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सत्यमेव जयते

Government of India
Ministry of Railways
Research Designs& Standards Organization
L U C K N O W
E S T T : 1 9 5 7

एच.एच.पी लोको के लिए सहायक शक्ति इकाई

AUXILIARY POWER UNIT FOR HHP LOCOMOTIVES

Specification Number	MP.0.2400.64		
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Brief Description
This specification covers the design requirements of a system (Auxiliary Power Unit –APU) for shutting down the idle engine to reduce emissions, noise, wasteful burning of fuel, wear and tear & maintain all the critical parameters of the locomotive that will keep the locomotive in a state of readiness for operation at very short notice.

FOREWORD

Auxiliary Power Unit is an important fuel saving device for saving fuel when loco is idling. The specification details the development of Auxiliary Power Unit for HHP Diesel Electric Locomotives.

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LIST OF AMENDMENTS

S. No.	Amendment Date	Revision	Details
1.	Nov,2009	0	First Issue
2.	March,2010	1	First revision
3.	August 2015	2	Second revision to incorporate the standard interface between AC-AC traction System and APU
4.	April 2021	3	Clause 7.1 : Test Standard for Engine is updated as ISO 8528 and SAE J 1349 Clause 7.1 & 7.2: Acceptance Test is changed to Performance Test to avoid confusion with routine acceptance test. Clause No. 17.2: Reference of RDSO document no. MP-M-8.1-1 and performance feedback format given. New Clause No. 21: Vendor Changes in Approved Status incorporated. New Clause No. 22: Preference to Make in India Clause incorporated. Annexure-2: Incorporated as Detailed Test Plan.

CONTENTS

LIST OF REFERENCED DOCUMENTS

S. No.	Document name / number
1.	IEC 60571
2.	IEC 60812
3.	IEC 60529
4.	IEC 62262
5.	ISO 8528
6.	SAE J 1349
7.	ISO 1217
8.	IS 10431
9.	IS 2500
10.	EDPS 179
11.	IEC-60349-1 (Latest)
12.	MP. 0. 2400.43 (Latest) for AC - AC traction system for 4500HP HHP Diesel - Electric Locomotives
13.	RDSO Document no. MP-M-8.1-1.

LIST OF ANNEXURES

Annexure 1	Interface Control Document
Annexure 2	Detailed Test Plan

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0 Introduction

A diesel engine in idle condition consumes roughly 20 liters of diesel oil per hour. While idling, the main engine of diesel locomotive performs two functions

a. Running the compressor to maintain Main Reservoir pressure between 8 to10 kg/cm2

b. Charging the locomotive batteries.

However, at stand still with brakes applied, the requirement of air from compressor is less and it is required to compensate leakage. These two functions requires approx. 25hp power, however as the main diesel engine runs to cater this requirement, the energy consumed is very large.

To cater the requirement of low power including the cab AC load (1.75 ton, 6.7 HP), this specification details the Auxiliary Power Unit as an add on unit comprising of Small DG Engine, Alternator, Compressor and associated control units and thus facilitates shut down main engine automatically based on monitoring of the engine and electrical parameters while loco is idling at standstill condition.

The APU (Auxiliary Power Unit) is an important fuel saving device for loco while loco is idle and standstill.

1 Objectives

This specification covers the design requirements of a system (auxiliary power unit –APU) for shutting down the idle engine to reduce emissions, noise, wasteful burning of fuel, wear and tear & maintain all the critical parameters of the locomotive that will keep the locomotive in a state of readiness for operation at very short notice. The specification also details the test standards to ensure reliability of APU.

Following benefits are derived with APU:

- Reduced Consumption of fuel and other lubricants.
- Reduced wear and tear of Engine components due to unnecessary idling.
- Reduced NOX emissions and noise pollution with a potential to earn carbon credits.

2 Scope of supply

The deliverables to this specification for APU shall include the complete APU system comprising of :

i. Microcontroller based Control unit with associated relays, contactors, sensors, cables and other associated parts.
ii. Minimum CPCB-II compliant (for emission) low SFC Diesel Engine.
iii. Small capacity of Brushless 3Phase permanent magnet type Alternator or separately excited with rectifier unit to charge loco battery and cater electrical load of 1.75 ton cab AC.
iv. Compressor to charge Main Reservoir of Loco to compensate Main reservoir leakage.

Control cables shall comply to EDPS 179.

3 Terms and abbreviations

S. No	Term / Abbreviation	Description
1.	LCC	Locomotive Control Computer
2.	MBCS	Microprocessor Based Control System
3.	PU	Production Units
4.	RDSO	Research Designs & Standards Organisation
5.	ZR	Zonal Railways
6.	IEC	International Electro Technical Communication
7.	SAE	Standard of Automotive Engineers
8.	DIALS	Digital into Analog LCD based display

4 General requirements

4.1 Manufacturers qualification

The manufacturer of the equipment shall be a reputed organization dealing with manufacture / integration of electronic, electrical and embedded systems. The manufacturer is having experience in development of control system on Microprocessor system in Rolling stock or solution of industrial automation on embedded system for emergency power application using DG set. The manufacturer shall be capable of providing spares and support services during the operational life of the equipment from setups located within the international boundaries of the India.

4.2 Equipment Requirements

The equipment supplied against this specification shall meet the following general requirements:

4.2.1. The equipment shall be designed for installation on diesel electric locomotives. The equipment manufacturer shall get the equipment design approved by RDSO before fitment on locomotives.

4.2.2. The equipment supplied shall be of good quality, rugged and reliable and capable to withstand environmental and service conditions. The individual components shall meet the lifecycle requirements for that category of equipment as elaborated at clause no.11.

4.2.3. The APU system shall be accommodated in the envelope of 1700 mm x 900 mm x 925mm (Excluding chimney) (LxBxH). Envelope is intended to mean the space available within the existing radiator compartment. DLW OGA drawing no.18002894 may be referred for guidance. The OGA drawing shall be furnished by the firm for RDSO approval.

4.2.4. The weight of the APU system in complete shall not exceed 1000 kg.

4.2.5. Where ever outsourced equipment is used, care shall be taken to ensure that the equipment is sourced from reputed manufacturers. Firm shall produce the relevant test compliances of outsourced equipments on demand from RDSO or inspecting agency.

4.2.6. The supplier of equipment supplied under this specification shall ensure proper interfacing and connectivity between equipment / software.

4.2.7. Failure Mode Effects and Criticality Analysis of the equipment shall be done during the design process in conformance to IEC 60812. The records of this analysis shall be provided upon requirement.

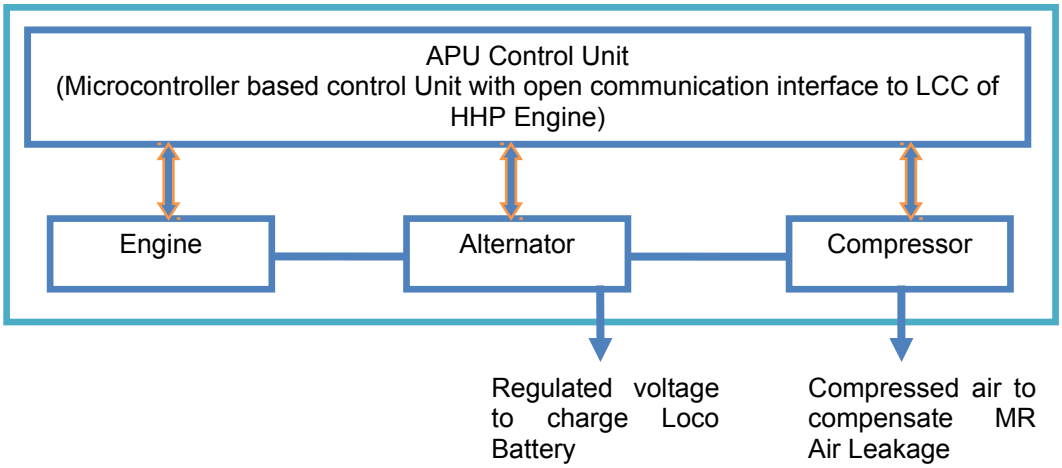
5 Environmental/Climatic requirements

The equipment shall be tested as per the environmental requirements of IEC 60571(Latest) for electronic and control equipment.

6 Functional requirements

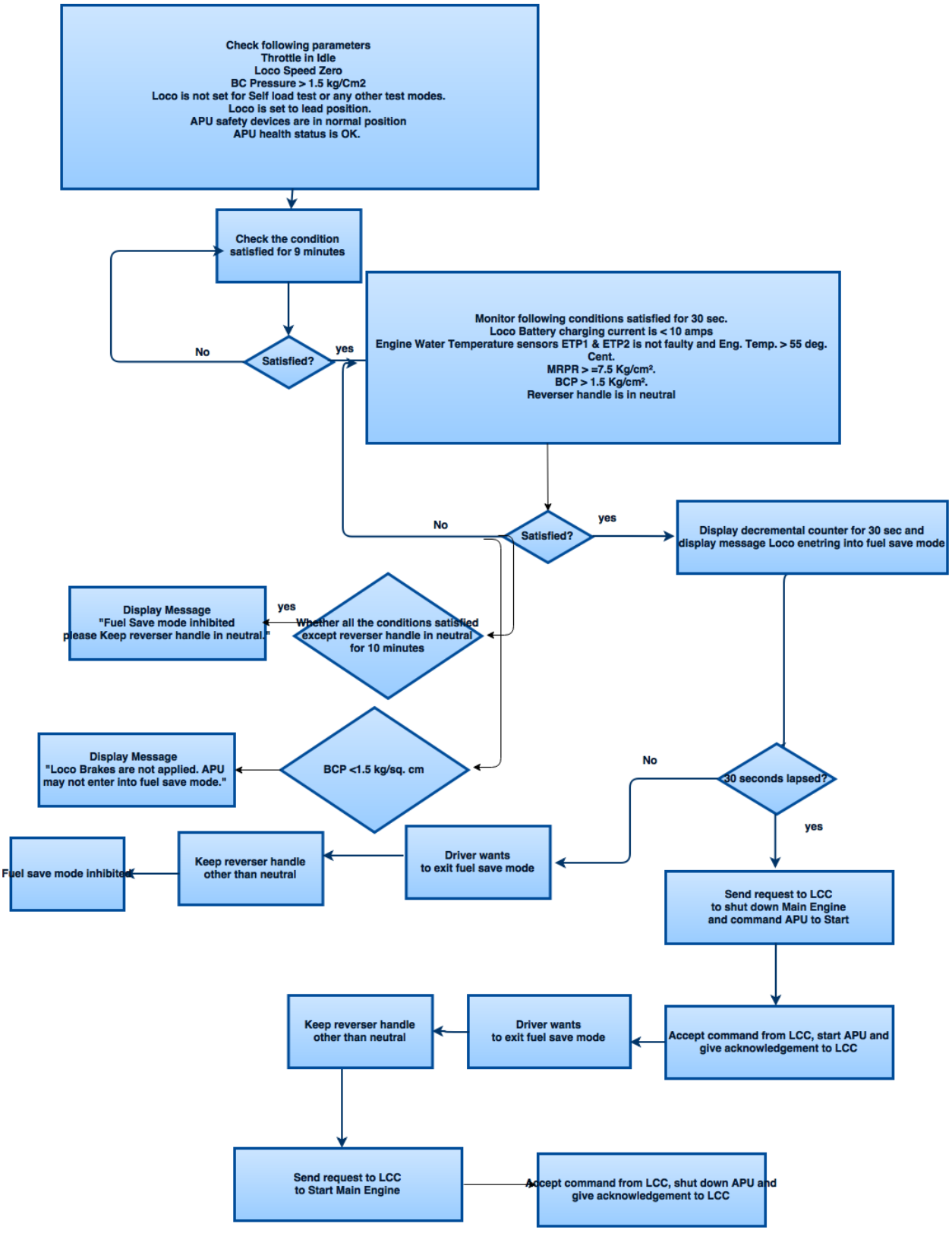
The APU must meet the following requirements for HHP diesel electric loco,

A small engine of low SFC coupled to a compressor and alternator will maintain the MR pressure and keep the batteries charged while the main locomotive engine remains shut down.
APU system will have the own microcontroller system which will monitor critical parameters of APU engine, alternator, compressor, and other associated equipments and will monitor the APU health status.



6.1 **Logic of fuel save mode in APU**

The APU System will have following logic to trigger main engine shut down with start APU and vice versa.



The parameters may be varied with the approval of RDSO based on field trials result.

6.2 Interface of APU with LCC

APU will have proper communication Interface with LCC. To facilitate interface with LCC, communication protocol is detailed at Annexure-1. The open interface will avoid duplicity of sensors already used in LCC. The responsibility of ensuring the interfacing with LCC will lie on APU manufacturer and that shall be verified by APU manufacturer during system integration with LCC through Protocol Analyzer as a

validation test during prototype test. The detailed interface control document between APU and LCC shall be furnished by APU manufacturer to RDSO.

6.3 Interface of APU with REMMLOT system:

To facilitate online data monitoring of APU and fuel savings, provision of interfacing with REMMLOT system of locomotive through LCC is required. REMMLOT in the Diesel Electric Loco is provided as per RDSO Specification no.MP.0.0402.04 (Latest)

6.3.1 GPRS facility with APU System (Optional feature)

Apart from the above, the APU system will also have GPRS facility to view the APU performance and fuel savings online using web application. The hosting of server and development of web application and maintenance thereof will be under the scope of APU manufacturer. The format of reports to be retrieved through web application should be approved by RDSO. The facility of GPRS should be enabled by the APU manufacturer whenever desired by Railway.

Note: Hosting of server and support of application software beyond warranty period may be extended on mutually agreed cost with Railways if Railways desires to extend the GPRS facility.

6.4 Feature of isolating APU

APU Circuit Breaker to enable/disable the APU should be provided on the CB Panel. Whenever the APU is disabled, a suitable Crew Message and audio-visual alarm should be given to the driver through LCC and log a fault. The APU must have self-diagnostic feature.

6.5 Feature of Data Logging:

The APU will have in built data logging facility to log the Fuel saving data and fault data in the prescribed format. Firm will have to submit the required reporting format of fuel data for approval by RDSO to incorporate during design approval.

Data logging should contain the fault log including communication failure with LCC with time stamp. 90 sec. fault data pack of APU should be stored in memory of APU containing all APU parameters and LCC Parameters obtained from LCC.

The data in the APU should be logged at an interval of one minute and should store the status of all the inputs to the APU system. A suitable graphical user interface (PC Based software with print facility) shall be provided for the analysis of the logged data. It should be possible to download the recorded data from the memory of APU Computer by using any commercially available USB pen drive. On-board data storage device of adequate capacity to record data for storing all data for at least 45 days and the data for engine idle time and fuel saving report for at least 90 days.
The APU health status, enable/disable status, APU related crew messages should be displayed on LCC/DIALS of AC-AC Traction Control system.

Note: Minimum 32 MB non-volatile flash memory as on board user memory for data logging and minimum 1 No. USB port (Preferred 2 Nos.) complied to USB 2.0 specification and OTG compatible are required in control unit.

Alternately, the data logging functionality can be accepted with AC-AC Traction control system provided that APU manufacturer and AC-AC Traction Control system manufacturer both jointly agreed and implemented in LCC/DIALS of AC-AC Traction Control system.

6.6 Emergency Shut down

APU can be shut down on emergency by isolating APU from CB panel. Shut down button should be provided on APU also to interrupt the APU and shut down APU in case of emergency.

6.7 Fail-safe Feature

The APU shall be provided with fail-safe feature so as to cause shut-down of the APU diesel engine in the event of malfunctioning of the APU.
As an add-on feature APU will in no case control the functionality of LCC. It will work as slave only and get isolated with APU shut down as fail safe measure. Driver will be prompted through LCC by displaying crew message of APU faulty.

7 Sub assembly of APU

The APU shall comprise following major sub assembly:-

7.1 Engine:

The engine should be sourced from a proven manufacturer. Prior approval of RDSO should be taken for use of any make or design of engine. The engine should be water cooled/air cooled with natural aspiration. The engine should also confirm to the central pollution control Board norms notification GSR no.448 (E) F NO.Q-15022/2/2001-CPA/24-2-09 issued by Ministry of Environment and Forest. The engine should have low SFC (170 grams/BHP hour±5%) at full load at rated speed. The engine should be capable of starting with power sourced either from the locomotive battery or separate low maintenance battery of adequate capacity. Suitable DC-DC Converter may be used to reduce the Loco battery voltage, if required. The engine should be maintenance friendly and should not require frequent schedule attention. Any attention to this APU engine shall have to necessarily coincide with the locomotive maintenance schedule.
APU manufacturer shall submit the test compliance of national/International standard, technical details, must change spare items details, maintenance schedule, lubricant details and frequency of lubricant change while seeking approval for use of the engine.
The performance test of engine will be as per ISO 8528 or SAE J1349.

7.2 Compressor

The compressor shall be directly coupled to the APU engine and shall therefore be able to deliver the required air flow at the rpm of the engine itself. The compressor shall be designed for operation at a discharge pressure of 10.2 Kg./Cm². The compressor shall preferably be air cooled and oil lubricated. In case of oil cooled rotary compressor the maintainability should be at par with air cooled compressor. Prior approval of RDSO shall have to be obtained for use of any make/design of the compressor. The compressor shall not consume more than 15 HP at maximum engine rpm in loading condition and delivers at least 1000 lpm FAD on 100% duty cycle. The compressor out let should be connected to MR tank through non-return valve.
Loading / unloading - The compressor should be loaded at 8.00 ±0.1 kg/cm² (approximately 120 PSI) and get unloaded at 10.0 ± 0.1 kg/cm² (approximately 140 PSI)
The compressor shall be sourced from reputed manufacturer. APU manufacturer will submit the test compliance of national/International standard, technical details, must change spare items details, maintenance schedule, lubricant details and frequency of lubricant change while seeking approval for use of the compressor.
The performance test will be as per ISO 1217. The capacity test of FAD (Free air delivery) will be carried out as per IS 10431.

7.3 Alternator:

This shall be a 3-phase brush less AC permanent magnet or separately excited alternator with IP55 enclosure. An automatic voltage regulator shall convert the generated AC voltage to DC voltage and regulate the output voltage to 72 V with alternator running at the same RPM as the APU engine**. The rating of the alternator shall be suitable capacity to cater Cab AC load (1.75 Ton of Refrigeration Capacity) also along with battery charging.** The output of the alternator shall be constantly monitored by the Microprocessor. In case the desired output voltage is not obtained at full rpm, a fault message shall be logged and crew message request given to the LCC for display.
Test compliance and standard shall be as per IEC-60349-1 (Latest).

7.4 Control Unit

The system should be an independent 32 bit Micro controller to control the APU Engine, Alternator and Compressor through associated control equipments such as Relays, Contactors and Sensors housed in the APU Control unit. The system offered must have its own data storage capability and for this purpose a suitable memory shall be provided. All the existing sensors being used by LCC should be used by APU

Control unit through communication interface from LCC. In case any additional sensor is imperative, RDSO approval shall be required for the same.
The system should Interface with different type of Loco Control Computer with suitable communication like Profi bus, MVB, Ethernet, OFC CAN communication. The system should be compatible with all layers of these serial communications as such it can be interfaced with any make of LCC having either of these protocols. Validation test and field trials of APU integrated with LCC on either of the above communication protocol is essential. However, the firm shall give undertaking that the APU is compatible with any of the communication protocol detailed at Annexure-1.Detailed complete Interface control document with connector type and pin configuration between APU and LCC shall be submitted to RDSO before integration of prototype APU with LCC.
In case of fault in APU, suitable message should be communicated to LCC and shut down APU instantly and send request to LCC to start main engine.
In case of communication failure or APU fault, APU should isolate itself and suitable message should be displayed through LCC as the case may be.

7.4.1 Real-time clock

The system shall have a real-time clock with accuracy of better than +/- 5 seconds over 30 days. The RTC shall be capable of time synchronization through laptop/ Display. The battery of RTC Clock should work for minimum 3 years and should be replaceable easily. Time synchronization through Laptop/Display based on Password protection should be provided.

7.4.2 Software:

Necessary software for adjusting the user settable parameters and analyzing the data of the APU shall be provided.

8 Numbering

Each Control unit, APU sub assembly shall contain a number plate indicating

a. Serial number
b. Date of manufacturing
c. Name of manufacturer
d. Model number.

The major sub-assemblies in each unit should also be numbered and recorded with the supplier for future reference.

9 Applicable drawings

10 Referred standards

The following standards are referred by this specification. Operational understanding of all the referred standards should be ensured.

- IEC 60571
- IEC 60812
- IEC 60529
- IEC 62262
- IEC 60349
- IS 2500
- EDPS 179

11 Life cycle management

The equipment supplier shall ensure that the lifecycle requirements of the equipment be met as detailed in the paragraphs below.

11.1 Expected life

The expected life of the equipment shall be 12 years or more.

11.2 Support during lifetime

The equipment manufacturer shall ensure that the following support is available on demand during the equipment lifetime:

- Service / spares support for the equipment
- Options for comprehensive maintenance contracts
- Modifications in equipment design to meet new requirements or to improve reliability

The options for demanding these support services shall be reserved by the Indian Railways and the equipment manufacturer shall provide the same on demand.

The equipment manufacturer shall submit an undertaking to support the equipment during its declared lifetime. This undertaking shall be provided during type testing and design approval and also while entering into purchase contracts.

Note: Cost of the services shall be determined through a mutually acceptable process between the manufacturer and the users on the Indian Railways.

11.3 End of equipment life management

The equipment manufacturer shall provide options to upgrade / refurbish equipment at the end of life of the equipment when requested by the Indian Railways.

The equipment manufacturer shall submit an undertaking to provide options for end of life management when required by Indian Railways. This undertaking shall be provided during type testing and design approval and also while entering into purchase contracts.

12 Documents required from manufacturer

The manufacturer shall supply the following documents with the equipment. All documents shall be provided in both hard copies and soft copies (PDF)

a. Product catalogue and standard data sheet of APU system
b. Outline and general arrangement drawings
c. Schematic circuit, functional description and protection scheme
d. The software logic of APU function in flow diagram.
e. Schedule of supply, listing all equipment with part numbers
f. Operating instruction and trouble shooting hand book
g. Maintenance manual with full description of maintenance and repair procedures
h. Maintenance schedules required along with list of components which are required to be replaced in those schedules
i. List of maintenance spares required for normal maintenance and emergency repairs
j. A copy of detailed bill of materials including relays, contactors, sensors, test compliance, make, model nos., qty used and location with supporting drawings.
k. List of in house and outsourced items of APU System.
l. Recommended list of spares with cost for 3 years maintenance after warranty
m. Test protocol with procedure of testing
n. Details of technical support and training offered
o. Detailed calibration procedure
p. Foot print and weight schedule of APU system.

13 Warranty

The manufacturer shall provide warranty as per IRS terms and conditions. Consumables should be provided by shed for APU maintenance during warranty period.

14 Training

The supplier shall train adequate number of IR personnel in operation and maintenance of the offered APU. Adequate documentation shall be provided. Personnel of Indian Railways shall be nominated to attend.
The equipment manufacturers shall arrange training for operations and maintenance of the equipment, as an integral part of the equipment supply.

15 Tests& Verification

The equipment shall be tested for functional capability, ability to withstand environmental conditions and for reliable performance under field conditions.

16 Sampling plan

Sampling shall be done as per IS 2500 wherever not specified but required. Sampling shall be done as per the requirements wherever specified in this document. If the specific contract includes specific clause for sampling, the same shall be applicable.

17 Types of tests

The equipment shall be subjected to the following types of test during different stages of design approval. Prove out, field trials and testing of the offered APU - Testing including prove out & validation shall be in accordance with the referred standard

SN	Category of Test	Remarks
1.	Type tests and Validation test (Prototype)	These tests shall be done on a sampled lot of prototypes as per following standards. a. IEC 60571 – For APU Control system b. IEC 60349-1 -For Alternator c. ISO 1217 and IS 10431 – For Compressor d. ISO 8528 or SAE J1349 & Clause no. 7.1 of Specification- For APU Engine Such tests are required only on initial approval, change of design and change of manufacturing processes. Prototype test and validation test protocol will be submitted by the firm for approval by RDSO before conducting prototype test. The detailed Test Plan is indicated as Annexure-2. These tests shall be done as pre-requisite for design approval.
2.	Field trials	These trials shall be conducted for establishing equipment reliability under field conditions. A minimum sample size shall be installed to work under field conditions and performance monitored for a specified time. These shall be conducted after type tests.
3.	Routine tests	Tests are required to verify the functional working of the system. These may require simulated inputs for testing the operations under full range of inputs. These tests shall be done by the manufacturer during manufacturing and records maintained for inspection.
4.	Acceptance tests	These tests shall be done on all or sample of lot for bulk supply. Sampling shall be done as per IS2500. These tests shall normally consist of routine tests and additionally those specified in the specific contract. Acceptance test protocol will be submitted by the firm for approval by RDSO.

17.1 **Type test and field trials:**

The prototypes of the equipment shall be subjected to type tests and field trials prior to approval.
Prove-out and validation - One APU shall be subjected to durability and performance test on suppliers test bed as per the referred standards in presence of IR personnel. APU manufacturer shall have in-house facility of test bed with simulator and protocol analyzer for testing and integration of APU apart

from regular testing and measuring equipments. After successful type test validation test will be conducted at Loco before clearing prototype for field trial.
Validation tests like wiring integrity and installation checks, Hi-pot, insulation resistance and self tests, complete performance establishment, load box examination, etc. shall be carried out on the load box at any nominated place mentioned by IR to establish the performance capability and integration of the microprocessor system with locomotive systems.

Note: ***Availability of Test bed with simulator for integration and verification of functionality is must as in house infrastructure requirement. RDSO shall be apprised and approval taken for testing of the equipment at any specific testing agency prior to the tests.***

17.2 Field trial

The specified Quantities shall be subjected to field trials for specified period before clearance is given for bulk supply. The Quantity and period of Field trials shall be governed by RDSO Document no. MP-M-8.1-1. During this period, the performance of the equipment shall be closely monitored and evaluated by RDSO. These trials are intended to prove

- Reliability under rigorous environmental and operating conditions
- Advantages for locomotive operation and maintenance
- Maintainability of the equipment.

Performance will be obtained from field as per following format.

	S. N.	Loco No./Type	APU make	Date of commissioning of APU	Date of failure (if failed)	Date of rectification (if failed)	Feedback/Remark incl. comments on issues related to APU and its associated subassemblies if any.
1.							
2.							
3.							

If modifications found necessary as a result of the tests, the supplier at his own cost shall carry out trials after the relevant modifications as approved by RDSO.

17.3 Makers test certificate for outsourced item

All items that are outsourced by the equipment manufacturer shall be indicated so. The type and extent of quality control that has been exercised shall be provided with proper documentation.
The manufacturers (of the outsourced sub-assembly) test certificates shall be provided.

18 Painting, labeling and marking

The equipment shall be appropriately painted for operational use, aesthetics and protection. The parts, connector ports, mounting points etc. shall be clearly marked in a manner that these are easily readable and remain legible over the lifetime of the equipment.

The offered APU and all major components and parts shall have proper identification and traceability to facilitate failure analysis and life cycle data.

ID plate Name of Component, Make, Sl. No, Date of Manufacture, Ratings shall be provided on all assemblies/subassemblies.

19 Packaging and delivery/shipment

The equipment consists of sensitive and fragile electronic systems. These should be packed with precautions required to prevent damage in transit.

All requirements of IRS conditions for packaging and delivery shall be applicable.

20 IPR disclaimer pin pointing responsibility on supplier for violation if any

20.1 Undertaking by equipment manufacturer

All the specifications issued by RDSO shall include a requirement of undertaking to be signed by Vendors on “INFRINGEMENT OF PATENT RIGHTS”. The undertaking can 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 disputes/matters lies with the manufacturer/ supplier.
>
> Details / design/documents given by them are not infringing any IPR and they are 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.

20.2 Declaration of confidentiality of submitted documents by manufacturers

While submitting a new proposal/design, manufacturer must classify their documents confidentiality declaration, such as

> This document and its contents are the property of M/s XYZ (Name of the vendor) or its subsidiaries. This document contains confidential proprietary information. The reproduction, distribution, utilization or the communication of this document or any part thereof, without express authorization is strictly prohibited. Offenders will be held liable for the payment of damages. Indian Railways/RDSO is granted right to use, copy and distribute this document for the use of inspection, operation, maintenance and repair etc.

21 Vendor changes in approved status

All the provisions contained in RDSO’s ISO proceeding laid down in document no. QO-D-8.1-11 dated 01.07.2020 or latest (titled: “Vendor changes in approved status”) and subsequent version/amendment thereof, shall be binding and applicable on the successful vendor/ vendors in the contract floated by Railway to maintain quality of products supplied to Railways.

22 Preference to Make in India

The Government of India policy on “Make in India” shall apply.

ANNEXURE 1

INTERFACE CONTROL DOCUMENT

23 Introduction

23.1 Purpose

- The purpose of this document is to detail the universal communication interface between the APU and LCC systems which shall be communicated by using Ethernet or MVB or Profibus or SAE J1708 or CAN.
- This document is intended to define the loco and APU related parameters that are to be communicated for the healthy operation of the APU system.
- This document also mentions various hardware interfaces required for the operation of the APU system.

23.2 Scope

- This document shall be used by vendors of the LCC system to interface with APU system.
- This document shall define the hardware interface in view of I/O channels and communication standards.
- This document specifies outline of all the communication parameters to be exchanged between either systems in the communication data packets. The detailed and complete Interface control document shall be furnished by APU manufacturer on integration of APU with LCC.
- This document only specifies the statistical and electrical parameters, but does not go in detail to the logical operations performed on these parameters.

23.3 References

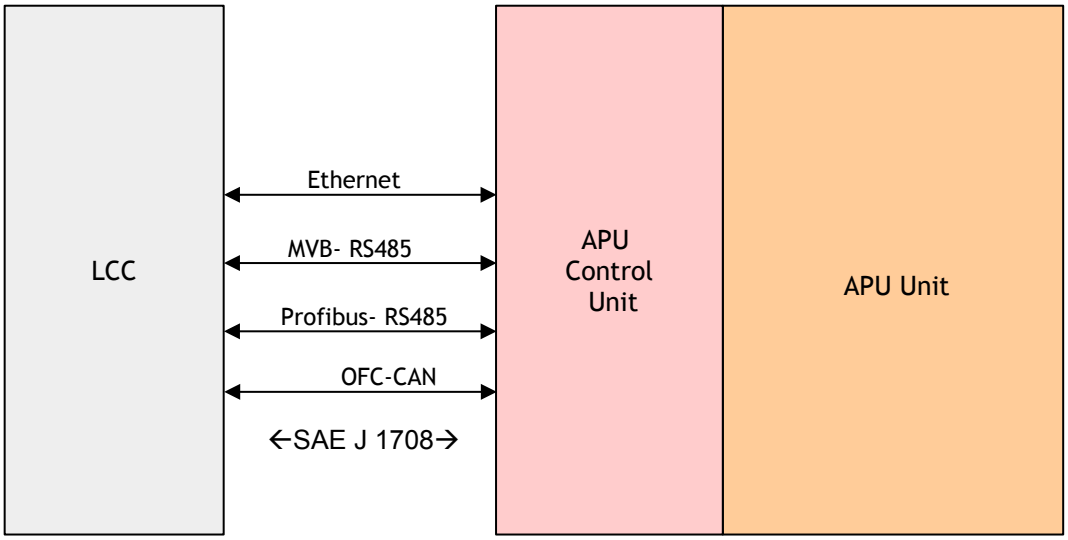
- Ethernet:
    - Internet Request For Comments (RFC) Documents
        - RFC 793 : Transmission Control Protocol
        - RFC 791 : Internet Protocol
    - Institute of Electrical and Electronics Engineers (IEEE)
        - IEEE 802.3
- MVB:
    - International Electro-technical Commission
        - IEC-61375.
- Profibus :
    - International Electro-technical Commission
        - IEC 61158
- SAE J 1708 :
    - Society of Automotive Engineers International
- CAN :
    - Controlled Area Network

23.4 Definitions And Acronyms

APU	Auxiliary Power Unit
MVB	Multifunction vehicle Bus
MR	Main Reservoir
LCC	Loco Control Computer
RDSO	Research Designs and Standards Organization of Indian Railways
TM	Traction Motor
TCP	Transmission Control Protocol
IP	Internet Protocol
NA	Not Applicable
PB	Profibus
OFC	Optical Fiber Cable
CAN	Controller Area Network
FPR	Fuel Pump Relay
SAE	Society of Automotive Engineers

24 INTERFACE REQUIREMENTS

Interface Overview
Communication interfaces



25 Description:

- The APU interface and the LCC shall be connected by any one of the communication interface as mentioned in sec-3 according to the compatibility of the LCC system.
- The LCC shall be the main interface in any of the communication interface for initiating the transfers as per their respective protocol.

- In MVB, the LCC shall be the master.
- In Ethernet, the LCC shall be the server.
- In Profibus, the LCC shall be the master.
- In SAE J 1708, the LCC shall be the master.

- The baud rate for transfers and the periodic communication timings for each of the communication interfaces are to be agreed upon by the two interfacing systems.
- The length and the sizes of the transmit and receive buffers for each of the communication interface are described separately under their protocols.
- The rest of this document describes the protocol for the communication and their frame formats.

26 Communication Protocol

26.1 **MVB:**

Description

- There shall be periodic communication between LCC-MVB device (treated as master) and APU-MVB device (Slave).
- For each periodic interval of 128 msec, the master sends the loco parameters in two different packets.

Data Packet

- The following packet and communication format is proposed:
- For a periodic interval of 128msec, the master sends two consecutive data packets to the specified device address in the following format :-

Master Packet 1:

Packet No (1 Byte)	Data Length (1 Byte)	Loco/Health Parameters Data (30 Bytes)

Master Packet 2:

Packet No (1 Byte)	Data Length (1 Byte)	Loco/Health Parameters Data + Spare Bytes (30 Bytes)

- For every period of 128msec, the slave responds to the master with the packet format given below.

Slave Packet 1:

Data Length (1 Byte)	Command Data (6 Bytes)	Spare Bytes (25 Bytes)

26.2 **Ethernet:**

Description

- There shall be periodic communication between LCC (Server) and APU communication interface device (Client).
- Client shall request server for Loco parameters data then server shall send Loco parameters data in reply.
- Client sends command data to server.

- This is cyclic communication for every 128ms.

Data Packet

- The following packet and communication format is proposed:

Data type (1 Byte)	Server/Client Data Length (1 Byte)	Server/Client Data (64 Bytes)

- Data type defines the type of message being sent/received from server/client:

0x11	Loco/Health Parameters Request
0x12	Loco/Health Parameters data
0x22	Command Data

- Server shall send Loco data in the below format:

Server Data Packet:

0x12	Data Length (1 Byte)	Loco/Health Parameters Data (64 Bytes)

- Client shall send command data/Request in the below format:

Client Data Packet :

0x22/0x11	Data Length (1 Byte)	Command Data/Request (6 Bytes)	Spare Bytes (25 Bytes)

26.3 Profibus

Description

- There shall be periodic communication between LCC-PB device (treated as master) and APU-PB device (Slave). For each periodic interval of 128msec, the master sends the loco parameters in two different packets.

Data Packet

- The following packet and communication format is proposed:
- For a periodic interval of 128msec, the master sends data packet to the specified device address in the following standard profibus data exchange format :-

Master Data Exchange Packet

SD (1Byte-68H)	LE (1Byte)	LEr (1Byte)	SD (1Byte-68H)	DA (1Byte-8xH)	SA (1Byte-8xH)	FC (1Byte)	Loco/Health Parameters Data + Spare Bytes (64 Bytes)	FCS (1Byte)	ED (1Byte-16H)

SD – Start Delimiter
LE – Length
LEr – Redundant Length
DA – Destination Address
SA – Source Address
FC – Function Code

FCS – Frame Check sum
ED – End Delimiter

H– (HexaDecimal)

- For every period of 128msec, slave responds to the master with the exchange packet format given below :-

Slave Data Exchange Packet

SD (1Byte-68H)	LE (1Byte)	LEr (1Byte)	SD (1Byte-68H)	DA (1Byte-8xH)	SA (1Byte-8xH)	FC (1Byte)	Command Data + Spare Bytes (32 Bytes)	FCS (1Byte)	ED (1Byte-16H)

26.4 **SAE J 1708**

Description

- There shall be periodic communication between LCC-SAE J 1708 device (treated as master) and APU-SAE J 1708 (Slave). For each periodic interval of 200msec, the master sends the loco parameters in Packet.

Data Packet

- The following packet will be send by Master:
- For a periodic interval of 200msec, the master sends data packet to the specified device address in the following standard SAE J 1708 :-

Master Data Exchange Packet

MID (1Byte-90H)	DB1 (1Byte)	DB2 (1Byte)	DB3 (1Byte)	DB4 (1Byte)	DB5 (1Byte)	DB6 (1Byte)	DB7 to DB19 Parameters Data + Spare Bytes (10 Bytes)	Life sign (1Byte)	CS (1Byte-)

MID – Machine Identified
Life sign – Incremental counter

CS – Check Sum

After receiving the data packet from master slave will send its packet after 40 ms.

- For every period of 200msec, slave responds to the master with the exchange packet format given below :-

Slave Exchange Packet

MID (1Byte-91H)	DB1 (1Byte)	DB2 (1Byte)	DB3 (1Byte)	DB4 (1Byte)	DB5 (1Byte)	DB6 (1Byte)	DB7 to DB19 Parameters Data + Spare Bytes (10 Bytes)	Life sign (1Byte)	CS (1Byte-)

MID – Machine Identified

Life sign – Incremental counter

CS – Check Sum

27 Communication Bus-Specific Parameters

27.1 **MVB:**

- The Communication Bus-specific parameters are to be frozen based on the feasibility of both the interfacing systems. The following are the proposed parameters :

S.NO.	PARAMETER	LCC SYSTEM (MASTER)	APU SYSTEM (SLAVE)
1	Logical address of master	To be specified from Master Device. Number of Logical addresses to be specified are equal to number of master packets to be communicated.	NA
2	Logical Address of Slave	NA	To be specified from Master Device
3	Periodicity of Data Packet from Master	128msec	NA
4	Periodicity of Data Packet from Slave	NA	128msec
5	Slave Device Address	Inputs of Available Slave address range	To be configured between 1 to 256
6	Required Data Bytes from the device (including spare bytes)	64Bytes	32Bytes
7	Number of Data Packets from the device (assuming a packet of 16words)	2	1

- Along with these, subscribing the interface device to publisher in either of the devices are to be specified. Data transfer from APU-MVB device is communicated through 'Process Data' packets.

27.2 **Ethernet:**

- The Communication - specific parameters are to be frozen based on the feasibility of both the interfacing systems. The following are the proposed parameters :

S.NO.	PARAMETER	LCC SYSTEM (SERVER)	APU SYSTEM (CLIENT)
1	IP address of Server	To be specified from LCC	NA
2	IP address of Client	NA	(Configurable in the range) 192.168.XX.XX
3	Server Port Number	To be specified from LCC	NA
4	Client Port Number	NA	1024
5	Periodicity of Data Packet from Server	128msec	NA

6	Periodicity of Data Packet from Client	NA	128msec
7	Required Data Bytes from the device (including spare bytes)	64Bytes	32Bytes
8	Number of Data Packets from the device	1	1

27.3 **Profibus**

- The following are the timings on each state :
- Entry in to data exchange state :
- The following table describes various communication protocol specific parameters to be followed:

S.NO.	PARAMETER	LCC SYSTEM (MASTER)	APU SYSTEM (SLAVE)
1	DSAP(Destination Service Access Point) – COM port of slave device	To be defined	To be defined
2	SSAP(Source Service Access Point) – COM port of master device	To be defined	To be defined
3	Device Address of Slave	NA	To be specified from Master Device
4	Periodicity of Data Packet from Master	128msec	NA
5	Periodicity of Data Packet from Slave	NA	128msec
6	Required Data Bytes from the device (including spare bytes)	64Bytes	32Bytes
7	Number of Data Packets from the device	1	1

27.4 **SAE J 1708:**

- The Communication Bus-specific parameters are to be frozen based on the feasibility of both the interfacing systems. The following are the proposed parameters :

S.NO.	PARAMETER	LCC SYSTEM (MASTER)	APU SYSTEM (SLAVE)
1	Logical address of master	90 H.	none
2	Logical Address of Slave	NA	To be specified from Master Device
3	Periodicity of Data Packet from Master	200 msec	NA
4	Periodicity of Data Packet from Slave	NA	200 msec
5	Slave Device Address	Inputs of Available Slave address range	To be configured between 1 to 256
6	Required Data Bytes from the device (including spare bytes)	18 Bytes	18 Bytes
7	Number of Data Packets from	2	1

	the device (assuming a packet of 16words)		

27.5 CAN protocol:

CAN Extended identifier (29 bit) format is used.

- The 29 bit CAN identifier is divided as

Spares	APU Address	Dir Bit	Message Type	Frame Number
28 to 18	17---15	14	13--7	6---0

27.6 Frame Number:

- ➢ 0 to 6 bits are allocated for frame numbers.
- ➢ Maximum of 128 frames can be transmitted.

- **Message Type:**
  - ➢ 7 to 13 bits are allocated for message type.
  - ▪ 1 – Loco Parameters
  - ▪ 2 – Command data
- **Direction bit :**
  - ➢ 0 master to slave LCC to APU.
  - ➢ 1 Slave to master APU to LCC.
- **APU Address :**
  - ➢ 15 to 17 bits are allocated for APU address.
  - ▪ 3 – APU Address

Note: The following protocol will describe several different types of frames and data formats. Their control By default, All other fields as per definition here in 3.1.

27.7 Loco Parameters from LCC to APU:

The following are the loco parameters to be communicated to APU system from LCC for every periodic interval as per the packet format which shall be defined as per mutual understanding of two interfacing systems

S. No	CAN Frame number	Parameter	No. Of bytes
1	Frame_zero	Engine RPM	2
2	Frame_zero	MR Pressure	2
3	Frame_zero	Battery Current	2
4	Frame_zero	Battery voltage	2
5	Frame_one	Engine temperature	2
6	Frame_one	Locomotive speed	2
7	Frame_one	Brake Cylinder Pressure (To Know the brake Application status)	2

8	Frame_one	Ambient Temperature(To switch over to main engine under cold conditions)	2
9	Frame_two	1. Throttle 1 to 8 digital input status 2. Throttle IDLE digital I/p status 3. Forward digital I/p status 4. Reverse digital I/p status 5. AV digital o/p status 6. BV digital o/p status 7. CV digital o/p status 8. DV digital o/p status 9. START digital I/p status	2
10	Frame_two	Spares	2
11	Frame_two	Spares	2
12	Frame_two	Spares	2
13	Frame_three	Spares	8
14	Frame_four	Spares	8

27.7.1.1 Command Data from APU to LCC:

The following commands would be communicated to LCC from APU for every periodic interval to control the locomotive based on APU system operation. Each of these fields are communicated as per the packet format which shall be defined as per mutual understanding of two interfacing systems.

27.7.1.2 APU Command Data (24 bytes): These are transmitted in the data field from APU.

Bits (191-6)	Bit6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Spare	APU working status	Engine shut down cmd	Engine cranking cmd	Lubrication ON cmd	Compressor ON cmd	Compressor OFF cmd	Fuel pump on cmd

1. Fuel pump on command (whenever Fuel need for APU tank, fuel pump needs to be enabled)
2. Compressor OFF command (To keep compressor unload during APU and Main engine cranking)
3. Compressor ON command (To load APU compressor through MVCC when main engine is off)
4. Lubrication ON command (To ensure lubrication before cranking main engine)
5. Engine cranking command
6. Engine shut down command.

S. No	CAN Frame number	Parameter	No. Of bytes
1	Frame_zero	Engine shut down cmd Engine cranking cmd Lubrication ON cmd Compressor ON cmd Compressor OFF cmd Fuel pump on cmd spares- 2bits	1
2	Frame_zero	spares	7

3	Frame_one	spares	8
4	Frame_two	spares	8

28 Data Formats:

28.1 Loco Parameters from LCC to APU:

- The following are the loco parameters to be communicated to APU system from LCC for every periodic interval as per the packet format which shall be defined as per mutual understanding of two interfacing systems.

1. Engine RPM
2. MR Pressure
3. Battery Current
4. Battery voltage
5. Engine temperature
6. Throttle 1 to 8 digital input status
7. Throttle IDLE digital I/p status
8. Forward digital I/p status
9. Reverse digital I/p status
10. AV digital o/p status
11. BV digital o/p status
12. CV digital o/p status
13. DV digital o/p status
14. START digital I/p status
15. Locomotive speed

28.2 Command Data from APU to LCC:

- The following commands would be communicated to LCC from APU for every periodic interval to control the locomotive based on APU system operation. Each of these fields are communicated as per the packet format which shall be defined as per mutual understanding of two interfacing systems.

1. Fuel pump on command (whenever Fuel need for APU tank, fuel pump needs to be enabled)
2. Compressor OFF command (To keep compressor unload during APU and Main engine cranking)
3. Compressor ON command (To load APU compressor through MVCC when main engine is off)
4. Lubrication ON command (To ensure lubrication before cranking main engine)
5. Engine cranking command
6. Engine shut down command
7. Message to display to LCC such as “Loco is entering in fuel save mode”, “APU faulty”, “Fuel save mode inhibited due to Reverser handle in Neutral position”, “Loco Brakes are not applied. APU may not enter into fuel save mode”.

29 Cable connectors standard and connector details

Cable connectors shall be MIL Standard Compliant and standard connectors suitable for digital communication interface shall be used. Pin configuration, make and model no. of the connector shall be furnished to RDSO.

ANNEXURE 2

A. Type test plan for Alternator

S. no.	Test name	Standard for Type test	Standard for Routine test	Test Location
01	Physical Verification	IEC 60349-1-Clause 6	IEC 60349-1-Clause 6	At firm's premises/ NABL labs
02	Temperature Rise Test	IEC 60349-1-8.1	—	At firm's premises/ NABL labs
03	Soundness Test	----	IEC 60349-1-9.1	At firm's premises/ NABL labs
04	Characteristics test	IEC 60349-1-8.2	IEC 60349-1-9.2	At firm's premises/ NABL labs
05	Transient test	IEC 60349-1-8.4		At firm's premises/ NABL labs
06	Over speed test	IEC 60349-1-8.7	IEC 60349-1-9.4	At firm's premises/ NABL labs
07	Dielectric Test	IEC 60349-1-9.5	IEC 60349-1-9.5	At firm's premises/ NABL labs
08	Vibration test	IEC 60034-14-8.1	IEC 60034-14-8.1	At firm's premises/ NABL labs
09	IP 55 Protection	IEC 60529 Clause 13.4,13.5 and 14.25	----	At firm's premises/ NABL labs

1. Physical Verification:

- ✓ Physical verification carried on equipment to ensure the unit is in good condition.
- ✓ The Physical dimensions are to be measured and recorded as per the RDSO approved drawing.
- ✓ Check Alternator serial number, name plate on unit, marking on terminal, any physical damages on equipment and lifting hook.

2. Temperature Rise test as per clause 8.1 of IEC 60349-1:

- ✓ Temperature Rise test is conducted by applying rated load to Alternator could to APU engine.

Acceptance Criteria: Max. Temp. Rise shall not increase more than accepted limits.

3. Soundness Test as per clause 9.1 of IEC 60349-1:

- ✓ Soundness Test shall be carried out as per specification of IEC 60349 and plot the heating and cooling curves as in 9.1.3 of IEC 60349.

4. Characteristic Test as per clause 8.2 and 9.2 of IEC 60349-1:

- ✓ **Voltage Droop test:** The Alternator output voltage shall be measured with gradual increase of Load Current.
- ✓ **No load Characteristics Test:** Alternator output voltage shall be measured at rated speed of Alternator at NO Load condition.

5. Transient Test as per clause 8.5 of IEC 60349-1:

- ✓ Test shall be conducted by shortening the full rectifier bridge and by shortening one arm bridge.
- ✓ **Acceptance Criteria:** Protection circuit should operate in both conditions and also there should be no physical or electrical damage.

6. Over speed test as per clause 8.7 of IEC 60349-1:

- ✓ Alternator shall be operated at speed and duration provided in clause 8.7 of IEC 60349-1.
- ✓ **Acceptance Criteria:** Subsequently it should pass Dielectric test as per clause 9.5 of IEC 60349-1.

7. Dielectric Test as per clause 9.5 of IEC 60349-1:

- ✓ The test voltage shall normally be carried out using A.C of near sinusoidal waveform and between 25 Hz and 100 Hz frequency, but D.C. testing may be employed if agreed between user and manufacturer before placing an order.
- ✓ **Acceptance Criteria:** There shouldn't be any flash over. Leakage of current should be less then specified limit.

8. Vibration test as per clause 8.1 of IEC 60034-14:

- ✓ Vibration test shall be carried out in all 3 axis at rated RPM as per IEC 60034-14.
- ✓ **Acceptance Criteria:** Vibration level should be less than accepted limit in all 3 axis.

9. IP 55 Protection (IEC 60529 Clause 13.4,13.5 and 14.25):

- ✓ This test shall be conducted as per IEC 60529.
- ✓ **Acceptance Criteria: The unit shall meet the protection class.**

B. Type test of Inverter based Sub assembly such as Power Supply Module & Battery Charger

S no.	Standard	Test Name	Test location	Remarks
01	IEC 61287-1-4.5.3.1	Visual Inspection	At firm's premises/ NABL labs	
02	IEC 61287-1-4.5.3.4	Marking Inspection	At firm's premises/ NABL labs	
03	IEC 61287-1-4.5.3.5	Cooling System Performance Test	At firm's premises/ NABL labs	
04	IEC 61287-1-4.5.3.6	Test of Degree of Protection	At firm's premises/ NABL labs	
05	IEC 61287-1-4.5.3.7	Dielectric Test	At firm's premises/ NABL labs	
06	IEC 61287-1-4.5.3.8	Insulation Resistance Test	At firm's premises/ NABL labs	
07	IEC 61287-1-4.5.3.9	Tests of mechanical and electrical protection and measuring equipment	At firm's premises/ NABL labs	
08	IEC 61287-1-4.5.3.13 IEC 61287-1-7.5.7	Temperature Rise test	At firm's premises/ NABL labs	
09	IEC 61287-1-4.5.3.14	Power Loss determination	At firm's premises/ NABL labs	
10	IEC 61287-1-4.5.3.15	Supply Over Voltage and Transient Energy Test	At firm's premises/ NABL labs	
11	IEC 61287-1-4.5.3.16	Sudden Variation of Load	At firm's premises/ NABL labs	
12	IEC 61287-1-4.5.3.17	Safety Requirement Inspection	At firm's premises/ NABL labs	
13	IEC 61287-1-4.5.3.18	Test for withstanding Vibration and Shocks	At firm's premises/ NABL labs	
14	IEC 61287-1-4.5.3.19 IEC 60571-12.2.8 & 12.2.9	Test of electromagnetic compatibility	At firm's premises/ NABL labs	

15	IEC 61287-1-4.5.3.20	Step change of line voltage test	At firm's premises/ NABL labs	
16	IEC 61287-1-7.5.2	Output Characteristics Test	At firm's premises/ NABL labs	
17	IEC 61287-1-7.5.3	Starting and Restarting Test	At firm's premises/ NABL labs	
18	IEC 61287-1-7.5.4	Short Circuit Test	At firm's premises/ NABL labs	
19	IEC 61287-1-7.5.6	Overload Capability Test	At firm's premises/ NABL labs	
20	IEC 61287-1-7.5.8	Load Brake Test	At firm's premises/ NABL labs	
21	IEC 60571-12.2.4	Cold Start Test	At firm's premises/ NABL labs	
22	IEC 60571-12.2.5	Dry Heat Test	At firm's premises/ NABL labs	
23	IEC 60571-12.2.6	Cyclic Damp Heat Test	At firm's premises/ NABL labs	
24	IEC 60571-12.2.11	Salt Mist Test	At firm's premises/ NABL labs	
25	IEC 60571-12.2.14	Equipment Stress Screening Test	At firm's premises/ NABL labs	

1. Visual Inspection (IEC 61287-1 Clause 4.5.3.1):

- ✓ It is done to ensure that equipment is free from physical defects and surface treatments have been duly carried out.
- ✓ It includes checking for presence of all internal and interface electrical and mechanical components and their conditions.
- ✓ It also includes checking that electrical and mechanical connectors have been assembled correctly and that the connection between components follow specified routes.

2. Marking Inspection (IEC 61287-1 Clause 4.5.3.4):

- ✓ Equipment shall be provided with a nameplate which shall be readable during the useful life of the converter and on which at least the following is inscribed: – manufacturer's make, Type, Month & Year of manufacture, Serial number, rating information etc.

3. Cooling System Performance Test (IEC 61287-1 Clause 4.5.3.5):

- ✓ Procedure: Air flow shall be simulated for Compressor fan during temperature rise test at the heat sink of converter.

- ✓ Acceptance Criteria: Air flow rate at APU running should not be less than specified value.

4. Degree of Protection Test (IEC 61287-1 Clause 4.5.3.6):

Protection against Dust for first characteristic numeral 5X and 6X:

- ✓ **Procedure:** Test shall be conducted in Dust chamber where Talcum Powder in in suspension for a period of 8 hrs.
- ✓ **Acceptance Criteria:** After test, no deposit of Talcum Powder is observable inside the equipment.

Protection against Water for second characteristic numerals X5:

- ✓ **Procedure:** The test shall be made by spraying enclosure from all directions with stream of water for specified period of time.
- ✓ **Acceptance Criteria:** No water accumulation and interference with correct operation of equipment.

5. Dielectric Test (IEC 61287-1 Clause 4.5.3.7):

- ✓ Procedure: All input & output terminals of Power Supply module & 72V circuits shall be shortened before performing this test. Test shall be conducted at specified voltage and duration. If the test has to be repeated, the test voltage shall be reduced to 80% of initial test Voltage.
- ✓ **Acceptance Criteria:** In dielectric test, arc over shall not be observe.

6. Insulation Resistance Tests (IEC 61287-1 Clause 4.5.3.8):

- ✓ **Procedure:** After Dielectric test, Insulation Resistance test shall be measured by applying a DC Voltage of at least 500V.
- ✓ **Acceptance Criteria:** Insulation Resistance shall not be less than 1MΩ for rated Insulation Voltages not exceeding 1000Ω/V
- ✓ For higher rated Insulation Voltages, the Insulation resistance shall exceed 1000Ω/V.

7. Test of Mechanical & Electrical protection & measuring Equipment (IEC 61287-1 Clause 4.5.3.9):

Below mentioned test shall be conducted in Power Supply Module:

S.No	Parameter	Remarks/Value
1	Input Under Voltage(Rectified DC) Protection Test	
2	Input Over Voltage (Rectified DC) Protection Test	
3	Input Over Current Protection Test	
4	Output Over Voltage Protection Test	
5	72V DC output Over Load Protection Test	
6	72Vdc Power Supply Module output short circuit Protection Test	
7	Over temperature protection Test	
8	72Vdc Output Fuse Fail indication test	
9	Test for Failure of Power supply to the control electronics	
10	Control supply full voltage variation test	

11	Control Power Supply Over Voltage Test	

Test on battery charger module:

S.No	Parameter	Remarks/Value
1	Input Under Voltage Protection Test	
2	Input Over Voltage Protection Test	
3	Output Over Load Protection Test	
4	Output short circuit Protection Test	

8. Temperature Rise Test (IEC61287-1 clause 4.5.3.13)

- ✓ **Procedure:** Temperature rise test of Power Supply Module to be done at full load. Readings shall be taken at all the power dissipated components.

Load on Power Supply Module during testing:

Paramter	Value
Power Supply Module Input Volt (V)	
Power Supply Module output Volt (V)	
Power Supply Module output current (A)	
Power Supply Module output load (kW)	

Load on BC during testing:

Paramter	Value
BC Input Volt (V)	
BC output Volt (V)	
BC output current (A)	
BC output load (W)	

9. Power Loss Determination (IEC61287-1 clause 4.5.3.14)

Power loss determination test has been done at full load.

Power loss determination test for Power Supply Module:

Parameter
Input Volt (Vac)
Input Current (Aac)
Input Power Factor
Input Power (kW)
Power Supply Module O/P Voltage (Vdc)
Power Supply Module O/P Current (Adc)

Power Supply Module O/P Power (KW)
% Efficiency = (Total O/P power/Input Power)*100

Power loss determination test for BC:

Parameter
Input Volt (Vdc)
Input Current (A)
Input Power (W)
BC O/P Voltage (Vdc)
BC O/P Current (Adc)
BC O/P Power (W)
% Efficiency = (Total O/P power/Input Power)*100

10. Supply Over voltage and Transient Energy Test (IEC 61287-1 clause 4.5.3.15)

Input Over voltage test:

For Power Supply Module, This test will be conducted by applying 125Vac for 1min at input of Power Supply Module. There should not be any damage in the Power Supply Module.

For Battery Charger module, this test will be conducted by applying 80V DC for 1min at input of BC. There should not be any damage in the BC.

Input Transient energy test: Purpose of this test is to know whether Power Supply Module can withstand transient energy. This test will be conducted by ON/OFF of the Power Supply Module input. There should not be any damage in Power Supply Module.

11. Sudden Variations of Load (IEC61287-1 clause 4.5.3.16)

Sudden Loading Test-

When Power Supply Module is working at no load, full load shall be connected suddenly Power Supply Module. There should not be any adverse effect in the Power Supply Module.

When BC is working at no load, full load shall be connected suddenly on BC. There should not be any adverse effect in the BC.

12. Safety Requirements (IEC61287-1 clause 4.5.3.17)

Power Supply Module **dc link Voltage Discharge-** Resistor is provided in parallel to the capacitor for discharging the capacitor. When Power Supply Module output capacitor was charged at 74Vdc Input has been disconnected and observe capacitor discharging time.

13. Vibration & Shock (IEC61287-1 clause 4.5.3.18)

Vibration & shock test shall be conduct as per IEC-61373-1.

Sl.No.	Test parameters	Specification
4.1		
a)	Long life test	Freq : 5Hz to 20Hz ASD : 0.461$(m/s^2)^2$/Hz Freq : 20Hz to 150Hz Slope : 6db/octave Axis : Longitudinal Duration : 5 Hours
b)	Shock test	Axis : Longitudinal Acceleration : 50 m/s^2 Duration : 30 ms No. of Shocks: 6 shocks
c)	Functional test	Freq : 5Hz to 20Hz ASD : 0.0144$(m/s^2)^2$/Hz Freq : 20Hz to 150Hz Slope : 6db/octave Axis : Longitudinal Duration : 10 minutes
4.2	**Axis : Transverse**	
a)	Long life test	Freq : 5Hz to 20Hz ASD : 0.192 $(m/s^2)^2$/Hz Freq : 20Hz to 150Hz Slope : 6db/octave Axis : Transverse Duration : 5 Hours
b)	Shock test	Axis : Transverse Acceleration : 30 m/s^2 Duration : 30 ms No. of Shocks: 6 shocks
c)	Functional test	Freq : 5Hz to 20Hz ASD : 0.0060$(m/s^2)^2$/Hz Freq : 20Hz to 150Hz Slope : 6db/octave Axis : Transverse Duration : 10 minutes
4.3	**Axis : Vertical**	
a)	Long life test	Freq : 5Hz to 20Hz ASD : 0.964$(m/s^2)^2$/Hz Freq : 20Hz to 150Hz Slope : 6db/octave Axis : Vertical Duration : 5 Hours

b)	Shock test	Axis : Vertical Acceleration : 30 m/s^2 Duration : 30 ms No. of Shocks: 6 shocks
c)	Functional test	Freq : 5Hz to 20Hz ASD : 0.0301 $(m/s^2)^2/Hz$ Freq : 20Hz to 150Hz Slope : 6db/octave Axis : Vertical Duration : 10 minutes

14. Test of Electromagnetic Compatibility (IEC61287-1 clause 4.5.3.19, IEC60571 clause 12.2.8 & 12.2.9)

Electromagnetic Compatibility tests are to be conducted on **Control Card module.**

Electromagnetic Compatibility Test to be done as per IEC62236-3-2 as mentioned in IEC61287-1 clause 4.5.3.19 and also mentioned in IEC60571 clause- 12.2.8 & 12.2.9.

Sl. No.	Test Name	Standard / Reference Clause
1	Surge Voltage test	IEC61000 – 4 – 5
2	Transient Burst Susceptibility test	IEC61000 – 4 – 4
3	Radio interference test	IEC61000 – 4 – 3 IEC61000 – 4 – 6

i) Surge Voltage Test

Procedure:

- Connect Surge voltage tester on input terminal of EUT (Equipment under test) and apply 1.8KV surge voltage at line to line.

Acceptance Criteria:

- No damage to EUT
- EUT should work normally after the test

ii) Transient Burst Susceptibility Test

Procedure:

- Connect transient burst tester on input terminal of EUT
- Test should be done as per test procedure mentioned in IEC 61000-4-4 i.e. 2KV, 5/50ns, 5KHz Repetitive Frequency.
- Severity level should be taken from Table-7 of IEC 62236-3-2.

Acceptance Criteria:

- No damage to EUT
- EUT should work normally during and after the test

iii) Radio interference test

This test will be conducted on **control card, Power Supply module & Battery Charger module.** .

15. Step Change of Line Voltage Test (IEC61287-1 clause 4.5.3.20)

Procedure:

To conduct this test, input voltage should be charged from 70Vac to 120Vac at working condition. There should not be any adverse effect in the EUT.

BC input voltage should be changed from 65V to 80V DC at working condition. There should not be any adverse effect in the BC.

16. Output Characteristic Test (IEC61287-1 clause 7.5.2)

Output characteristic tests shall be done as per IEC 61281-1-7.5.2

17. Starting and Restarting Test (IEC61287-1 clause 7.5.3)

Power Supply module & Battery Charger modules will be tested with direct turn-on and direct turn-off of its input nominal Supply. There should not be any adverse effect in the Power Supply module & Battery Charger modules.

18. Short Circuit Test (IEC61287-1 clause 7.5.4)

Test shall be conduct as per IEC 61287-1-7.5.4.

19. Overload capability test (IEC61287-1 clause 7.5.6)

Power Supply module & Battery Charger modules shall be tested by momentarily loading with 120% of rated current for 5 Seconds.

20. Load Break test (IEC61287-1 clause 7.5.8)

Procedure:

When Power Supply module is working at full load, load shall be removed from Power Supply module suddenly. There should not be any adverse effects in the Power Supply module.

When Battery Charger is working at full load, load shall be removed from Battery Charger suddenly. There should not be any adverse effects in the Battery Charger.

21. Cold Start Test (IEC60571 clause 12.2.4)

Purpose:

To prove the capability of unit to withstand at -10deg C. Cold start test to be conducted in all Control Electronics.

Procedure:

- This test shall be in accordance with IEC 60068-2-1 – 5.3. (mentioned in IEC 60571-12.2.4)
- Parameters shall be taken from 6.6.1 & 6.6.2 of IEC 60068-2-1.

Set temperature: -10ºC

Duration: 2h (after thermal stabilization)

- The ambient temperature setting of the chamber shall be kept at -10 ±2°C. Temperature reach from ambient to -10ºC in 30 Minutes.
- After stabilizing the temperature at -10°C the Equipment under Test (EUT) kept in the environment condition for 2 hours in power OFF condition.
- After completion of two hours, EUT switched ON at -10°C and temperature raised to ambient temperature (30ºC).
- At the end of this period functional tests conducted.

Acceptance Criteria:

- No damage shall occur to the Unit.
- EUT should work normally after the test.

22. Dry Heat Test (IEC60571 clause 12.2.5)

Purpose:

To prove the capability of units to withstand against high temperature. Dry Heat test to be conducted in all Control Electronics.

Procedure:

- This test shall carried out in accordance with IEC 60068-2-2
- Parameters to be taken from 6.5.2 of IEC 60068-2-2 and 12.2.5 of IEC 60571.

Set temperature: 70ºC

Duration: 6 hrs in power ON condition (after thermal stabilization)

- The ambient temperature setting of the chamber is kept at 70 ±2°C, and raised from ambient to set point.
- After stabilizing the temperature at 70°C the Equipment Under Test (EUT) kept in this environment condition for 6 hours by applying nominal input voltage (72V DC). Observed the functionality of EUT.
- The temperature of chamber lowered to 30ºC.
- After completion of dry heat test, functional tests conducted.

Acceptance Criteria:

- No damage shall occur to the Unit.
- EUT should work normally after the test.

23. Cyclic Damp Heat Test (IEC60571 clause 12.2.6)

Purpose:

To prove temperature variations should not cause any damage to the unit functionality. Cyclic Damp Heat test to be conducted in all Control Electronics.

Procedure:

- In this test, the equipment is placed in a Humidity chamber in Power-OFF condition.
- This test is carried out as per IEC 60068-2-30,Variant 2 cycle, which is explained below stepwise

Temperatures: +55°C and +25°C

Number of cycles: 2 (respiration effect)

Time: 2 x 24 hrs (48 Hours)

- The ambient temperature setting of the chamber is kept at 55±2°C, and raised from 25±2°C

within 3 hrs.

- The Humidity setting inside the chamber is kept at 95 % RH.
- After stabilizing the temperature at 55°C and the Humidity at 95% RH. The equipment kept in this environment condition for 12 hrs from the starting of the test.
- The temperature lowered to 25ºC within 3 hrs to 6 hrs. This temperature maintained 6 hrs or up to the time period which completes 24 hrs cycle.
- The above cycle repeated for the second time to complete the test.
- After completion of second cycle, allowed the unit to return normal application conditions and conducted performance test.

Acceptance Criteria:

- No damage shall occur to the Unit.
- EUT should work normally after the test.
- Insulation resistance value should be >10MΩ.

24. Salt Mist Test (IEC60571 clause 12.2.11)

Purpose:

The purpose of conducting this test is to ensure the equipment for corrosion free. Salt Mist test has been conducted in all Control Electronics.

Procedure:

- This test shall carried out as per IEC 60571-12.2.11.
- The solution for producing the salt mist is prepared by dissolving (50 ± 1)gm sodium chloride NaCl in 1 litre distilled water.
- The pH value of the solution lie between 6.5 to 7.2.
- During the test, the temperature in the test chamber is maintained at 35ºC.
- Test to be done for class ST1 i.e. for 4hours

Acceptance Criteria:

- No damage shall occur to the Unit.
- EUT should work normally after the test.

25. Equipment Stress Screening Test (Burn-in Test) (IEC60571 clause 12.2.14)

Purpose:

To ensure the functionality of unit from low temperature (-25ºC) to high temperature. (70ºC). Burn-in test to be conducted in all Control Electronics.

Procedure:

- This test shall be conducted as per IEC 60571-12.2.14

Minimum temperature: -25ºC

Maximum temperature: 70ºC

This test conducted for the unit in energized condition for duration of 45 hours minimum with 3 cycles. Each cycle followed as below.

1. The ambient temperature setting of the chamber is kept 25°C.
2. The minimum temperature setting of the chamber is kept at -25°C, and decreased from ambient to set point within 1hour 40 Minutes. At this time Unit kept in power OFF condition.
3. After stabilization at -25ºC temperature, unit kept at this environment for 30 minutes. In this 30 minutes period, first 15 minutes unit kept in OFF condition and second 15 minutes in powered ON.
4. Then temperature should be raised from -25ºC to 70ºC within 3 hours 10 minutes. At this time unit should be in power ON condition.
5. After stabilization at 70ºC temperature, unit kept at this environment for 30 minutes.
6. For this period power cycle followed as
    - 7 minutes – power ON

- 15 minutes – power OFF
- 8 minutes – power ON

7. Then temperature ramp down to -25ºC within 3 hours 20 minutes. At this period unit kept in power ON condition.
8. After stabilization at temperature -25ºC, unit kept for 30 minutes in following manner.
   - 7 minutes – power ON
   - 15 minutes – power OFF
   - 8 minutes – power ON
9. Then temperature raised from -25ºC to 70ºC with in 3hours 10 minutes. At this time unit kept in power ON condition.
10. After stabilization at 70ºC temperature, unit kept for 30 minutes in following manner.
    - 7 minutes – power ON
    - 15 minutes – power OFF
    - 8 minutes – power ON
11. Then temperature ramp down to 25ºC (ambient) within 1 hour 40 minutes. At this time unit kept in power ON condition.
12. Up to here one cycle is completed with duration of 15 hours.
13. Repeated from step 1 to 11 for 3 times for completing this test.

Acceptance Criteria:

- No damage shall occur to the Unit.
- EUT should work normally after the test.

C. Type test of APU Micro-controller

Following table summarizes the type test of the equipment/system as per IEC 60571(Latest):

S. No	Standard	Test Name	Test Location	Test Result/Remarks
1.	IEC 60571 - 12.2.2	Visual Inspection	At firm's premises/NABL Labs	Pass/Fail
2.	IEC 60571 - 12.2.10.2	Insulation Measurement Test	At firm's premises/NABL Labs	Pass/Fail
3.	IEC 60571 - 12.2.10.3	Voltage Withstand Test	At firm's premises/NABL Labs	Pass/Fail
4.	IEC 60571 - 7.2.6	Reverse Polarity Test	At firm's premises/NABL Labs	Pass/Fail
5.	IEC 60571 - 5.1.1.2	Voltage Variation Test	At firm's premises/NABL Labs	Pass/Fail
6.	IEC 60571 - 12.2.3	Performance Test with Simulator	At firm's premises/NABL Labs	Pass/Fail
7.	IEC 60571 - 12.2.6	Damp Heat Test	At firm's premises/NABL Labs	Pass/Fail
8.	IEC 60571 - 12.2.4	Cooling Test	At firm's premises/NABL Labs	Pass/Fail
9.	IEC 60571 - 12.2.5	Dry Heat Test	At firm's premises/NABL Labs	Pass/Fail
10.	IEC 60571 - 12.2.8.1	Surge Voltage Test	At firm's premises/NABL Labs	Pass/Fail

S. No	Standard	Test Name	Test Location	Test Result/Remarks
11.	IEC 60571 – 12.2.12 & IEC61373-Cat.1-Class-B	Vibration and Shock Test	At firm's premises/NABL Labs	Pass/Fail
12.	IEC 60571 - 12.2.8.3	Transient Burst Susceptibility Test	At firm's premises/NABL Labs	Pass/Fail
13.	IEC 60571 - 12.2.9.1	Radio Frequency Susceptibility Test	At firm's premises/NABL Labs	Pass/Fail
14.	IEC 60571 - 12.2.9.2	Radio Frequency Emission Test		
15.	IEC 60571-12.2.11	Salt Mist Test	At firm's premises/NABL Labs	Pass/Fail
16.	IEC 60571-12.2.13	Water Tightness Test	At firm's premises/NABL Labs	Pass/Fail
17.	IEC 60571-12.2.14	Equipment Stress Screening Test	At firm's premises/NABL Labs	Pass/Fail
18.	IEC 60571-12.2.15	Low temperature storage test	At firm's premises/NABL Labs	Pass/Fail

1. Visual Inspection as per clause 12.2.2 of IEC 60571

30 Physical Dimensional Check

The Physical dimensions are to be measured and recorded as per the RDSO approved drawing.

31 Equipment Number plate verification:

Equipment number plate is to be verified.

32 Power ON check:

This check is to ensure that the system is working normal when the rated input voltage is connected to the system.

2. Insulation Measurement test as per clause 12.2.10.2 of IEC 60571

- All the Input / Output pins of the unit are shorted together. All the Cards are removed from the respective enclosures.
- The Insulation Resistance is measured through a 500V DC Megger between the body of unit and above pins.
- The value should be >100 Meg Ohms.

3. Voltage Withstand (Di-Electric) Test as per clause 12.2.10.3 of IEC 60571

- All the Input / Output pins of the unit are shorted together.
- A test voltage of 1000V ac to be applied by gradually increasing the voltage amplitude to set limit and maintained at that level for 1 min.

Observations

- No disruptive discharge or flash over should occur.The system should work satisfactorily.

IR Test after Dielectric Test

Repeat the “Insulation Resistance Test” after the Dielectric test once again and record the Insulation Resistance Values. Values of insulation resistance should not deteriorate much.

4. Reversal of Polarity as per clause 7.2.6 of IEC 60571

- The equipment is connected with 72V DC in Reverse Polarity at the Power Supply input Terminals and kept in that condition for one minute.
- The equipment is then connected with normal polarity of 72V DC and status LEDs are to be verified

Observations

- No damage to the equipment because of reverse polarity.
- The equipment found working normally after reverse polarity test.

5. Effect of Voltage Variation Test as per clause 5.1.1.2 of IEC 60571

- The equipment is connected to a variable DC source with normal polarity and the voltage is set to 50V DC, (0.7 times of the rated voltage 72V DC).
- Status LEDs are to be verified
- Then the voltage is slowly increased and set at 90V DC (1.25 times of the rated voltage 72V DC).
- Status LEDs are again to be verified
- Finally the voltage is set to rated voltage of 72V DC.
- Status LEDs are to be verified.
- There should be no damage to the equipment or malfunctioning because of voltage variations.
- The equipment should work satisfactorily in all above conditions.

6. Performance Test as per clause 12.2.3 of IEC 60571

- Performance test or functionality of the system as per clause 4 to clause 10 of this specification is to be checked by RDSO on Simulator/test bed at the firm’s premises.

7. Damp Heat test as per clause 12.2.6 of IEC 60571

- Test to be carried out as per IEC 60068-2-30, Test db. With +55°C as upper temperature limit and 2 cycles of 24 hours.
- The equipment to be placed in the test chamber without powering ON.
- A functional performance test to be carried out at the beginning of second cycle.
- After test to be completed, equipment to be allowed to recover to ambient conditions.
- An Insulation Measurement and Di-electric Test to be carried out.

Observations

- No damage to the equipment or malfunctioning because of Damp Heat.
- The equipment to be working satisfactorily during Damp Heat Test.
- The Insulation Resistance to be measured and found value >100 M Ohms.
- No disruptive discharge or flash over in the Di-electric test.

8. Cooling start Test as per clause 12.2.4 of IEC 60571

- This test to be carried out in accordance with IEC 60068-2-1
- The equipment is placed in a cold chamber without any voltage applied condition.
- The temperature is lowered from ambient to -0±2°C gradually.
- Once the temperature in the chamber is stabilized at -0±2°C, the equipment is retained in the chamber about 2 hours at that temperature.
- The equipment is then powered up after approx 5 to 10 minutes.
- There should not be any damage to the equipment.
- Status LEDs are to be verified.

Observations:

- No damage found to the equipment because of Cooling start test.
- The equipment is working satisfactorily.

9. Dry Heat test as per clause 12.2.5 of IEC 60571

- This test is carried out in accordance with IEC60068-2-2,
- The equipment is connected with 72V DC in normal polarity and placed in a hot chamber.
- The temperature is raised from ambient to 70±2°C.
- Equipment is kept in this condition for 6 hours, after stabilization of temperature.
- Status LEDs are verified as per sl. no. at the end of 6 hours period.
- There should not be any damages to the equipment after the test.

Observations:

- No damage to the equipment because of Dry Heat Test.
- The equipment is working satisfactorily after the test.

10. Surge Voltage test as per clause 12.2.8.1 of IEC 60571

- The surge waveform shall be generated and tested using the generator and waveform as specified in IEC 62236-3-2:2008
- Surge Voltage to be applied at BP and BN pins of working equipment.
- Status LEDs are to be verified after the test.
- There should not be any damage to the equipment.

Observations:

- No damage observed to the equipment because of Surge Voltage Test.
- The equipment is working satisfactorily after the test.

11. Vibration, Shock and bump test as per clause 12.2.12 of IEC 60571

- The complete cubicle with its mounting arrangements shall be subjected to the tests indicated in IEC 61373.
- There should not be any damages to the equipment after the test.

Observations:

- No damage to the equipment because of test.
- The equipment to be working satisfactorily after the test.

12. Transient Burst Susceptibility test as per 12.2.8.3 of IEC 60571

- Test voltage of 2KV, 5/50 nS, 5KHz as per IEC 62236-3-2:2008 to be used for testing.
- The test to be carried out in working condition of equipment as per procedure of IEC 61000-4-4.

Observations:

- No damage observed to the equipment because of test.
- The equipment to be working satisfactorily after the test.

13. Radio Frequency Interference Immunity test as per 12.2.9.1 of IEC 60571

- Radiated Radio Frequency Interference test to be performance with 10V/m (r.m.s) severity as per IEC IEC61000-4-6
- The equipments to be kept energized during the test.

Observations:

- For conducted disturbances induced by radio frequencies fields, refer to IEC 62236-3-2:2008 (Table 7 and Table 8).
- For radiated disturbances induced by radio frequencies fields, refer to IEC 62236-3-2:2008 (Table 9).

14. Radio Frequency Interference Emission test as per 12.2.9.2 of IEC 60571

- Radio Frequency Interference emission test to be performance as per IEC IEC62236-3-2:2008
- The equipments were kept energized during the test.
- The test will be carried out at ETDC/NABL Lab.

Observations:

The equipment shall be tested to the requirements as specified in IEC 62236-3-2:2008 (Table 3, Table 4, Table 5, and Table 6).

15. Salt Mist Test as per IEC 60571-12.2.11

Salt solution

- The solution for producing the salt mist shall be prepared by dissolving (50 ± 1) g sodium chloride (NaCl) analytical reagent quality, in distilled or demineralised water to make up(1 ± 0,02) l of final solution at 20 °C; if the pH does not lie between 6,5 and 7,2, the solution shall be rejected.

Test procedure

- During the test, the temperature in the test chamber shall be maintained at (35 ± 2) °C.
- The solution and the air used to produce the salt mist shall have a temperature equal to that of the test chamber.
- The equipment should be tested in the manner in which they are expected to be used, i.e. protective covers should be in position and the equipment arranged, as nearly as possible, inthe position it will occupy in actual use.
- The test chamber shall be kept closed and spraying of the salt solution shall continue without interruption during the whole conditioning period.

- The period shall be:

  – for class ST2: 16 h;
- At the end of the test, the equipment shall be washed in running tap water for 5 min, rinsed in distilled or demineralised water, then dried to remove droplets of water and stored under standard atmospheric conditions of the testing area for not less than 1 h, no more than 2 h.
- After that, the equipment is subjected to a visual examination.

Observations:

- No major damage shall occur.
- A performance check shall not show any failure or damage nor any results which are beyond the specified tolerances.

16. Water tightness test as per IEC 60571-12.2.13

- As electronic equipment is generally mounted either inside the body of the vehicle or in boxes outside, there is no need to carry out water tightness tests, apart from exceptional cases to be defined between user and manufacturer.

17. Equipment stress screening test as per IEC 60571-12.2.14

- A screening procedure to be applied to completed equipment or a part of it, for the purpose of eliminating dormant manufacturing or component defects.
- Burn-in test

After mounting of components, the populated PCB cards kept in proper chassis in energized condition shall be burnt in for minimum 45 hrs at +70 deg. C and - 25 deg C as per the cycle at figure above, wherever specified in the main specification. The PCBs will be tested for functionality to the extent possible during the burn-in test. This will be mutually decided.

18. Low temperature storage test as per IEC 60571-12.2.15

- This test shall be in accordance with IEC 60068-2-1.
- The temperature value for the test shall be –40 °C and the time period shall be 16 h minimum.
- After recovery, a performance check shall be carried out at ambient temperature.

Observations:

- No damage shall occur,
- The functional check does not show any failure nor any results beyond the specified tolerances.

D. Type test of APU Compressor

- The test shall be conducted as per ISO1217.
- The capacity test of FAD (Free air delivery) will be carried as per IS 10431.

E. Test of APU Engine

- The test shall be conducted as per ISO 8528 or SAE J1349 and clause no. 7.1 of the specification.

Note: The Test plan given above is the minimum requirement and strictly governed by referred IEC standard or other Standard as applicable. The latest edition of standards shall apply mutatis mutandis to this Test plan. The test other than above as specified may also be considered with mutual agreement between vendor and Vendor approving authority, if desired so.

Acceptance Test

1. VISUAL INSPECTION

a) Dimensional details:

Sr No.	Dimensions	As per Drawing	Result
01	Height		
02	Width		
03	Length		
04	Others		

b) There should be no hanging wires.
c) There should not be any unconnected pipelines.
d) There should not be any physical damages.

2. IR Test@500V:

Test Condition	Acceptance Criteria	Results
All the Input / Output pins of the unit are shorted together. Perform IR test between shorted terminals and APU body with 500V megger.	Insulation Resistance shall not be less than 1MΩ for rated Insulation Voltages not exceeding 1000Ω/V. For higher rated Insulation Voltages, the Insulation resistance shall exceed 1000Ω/V.	

3. HV Test:

Test Condition	Acceptance Criteria	Results
Perform HV test between live terminal and body at 1.5KV AC for 60 seconds.	Should withstand	

4. Functional Test:

Functional Test Procedure	Acceptance Criteria	Result
The APU unit under test is interfaced with LCC simulator.	• APU Engine will run at Specified RPM with load.	

• Main engine started normally in the LCC Simulator. • Adjust BCP pressure more than 1.5 Kgs/Sq.cm. • Keep reversal handle in Neutral position. • After specified time lapsed (when all entry conditions satisfied), 60 seconds decremental counter shall start on the screen. • After the 60 seconds counter is finished, the APU engine shall start automatically and main engine shall shut down after APU engine cranked. • After few minutes, keep RH in any working condition. • Main engine shall start automatically and APU Engine shall shut down.	• MRPR should maintain between 8-10 kg/sq.cm (Loading at 8kg/sq.cm and unloading at 10 kg/sq.cm). • 72V battery should be in charging condition (Battery Charging current should be > 0 Amps). • APU 12V battery should be charging.	

The above cycle of testing repeated three to four times and found auto change over (Main engine to APU engine and APU engine to main engine) is normal.

5. Safety Function:

Test Condition	Acceptance Criteria	Result
While APU running, MR pressure is drained continuously. When the MR is dropped below 5.5 kgs/Sq.cm. The APU engine shut down and main engine cranked automatically.	Auto changeover from APU to Main Engine	
While APU is running, alternator field wire is disconnected (to be disconnected while APU engine is off) to simulate 72V DC Generator fault. After 5 minutes, No APU Generator Output, fault will log and Main engine will start and APU Engine will shut down automatically.	Auto changeover from APU to Main Engine with No APU Generator Output Fault.	
APU Engine Safety functions		
While APU is running, simulate APU low lube oil Pressure fault. After 3 seconds, “APU Lube oil pressure Low fault" will log and APU engine will shut down & main Engine cranked automatically.	Auto changeover from APU to Main Engine with “APU Lube oil Pressure Low fault”.	
While APU is running, simulate APU low water fault. After 3 seconds, “APU Water Level Low/temperature high fault" will log and APU engine will shut down & main engine cranked automatically.	Auto changeover from APU to Main Engine with “ APU Water Level Low/temperature High fault“.	

6. Record the below parameter values during APU running:

EngRPM		APU Engine RPM			
BATTERY VOLTAGE		Alternator_Current		BATTERY_CURRENT	

Lube Oil Tmperature		Engine Water Temperature		BC Pressure	
MR.Pressure		AIR Temperature			

BIS standard equivalent, if available to referred International Standard will also be acceptable.