भारत सरकार

रेल मंत्रालय

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

सहायक शक्ति इकाई की सहायता से बंद इंजन के स्वतः नियंत्रण के लिए विशिष्टि

Automatic control of Engine Stop with Auxiliary Power unit – ACES with APU

(Applicable for ALCo Type Loco)

विशिष्टि संख्या चा. श.0.2400.62 (संशो- 1.00) मार्च 2021

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LIST OF AMENDMENTS

S no.	Amendment Date	Revision	Details
1	September 2009	0	First Issue
2	March 2021	1	• Clause no 4.7, 4.8 : Mention of "MEP" for control system is replaced by "MBCS/APU controller". • Clause No. 4.7, 4.8, 4.9 : BCP pressure threshold limit for APU modified. • Mention of word "Tenderer" is replaced by "Vendor" in the specification. • Clause No. 7: Reference of IEC standard updated as IEC 60571. • Clause No. 13,14,15: Test requirement summary reworded with reference to International Standard and detailed test is incorporated as Annexure-1. • Clause No. 16: Reference of RDSO document no. MP-M-8.1-1 given. Performance feedback format for Field Trials incorporated. Clause No. 17 modified for consumables. • New Clause No. 21 : Vendor Changes in Approved Status incorporated. • New Clause No. 22 : Preference to Make in India Clause incorporated. • New Clause No. 23 : Intellectual Property Rights incorporated. • Annexure-1 : Detailed Test Protocol alongwith Acceptance Test is incorporated and elaborated. • Annexure -2: The mandatory requirement of In house facility for APU is reworded as "Manufacturing facility to APU Microcontroller" and following Note is added. *"Note: If the APU controller is outsourced, the outsourcing firm should possess the minimum infrastructure given above and the name of the outsourcing firm should be part of the QAP of the APU Supplier. The discretion of permitting the outsourcing lies with RDSO/ vendor approving authority considering the capability of the firm for APU manufacturing and System Integration."*

CONTENTS

LIST OF REFERENCED DOCUMENTS

S. No.	Document name / number
1.	IEC 60571
2.	IEC 60812
3.	IEC 60529
4.	IEC 62262
5.	ISO 3046/IS-1000
6.	ISO 1217
7.	IS 10431
8.	IS 2500
9.	EDPS 179
10.	IEC-60349-1 (Latest)
11.	RDSO Specification no. MP. 0. 2400.26 (Latest) for Microprocessor Based Control System with Automatic Flasher Light Control, Multi-Setting Vigilance Control & Event Recorder for Diesel Electric Locomotives (ALCO)
12.	RDSO Document no. MP-M-8.1-1

LIST OF ANNEXURES

Annexure 1	Details of Test Scheme
Annexure 2	Manufacturing Facilities for APU Micro Controller
Annexure 3	Testing Facilities

1 Introduction:

1.1 Analysis of the locomotive data has shown that 50% of the run time of the locomotive is spent in IDLING hours only. This is especially true for the goods trains that are awaiting signals in the station & yards for prolonged periods of time.

1.2 While a diesel engine is idling at 400 RPM, the diesel engine consumes roughly 25 to 30 litres of diesel oil per hour. The diesel locomotive performs two functions while idling at stand still; the compressor maintains Main Reservoir pressure between 8 to 10 kgs./Sq.Cm and charges the locomotive batteries. However, at stand still with brakes applied, the requirement of air from compressor is less and it is required only to compensate leakage. These two functions do not require much power, however as the full diesel engine runs to cater this requirement, the energy consumed is very large.

1.3 Instructions exist for shutting down the engine to avoid unnecessary idling. However, drivers generally avoid shutting down to avoid difficulty in re-starting the engine.

2 Scope of specification:

This specification covers the design requirements of a system (Automatic control of engine stop with auxiliary power unit –ACES with 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.

3 Benefits:

- Reduced Consumption of fuel and other lubricants.
- Reduced wear and tear of Engine due to unnecessary idling.
- Reduced NOX emissions and noise pollution with a potential to earn carbon credits.
- The facility of loco monitoring from a remote location using GPRS based interface with an ftp protocol based front end software.

4 Principle of operation:

4.1 A small engine of low SFC coupled to a compressor and alternator can maintain the MR pressure and keep the batteries charged while the main locomotive engine remains shut down. A small engine with low specific fuel consumption in place of the high horse power main engine running at low speed will save substantial quantity of fuel.

4.2 The ACES-APU should monitor the critical locomotive parameters that are required either to restart the locomotive or to keep the locomotive in state of readiness for movement at a short notice while the main engine is idling.

4.3 Once these parameters are stabilized at engine idle, the ACES will automatically shut down the engine. In shut down condition also, the ACES will keep on monitoring these parameters; in case any of these parameter value falls below the preset value, the ACES will start the auxiliary engine (APU) to bring back the parameters to the predefined levels. Once the parameters are stabilized, the ACES will shut down the APU. This cycle will

repeat as long as the ACES is enabled. It also monitors and follows to various safety features of engine operation as described in later part of the specification.

4.4 The ACES-APU is designed with following subassemblies;

(1) Diesel Engine to generate required amount of power.
(2) A compressor to maintain MR pressure in the locomotive, which is essential for proper working of brake system.
(3) Three phase alternator to supply low voltage power to charge the locomotive batteries.
(4) Suitable 16 bit (minimum) microprocessor (for standalone system)

4.5 The compressor is directly coupled to Diesel engine through a coupling and the alternator is directly coupled to the compressor. The diesel engine directly drives the compressor and the alternator. These three sub-assemblies are integrated with associated interconnections to form into the APU.

4.6 ACES-APU may be designed as an add on unit to the main locomotive Microprocessor control system or it can a stand-alone system with its own microcontroller. In case it is integrated with the existing locomotive microprocessor, the software of the microprocessor shall have to be suitably modified to take over the functioning of the ACES-APU also.

4.7 Auto Change over to FUEL SAVE mode:
The ACES microcontroller continuously monitors the loco idling condition i.e. throttle should be in IDLE, Loco speed should be zero and BCP should be greater than 1.5 Kg/cm². AS soon as loco IDLE conditions are satisfied, MBCS/APU Controller should start an internal counter and monitor the following parameters:

- ACES-APU switch is in enable position.
- Engine RPM is 350 to 400.
- Loco speed is zero.
- Loco is not set for load box /self-load mode.
- Loco is set to lead position or MCB1 & MCB2 are in ON position.
- APU safely devices are in normal position and APU health status is good.

    - ✓ APU shout down contactor is in normal off position
    - ✓ Water in the APU engine is full.
    - ✓ Lube oil pressure switch is in normal position.
    - ✓ Fuel level is above the threshold level.
    - ✓ APU shout down contactor is in OFF position.

4.8 Microprocessor based control System (MBCS)/APU Controller monitors the above parameters continuously for 10 minutes in case all the parameters in para 4.7 are stabilized, the ACES-APU enters into the fuel save mode. If any of the parameters are not satisfied, the loco shall not enter into fuel save mode and appropriate fault message shall be displayed on the LCD screen. Once the above parameters are satisfied for 10 minutes, then MBCS/APU Controller checks the following parameter:

- ✓ Battery charging current is < 10 amps
- ✓ EWT sensor is not faulty and EWT > 30 deg. Cent.
- ✓ EOT sensor is not faulty and EOT > 30 deg. Cent.
- ✓ MRPR > =7.5 kgs./Sq. cm
- ✓ BCP > 1.5 kgs./Sq. cm
- ✓ Reverser handle is in neutral.

The system should ensure that the above parameters are met.

4.9 If the BCP < 1.5 kgs./sq. cm a message "loco brake are not applied may not enter into FUEL SAVE mode" should display on the screen. Similarity if the reverser handle is in forward /reverse position, an appropriate message should be displayed and so forth. The system should repeat these messages every 10 minutes (configurable) to warn the driver to set the parameters correct to enable system to go into fuel save mode.

4.10 The driver can put the system into FUEL SAVE mode simply by keeping the RH in neutral position and applying loco brakes. As soon as the driver keeps the Reverse handle in neutral with loco brakes applied, the microprocessor should display a decrementing counter and a message "system will enter into fuel save mode with in xx seconds" with intermittent buzzer sounds. This would be the final warning message to driver before entering into FUEL SAVE mode. Even at this juncture before the countdown is finished, if the driver wants to start the train, he should be able to avoid this mode by simply shifting the reverser handle to working direction. The display should automatically change to normal mode and the driver can work the locomotive normally

4.11 In case the driver does not want the system to go into FUEL SAVE mode, he can keep the RH in working direction.

4.12 A switch to enable/disable the APU should be provided. Whenever the APU is disabled, a suitable audiovisual alarm should be given to the driver. The APU must have self-diagnostic feature.

5 Data Logging Features:

The data should be logged at an interval of one minute and should store the status of all the inputs to the ACES-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 ACES-APU system by using any commercially available USB pen drive. Onboard 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 180 days.

6 GPRS Features:

The ACES with APU system should have the provision of built in GPRS interface for remote monitoring of the locomotive through the online and cumulative parameters stored by the system as listed below:

- Fuel saving reporting; *this will be in terms of total idle hours saved by the system by shutting down the engine and saving in terms of diesel oil*
- Total Loco/engine Monitoring Timer.
- Total time the system was put in Active Mode.
- Total Time the system was put in Bypass Mode.
- Total engine Start Timer.
- Total engine Stop Timer.
- Total Idling Time with engine in start condition.
- Total number of times loco shut down by the ACES with APU System.
- Total number of times loco restarted by the ACES with APU System.
- Number of times loco restarted due to low air pressure and its mean time of restart.
- Number of times loco restarted due to water temperature and its mean time of restart.
- Number of times loco restarted due to ambient temperature and its mean time of restart.
- Number of times loco restarted due to low battery voltage and its mean time of restart.

- Image of last event by ACES with APU system w.r.t. time stamp and reason.
- Online status of the following parameters:
    1. Currently ACES with APU system in Active/Bypass mode.
    2. Currently Engine Start/Stop
    3. Lube Oil Pressure
    4. Air Pressure
    5. Battery Voltage
    6. Water Temperature
    7. Ambient Temperature

7 Scope of Supply

7.1 APU 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 (in the range of 165 to 170 grams/BHP hour at full load. The engine should be capable of starting with power sourced from the locomotive battery or may have its own battery that shall not exceed 12 volts. 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 schedule.

7.2 Compressor and its functionality:

The compressor should be directly coupled to the APU engine and should therefore be able to deliver the required air flow at the rpm of the engine itself. The compressor should be designed for operation at pressure of 10.2 Kg./cm². The compressor should be air cooled and splash lubricated. Compressor may be reciprocatory or rotary type. Prior approval of RDSO shall have to be obtained for use of any make/design of the compressor. The compressor should not consume more than 15 HP at maximum engine rpm in loading condition. The compressor out let should be connected to MR tank through non-return valve.

7.3 Alternator and its functionality

This should be a 3-phase brush less AC alternator with IP55 enclosure. An automatic voltage regulator should convert the generated AC voltage to DC voltage and regulate the output voltage to 72 V with alternator running at the same as the APU engine. The rating of the alternator should not exceed 2KW and the output of the alternator should be constantly monitored by the Microprocessor. In case the desired output is not obtained at full rpm, a fault message should be lodged and audiovisual indication given to the driver

7.4 Microcontroller:

The system should be equipped with a minimum of 16-bit industrial Microcontroller in case it is designed as a stand-alone system. In case it is integrated with the locomotive microprocessor, the software of the microprocessor shall have to be modified.

7.5 Weight and Dimensions:

The weight of the APU should not exceed 1000 kgs, while the overall dimensions should not exceed 1700x 900x 1900 (including chimney) (Lxbxh). Dimensions beyond these will render the APU unfit for installation in the available space on the locomotive. Weight calculations should be submitted by the successful-vendor. The location of filters, air inlet and outlet, filling cap of lube oil etc. should be so located so as to enable easy maintenance while installed on the locomotive. For this purpose, the vender shall acquaint themselves regarding the location of APU on the locomotive. The complete

APU comprising of all the assemblies mentioned above should be enclosed in a suitable housing.

8 Environmental Condition

The ACES-APU microprocessor control system shall comply with extant IEC, UIC, IS specifications for locomotive mounted electronic equipment specifically including IEC60571.

The equipment shall be required to work at an ambient temperature between 5 ºC and 70 ºC and relative humidity up to 100% and will be subject to vibrations and dust in service when installed in the contactor compartment. The vibrations are assumed to be of sine wave form with frequency between 1 Hz and 50 Hz. The effect of sudden variations in speed and track condition may cause vertical or lateral acceleration up to 3 g with peak values not exceeding 3.5 g (g being acceleration due to gravity).

9 Power Supply

A 64 V battery is available on the locomotive for meeting the power requirement of the system. When the engine is running, this battery floats across 72±2 V regulated supply from an auxiliary generator.

10 Documentation

Documents to be furnished

a. Block diagram of system and its interface circuit with IR locomotive.
b. Circuit description & control logic.
c. Circuit descriptions.
d. Detail specification for the equipment offered.
e. Out line and general arrangement drawing.
f. Maintenance manual with full description of maintenance and repair procedure.
g. Drivers operating instructions and trouble shooting handbook.

11 Equipment for Troubleshooting, Maintenance & Testing

The firm shall supply special tools along with comprehensive lists for testing, troubleshooting & maintenance of the AESS system to be supplied by firm. The firm can take the equipment back after completion of field trials and finalization of control software.

12 Training

The vendor shall arrange free of cost training to the personnel of Indian Railways in India and abroad to make them proficient in the operation and maintenance of the system and associated equipment providing adequate guidance to enable them to train their subordinate staff in these functions. The to and fro fare and living expenses shall be borne by Indian Railways. Details of the training requirement shall be indicated by the vendor in its offer.

13 System Integration

The vendor shall be responsible for the complete system integration of the microprocessor based ACES-APU system with the excitation/propulsion control system of the locomotive.

14 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 prototype 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 and 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 as per Test Scheme attached as Annexure-1 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.

15 Type Tests

Requirement of Type Test of the Sub-Assemblies is detailed at Annexure-1

15.1 Performance Test on Test Bed:

Complete Prototype shall be subjected to durability and performance test on suppliers test bed as per the referred standards in presence of IR personnel to test the functionality as per APU Specification.

16 Validation Test

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.

17 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.							

18 Warranty and Service Support

The vendor shall guarantee the equipment against design and manufacturing defects for a period of two years from the date of commissioning. The system reliability of the ACES-APU microprocessor equipment's should be such that the locomotives fitted with the microprocessor equipment should be available for a minimum of 95% notwithstanding anything that may be specified in this specification, the final responsibility for the suitability of the design shall lie with the vendor who shall undertake to carry out all modifications and alterations to equipment supplied by them for satisfactory functioning in accordance with this specification as may be necessary during the period of two years. When the equipment is taken in hand for installation at a nominated shed/workshop/production unit, the vendor shall be responsible for providing all necessary service support and guidance for satisfactory installation and commissioning.
Consumables for APU maintenance during warranty has to be procured and provided by railways

19 Packaging

i) The component packing must be in assembled form of all the subassemblies. The packing list must totally match the complete bill of material (BOM) to be given by the supplier and this match shall be clearly indicated in the documents accompanying the supply.

ii) The above segments shall be suitably packed to prevent any transit damage. It shall be in line with the standard Indian Railways packing instruction.

20 Infrastructure for Manufacture and Quality Assurance

The firm shall be having the infrastructure facilities for manufacture and quality assurance as per Annexure – 2 & 3 enclosed.

All the facilities are necessary at the time of development and will be verified by RDSO representative.

21 Submission of Tender Document & Evaluation Criteria:

The vendor offering their standard proven product for similar diesel traction application should submit the following credentials with the tender document:

- Printed standard catalogues of the quoted product consisting complete technical details.
- Credentials of supplying the offered product (against the tender items) Reference lists of customer with complete supply and purchase details for the offered product.
- Outline general arrangement (OGA) and mounting drawings of quoted item. It is desirable that the 3D Uni-Graphics (NX3) model on CD may also be submitted along with the offer.
- Deviation in the technical specifications to be clearly brought in the outstation by vendor.

The vendor who has quoted for the development of the tendered product should submit all the above documents of their similar product to establish their credential (capacity & capability) in manufacturing & supplying the similar capacity item for diesel electric traction application for established railways system.

22 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.

23 Preference to Make in India

The Government of India policy on "Make in India" shall apply.

24 Intellectual Property Rights

24.1 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.

24.2 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.

Annexure 1

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 Voltage Converter & 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 Voltage Converter & 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 Voltage Converter:

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 VOLTAGE CONVERTER 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 Voltage Converter to be done at full load. Readings shall be taken at all the power dissipated components.

Load on Voltage Converter during testing:

Paramter	Value
VOLTAGE CONVERTER Input Volt (V)	
VOLTAGE CONVERTER output Volt (V)	
VOLTAGE CONVERTER output current (A)	
VOLTAGE CONVERTER 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 VOLTAGE CONVERTER:

Parameter
Input Volt (Vac)
Input Current (Aac)
Input Power Factor
Input Power (kW)
VOLTAGE CONVERTER O/P Voltage (Vdc)
VOLTAGE CONVERTER O/P Current (Adc)
VOLTAGE CONVERTER 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 VOLTAGE CONVERTER, This test will be conducted by applying 125Vac for 1min at input of VOLTAGE CONVERTER. There should not be any damage in the VOLTAGE CONVERTER.

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 VOLTAGE CONVERTER can withstand transient energy. This test will be conducted by ON/OFF of the VOLTAGE CONVERTER input. There should not be any damage in VOLTAGE CONVERTER.

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

Sudden Loading Test-

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

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)

VOLTAGE CONVERTER dc link Voltage Discharge- Resistor is provided in parallel to the capacitor for discharging the capacitor. When VOLTAGE CONVERTER 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

SL.NO	Equipment Name	Acceptance Criteria
1	VOLTAGE CONVERTER Control Card	Health LED's Should Glow
2	VOLTAGE CONVERTER PS Card	
3	Battery Charger Module	

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

SL.NO	Equipment Name	Acceptance Criteria
1	VOLTAGE CONVERTER Control Card	Health LED's Should Glow
2	VOLTAGE CONVERTER PS Card	
3	Battery Charger Module	

iii) Radio interference test

This test will be conducted on VOLTAGE CONVERTER **control card & Battery Charger module.** .

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

Procedure:

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

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)

VOLTAGE CONVERTER & BC 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 VOLTAGE CONVERTER & BC.

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

Test shall be conduct as per IEC 61287-1-7.5.2.

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

VOLTAGE CONVERTER & BC 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 VOLTAGE CONVERTER is working at full load, load shall be removed from VOLTAGE CONVERTER suddenly. There should not be any adverse effects in the VOLTAGE CONVERTER.

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

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.

Sl.No.	Equipment Name	Acceptance Criteria
1	VOLTAGE CONVERTER Control Card	Health LED's Should GLow
2	VOLTAGE CONVERTER Power Supply Card	
3	Battery Charger Module	

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
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**

25 Physical Dimensional Check

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

26 Equipment Number plate verification:

Equipment number plate is to be verified.

27 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:

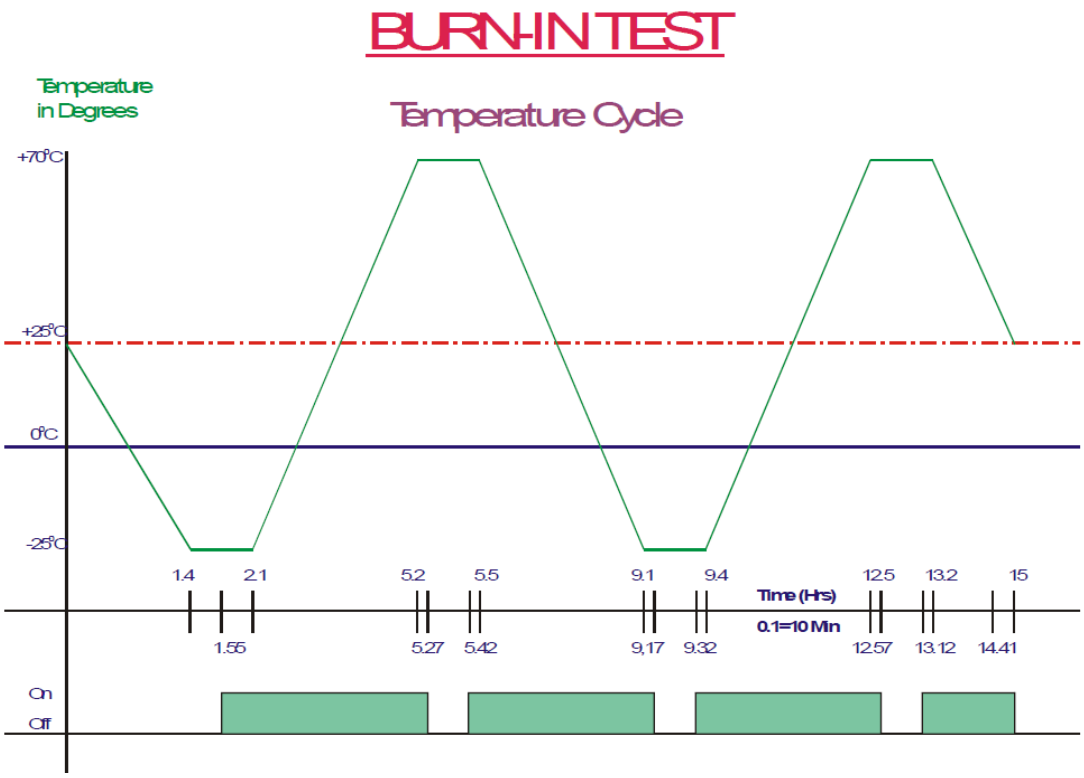
- No major damage shall occur.
- A performance check shall not show any failure or damage nor any results which are beyond the specified tolerances.

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 and clause no. 7.1 of the specification.

F. **Functional test:**

These tests will be carried out under simulated conditions at supplier's premises to establish that the APU is functioning as per the specification. The detailed functional test plan may vary from vendor to vendor based on their design. Hence, vendor shall submit the detailed functional test plan as per their design meeting the functional requirement of the specification for approval by RDSO before prototype test. On satisfactory completion of environmental and functional tests, the prototypes will be subjected to Loco Validation tests.

G. **Loco Validation test**

After successful prototype test as given above, the prototype shall be subjected to loco validation test. Clause 16 of the specification may be referred.

On satisfactory completion of the performance tests, the APU will be cleared by the inspecting authority for field trials.

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
Remove 12V battery connections and insulate the cables. Short all the terminals on the APU TB, except 12V battery -ve terminal. Also short the AVR term and join them with APU TB. Remove the connections at 12V alternator. Perform IR test between shorted terminals and APU body with 500V megger.	≥ 100 MΩ	

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	• APU Engine will run at	

simulator. • Main engine started normally in the Simulator. • Adjust BCP pressure more than 1.5 Kgs/Sq.cm. • Keep reversal handle in Neutral position. • After 10.5 minutes 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(Reverser Handle) in any working condition. • Main engine shall start automatically and APU Engine shall shut down.	1500+20RPM with load. • 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 l2V buttery 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, operate water level switch to generate 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".	

Note : The parameter of time and other given in the Functional test and Safety Function is subject to change after approval from RDSO.

6. Record the below parameter values from APU Screen during APU running:

EngRPM		APU ERPM		KMPH	
BAT_V		AGA_A		BAT_A	
LOW Tmp		EW Tmp		BC Pr	
MR.Pr		AIR Tmp			
		Loco Status			

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.

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

ANNEXURE – 2

Manufacturing Facilities for APU Micro Controller

The following facilities are considered essential for the manufacture of quality and reliability product of APU Micro Controller:

1. Dust fee environment for the assembly of PCBs
2. Component lead forming machine/fixture for assembly of PCBs.
3. Testing jigs for the testing of assembled PCBs along with measuring instruments for different parameters.
4. Temperature controlled wave-soldering machine with auto-fluxing facilities.
5. Dry heat test chamber
6. Functional testing of PCBs preferably with computer
7. Electro static discharge protection in line with IS: 10087-1981. Work procedure for following ESD practices needs to be submitted.
8. Automatic/light beam guided component insertion machine for PCBs or SMD pick and place machine whichever is applicable.
9. In circuit testing machine for checking the correctness of component inserted in PCBs.
10. SMD Soldering station for soldering surface mounted technology component.
11. ISO Certification from NABL Accredited agency.

All the above facilities are considered essential at the developmental stage and shall be verified by RDSO before considering the firm as a developmental source.

Note: If the APU controller is outsourced., the outsourcing firm should possess the minimum infrastructure given above and the name of the outsourcing firm should be part of the QAP of the APU Supplier. The discretion of permitting the outsourcing lies with RDSO/ vendor approving authority considering the capability of the firm for APU manufacturing and System Integration.

ANNEXURE – 3

TESTING EQUIPMENT

IN-HOUSE TESTING FACILITIES

The following instruments are considered for testing purpose.

1. Power analyzer
2. Storage type oscilloscope
3. Power factor meter
4. H.V. Tester
5. Humidity test Chamber (for 55DegC & upto 95%Rh)
6. Adequate number of Analog/Digital type meters to measure the current, voltage, power and frequency etc at a particular instant of time
7. Megger (500Volt)
8. Measuring Gauges such as Vernier caliper, micrometers, dial gauge, digital stopwatch, Thermometer, thermocouple etc.
9. Digital multimeter
10. Milivolt meters
11. Noise/Decibel meter
12. Testing facility for Water proofness (suitable to dip the entire unit in water)
13. Multi-channel Temperature Scanner (minimum 12 channels)
14. Complete test bench for measuring the different parameters
15. ISO Certification from NABL Accredited agency.

All the above facilities are considered essential at the developmental stage and shall be verified by RDSO.