotives to be manufactured at CLW, Chittaranjan. The locomotive shall be manufactured as per the final layout arrangement of the equipment to be decided during design finalisation. Fitment of various equipment shall be so decided that the weight is properly distributed. The existing equipment layout in the machine room shall be studied by the supplier and revised layout drawings wherever necessary shall be submitted. Present mechanical drawings can be obtained from CLW/Chittaranjan.

1.4 The performance requirements, environmental & service conditions, technical requirements and inspection, tests and trials are specified in the following chapters of this specification.

1.5 Bidders intending to participate in the tender should be able to manufacture the equipment in India in their own factories or in collaboration with any reputed Indian manufacturer as per the requirement of Indian Railways after successful delivery and trials of equipment being procured through this tender. The equipment should be such that their sub-assemblies / parts can be manufactured indigenously and the same should be available to Indian Railways on long term basis with support of Indian Industry.

1.6 The design and manufacture of equipment shall be based on sound, proven and reliable engineering practice. The equipment used in different sub-systems shall be of proven technology and design.

2.0 Abbreviations and Definitions

'IR' means Indian Railways

'RDSO' means Research Designs & Standards Organisation

'CLW' means Chittaranjan Locomotive Works

'Tenderer' means Firm/companies participating in the tender

'Contractor' means the person, firm or Company with whom the order for supply of the work has been placed.

'Sub Contractor' means any person, firm or company from whom the contractor may obtain any materials or fittings to be used for the works

'Purchaser' means the President of the Republic of India as represented by the Railways organisation entering into the contract.

'Inspecting Officer' means person, firm or department nominated to inspect the locomotive or the representative of the inspecting officer so nominated

'TOT' means Transfer of Technology

'OEM' means Original Equipment Manufacturer

'BG' means 1676 mm Broad Gauge used in IR

'IS' means Indian Standard

'IRS' means Indian Railways Standard

'IEC' means International Electrotechnical Commission

'IEEE' means Institution of Electrical and Electronics Engineers

'UIC' means Union International des Chemins de fer (International Union of Railways)

'ORE' means Office of Research and Experiment if the 'UIC'

'ISO' means International Standards Organisation

3.0 References to Various Standards:

This Specification is based on the following Normative References and standards

1. IEC-61287 : Electronic Power Converter mounted on board rolling stock.
2. IEC-60571 : Specific rules concerning the electronic control part of converters.
3. IEC – 60349 –2 : Electronic converter fed alternating current motors
4. IEC-563-1976 : Permissible limiting temperature in services for component of electrical equipment of traction vehicles.
5. IEC –505-1975 : Guide for the evaluation and identification of insulation systems of electrical equipment.
6. IEC –61375-1 : Electric Railway Equipment-Train Communication Network.
7. IEEE – 429 : IEEE recommended Practice for thermal evaluation of sealed insulation systems for AC electric machinery employing form-wound pre-insulated stator coils for machines rated 6900 V & below
8. EN 50121-3-2 : Railway applications – Electromagnetic compatibility – Part 3-2 : Rolling stock – Apparatus.
9. EN 50121-2 : Railway applications – Electromagnetic compatibility – Part 2 : Emission of the whole railway system to the outside world.
10. IEC 310 : Transformer and Chokes
11. BS 149-1984 : Transformer Oil
12. IS 3231 : Relays and Contactors
13. IEC 228, IS 10810 : Cables
14. IEC 61373 : Railway applications – Rolling stock equipment – shock and vibration test
15. IEC 61377-1 : Combined testing of inverter-fed alternating current motors and their control system
16. IEC 60077–1 : Electric equipment for rolling stock – General service conditions and general rules
17. IEC 60077–2 :Electric equipment for rolling stock – Electrotechnical components - general rules
18. IEC 61131 : Programming languages for PLC

4.0 Submission of offers

4.1 The bidder is required to offer clause-by-clause comments to this specification either confirming acceptance of the clause and elaborating in detail where necessary or indicating deviations there from. The bidder shall be specific about deviations required by them.

4.2 Tenderer shall enclose with the offer, details of their system design, weight particulars of each major equipment, details of all major items viz. transformer, traction converter-inverter, auxiliary converter, hotel load converter, traction motor, auxiliary machines, basic software specification, control system/electronics, communication protocols, display systems, and any other aspect / equipment which is within the scope of supply of the tenderer. The tenderer shall also submit in their offer the simulated values of the maximum interference currents in the power supply.

4.3 Unit exchange spares and maintenance spare for 3 years requirements of normal service of the equipment in the scope of supply shall be listed out in the tender.

5.0 Scope of Supply

5.1 The main equipment under the scope of supply of this specification shall be:

- Main Transformer, along with associated Cable Head termination
- IGBT based Power Converter / Inverter
- IGBT based Hotel Load Converter / Inverter (for WAP7 only)
- IGBT based Auxiliary Converter / Inverter
- Control, communication and protection system, including sensors & transducers
- Traction Motor along with speed and temperature sensors as per requirement
- Traction motor pinion and the bull gear
- Fire detection and alarm system
- Equipment for synchronous control between locomotives through wireless signals
- Interface of the system with the driver (Man-machine interface) including Master Controller, Control/Selector Switches, Meters, Displays etc.
- Interface with other equipment not in the scope of the supple of this specification such as D&M / Sab-Wabco design E-70 brake system, speedometer.
- Apparatus / arrangement for ensuring safety of the operating and maintenance personnel
- All cables including power and control cables and termination arrangement connecting to equipment in the scope of supply.

5.2 The scope of supply shall extend to the following:

5.2.1 Supply of complete documentation, final design drawings, calculations, manuals etc. and design details to the satisfaction of IR and support material associated with the operation and maintenance of the locomotives supplied against this specification. The full documentation shall include drawings, design calculations and data, Maintenance Manuals, Operation Manuals, Troubleshooting Directory, Training Manuals, Logistics Manuals, QA documentation etc.

5.2.2 Supply of modified mechanical drawings in the locomotive body, wherever necessary to accommodate the equipment proposed to be supplied.

5.2.3 Supply /installation of special tools, jigs & fixtures and instruments special test equipment, special training instrument required for testing, commissioning, maintenance and operation.

Supply of a software tool for interacting with the Vehicle Electronics is included in the scope. The scope shall also include specification for the special tools, jigs & fixtures etc.

5.2.4 Supply of unit exchange spares and maintenance spare for 3 years requirements of normal service of the locomotive shall be offered. The tenderer shall list out the maintenance spares in the tender.

5.2.5 Software packages along with the suitable hardware / machines & system support for scrutinising the design calculations and ensuring that it meets the performance requirement.

6.0 *Contractor's Responsibilities*

In addition to the requirements spelt out elsewhere in this specification, the contractor's responsibility shall also include the following:

6.1 The equipments is to be retrofitted in the mechanical structure (body and bogie) of existing WAG9 / WAP7 locomotives. The tenderer / supplier is expected to study the existing design, drawing and layout of these locomotives. The drawings can be obtained from Chittaranjan Locomotive works, Chittaranjan. The contractor shall study the present mounting arrangement of equipment and use the same to the extent possible. Where changes are necessary, the design shall be such that no major change in the loco body and bogie is required. Wherever the supplied equipment has to mechanically interface with the existing equipment, requisite matching shall be ensured.

6.2 The Contractor shall supply all materials, cartage, tackle, plant, spare parts, samples, special tools and appliances which may be necessary for the complete and efficient installation, testing and commissioning of the propulsion equipment, even though such material or work may not be specifically mentioned in this Specification. The Contractor shall also supply all labour necessary and technical supervision for the installation, testing and commissioning.

6.3 The contractor shall depute a team of engineers for commissioning, testing and field trials of the equipment in service. The Contractor shall arrange the required instrumentation and carry out detailed tests and field trials jointly with RDSO. The contractor shall ensure availability of tools, testing equipment, measuring instruments & spare parts in adequate quantity for test and field trials, to be done as part of commissioning.

6.4 Purchaser (IR) shall supply free of charge basic facilities like space, water & electricity to the extent possible.

6.5 The Contractors shall be entirely responsible for the execution of the Contract in accordance with the requirements of this Specification. The Contractor shall comply with the provisions of the General Conditions and the Special Conditions of the Contract in scheduling, executing, and obtaining the Purchaser's approval of this design (please refer to para 8 below).

6.6 The supply against this contract shall be designed in accordance with the specification and the Contractor's Technical Proposal for the satisfactory performance of the stock in service notwithstanding any approval which the Engineers or the Inspecting Officers may have given:

i) to the detailed drawings prepared by the Contractors,
ii) of a sub-contractor for material,
iii) of other parts of the work involved by the contract,

iv) of the tests carried out by the Contractor, Engineer or Inspection Officer.

6.7 The contractors shall comply with the instructions of the Inspecting Officer, if in his opinion further precautions than those adopted by the Contractors are necessary for the proper execution and safe delivery in India of all parts of the work.

6.8 During the prototype tests/trials or services, if any problem is observed or feed-back information is obtained, which warrants a re-check of the design / manufacture / quality of the equipment and components, necessary action will be taken by the contractor to carry out the required investigations and to incorporate the modifications / improvements considered most appropriate to comply with the specification & to ensure better reliability and performance without any extra costs to the purchaser. The contractor shall not proceed with any modifications / improvements unless approved by RDSO. Such modifications / improvements will be carried out in all locomotives and will be evaluated for their validity for a further period of time as may be agreed mutually in each case.

6.9 Modifications mutually agreed to comply with the specification will be incorporated by the Contractor at his own cost in the locomotives in a manner approved by the purchaser. Drawings incorporating the modifications found necessary as a result of test and trial will be submitted to RDSO for approval before carrying out the modifications.

6.10 In the event of the Contractor's failing to carry out any work, for which he is liable under this clause, within a reasonable time of two months, or if in the opinion of the engineers the urgency of the case demands it, the Purchaser may, without prejudice to his other rights under the Contract, carry out the work himself at the expense of the contractor.

6.11 The Contractor shall further, notwithstanding any exercise by the Inspecting Officer of the power of superintendence, be responsible for the sufficiency of the packing, marking etc. of all imported parts of the work to ensure their delivery in India without damage.

6.12 **Training**: After the signing of the contract a project team of the purchaser shall visit the contractors premises and the associated units to work out an agreement containing the schedule of training for the purchaser personnel. The time spent by the project team during the visit shall not be a part of the specialised training as indicated below and shall be free of charge.

6.13 The contractor shall arrange for the training of maintenance & operating personnel of the purchaser of 20 man months against the supply contract, where each man month shall be of 25 working man days. The details of the training shall be worked out during contract finalisation stage/design approval stage.

7.0 GUARANTEE / WARRANTY:

7.1 The contractor shall be responsible for any defect/failure of locomotive supplied by him due to defective design, material or workmanship up to the period of i) 60 months from the date of taking over the equipment after successful commissioning or ii) 72 months from the date of despatch of material, whichever is earlier. The contractor shall replace/repair all such equipment during the guaranteed period at his own expenses.

Further, should any design modification be required to be made in any part of the equipment, the modified part should be guaranteed for 60 months and the period of 60 months will commence from the date when the modified part is commissioned in service.

7.2 The warranty for the special tools and test equipment shall not expire before 12 months from date of supply.

7.3 The warranty for the maintenance spares and unit exchange spares shall not expire earlier than 36 months from date of supply.

7.4 All replacement and repairs that the purchaser shall call upon the contractor to deliver or perform under this warranty shall be delivered and performed by the contractor within 30 days promptly and satisfactorily, by borrowing, if necessary, the components from the bank of spares as available with the purchaser.

7.5 However the contractor shall also maintain their own bank of spares at the nominated places, to be decided mutually with the purchaser, to ensure timely replacement / repairs of defective equipment under warranty obligations.

7.6 During the warranty period the Contractor shall maintain a service group in India.

7.7 Beyond the Warranty period the Contractor should be committed to support the stock for a minimum period of 20 years for spare requirements etc. If, during this period, the supplier intends to discontinue the manufacture of spares or replacement parts for the stock, advance notice of such intention shall be given by the contractor to the purchaser. In such a case, the contractor shall assist the purchaser to develop alternative sources with same technology, reliability and performance.

8.0 APPROVAL OF DESIGN

8.1 The design shall be developed based on the requirements given in this specification and sound engineering practices. The design shall be developed in SI units.

8.2 The entire design shall be supplied by the contractor with required technical data and calculations to RDSO for approval. The manufacturing will commence after and as per the approval of design by RDSO. The details would be provided to RDSO progressively over a period of 4-6 months. Any calculation which is evaluated on the basis of software simulations shall be supported with sample calculations. Three sets of RDSO approved design are to be supplied by contractor. The actual distribution shall be finalised during design stage.

8.3 Programme for submission of design & drawings shall be furnished with the tender to enable RDSO to plan in advance. The programme shall be finalised at the time of contract finalisation.

8.4 The Contractor shall submit all necessary data, designs, calculations, drawings and specifications referred in their drawings or design documents in English language as required by RDSO for examination and shall provide explanation and clarification of the documents for which approval is sought. Approval or decision by RDSO shall normally be given within 3 weeks of submission of all clarifications by the contractor to the satisfaction of RDSO. For the purpose, the contractor shall depute its technical experts to RDSO for design discussions and finalisation. After the final design is approved the contractor shall furnish complete set of specifications and standards as mentioned in the approved drawings & documents and shall also submit the list of equivalent Indian Standards, wherever applicable.

8.5 Contractor shall submit complete design details, block diagrams, functional description of all sub-systems, schematic drawings, loading calculations, circuits, wiring diagrams, device rating & data sheets of converter, inverter and other power, control and the major equipment, loading of electronic equipment /components calculated under the ambient conditions as specified, ventilation design, component rating etc. The aspects covered above are not exhaustive and the contractor shall commit to supply / furnish complete

technical details with respect to their system and equipment design and to the satisfaction of RDSO for design approval.

8.6 Contractor shall enclose details of their system design, weight particulars and its disposition covering all major items, viz, Transformer, Converter/Inverter, Auxiliary Converter, Hotel Load Converter, Traction Motor, Auxiliary machines, control system etc. Contractor shall refer to Annexure A while enclosing the details.

8.7 Deviations proposed by the contractor in the interest of reliability and better performance will be examined by RDSO in close consultation and association with the manufacturer so as to arrive at the final locomotive design.

8.8 The contractor shall submit the complete material / technical specification and sources of the components during design approval. The specification shall specifically be indicated on relevant drawings / documents.

8.9 The contractor shall furnish details of its Quality Assurance and Quality Control at the design approval stage. The quality checks to be made at various stages of manufacture, final assembly and commissioning with tolerance would be indicated. The system would also cover the quality assurance for bought out items.

8.10 Approval of design means the approval of general design features. Notwithstanding approval from RDSO the Contractor shall be wholly and completely responsible for the satisfactory performance of the equipment. Deviations proposed by the Contractor in the interest of reliability and better performance will be examined by RDSO in close consultation and association with the manufacturer so as to arrive at the final design.

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

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

9.0 STANDARD SPECIFICATIONS

International Electro-Technical Commission (IEC) publications and Indian Standards (IS) as far as applicable and relevant to the various equipment, systems and sub-systems will be considered. The standards applicable for equipment as well as for materials will be furnished during design approval stage. In case of any conflict between the requirements of this specification and standards, the stipulations of this specification will have precedence. In case of contradictions between these standards, the same will be agreed mutually. Any deviations from these specifications as specified herein and as may be mutually agreed to subsequently between the Contractor and RDSO should not reduce reliability or decrease safety margins.

10.0 DOCUMENTATION

10.1 The Contractor will furnish as made drawings and tracings, manual of instructions for operation and maintenance of the locomotive and equipments, trouble shooting instructions and such other technical information as may be required for the maintenance and operation of the locomotives in India. A preliminary version will be supplied along with the despatch of the first locomotive of each type from the Contractor's works. Final documentation will be provided incorporating experience gained in final manufacturing phase and the first

period of trials within 6 months after completion of these trials. Terms and conditions in this regard will be incorporated in the contract documents.

10.2 **Operation Manual**

The operation manual shall be comprehensive, easy to read & understand and should include the Trouble Shooting Directory, the equipment ratings & operating limits of installed system and control & safety features.

10.3 **Maintenance Manual**

The maintenance manuals shall include details of the various systems and sub-system from a maintenance and fault finding stand point, with particulars of operating parameters, tools for dismantling and testing methods of assembly and disassembly tolerances, repair techniques, lubrication details, software details and trouble shooting tools and all other information necessary to set up repair and servicing programme. Those should be accompanied by suitable illustrations & diagram. It should include inspection / overhaul procedure and periodicity of various inspection / overhaul schedules in detail, including the tools, special tools / plants, and facilities required. An illustrated parts catalogue with sufficient information to identify and requisition any part should be included.

10.4 Clarification and amendments to the document, particularly operations and maintenance manual, as necessary during the defect liability period shall be supplied by the contractor. Updates shall be provided for the original and all copies supplied.

10.5 The operations & maintenance manuals shall be supplied @ 1 set (hard copies) per loco. All the document shall be supplied in electronic form on Compact Discs also along with software and hardware tools to read and print them. The format of electronic copies shall be proven in at least two other applications.

10.6 The manual shall be generally in A4 size and shall be bound with wear resistant covers.

CHAPTER 2

OPERATING & SERVICE CONDITIONS AND DESIGN CONSTRAINTS

1.0 Power Supply System:

Nominal supply voltage	25 kV, 50 Hz, single phase, AC
Normal variation in supply voltage	19 kV to 27.5 kV
Occasional maximum voltage	30 kV
Occasional minimum voltage	16.5 kV
Variation in supply frequency	± 8% (46 to 54 Hz)

2.0 Climatic and Environmental Conditions:

➢ Atmospheric temperature	Under Sun : 70°C max. In shade : 50°C max. Temp. inside working locomotive may reach 55°C. Minimum temperature: 0°C
➢ Humidity	100% saturation during rainy season.
➢ Reference site conditions	i) Ambient Temp.: 47°C ii) Temp. inside loco: 55°C iii) Humidity: 60% iv) Altitude: 160 m above mean sea level.
➢ Rain fall	Very heavy in certain areas.
➢ Atmosphere during hot weather	Extremely dusty and desert terrain in certain areas. The dust concentration in air may reach a high value of 1.6 mg/cub. In many iron ore and coalmine areas, the dust concentration is very high affecting the filter and air ventilation system.
➢ Coastal area	Locomotive and equipment shall be designed to work in coastal areas in humid and salt laden atmosphere with maximum pH value of 8.5, sulphate of 7 mg per litre, max. concentration of chlorine 6 mg per litre and maximum conductivity of 130 micro siemens /CM
➢ Vibration	High level of vibration and shocks.
➢ Electromagnetic Pollution	High degree of electromagnetic pollution is anticipated in locomotive machine room, where the equipment will be mounted. Necessary precaution should be taken in this regard.

The locomotive equipment shall be able to start up at the maximum temperature, which may be reached inside a locomotive standing in sun, without any pre-cooling requirement.

3.0 Signal and Telecommunication Installations:

3.1 The tracks over which the offered locomotive propulsion system will work may be equipped with DC track circuits, 83-1/3 Hz track circuits as well as track circuits at higher frequencies. Similarly, other devices like axle counters, block instruments, point machines, etc., may also be employed. On the communication network, control circuits, teleprinter circuits, as well as VHF/UHF and micro-wave circuits are employed.

3.2 The harmonic currents injected in the overhead supply system (as also the track return current) can introduce voltage harmonics on power supply and can interfere with signal and telecom circuits. The design of the power electronics and control electronics provided on the propulsion system will be such as not to cause levels of interference exceeding the levels specified below at any point in the operating envelope of the locomotive:

Psophometric current	10.0 A
DC component	4.7 A
2nd Harmonic component	8.5 A
1700 ± 50 Hz component	400 mA
2000 ± 50 Hz component	400 mA
2300 ± 50 Hz component	400 mA
2600 ± 50 Hz component	400 mA
5100 ± 50 Hz component	270 mA

Emission from locomotives to outside world will be limited to level specified unde CELELEC standard 50121 –2.

4.0 Weight and layout particulars

4.1 Weighs of the existing major equipment are as follows:

- Main Transformer (1 no.) with expansion tank : 9626 kg.
- Traction Converter / Inverter (2 nos.) : 3330 kg each
- Auxiliary Converter (3 nos. in 2 boxes) : 560 kg (box1) + 860 kg (box2)
- Traction Motor (6 nos.) : 6 x 2100 = 12600 kg
- Auxiliary Cubicles HB1 & HB2 : 220 kg + 105 kg = 325 kg
- Control cubicle SB1 & SB2 incl. control electronics : 160 kg + 170 kg = 330 kg
- Filter cubicle : 520 kg

The total weight of equipment to be supplied against this specification should be in the same range as indicated above. However, some increase will be permissible on account of Hotel load converter on WAP7 locomotive.

5.0 Interface

5.1 The traction motor alongwith gear-pinion has to be fitted on the existing bogie, MSU, gear case and axle. The design has to be made accordingly. Drawings can be collected from CLW.

5.2 The Main Transformer is to be fitted in the well available on IOW body and should be designed accordingly for the other major equipment to be fitted in the machine room. Modification in layout will be permissible but effort should be made to minimize the layout changes. Modified layout drawings shall be submitted by the contractor.

5.3 Cooling of the Traction Motor shall be from the existing TM blower. The air flow scheme should match with the existing ducting. It is expected that available air flow will be sufficient for cooling the TMs. This aspect should be studied and confirmed. Please also refer to Clause 8.0 in Chapter-3.

CHAPTER 3
PERFORMANCE REQUIREMENTS

1.0 Performance: With line voltage of 22.5 kV AC and half worn wheels, locomotive fitted with the propulsion equipment shall be capable of the following performance under the reference site conditions:

	Parameter	WAG9 locomotive	WAP7 locomotive
(i)	Starting tractive effort under dry rail condition	Not less than 510 kN t	Not less than 340 kN t
(ii)	Continuous rated speed	Not more than 50 kmph	Not more than 70 kmph
(iii)	Max. design speed	100 kmph	140 kmph
(iv)	Continuous rated power at rail	Not less than 7000 HP at all speeds from continuous speed to max. design speed	Not less than 6000 HP at all speeds from continuous speed to max. design speed
(v)	Regenerative brake	Maximum possible without skidding over full speed range	
(vi)	Hotel load output	Not applicable	2 x 450 kVA, 750 V, 3Ø AC

1.1 Full traction power and full Hotel Load power shall be available in the specified range of normal variation of voltage of power supply as per clause 1.0 of chapter 2. Reduction of power beyond the normal variation of voltage shall be permissible, but the loco shall be able to work and Hotel Load and Auxiliary output shall be available under such voltage conditions for extended durations. Variation of power, if any, in the specified occasional maximum to minimum voltage range shall be specified. Method of reduction / limitation of Hotel Load and Auxiliary power shall be finalised during design approval stage in consultation with RDSO

1.2 There shall be no reduction in the max. tractive effort in the max. to min. voltage range.

2.0 Duty Cycle:

WAG9 locomotive working in adverse terrain will be required to negotiate longer periods at lower speeds. The typical duty cycle encountered in operation could be as given below and loco propulsion system and equipment should be able to work satisfactorily under such conditions.

Speed (in km/h)	0-10	10-30	30-60	60-80	80-100
% of total running time of locomotive	05 %	10 %	20 %	50 %	15 %

3.0 Adhesion:

The design of the adhesion control will be optimised for maximum utilisation of adhesion factor and should be such that it is capable of generating the required starting tractive effort under dry rail conditions. The contractor will state the value of maximum starting tractive effort that will be developed under dry rail conditions and also under all weather conditions, which will be demonstrated during testing. The achievable running adhesion characteristics will be made available. The formulae for linking adhesion characteristics with the operating speed will be indicated.

CHAPTER 4
TECHNICAL REQUIREMENTS

1.0 GENERAL

1.1 The equipment shall be of proven state of the art technology that has been tried/tested in rail traction application with good level of performance and result. The details of such applications and user experience shall be provided. Features to yield high availability for traffic use, low maintenance requirements, easy maintainability, high reliability in operation and high efficiency will be incorporated.

1.2 The system and equipment should be specially adopted for application to meet the performance requirements under environmental conditions specified in Chapter 2 & 3 of this specification. Adequate margin will be built in the design, particularly to take care of condition of high ambient temperatures, dusty condition, high humidity prevailing in India. The equipment, sub-system and their mounting arrangement shall be designed to withstand satisfactorily vibrations and shocks encountered in service as specification in relevant IEC publications unless otherwise prescribed.

1.3 The existing roof equipment shall be retained. Therefore, design of the transformer and other equipment have to be done suitably to work with them, i.e., Surge Arrestor, Line Voltage Transformer, Pantograph, Current Transformer and Vacuum Circuit Breaker.

1.4 The existing gear case and motor suspension unit shall be retained. The gear-pinion system within the scope of this tender shall be suitable for the existing axle/gear case.

1.5 Easy access for inspection and maintenance requiring minimum attention shall be given special consideration in the design and layout.

1.6 It should be possible to use the locomotive in multiple unit operation up to 02 locomotives in one group. The entire control of both locomotives shall be achieved from the leading locomotive under multiple locomotive operation.

1.7 Provision shall be made in the control circuitry of the locomotive, to limit the starting tractive effort to predefined values when required during operation. The predefined values shall be around 30 ton per locomotive, to be decided during design stage.

1.8 Provision shall be made to enable operation of locomotive under inching control mode, i.e., at a very small constant speed set by driver irrespective of the load, gradient, curvature of track etc. It shall be possible to change from inching control mode to Normal Mode and vice versa by the driver depending upon his requirement.

1.9 The locomotive shall be provided with a synchronous control system through wireless signals between locomotive or locomotive consist at the front, in the middle or at the rear end of train formation for operation of heavier and longer trains. For this, all the control and operating signals from the lead locomotive shall be transmitted to the distributed trailing locomotive(s) through radio transceiver, so that all of them are run in synchronization with a single driver control from the lead locomotive. Encryption shall be provided for commands sent from the lead locomotive and feedback messages from the trail locomotives for security purpose. The display shall indicate the status feedbacks received from the trailing units. At any time, it shall be possible to view the status of all

trailing locomotives from the leading locomotive by the driver. It shall be possible to use any locomotive fitted with this system in leading or trailing position.

1.10 Adequate redundancy should be built-in with the design in order to improve reliability and availability. In the vital units of the power and control circuit, where any defect/failure of a component would cause complete failure of locomotive's electrical system, suitable redundancy /duplication should be provided to avoid locomotive failure or drastic reduction in performance due to such defects. The control circuits shall be provided with hot redundant Power supplies. The offer should clearly spell out the redundancy concept.

1.11 The protection/alarm/indication circuits should normally have self-correcting features rather than cause tripping of the locomotive or drastic reduction in tractive effort. If Driver's intervention is needed, sufficient time/advance indication should be made available to the Driver to enable corrective action to be taken in time.

1.12 In design and construction, reliability and maintainability will be of paramount consideration. Tenderer will submit reliability calculations indicating MTBF for different devices, cards and sub-assemblies. Adequate margin will be provided to take into account ambient conditions prevailing in India.

1.13 High efficiency of equipment will be important consideration, next only to high reliability. The components and technology used shall ensure very high efficiency of the converter. Tenderer shall furnish the expected efficiency with respect to vehicle load and speeds.

1.14 Modular constructions will be adopted wherever considered possible. Easy access for inspection/maintenance and minimum maintenance requirement will be given special consideration in design and layout. In this reference, the scheduled maintenance activities shall be a part of design documents and have to be got approved along with design approval.

1.15 In the design and construction of IGBT based converter/inverter and associated control equipments, reliability and maintainability are paramount considerations. Adequate margin shall be provided to taken into account conditions prevailing in India. Freedom from dust and protection from surges shall be ensured. Modular construction shall be adopted wherever considered possible for achieving the above requirements.

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

1.17 The design calculations of worst case temperature rise of equipment shall be made after taking into account 25% choking of filters and heat sink/radiator fins. A safety margin of at least 10°C shall be kept with respect to maximum permissible junction temperature of power devices declared by the manufacturer.

1.18 The power equipment will be designed and operated to achieve near unity power factor and minimum harmonic interference current from OHE. The input power factor shall be settable close to unity within the normal variation range of line voltage at all speeds of operation of the locomotive. The maximum interference current permitted is specified in

chapter 2 of this specification. Pantograph bouncing normally experienced in service should not adversely affect the propulsion equipment.

1.19 The equipment for WAG9 and for WAP7 shall be identical in all respects except for the Hotel Load converter (required for WAP7 only) and Gear Pinion.

1.20 Energy metering (energy consumption and energy regeneration) function shall be integrated in the control software.

2.0 Main Transformer:

2.1 Fixed ratio main transformer shall be provided with multi-traction windings suiting the requirements of Power Converter adopted, a Hotel load winding for the Hotel Load Converter and an Auxiliary winding for supply to auxiliary machines.

2.2 The kVA rating of the transformer shall be specified at a line voltage of 22.5 kV and shall be designed to deliver a total current corresponding to the continuous rated traction motor currents at full voltage. The transformer traction winding shall also be designed to deliver the rated current at the maximum line voltage of 27.5 kV.

2.3 The transformer shall be designed with adequate overload capacity to permit full utilization of the traction motor capacity during the starting as well as running.

2.4 The transformer shall be designed to conform to IEC: 60310 and the temperature rise limits on the windings and the oil shall correspond to IEC: 60310 limit minus 20°C under all conditions of operation.

2.5 The transformer shall be oil immersed and forced oil cooled by means of an oil circulating pump and a radiator. The oil cooler (radiator) shall be air blast cooled by means of a motor driven blower set. Means shall be provided for letting out the oil from the transformer through the floor to the underside of the locomotive, in the event of any fault/electrical disturbance in the transformer causing oil to rush out.

2.6 The chokes and inductor in the main power circuit shall be oil cooled. The cooling circuit will be common with that of main transformer. Integration of any chokes / inductors for Hotel Load and Auxiliary circuit in the main Transformer may be considered.

3.0 High Voltage Cable Assembly

High Voltage Cable Assembly from locomotive roof to transformer shall be of 45 kV grade with 185 sq. mm XLPE/EPR cable having interface with transformer bushing at the transformer end and with micafil bushing fitted at locomotive roof. The present arrangement is with T-type screened plug at both the ends, but due to inaccessibility and blind fold action of electrical connection inside the plug, vertical take off type High Voltage Cable assembly shall be preferred.

4.0 Power converter

4.1 Single axle drive system shall be adopted to maximize adhesion and minimize the performance reduction in case of single sub-system failure. Individual and independent inverter will be provided for each TM / axle and design should be such that one Inverter /

TM / axle can be isolated in the event of fault on one TM/inverter and train worked with remaining TMs. The adhesion control system will be optimised for the individual axle drive.

4.2 The wheel slip detection and correction system shall be an integral part of the control system of the Power converters/inverter and shall supervise excessive acceleration, differential speeds between axles, over speed and any other parameter considered necessary to maximize adhesion and minimize wheel slipping / skidding. The adhesion control system will be capable of giving high adhesion through a wheel slip control system of proven performance. Wheel slip control system with Dropper Radar for high despatchable adhesion shall be adopted. The objective should be to maximise the delivered draw bar pull through control system in conjunction with sanding.

4.3 The converter/inverter system will be capable of withstanding the maximum short circuit current under fault conditions and these will be established through calculations. The converter / inverter system shall also be designed to withstand extreme disturbances like short-circuit / open circuit etc. at all points of input / output interfaces with locomotive, without any failure. This will be demonstrated during prototype tests as per the relevant clause of the IEC.

4.4 Wheel diameter difference permissible will be more than or equal to the present limits, which are as follows:

- Wheels on different axles of the same bogie : 8.0 mm
- Wheels on axles of the different bogies : 25.0 mm

5.0 Traction Motor

5.1 The general design and manufacture of the motor shall be of the highest standard in accordance with the modern traction practices. The design shall include all those features, which are known to have worked well in the tropical climatic conditions.

5.2 The motor will be liberally rated as per the loco performance requirements for the 'most severe normal service' as defined vide clause 2.2(a) of IEC: 563-1976.

5.3 The motor shall be designed so as to be capable of withstanding transients such as line voltage fluctuations, switching surges and such other conditions caused by stalling and wheel-slips under different operational conditions. Rotor design should be robust and capable of withstanding torsional vibrations encountered in service, for example during wheel-slip.

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

- Excessive vibration that are experienced because of average track maintenance conditions in India.
- Prevalence of high temperature and humidity for the most part of the year.
- Operation of the loco over a long country terrain in which the climate will vary from excessive dry heat on one end to high humidity on the other end or during winter months from very cold to moderately warm and humid conditions on the other end.
- Operation under highly dusty environments.

5.5 In determining the ratings, design parameters and construction of the traction motor, full consideration shall be given to the duties imposed by requirement of regenerative braking.

5.6 Insulation System:

- The insulation system to be employed shall be particularly designed to withstand the adverse environmental conditions. The materials comprising this system and the system itself shall have been proved to be of the highest reliability in traction application. Imperviousness to moisture will be a special requirement.
- The evaluation of the insulation system for thermal endurance shall be made with fabricated test models by way of accelerated ageing tests as per the test programme drawn up in accordance with the norms specified in IEC: 34-18. Evaluation of the insulation system shall be done as per IEC 34-18.
- Evaluation of insulation system for sealing against moisture shall be taken into consideration.
- Various ageing parameters, such as heat, vibration, mechanical/compressive stresses, special environmental effects of humidity, dust, metallic dust from brake shoes, etc., will be incorporated to simulate the actual working conditions as closely as possible.
- The temperature at which an extrapolated life of 20,000 hours is obtained shall be treated as the thermal endurance limit (Temperature Index) of the insulation system.
- The motor shall be designed such that the "hot spot" temperature under any condition of loading in winding does not exceed the average temperature of that winding measured by resistance method, by more than 15°C.
- Having regard to the system of insulation adopted and the environmental conditions, the manufacturer shall provide maximum possible margins in temperature rise, for prolonged life of the traction motors.

5.7 The mechanical design of the motor, fixing arrangement on the bogies, the gears and pinions, gear case, etc. shall receive particular attention. Lubrication system for the TM bearings, Suspension tube bearings and Gear/Pinion shall be kept separate.

5.8 Maximum temperature rise of Traction Motor shall be limited to Ti -95° C considering 25% choking of filters. (Ti is the temperature index of the insulation system).

5.9 Maximum speed of the Traction Motor at the highest working speed shall be within 3500 revolutions per minute.

5.10 Harmonic/Ripple factor:

The traction motor shall operate satisfactorily over the entire range of loading, with harmonics/ripples imposed from the supply system, (comprising transformer, converter, inverter, etc.), both during motoring and regenerative braking conditions. The manufacturer shall conduct necessary tests on the traction motor to establish compliance with this requirement.

5.11 Traction motors shall be provided with grease lubricated roller bearings. The L10 life should not be less than 5 million km.

5.12 Various components of traction motor shall be manufactured with such tolerances so as to enable complete interchangeability of components from one motor to another of same design.

5.13 Type tests and routine tests on the TM shall be carried out as per IEC 60349-2 (2002). In addition to type tests and routine tests, additional special tests may be carried out to check trouble free functioning of motor in actual operating and environmental conditions mentioned in clause 5.4 above.

6.0 Hotel Load Converter

6.1 The Hotel Load output shall be used for feeding power to the coaches for air-conditioning, train lighting and other requirements of the coaches. The output shall be extended from the locomotive to the coaches in the train through couplers. Design shall be suitable for carrying the Hotel Load output to long distances over 24 coaches i.e., 600 m without any undue distortion in the quality.

6.2 Two numbers of Hotel Load Converters shall be provided, each of 450 kVA, 750V 3 phase AC. The Hotel Load Converters may be physically accommodated within the cubicle of the Power Converter and may share the cooling arrangement with it. If any alternative arrangement is proposed within existing space, full details shall be submitted.

6.3 The Hotel Load Converters shall be galvanically isolated from the Power / Auxiliary Converters with separate earth fault detection system. Therefore there will be separate winding in the Main Transformer for the Hotel Load.

6.4 Hotel Load Converter shall be IGBT based. The control shall be microprocessor / micro-controller based with diagnostic features. Protection from overload/short circuit, single phasing and any other protection considered necessary for reliable functioning shall be provided.

6.5 It will be ensure that there is no surge / spike in the output voltage between phase to phase and with respect to earth. Suitable sinewave filter shall be provided at the Converter output.

6.6 Power quality of the Hotel Load output shall be as under:

- Output Voltage : 750V, 3Ø AC
- Variation in output : ± 5%
- Output Frequency : 50Hz ± 3%
- Short time current overload rating : 125% for 20 sec.
- Total harmonic distortion (THD) : Less than 10% in output voltage
- dv / dt : Less than 5 V / Microsecond
- Voltage unbalance : Less than 1 %

7.0 Auxiliary System:

7.1 Auxiliary system shall consist of Auxiliary Converters, Auxiliary motors/blowers (not in the scope of supply), Battery Charger and associated protection system. The Auxiliary system shall be galvanically isolated from the traction power system. Auxiliary system design shall ensure that there is no surge / spike in the output voltage between phase to phase and with respect to earth.

7.2 Auxiliary Converter shall be IGBT based and forced air-cooled. The control shall be microprocessor / micro-controller based with diagnostic features. Protection from overload/short circuit, single phasing and any other protection considered necessary for reliable functioning shall be provided.

7.3 Two / three Auxiliary converters identical in all respects and battery-charging unit shall be provided in one loco. Design and rating of Auxiliary Converter and load distribution shall be such that in case one Auxiliary Converter fails, the remaining shall take the entire Auxiliary load and the loco remains healthy. The changeover arrangement shall be automatic.

7.4 The connected load to the Auxiliary Converter are presently as follows:

- TM Blowers 2 x 25 kW
- Oil Cooler Blower 2 x 25 kW
- Main Compressor 2 x 15 kW
- Scavenger Blower 2 x 03 kW
- Oil Pump Converter 2 x 11 kW
- Oil Pump Transformer 2 x 4.7 kW
- Battery Charger 12 kW

7.5 Rating of the Auxiliary Converters to be offered shall be decided after considering adequacy of the TM & Oil Cooler blowers, need for and adequacy of Oil Pump capacities, need for any additional blowers, possibility of connecting the existing Machine Room blowers also to 3 phase supply, requirement of redundancy as described in para 7.3 above and keeping a margin of 40 kW for possible increase of load in future. At present the Machine Room blower motor is three phase machine but works off single phase supply.

7.6 The Battery Charging unit shall be a part of the Auxiliary Converters and supply the control voltage at 110 V DC (nominal) and charge the 199 AH Nickel-Cadmium battery (not in the scope of supply) with suitable charging characteristics and separate monitoring of battery voltage / current. Apart from the locomotive control circuit and battery, the locomotive Head Light, Flasher Light and Marker Light etc. are also connected to the 110V DC circuit.

7.7 Power quality of the 415 V three phase AC shall be as under:

- Output Voltage : 415V ± 5%
- Output Frequency : 50Hz ± 3%
- Short time current overload rating : 125% for 20 sec.
- Total harmonic distortion (THD) : Less than 10% in output voltage
- dv / dt : Less than 10 V / Microsecond
- Voltage unbalance : Less than 1 %

7.8 In addition to above, 230 V AC, single phase supply of 1 kVA shall also be made available to enable powering any small equipment when the locomotive is standing in the shed.

8.0 Cooling

8.1 Cooling of Power Converter and Main transformer is presently by common oil cooler radiators (aluminum alloy heat exchanger modules) but with different oil circuits. There are two cooling units, one for each bogie.

8.2 The tenderer can either use the existing radiator and cooling circuit with blower and pumps for the cooling of the Transformer, Traction Converter and Hotel Load Converter or suggest his own scheme within the existing floor layout available. The cooling arrangement together with the radiators, blower, coolant, cooling circuit with pumps should be of rugged construction to withstand vibrations, shock. The sealing of the cooling system should be such as to prevent spillage/Leakage of the coolant. In case the coolant used for the converter is other than oil, for example water, tenderers shall try to accommodate the new (additional) radiator at the present location utilising the same blower. Any alternative arrangement has to be clearly spelt out. The detailed drawings of the existing system can be obtained from CLW.

8.3 It is felt that the present cooling capacity of the traction motor blowers and Oil Cooler Blowers would be adequate for new Transformer and Power Converters, Hotel Load Converters and Traction Motors to be offered by the tenderer. However, in case any additional air flow is needed, the design modification of the blower shall be supplied by successful tenderer to IR.

8.4 The machine room blowers (2 x 3kW each) cool the Central Electronics, Power Converter Electronics and the Auxiliary Converters (Electronics as well as power part) also. The adequacy of the same should be studied and confirmed. In case, self-ventilated auxiliary converter is offered, its heat dissipation should not cause undue rise in machine room temperature.

8.5 The tenderer shall study the existing arrangement of cooling the major equipment and should submit in the offer detailed cooling scheme along with calculations. It is will be preferred to transfer the Machine Room blower loads to three phase supply from the existing single phase supply.

9.0 Electronics, Control and Communication:

9.1 The general provisions of para 9.0 shall be applicable to the Electronics used in the other equipment, i.e., Power / Hotel Load / Auxiliary Converters. The electronics used shall conform to IEC-60571. However, due to higher ambient temperature in India, it shall be suitable for working for short time (at least 15 minutes) at high temperatures as expected to be encountered in locomotive standing under sun (refer to clause 2.0). Therefore there should be no requirement of pre-cooling of the electronics on locomotive standing in summer sun for long duration. The electronic control equipments should be protected against unavoidable EMI in the machine compartment.

9.2 Control and communication shall be based on open control architecture and compliant to IEC-61375 "Train Communication Network" protocol or any other superior, internationally published protocol. The programmable devices should be programmed using language compliant to IEC-61131.

9.3 It is desirable that the majority of control and monitoring function is implemented by software so as to reduce hardware and cables.

9.4 The control system shall integrate the task of fault diagnostics and display in addition to control task. It should be capable of real time monitoring the status of all the vital equipment continuously and occurrence of faults. It should also take appropriate protective action and shut down the equipment wherever necessary. Features of self-check, calibration and plausibility checks must be incorporated in the design.

9.5 The vehicle control unit (VCU) has to interface with the existing brake systems. Presently two types of brake systems are used : i) E-70 brake system of M/s D&M / Sab-Wabco / Faively Transport used on majority of locomotives, and ii) CCB Brake system of M/s. Knorr Bremse used on some locomotives. The interface hardware and software has to be designed accordingly. In addition, provision will be kept to interface with the brake system through multiplexed pair of wire on RS-485 protocol.

9.6 The VCU should have a diagnostics computer, with non-volatile memory, to store all the relevant diagnostic data. On occurrence of each fault related to propulsion system in the scope of this specification, besides the fault information on equipment parameters, background data with time stamp shall also be captured and stored with a view to enable proper fault analysis. There must be facility to capture post trigger and pre-trigger background information. Application software shall be provided to facilitate the fault diagnosis and the analysis of equipment wise failures.

9.7 The vehicle control unit (VCU) should also provide on-line, context sensitive trouble shooting assistance to the driver in case of any fault, through the driver's display.

9.8 It should be possible to access all the processors within a vehicle and also the same in other vehicles in a train formation using a standard laptop connected to one of the ports provided on the VCU rack. Such access is needed for uploading of firmware/application program, visualization of process parameters and also force or record the same and downloading the diagnostic data. Required interfaces should be built in the VCU so that standard laptops can be directly plugged to the VCU without any special interface. Supply of a suitable software tool is included in the scope. Using this tool, it should be possible to reset the diagnostic memory for further recording. This tool must also provide detailed off line analysis facility.

9.9 It should be possible for the Railways to execute parametric changes in the software in respect of user's interface viz: modifying some of the permissible parameters for adjusting the characteristic within permissible range, add/alter the protection features, if so required in future in order to improve the operation of locomotive. Contractor shall provide all necessary equipment and accessories required for the purpose.

9.10 The electronics shall be designed to be sealed from the remaining part of the machine room so as to ensure that there is no dust ingress whatsoever in to the electronics. For its cooling, internal ventilation arrangement along with heat exchanger for removal of heat shall be provided. Temperature difference between inside of the electronics cubicle and the Machine room shall not be more than 15°C.

9.11 Use of Application Specific Integrated Circuits (ASICs) shall be avoided. Circuit Boards shall use general purpose ICs to the extent possible.

9.12 The electronic cards shall be mechanically coded to ensure that insertion of card in wrong slot is not possible.

10.0 Control Equipment:

10.1 All necessary control equipment including driver's controls and indications for electrical circuits shall be provided. Necessary operational, protective and safety devices in the form of relays, contactors, switches as may be required by circuit design shall be incorporated for the proper functioning of the power auxiliary and control equipments.

10.2 The control equipments, relays and switches, and such other devices shall represent the latest and proven technology established under the most severe operating conditions, with particular regard to reliability. The use of relays and contactors shall be to bare minimum.

10.3 Wherever considered necessary, contacts shall be duplicated to provide redundancy.

10.4 Interlocks and auxiliary contacts with important protective, operation, control, auxiliary and safety circuits shall be housed in dustproof enclosures either by providing the complete equipment in dust-proof cabinets and/or pressuring the cabinets or by covering the contacts only by dust-proof covers of a satisfactory design.

10.5 The working of all relays and contactors shall be satisfactory in the range –30%/+25% corresponding to a nominal battery voltage of 110V DC when the operating coils are at their rated temperature and the contacts are subjected to normal pressure.

10.6 Rubber components, such as pistons, 'O' rings etc. wherever employed in control gear shall be entirely suitable for humid and environmentally unfriendly conditions in India.

10.7 Surge suppression circuits shall be incorporated to eliminate surges, wherever required.

10.8 Capacitors shall be liberally rated, keeping in view the high ambient in India, vibrations of electric rolling stock and electrical surges expected during operation.

10.9 Special endurance tests may be required to be conducted both mechanical and electrical to prove the reliability of the control equipments used.

11.0 Master Controller:

A Master Controller of proven design shall be provided in each cab. It will be integrated with stepless traction / braking lever, forward/reverse switch, cab activation switch etc. In the design of the driver's controls, the following aspects may be kept in view:-

(i) It should not be possible for unauthorized persons to operate the master controller.

(iii) The reverser handle shall be so inter-locked that master controller handle can move only when the reverser is placed in an operative position. Conversely, it shall be necessary for the master control to be returned to the off position, before the reverser handle can be returned to the OFF position.

(v) Interlocks with braking system shall be incorporated in the master controller.

(vi) Traction should be possible only from one cab at a time.

(vi) It shall be designed to be maintenance-free and not requiring any adjustment / maintenance before overhaul. Provision shall be made to ensure unhindered operation in case of failure of Master Controller

12.0 Instruments:

Instruments provided shall include indication / display of line voltage, actual tractive / braking effort and any other important parameter for display to the driver. The instruments shall have back-lit illumination.

13.0 Cables:

(i) All power, control & auxiliary cables shall use high grade electrolytic copper stranded tinned conductors. They shall be electron beam irradiated, thin walled cables of fire retarding type conforming to International Standards for such applications.

(ii) The cables shall be derated to take care of the adverse ambient conditions. All derating factors shall be applied together with the maximum permissible conductor temperature for the particular insulation type. In no case, the conductor continuous temperature shall exceed 90°C. The maximum short circuit temperature shall not exceed 250°C. The cable insulation shall be capable of withstanding these temperatures.

(iii) Loading of Power cables shall not be more than 75% of its capacity.

(iv) No cable having conductor size of less than 2.5 sq.mm shall ordinarily be used. Smaller size cables for internal wiring of panels, control cubicles, consistent with the mechanical and electrical requirements, may be adopted.

13.1 Wiring and Cabling:

(i) Cables and connections carrying different types of voltages shall be physically segregated from each other. Layout of the cables shall be such that contamination by oil is avoided.

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

(iii) Adequate number of standby vital spare control wires will be provided with adequate indications.

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

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

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

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

14.0 Driver's Display:

14.1 Display units for driver shall be provided in each cab on driver's desk displaying important information relevant to the driver, such as operational aspects, fault status / messages and status of various important parameters as selected by driver maintenance staff or as required for the satisfactory system operation. etc. The display will be menu driven. The interface with the driver should be very simple considering average level of proficiency of drivers in handling electronic devices.

14.2 The display shall be designed to provide full guidance and assistance to driver about action to be taken in case of fault. The interface will be user friendly and there should normally not be any need for a separate Trouble Shooting Directory for driver's use.

14.3 Selection of display medium should take into account high ambient temperature and light , due to direct sunlight on the driver's desk. Backlit arrangement should be provided for night visibility. The display system shall be protected against dust and moisture.

15.0 Insulating materials:

In selecting materials of insulation, the moist tropical weather conditions prevailing in India shall be kept in view. In this regard, the manufacturer shall furnish full information regarding the suitability of the selected materials under various climatic conditions referred to in this specification. Additional necessary tests, if any, for ensuring suitability of materials shall be conducted by the manufacturer in the presence of Indian Railway's representative and the test results advised to the Purchaser.

16.0 Safety measures:

Standard protective systems for protection of the electrical equipments against abnormal currents, excessive voltages, etc., as well as indication of normal and abnormal conditions so as to ensure safe and correct operations shall be provided. While working in multiple, the faults in the trailing locomotives should be indicated in the leading loco.

All equipments shall be adequately earthed insulated, screened or enclosed and provided with essential interlocks and keys as may be appropriate to ensure the protection of the equipments and safety of those concerned with its operation and maintenance. The present arrangement of safety interlocking of the major equipment may be studied by the tenderer and appropriate arrangement for the equipment under the scope of this tender may be offered.

A sensitive reliable protection arrangement against earth fault shall be provided.

All electrical circuits shall be fully insulated from the superstructure on both positive and negative sides. The super-structure shall not be used as a portion of an earth return circuit.

Fire prevention measure:- The design of equipment shall incorporate all measures to prevent fires and shall be such that should any fire take place, the effect should be minimized and no spread of fire should take place. Materials, which are not fire-retardant, shall not be used. The locomotive shall be provided with maintenance-free fire detection equipment of proven design, suitable for the dusty environment prevalent in India.

All safety features in the matter of design construction and materials used shall conform to the best safety standards and shall in particular prevent fires in locomotives.

CHAPTER 5

INSPECTION, TESTS AND TRIALS

1.1 The propulsion system shall be tested at manufacturer's works on a combined test bed generally in accordance with the IEC: 61377-1. The individual equipment and system/sub-systems as may be necessary shall be type and routine tested in accordance with the relevant standards/specification/publications/details given elsewhere in this specification, which, if required, may be modified to suit local conditions. Along with the mandatory tests as described in the recent relevant IECs, optional tests shall also be carried out. Dry Heat test of the Electronics shall be carried out at 80° C as per IEC: 60571. Details shall be worked out during design approval stage.

1.2 Type tests shall be carried out by the manufacturer at his own responsibility and cost and in the presence of and to the satisfaction of representatives of RDSO.

1.3 Wherever the relevant standard test procedures do not adequately cover the requirements of arduous environmental conditions prevailing in India, RDSO might lay down special tests apart from those specified that will be required to be conducted at manufacturers works. These may include accelerated ageing tests and endurance test.

1.4 The supplier will formulate and submit a type test protocol / plan for approval of RDSO before undertaking manufacture. It shall, however, be open for RDSO to waive some of tests in case of equipment and sub-assemblies, where the manufacturer can establish to the satisfaction of RDSO that such tests have already been carried out earlier on the same equipment and where equipment has been proved in prolonged service.

1.5 Prototype locomotives, on which the electrical equipment under the scope of this tender is fitted, shall be subjected to the following tests to satisfy Indian Railways regarding operational performance, capability and safety:-

(i) Dynamometer car tests to ascertain starting and rolling resistance of the locomotive and to prove tractive effort / braking effort – speed characteristics.

(ii) Adhesion tests to prove the adhesion capability of the locomotive.

(iii) Tests to determine the levels of interference with the traction power supply and signal and telecommunication equipments to prove that these are within acceptable limits.

(iv) Any other tests that may be found necessary.

1.6 Wheel slip and adhesion characteristics will receive proper attention during the tests and trials under different track conditions.

1.7 The locomotive shall also be evaluated during operation under actual load conditions. These shall be termed as "Service Trials". Apart from checking on the repeatability of the operational performance under different conditions, these tests will also enable practical evaluation of the maintainability, accessibility of components, reliability in service and such other aspects, which have been envisaged in this specification.

1.8 Modifications found necessary as a result of the tests/trials shall be incorporated by the supplier at his own cost in the locomotives in a manner approved by the purchaser. Drawings incorporating the modifications found necessary, as a result of tests and trials, shall be submitted to RDSO for final approval.

1.9 The components of major equipment like Transformer, Traction/Auxiliary/Hotel Load Converter / Inverter, Traction Motor etc. shall not be subjected to type tests but their test certificates shall be submitted to RDSO by the contractor.

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Annexure A

DESIGN DATA, CALCULATIONS AND DRAWINGS TO BE SUBMITTED BY THE SUPPLIER

DESIGN DATA

A) **Design data should include following particulars:**

1. **TRANSFORMER:** Make and type, type of construction, particulars of windings with their continuous rating, permissible duty cycle, percentage impedance voltage of each winding with different combinations of windings shorted, no-load magnetization current, current density in windings, transformer losses and efficiency, permissible temperature rise, details of cooling system, details of insulation of windings, dielectrics levels, overall dimensions and weight of the transformer with and without cooling equipment. Suspension arrangement and calculations.

2. Details of the radiator, relays and other devices associated with the transformer.

3. **Power, Hotel Load & Auxiliary Converter / Inverter:** Make and type, number of cubicles per loco, thermal characteristics of IGBTs, arrangement of devices, margin in current, voltage and junction temperature, heat sink details of IGBTs, cooling system, design details including air/water flow rates and arrangement of filtered air, noise level, configuration with detail calculation of branch wise current providing adequacy of the devices used, Rating of each IGBT, Thermal margin with calculations, overall dimensions and weight, . Details of the capacitor for DC link as well as resonance circuit, if provided, details of the protection of power converter, the designed power loss in the converter.

4. **Vehicle control and diagnostic system:** Make and type, details of microprocessor, Complete functional description, details of faults to be displayed in driving cab and stored in permanent memory, procedure for down loading the details of faults from memory, details of all protection schemes of all equipments, details of control for converter, DC link, inverter, traction motor, braking etc.

5. **Smoothing Reactor / Filters:** Make and type, number and rating of the coils, inductance and ripple characteristics up to 1.5 times the rated current, details of the conductor and insulation system, current density, losses, temperature rise limit, details of cooling system, dielectric test voltages, overall dimensions and weight of the equipment.

6. **Traction Motor:** Make and type, continuous rating, one hour rating and short time rating, maximum starting current and duration, current ratings for various operating voltages, gear ratio, traction motor characteristics under different conditions, details and data of windings, estimated temperature rise of stator winding, air flow, ventilation to Watt loss ratio, maximum designed / test / service speed, unventilated rating, details of insulation, details of the bearings, L-10 life calculation of the bearings, FEM analysis of the rotor shaft, details of banding, data for motorette test, fits and clearances adopted, details of lubrications to be used in gear case and different bearings, overall dimensions and weight of the traction motor.

7. **Gears and Pinions:** Make and type, grade of steel used, particulars of heat treatment, material and type of construction of gear case, make and type of compound of gear case.

8. **Auxiliary Machines & Blowers:** Make and type of various auxiliary machines, nominal voltage, starting current and torque, torque speed characteristics at various voltages, continuous rating, speed, power factor and slip of the motor, type of enclosure, details of cooling fan, air gap, details of windings and insulation, conductor size, current density, type of conductor insulation, details of impregnation, details of lead wire, terminals and

terminals block, material of core stampings and average flux density, details of rotor end rings and bars with current density, details of bearing giving sizes, clearances, tolerances, dimensions, L-10 life calculation of the bearings and weight of machines, tests conducted to ascertain the reliability of windings/motors. Make and type of the blower units, power consumption of rated capacity, dimensions and weight of the blower.

9. **Contactors / MCB:** Make and type, rated voltage and current, making and breaking capacity, number of auxiliary contacts with control circuits voltage, magnet valve and coil details, overall dimensions and weight, mechanical and electrical endurance test data.

10. **Master and Brake Controller:** Make and type, rated current, making and breaking current, positions of reverser and main handle and auxiliary interlocks, overall dimensions and weight, mechanical and electrical endurance test data.

11. **Relays:** Make and type of various relays, rated current and voltage, range of setting, rated control voltage, rating of contacts, details of material of the contact, type of enclosure, temperature rise limit, indication system provided, overall dimensions and weight, mechanical and electrical endurance test data.

B) **Design Calculations shall include:-**

a) Weights and centre gravity of each equipment with weight unbalance calculations etc.

b) Adhesion calculation.

c) System performance calculations.

d) Gears pinions, analysis of stresses, selection of bearing, gear case and transmission assembly.

e) Calculations for lateral and longitudinal equipment balancing.

f) Cooling system calculations.

g) Tractive and braking effort vs speed curves showing balancing speed.

h) Detailed step-wise calculations for equipment ratings and performance requirement.

i) Curves of efficiency, power factor, frequency, slip as a function of speed.

j) Traction Motor performance curves.

k) Calculations for life of bearings used in Traction Motors and Aux. Machines.

l) Harmonic calculations.

m) Calculation of shaft strength for Traction and Aux. Machines, calculation of moment of inertia, shaft strength etc.

n) Reliability predictions of each equipment at 40°C.

C) **Drawings:-**

1. Schematic diagram of power, dynamic braking, control and auxiliary circuits including multiple operation.

2. Drawing showing mounting arrangement of traction motor.

3. Motor suspension arrangement.

4. Traction motor outline assembly, longitudinal section, cross-section, stator, rotor, shaft details, motor terminal box and bearing housing.

5. Mounting details of major equipment.

6. General arrangement of transformer, winding, core and auxiliaries, if any.

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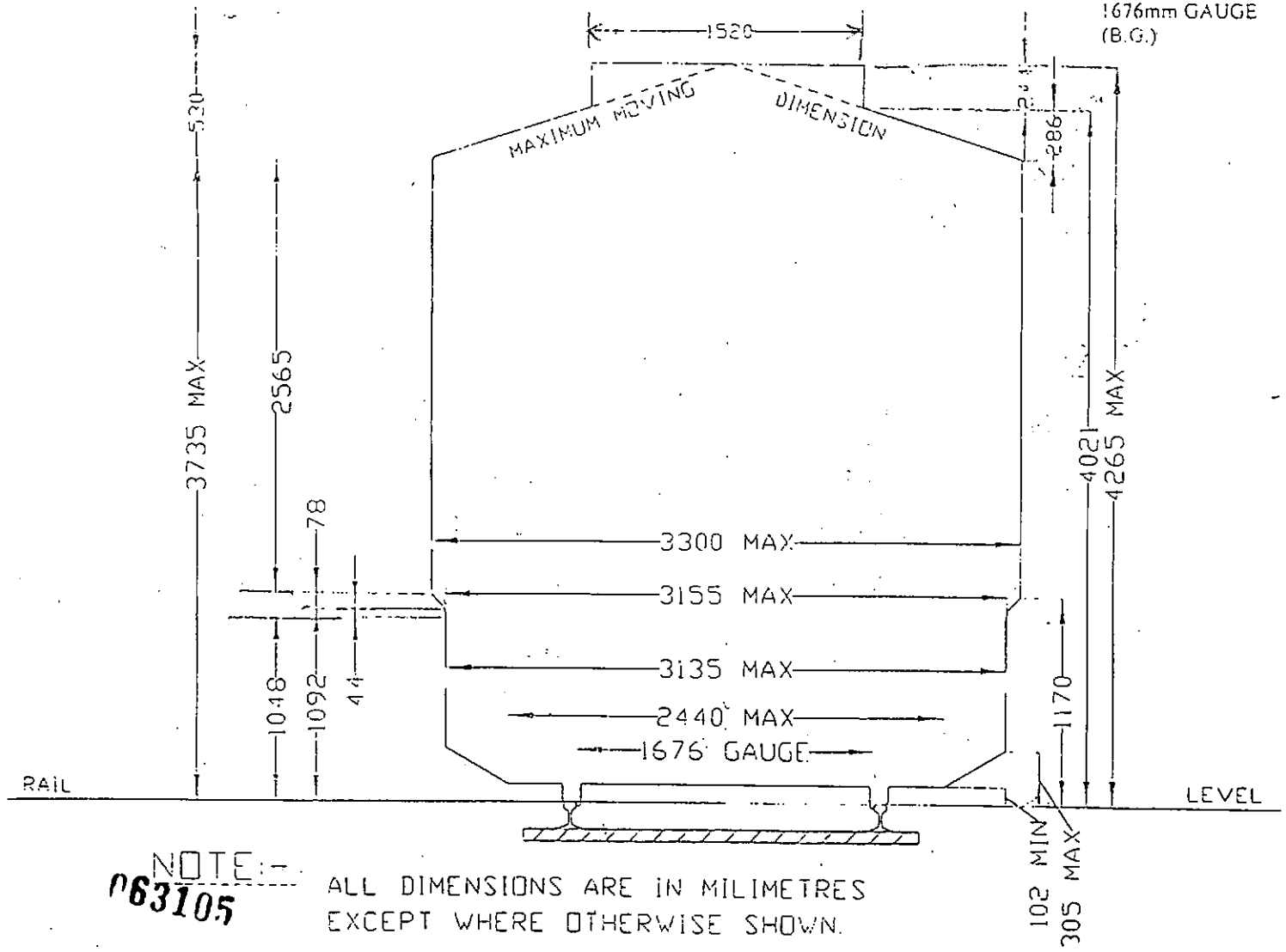
MAXIMUM MOVING DIMENSIONS OF THE PROFILE PROPOSED FOR REVISED SCHEDULE OF DIMENSIONS.

DIAGRAM No.1D
1676mm GAUGE
(B.G.)



NOTE:-

063105

ALL DIMENSIONS ARE IN MILIMETRES
EXCEPT WHERE OTHERWISE SHOWN.

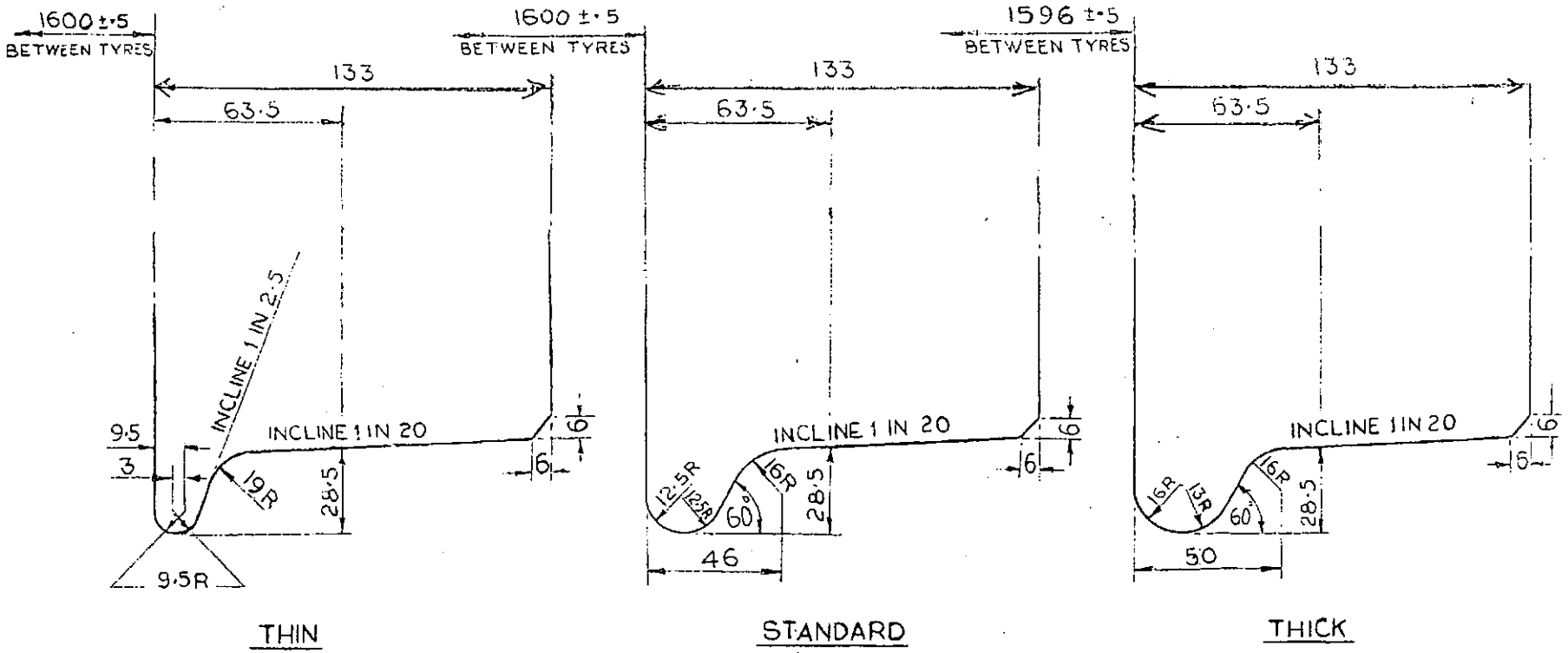
Annexure A1

STANDARD DIMENSIONS IN STATIONS
TO SUIT 25 KV.A.C. TRACTION SCHEDULE-I-CHAPTER-II

DIAGRAM NO. 2
1676 mm GAUGE

	D	T	C	TC
DT 28-11-89	[illegible]		[illegible]	[illegible]

APP'D.



FINISHED IR'S TYRE PROFILES FOR 1676 mm GAUGE LOCOS

C63106

DRG. NO. C.S.L.–3040

ALT. NO. 2

Annexure A