

RD.21/22801.5 05August 2021

RfQ for BEML 1500hp V12 Diesel Engine – IP (Display Unit) - Part No. : 550 819 0019

1 INTRODUCTION

BEML Limited was established in May 1964 as a Public Sector Undertaking and plays a pivotal role serving India's core sectors such as Defence, Rail, Power, Mining and Infrastructure. The manufacturing units located at Bangalore, Kolar Gold Fields (KGF), Mysore and Palakkad along with all India Sales & Service network and backed up by a strong R&D base. For more details please visit www.bemlindia.in.

2 PROJECT BACKGROUND

BEML, in association with CVRDE, has taken on the development of a 1500hp, 12V, 25Ltr capacity diesel engine for use within an Armoured Fighting Vehicle (AFV), to meet Indian Military requirements.

BEML has hired RICARDO for design & development activities, supplier selection and technical support throughout the duration of the Project. BEML shall manufacture & test the engine and supply to CVRDE for field trials. BEML, RICARDO & CVRDE shall work jointly on this project.

A project period of 5 years is envisaged from design phase to serial production stage. An Initial manufacture run of 20 prototype engines is planned to prove out (testbed and field trials) at BEML. Serial production will begin after a successful completion of these trials.

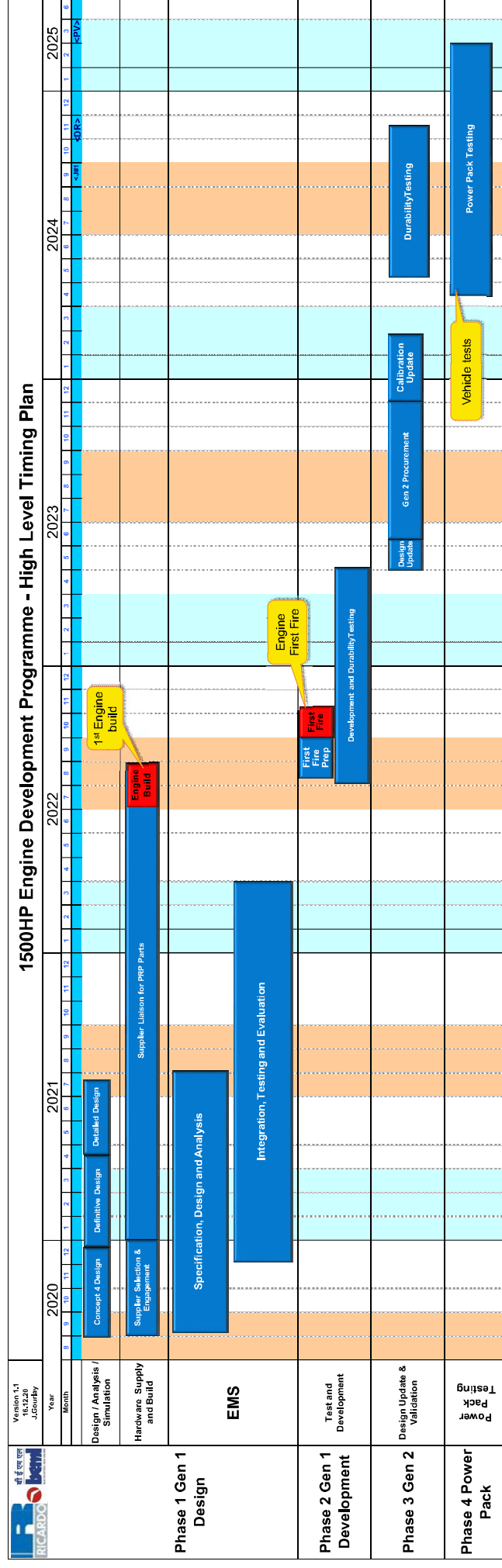
The project commenced in September 2020. The engine design concept refinement phase is completed, and key engine specifications are finalised. Key component technical parameters are finalised such as Concept 3D models, Design Concept Sheet (DCS) and GA drawings etc. The Design Concept Sheets have been used during the early stages of supplier engagement to support the initial discussions regarding proposed requirements – these are to be used as a guide; the specification defined within this RfQ should be considered the master document for the technical requirements.

Candidates for component supply have been shortlisted through a supplier selection process managed by RICARDO. Once BEML has identified the selected supplier through a tendering process, RICARDO shall work with them for the definitive design phase supporting finalisation of the manufacturing design.

BEML are happy to announce that you are one of the finalised candidates shortlisted based on your strong inhouse designing and manufacturing capabilities and BEML will look forward to working with you in partnership for this prestigious project of national importance.

3 PROJECT APPROACH & TIMING

The high-level project timing plan is shown below.



4 PROJECT RESPONSIBILITIES – RASIC TABLE

Item	Supplier	BEML	Ricardo	CVRDE	Other
Specification of the overall engine E/E system to meet application requirements	S	A	R	S	
Management of E/E system suppliers to ensure E/E system deliverables achieved	S	A	R		
Specification of IP Requirements					
IP hardware requirements	S	A	R	A	
IP functionality requirements	S	A	R	A	
Physical Design					
Electronic hardware specification to meet requirements	R	A	S	S	
Provision of IP installation & packaging requirements	R	I	I	A/S	
Design of IP	R				
Provision of IP CAD models	R				
Approval of IP CAD models	S	S	S	R	
Software Functionality					
Specification of IP software functionality		A	R	A	
Development & implementation of all software, integrated into IP	R		A	A	
Input / Outputs					
External I/O definition (discrete I/O, CAN messages, etc, including integration with EMS)	S	A	R	S/A	
IP pin-out definition, connector specifications	R	A	S	S/A	
Harness pin-to-pin definition	S	A	R	S/A	
Harness build					R (harness supplier)
Bench Testing					
Specification of bench testing requirements	S	A	R	A	
Bench testing of IP (functionality & interface testing)	R		A	A	
Robustness Testing					
Environmental & robustness testing (as per Technical Specification)	R	A	S		
EMI/EMC testing (as per Technical Specification)	R	A	S		
Vehicle Testing					
Validation testing in vehicle	S	S	S	R	

5 SCOPE OF SUPPLY

- a) Component design, functional & durability analysis, engineering, manufacture, assembly, testing and supply of Display Unit (IP) in fully assembled condition to meet the requirements detailed within the Technical Specification section of this document, the Drawing: '5508190019_Display' and Design Concept Sheet: 'BEML DCS.0029.2 Display Unit'.
- b) Development support for connected parts

- c) Support for installation and integration with engine control system (EMS) and relevant training to be provided

NOTE:

- i. The attached drawing ['5508190019_Display'] is preliminary, final drawings (2D and 3D) to be prepared by the supplier with the support of RICARDO and BEML during Definitive Design stage and Display Unit (IP) will be developed in two generations, namely Gen-1 & Gen-2
- ii. All the inspections are to be carried out jointly with BEML and RICARDO teams

5.1 Engineering

Development of IP hardware and software to fulfil the technical requirements defined in section "Technical Specification" and within the Drawing: '5508190019_Display' and Design Concept Sheet: 'BEML DCS.0029.2 Display Unit', including technical support to engineering of the IP into the vehicle according to the responsibilities defined in "Project Responsibilities – RASIC Table".

5.2 Physical Scope of Supply

SI No.	Overall Specifications	Ref Dwg Number	Weight [Kg]	Material	Total Qnty. [No.]
1	BE1500 - Display unit	5508190019	Refer Drawing	Refer Drawing	7

5.3 Testing & Validation

Supplier to test electrical components for compliance to the following, and provide compliance evidence from testing to Ricardo & BEML:

- MIL-STD-461G (EMC/EMI)
- MIL-STD-1275E (Electrical supply)
- Environmental and Robustness Requirements, as defined in "Technical Specification", section "IP Hardware Robustness"
- Any other validation testing as necessary to ensure IP durability and performance in the vehicle application
 - Supplier is responsible for defining this validation plan

Supplier is responsible for defining any validation testing, data, and hardware requirements from the vehicle integration activities to support the in-vehicle validation.

5.4 Documentation

Supplier to provide the following documentation as part of the scope of supply:

- Technical specification of IP hardware and software components
- Manuals (hardware and software systems):
 - Operational and Maintenance
 - Service and Troubleshooting
 - Installation

- GA (General Assembly) drawing both 2D and 3D of the complete assembly with dimensions and installation requirements
- Acceptance Test Procedure (ATP) and Acceptance Test Criteria (ATC) of the supplied parts
- Performance and durability test certificates of supplied parts
- Report of Design Validation Plan (DVP) tests carried out additionally (if any)
- IP electrical connector specifications
- IP pin-out specifications
- IP interface specifications (EMS, hardwire and comms bus interfaces, and comms protocol for fault code interrogation)
- Release notes for any software updates
- IP HiL testing report
- IP in-vehicle test report
- Certificates of compliance and test reports of IP to the electrical, EMC/EMI and environmental and robustness standards specified in the Technical Specification

6 TECHNICAL SPECIFICATION

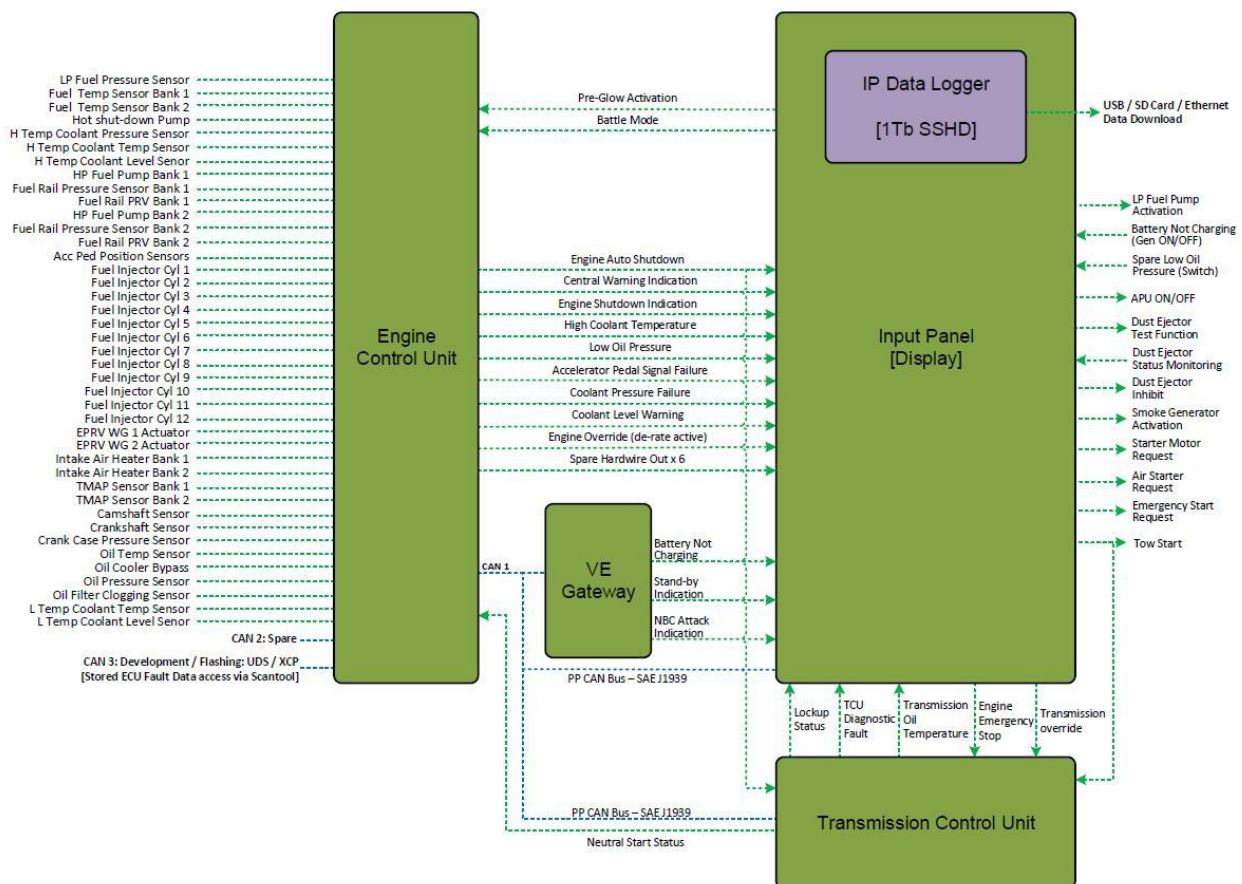
6.1 Engine Specification

The table below summarises the main engine specifications:

Main Engine Specifications	
Engine Type	12 Cylinder, 4-stroke, V-90 configuration, 25L, Turbocharged, Water cooled CAC, DI, liquid cooled Diesel Engine, working at -40° to 55° C
Swept Volume	25L (Bore: 138 mm & Stroke: 140 mm)
Rated Power	1500hp (1103 kW) as per ISO 1585 (w/o fan)
a) Performance at 55°C ambient temperature at sea level	No power reduction allowed
b) Performance at 1000m altitude	No power reduction allowed
c) Performance at 5000m altitude	Engine should be able to operate up to 5000m altitude safely. Minimum power reduction is permissible at this altitude.
Torque backup (min)	18% at 60%-65% of rated engine speed (4780@1560 rpm)
Rated speed	2600 rpm
Power at 50% rated speed (min)	610 kW @ 1300 rpm
Power at idling speed (min)	145 kW @ 800 rpm
SFC at peak torque speed	210 g/kW.hr (max)

Continuous over speed	110% of rated speed (2860 rpm)
Instantaneous over speed	125% of rated speed (3250 rpm)
Fuel	Diesel DHPP-A and its variants
Oil sump	Dry sump
Permissible engine inclination	35° in any direction. Engine should be able to stop for any duration and start under these inclinations
Peak Firing Pressure Limit (operational / design maximum)	180 / 190 bar

6.2 IP Interface Schematic (Proposed, final schematic TBD)



6.3 Functional Requirements for Input Panel (IP)

6.3.1 Parameter Display & Operator Commands

The IP will display real-time information from the engine and transmission and the status of the hull electrical system.

Functional buttons and a touch screen will be used by the operator to control the IP parameter display.

A main page on the display will display critical parameters by default. It will not be possible for the operator to alter the parameters on this page.

Further pages may be populated with parameters of the operators choosing. For engine parameters, these may be chosen from the information made available by the ECU on the PP CAN bus.

The IP will provide an interface for the operator to manage the engine starts (in numerous modes) and activate the smoke generator.

6.3.2 Master Key Switch

The master key switch will be used to control electrical power to all vehicle systems:

Position	Functionality	
Position 0	All systems to be powered off in the vehicle	Main relay switched OFF. The main relay controls the power of the complete vehicle electrical system
Position 1	Standby position: IP to be powered ON, and will start-up	Main relay to be powered ON, supplying power to systems in vehicle
Position 2	Drive position: ECU to be powered ON, LP fuel pump(s) to be switched ON	Drive relay should be switched on feeding power to ECU and TCU and drive electronics. Power to the Fuel Fired Coolant Heater unit to be cut.

6.3.3 Manual Override Switches

The IP will provide an interface for the driver to command manual overrides of certain functionality in the ECU and TCU.

This will be controlled by switches on the IP which will be connected by hardwires or CAN to the ECU, TCU and other components in the E&E system.

6.3.4 Hardwire Switches

The IP will have switches for each of the functions detailed in the drawing '5508190019_Display' and within the table below, in addition to 6 x Spare switches connected to hardwire outputs.

Switch	Positions	Functionality
Pre-glow Start Switch	Push button with 2 momentary positions: 1. Pre-glow 2. Start	For normal engine start procedure: 1. Starts preheating of the combustion air 2. Cranks and starts the engine
Startlock (Transmission)	Momentary Toggle switch (Pull to operate)	Bypasses the start-lock conditions from TCU
Engine emergency start	Momentary Toggle switch (Pull to operate)	Directly sends 24V to the starter motor (bypassing any interlocks that inhibit cranking)
Engine stop switch	Push Button ON/OFF	Commands ECU to stop fuelling engine, triggering engine stop

Fording switch	Toggle switch ON/OFF (Pull to operate)	Prepares vehicle for fording by inhibiting: 1) the operation of the Dust Ejector system 2) automatic shutdown of engine (achieved by activation of ECU 'Battle Mode') 3) the smoke generator
APU switch interlock	Toggle Switch ON/OFF	Energises the APU, only when main generator is off
Transmission override switch	Toggle switch ON/OFF (Pull to operate)	Inhibits downshifting, even during over-temperature condition of the transmission oil
Tow Start Switch	Toggle switch ON/OFF (Pull to operate)	Indicates to TCU that vehicle will be towed to crank engine, TCU to engage specified gear to enable this. To be used in combination with the pre-glow start button
Air Start Switch	Momentary Toggle Switch ON/OFF	Starts the engine using compressed air to crank engine
Battle Mode	Toggle switch ON/OFF (Pull to operate)	Overrides fault protection de-rate and shutdown functionality within the ECU, to enable engine operation in presence of faults (to be used only in emergency situations, due to risk of engine damage)
Dust Ejector Test	Toggle Switch ON/OFF	Whilst held depressed, switches on dust ejector to allow operator to test operation
Smoke Generation	Toggle Switch ON/OFF	Switches on the Smoke Generator
LP Fuel Pump switch	Push Button ON/OFF	Restarts, or stops, the LP fuel pump(s)
Up to 6 x Spare Digital IO	-	To be added retrospectively as and when needed during development

Note: switches should have Opto-isolation, and rugged military grade switches should be used.

6.3.5 Start Control

The IP shall support multiple methods for starting the engine.

- Normal Start
 - When the operator selects Position 2 on the Pre-glow Start Switch, the IP shall provide 24V to the starter motor, subject to specified conditions
- Emergency Start
 - When the Engine Emergency Start switch is pressed, the IP shall provide 24V direct to the starter motor, with no inhibit or interlock logic
- Air Start

- When the “Air Start Switch” is pressed, the IP shall trigger engine cranking via the air start control valve
- Tow Start
 - When the “Tow Start Switch” is pressed, the IP shall provide a signal to the TCU, in response to which the TCU will engage gear
- Cold Start
 - Pre-Glow:
 - When the operator selects Position 1 (Pre-glow) or Position 2, the IP shall switch on the intake air heaters
 - The IP shall inhibit operation of the intake air heaters after TBD seconds of continuous engine running
 - Fuel Fired Coolant Heater:
 - The IP shall deactivate the Fuel Fired Coolant Heater when an Engine Start Request is made

6.3.6 Air Intake Dust Ejector

The IP shall only switch ON the air intake dust ejector after completion of engine starting.

The IP shall switch OFF the air intake dust ejector when the engine is stopped.

The IP shall switch OFF the air intake dust ejector when the Fording switch is ON.

The IP shall provide a Dust Ejector Test function, by which the dust ejector is switched ON for the duration that the Dust Ejector Test is pressed. Once released, the dust ejector will be switched OFF.

The IP shall receive and display the status and diagnostic data from the Dust Ejector system.

6.3.7 Smoke Generator

The IP shall switch ON the smoke generator when the Smoke Generator switch is ON.

Smoke generation shall be inhibited under specified conditions.

6.3.8 LP Fuel Pump

The IP shall switch ON the LP fuel pump(s) when the Master Key Switch is switched to Position 2.

If the engine is not started after a defined period of time whilst the MKS is in Position 2 and the LP fuel pump(s) is ON, the IP shall switch OFF the LP fuel pump(s).

If the LP Fuel Pump switch is pressed when both the MKS is in Position 2 and the engine is not running:

- The LP fuel pump(s) shall be switched ON if they are not running
- The LP fuel pump(s) shall be switch OFF if they are already running

6.3.9 IP Critical Warnings

The IP will notify the operator of critical warnings, using LED indicators as detailed in the drawing '5508190019_Display'.

Note: LED indications should have Opto-isolation.

6.3.10 Operating System Specification

The IP shall run with a capable operating system (Windows, Linux, or alternative) so that all functional requirements (as specified in the Technical Specification, Drawing '5508190019_Display' and Design Concept Sheet: 'BEML DCS.0029.2 Display Unit') are met, and interfaces with other systems (EMS, TCU etc.) and hardwires/switches are managed to a high level of robustness. Specific processor type and rating requirements are for discussion with the supplier (recommended best match for application).

The IP operating system shall manage the data storage and file transfer activities.

6.3.11 Connectivity Requirements

The IP shall include USB and SD Card sockets to be used for data transfer from the internal data logging hard drive and for updating IP software/firmware.

The SD Card Socket shall have the ability to be sealed securely so that unnecessary or unwarranted access is protected for (the SD card can be 'locked' in position).

An Ethernet port shall also be integrated if deemed necessary (for interfacing communication/data transfer). Details of these sockets' requirements, and others, are to be found in the Drawing '5508190019_Display' and within the following "IP Data Logging" section.

6.3.12 IP Data Logging

The IP will be responsible for logging engine data for later use by the operator for purposes such as diagnostic fault finding.

The IP will receive data from the ECU primarily using the J1939 / MilCAN interface (PP bus). If internal variables not included on CAN are required for logging by the IP, then the IP will need to support appropriate protocols (e.g. UDS – Unified Diagnostics Services) and, even a second CAN bus to communicate this information. The number and logging rate of signals will be limited by the available bus load and ECU/IP computing capacity.

The IP will store the received data to an integrated 1TB (minimum capacity) hard disk.

A default set of signals will always be logged at a default rate. The IP will include a function for the operator to specify extra signals and the rate at which they should be logged.

When a set of default trigger conditions are met, the IP will store the data that has been recorded over a default period of time before the event trigger in a protected area (for example, if a fault is detected, the previous 30 minutes of data will be stored to the protected area). The operator will be able to define further conditions to trigger storage to the protected area and the time before the event to be stored when these are met. Any logs stored in the protected area will not be overwritten without command by the operator.

If the free space on the IP hard drive passes below a pre-determined threshold, the IP will begin to overwrite stored data (starting with the oldest logs first) when storing new data logs to the hard drive.

The IP will provide an interface for the operator to access logged data using an external computer. This will be accessed either via anSD Card Socket, USB interface of type MIL-DTL-38999 Series III D38999/XXαA35N or CAN connector of type MIL-DTL-38999/ffeA35zA Series 3. If possible, it is desirable to access live CAN data through the same method.

A fourth interface will be provided as an ethernet connector of type MIL-DTL-38999 Series III, D38999/XXαB35SN (or A). This will provide access to logged data as well as programming of the IP.

6.3.13 Diagnostics

The IP will act as a diagnostics interface for the driver, therefore it will include an application which allows the operator to search for active fault codes and the freeze-frame data associated with them, such that appropriate diagnosis of faults can be made.

The IP will allow the operator to request to clear stored fault codes from the ECU.

The IP will display warning notices on the active screen if a fault code is raised during operation.

The IP will set the “Central Warning Indication” to true as commanded by the respective hardware.

6.4 Electrical and EMI/EMC

The IP will be compatible with an electrical power supply complaint with MIL-STD-1275E, but shall operate on a voltage range of 9-36V DC (which is a larger voltage range than defined in MIL-STD-1275E). This standard defines protection requirements for overvoltage, reverse polarity, transients, etc.

The IP will be compatible with the EMI & EMC requirements defined in MIL-STD-461G.

6.5 IP Hardware Robustness

The IP will meet the following environmental and robustness requirements for qualification.

QUALIFICATION ENVIRONMENTAL TESTS

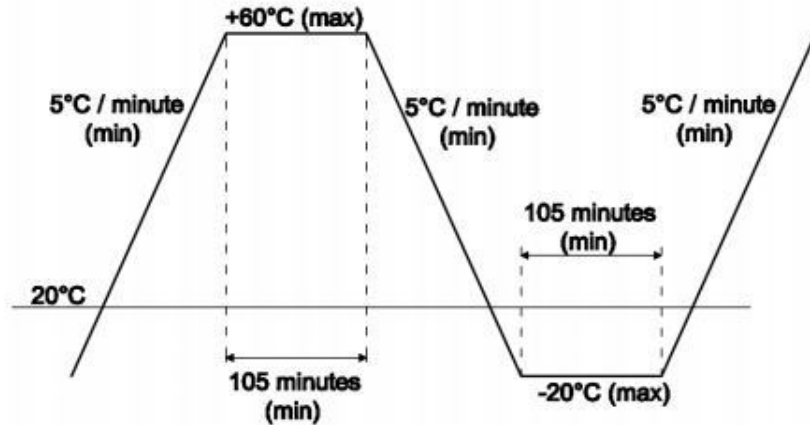
Order of Testing	TEST NAME	SPECIFICATION	REMARKS
1	Environmental Stress Screening (ESS)	12 number of cycles (8 defect free cycles) shall be done so that total duration at high temperature and at low temperature will be at least 1260 minutes respectively. Each thermal cycle should be done as per figure enclosed in Appendix - 'L'. After completion thermal cycling random vibration to be carried out.	1. System ON during positive cycle and System OFF during the negative cycle. 2. Limited Performance check during each positive cycle of the test when the unit is inside the chamber. 3. Performance check after recovery.
2	Vibration Test	Random Vibration in 3 axis $10(m/s^2)^2/Hz$ during 20 to 500 Hz falling to $1(m/s^2)^2/Hz$ at 2000 Hz for 2 hours in each axis.	1. System ON during the test 2. Limited Performance check during the test. 3. Performance check after recovery
3	High Temperature (Operational) (*)	100°C +/- 3°C for 24 hours	1. System ON during the test 2. Limited Performance check during last half an hour
4	High Temperature (Storage) (*)	85°C +/- 3°C for 24 hours.	1. System OFF during the test 2. Performance check after recovery
5	Low Temperature	-30°C +/- 3°C for 24 hours.	1. System OFF during the test 2. System ON during last half an hour 3. Limited Performance check during last half an hour 4. Performance check after recovery
6	Damp Heat	40°C +/- 2°C for 16 hours. RH > 95%	1. System OFF during the test 2. Performance check during last half an hour
7	Drop Test	Height of drop = 100 mm; No of drops/face = 1 on all faces except connector side.	1. Performance check after test
8	Dust Test	Chemical Composition: SiO ₂ : 97 – 99% Fe ₂ O ₃ : 0-2% : Al ₂ O ₃ : 0 to 1% : TiO ₂ : 0 to 2% : MgO : 0 to 1% : Ignition Losses : 0 to 1% One hour. temp 40°C +/- 3 RH < 50%	1. Performance check after recovery
9	Bump Test	4000 bumps at 25 g; pulse duration: 6 ms, half sine wave.	1. System OFF during the test 2. Performance check after recovery
10	Shock Test	40 g, 2 shocks per direction, Pulse duration : 18 ms.	1. System OFF during the test 2. Performance check after recovery
11	Water Immersion Test	6 meter water column depth (Pr - 58.7 kPa), Duration 2 hours	1. System OFF during the test 2. Performance check after recovery
12	Mould Growth Test	30 °C +/- 1 °C and RH > 90 %, Duration: 28 days (Test No.21).	1. System OFF during the test 2. Performance check after recovery
13	Salt Spray Test	35°C +/- 2°C, RH 90 - 95 %, Duration 3 days (Test No: 9, Procedure 2).	1. System OFF during the test 2. Performance check after recovery
14	Contamination Test	One or more of the following contaminating fluids to be sprayed - Paraffin, Petrol, Lubricating oil, Hydraulic fluids and Ester based lubricating oils. After spraying, maintain temperature 50°C for 48 hrs	1. System OFF during the test 2. Performance check after recovery

(*) Applicable for systems fitted in Engine Compartment. For systems fitted outside engine compartment, High temperature (operational) is 55°C and High temperature (Storage) is 85°C

Note: Tests 2 to 14 are to be conducted as per JSS 55555: 2012 rev3, L2J and L3 class

Environment Stress Screening (ESS)

Burn-in-test



Burn-in-test: Thermal cycle shall be as follows (MIL STD 2164):

- 12 number of cycles shall be done so that total duration at high temperature and at low temperature will be at least 1260 minutes each
- After completion of thermal cycling Random Vibration test to be carried out as follows:
 - Random Vibration on 3 perpendicular axes.
 - $10 (m/s^2)^2/Hz$ during 20 to 500 Hz falling to $1 (m/s^2)^2 /Hz$ at 2000 Hz for 2 hours in each axis.

7 QUALITY REQUIREMENTS

All Deliverables and Scope of Supply should be as the Technical Specification in this document. Before any components are manufactured or delivered by the Supplier, the Supplier drawings must be approved by Ricardo.

8 DELIVERY PERIOD

GEN-1: Fully functional 2 Nos. of Display Unit to be delivered within 6 months from the receipt of PO / as per BEML confirmation.

GEN-2: Fully functional 5 Nos. Display Unit to be supplied within confirmation from BEML (Tentatively February 2023).

9 DELIVERABLES

9.1 Parts

As specified in the **Physical Scope of Supply [5.2]** section, as per GEN-1 & GEN-2 **Delivery Period [8]**.

9.2 Drawings

As specified in the **Scope of Supply – Documentation [5.4]** section.

[3D native models in PTC Creo].

9.3 Reports

As specified in the **Scope of Supply – Documentation [5.4]** section.

10 OTHER GENERAL GUIDELINES

The firm should submit a detailed technical proposal comprising the following additional points wherever applicable:

- a) Development approach for the activities mentioned in scope of work
- b) Willingness letter for supplying of parts for proto (07 No's) Batch and serial production for minimum of 30 years
- c) Any other relevant information considered necessary for successful implementation of the proposed scope of work

11 COMMERCIAL OFFER, TERMS & CONDITIONS

Prices shall be fixed for period of Project completion and shall have following break up components as per deliverables:

1. Unit price – Display Unit (Part No. 550 819 0019).
2. Development cost if applicable.
3. Others such as Applicable taxes, P&F, Currency etc.
4. Bank guarantee to be submitted for advance payment if any, as per the BEML norms.
5. Performance Bank Guarantee to be submitted as per BEML norms.
6. Warranty for 24 months from the date of supply.
7. LD applicable @ 0.5% /week for delayed period and max up to 10%.