Technical Specification for
‘Design and development of dual fuel 1600 HP DPC engine for DEMU’
1.0 Introduction:

1.1 Indian Railways plans to convert engines of Diesel Electric Multiple Units (DEMU)/Diesel Power Car (DPCs) into dual fuel i.e. to work with diesel and CNG. This work will be executed at Integral Coach Factory (ICF), Chennai.

IROAF, ICF, Nominated Zonal Railways and RDSO as per requirement, may be associated with the conversion and proving out on load box as well as during field trials.

1.2 This document presents the technical specifications for design, development and supply of natural gas kit for conversion of a 1600hp diesel engine to dual fuel mode.

1.3 Procurement of diesel engine to be used on a 1600 hp DEMU is guided by RDSO Specification No.MP-08.00.102 (Rev.1 or Latest) of August 2012. The same may be referred for base diesel engine characteristics broadly, which would be provided/available on a DEMU. [Enclosed at Annexure 5].

1.4 The scope of this specification covers supply and fitment of CNG kit, CNG cascade and associated accessories to ICF, Chennai for fitment on DEMU which is under manufacture or planned for manufacture at ICF, Chennai.

1.5 Conversion has been envisaged to be done based on fumigation technology.

2.0 Project Objectives:

2.1 Tenderer would need to design, build, test, optimize and validate a prototype dual fuel system including CNG storage system on a 1600 HP engine on its engine test bed facilities and then after fitment of the same on the DPC.

2.1.1 Conduct a performance test and engine exhaust emission test on the diesel engine to be converted on its test bed. Results of testing will form baseline for comparison.

2.1.2 Conduct performance test and engine exhaust emission test of dual fuel engine in dual fuel mode, on its test bed after conversion following a similar protocol as in 2.1.1.

2.1.3 Expected test bed facilities on tenderers test bed-

2.1.3.1 Testing engine as per engine particulars, CNG storage and delivery system, measurement facilities for regulated emissions viz. NOx, CO, THC, PM, smoke opacity, Coriolis based mass flow measurement system for net diesel fuel consumption and CNG consumption, measurement facilities for engine performance parameters etc. to enable testing first in pure diesel mode and then subsequently after conversion to dual fuel in diesel and in dual fuel mode.
2.1.3.2 Should have capability of stepped control/variation in speed/torque etc. so that full mapping of engine performance and emissions is possible in different load speed combinations notch vise.

2.1.3.3 Should have electronic control devices to control and monitor the engine output and performance parameters, sensors for temperature, pressures, safety equipment etc.

2.2 Delivery and fitment of natural gas kit on DPC at ICF including the CNG storage and gas delivery system, safety accessories, sensors etc. as required.

2.3 Conduct comparison of the engine performance in diesel and dual fuel mode on a load box duly ensuring working of all sensors, control devices, safety devices etc.

2.4 Reliability and verification testing during field trial for 2000 km in commercial service in a zonal railway. The run should be without any major problem on DPC; failing which the DPC would be rectified again and put on trial and period of trial counted afresh.

2.5 Same design to be replicated in subsequent supplies.

2.6 The system should be sturdy and reliable in operation and incorporate components that can withstand the environmental conditions as indicated in specification No.MP-0.08.00.102 (Rev.1 or Latest) of August’2012.

2.7 Interfacing of electronic control unit, if any, of the dual fuel conversion kit with the existing ECU if provided on the base diesel engine shall be the responsibility of the tenderer.

2.8 Dual fuel DPC should have in built diagnostics and should run a full self diagnostic on every power on; in addition it should also run diagnostics at regular intervals even while the engine is in operation. This operation shall be transparent and should not affect the normal working of the system. All faults should be logged for later downloading to a PC/Laptop. Major fault conditions should be indicated by a suitable indicator mounted on the ECU itself.

2.9 The conversion kit should be so designed, that no major modification to the existing engine be required for its fitment. Even after conversion, automatic/manual flexibility be provided to enable the engine to run in pure diesel mode on nominal load in case of failure/no supply of natural gas to the engine.

2.10 It should be suitable for rail traction service which is characterized by wide, fluctuating, cyclic load patterns, and extended intervals of operation at idle & full load.

2.11 The complete system including the conversion kit, fuel storage system and allied accessories, electronics and transducers to be mounted on the DPC without affecting the accessibility, maintainability and operation of the engine and other
To ensure easy fitment, installation of CNG fuelled diesel engine and cascade to be carried out in DPC as per indicative layout design of these Power Cars. (Ref. Drawing No. CG – K5021 at Annexure 2).

However, based on weight calculation as per cascade weight, Motive Power/Carriage Dte., RDSO may need to be approached for weight calculations and clearance if required for prototype.

The entire system/materials should be of good quality and should have clearances/certifications from CCOE, Nagpur, as applicable or other such organizations of Govt. of India, which needs to be obtained by the tenderer.

No major modification should be required to be done on engine for fitment of natural gas kit. The engine should not exceed the peak cylinder firing pressure limit as defined by OEM in dual fuel mode.

The system offered should allow complete freedom and flexibility to program any engine speed at any notch, by a simple change in the software. The system should be designed in such a way, as to allow it to be adapted to different engine/ DPC requirements in a variety of ways.

Safety Requirements:

Both the electronic, mechanical, gas supply systems of CNG fuelled diesel engine be so designed that safety of components of DPC and personnel is not compromised.

Electrical Cabling, fittings, motors, other electrical equipment should be fire resistant, suitable for such operation and should conform to IR/ICF specification. Wiring should be taken through a fire resistant conduit to prevent damage. There should be no fire hazard from any type of electrical short circuit. Sensors, devices should be shrouded with fire resistant and abrasion resistant materials and should be routed through a proper conduit.

100% redundancy is desired for sensors and devices whose failure can lead to unsafe operation of engine. For those sensors, where 100% redundancy has not been provided, a fail-safe, fall-back strategy shall be adopted for all likely failures. Failure of any single component/ sensor/ sub-system should not lead to a complete shutdown of engine.

Gas detection, fire detection, exhaust fans etc. should be adequate and be installed in cascade room as well in engine room. Gas supply should stop from cascade room automatically (as well as manually override switch by driver) in case of shutoff,
engine stop, leak or fire is detected in cascade room or in engine room. Automatic operation of safety devices for fast dispersal of gas in to atmosphere should happen in such an eventuality.

4.0 Preventive maintenance:

4.1 No maintenance including inspection of any type shall be required before 120 days. Tenderer shall specify preventive maintenance schedule required. Care shall be taken by the tenderer to ensure that these schedules match the existing DPC schedules, and least work content in these schedules would be preferred.

5.0 Scope of supply:

Broadly the scope of supply may consist of following items, but not limited to:

5.1 Gas admission and throttle valves.

5.2 Gas injection control system.

5.3 Gas supply system mixer system of adequate capacity and gas train system consisting of various stages pressure regulators, pressure relief valves, automatic shut off valves, manual shut off valves etc. as required.

5.4 Additional air after cooler along with pump, radiator tanks and their accessories if considered required.

5.5 Electronic knock and misfire control system if considered required.

5.6 Gas actuator with dual fuel control Unit comprising of Engine speed control, exhaust temperature control engine temperatures control engine map control, generator management and fuel management etc.

5.7 Complete set of piping’s, tubing’s, cable harnesses.

5.8 On board gas consumption meter.

5.9 One complete set of associated electronic components, transducers, sensors, detectors, alarms, valves, switches etc. and adaptation parts for retro fitment on engine of 1600 HP DPC.

5.10 Clearance certificates from CCOE, Nagpur or other government agencies if applicable.

5.11 Any required software including diagnostic and installation software.
5.12 CNG Storage system: CNG cascade consisting of 40 high pressure cylinders. Cylinders indicative specification :- Water capacity - 50lttrs, Outer diameter - 232 mm, Wall thickness - 7.0 mm, Length - 1515 mm, Steel grade - seamless chrome molybdenum steel. These specifications are indicative and successful tenderer may offer CNG cascade /cylinders with better specifications. Cylinders in the cascade to be firmly secured in their position to prevent any movement during run.

5.13 Gas detection system with audio/video alarm indications.

5.14 Automatic and fast gas dispersal system including suitable illumination fittings for CNG cascade and engine room.

5.15 Tenderer may add components as required in its offer to supply a self-supporting complete set to meet the requirement of successful operation of DPC.

6.0 Scope of work:
The following would be tenderer’s scope of work consisting as given below, but not limited to:

6.1 Design, development, supply and fitment of various components as indicated above.

6.2 Guidelines, material, training and fitment support to ICF for installation and fitment of conversion kit including provision of high pressure leak proof pipelines joints and other accessories, CNG Storage system, dual fuel kit and other accessories.

6.3 Fitment of pressure regulators, reinforcement members, base frame, supports structure, modification required for placement of CNG storage.

6.4 Modification of air intake pipe to install air gas mixtures. CNG supply pipe from CNG storage compartment to engine room should be over the roof of passenger sitting area.

6.5 Installation of gas actuators and gas mixtures. Fabrication and fitment of HP pipe line from CNG storage outlet to inlet of pressure regulator conforming to SS 316 or better material suitable for 250 kg/cm² pressure.

6.6 Installation of electronic dual fuel control unit with all its accessories, knock controller, exhaust temperature sensors and all associated electrical wiring.

6.7 Provision of separate cooling system for after cooler by providing additional water pump & motor, radiator, junction boxes and Low Temperature After cooler expansion, re-routing of water lines, if considered as required.

6.8 Installation, fitment & testing of slam shut off valves, high pressure gas shut off
valves, low pressure gas solenoid valve etc. As required.

6.9 Installation, fitment & testing of at least two numbers of ventilation fans of minimum 500 cfm along with flame proof motors and self supporting frames.

6.10 Installation, fitment & testing of at least two numbers of flame proof lights.

6.11 Installation, fitment & testing of for power supply arrangement to ventilation motors, gas detector & flameproof lights.

6.12 Installation, fitment & testing of Gas leak detector & Alarm system comprising of four sensors suitable for CNG storage area and four channel control monitor, battery backup for at least 10 minutes, high dB horn, relay output for external configuration, splash guard for sensors.

6.13 Wiring of all safety items in Cascade compartment ensuring all safety requirements of men and material.

6.14 Re-routing of DPC wiring inside the coach.

6.15 Preparation of cascade compartment for installation of CNG cascade including isolation of this area from passenger area of DPC.

6.15.1 Removal of 30 passenger seats from DPC passenger area and fabrication of a double walled GI partition with mineral wool/glass wool packing between passenger area and CNG cascade compartment for isolating passenger area from CNG storage area.

6.15.2 Re routing of air ducting for traction motors from DPC floor to side wall if required to provide space for placing CNG cascade.

6.15.3 Cutting/rebuilding of roof of DPC if required for fitment of CNG cascade.

6.16 Soap testing of complete natural gas line for any leakage in the system. Portable gas detectors to be used for detecting gas in engine room or CNG room.

6.17 Tenderer’s expert should be available on DPC during trial for any on site repair and monitoring. This would be jointly monitored by IR and tenderer during field trial and warranty period. All problems noticed during this period shall be logged and rectified by tenderer.

6.18 Any other work considered necessary to meet the requirement of successful operation of DPC.

7.0 Calculation method of substitution % after fitment of conversion kit:

7.1 Engine will be run at all engine notches in sequence after thermal stabilization of engine. Sufficient number of runs as required would be taken for data collection.
7.2 Engine will be run in diesel fuel mode and net consumption of diesel fuel will be measured by use of Coriolis based mass flow meters.

7.3 Engine will be run in dual fuel mode and net consumption of diesel fuel and natural gas will be measured separately by use of Coriolis based mass flow meters.

7.4 At each engine notch amount of each fuel will be indicated in terms of kg/hr. This mass flow will be multiplied by lower heating value of each fuel (viz. 44 MJ/kg for diesel and 54 MJ/kg for natural gas) to arrive at the energy consumption per hour. Duty cycle energy per hour will be calculated by adding the energy consumed through diesel fuel and natural gas on each notch and multiplied by respective notch vise weighing factors as per the duty cycle.

7.5 Duty cycle energy consumption should be similar in dual fuel mode and diesel mode or better.

7.6 Displacement of diesel by natural gas in dual fuel mode will be calculated as following formula-

\[ \text{Diesel Displacement } \% = \frac{\text{Total of weighted energy by natural gas} \times 100}{\text{Total weighted energy}} \]

8.0 Acceptance criteria:

8.1 Displacement of diesel fuel by natural gas, 20% or more by energy content over the duty cycle.

8.2 Engine performance and emission performance in dual fuel mode should be similar or better than that in diesel mode over the duty cycle.

8.3 The brake specific energy consumption of the converted DPC should be similar or better than that in diesel mode.

9.0 Inspection:

9.1 Inspection would be done at stage of 2.1.1 and 2.1.2 as defined above for successful prove out.

9.2 At stage 2.2 as per purchase order for BOM.

9.3 At stage 2.3 after fitment on DPC and at the time of load box.

9.4 Subsequent to prototype clearance as defined in 2.5 and above except 9.1.

10.0 Training:

10.1 To arrange training to IR personnel during installation and commissioning of equipment according to needs and requirements of diesel engine and DPC. This should include training in manipulation of parameters provided in software and any
other requirements to obtain self-sufficiency for successful reliable operation and maintenance of DPCs.

11.0 **Confidentiality of test results:**

11.1 All data that is generated as result of testing on engine and/or the test rigs by IR shall automatically become the sole property of IR. No part of such information shall be disclosed to any third party without proper written consent to IR.

12.0 **Documents to be provided by tenderer:**

12.1 Literature, Maintenance manual and operating instructions, spare part catalogues (including drawing's reference parts) and tools catalogues as appropriate.
Annexure 1

Typical Indian Railways operating duty cycle for DEMU

- Will be added shortly.
Annexure 2

Drg. of DPC CG-K 5021 indicating cascade position as approved by MP dte.

*Only for guidance.*
Annexure 3

Indicative 1600 hp DPC layout drawing
Engine particulars

Following are broad details pertaining to a 1600 HP Diesel Engine:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rated Engine Speed</td>
<td>1800 RPM</td>
</tr>
<tr>
<td>2</td>
<td>Number and arrangement of Cylinders</td>
<td>16 cylinders, V-arrangement</td>
</tr>
<tr>
<td>3</td>
<td>Idling Speed</td>
<td>700 rpm</td>
</tr>
<tr>
<td>4</td>
<td>Specific Fuel consumption at nominal load</td>
<td>221 g/kw hr</td>
</tr>
<tr>
<td>5</td>
<td>No. of Engines</td>
<td>2 Engines Per Rack</td>
</tr>
<tr>
<td>6</td>
<td>Temperature of Exhaust Gases at Turbo Inlet at Rated Output</td>
<td>1,346 deg. F (Max.)</td>
</tr>
<tr>
<td>7</td>
<td>Method of Starting the Engine</td>
<td>Electric Starter Motor</td>
</tr>
<tr>
<td>8</td>
<td>Water Pump</td>
<td>One, with flow rate to match jacket water and Low temperature aftercooler requirements.</td>
</tr>
<tr>
<td>9</td>
<td>Fuel Injection Timing</td>
<td>Variable with Engine Speed and Load</td>
</tr>
<tr>
<td>10</td>
<td>Number of Turbochargers Used Per Engine</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>Engine Intake Air System</td>
<td>4 Air Cleaners.</td>
</tr>
</tbody>
</table>

- This is only indicative of a type of 1600 HP engine and may vary with actual.
- To be used only for guidance.
Annexure 5

Specification No. Mp- 0.08.00.102 (rev. - 01) August – 2012

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(केवल सरकारी प्रयोग हेतु)

भारत सरकार
रेल मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

SPECIFICATION
FOR
NEW GENERATION DIESEL ENGINE FOR APPLICATION
IN
1600hp BC DMUs

Specification No. MP- 0.08.00.102 (Rev. 01)
August - 2012

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PREFACE

1. BRIEF DESCRIPTION:

This document contains the specification of the new generation diesel engine for the application in 1600hp BG DMUs over Indian Railways.

2. FOREWORD:

This document is a specification of new generation diesel engines required for 1600hp BG DMUs over Indian Railways. This is the document which indicates the broad characteristics of a diesel engine. The specifications given in this document are generic and are expected to change in future with the development.

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Website: www.rdo.indianrailways.gov.in
GENERAL REQUIREMENTS

1. INTRODUCTION:
1.1 The proposed diesel engines shall be utilized for 1600hp BG DMUs over Indian Railways. A standard set of DMU comprises five cars (DPC+4TCs) with one diesel engine per DPC. For break down cases there shall be one engine per case.

1.2 DPC i.e. Driving Power Car of DMUs shall be fitted with one 1600hp diesel engine as a prime mover for traction requirement. This document contains the technical specification of these diesel engines.

1.3 The technical requirements mentioned in this document are the basic features of the diesel engines. It is the responsibility of the manufacturer/supplier to supply the engine as per requirements of this specification.

2. ENVIRONMENTAL / CLIMATIC CONDITIONS:

2.1 The engine & its accessories shall be in continuous operation under the following atmospheric and climatic conditions:

| i. | Ambient temperature | -10 to 55 °C. The maximum temperature under the sun in summer could reach 70 °C. Provision shall be made by OEM for the satisfactory operation of engine in the extreme atmospheric conditions. For working in extreme cold conditions, the OEM must make provisions for starting aid and anti freezing of various fluids. |
| ii. | Altitude | From Sea level to 1800 m. The OEM shall provide an operation chart for working at higher altitudes i.e. up to 1800 m. |
| iii. | Humidity | 100% saturation during rainy season |
| iv. | Rainfall | Very heavy in certain areas |
| v. | Atmospheric conditions | Extremely dusty and desert terrain in certain areas. The dust content in air may reach a high value of 1.6 mg/f. In many non-urban and rural areas, the dust concentration is very high affecting the filter & air ventilation system |
| vi. | Coastal area | Humid & salt laden atmosphere with maximum pH value of 8.5, sulphate of 7 mg per litre, maximum concentration of chlorine 6 mg per |

2.2 The equipment and their mounting arrangements shall withstand satisfactorily the vibrations and shocks normally encountered in service as indicated below:

(i) Max. Vertical acceleration - 3.0 g
(ii) Max. Longitudinal acceleration - 5.0 g
(iii) Max. Transverse acceleration - 2.0 g

(g being acceleration due to gravity)

3. SFC and lube oil consumption

3.1 OEM shall indicate the specific fuel consumption & lube oil consumption at maximum rated output & load.
4. **TRAINING**

The OEM shall arrange training to Indian Railways personnel at their premises or premises of its sub-contractors on operating & maintenance & upkeep of the engine & its accessories supplied for a cumulative period of around 40 man days free of cost at the said premises. The travel and local fare and living expenses shall be borne by Indian Railways.

5. **SERVICE NETWORK:**

OEM shall have a wide service network in India (at least 5 points i.e., North, East, West, South & Central zones) for maintaining these diesel engines. Also, OEM shall submit a list of service network with their service points.

6. **SERVICE SUPPORT AFTER SALES:**

OEM must provide spare parts and service support to Indian Railways for 20 years after sales of engine or engine's initial life, whichever is more.

7. **MINIMUM NO. OF ENGINE SUPPLIED BY OEM:**

OEM shall submit quantity & details of the engine supplied to Railways. For BG DMUs the OEM should have supplied at least 10 engines for similar application to Indian Railways/any foreign Railways.

8. **WARRANTY:**

The OEM shall at its expense, replace any part of the equipment failing or proving unsatisfactory in service due to defectiveness of design, defective material or bad workmanship within a period of 24 months from the date of commissioning in service or 30 months from date of delivery whichever is earlier. The period of warranty shall stand extended by the time taken by the OEM in replacing the defective component from the date of lodging of complaint by the user Railway.

9. **IFR DISCLAIMER:**

The respondents must also provide the following undertakings in signed copies.

9.1 **UNDERTAKING BY EQUIPMENT MANUFACTURE:**

All respondents shall provide a signed copy of the undertaking on "INFRINGEMENT OF PATENT RIGHTS". The undertaking shall be as under:

Indian Railways shall not be responsible for infringement of patent rights arising due to similarity in design manufacturing process, use of similar components in the design & development of this item and any other factor not mentioned herein which may cause such a dispute. The entire responsibility to settle any such dispute rests with the OEM supplier.

Details of design documents given by them are not infringing any IPR and responsible in absolute and full measure instead of railways for any such violations. Data, specifications and other IP as generated out of interaction with railways shall not be unilaterally used without the consent of RDSO and right of Railways/RDSO on such IP is acceptable to them.
10. DECLARATION OF CONFIDENTIALITY OF SUBMITTED DOCUMENTS BY OEM:

While submitting a new proposal design, OEM must classify their documents confidentiality declaration, such as:

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Specification of 1600hp Diesel Engine

1. INTRODUCTION:

1.1 The proposed 1600hp diesel engines shall be utilized for BG DMUs. A standard set of DMUs comprises five cars (DPC+4TCs).

1.2 DPC i.e. Driving Power Car of DMUs shall be fitted with one 1600hp diesel engine as a prime mover for traction requirement. This document contains the specification of these diesel engines.

1.3 SCOPE OF SUPPLY FOR 1600 HP DIESEL ENGINES FOR BG DMUs APPLICATION:

The following equipments shall be in the scope of supply. All the assembly & sub assembly shall be within the envelope size mentioned in the Clause no. 4.

| i. Complete engine (1600hp continuous rating) with standard accessories and its mountings. The engine shall be supplied with initial fill of lube oil & fuel oil, coolant, one change of lube oil along with lube oil and fuel oil filters after initial commissioning. |
| ii. Suitable anti-vibration mountings. |
| iii. Air intakes & air filter assembly with mounting arrangements. |
| iv. Exhaust & turbocharger along with after cooler assembly with mounting. |
| v. Cooling system with radiator along with its mountings arrangements. |
| vi. Expansion tank for radiator with glass type water level gauge & electronic type LCWL indicator with provision to provide in driver’s cabin of DPC. |
| vii. Engine room ventilation along with its mountings arrangements. |
| viii. Excitation control & speed governing system. The supplier shall facilitate and supply all details required for interfacing of electronic control module of the engine with loco controller. |
| ix. Engine driven alternator or through aux. converter for charging battery for engine cranking. |
| x. Hydrostatic/hydraulic cooling equipment complete with radiator. |
| xi. Hoses and fittings and suitable engine room ventilation system. |
| xii. Centrifugal type lube oil cleaner with mountings. The OEM will provide lube oil cleaning arrangement as per their design. |
| xiii. Air compressor with the capacity of 750 LPM at 800 rpm and 300 LPM at rated rpm or more driven with the mentioned engine or motor — compressor—air dryer module of capacity 1000 LPM. |
| xiv. Controls & gauges as per Clause no. 26. |

2. FUNCTIONAL REQUIREMENTS:

2.1 DIESEL ENGINE FOR 1600HP BG DMUs:

2.1.1 The engine shall be a fuel efficient diesel engine capable of producing not less than 1600hp (continuous) at 1800 rpm under standard conditions (as per clause 4.2.1 of UIC 623-2 CR, it is 100 kPa, 20°C and 30% RH) and provided with suitable speed control exciter control.

2.1.2 The engine shall work satisfactorily with AC-DC and AC-AC transmission system.

2.1.3 The offered diesel engine shall meet the emission standard of Euro-II or equivalent standard. However, the tenderer shall clearly spell out the emission standards of the engine being offered.

2.1.4 The diesel engine shall be supplied with the features of EFI (electronic fuel injection).
2.2 COOLING SYSTEM FOR 1600HP DIESEL ENGINE FOR BG DMUs:

2.2.1 The cooling equipment for diesel engine shall be required to work efficiently under climatic conditions specified under Clause 2 (page no.2). Apart from meeting the cooling requirement of diesel engine including after cooling, the cooling equipment shall be required to dissipate heat of lubricating oil, hydraulic oil used for hydraulic fan (in case of hydraulic drive) with 30% checked condition of radiator. Airflow required for the radiator fan shall be at least 15% more than actually required to make up for any reduction in airflow due to train movement.

2.2.2 The initial filling of hydraulic oil for hydraulic operation of fans in the cooling system as proposed by the supplier shall be in the scope of supply.

2.2.3 The drive for hydraulic pump / electrical motor for radiator fan / ventilation fan shall be from extension of engine crankshaft on free end of engine.

2.2.4 Hydraulic hoses of IC/FRESO approved sources with adequate factor of safety shall be used for cooling system. The hoses shall be properly routed and secured so that it does not fail due to vibration or misalignment. The hoses shall be of proper length without undue bend restricting the flow. The metallic/ rubber hydraulic pipes mounted & routed on the floor shall be properly covered with suitable cover of adequate strength to protect from damage while carrying out maintenance by maintenance crew and ingress of contaminants.

2.2.5 For mounting of radiators, fan drive & ventilation system, ICF drawing no. DMUDP/C7-6.4-702 (Sheet 1 & 2) for Radiator Room Arrangement & drawing no. DMUDP/C7-6.4-701 (Sheet 1 & 2) for Engine Room Arrangement shall be followed. The drawings can be collected from ICF, Chennai. Any other arrangement proposed by OEM shall be approved by EDSO.

2.2.6 The drawings (with latest alteration) for mounting of fan drive arrangement for radiator and ventilation fan in DFC shall be submitted to EDSO for approval.

2.2.7 Expansion tank: It shall be provided at a suitable location for ease of maintainability. It shall be provided with water level indicator in the driver’s cabin. The capacity of the tank may be indicated (in litres) on the tank itself. Its filling point shall be provided with pressurised cap & screw. The layout of the tank along with filling arrangements as proposed by OEM shall be approved by EDSO.

2.2.8 Suction type roof mounted radiator fan and ventilation fan shall be provided so that the fan sucks air from side-mounted radiator / side panel filters and blows out through roof opening provided for fan respectively. Layout of radiator fan & ventilation fan arrangement shall be approved by EDSO.

2.2.9 During operation at maximum output, the radiator fan and ventilation fan shall not be source for noise and vibration.

2.2.10 The vendor shall submit following details and calculations for the cooling system:

i. Cooling requirement for all sources of heat (with break up)
ii. Heat dissipative characteristics of the radiator and its resistance characteristics
iii. Radiator fan characteristics showing the air flow Vs total heat at different speeds
iv. Cooling system matching calculations
v. Schematic cooling circuit diagram showing water, oil and airflow
vi. Installation drawing of radiator, fan assembly for both cooling and ventilation arrangement shall be provided.
vii. Cooling proving trial including testing of hydraulic oil cooler, shall be conducted at contractor’s premises to prove adequacy of the offered cooling system for prototype in presence of authorized representatives of purchaser. The maximum temperature of hydraulic oil shall not exceed 70°C.
2.2.11 In case the hydraulic oil tank shall be of stainless steel. It shall be provided with oil level indicator, temperature indicator, oil level switch and oil filter with restriction indicator. A micro/limit switch shall be provided and interlocked with delivery side shut-off valve.

2.3 **POWER TRANSMISSION FOR 1600HP BG DMUS:**

2.3.1 The contractor shall submit proposed drawings for engine mounting base frame.

2.3.2 The engine shall be mounted with all driven equipment/accessories on a common base design with suitable anti-vibration mountings (AVMs) connecting to the DMU/ frame structure. The type of AVMs and numbers provided shall be indicated. The deflection characteristics of AVMs shall be submitted.

2.3.3 The contractor shall use threaded fasteners of appropriate quality for coupling engine to the transmission and also to the base rail frame.

2.4 **CONTROLS AND GAUGES FOR 1600HP BG DMUS:**

2.4.1 Adequate control equipment including gauges, instruments and safety devices shall be provided for safe and satisfactory operation. All gauges shall be of proven and reliable design. Graduations of all gauges shall be in metric units. Following gauges shall be provided in the cab:

i. Local engine starting switch/push button
ii. Battery charging/discharging ammeter
iii. Local engine stop switch/push button
iv. RPM meter
v. Engine lub oil pressure gauge
vi. Cooling water temperature gauge (Electronic)

vii. Fuel oil pressure gauge
viii. Water level indicator (Electronic)

2.4.2 The following audio-visual signals or reference panel lights shall be provided.

i. Low engine lubricating oil pressure
ii. Radiator water temperature too high
iii. Cranking contactor welding indication

2.4.3 The following safety devices, indicators, shall be provided:

i. Water temperature too high - Transmission cut-off and engine will return to idle
ii. Low water in radiator - Power to transmission cut-off and engine shut down
iii. Low lub oil pressure - Power to transmission cut-off and engine shut down
iv. Engine speed too high (Over speed trip) - Power to transmission cut-off and engine to shut down
v. Adequate protection of an approved design shall be provided against overloads.

2.5 **STARTER BATTERY:**

24 V, 450 Ah, low maintenance Lead Acid storage batteries (5 hrs. discharge rate) conforming to RDSO/PE/SPECTRL/0001-1998 (Rev. 0) and approved make shall be provided. Adequate fire protection is given in positive and negative battery circuit. The battery shall cater to 3 cranking of engine at 10 seconds' interval.
2.6 **COMPRESSOR:**

One air compressor, with the capacity as indicated in the scope of supply, shall be provided with each engine. OEM shall specify the correct grade of compressor oil suitable for operation of compressor under given condition as per Clause no. 16.(b). The coupling of compressor with engine shall be as per arrangements offered by supplier and approved by RDSC.

2.7 **Piping and Pipe Fittings:**

2.7.1 Seamless stainless steel pipe bright annealed to ASTM A 269, Gr 304, which can be bent cold, shall be used. The layout of piping shall be as short and straight as possible. Bends should be used throughout, but where elbows have to be used, they shall be of round type. Where the pipe itself are bent, then internal area shall be maintained uniformly.

2.7.2 Double ferrule pipe fitting consisting of body, front ferrule, back ferrule and nut shall be provided. The body and nut will be of carbon steel to ASTM A-18 Grade II with electro galvanic zinc plating with chromic passivation. The front ferrule and back ferrule will be made from Stainless Steel to ASTM A 276 TP 316 SS and conforming to ICF specification no ICF/MD/SPEC-166 with latest amendments.

2.7.3 All pipes shall be adequately clamped to the frame assembly. Compro to RDSC spec. No. C-94017-type II clamps shall be used.

2.7.4 Flexible pipes shall be provided at all the locations prone to vibrations. Flexible hose connections conform to spec. SAE 100R, only shall be used.

2.8 **Lubrication:**

Grease nipples shall conform to IS specification No. 4009. All the grease nipples & adapters, where used, shall be tack welded to prevent them from unsewing and falling off in service.

3. **Technical Requirements:**

3.1 The OEM shall submit the details of power absorbed by the individual accessories essential for the working of the engine.


3.3 Filters for engine air intake shall be provided with restriction indicator to ensure satisfactory performance under duty environment.

3.4 The noise level due to engine and other equipment shall be within the limit as per clause 2.10 of UIC 651 OR.

3.5 The engine shall be provided with a flexible coupling to suit traction alternator. The coupling shall be of adequate capacity to withstand high deflection and torque (at starting, stopping and due to any misfiring of the cylinders) so that no damage is caused to transmission and engine components in service.

3.6 The tenderer shall supply engine driven alternator of adequate capacity as standard accessory for charging battery for engine cranking.
3.7 Suitable provision for lube oil drain arrangement from engine sump easily shall be provided to avoid oil spillage.

3.8 Provision of centrifuge lube oil cleaner shall be provided.

3.9 The supplier shall time to time inform Railways about the modification to be carried out on the engine.

3.10 The supplier shall co-ordinate with Railway administration for carry out any modification suggested by RDSO.

3.11 In view of the passenger safety, any modification suggested by RDSO shall be carried out by the supplier and the same shall be in the scope of supply.

3.12 Any safety related modifications issued by Indian Railways shall be carried out by the OEM.

4. **MAXIMUM LIMITING DIMENSIONS (ENVELOP) FOR 100HP DIESEL ENGINE & ACCESSORIES**

The diesel engine alongwith accessories shall be subjected to the fitment within the following maximum limiting dimensions (Envelop):

<table>
<thead>
<tr>
<th>Length</th>
<th>Width</th>
<th>Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2m</td>
<td>1.8m</td>
<td>2.0m</td>
</tr>
</tbody>
</table>

4.1 The OEM shall provide suitable thermal insulated lagging over exhaust manifolds of the Diesel Engines.

5. **DOCUMENTS REQUIRED FROM SUPPLIER:**

5.1 The tenderer shall submit with data of Engine, rpm and power alongwith other important parameters responsible for ensuring the reliability of engine.

5.2 The supplier shall submit the details of schedules to be carried out on the engine duly indicating the cost of each schedule along with periodicity of each schedule and work out a life cycle cost of the engine as mentioned in 6.3.

5.3 The supplier shall submit the details of life cycle costing of the engine assuming a service of 10 hours per day over a specified period of maintenance and life span as indicated by OEM.

5.4 The envelope size of the diesel engine shall be kept as low as possible in order to provide sufficient pathways on both the sides & easy maintainability from either side within MMD of coach as per BG IR/SCO, Revised 2004 or latest. The OEM shall be responsible for ensuring proper alignment of engine and traction alternator (TA). The tenderer shall submit its tentative General Arrangement layout drawing with complete technical details at the time of submitting the tender for scrutiny.

5.5 The tenderer shall submit General Arrangement (G.A.) layout drawing indicating the main equipments such as engine compressor, cooling system, mounting arrangement etc. along with complete details at the design stage for scrutiny. The same shall be approved by ICF.

5.6 The tenderer shall submit General Arrangement (G.A.) layout drawing indicating air intakes with filters, ducts and exhaust arrangement shall be compatible with engine system. The same shall be approved by ICF.

5.7 The tenderer shall submit General Arrangement (G.A.) layout drawing indicating the exhaust and silenced arrangement of power equipment. The same shall be approved by ICF.
5.8 The tenderer shall indicate the fuel consumption at idle rpm and rated rpm & output.

5.9 The tenderer shall furnish a copy of 100 hours Type Testing report of the engine conforming to UIC 623-2 OR in support of their claim regarding performance, reliability & specific fuel consumption. In case, the offered engine is to be used first time in Indian Railways, the 100 hours type testing shall have to be carried out in accordance with UIC 623-2 OR in the presence of RDSO’s authorized representative and the scheme for type testing shall be finalized by RDSO & supplier jointly.

5.10 For all the remaining engines, other than the first engine offered for 100 hours type test, the Routine test report shall be required to be submitted along with respective engines at the time of supply.

5.11 The supplier shall inform about any modification carried out in the diesel engine & accessories at any stage.

5.12 The tenderer shall submit three copies of operating, maintenance & service manual and complete spare parts catalogue along with the details of various sub-systems with illustrations and block diagrams to the engineer at the address given below. Virtual animation of operating, assembly, repair and maintenance with user interface in 3D animation shall also be submitted in exe file for effective training of end users.

Director General (MP), RDSO,
Ministry of Railways, Manak Nagar, Lucknow – 226 011

And one set of Operation & Maintenance manual and spare parts catalogue shall also be supplied free of charge to the purchaser for use on the Railway.

6. **SPECIAL TOOLS FOR MAINTENANCE:**

6.1 A comprehensive maintenance schedule shall be prepared by the OEM for efficient working of subject diesel engine. A basic list of tools to be used for carrying out the proposed maintenance schedules shall be advised by the OEM. The OEM shall supply one set of tools for 4 diesel engines.

The cost of such basic tools shall be included in the cost of proposed engine.

6.2 The tenderer will also offer separately a list of special jigs & tools and instruments which shall be essentially required for maintenance. The tenderer shall explain the purpose/justification of the specialized equipment as offered. The tenderer shall supply sets of such jigs, tools and instruments @ one set for 4 diesel engines and shall quote for the same separately if, asked for.

6.3 The final decision, for the supply of special jigs & tools, instruments (as mentioned in Clause 7.2 above), is reserved with Indian Railways.

7. **RECOMMENDED SPARE PARTS – for diesel engine:**

7.1 The OEM will have to quote and submit the detailed description, drawing no., source of supply, part number & price of the unit spares and consumable spares required for maintenance purposes. The Railways reserve the right to order these spares as per the list(s) or part thereof as an option.

7.2 **Unit Exchange spares:** The successful OEM shall supply ‘unit exchange spares’ at the rate of 10% of the total population of that equipment in the tendered quantity. List of such items is as below. These items shall be priced separately in the offer:

i. 24V Battery
ii. Ventilation fan
iii. Engine (complete with all assemblies)
iv. Engine Governor
v. Radiator fan and motor.

The above items shall be provided through the nearest service network of OEM.

7.3 The OEM shall be responsible for ensuring subsequent availability of spare parts for efficient working of the respective equipments.

7.4 The OEM shall prepare a spare parts catalogue listing all components manufactured or purchased and shall submit to RDSO for approval within 4 weeks of clearance of the prototype.

7.5 The OEM shall be responsible for ensuring availability of spare parts and maintenance support for entire life span of the proposed engine.

7.6 In case proposed model is becoming obsolete, the OEM shall intimate Indian Railways well in advance, and continue to cater for the spare parts and maintenance support for the next 5 years.

8. TESTS FOR VERIFICATION & VALIDATION:

The following tests shall be conducted for testing the diesel engine & accessories for compliance and suitability to requirements:

i. Visual check
ii. Verification of test certificates and reports submitted
iii. Fitment & trials on BO DMUS
iv. Performance shall be closely monitored and evaluated by RDSO for:
   a) Reliability under actual operating conditions
   b) Maintainability of the engine & its accessories
   c) Fuel & lube oil consumption at rated out & load
   d) Overall maintenance cost

Notwithstanding anything that may be specified in the specification, the final responsibility for the suitability of the design shall lie with the respondents and shall carry out all modifications for satisfactory functioning during the period of field trials.