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Heavy Plates & Vessels Plant
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INVITATION TO TENDER

::1::

Ref: OS/SC/2024-25/76/43 **Date: 10.08.2024**

Sub: Contract for conducting Qualification Tests (QT) on 1 Unit of Liquid Cooling System (2KW Module) for R&D, BHEL-HPVP, Visakhapatnam – Reg.

Tenders are invited under **two parts bid system**, Techno-Commercial Bid (Part-I) and Price Bid (Part-II) from the reputed and experienced contractors with sound technical and financial capability for the subject work.

SL. NO.	NAME OF THE WORK	Contract Period	LAST DATE FOR RECEIPT OF TENDER
01	Contract for conducting Qualification Tests (QT) on 1 Unit of Liquid Cooling System (2KW Module) for R&D, BHEL-HPVP, Visakhapatnam	**Six Months**	**16.08.2024** thru GeP NIC Portal

1. ELIGIBILITY CRITERIA:

I. Average annual turnover of the contractor duly certified by a practitioner-chartered accountant during the last 3 years ending 31st March 2023 should be at least. ₹10.00 Lakhs.

Tenderer should enclose PAN, GSTIN registration no., Income tax returns for last three years (AY-2021-22, 2022-23 & 2023-24) and Profit & Loss account and Balance Sheet certified by the Practicing Chartered Accountant for the last 3 years.

II. The Contractor should have experience of completing similar works during last 7 years ending 31st July 2024 as given below:

(a) Three similar completed works costing not less than the amount equal to ₹13.33 Lakh each

OR

(b) Two similar completed works costing not less than the amount equal to ₹16.66 Lakhs each

OR

(c) One similar completed work costing not less than the amount equal to ₹26.66 Lakhs

Work orders & Job Completion Certificates from the customer shall be enclosed in support of successful and satisfactory completion of the orders.

Note:

1. **Work orders & Job Completion Certificates from the customer shall be enclosed in support of successful and satisfactory completion of the orders.**
2. **Similar work means carrying out qualification test for Modules or Similar Systems as mentioned in the tender in State/ Central Govt. / undertakings or private firms**

III. The works executed in the own name of the tenderer will only be considered for eligibility criteria.

IV. Test facilities of at least any 12 facilities out of 31 tests must be available at the vendor works. Proof is to be submitted.

2. SCOPE OF WORK:

Work is to be carried out as per Scope of Work (Annexure – I), GCC and Schedule of Quantities & Rates.

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Ref: OS/SC/2024-25/76/43 **Date: 10.08.2024**

3. LOCATION OF WORK:

a. The subject work is to be carried out at Vendor works.

b. **Sending & receiving of Items/ Equipment for testing to vendor's work are in the scope of BHEL-HPVP, Visakhapatnam.**

c. Vendor is responsible for equipment transportation from vendor works to other labs or his sub vendor works to conduct the tests as part of qualification testing

4. INSPECTION:

Inspection shall be carried out by M/s. BHEL-HPVP, Visakhapatnam / Authorized Inspection Agency as per applicable QAP and relevant documents.

5. CONTRACT PERIOD:

Contract is valid for a period of **Six months** from the date of work order or intimation from Engineer-in-Charge, whichever is later.

Completion Period:

All tests are to be completed within two months from handing over of the item at vendors work.

6. LIQUIDATED DAMAGES:

In the event of any delay in completion of work or part thereof as per the contractual completion period due to the reasons attributable to contractor, BHEL - HPVP shall have the right to impose Liquidated Damage at the rate of 0.5% of the total value for every complete week of delay or part thereof subject to a maximum of 10% of the total executed value during delay period.

7. EARNEST MONEY DEPOSIT: Not applicable

8. SECURITY DEPOSIT:

A. Security deposit means the security provided by the contractor towards fulfilment of any obligations in terms of the provisions of the contract.

B. The total amount of the security deposit will be **5%** of the contract value. EMD of the successful tenderer (if any) shall be converted and adjusted towards the required amount of Security deposit.

C. **Modes of Deposit:**

The required amount of Security Deposit of **5%** of the contract value may be accepted in the following forms:

a) Cash (as permissible under the extant Income Tax Act)

b) Local Cheques of Scheduled Banks (subject to realization)/ Pay Order/ Demand Draft/ Electronic Fund Transfer in favour of BHEL.

c) Bank Guarantee from Scheduled Banks/ Public Financial Institutions as defined in the company's act. The bank guarantee format should have the approval of BHEL.

d) Fixed Deposit Receipt issued by Scheduled Banks/ Public Financial Institutions as defined in the company's act (FDR should be in the name of the contractor, a/c BHEL.

e) Securities available from Indian Post offices such as National Savings Certificates, Kisan Vikas Patras etc. (held in the name of Contractor furnishing the security and duly endorsed/ hypothecated/ pledged, as applicable, in favour of BHEL)

f) Insurance Surety Bonds.

(**Note:** BHEL will not be liable or responsible in any manner for the collection of interest or renewal of the documents or in any other matter connected therewith)

D. **Collection of Security deposit**:

At least 50% of the required Security Deposit, including the EMD, should be collected before start of the work. Balance of the Security Deposit can be collected by deducting 10% of the gross amount progressively from each of the running bills of the Contractor till the total amount of the required Security Deposit is collected.

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In case of delay in submission of performance security, enhanced performance security which would include interest (Repo rate + 4%) for the delayed period, shall be submitted by the bidder.

If the value of work done at any time exceeds the contract value, the amount of Security Deposit shall be correspondingly enhanced and the additional Security Deposit shall be immediately deposited by the Contractor or recovered from payment/s due to the Contractor.

The recoveries made from running bills (cash deduction towards balance SD amount) can be released against submission of equivalent Bank Guarantee in acceptable form, but only once, before completion of work, with the approval of the authority competent to award the work.

Note: In case of (a) small value contracts not exceeding Rs. 20 lakhs or (b) SAS jobs, work can be started before the required Security Deposit is collected. However, payment can be released only after collection/ recovery of initial 50% Security Deposit.

E. **Refund of Security Deposit:**

i. The security deposit shall be refunded after successful completion of the Contract as per agreement and subject to deduction of any amount due to BHEL.

ii. Security deposit shall not be refunded to the Contractor except in accordance with the terms of the Contract.

iii. The successful tenderers shall furnish Security Deposit within 15 days from the date of Work Order / Letter of Intent. The Security Deposit shall be furnished by the successful tenderers before commencement of work by them.

iv. The security deposit shall not carry any interest.

Note: Acceptance of Security Deposit against Sl. No. (d) and (e) above will be subject to hypothecation or endorsement on the documents in favour of BHEL. However, BHEL will not be liable or responsible in any manner for the collection of interest or renewal of the documents or in any other matter connected therewith).

F. Security Deposit / Bank Guarantee will be released after the maintenance **period of 2 months** or **on closure of contract whichever is later.**

9. PAYMENT TERMS:

Bill payments will be arranged within 45 days for MSE (Micro/Small), 60 days for Medium Enterprise, 90 days for non-MSEs from the date of submission of correct/ complete bill with all relevant documents to Engineer-in-Charge.

Bills (RA/Final Bill) to be submitted to Engineer-in-charge along with following documents:

R A Bill / Final Bill

a) Invoice
b) Job completion certificate issued by the Engineer-in-charge.
c) Proof of GST payment as per annexure - GST.
d) RTGS form
e) WAM 06/ WAM 07 (for Final Bill) duly filled & signed
f) For any reduction in the Invoice value, Credit Note (under GST Act) to be issued by vendor and vice versa.
g) In case of release of security deposit, WAM-10 to be filled and submitted (final Bill)
h) No dues & No claim Certificate (final Bill).

Note: Final bill means last month bill for service contracts. In case of works, final bill means bill for finally executed quantity. All payments will be released only through RTGS / NEFT only.

10. INCOME TAX:

Income tax as per statutory requirement will be deducted on each payment made to the contractor and TDS certificate will be issued to this effect.

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11. TDS ON GST:

TDS on GST amount as per statutory requirement as applicable will be deducted on each payment made to the contractor. Present TDS on GST is 2%.

12. PRICE SCHEDULE, TAXES & DUTIES:

a. Prices shall be quoted **in e-procurement Portal** as per price schedule attached to the tender.

b. The quoted prices shall be **exclusive of GST**. However, GST as applicable shall be payable by contractor & the same will be reimbursed as per **Annexure - GST**.

c. In addition to existing taxes, any new taxes imposed by Central/ State Govt. shall be payable by the contractor and same shall be reimbursed on submission of relevant documents/proof of payment.

d. In case, any new tax is imposed instead of existing tax, difference of the amount shall be reimbursed/ recovered on submission of documentary evidence.

e. Any new tax is imposed by Central/ State Govt. or there is any variation in taxes after expiry of delivery / contract period, the same shall be borne by contractor only.

f. All terms & conditions of the contract in respect of taxes & duties are subject to new taxation laws introduced time to time by Govt. and terms & conditions will deemed to be modified in accordance with the provisions of New Laws (i.e., GST).

g. The quoted prices shall be fixed & firm without any escalation during the entire period of contract and till completion of the work.

13. VALIDITY OF OFFER:

The offer shall be valid for a period of **3 months** from the last date for tender submission.

14. RISK PURCHASE:

In case the contractor fails to execute the work due to any reason, BHEL reserves the right to get the same completed through some other party at the risk & cost of the contractor and any additional expenditure incurred due to the same shall be charged to the contractor. Risk & Cost will be implemented as per STANDARD OPERATING PROCEDURE FOR IMPLEMENTATION OF RISK & COST of BHEL.

15. GENERAL:

a) Bidders shall confirm their acceptance to all the terms & conditions of the tender enquiry.

Deviations to the tender conditions are not acceptable and BHEL-HPVP reserves the right to reject such offers which do not meet Technical / Commercial requirements without any / further correspondence**.**

Bids not accompanied with requisite documents, delayed bids, incomplete / conditional offers, bids not conforming to the terms & conditions specified in the tender documents are liable for rejection.

b) BHEL reserves the right to modify or cancel or short close the tender at any stage at its discretion without assigning any reason thereof.

c) The bidders shall study the tender documents, drawings and all other relevant documents in detail for understanding the scope of work involved in various items before submission of offers.

For any clarifications required on this tender document, scope of work etc., the bidders shall depute their authorized representatives to HPVP, Visakhapatnam with prior intimation to get clarifications from concerned authorities.

d) **Manager (Engg-R&D**) shall be the Engineer-in-charge for herein after referred to as such in the tender. Contact details: Ph: 0891- 288 1149, email: satishd@bhel.in

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e) Lowest offer need not be the rate acceptable to BHEL-HPVP and BHEL-HPVP reserves the right for negotiation with the L1 bidder.

f) The following documents (enclosed) shall form part of the contract including this Notice Inviting Tender: -

PART - I: TECHNO COMMERCIAL BID

a) Scope of Work : Annexure – I
b) General Conditions of Contract (Works/Service) : Annexure – II
c) Acceptance to the tender terms & conditions : Annexure – III
d) Contractor Information : Annexure – IV
e) Check List : Annexure – V
f) Service Level agreement & GTC of GeM: to be downloaded from GeM Portal.

PART - II: PRICE BID

g) Price Bid (Schedule of Quantities & Rates) : Annexure – VI

g) Submission of offer by a tenderer implies that all the tender documents were read by the tenderer and the tenderer is aware of the scope and specifications of the work, site condition, local conditions and rates at which stores, tools and plant, free / chargeable materials etc., will be issued to him by BHEL - HPVP and other factors having bearing on the execution of the work.

16. TENDER SUBMISSION AND OPENING OF TENDERS:

Bidders shall submit bids on or before the due date, prescribed in GeP NIC (BHEL e-procurement) Portal. Techno-commercial Bids will be opened on **16.08.2024** at prescribed time in GeP NIC (BHEL e-procurement) Portal

17. REVERSE AUCTION:

A. BHEL shall be resorting to Reverse Auction (RA) (**Guidelines as available on https://www.bhel.com/guidelines-reverse-auction-2021)** for this tender. RA shall be conducted among all the techno-commercially qualified bidders.

Price bids of all techno-commercially qualified bidders shall be opened and same shall be considered as initial bids of bidders in RA. In case any bidder(s) do(es) not participate in online Reverse Auction, their sealed envelope price bid along with applicable loading, if any, shall be considered for ranking." This will be decided after techno-commercial evaluation. Bidders have to give their acceptance with the offer for participation in RA. Non-acceptance to participate in RA may result in non-consideration of their bids, in case BHEL decides to go for RA. Those bidders who have given their acceptance to participate in Reverse Auction will have to necessarily submit 'Process compliance form' (to the designated service provider).

B. PROCEDURE OF REVERSE AUCTIONING:

1) Price bids of all techno-commercially qualified bidders shall be opened.
2) Reverse Auction: The 'bid decrement' will be decided by BHEL.
3) The lowest bidder in sealed envelope price bid shall be shown as current L1 automatically by the system and no acceptance of that price is required. System shall have the provision to indicate this bid as current L1.
4) Bidders by offering a minimum bid decrement or the multiples thereof can displace a standing lowest bid and become "L1" and this continues as an iterative process. However, no bidder shall be allowed to lower its bid below the current L1 by more than 5 decrements at one go.
5) After the completion of the reverse auction, the Closing Price shall be available for further processing.

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6) Wherever the evaluation is done on total cost basis, after Reverse Auction, prices of individual line items shall be reduced on pro-rata basis.

C. REVERSE AUCTION PROCESS:

1) Reverse Auction will be conducted if two or more bidders are techno-commercially qualified.
2) In case of two or three qualified bidders, there shall be no elimination of H1 bidder (whose quote is highest in sealed envelope price bid).
3) In case of four qualified bidders, the H1 bidder shall be eliminated whereas in case of five qualified bidders, H1 & H2 bidders shall be eliminated.
4) In case of six or more qualified bidders are available, RA would be conducted amongst first 50% of the bidders arranged in the order of prices from lowest to highest. Number of bidders eligible for participating in RA would be rounded off to next higher integer value if number of qualified bidders is odd (e.g. if 7 bids are qualified, then RA will be conducted amongst lowest four bidders).
5) However, there will be no elimination of qualified bidders who are MSE or qualifying under PPPMII, Order 2017, provided their bids are within their respective margin of purchase preference {presently 15% for MSEs and 20% for PPP-MII, or as amended from time to time}.
6) In case of multiple H1 bidders, all H1 bidders (except MSEs and bidders qualifying under PPPMII, Order 2017, who are within the margin of purchase preference) shall be removed provided minimum two bidders remain in fray, else no H1 removal.
7) The lowest bidder in sealed envelope price bid shall be shown as current L1 automatically by the system. System shall have the provision to indicate this bid as current L1 for further bidding. This price can be displaced by an even lower bid of a competing bidder.
8) Start price for RA shall be lowest of sealed envelope price bid. Note: Wherever more than one lowest sealed envelope price bids are identical, RA committee shall declare the start price by reducing the lowest sealed envelope price bid by maximum of one decrement.
9) If the start price is lower than the lowest sealed envelope price bid (in line with clause 8), on acceptance of such start price by any bidder this bid would be indicated as current L1 for further bidding. However, if no bidder accepts the start price, RA shall be treated as cancelled for the respective line item(s) and the tender shall be processed accordingly.
10) In case of no further bidding, RA will be deemed to have been successful with current L1 bidder. During RA, all bidders will see their rank and current L1 price on the screen. Once the RA is done, the ranking status would be based on the last quoted price of the bidder(s) irrespective of the quote received in RA or sealed envelope price bid.
11) No bidder shall be allowed to lower its bid below the current L1 by more than 5 decrements at one go.

For detailed Guidelines visit our website*:* https://www.bhel.com/guidelines-reverse-auction2021

18. The Bidder declares that they will not enter into any illegal or undisclosed agreement or understanding, whether formal or informal with other Bidder(s). This applies in particular to prices, specifications, certifications, subsidiary contracts, submission or non-submission of bids or any other actions to restrict competitiveness or to introduce cartelization in the bidding process.

In case, the Bidder is found having indulged in above activities, suitable action shall be taken by BHEL as per extant policies/ guidelines.

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ANNEXURE – I

Ref: OS/SC/2024-25/76/43 **Date: 10.08.2024**

SCOPE OF WORK

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1. Vendor shall perform all qualification tests (QT) of sample/ component as per the following documents.
    a. QTP-ACM-001
    b. QTP-LCS-LCU-001
    c. ATP-ACM-001
    d. ATP-LCS-LCU-001
    e. DARE/SRK/031/REP/05

    List of tests are mentioned at sl no. 17 of this annexure
2. The bidder should have experience of performing similar tests in Airborne Application (with similar specification) for aerospace industry in last 5 years from the tender issue date. Un-priced PO copy & work completion certificate shall be submitted along with the bid as part of PQC (Pre-Qualification Compliance) for testing.
3. Details of inhouse test facilities and external test facilities (in case, the test is offloaded by vendor due to non-availability of test facility at vendor works) shall be submitted along with Bid.
4. BHEL will provide only 1 No. of test sample/component for testing. Vendor shall perform all tests as specified in Sl. No.1 on sample provided by BHEL in vendor's test facility. All machines, fixtures, materials, instruments, manpower, Accessories, tools and tackles, any other items required for testing shall be arranged by vendor.
5. In case test sample is failed while testing, BHEL will provide another sample and vendor shall perform balance tests on new equipment.
6. Vendor is responsible for transportation of equipment from vendor works to other labs to conduct the tests as part of qualification testing.
7. Vendor shall comply all the conditions of Annexure-1 of AS9100.
8. Tests listed under section 9.3 of ATP-ACM-001 shall be carried out on ACM module during Pre and Post individual qualification tests to verify integrity. And refer ATP-LCS-LCU-001 for LCU module. (Ref. Remarks column in Sheet 2).

    The functional tests to be carried out for ACM and ECU at CASDIC, Bangalore and Mistral labs, Bangalore respectively as part of QT, will be coordinated by BHEL for arranging the respective lab facilities. The tests in CASDIC and Mistral will be performed by BHEL. However, logistics for the equipment shall be arranged by vendor.
9. BHEL will supply the rig for functional test (which is part of acceleration test (Structural)) of LCU Module.
10. BHEL will provide the case for Transit Drop test.
11. Vendor shall provide the valid calibration reports, NABL approvals of the test rigs, schematic details of test rigs, schematic details of testing method before start of testing for reference.
12. Vendor shall inform to BHEL 2 weeks in advance about the schedule of the test. BHEL, CASDIC & AQA personal will witness the testing. Necessary entry passes shall be arranged by vendor in case the test is being carried out at another facility.
13. The Dimensional Details of test sample are specified below.
    a. ACM Module: 420 x 360 x 650 mm – ~25kg
    b. LCU Module: 230 x 230 x 350 mm - ~8kg
    c. ECU Module: 300 x 200 x 100 - ~3kg
14. BHEL will provide the final approved documents (QTP-ACM-001, QTP-LCS-LCU-001 along with PO.
15. Mil grade power source shall be used during testing. The Rating of power source shall be as follows as minimum (115/200 V, 400 Hz 3-phase AC prime power).

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SCOPE OF WORK

16. Crash Hazard Test shall be performed on sample as a last test.

17. Following test are to be carried out:

A. ACM MODULE TESTS

1) Thermal shock test
2) Rain drip test
3) Fungus test
4) Salt fog test
5) Transit drop test
6) Bench handling test
7) Fluid contamination test
8) Blowing dust test
9) Humidity test

B. **LCU TESTS**

1) Thermal shock test
2) Rain drip test
3) Fungus test
4) Salt fog test
5) Transit drop test
6) Bench handling test
7) Fluid contamination test
8) Blowing dust test
9) Humidity test
10) Random Vibration Test
11) Acceleration Test (Structural)
12) Mechanical Shock Test (Functional)
13) MECHANICAL SHOCK TEST (Crash Hazard Test)

C. ECU TESTS

1) Thermal shock test
2) Rain drip test
3) Fungus (Mould Growth) Test
4) Salt fog test
5) Transit drop test
6) Bench handling test
7) Fluid contamination test
8) Blowing dust test
9) Shock Crash Hazard

18. **OTHER TERMS & CONDITIONS TO COMPLY AS9100 GUIDELINES FOR SUPPLY:**

a) Supplier shall have approvals of methods, process and equipment used for the manufacturing of items to be supplied to BHEL.
b) The control and monitoring of supplier performance by BHEL, Visakhapatnam.
c) Supplier should provide access to BHEL or its customer or its any regulatory authority for verification or validation of activities and to check applicable records at the supplier premises at any level of supply chain.
d) Supplier shall carry out test inspection and verification including FAI.
e) Supplier should implement a Quality Management System.

Contd….3

SCOPE OF WORK

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f) **Insurance for damage / theft in vendors work or their sub vendors work shall be borne by vendor.**
g) Supplier shall notify BHEL of any Non-conforming process, products or services and obtain approval for disposition.
h) Supplier should prevent use of counterfeit parts.
i) Supplier shall notify BHEL of any product, process or service change including changes made by their suppliers or change in location of manufacture and obtain approval.
j) Supplier shall flow down to their supply chain to implement requirements of BHEL by sharing the specification.
k) Retention period of all records shall be 10 years.
l) Supplier shall keep records of all interaction with BHEL
m) Supplier shall ensure awareness of the following to all the people at supplier premises:
    i. Contributing to product or service conformity
    ii. Contributing to product safety
    iii. Importance of ethical behaviour

Following documents are attached for reference:

a. QTP-ACM-001
b. QTP-LCS-LCU-001
c. ATP-ACM-001
d. ATP-LCS-LCU-001
e. DARE/SRK/031/REP/05

PENDING QUALIFICATION TEST PROCEDURE

FOR

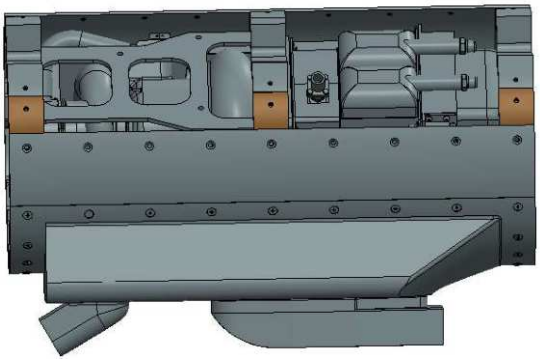
ACM MODULE OF 2 KW AIR CYCLE MACHINE BASED LIQUID COOLING SYSTEM

(PART No. 2041 101 000)

(Sl No. 02)

Doc No: QTP-ACM-001

PROJECT- SRK



Bharat Heavy Electricals Ltd. **HPVP, Visakhapatnam**	**Combat Aircraft Systems Development & Integration Centre (CASDIC) DRDO, Bangalore**

Contents

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1 INTRODUCTION

BHEL has developed the 2KW ACM Module based liquid cooling system as per CASDIC specification DARE/MED/041/REP/36 dated 04-05-2020. The cooling system consists of 4 LRU's

- Air cycle Machine (ACM) Module P/N 2041 101 000
- Liquid circulation Module P/N 2041 102 000
- Phase change material heat exchanger P/N 2041 103 000
- Electronic control unit P/N 2041 104 000

1.1 SCOPE

This document brings out the list of qualification tests to be carried out on the ACM Module P/N 2041 101 000.

1.2 OVERVIEW OF ITEM

The 2 KW Air Cycle Machine Module generate the cold air from ram air using an air cycle machine positioned in the module. The module also houses an Air to Liquid Heat Exchanger (ALHE), control valves, temperature sensors, ground cooling fan etc. The hot coolant from the heat load is sent to the air to liquid heat exchanger and cold air from the air cycle machine is sent to ALHE for taking away the heat from the coolant. The control valve is used to regulate the flow either to the ACM inlet or directly to the heat exchanger depending on the mode of operation of the system. A ground cooling fan is provided to enable circulation of air through the ALHE during the ground mode of operation.

1.3 REFERENCE DOCUMENT

- Technical Specification for the 2 KW Air Cycle Machine based Liquid Cooling System for Pod application DARE/MED/041/REP/1 –R3
- Technical Specification for the ACM Module of 2 KW Cooling System for Pod application DARE/MED/041/REP/24 Rev 1.0 Dt 04-03-2024
- Limited qualification test procedure for ACM module of 2KW ACM Based liquid cooling system LQTS-ACM-001 Dt 31.08.2021
- Limited qualification test report for ACM Module of 2KW ACM based liquid cooling system LQTR/ACM/001
- Acceptance test procedure for ACM module of 2KW ACM Based liquid cooling system ATP-ACM-001 Rev 1.0 Dt 26.06.2023
- Functional test procedure for ACM module of 2KW ACM Based liquid cooling system LCS-FTP-001 Rev 0.0 Dt 19.10.2021

1.4 ACM MODULE SPECIFICATION

- Size : Ø200 x 250 mm.
- Weight :< 6 kg.

1.5 TEST TO BE CODUCTED

Sl.No.	TYPE OF TEST
1	Thermal shock test
2	Rain drip test
3	Fungus test
4	Salt fog test
5	Transit drop test
6	Bench handling test
7	Fluid contamination test
8	Humidity test
9	Blowing dust test

1.6 QUALIFICATION TESTING DETAILS

Sl. No.	TEST & PROCEDURE	SEVERITY	DURATION	REMARKS	Test conducted on LQT / QT
1	Thermal shock Test *Procedure:MIL-810F Method-503.4 Procedure-II*	Stabilize at -40°C, soak for 1 hour. Transfer and stabilize at +65°C and soak it for 1 hour. Transfer it to -40°C for 1 hour. This constitutes 1 cycle	3 cycles	Transfer from low temperature to high temperature chamber and vice versa is to be effected within 5 minutes	To be conducted as part of QT

Sl. No.	TEST & PROCEDURE	SEVERITY	DURATION	REMARKS	Test conducted on LQT / QT
2	Rain-Drip Test *Procedure:MIL-810F Method-506.4 Procedure-II*	Volume flow rate 250 to 280 lit/m^2/Hour. Dispenser placed approximately 1 meter above equipment	15 minutes (Configuration as installed on the aircraft)	. --	To be conducted as part of QT
3	Fungus (Mould Growth) Test *Procedure:MIL-810F Method-508.5*	The spore suspension will be prepared using Fungi	Wet the entire surface of test item with spore suspension for 10 mins. Incubation period 28 days at 30°C, 95% RH	• This test can be carried out on representative samples of parts used in equipment. .	To be conducted as part of QT
4	Salt Fog Test *Procedure:MIL-810F Method-509.4*	Salt solution of 5±1% concentration -24 Hours exposure & -24 Hours drying constitute one cycle	2 cycles	• Composition of salt for preparation of solution shall be with NaCl solution containing not greater than 0.1% Sodium Iodide & not greater than 0.5% Impurities • Drying shall be at prevailing ambient conditions	To be conducted as part of QT
5	Transit Drop Test *Procedure:MIL-810F Method-516.5 Procedure-IV*	For equipment lighter than 45.4 kg Height of Drop 122 cm	26 drops (1 drop/each face, edge & corner)	The Equipment shall be tested with an approved packing box	To be conducted as part of QT
6	Bench Handling Test *Procedure:MIL-810F Method-516.5 Procedure-VI*	Raise one edge by 10 cm or 45°C whichever is less	4 drops on each face	• Applicable only when any of the dimension is greater than 23 cm	To be conducted as part of QT

Sl. No.	TEST & PROCEDURE	SEVERITY	DURATION	REMARKS	Test conducted on LQT / QT
7	Fluid Contamination Test *Procedure:MIL-810F Method-504.1*	Test Temperature:65°C± 3°C Test Fluids i. EGW 65:35	7 days/test fluid	This test can be carried out on representative samples of parts used in equipment. This test is done for the POD Shell in which the equipment is kept	To be conducted as part of QT
8	Humidity Test *Procedure:MIL-810F Method-507.4 Procedure-III*	Temperature: 30°C to 60°C RH: 85% to 95% Temperature, Humidity diurnal cycle as per Fig 37	10 cycles		To be conducted as part of QT
9	Blowing Dust Test *Procedure:MIL-810F Method-510.4 Procedure-II*	Blowing Dust Air Velocity 1.5 m/sec to 8.9 m/sec. RH= 30%	6 Hrs. at 23^0C	• Dust concentration 10.6±0.7 grams/m3 • Material of Dust: Silicon Dioxide or China Clay • Test applicable only for externally mounted LRUs. • Alternately this test can be carried out as per JSS55555.	To be conducted as part of QT

2.1 THERMAL SHOCK TEST

The thermal shock test will be carried out as per MIL- 810F Method-503.4, procedure II

Test Procedure

Step 1: Place the test item in the thermal chamber and adjust the chamber air temperature to the low temperature (T1) at a rate not to exceed 3°C/min. Stabilize the temperature for a period of 1 hour.
Step 2: Stabilize at-40 ^{O}C sock for 1 hour. Transfer and stabilize at+65 ^{O}C for 1hour
Step 3: Transfer the test item in no more than one minute to an atmosphere at temperature (T2) that will produce the thermal shock specified in the test plan, and stabilize the temperature for a period of 1 hour.
Step 4: Transfer the test item back to the T1 environment in less than one minute. Stabilize the temperature for a period for 1 hour
Step 5: Repeat steps 1-3 twice, so that the unit is subjected to a total of 3 cycles thermal shocks.
Step 6: Return the test item to standard ambient conditions.
Step 7: Examine the test item visually for defects and perform integrity check.

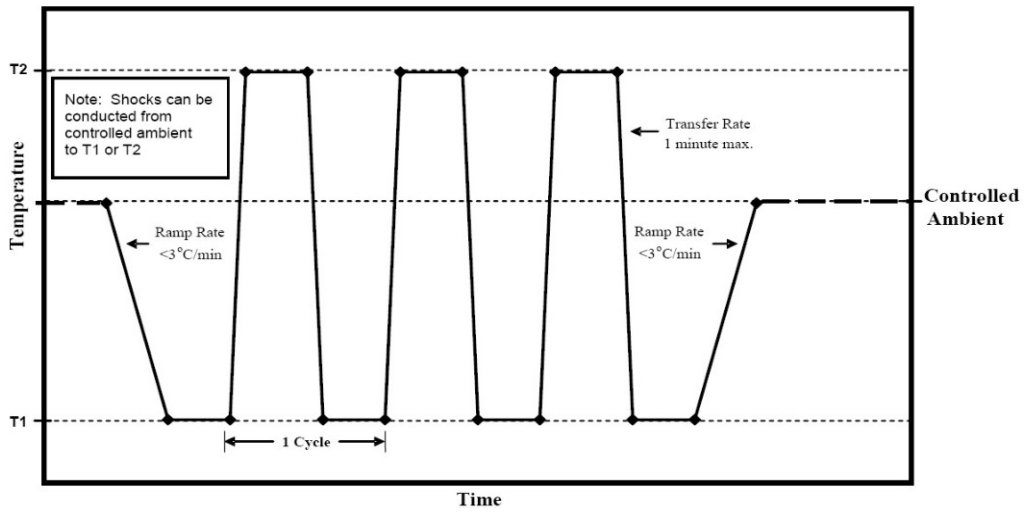


Figure:Thermal shock Test Profile

Note: The value of T1 and T2 will be taken as -40 ºC and +65 ºC respectively.

Test Interruption

Follow any interruption by re stabilization at the identified levels and continuation of the test from the point of the interruption. If the interruption occurs during the transfer reestablish the item at the previous temperature and then do the transfer.

Acceptance Criteria

- Integrity checks as per section 9.3 of the ATP-ACM-001 shall be satisfactory pre and post the test

2.2 RAIN DRIP TEST

Rain drip test needs to be carried out as per MIL- 810F Method-506.4 Procedure-III

The test item configuration should be as similar to the condition during actual use as per section 2.3.1 under method 506.4 MIL 810F. Hence the electrical connectors in the ACM module will be engaged with mating connectors. The top and side open faces of the ACM module will be covered with appropriate covers to mimic its installation within the pod.

Test Conditions

- Water Fall Rate: 205 to 280 ltr/mtr^2/hr
- Duration: 15 min.
- Dispenser should be placed approximately 1 meter above equipment

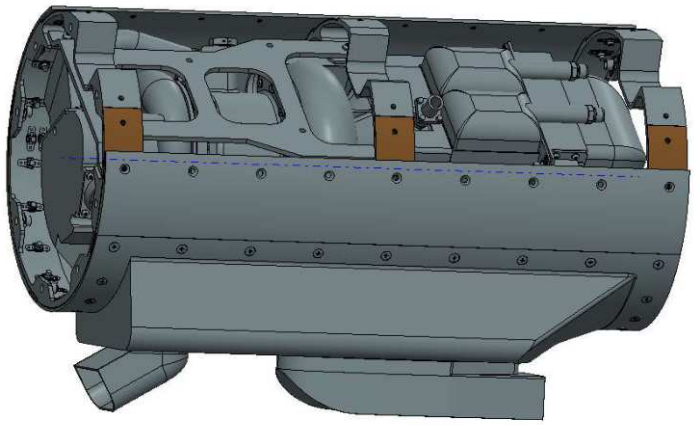


Figure: All faces of ACM Module to be covered to emulate its installation in ASPJ Pod

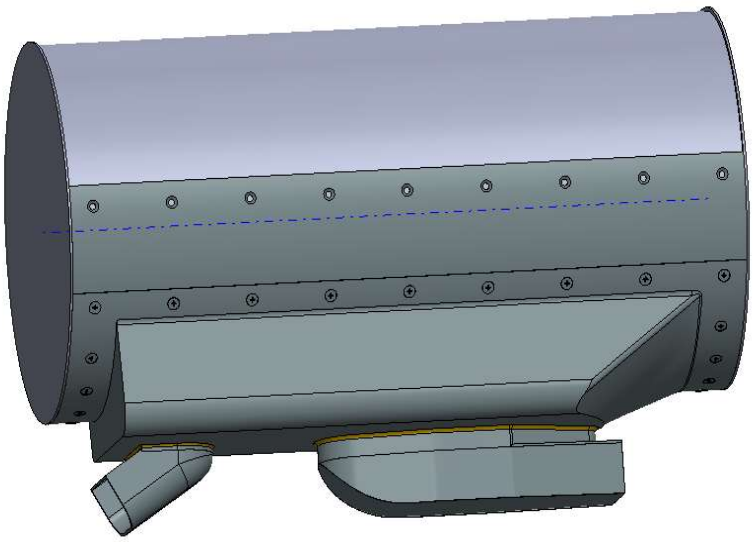


Figure: ACM module covered to Emulate pod installation

Test Procedure

Step 1: The UUT while being under the laboratory atmospheric conditions shall be introduced into the rain drip test chamber, the latter also being under the same conditions.

Step 2: UUT shall then be exposed to rain drip test for 15 min at a water fall rate of 280 ltr/mtr^2/hr from a height of 1 meter and unit shall be non-operational.
Step 3: After completion of the test, the unit shall then be removed from the chamber and shall be allowed to remain under standard conditions for a period of 2 Hours.
Step 1: The unit shall be examined for corrosion and deterioration of metal parts, finishes, materials and components.

Acceptance Criteria

- Integrity checks as per section 9.3 of the ATP-ACM-001 shall be satisfactory pre and post the test.

2.3 FUNGUS TEST

The test needs to be carried out as per MIL- 810F Method-508.5

This test is carried out on representative samples of parts used in equipment. Alternatively, if material analysis reveals that the material is not a nutrient to any fungus listed in table below, then this test can be dispensed with.

Following samples of the ACM Module will be subjected to fungus test,

- Sample of Aluminum alloy 6061 T6 and 2014 T6 anodized as per MIL A 8625F
- Sample of Aluminum alloy 6061 T6 and 2014 T6 anodized as per MIL A 8625F and painted with paint and primer.
- Sample of O Rings material used in ACM Module
- Sample of Gaskets used in ACM Module
- Sample of Anchor nuts used in ACM Module
- Sample of Screws used in ACM Module.

Following types of fungus will be utilized-

SL.NO.	NAME OF CULTURE	STRAIN
1	Apergilius Niger	V.Tieghem
2	Apergilius Terrens	Thom
3	Aureobasidium Pullulans	(De Barry)Arnaud
4	Paecilomyces Varietal	Bainer
5	Pencillium Funiculosum	Thom
6	Pencillium Ochro-Chloran	Biourge
7	ScopularioPsisBrevicaulis	Bain VarGlabra
8	TrichodermaViride	Pers-ex Fr

Test Procedure

Preparation for incubation-

Step 1: Assure the condition of the items to be tested is similar to their condition as delivered by the manufacturer or customer for use, or as otherwise specified. Accomplish any cleaning of the test item at least 72 hours before the beginning of the fungus test to allow for evaporation of volatile materials.

Step 2: Install the test item in the chamber or cabinet on suitable fixtures, and remove any covers.

Step 3: Hold the test item in the test chamber at 30 °C and RH of at least 95 percent but less than 100 percent for at least four hours immediately before inoculation.
Step 4: Inoculate the test item and the cotton fabric chamber control items with the mixed fungus spore suspension by spraying the suspension on the control items and on and into the test item(s) (if not permanently or hermetically sealed) in the form of a fine mist from an atomizer or nebulizer. Ensure personnel with appropriate knowledge of the test item are available to aid in exposing its interior surfaces for inoculation.
Step 5: In order for air to penetrate, replace the covers of the test items without tightening the fasteners.
Step 6: Start incubation immediately following the inoculation.

NOTE: In spraying the test and control items with composite spore suspension, cover all external and internal surfaces that are exposed during use or maintenance. If the surfaces are non-wetting, spray until drops begin to form on them.

Incubation of the test item -
Step 1: Except as noted in Step 2 below, incubate the test items at constant temperature and humidity conditions of 30 °C and a relative humidity of at least 95 percent but less than 100 percent for the test duration (28 days).
Step 2: After 7 days, inspect the growth on the control cotton strips to verify the environmental conditions in the chamber are suitable for growth. At this time, verify that at least 90 percent of the surface area of each test strip located at the level of the test item is covered by fungus. If it is not, repeat the entire test with the adjustments of the chamber required to produce conditions suitable for growth. Leave the control strips in the chamber for the duration of the test.
Step 3: If the cotton strips show satisfactory fungus growth after 7 days, continue the test for the required period from the time of inoculation as specified in the test plan. If there is no increase in fungus growth on the cotton strips at the end of the test as compared to the 7-day results, the test is invalid.

Inspection -
At the end of the incubation period, inspect the test item immediately. If possible, inspect the item within the chamber. If the inspection is conducted outside of the chamber and is not completed in 1 hour, return the test item to the test chamber or to a similar humid environment for a minimum of 2 hours. Except for hermetically sealed materiel, open the test item enclosure and examine both the interior and exterior of the test item. Record the results of the inspection.

Acceptance Criteria

- Material should not show degradation post the fungus test.

2.4 SALT FOG TEST

The test is conducted as per MIL-810G Method-509.5

The salt fog method is performed to determine the effectiveness of protective coatings and finishes on materials.

Since the ACM Module is installed as part of the ASPJ Pod, the internal components of the ACM Module are not exposed to Salt fog directly. The open faces of the ACM Module should be covered appropriately as before subjecting it to salt fog test. This is done to emulate the same installation condition of the ACM module as that in ASPJ Pod.

Test Conditions

Standard Exposure: 24 hrs
Drying shall be at prevailing ambient conditions
No of cycles: 2 [24 hours of exposure and 24 hours drying form one cycle]
Salt Concentration: 5% ± 1% by weight neutral NaCl solution containing not greater than 0.1% Sodium iodide & not greater than 0.5% Impurities in 95% of water
Chamber Temperature: +35°C ± 2°C

Test Procedure

Step 1: The samples while being under the laboratory atmospheric conditions shall be introduced into the salt spray test chamber.
Step 2: The samples shall then be exposed to salt mist, as per the specified test conditions. Conduct the test for 2 cycles.
Step 3: The samples shall then be removed from the chamber and shall be allowed to remain under standard conditions for a period of 2 to 4 Hours.
Step 4: The samples shall be examined for corrosion and deterioration of metal parts, finishes, materials and components.
Step 5: Composition of salt for preparation of solution shall be with NaCl solution containing not greater than 0.1% sodium Iodide & not greater than 0.5% Impurities.

Acceptance Criteria

The ACM Module shall not exhibit any discoloration of the surface finish, corrosion and deterioration of metal parts, finishes, materials and components.

2.5 TRANSIT DROP

Test is carried out as per MIL-810F Method-516.5 Procedure-IV

The 26-drop requirement (table 516.5-VI) may be divided among up to five samples of the same test item in any combination.
Height: 122 cm, No of drops: 26 (For equipment lighter than 45.5 kg)

Test Procedure

Step - 1: The unit shall be fastened to the packing case and shall be subjected to a Transit Drop Test in accordance with the above test conditions.

Acceptance Criteria

- After completion of the test, unit shall be free from physical deformation and discoloration of the surface finish. Integrity checks as per section 9.3 of the ATP-ACM-001 shall be satisfactory pre and post the test

2.6 BENCH HANDLING

Test needs to be carried out as per MIL-810F Method-516.5 Procedure-VI

Procedure VI brings out that the drops are to be carried out on each face on which the test item could be placed practically during serving. Since the ACM module resembles a cylinder, there are three faces on which it could be placed practically during service as shown in figure 35 and 36.

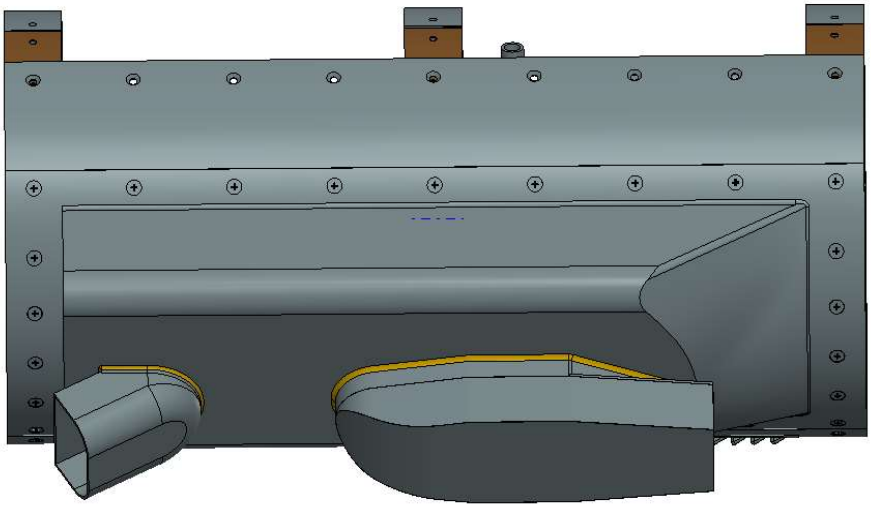


Figure: Cylindrical face

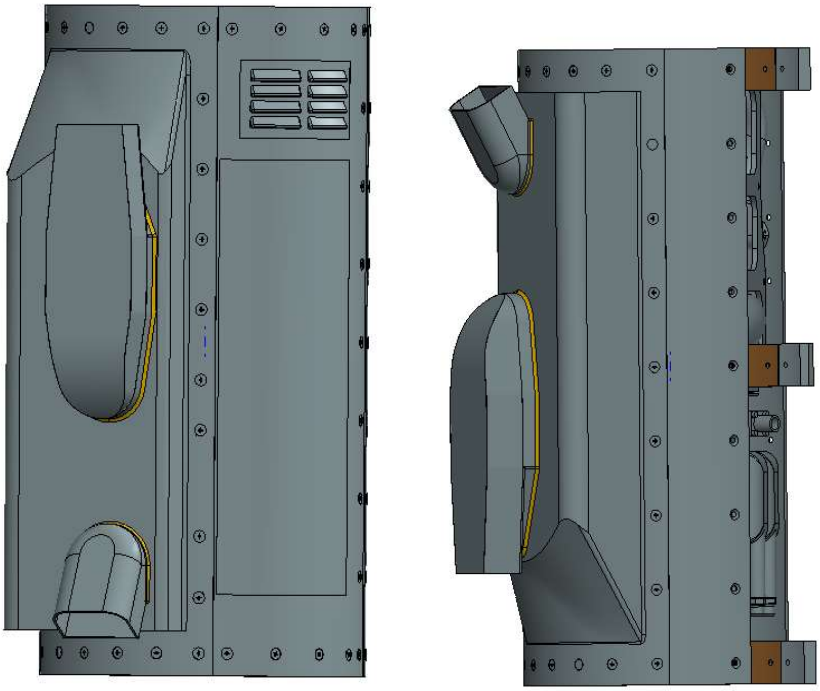


Figure: Flat surfaces

Test Procedure

Step 1- Raise the test item at one edge 100 mm (4”) above a solid wooden bench top or until the chassis forms an angle of 45°C with the bench top or until point of balance is reached, whichever is less.
Step 2- Perform 4 drops on each face.
Step 3- After each drop visually inspect the ACM module for cracks, defects.

Note: Applicable only when any of the dimension is greater than 23cm

Acceptance Criteria

- After completion of the test, unit shall be free from physical deformation. Integrity checks as per section 9.3 of the ATP-ACM-001 shall be satisfactory pre and post the test

2.7 FLUID CONTAMINATION

Test is conducted as per MIL-810F Method-504.1

The fluid which the components can be exposed to during its service is OJ LENA 65 also known as NYCOSOL 51(EGW65:35). Same will be used for the test.

The contamination can result due to the hose leakage or heat exchanger leakage due to which coolant can spill over the various parts inside the ACM Module. The total volume to liquid within ACM Module is nearly 1 liter, same amount of fluid will be sprayed onto the ACM module (occasional contamination) and exposed time of 8 hours will be maintained.

The electrical connectors will be engaged with mating connectors to mimic actual operating conditions.

Test Procedure

Step 1: The ACM Module shall be positioned on in an appropriate thermal chamber
Step 2: Stabilize the chamber temperature to 65°C ±3°C to simulate high temperature conditions
Step 3: 1 litter of coolant OJ Lena will be heated to 65°C±3°C and sprayed uniformly over the inner surfaces of the ACM Module.
Step 4: Ensure that the equipment shall be thoroughly wetted by the contaminating fluid or fluids which may be applied by brush dip or spray condition and maintain the wetted condition for 08 hours and ambient conditions at 65°C±3°C.
Step 5: At the end, the equipment shall be removed from the chamber and shall be allowed to remain under the standard recovery condition for a period of 2 hours.
Step 6: The accumulated liquid is to be drained by tilting or shaking the ACM Module
Step 7: Then the test item shall be visually examined for any deterioration.

Acceptance Criteria

- After completion of the test, unit shall be free from physical deformation. Integrity checks as per section 9.3 of the ATP-ACM-001 shall be satisfactory pre and post the test.

2.8 HUMIDITY TEST

This test is to determine the resistance of material to the effects of a warm, humid atmosphere. The test is to be carried out as per Procedure:MIL-810F Method-507.4 Procedure-III

Test Severity

- 30ºC to 60ºC Temperature
- No. of cycles: 10.
- RH Value: 85% to 95 %. During Transition 85%.

Test Setup

Make the Test setup as given in Fig 37

Test Procedure:

Step 1: Perform functional Check on EUT (at room temperature) as given in the ATP Document

Step 2: Place the EUT in the Chamber in its Operational Configuration

Step 3: Set the Chamber Temperature with RH value as per the profile give in Fig.37. for 10 cycles

Step 4: Performance check (Integrity check as per section 9.3 of ATP-ACM-001) as per ATP document shall be carried out for last 30 mins in every cycle. Record the results

Step 5: After completion of the Test, Remove the EUT from the Chamber.

Step 6: Conduct thorough visual examination of the EUT and Performance check (at room temperature) as per the ATP document and Record the Results.

Pass/Fail Criteria

- Integrity checks should be carried out as per section 9.3 of the ATP-ACM-001 shall be satisfactory pre and post the test.
- Last 3 cycles shall be defect free

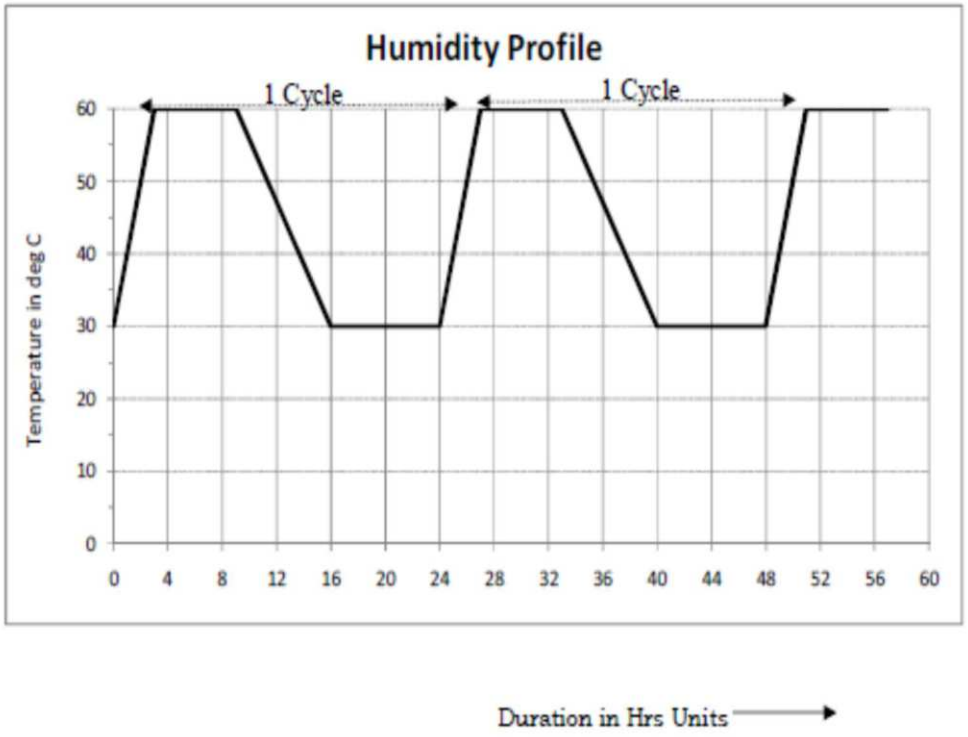


Figure: Humidity Test Profile.

2.9 BLOWING DUST TEST

Procedure: MIL-810F Method-510.4 Procedure -I & Procedure-II

The test item configuration should be as similar to the condition during actual use as per section 2.3.2.1 under method 510.4 MIL-STD-810F. Hence the electrical connectors in the LCU will be engaged with mating connectors.

- **Blowing Dust (150µm to 850µm particle size) procedures**: These tests are performed to help evaluate if material can be stored and operated under blowing sand conditions without degrading performance, effectiveness, reliability and maintainability due to abrasion (erosion) or clogging effects of large, sharp edged particles.

Severity

- Air velocity: 1.5m/s to 8.9m/s
- Blowing Sand: 18-29 m/s
- RH: less than 30%
- Blowing Sand particle size: 150µm to 850µm
- Temperature: 25°C
- Duration: 90 minutes
- Dust concentration 10.6 +0.7 grams/3
- Material of Dust: Silicon Dioxide or China Clay

Test Procedure

Step 1: Place the LCU in the chamber at standard ambient temperature and adjust the air velocity and temperature to the specified level.
Step 2: The adjust the relative humidity to the level specified.
Step 3: Adjust the sand feed control for sand concentration / Dust control concentration as specified above.
Step 4: Maintain the above steps for duration specified in the test plan.
Step 5: Stop the Sand/Dust feed and reduce the chamber temperature to the ambient condition after the specified duration is complete. Stop any air flow to allow the Sand/Dust to settle.
Step 6: Remove the accumulated Sand/ Dust from the unit by brushing, wiping, or shaking.
Step 7: After completing the test, conduct a visual examination for any abrasion/erosion on the UUT.

Acceptance Criteria

After completion of the test, unit shall be free from physical deformation. Functional checks as per section 10.8 of the ATP-ACM-001 shall be satisfactory pre and post the test.

QUALIFICATION TEST PROCEDURE
(QTP-LCS-LCU-001)

For

LIQUID CIRCULATION UNIT

(LCU) OF 2KW ACM BASED

LIQUID COOLING SYSTEM

(Part No: 2041 102 000)

PROJECT: PRAVAH

Bharat Heavy Electricals Ltd.

HPVP, Visakhapatnam

Combat Aircraft Systems Development & Integration Centre (CASDIC) DRDO, Bangalore

Contents

LCU Specifications:

Specifications	Dimension
Weight	10 Kg approx.
Length	180 mm
Width	180 mm
Height	288 mm

Tests to be carried out:

Sl No.	Tests
1	Random Vibration Test
2	Acceleration Test (Structural)
3	THERMAL SCHOCK TEST
4	Mechanical Shock Test (Functional):
5	MECHANICAL SHOCK TEST (Crash Hazard Test)
6	TRANSIT DROP
7	BENCH HANDLING
8	SALT FOG TEST
9	FUNGUS TEST
10	HUMIDITY TEST
11	RAIN DRIP TEST
12	BLOWING DUST TEST
13	FLUID CONTAMINATION

Sl. No.	TEST & PROCEDURE	SEVERITY	DURATION	REMARKS
1	Mechanical & Visual Inspection	Refer ATP document Section 10.1		To be conducted on LCU (Part No. 2041102000 – V3, S. No. 101).
2	Functional Performance test	Refer ATP document Section 10.1		
3	ESS tests	Refer ATP document Section 10.1		
4	Random Vibration Test *Procedure:MIL-810F Method-514.5 Procedure-I* Refer Section 5.2	As per Random vibration spectrum	1 hour/axis in all three axes The equipment shall be operational during the test	To be conducted on LCU (Part No. 2041102000 – V3, S. No. 101).
5	Acceleration –Structural Test *Procedure:MIL-810F Method-513.5 Procedure-I& Procedure-II* Refer Section 5.6	Fore: 3.0 Aft: 9.0 Up: 18 Down: 4.5 Right: 20 Left: 20	1 minute along each direction The equipment shall Be non-operational during this test	To be conducted on LCU (Part No. 2041102000 – V3, S. No. 101).
6	Thermal shock Test *Procedure:MIL-810F Method-503.4 Procedure-II* Refer Section 5.8	Stabilize at -40°C, soak for 1 hour. Transfer and stabilize at +65°C and soak it for 1 hour. Transfer it to -40°C for 1 hour. This constitutes 1 cycle	3 cycles	• To be conducted on LCU (Part No. 2041102000 – V3, S. No. 101). • Transfer from low temperature to high temperature chamber and vice versa is to be effected within 5 minutes
7	Shock -functional Test *Procedure:MIL-810F Method-516.5*	20g Saw tooth (or 15g Half sine) 11ms	3 shocks in each of six directions	• To be conducted on LCU (Part No. 2041102000 – V3, S. No. 101).

	Refer Section 5.5			• The equipment shall be operational during the test
8	Shock –Crash Hazard Test *Procedure:MIL-810F Method-516.5*	40g Saw tooth (or 30g Half sine) 11ms	2 shocks in each of six directions	Test to be carried out mechanically equivalent mockup.
9	Transit Drop Test *Procedure:MIL-810F Method-516.5 Procedure-IV* Refer Section 5.13	For equipment lighter than 45.4 kg Height of Drop 122 cm	26 drops (1 drop/each face, edge & corner)	• To be conducted on LCU (Part No. 2041102000 – V3, S. No. 101). • The Equipment shall be tested with an approved packing box
10	Bench Handling Test *Procedure:MIL-810F Method-516.5 Procedure-VI* Refer Section 5.14	Raise one edge by 10 cm or 45°C whichever is less	4 drops on each face	• To be conducted on LCU (Part No. 2041102000 – V3, S. No. 101). • Drop in Table with Antistatic material.
11	Salt Fog Test *Procedure:MIL-810F Method-509.4* Refer Section 5.12	Salt solution of 5±1% concentration -24 Hours exposure & -24 Hours drying constitute one cycle	2 cycles	• Composition of salt for preparation of solution shall be with NACl solution containing not greater than 0.1% Sodium Iodide & not greater than 0.5% Impurities • Drying shall be at prevailing ambient conditions • This test can be carried out with LCU installed inside a representative pod structure.
12	Fungus (Mould Growth) Test *Procedure:MIL-810F Method-508.5* Refer Section 5.11	The spore suspension will be prepared using Fungi specified in Table-7 of (T.S)	Wet the entire surface of test item with spore suspension for 10 mins. Incubation period 28 days at 30°C, 95% RH	• This test can be carried out on representative samples of parts used in equipment. • Alternatively this test can be carried out as per JSS55555.

13	Humidity Test *Procedure:MIL-810F Method-507.4 Procedure-III* Refer Section 5.10	Temperature: 30°C to 60°C RH: 85% to 95% Temperature, Humidity diurnal cycle	10 cycles	• To be conducted on LCU (Part No. 2041102000 – V3, S. No. 101). • This test is not mandatory if CATH Test is carried out.
14	Rain-Drip Test *Procedure:MIL-810F Method-506.4 Procedure-II* Refer Section 5.9	Volume flow rate 250 to 280 lit/m^2/Hour. Dispenser placed approximately 1 meter above equipment	15 minutes (Configuration as installed on the aircraft) Applicable if the LRU is installed in an environment where rain drip is encountered.	To be conducted on LCU (Part No. 2041102000 – V3, S. No. 101).
15	Blowing Dust *Procedure:MIL-810F Method-510.4 Procedure-I* Refer Section 5.16	Blowing Dust Air Velocity 1.5 m/sec to 8.9 m/sec. RH= 30%	6 Hrs. at 23^0C concentration 10.6±0.7 grams/m3 Material of Dust: Silicon Dioxide or China Clay Test applicable only for externally mounted LRUs. Alternately this test can be carried out as perJSS55555.	Test will be conducted with LCU installed inside a representative pod structure.
16	Fluid Contamination Test *Procedure:MIL-810F Method-504.1* Refer Section 5.17	Test Temperature:65°C ±3°C Test Fluids i. Ethylene Glycol water mixture (65:35)	7 days/test fluid	This test can be carried out on representative samples of parts used in equipment.

INTRODUCTION:

Purpose & Scope

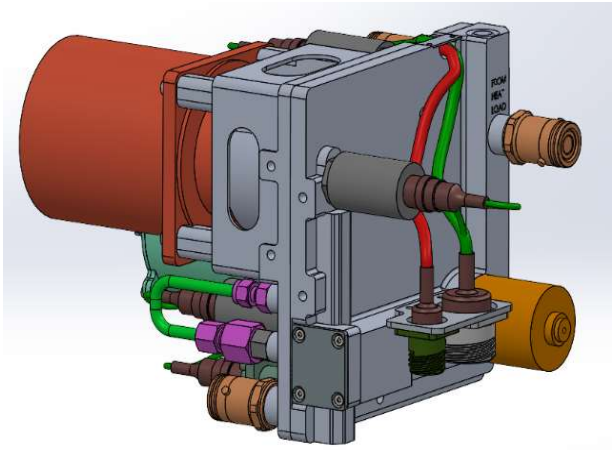
The purpose of the document is to provide the test procedures for Qualification Testing of Liquid Circulation Unit (LCU) (Part No.-2041 102 000).

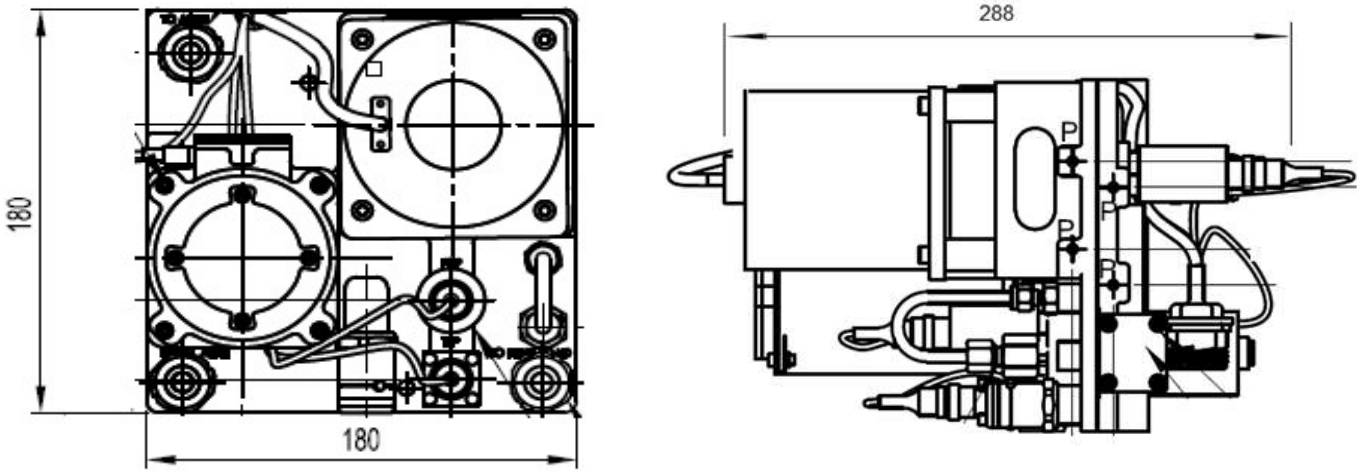
Overview of Item

The 2 KW Liquid Circulation Unit (LCU) based Liquid Cooling System (LCS) is used for maintaining the coolant temperature less than 45ºC while entering the heat loads. The Liquid Circulation Unit (LCU) of the LCS will circulate the coolant through the heat loads as well as other cooling system components like heat exchangers, heat loads and their interconnecting pipes at the desired flow rate. It should be able to handle the pressure drop of the various sub-systems and components in the entire coolant circuit including the internal pressure drop inside the LCU when the liquid is circulated at the desired flow rate as per the technical specifications of the unit.

Standards

- MIL-STD-810F – ENVIRONMENTAL ENGINEERING CONSIDERATIONS AND LABORATORY TESTS
- MIL-STD-461E/F – REQUIREMENTS FOR THE CONTROL OF ELECTROMAGNETIC INTERFERENCE CHARACTERISTICS OF SUBSYSTEMS AND EQUIPMENT
- MIL-STD-704F – AIRCRAFT ELECTRIC POWER CHARACTERISTICS
- MIL HDBK 704 - GUIDANCE FOR TEST PROCEDURES FOR DEMONSTRATION OF UTILIZATION EQUIPMENT COMPLIANCE TO AIRCRAFT ELECTRICAL POWER CHARACTERISTICS.
- MIL HDBK 2164 A - ENVIRONMENTAL STRESS SCREENING PROCESS FOR ELECTRONIC EQUIPMENT.





GA drawing of EUT

ENVIRONMENTAL TESTS:

1 Random Vibration Test:

Test Specification / Severity

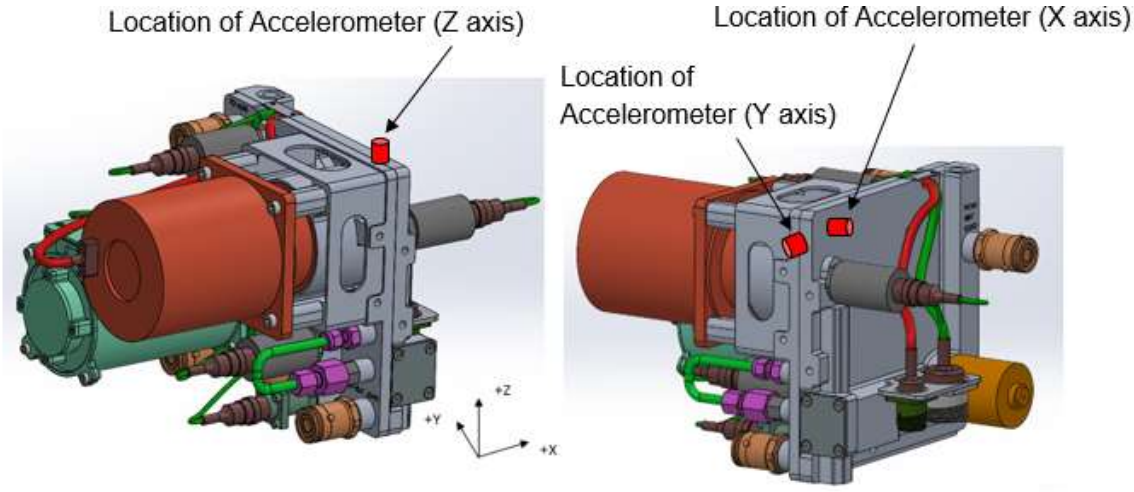
As per MIL-STD-810 F Procedure I Method 514.5

As per profile give in Figure below in all 3 mutually perpendicular axes. Duration: 1Hr per axis

Test Setup

Make the Test setup as given in the ATP Document

Location ofAccelerometer (X axis)



Vibration test set up

Test Procedure:

- Carryout the test on EUT as per ATP. The equipment shall be operational during the test
- Fix the EUT on to the Vibration Table using a suitable Fixture.
- Set the Vibration Test level as defined in below graph.
- During vibration, performance of the unit shall be monitored and recorded after every 15 min interval.
- Repeat the above steps for remaining 2 axes.
- After completion of Test, conduct the visual inspection and performance check as per ATP document and record the results.

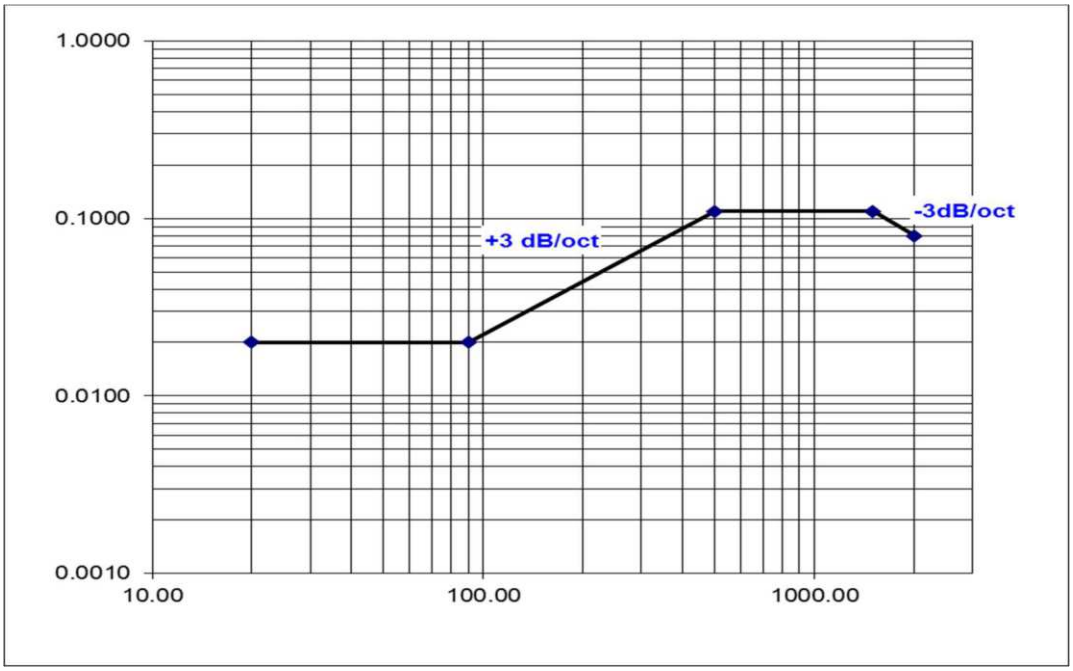
Remarks:

During vibration, the Unit shall be in Power 'ON' condition and Performance will be monitored during vibration in each of the axes. The unit shall be operated at the design

point i.e. 10 ± 0.5 lpm @ 5.6 bar differential pressure (refer ATP document). The temperature of the unit shall be maintained constant (anywhere between 30ºC - 55 ºC) with the help of an inline heat exchanger

Acceptance Criteria:

The EUT shall perform without any functional degradation or physical damage before and after the test.



Vibration Test Profile for Random Vibration Testing

Frequency, Hz	P.S.D, g^2/Hz	Slope	Grms
20	0.02	---	13.57
90	0.02	+3 dB/ Octave	
500	0.11		
1500	0.11	-3 dB/ Octave	
2000	0.08		

Frequency Range

2 Acceleration Test (Structural):

Severity

- Fore: 3.0
- Aft: 9.0
- Up: 18
- Down: 4.5s
- Right: 20
- Left: 20
- Test Duration 1 minute after the specified ‘g’ level is reached on each axes.
- Unit will be in Power OFF Condition.

Test Procedure:

- Perform a Functional Test on the EUT as per ATP document.
- Bring the centrifuge to the speed required to induce the specified g level in the EUT as determined for the particular orientation. Maintain the level for at least one minute after the centrifuge rpm has stabilized.
- Stop the centrifuge and inspect the test item.
- Repeat steps ‘a’ to ‘c’ for the five remaining directions.
- Upon completing the tests in the six test directions, carryout Functional test and inspection carried out on EUT. Record the results.

Remarks:

EUT is in OFF condition during shock test. Functional performance check shall be done before and after the test.

Acceptance Criteria

The EUT shall perform without any functional degradation in performance or physical damage during and after the test.

3 THERMAL SCHOCK TEST

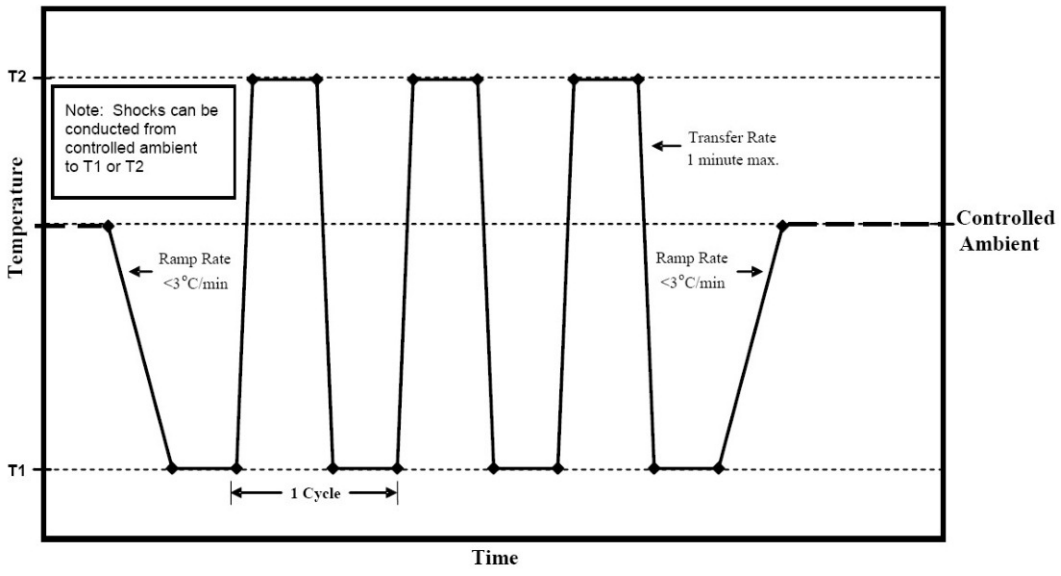
MIL- 810F Method-503.4

Severity

Stabilize at -40°C, soak for 1 hour. Transfer and stabilize at +65°C and soak it for 1 hour. Transfer it to -40°C for 1 hour. This constitutes 1 cycle.

Test Procedure

- Place the test item in the thermal chamber and adjust the chamber air temperature to the low temperature (T1) at a rate not to exceed 3°C/min. Stabilize the temperature for a period of 1 hour.
- Transfer the test item in no more than one minute to an atmosphere at temperature (T2) that will produce the thermal shock specified in the test plan, and stabilize the temperature for a period of 1 hour.
- Transfer the test item back to the T1 environment in less than one minute. Stabilize the temperature for a period for 1 hour
- Repeat steps 1-3 twice, so that the unit is subjected to a total of 3 thermal shocks.
- Return the test item to standard ambient conditions.
- Examine the test item visually for defects and perform integrity check.



Thermal shock Test Profile

Note: The value of T1 and T2 will be taken as -40 ºC and +65 ºC respectively.

4 Mechanical Shock Test (Functional):

Severity

- 20g, 11ms or equivalent half sine wave.
- Pulse Shape: Saw tooth pulse
- No. of Shocks: 3 Shocks per axis on each of 6 directions.
- Total 18 Shocks

Test Procedure

- Perform a Functional Test on the EUT as per ATP document.
- Install the EUT on to the Shock Table
- Subject the EUT to the Test shock input.
- Record necessary data to show that the shock met or exceeded desired Test levels within the specified tolerance.
- Repeat steps 'b' to 'e' three times for each orthogonal test axis.
- Document the test sequence.

Remarks: EUT is in OFF condition during shock test

Functional performance check shall be conducted before and after completion of the test.

Acceptance Criteria

The EUT shall perform without any functional degradation or physical damage after the test.

5 MECHANICAL SHOCK TEST (Crash Hazard Test)

The LCU shall be subjected to Mechanical Shock Crash Test in accordance with MIL-STD-810F, Method 516.5. The purpose of this test is to check the structural integrity of the unit to crash shock. Procedure for the test and requirements to be met by the equipment to pass the test are described below

Test Procedure:

- The Crash test is performed on an equivalent dummy unit of LCU.
- The Monoblock of the LCU is maintained same whereas the units of the LCU such as Pump motor unit, accumulator, sensors etc. are replaced with an equivalent dummy weight.
- The mounting points of the dummy weights are maintained same as that of the original units.
- The dummy LCU Module shall be mounted onto a suitable fixture, which shall then be mounted on the shock test setup.
- Two shocks shall be applied along each of three principal axes by orienting the Equipment along each axis in turn.
- Shocks shall be of Saw-Tooth form with a magnitude of 40g's over a duration of 11 ± 1 ms (or 30g half sine for 15 m sec)

Acceptance Criteria:

- The dummy units installed inside the LCU should not dislodge from its mounting points.
- Deformation of the structure post-crash test is permitted. However, ACM Module should have structural integrity and should not disintegrate from the fixture.

6 TRANSIT DROP

MIL-810F Method-516.5 Procedure-IV

The 26-drop requirement (*MIL-810F* table 516.5-VI) may be divided among up to five samples of the same test item in any combination.

For equipment lighter than 45.4 kg Height: 122 cm, No of drops: 26 (1drop/each face, edge & corner)

Test Procedure

- The unit shall be packaged in to the approved packing case and shall be subjected to a Transit Drop Test along with the packing box in accordance with the above test conditions.

Acceptance Criteria

- After completion of the test, unit shall be free from physical deformation and discoloration of the surface finish. Functional check as per section 10.8 of the ATP-LCS-LCU-001 shall be satisfactory pre and post the test

7 BENCH HANDLING

MIL-810F Method-516.5 Procedure-VI

Procedure VI brings out that the drops are to be carried out on each face on which the test item could be placed practically during serving.

Test Procedure

- Raise the test item at one edge 100 mm (4 in) above a solid wooden bench top or until the chassis forms an angle of 45° with the bench top or until point of balance is reached, whichever is less.
- Perform 4 drops on each face.
- After each drop visually inspect the LCU for cracks, defects.
- Applicable only when any of the dimension is greater than 23cm,
- Drop in Table with Antistatic material

Acceptance Criteria

- After completion of the test, unit shall be free from physical deformation. Functional check as per section 10.8 of the ATP-LCS-LCU-001 shall be satisfactory pre and post the test

8 SALT FOG TEST

MIL-810F Method-509.4

The salt fog method is performed to determine the effectiveness of protective coatings and finishes on materials.

The LCU is fabricated from AL 6061 -T6 with Electro Less Nickel plating as per MIL-C-20674. However, since the LCU is mounted inside the Pod shell, it will not be exposed directly to Salt fog conditions. Hence this test shall be carried out by mounting LCU inside suitable case closed from all ends to mimic its mounting in the Pod shell.

Standard Exposure: 24 hrs.

Drying Period: 24 hrs.

No of cycles: 2 [24 hours of exposure and 24 hours of drying for one cycle]

Salt Concentration: 5% ± I% by weight neutral NaCI in 95% of water

Chamber Temperature: +35°C ± 2°C

Test Procedure

- The UUT will be enclosed in a representative pod structure for subjecting it to salt fog conditions
- The UUT enclosed in pod structure while being under the laboratory atmospheric conditions shall be introduced into the salt spray test chamber.
- The UUT enclosed in pod structure shall then be exposed to salt mist, as per the specified test conditions. Conduct the test for 2 cycles.
- The UUT enclosed in pod structure shall then be removed from the chamber and shall be allowed to remain under standard conditions for a period of 2 to 4 Hours.
- The UUT shall be examined for corrosion and deterioration of metal parts, finishes, materials and components.
-

Acceptance Criteria

- The UUT shall not exhibit any discoloration of the surface finish, corrosion and deterioration of metal parts, finishes, materials and components.

9 FUNGUS TEST

MIL- 810F Method-508.5

This test is carried out on representative samples of parts used in equipment. Alternatively, if material analysis reveals that the material is not a nutrient to any fungus listed in table below, then this test can be dispensed with.

The LCU is fabricated from AL 6061 T6 with anodization as per MIL A 8625F and paint and primer as per PU paint 36280. Also it contains gaskets and O rings of silicon rubber material.

Hence representative samples of the above materials shall be studied by test or alternatively material analysis will be presented.

Following types of fungus will be utilized- Aspergillus flavus or Aspergillus versicolor or Penicillium funiculosum

Test Procedure

Preparation for incubation-

- Assure the condition of the items to be tested is similar to their condition as delivered by the manufacturer or customer for use, or as otherwise specified. Accomplish any cleaning of the test item at least 72 hours before the beginning of the fungus test to allow for evaporation of volatile materials.
- Install the test item in the chamber or cabinet on suitable fixtures, and remove any covers.
- Hold the test item in the test chamber at 30 °C and a RH at 95 percent at least for four hours immediately before inoculation.
- Inoculate the test item and the cotton fabric chamber control items with the mixed fungus spore suspension by spraying the suspension on the control items and on and into the test item(s) (if not permanently or hermetically sealed) in the form of a fine mist from an atomizer or nebulizer. Ensure personnel with appropriate knowledge of the test item are available to aid in exposing its interior surfaces for inoculation.
- In order for air to penetrate, replace the covers of the test items without tightening the fasteners.
- Start incubation immediately following the inoculation.

NOTE: In spraying the test and control items with composite spore suspension, cover all external and internal surfaces that are exposed during use or maintenance. If the surfaces are non-wetting, spray until drops begin to form on them.

Incubation of the test item -

- Except as noted in Step 2 below, incubate the test items at constant temperature and humidity conditions of 30°C and a relative humidity of at least 95 % for the test duration (28 days).
- After 7 days, inspect the growth on the control cotton strips to verify the environmental conditions in the chamber are suitable for growth. At this time, verify that at least 90 percent of the surface area of each test strip located at the level of the test item is covered by fungus. If it is not, repeat the entire test with the adjustments of the chamber required to produce conditions suitable for growth. Leave the control strips in the chamber for the duration of the test.
- If the cotton strips show satisfactory fungus growth after 7 days, continue the test for the required period from the time of inoculation as specified in the test plan. If there is no increase in fungus growth on the cotton strips at the end of the test as compared to the 7-day results, the test is invalid.

Requirement

- Material should not show degradation post the fungus test.

10 HUMIDITY TEST

Severity

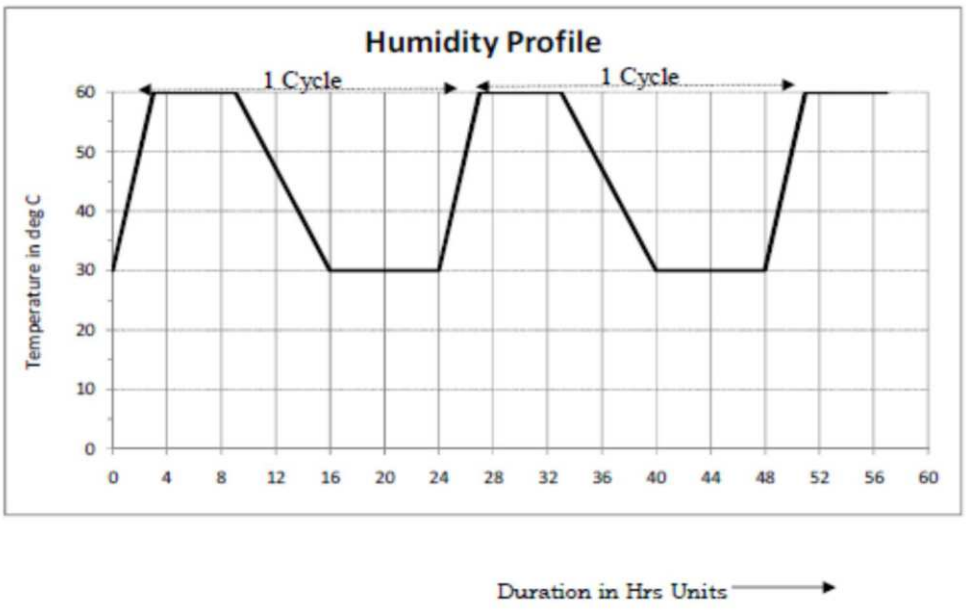
Temperature: +30°C to +60°C (24 Hour Cycle),
RH: 85% to 95%, (10 Cycles) Non-Operational.

Test Setup

The required apparatus consists of a chamber or cabinet and auxiliary instrumentation capable of maintaining and monitoring the required conditions of temperature and relative humidity throughout the envelope of air surrounding the test item.
Verify that environmental monitoring and measurement sensors are of an appropriate type and properly located to obtain the required test data.

Test Procedure

- The UUT shall be subjected to this test under "unpackaged" and "switched off' condition. The UUT under laboratory atmospheric conditions shall be introduced into the test chamber, the latter also being under the same conditions.
- Humidity Test shall be carried out as per profile shown in Figure - 33, Gradually raise the internal chamber temperature to 60°C and the relative humidity to 95% over a period of 2 hrs.
- Maintain the above conditions [or 6 hours.
- Maintain 85% of relative humidity and reduce internal temperature to 30°Cover a period of 8 hrs.
- Maintain the chamber at 30°C and RH of 95% for a period of 8 hours.
- Repeat steps 4, 5,6 & 7 for a total of 10 cycles (240 Hours).
- After completion of the test, the OUT shall then be removed from the chamber and shall be allowed to remain under standard conditions for a period of 2 to 4 Hours.



Humidity test cycle.

Note: At the end of 5th cycle, the unit shall undergo for physical inspection.

Acceptance Criteria

- After completion of the test, unit shall be free from physical deformation and discoloration of the surface finish. Perform FT2. Unit is acceptable if functional test results are satisfactory.

11 RAIN DRIP TEST

MIL- 810F Method-506.4 Procedure-III

Severity

- Water Fall Rate: 250 to 280 ltr/mtr^2/hr
- Duration: 15 min.
- Height 1 Mt.

Test Procedure

- The UUT while being under the laboratory atmospheric conditions shall be introduced into the rain drip test chamber, the latter also being under the same conditions.
- UUT shall then be exposed to rain drip test for 15 min at a water fall rate of 250-280 ltr/mtr^2/hr from a height of 1 meter and unit shall be non-operational.
- After completion of the test, the unit shall then be removed from the chamber and shall be allowed to remain under standard conditions for a period of 2 Hours.
- The unit shall be examined for corrosion and deterioration of metal parts, finishes, materials and components.

12 BLOWING DUST TEST

Procedure: MIL-810F Method-510.4 Procedure-II

Test Conditions

- Temperature: 23ºC ± 2 ºC
- RH: = 30% ± 5%
- Air Velocity: 1.5m/s to 8.9m/s
- Dust Concentration: 10.6 ± 0.7 grams/m3
- Duration: 6 hr. at 23ºC ± 2 ºC
- Orientation: As installed in the pod shell.
- Material of Dust: Silicon Dioxide or China Clay

Test Procedure

- Perform functional Check on EUT as given in the ATP Document
- With the EUT in the chamber, adjust the test section temperature to 23ºC ± 2 ºC and the air velocity to 1.5m/s to 8.9m/s. Adjust the Test section relative humidity to less than 30% and maintain it throughout the test.
- Adjust the dust feed control for a dust concentration of 10.6 ± 0.7gms/m^3
- Maintain the conditions of Steps ‘b’ and ‘c’ for 6 hrs.
- Stop the dust feed. Reduce the Test section air velocity to 1.5m/s approximately and adjust the temperature to 23ºC ± 2 ºC.
- Maintain the Test condition for 1 Hrs. following test temperature stabilization.
- Adjust the Air velocity to that used in LCU and restart the dust feed to maintain the dust concentration as in chamber.
- Continue the exposure for at least 6 hrs.
- Allow the UUT to return to standard ambient conditions, and the dust to settle.
- Remove accumulated dust from the UUT by brushing, wiping or shaking, taking card to avoid introduction of additional dust or disturbing any which may have already entered the UUT. Do not remove dust by either air blast or vacuum cleaning unless these methods are likely to be used in service.
- Perform the performance check in accordance with the approved ATP document and Record the Results.
- Inspect the UUT for dust penetration, Document the results.

Acceptance Criteria

- After completion of the test, unit shall be free from physical deformation. Functional checks as per section 10.8 of the ATP-LCS-LCU-001 shall be satisfactory pre and post the test

13 FLUID CONTAMINATION TEST

MIL-810F Method-504.1

The fluid which the components can be exposed to during its service is OJ LENA 65 also known as NYCOSOL 51. Same will be used for the test. The LCU is fabricated from AL 6061 T6 with Electrolysis Nickel plating as per MIL C 20674 and paint and primer as per PU paint 36280. Also it contains gaskets and O-rings of silicon rubber material. Representative samples of each of this material will be used for the test and exposed time of 8 hours per day will be maintained (7 days'/test fluid).

Test Procedure

- The representative samples will be dipped in the OJ Lena (Ethylene - glycol water mixture 65:35) maintained at 65°C±.3°C
- This condition of exposure shall be maintained for 8 hours per day and at the end, test items shall be visually examined for any deterioration (cracking, swelling of rubber, paint or coating removal or degradation)
- This test can be carried out on representative samples of parts used in equipment.

Acceptance Criteria

- Samples shall be free from cracks or coating or surface finish damages post the exposure.

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ACCEPTANCE TEST PROCEDURE

FOR

ACM MODULE OF 2 KW ACM BASED LIQUID COOLING SYSTEM

PART NO: 2041 101 000

M/s Bharat Heavy Electricals Ltd.

Heavy Plates & Vessels Plant

Visakhapatnam-530012

Combat Aircraft Systems Design and Integration Centre (CASDIC), Old DARE Complex, P.B. No. 9366, C V Raman Nagar, Bengaluru – 560093

DOCUMENT CONTROL DATA SHEET

DOCUMENT NUMBER	**ATP-ACM -001**	REV. No.	**0**
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TITLE	**Acceptance test procedure for ACM Module of 2KW ACM Based Liquid Cooling System. Part No (2041 101 000)**		
ORIGINATING GROUP/ORGN.	BHEL-HPVP, VISAKHAPATNAM		
ABSTRACT	The ATP document brings out the acceptance test methodology of the ACM Module		
CLASSIFICATION	Restricted		

BHEL HPVP, Vishakhapatnam	**CASDIC, Bangalore**
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Approved (DGAQA)	

RECORD OF AMENDMENTS

Issue NO.	Issue Date	Brief Description of Amendment	Remarks
01	25/11/2021	Initial Release, comments by CASDIC IQA incorporated	--

Distribution List

BHEL	CASDIC	Certifying Agencies
AGM (Quality),BHEL HPVP, Vishakhapatnam	Project Office	CEMILAC
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Contents

LEGEND

ACM: AIR CYCLE MACHINE

BHEL HPVP: BHARAT HEAVY ELECTRICALS LIMITED HEAVY PLATES AND VESSELS PLANT

QAP: QUALITY ASSURANCE PLAN

ATP: ACCEPTANCE TEST PROCEDURE

RCMA: REGIONAL CENTRE FOR MILITARY AIRWORTHINESS

CEMILAC: CENTRE FOR MILITARY AIRWORTHINESS AND CERTIFICATION

DGAQA: DIRECTORATE GENERAL OF AERONAUTICAL QUALITY ASSURANCE

LCS: LIQUID COOLING SYSTEM

IQA: INTERNAL QUALITY ASSURANCE

CASDIC: COMBAT AIRCRAFT SYSTEMS DESIGN AND INTEGRATION CENTRE

SOP: STANDARD OPERATING PROCEDURE

LQT: LIMITED QUALIFICATION TEST

ALHE: AIR TO LIQUID HEAT EXCHANGER

EGW: ETHYLENE GLYCOL WATER

QAP: QUALITY ASSURANCE PLAN

1. INTRODUCTION

The 2 KW Air Cycle Machine (ACM) based Liquid Cooling System (LCS) is used for circulating the coolant through the heat load and maintaining the coolant temperature less than 45^0C using the cold air generated by the ACM, over the operational envelope of the aircraft. The heat absorbed from the heat load will be dissipated to the heat exchangers, which are part of the cooling system. The ACM present in the cooling system is driven by the ram air and generates the cold air, which is used for cooling the hot coolant by passing through an Air to Liquid Heat Exchanger (ALHE).

The ACM Module consists of Air cycle Machine, air control valves, ground fan, temperature sensor, check valves, heat exchanger, structure and associated gaskets, fasteners.

2. SCOPE & OBJECTIVE

This Acceptance Test procedure (ATP) describes the test procedures to be followed for acceptance of the ACM Module Part No. 2041 101 000 developed by M/s BHEL-HPVP, Visakhapatnam

3. APPLICABLE DOCUMENTS

I. Technical Specification for ACM Module (Part No. 2041 101 000) of 2KW Cooling system DARE/MED/041/REP/24 dt.04-05-2020.

4. APPLICABILITY

- The acceptance test shall be carried out on each ACM Module after fabrication and assembly. Other activities with the ACM module shall be taken up only after successful completion of the ATP
- Tests listed under section 9.3 shall be carried out Pre and Post individual qualification tests to verify integrity

- Tests listed under section 9 shall be carried out in the event of disassembly and subsequent assembly of the ACM Module for any requirement.

5. INSPECTION AUTHORITY

All Acceptance Tests shall be witnessed and inspected by BHEL-HPVP's Quality Control inspector, representatives from DGAQA and CASDIC IQA in accordance with the requirements and procedures specified in this document for each ACM Module. The test report shall be submitted to CASDIC, Bangalore along with each ACM Module

6. INSTRUMENTATION

All instruments used for Acceptance Tests shall be calibrated and certified in accordance with applicable MIL document or BHEL-HPVP's standard calibration system or at NABL accredited Laboratories.

7. TEST ENVIRONMENT

All tests described throughout this document shall be performed on the ACM Module while it is kept at ambient (room) temperature, ambient pressure and humidity, unless otherwise specified in this document.

8. TOLERANCES ON TEST PARAMETERS

The maximum allowable tolerances on various test parameters (exclusive of equipment accuracy) for various tests described throughout this document shall be as follows, unless otherwise specified in this document.

Flow	:	± 5 %
Pressure	:	± 5 %
Temperature	:	± 5 °C

9. ACCEPTANCE TEST SEQUENCE

The Acceptance tests as per sequence below shall be performed on all ACM Modules.

Table 1 Acceptance tests sequence

Sequence	Name of Test
1	Visual Examination and build standard of ACM Module
2	Leakage Test of ACM Module
3	Integrity Check of ACM Module
4	ESS Test of ACM Module

9.1 VISUAL EXAMINATION & BUILD STANDARD

- Visually examine all the components/sub-assy. for corrosion, dents and visual external damage.
- ACM Module shall be manufactured and assembled as per QAP ACM Module 001 .Any deviations from the drawing shall be reported to CASDIC IQA and DGAQA, Bangalore for study and acceptance.
- Following conformances shall be verified for the components of the ACM Module.

Table 2 Compliance matrix

Sl No	Description	Remarks
01	Air cycle Machine, Air flow valve, ground fan, check valve, temperature sensor.	COC
02	Electrical Loom	COC for connectors, wires, continuity reports
03	Heat exchanger	Test reports as per section 10

Table 3 ACM Module Visual Inspection test report

NO	TEST Description	PASS/FAIL	Remarks
1	Visual Examination ACM Module for corrosion, dents and visual external damage.		
2	Compliance matrix		

9.2 LEAKAGE TEST

The entire air path of the ACM shall be tested for absence of any leaks using air at 0.5 bar pressure (gauge). Procedure for the test and requirements to be met by the ACM Module to pass the test are described below.

9.2.1 PROCEDURE

A schematic of the ACM Module is shown in figure 1-2.

- The scoop and cover assembly shall be removed from the ACM Module since the inlet and outlet scoops are of non- standard shapes, hence ensuring a leak proof clamping for the same would not be possible.

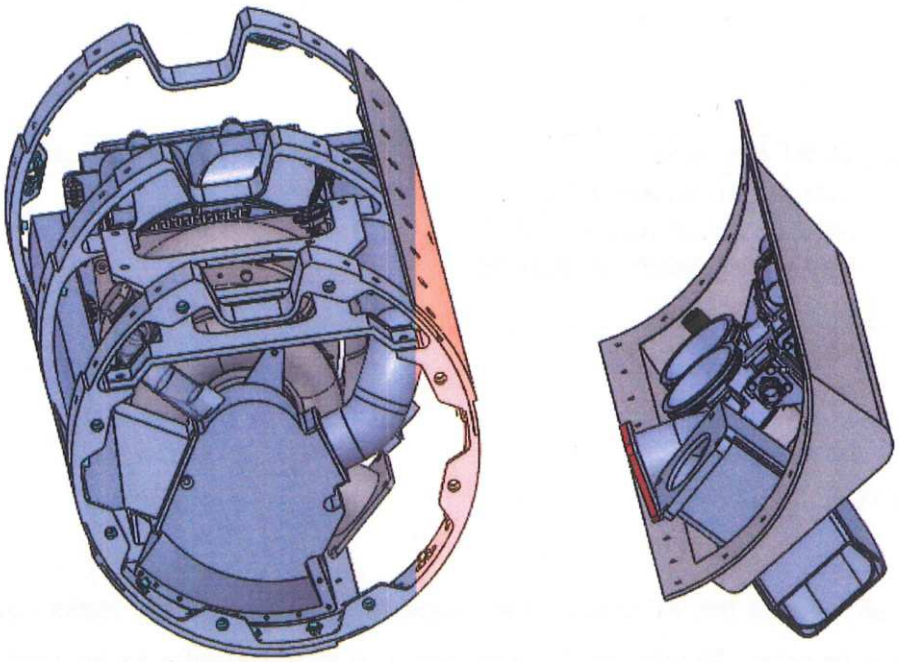

Figure 1 Scoop cover assembly

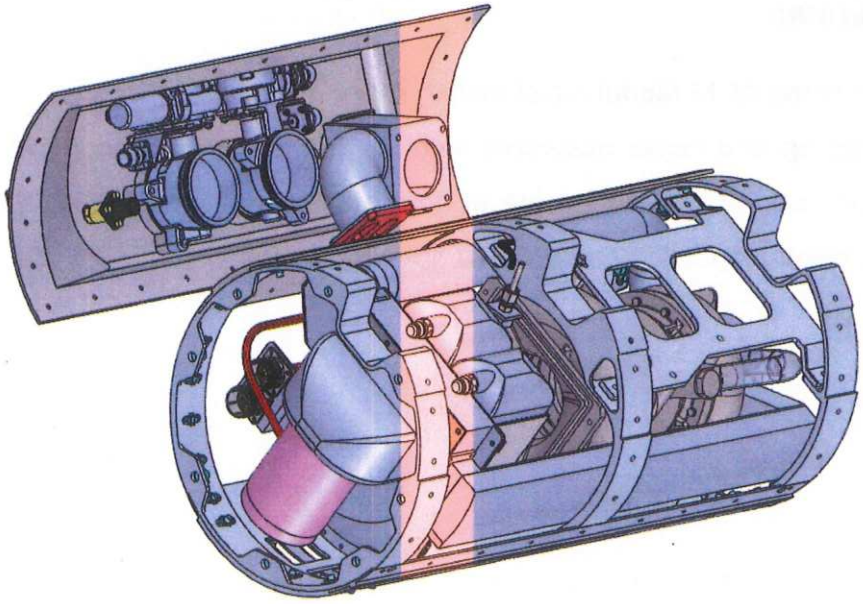

Figure 2 Scoop cover assembly view2

- Further all the openings as shown in figure 3 shall be plugged by using appropriate gasket and metal blanks.

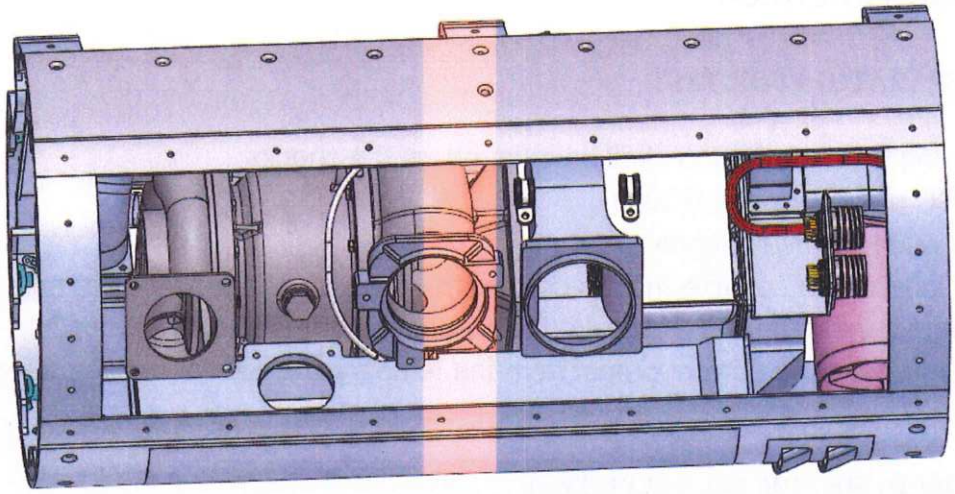

Figure 3 ACM Module openings

- Pressured air supply to the turbine inlet shall be provided to the ACM Module, the compressor exit shall be blocked by using a suitable blind.
- Pneumatic pressure shall then be raised gradually to 0.5± 0.25 kg/cm2(g) by checking the reading on the pressure gauge.
- This pressure shall be maintained for a period of 5 (five) minutes.

9.2.2 ACCEPTANCE CRITERIA

The ACM Module, when tested, shall not show any evidence of leakage. If leakages are found, they are to be addressed by utilizing suitable sealants/gaskets. And the test may be repeated to satisfy the above requirement.

Table 4 Leak test Report of ACM Module

NO	TEST Description	PASS/FAIL	Remarks
1	Leak test of ACM Module at 0.5± 0.25 kg/cm2(g)		

9.3 INTEGRITY CHECK

9.3.1 PREPARATION FOR TEST

The following instrumentation shall be sourced for the checks

- Variable DC power supply (0-28V)
- AC 115 V 400 Hz Power supply
- Electrical looms with suitable mating connectors shall be connected with the power and signal connectors in the ACM Module (D38999 20WD35PN and 20WD18PN)
- Multimeter to measure current output from the temperature sensor in micro amps.

9.3.2 PROCEDURE FOR AIR VALVE TEST

- Energize the Air valve 1 and 2 which are positioned at the turbine inlet and ram air bypass locations by connecting the electrical loom to the DC power supply.
- A supply voltage of 28-30 Volts may be provided to actuate the valves.
- Once the valve rotation is complete from full open to full close condition, the valve automatically stops and does not draw any additional current from the supply.
- The opening and closing of the valve may be carried out 10 times to notice any anomalies.

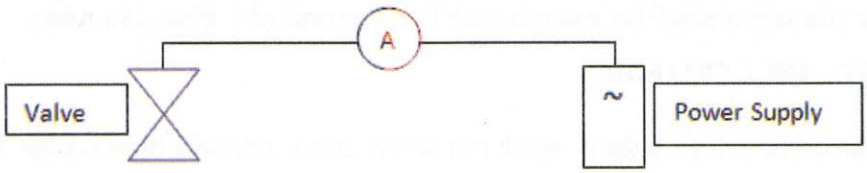

Figure 4 Air valve test schematic

ACCEPTANCE CRITERIA

The valve should successfully open and close during the test which can be seen visually if the scoop cover is opened else it is to be inferred by the sound of the valve operation.

9.3.3 PROCEDURE FOR TURBINE SCROLL HEATER

- Energize the turbine scroll heater by connecting the electrical loom to the AC power supply for duration of 30 seconds.

ACCEPTANCE CRITERIA

- Measure the voltage supplied and current drawn by the heater using clamp meter or external ammeter, the total power drawn by the heater shall be less than 150 Watts.

9.3.4 PROCEDURE FOR GROUND FAN

- Energize the ground fan by connecting the electrical loom to the AC power supply for duration of 1minute.

ACCEPTANCE CRITERIA

- No abnormal sound /rubbing during the fan operation is acceptable
- Measure the voltage supplied and current drawn by the fan, the total power drawn by the fan shall be less than 300 Watts.

9.3.5 PROCEDURE FOR RAM AIR TEMPERATURE SENSOR

- The Ram air temperature sensor is of RTD type. Connect the same to a multi meter through the electrical loom and measure the resistance output from the sensor.

ACCEPTANCE CRITERIA

- Verify the measured value of resistance against the RTD calibration chart as per annexure A.
- The measured value should correspond to the ambient temperature.

9.3.6 PROCEDURE FOR TURBINE OUTLET TEMPERATURE SENSOR

- The turbine outlet temperature sensor is of AD590 IC type. The sensor shall be connected to DC power supply with the multi meter in series.
- A DC power supply of 5-10 V shall be provided to the sensor and the current consumed shall be measured in micro amps.
- The sensor provides an output of 1μamp /Kelvin.

ACCEPTANCE CRITERIA

- The measured value should correspond to the ambient temperature around the turbine outlet.

9.3.7 PROCEDURE FOR ACM ROTATION

- Air supply from an external fan or blower may be directed towards the turbine inlet of the air cycle machine.

ACCEPTANCE CRITERIA

- Examine the rotation of the ACM.
- No irregular noises, unexpected behavior of the ACM should be seen.

Table 5 Integrity Check Report

NO	TEST Description	Criteria	PASS/FAIL	Remarks
1	Air valve operation	Open/close 10 times		
2	Turbine scroll heater operation	Power consumption less than 150W		
3	Ground fan operation	Power consumption less than 300 W		
4	Ram air temperature sensor operation	Ambient temperature		
5	Turbine outlet temperature sensor operation	Ambient temperature		
6	ACM Rotation	Presence of any abnormal rubbing sound		

9.4 ESS Test

9.4.1 PREPARATION FOR TEST

- The ACM Module shall be mounted onto an appropriate vibration fixture and affixed onto the vibration table in x,y or z axis.

9.4.2 PROCEDURE FOR ESS TEST

- ACM Module shall undergo vibration test as per profile below for 5 minutes in each axis.

Table 6 Vibration profile

Sl. No.	TEST & PROCEDURE	SEVERITY	DURATION	REMARKS
1	Random Vibration Test *Procedure:MIL-810F Method-514.5 Procedure-I*	Random vibration spectrum as given in Fig-5	Random vibration test to be carried out for 5 min /axis in each of the three axes	The test will be carried out with unit in off condition

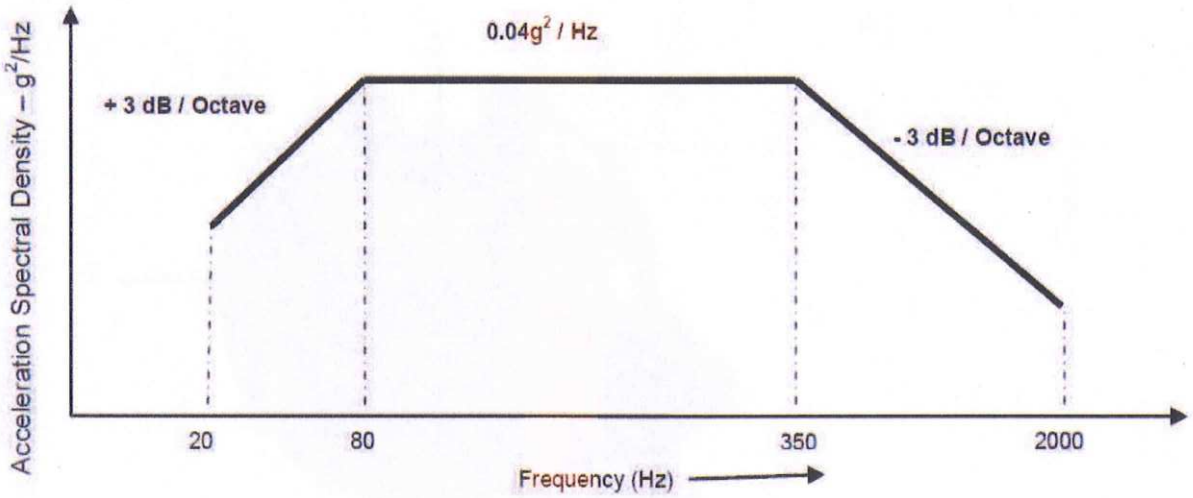

Figure 5 ESS profile

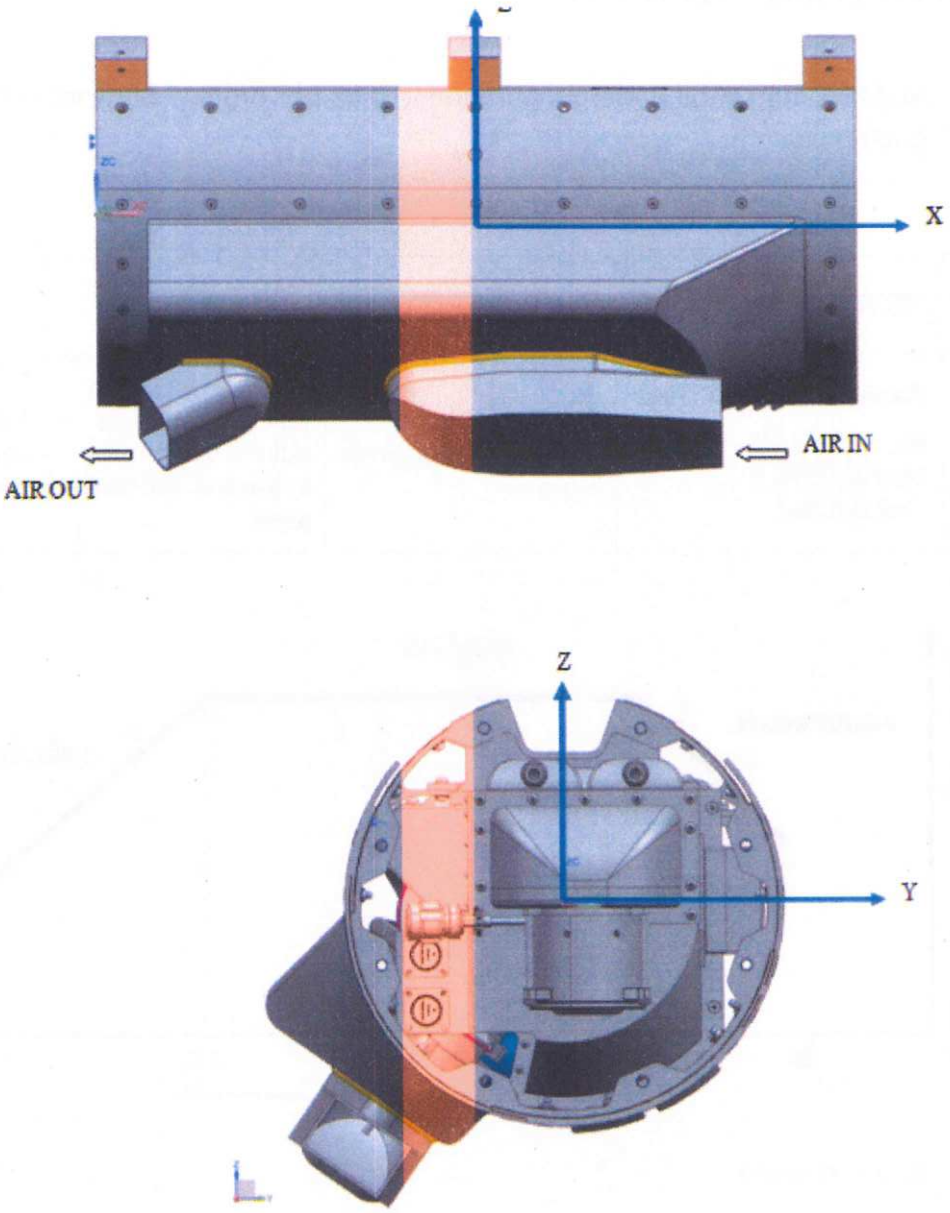

Figure 6 Vibration axis

ACCEPTANCE CRITERIA

- Physical inspection post ESS test should not reveal any mechanical damage and any fasteners should not be expelled from the module.

Table 7 ESS test report

NO	TEST Description	PASS/FAIL	Remarks
1	Visual inspection post random vibration		
2	Random vibration test profile		

10 ACCEPTANCE TEST OF HEAT EXCHANGER

10. 1 VISUAL EXAMINATION OF HEAT EXCHANGER

- Visually examine all the components/sub-assy for corrosion, dents and visual external damage

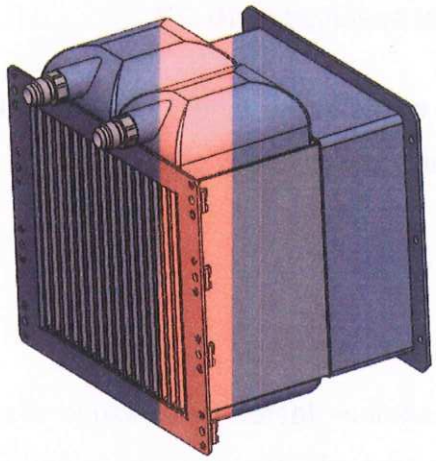

Figure 7 Heat exchanger

10.2 ACCEPTANCE CRITERIA

i. Overall dimensions of the Air to Liquid Heat Exchanger shall conform to BHEL-HPVP drawing no. RD-41016601-A-200.

ii. The dry weight of the Heat Exchanger assembly shall not exceed 2.1Kgs.

10.3 PROOF PRESSURE TEST

The test intends to prove that Ethylene Glycol circuit of the Air to Liquid Heat Exchanger can withstand without permanent deformation a Proof pressure which is equal to 9 Kg/cm^2 (g) at room temperature

10.3.1 PROCEDURE

- The Ethylene Glycol exit port of the Air to Liquid Heat Exchanger shall be capped using a suitable blank connector.
- The Ethylene Glycol circuit of exchanger shall be filled with water. The Ethylene Glycol inlet port of the unit shall be connected to a hydraulic pump.
- A pressure gauge of adequate range shall be connected to the line between the hydraulic pump and Ethylene Glycol inlet port. It shall be ensured that no air bubbles remain in either the Heat Exchanger or hydraulic line.
- Hydraulic pressure shall then be raised gradually to 9.0± 0.5 kg/cm^2 (g) by checking the reading on the pressure gauge.
- This pressure shall be maintained for a period of 2 (two) minutes. The exchanger shall pass the requirement specified in 10.3.2

10.3.2 ACCEPTANCE CRITERIA

The Ethylene Glycol circuit of the Air to Liquid Heat Exchanger, when tested, shall not show any evidence of leakage/sweating or permanent visual deformation anytime during the tests.

10.4 AIR SIDE LEAK TEST

The Air circuit of the ALHE shall be tested for absence of any leaks using air / inert gas at 4.0 Kg/cm2(g), to ensure that all joints in it are sound after all other tests. This test Procedure for the test and requirements to be met by the heat exchanger to pass the test are described below.

10.4.1 PROCEDURE – PNEUMATIC LEAK TEST

- The air circuit of the ALHE shall be capped using a suitable blank and shall be connected to a compressed air / inert gas source, through a suitable isolation valve.
- A pressure gauge of adequate range shall be connected to the line between the isolation valve and air inlet port. The exchanger shall then be kept submerged inside a tank filled with water.

- Air / inert gas supply into the exchanger shall then be turned on by gradually opening the isolation valve. The exchanger shall be kept submerged under water throughout the test duration.
- A supply pressure of 4.0 ± 0.5 kg/cm2 (g) shall be maintained, by checking the reading on the pressure gauge, for a period of 2 (two) minutes.

10.4.2 ACCEPTANCE CRITERION – PNEUMATIC LEAK TEST

The Air to Liquid Heat Exchanger, when tested as specified above, shall not show any evidence of leakage in the form of air bubbles emerging from the water in which the exchanger is kept submerged.

10.5 PRESSURE DROP TEST

The Ethylene Glycol and Cold Air circuits of the Air to Liquid Heat Exchanger shall be tested individually for pressure drop performance within permissible limits. These tests shall be conducted at room temperature (RT) at the respective test rigs using Ethylene Glycol and compressed air.

Procedure for the tests and requirements to be met by the heat exchanger to pass the tests describe below.

10.5.1 PROCEDURE – PRESSURE DROP TEST

ETHYLENE GLYCOL CIRCUIT

- The Ethylene Glycol inlet & outlet ports of the Air to Liquid Heat Exchanger shall be connected to the respective hoses at the Ethylene Glycol Circuit Test Rig.
- The Ethylene Glycol pump of the rig shall then be switched on. Inlet flow through it shall be stabilized at 10 ± 1 LPM by slowly adjusting the flow & pressure control valves of the rig.
- Inlet pressure, temperature, flows and pressure drop across the heat exchanger shall be recorded. Pressure drop across Ethylene Glycol circuit of the exchanger at the above test condition shall not exceed 0.45 bar.

COLD AIR CIRCUIT

- Connect the Cold Air inlet connector of the Air to Liquid Heat Exchanger to the corresponding upstream connector in the LP (Low Pressure) branch line at the Pressure Drop Test Rig with proper clamping.
- Similarly connect the outlet connector of the circuit to the corresponding downstream connector. Switch on the control circuitry of the rig and select to test Cold Air Circuit Pressure Drop at the Control Monitor.
- The settings for the Flow Control Valve for this test is at 9.54±0.5 Kg/min
- Open the Flow Control Valves gradually in turn until the system is stabilized at the set pressure and flow. Switch on the recorder / data acquisition device to record the inlet pressure, temperature, flow and pressure drop across Heat Exchanger.
- Adjust the downstream Flow Control valve so as to maintain the flow if required. Continue recording for 1 (one) minute.
- Pressure drop across the Cold Air Circuit of the Heat Exchanger at the above test condition shall not exceed 1048 Pa ±5%

Note: In case above tests are conducted at entry pressure(s), temperature(s) & flow(s) other than the corresponding specified values, the measured pressure drops(s) shall be corrected by multiplication with density & flow correction factors to arrive at the pressure drop(s) that would be achieved at the specified entry pressure (s) temperature(s) & flow(s)

10.5.2 ACCEPTANCE CRITERIA

ETHYLENE GLYCOL CIRCUIT

The Pressure drop across Ethylene Glycol circuit of the Air to Liquid Heat Exchanger, when tested at room temperature shall not exceed 0.45Bar.

COLD AIR CIRCUIT

The Pressure drop across Cold Air circuit of the Air to Liquid Heat Exchanger, when tested at room temperature shall not exceed 1048 Pa ±5%.

Table 8 Heat exchanger test report

NO	TEST Description	Criteria	PASS/FAIL	Remarks
1	Visual examination	Absence of visual defects cracks. Dry weight less than 2.1kg		
2	Proof pressure	Liquid side pressure at 9±0.5 kg/cm^2 (g)		
3	Air side leak test	Air side pressure at 4±0.5 kg/cm^2 (g)		
4	Pressure drop test liquid side	Liquid flow rate at 10 ± 1 LPM. Pressure drop less than 0.45 bar		
5	Pressure drop test air side	Air flow rate 9.54±0.5 Kg/min. Pressure drop less than 1048 Pa ±5%		

BHEL (Performed By)		
CASDIC (Witnessed By)	REP (IQA)	REP(Project Group)
Certifying agencies (Witnessed By)	REP (DGAQA)	

Annexure A –RTD Chart

RTD(PT100) Sensor Mapping

Temperature (°C)	Equivalent Resistance(Ω)	Currenet Excitation(uA)	Resistance to Voltage(mV)	Amplifier Gain	Amplifier Output Voltage/ADC input Voltage(V)
-60	76.32784355	100	0.4827844	221	0.106695342
-55	78.31886908	100	0.6818869	221	0.150697007
-50	80.30628188	100	0.8806282	221	0.194618829
-45	82.2901792	100	1.0790179	221	0.23846296
-40	84.27065203	100	1.2770652	221	0.28223141
-35	86.24778508	100	1.4747785	221	0.32592605
-30	88.22165677	100	1.6721657	221	0.369548615
-25	90.19233926	100	1.8692339	221	0.413100698
-20	92.15989843	100	2.0659898	221	0.456583755
-15	94.1243939	100	2.2624394	221	0.499999105
-10	96.08587899	100	2.4585879	221	0.543347926
-5	98.04440076	100	2.6544401	221	0.586631257
0	100	100	2.85	221	0.62985
0.1	100.0390824	100	2.8539082	221	0.630713722
5	101.9527063	100	3.0452706	221	0.673004808
10	103.902525	100	3.2402525	221	0.716095803
15	105.8494563	100	3.4349456	221	0.759122983
20	107.7935	100	3.62935	221	0.80208635
25	109.7346563	100	3.8234656	221	0.844985903
30	111.672925	100	4.0172925	221	0.887821643
35	113.6083063	100	4.2108306	221	0.930593568
40	115.5408	100	4.40408	221	0.97330168
45	117.4704063	100	4.5970406	221	1.015945978
50	119.397125	100	4.7897125	221	1.058526463
55	121.3209563	100	4.9820956	221	1.101043133
60	123.2419	100	5.17419	221	1.14349599
65	125.1599563	100	5.3659956	221	1.185885033
70	127.075125	100	5.5575125	221	1.228210263
75	128.9874063	100	5.7487406	221	1.270471678
80	130.8968	100	5.93968	221	1.31266928
85	132.8033063	100	6.1303306	221	1.354803068
90	134.706925	100	6.3206925	221	1.396873043
95	136.6076563	100	6.5107656	221	1.438879203
100	138.5055	100	6.70055	221	1.48082155
105	140.4004563	100	6.8900456	221	1.522700083
110	142.292525	100	7.0792525	221	1.564514803
115	144.1817063	100	7.2681706	221	1.606265708
120	146.068	100	7.4568	221	1.6479528
125	147.9514063	100	7.6451406	221	1.689576078

ACCEPTANCE TEST PROCEDURE FOR

LIQUID CIRCULATION UNIT (LCU)

OF 2 KW ACM BASED LIQUID COOLING SYSTEM

(Part No: 2041 102 000)

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No. of Pages			22
Title	**Acceptance Test Procedure(ATP) for Liquid Circulation Unit of 2KW Air cycle machine based Liquid Cooling System**		
Originating Group/Orgn.	BHEL Corporate R&D, Hyderabad		
Abstract	The ATP document provides details of tests to be carried out on the LCU after manufacturing the unit for acceptance of the unit.		

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Record of Amendments

Rev No.	Issue Date	Brief Description of Amendment	Affected Pages
00	17/09/21		
01	23/11/21	Annexure-1 added w.r.t LCU test set up	Page 19.
		Megger test table updated	Page 10

Distribution List

BHEL	Combat Aircraft Systems Development and Integration Center (CASDIC)	Certifying Agencies
AGM (Quality),BHEL Corporate R&D, Hyderabad	Project Office	DGAQA
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Contents

1. Introduction

The 2 KW Air Cycle Machine (ACM) based Liquid Cooling System (LCS) is used for maintaining the coolant temperature less than 45^{0}C while entering the heat loads. The Liquid Circulation Unit (LCU) of the LCS will circulate the coolant through the heat loads as well as other cooling system components like heat exchangers, heat loads and their interconnecting pipes at the desired flow rate. It should be able to handle the pressure drop of the various sub-systems and components in the entire coolant circuit including the internal pressure drop inside the LCU when the liquid is circulated at the desired flow rate as per the technical specifications of the unit.

2. Scope & Objective

This Acceptance Test Procedure (ATP) describes the test procedures to be followed for acceptance of the Liquid Circulation Unit Part No. 2041102000 developed by M/s BHEL-Corporate R&D, Hyderabad meeting the requirement of Technical Specification No. DARE/MED/041/REP/36 dated 04-05-2020 and MoM of DDR, Ref. No. DARE/MED/PRAVAH/2021/12, Dt. 20/02/2021

3. Applicable Documents

I. CASDIC, Bangalore Technical Specification for the 2 KW Air Cycle Machine based Liquid Cooling System for Pod application DARE/MED/041/REP/36 dt.04-05-2020.
II. BHEL-Corporate R&D GA drawing 0-LCS-45-02000 for Liquid Circulation Unit (LCU).
III. DGAQA Approved QAP (QAP-LCS-LCU-001 dated 17/08/2021).
IV. CEMILAC approved MDI document (MDI-LCS-LCU-001 Rev 03, dated 09/10/2021) Ref No: RCMA(A/C)/PRAVAH/LCU/3, Dt 02/11/2021
V. HTF/DARE/TR001 dated 17/09/2021 –CASDIC clearance for Demonstrational setup for LCU.
VI. ECN Ref No: CASDIC/PRAVAH/ECN/02/21 Dt 21/12/21

4. Test Centre & Sampling

All Acceptance Tests described in this document shall be carried out at the test facility at BHEL Corporate R&D/Accredited Labs, Hyderabad, after manufacture of each Liquid Circulation Unit.

5. Inspection/Certification Authority

All Acceptance Tests shall be witnessed and inspected by BHEL-Corporate R&D's Quality cell personnel, QAG representative from CASDIC and representative from DGAQA, Hyderabad in accordance with the requirements and procedures specified in this document for each Liquid Circulation Unit. The test report shall be submitted to CASDIC, Bangalore along with each Liquid Circulation Unit.

6. Instrumentation

All instruments used for Acceptance Tests shall be calibrated and certified in accordance with applicable MIL document or BHEL-Corporate R&D's standard calibration system or at NABL accredited Laboratories. Test set up used for ESS testing is certified by CASDIC.

7. Test Environment

All tests described throughout this document shall be performed on the Liquid Circulation Unit while it is kept at ambient (room) temperature, ambient pressure and humidity, unless otherwise specified in this document.

8. Tolerances On Test Parameters

The maximum allowable tolerances on various test parameters (exclusive of equipment accuracy) for various tests described throughout this document shall be as follows, unless otherwise specified in this document.

Flow	:	± 5 %
Pressure	:	± 5 %
Temperature	:	±10 °C

9. Acceptance Test Sequence

The following Acceptance Tests shall be performed on the Liquid Circulation Unit in the sequence specified in table -1 below.

Note: Acceptance test of individual components will be done separately before assembly of the components to form the LCU.

Sequence	Name of Test
1	Visual Examination
2	Mechanical Properties Checks
3	Dimension & Weight Check
4	Physical Interface Checks (Mechanical & Electrical)
5	Proof Pressure Check
6	Pressure Relief Valve Check
7	Accumulator Check
8	Functionality Check (Pre ESS)
9	Environmental Stress Screening
10	Functionality Check (Post ESS)
11	Final Inspection

Table-1 Acceptance test sequence

10. Acceptance Test Detail:

10.1 Visual Examination:

i. Visually examine all the components/sub-assemblies (refer table -2) for corrosion and visual external damage like paint peel-off etc.

Sl. No.	Major sub assembly	Part No	Serial No.	Result
1	Monoblock Assembly			

2	Pump Assembly – Drive end			
3	Pump Assembly – Suction end			
4	Motor Assembly			
5	Accumulator			
6	Solenoid Valve			
7	Pressure transducers – 100 psig			
8	Pressure transducers – 200 psig			
9	Temperature Sensor			
10	Check Valve			

Table-2 Major assembly/Sub assembly/ Components details

ii. The Liquid Circulation Unit shall be manufactured and assembled as per BHEL Corporate R&D drawing no. 0-LCS-45-02000 and checked for conformity with approved MDI. Any deviations from the drawing shall be reported to CASDIC project team/CASDIC IQA / RCMA for study and acceptance.

iii. Verify and note down the name plate details of the unit like Sl. No., Part No., weight (empty) etc. as given in the Table -3 below-

Sl. No.	Action	Expected result	Observed value	Pass/Fail
1	Part No.	2041 102 000		
2	Sl. No.	--		
3	Weight	12.5 kg (max)		
4	Manufacturing Year	---		
5	Version No.	01		

Table-3 Name Plate details

10.2 Mechanical Properties Checks: Following mechanical property checks to be carried out and document in table -4

a. The mono block material shall be AA 6061-T6. The test certificate to be provided.
b. The Hardness of the block shall be greater than or equal to 95 BHN. The test report to be provided.

S. No.	Test certificate/report	Observations /Remarks	Pass/Fail
1	Material test certificate		
2	Material Hardness report		

Table-4 Material properties check

10.3 Dimension & Weight Check:

i. Measure the dry weight of the LCU as per BHEL-Corporate R&D drawing no. 0-LCS-45-02000 using a weighing machine.
ii. Measure the overall dimensions of the LCU as per BHEL-Corporate R&D drawing no. 0-LCS-45-02000and document as per the table -5 given below-

Sl. No.	Action	Expected value	Observed value	Pass/Fail
a	Dry weight of unit	12.3 +/- 0.2 Kg		
b	Length (mm)	288+2 (max)		
c	Width (mm)	197 +2 (max)		
d	Height (mm)	218+2 (max)		

Table-5 Weight & Overall Dimensions of LCU assembly

10.4 Physical Interface Checks (Mechanical & Electrical):

Following mechanical and electrical interface checks shall be carried out on the LCU:

a) Confirm location of QDCs as per the GA drawing No. 0-LCS-45-02000 and genders of Quick disconnect couplings (QDCs). All QDCs shall be Plug type.
b) Confirm location and gender of the Signal connector and Power connector.
c) Continuity test shall be conducted for Electrical loom. All Pins shall be connected as per Loom ICD (Refer drawing No. 3-LCS-45-01028). Ensure the loom is qualified for airborne applications.
d) Carry out Megger Test for the Pump motor and record the observations as per table -6 given below –

Sl. No.	Action	Expected result	Observed value	Pass / Fail
1	Measure Ground voltage	0 V AC		
2	Measure phase resistance to ground @ 600 V DC (Megger Test)	>20M ohm		

Table-6 Megger test report

10.5 Proof Pressure Check

The proof pressure checks shall be carried out using the setup shown in Fig 3 of Annexure A and as per the procedure given below. Results are to be documented in table-7:

a) Pressurize the LCU with a help of charging equipment. Ethylene Glycol Water Mixture (65:35) or any other equivalent liquid with similar density can be used for pressurizing the LCU.
b) Ensure that all the components of LCU (UUT) are connected properly to mono block.
c) Slowly pressurise unit to 9 Bar and Isolate UUT from the pressure source.
d) Keep the UUT isolated from the pressure source and monitor the pressure for 2 minutes.
e) Slowly reduce the pressure inside the UUT to atmospheric pressure.

Acceptance criteria – There should be no leakage in the unit.

S. No.	Test	Observations	Pass/Fail
1	Proof pressure test		

Table-7 Proof pressure check

10.6 Accumulator Check:

During the proof pressure test mentioned in Para 10.5, monitor and record the level sensor readings of the accumulator as given below –

a) Ensure that accumulator level sensor is connected to a multi meter to measure the voltage.
b) When the circuit pressure is zero, measure the output voltage of level sensor. The level sensor should indicate 0.3125 ± 0.1Volts
c) Connect pressure source to inlet port of LCU and slowly pressurise unit to 1 Bar gauge pressure. Measure the output voltage from level sensor. Record the output voltage as per the Table -8.

d) Slowly Increase the pressure to 6 bar and measure the output voltage from level sensor.
e) Slowly reduce the pressure to 1 Bar. Measure the output voltage from level sensor.
f) Slowly reduce the pressure inside the LCU to zero. Measure the output voltage of level sensor.

Sl. No.	Action	Level sensor output (Volts)	Observed value (Volts)	Pass/Fail
1	Circuit Pressure – '0' bar gauge	0.3125 ± 0.1		
2	Circuit Pressure – '1' bar gauge	2.5 ± 0.4		
3	Circuit Pressure – '6' bar gauge	4.68 ± 0.4		
4	Circuit Pressure – '1' bar gauge	2.5 ± 0.4		
5	Circuit Pressure – '0' bar gauge	0.3125 ± 0.1		

Table -8 Level sensor output

10.7 Pressure relief valve check

Ensure the LCU is charged with the operating coolant (EGW mixture) into the LCU. Keeps the coolant charging equipment connected.

a) Remove the pressure relief valve outlet pipe from the LCU.
b) Increase pressure in the LCU gradually to 6 bar (operating pressure).
c) There should be no leakage through the Pressure relief valve.
d) Increase the pressure to (9+0.5) bar and check if the PRV has cracked and started leaking.
e) Decrease the pressure to 8+0.5 bar to ensure there is no flow at the outlet of the PRV and it is reseated properly.
f) Repeat steps (b) to (e) once again to confirm the results.

S. No.	Test	Observations	Pass/Fail
1	Pressure relief valve check		

Table -9 Pressure Relief valve

10.8 Functionality Check (Pre/ Post ESS Testing)

1. **Functional Test Procedure:**

a) Charge the unit along with full circuit with Ethylene glycol- water mixture (65:35) up to 1bar gauge pressure. The pressure reading can be obtained either from Pressure sensor -'1' or Pressure sensor -'2'. The charging shall be carried out with external charging unit.

b) Switch 'ON' Solenoid valve -1(Thermal By pass) manually with the help of electrical switch. (Solenoid valve -2 &3 shall be in Switched 'OFF' condition.

c) Switch 'ON' the pump and measure the readings as per the table-5, The pump shall be turned 'OFF' while manually switching ON/OFF the solenoid valves.

d) Adjust the 'control valve' on the demonstrational test setup such that the discharge pressure is 5.6 bar gauge.

e) Readings shall be taken as mentioned below and should be documented in Table -10-

   i. Measure the flow rate of the pump with the help of flow meter mounted on the demonstrational test setup.

   ii. Power and current measurement shall be taken with the help of Power analyzer.

   iii. The Coolant temperature, Discharge pressure and suction pressure shall be measured with the help of sensors mounted on LCU.

   iv. Switch 'OFF' the pump.

   v. The level sensor reading shall be taken with multi meter (in Volts).

f) Similarly, Switch 'ON' Solenoid valve -2 (ALHE) with other two solenoid valves in closed condition. Record the readings as per table -5 and Switch 'OFF' the pump.

g) Repeat the same process for Solenoid valve -3 (PCMHE).

h) The total duration of the test shall be 10 minutes (around 3minutes operation with each solenoid valve open) including time required for switching ON/OFF the solenoid valves.

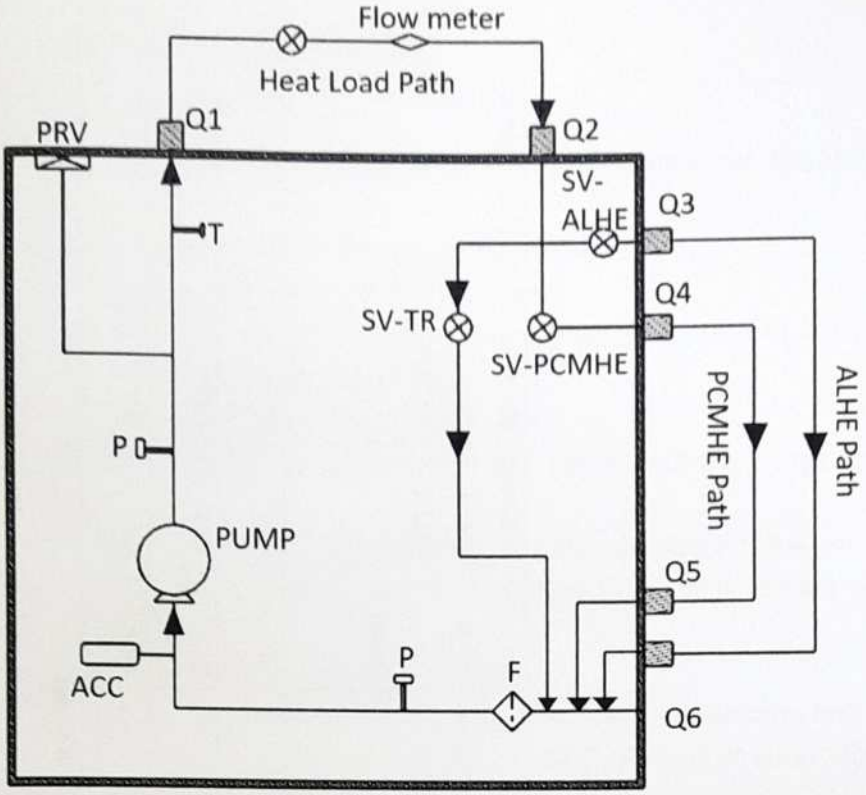


Fig-1 Schematic of Basic Test Setup for LCU

Acceptance Criteria:

Observed readings shall be within the ranges provided below –

a) Flow rate: 10 ± 0.5 LPM

b) Discharge Pressure: 5.6 ± 0.3 bar

c) Suction Pressure: 1± 0.2 bar

d) Power consumption: 400 ± 20 Watts

e) Coolant temperature: 25± 10ºC

Time	Duration of Testing (Min)	Discharge pressure (bar gauge)	Suction Pressure (bar gauge)	Coolant Flow Rate (LPM)	Coolant Temperature (Deg C)	Power Consumption (Watts)	Solenoid valve -1 (By Pass)	Solenoid Valve -2 (ALHE)	Solenoid valve -3 (PCMHE)	Pass/Fail	Remarks
	1- 4						**ON**	OFF	OFF		
	4 - 7						OFF	**ON**	OFF		
	7- 10						OFF	OFF	**ON**		

Table -10 Test Data sheet

10.9 Environmental Stress Screening:

10.9.1 Random Vibration Test

The random vibration test, as part of the ESS is explained below. The test profile is shown below.

- Mount the UUT on vibration table with suitable fixture.
- Ensure the cables are secured to the fixture firmly.
- Carry out vibration test on the UUT along 'X' axis for duration of five minute in accordance with test profile shown in fig 2.
- Similarly, repeat the test in 'Y' and 'Z' axes also.
- During vibration the UUT should be charged with coolant (EGW) to charging pressure, i.e. 1 bar.
- Carry out physical check of the UUT before and after completion of the test.
- Check the pressure of the UUT after the test. There should be no leakage of coolant from UUT after the test.
- Random Vibration test details are as follows:

Test Profile: increase in PSD level at the rate of +3 dB/octave from 20 to 80 Hz upto 0.04 g^2 / Hz.0.04 g^2 / Hz from 80 Hz to 350Hz. decrease in PSD level at the rate of -3 dB/octave from 350 to 2000 Hz. (Refer Fig-2)

Duration: 5 min /Axis (for all 3 perpendicular axis)

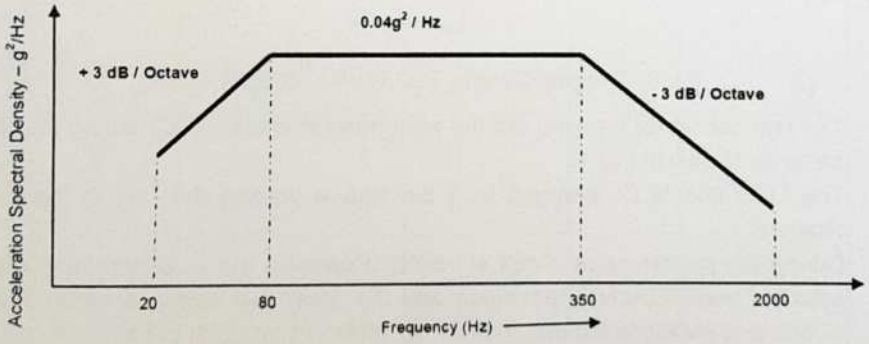


Figure 2-Random Vibration Level

Acceptance Criteria: LCU should be free from structural failure. All components installed on the mono block of LCU should be intact and no looseness should be observed. There should not be any leakage of the coolant after the vibration test.

10.9.2 Thermal Cycle

The UUT will be subjected to the temperature extremes of -40°Cand +55° C for ten cycles as per profile given in Fig 3 to the test item. The rate-of-change of temperature from minimum to maximum, and vice versa, shall be at an average rate of 5°C / min. During the thermal cycle, do the Performance Test at the Test Points mentioned in the figure -3 and records the result.

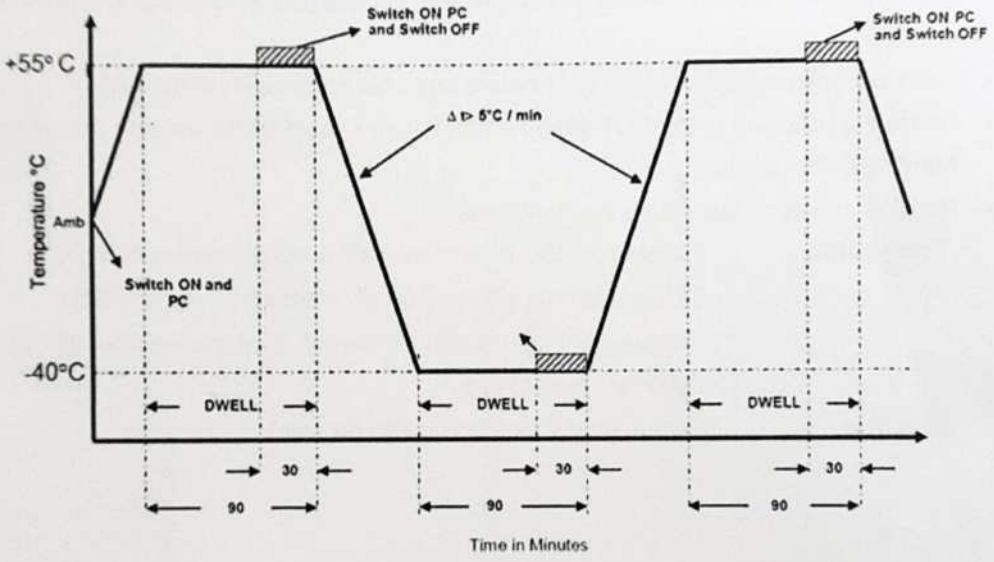


Fig 3 -Thermal Cycling Test Profile for ESS Testing

- The test set up for carrying out the performance checks (PC) during the ESS is same as shown in Fig-1.
- The LCU should be charged to 1 bar before placing the unit in the thermal chamber.
- During the performance check at +55^{0}C, Power-on the LCU and keep only the solenoid valve-2(ALHE)Path open and the other two solenoid valves shall be closed and measure the readings as per table -11 for each cycle.
- Similarly, During the performance check at -40^{0}C, Power-on the LCU and keep only the solenoid valve-1(Bypass)Path open and the other two solenoid valves shall be closed and measure the readings as per table -11 for each cycle. Record the readings as per table -11

Thermal Cycle Number	Time	Duration of Testing (Min)	Chamber temp. (ºC)	Discharge pressure (bar gauge)	Suction Pressure (bar gauge)	Coolant Temp. (ºC)	Power Consumption (Watts)	Solenoid valve - 1 (By Pass)	Solenoid Valve - 2 (ALHE)	Solenoid valve -3 (PCMHE)
Cycle -1			+55					OFF	**ON**	OFF
			-40					**ON**	OFF	OFF
Cycle -2			+55					OFF	**ON**	OFF
			-40					**ON**	OFF	OFF
Cycle -3			+55					OFF	**ON**	OFF
			-40					**ON**	OFF	OFF
Cycle -4			+55					OFF	**ON**	OFF
			-40					**ON**	OFF	OFF
Cycle -5			+55					OFF	**ON**	OFF
			-40					**ON**	OFF	OFF
Cycle -6			+55					OFF	**ON**	OFF
			-40					**ON**	OFF	OFF

Cycle -7			+55					OFF	**ON**	OFF
			-40					**ON**	OFF	OFF
Cycle -8			+55					OFF	**ON**	OFF
			-40					**ON**	OFF	OFF
Cycle -9			+55					OFF	**ON**	OFF
			-40					**ON**	OFF	OFF
Cycle -10			+55					OFF	**ON**	OFF
			-40					**ON**	OFF	OFF

Table -11 Test Data sheet (Thermal Cycling)

BHEL QA CASDIC QA ORDAQA

Acceptance Criteria: LCU should not have any degradation of performance. There should be no leakage of coolant from the unit.

10.9.3 Random Vibration Test

Repeat Random vibration tests as per Sl. No. 10.9.1, after completion of Thermal cycling test

10.10 Final Inspection: LCU shall be inspected visually. There should be no mechanical damage and leakage in the unit. Functional test to be carried out post ESS.

10.11 Packing and shipment : Item shall be dispatched as per TS para 16 for packing and shipment.

Annexure - A

CASDIC Clearance for Demonstrational setup for LCU functional testing

Document No. HTF/DARE/TR/001 **Date:** 17/09/2021

1.0 Introduction : The functional testing of the Liquid Circulation unit (LCU)will be carried out in demonstrational setup at BHEL R &D, Hyderabad.

2.0 Test set up for ATP of LCU :

The schematic of the test set up for the ATP of the unit is given in the figure 3. The set up consists of a Reservoir to charge the circuit, Pressure regulating device to maintain the discharge pressure, Liquid Filter and Flow meter to measure the flow rate of the coolant.

The pressure and temperature of the coolant at the suction and discharge location will be taken with the help of pressure and temperature sensor mounted on the LCU. The Full test set up is shown in the figure 1.

Electrical power will be provided to the LCU through external power supply.

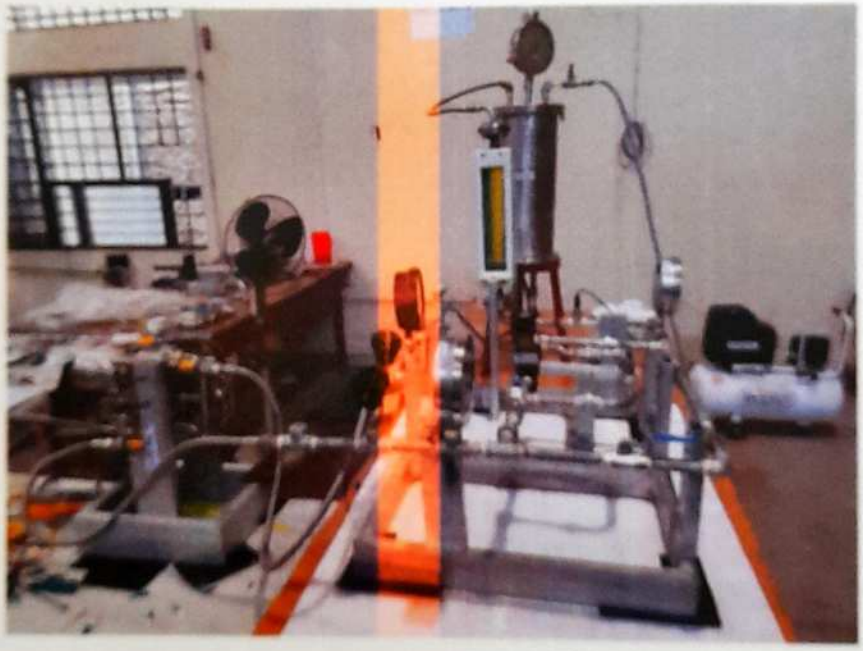


Fig 1. Demonstrational setup for ATP of Liquid Circulation Unit

3.0 Test set up for ESS of LCU :

The schematic of the test set up for the ESS of the unit is given in the figure 4. The set up consists of a Pressure regulating device to maintain the circuit pressure and flow meter to measure the flow rate of the coolant.

The pressure and temperature of the coolant at the suction and discharge location will be taken with the help of pressure and temperature sensor mounted on the LCU. The Full test set up is shown in the figure 2.

Fig 2. Demonstrational setup for ESS testing of Liquid Circulation Unit

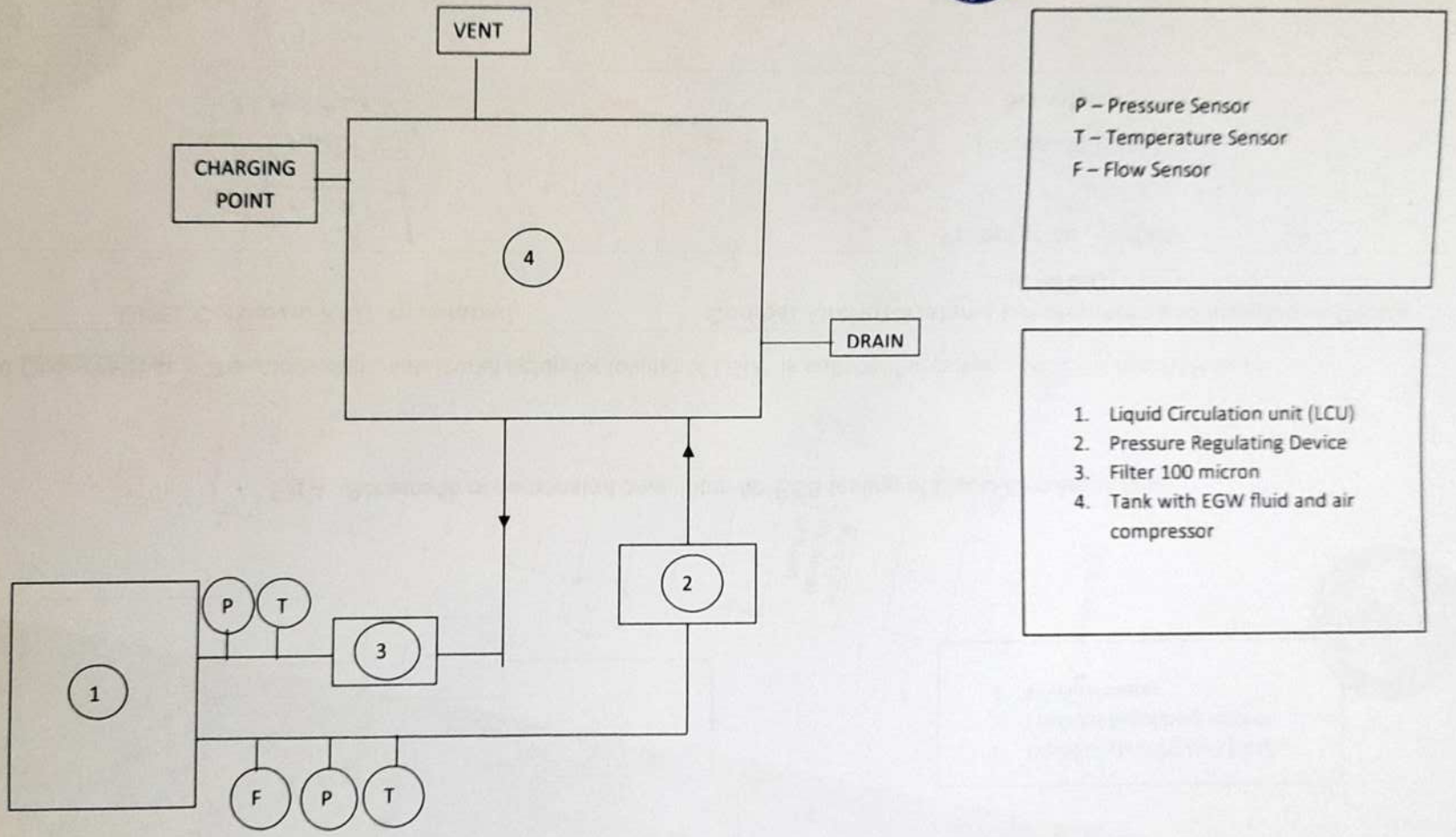
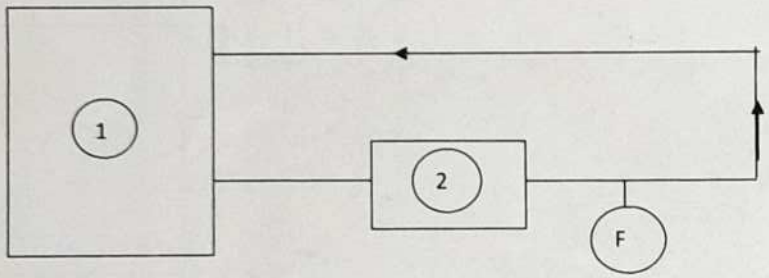


Fig 3 . Schematic of Demonstrational setup for ATP of Liquid Circulation Unit



1. Liquid Circulation Unit (LCU)
2. Pressure Regulating system
3. F – Flow meter

Fig 4. Schematic of demonstrational setup for ESS testing of Liquid Circulation Unit

4.0 Observations: The above demonstrational setup for testing of LCU is suitable for carrying out ESS and ATP tests.

BHEL Corporate R&D, Hyderabad	**Combat Aircraft Systems Development and Integration Centre (CASDIC)**
(A.SANDEEP) MANAGER	Project office (Verified): **(Sreenath Bhat)** **Scientist 'F'**

PROJECT

SWAYAM RAKSHA KAVACH

QUALIFICATION TEST PLAN DOCUMENT FOR ELECTRONIC CONTROL UNIT (ECU) OF LIQUID COOLING SYSTEM

Part No: 2041 104 000 (Hardware Ver: 2.0)

Bharat Heavy Electricals Ltd.

HPVP, Visakhapatnam

Combat Aircraft Systems Development & Integration Centre (CASDIC) DRDO, Bangalore

Contents

1 INTRODUCTION

1.1 PURPOSE & SCOPE

This document provides the Qualification Test Plan for the Electronic Control Unit (ECU) used in an airborne liquid cooling system of Advanced Self Protection Jammer (ASPJ) Pod of EW Suite for LCA Mk1A being developed as part of Swayam Raksha Kavach project. The purpose of the control unit is to monitor and control the operation of an Airborne Liquid Cooling System (ALCS). The ECU receives signals from various sensors of the airborne liquid cooling system, executes a predefined logic and controls different modes of operation of the ALCS. The ECU also reports the faults observed in the ALCS to an external EW Controller. These tests have to be carried out to show that this item will not cause a hazard in the aircraft and it will function satisfactorily in the envisaged environment.

The ECU with Part No 2041 104 000 V2 and Sl. No 004 has undergone Limited Qualification testing as part of PRAVAH technology development project. Majority of the environmental tests have been completed as part of LQT. The balance pending tests of the QT are proposed to be carried out as part of QT on the same LQT unit.

1.2 OVERVIEW OF ITEM

This document explains about the Qualification Test plan for ECU in detail.

1.3 REFERENCE DOCUMENT

Sl. No	Document No.	Title
1	DARE/MED/041/REP/26, Rev 1.0 Dated 26/09/23	TECHNICAL SPECIFICATION
2	DARE/MED/041/REP/HW-2.0/51, Rev 3.0 Dated 11/10/2021	ACCEPTANCE TEST PROCEDURE FOR ELECTRONIC CONTROL UNIT (ECU)OF LIQUID COOLING SYSTEM
3	DARE/MED/041/REP/HW-2.0/48 Dated 11/10/2021	FUNCTIONAL TEST PROCEDURE FOR ELECTRONIC CONTROL UNIT OF LIQUID COOLING SYSTEM
4	FY20114/ECU/HW-2.0/SOP, Rev.2.0 Dated 11/10/23	STANDARD OF PREPARATION DOCUMENT FOR ELECTRONIC CONTROL UNIT(ECU)
5	DARE/PRAVAH/041/REP/52, Rev 2.0 Dated 11/10/2021	LIMITED QUALIFICATION TEST PLAN FOR ELECTRONIC CONTROL UNIT (ECU) OF LIQUID COOLING SYSTEM
6	DARE/PRAVAH/041/REP/23/01, Rev 1.0 Dated: 20/01/23	LIMITED QUALIFICATION TEST REPORT (SL.NO.004) FOR ELECTRONIC CONTROL UNIT (ECU) OF LIQUID COOLING SYSTEM

1.4 ECU SPECIFICATIONS

UNIT	DIMENSIONS (LXWXH)	WEIGHT (KG)
ECU	270X150X45mm	3.3Kg ±0.3 Kg

1.5 TSET TO BE CARRIED OUT

SL NO	TEST
1	Thermal Shock Test
2	Shock Crash Hazard
3	Transit drop test
4	Bench Handling Test
5	Salt Fog Test
6	Fungus (Mould Growth) Test
7	Rain Drip Test
8	Blowing Dust
9	Fluid Contamination Test

1.6 QUALIFICATION TEST SPECIFICATIONS

Sl. No.	**Test Name**	**Test Specification**	**Test as per FTP/ATP/LQT**
1	Thermal Shock Test	Stabilize at -40°C, soak for 1 hour. Transfer and stabilize at +65°C and soak it for 1 hour. Transfer it to -40°C for 1 hour. This constitutes 1 cycle	Transfer from low temperature to high temperature chamber and vice versa is to be effected within 5minutes

2	Shock Crash Hazard	40g Saw tooth (or 30g Half sine) 11ms, 2 shocks in each of six directions.	Test will be carried out on ECU Mockup Unit as per Technical specification
3	Transit drop test	For equipment lighter than 45.4kgs, 26 drops (1 drop/each face, edge & corner) Height of drop 122cm	The equipment shall be tested with an approved packing box
4	Bench Handling Test	Raise one edge by 10 cm or 45°C whichever is less. 4 drops on each face	• Applicable only when any of the dimension is greater than 23 cm • Drop in table with Antistatic material
5	Salt Fog Test	Salt solution of 5±1% concentration -24 Hours exposure & -24 Hours drying constitute one cycle 2 cycles	• Composition of salt for preparation of solution shall be with NaCl solution containing not greater than 0.1% Sodium iodide not greater than 0.5%impurities • Drying shall be at prevailing ambient conditions.
6	Fungus (Mould Growth) Test	Wet the entire surface of test item with spore suspension for 10 min. Incubation period 28 days at 30°C, 95% RH	This test can be carried out on representative samples of parts used in equipment's Alternatively this test can be carried out as per JSS55555
7	Rain Drip Test	Volume flow rate 250 to 280 lit/m2/Hour. Dispenser placed approximately 1 meter above equipment. 15 minutes (Configuration as installed on the aircraft)	Applicable of LRU is installed in an environment where rain drip is encountered
8	Blowing Dust	Blowing Dust Air Velocity 1.5 m/sec to 8.9 m/sec. RH= 30% 6 Hrs. at 23°C	Dust concentration 10.6±0.7 grams/m3 Material of dust: silicon dioxide or china clay test applicable only for externally mounted LRU'S Alternatively this test can be carried out as per JSS55555

9	Fluid Contamination Test	Test Temperature:65°C±3°C 7 days / test fluid Test Fluids 1.Fuel DERD 2494 2.Hydraulic fluid MIL-H-5606E 3.Lub oil mixture to DERD 2497/MIL-L-7808 4.Soap Water	This test can be carried out on representative samples of parts used in equipment

1.7 THERMAL SHOCK TEST

Test Severity:

- Temperature: -40°C to +65°C
- Duration: 1Hr (at -40°C) & 1Hr (at+65°C)
- Transit time < 1 min
- No. of Cycles: 3 cycles
- Unit in Power OFF Condition
- Ref Standard: MIL- 810F Method-503.4

Test Procedure

a. Perform functional Check on EUT as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51)
b. Place the EUT in the chamber.
c. Adjust the chamber air temperature to the low temperature extreme (-40^0C). Maintain this for a period of 1Hr.
d. Transfer the EUT to the maximum air temperature of the High Temperature ($+65^0$C) in no more than 1 minute. Maintain this temperature for 1Hr.
e. Repeat step ‘c’ to ‘d’ for 3 cycle.
f. Examine the EUT and perform performance check as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51) and record the results.

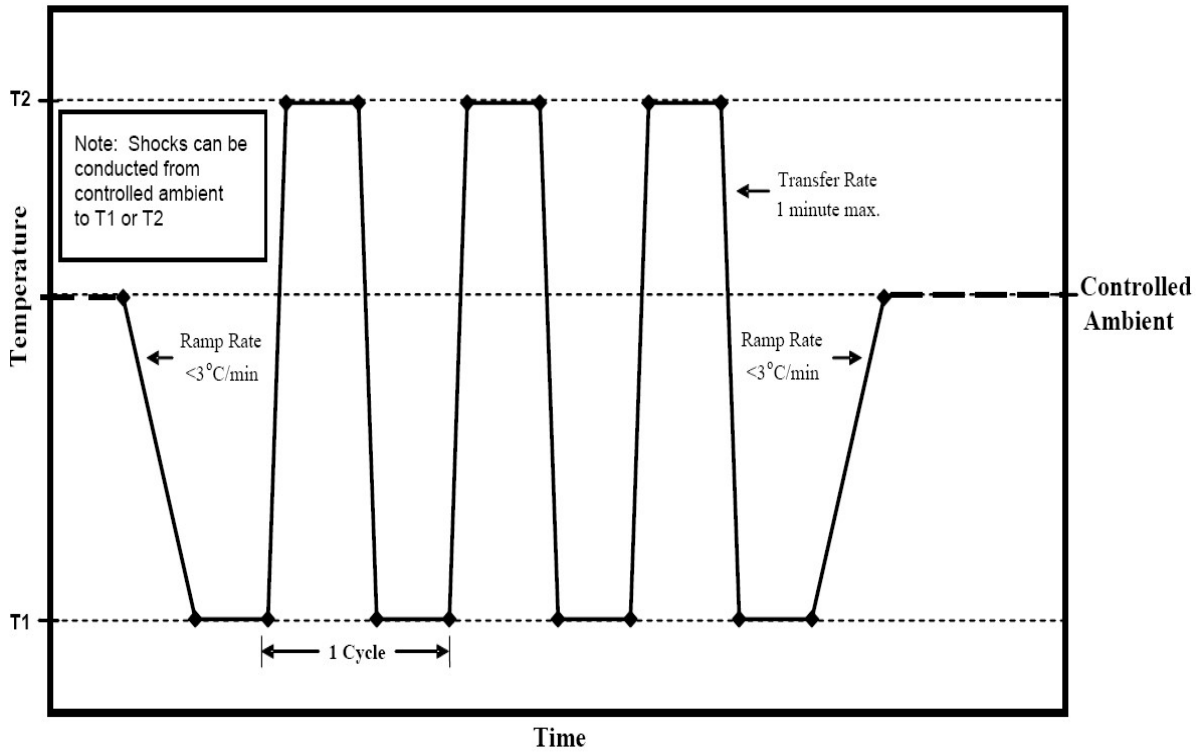


Figure 1: Thermal shock Test Profile

Note: The value of T1 and T2 will be taken as -40 ^{o}C and +65 ^{o}C respectively.

Test Interruption

Follow any interruption by re stabilization at the identified levels and continuation of the test from the point of the interruption. If the interruption occurs during the transfer reestablish the item at the previous temperature and then do the transfer.

Acceptance Criteria:

At the end of the test, Visually Examine the Unit and Perform the performance check as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51). ECU should not have any degradation in performance.

1.8 SHOCK TEST (CRASH HAZARD)

Test Purpose:

The purpose of this test is to check the structural integrity of the unit to crash shock

Test Conditions:

- As per MIL-STD-810F, Method 516.5.
- Shock pulse characteristics: 40g Saw tooth (or 30g Half sine) 11ms.
- 2 shocks in each of six directions
- Test to be carried out mechanically equivalent mock-up.

Test Procedure:

The Crash test is performed on an equivalent dummy unit of ECU. The Chassis of the LCU is maintained same whereas the units of the ECU such as microcontroller board, power supply board etc. are replaced with an equivalent dummy weight. The mounting points of the dummy weights are maintained same as that of the original units. The dummy ECU shall be mounted onto a suitable fixture, which shall then be mounted on the shock test setup. Two shocks shall be applied along each of three principal axes by orienting the Equipment along each axis in turn. Shocks shall be of Saw-Tooth form with a magnitude of 40 g's over a duration of 11 ms (or 30g half sine for 11 m sec)

Acceptance Criteria:

The ECU Chassis should not get dislodged from its mounting point.

1.9 TRANSIT DROP TEST

Test Purpose:

This test is to determine whether EUT is capable of withstanding shocks normally inducted by loading and unloading when it is, outside of its transit or carrier and inside its transit case. Such shocks are accidental but may impair the functioning of the equipment.

Test Severity:

- As per MIL– STD– 810F, Method 516.5 Procedure – IV
- For equipment lighter than 45.4 kg.
- Height of drop: 122 cm.
- No. of drops: 26 (1 drop on each face, edge and corner)
- The EUT shall be kept in its normal packed conditions during the Test.
- The Equipment shall be tested with an approved packing box.

Test Procedure:

a. Perform functional Check on EUT as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51).
b. Pack the EUT in normal packing condition as prepared for field use.
c. Height of drop: 122cms and No. of drops: 26 (1 drop on each face, edge and corner)
d. Perform the required drops using the apparatus from the required height. Periodically, during the Drop Test, Visual inspection to be carried out, to simplify any follow-on failure evaluation that may be required.
e. Document the impact point or surface for each drop and any obvious damage.
f. Following completion of the required drops, visually examine the EUT and Record the results.
g. Conduct Performance check on the EUT as per ATP document and Record the results.

Acceptance Criteria:

At the end of the test, Visually Examine the Unit and Perform the performance check as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51). ECU should not have any degradation in performance

1.10 BENCH HANDLING TEST

Test Purpose:

This test is to determine the ability of the EUT to withstand representative levels of shock encountered during typical bench handling, bench maintenance or packaging. Such shocks might occur during repair.

Test Severity:

As per MIL– STD– 810F, Method 516.5 Procedure – VI. The Drops shall be performed on all faces on which the unit could be placed practically during servicing. For each face, a maximum of 4 drops shall be carried using each practical edge as pivot points.

Test Procedure:

a) Perform functional Check on EUT as per as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51).
b) Position the EUT as it would be for servicing. The EUT will be non-operational during the test.
c) Using one edge as a pivot, life the opposite edge of the chassis until one of the following condition occurs (whichever occurs first)
    - The lifted edge of the chassis has been raised 100mm above the horizontal bench top.
    - The chassis forms an angle of 45º with the horizontal bench top.
    - The lifted edge of the chassis is just below the point of perfect balance. Let the chassis drop back freely to the horizontal bench top. Repeat using other practical edges of the same horizontal face as pivot points, for a total of four drops.
d) Repeat step ‘c’ with the EUT resting on other faces until it has dropped for a total of four times on each faces on which the test item could be placed practically during servicing.
e) Visually inspect the EUT and Record the Results.
f) Conduct Performance check on the EUT as per ATP document and Record the results.

Acceptance Criteria:

At the end of the test, Visually Examine the Unit and Perform the performance check as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51). ECU should not have any degradation in performance.

1.11 SALT FOG TEST

Test Purpose:

This test is to determine the resistance of the EUT in terms of quality and uniformity of the protective coating and material finish to the effect of salt atmosphere.

Test Severity:

- Salt Concentration: 5 ± 1%
- Composition of salt for preparation of solution shall be with NaCl solution containing not greater than 0.1% Sodium Iodide & not greater than 0.5% Impurities. Drying shall be at prevailing ambient conditions.
- Test sequence for the above shall be as follows:
- One cycle consists of 24 Hr. exposure and 24 Hr. Drying (48 hours)
- Temperature: Standard ambient
- No. of Cycle: 2
- Duration: 96 hours
- This test shall be carried out on the complete assembled unit
- Ref standard MIL-810F Method-509.4

Test Procedure:

a. Perform functional Check on EUT as per as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51).
b. Adjust the test chamber temperature to 35ºC and condition the EUT for at least for 2 hrs. before introducing the salt fog.
c. Continuously atomize a salt solution into the chamber for a period of 24 hrs. During the entire exposure period measure the salt fog fallout rate and pH of the fallout solution. Ensure the fallout is between 1 and 3ml/80cm^2/hr.
d. Dry the EUT at standard ambient temperatures and a relative humidity of 50% or less for a period of 24 hrs. Do not disturb the EUT during the drying period. At the end of the drying period, replace the EUT in the salt fog chamber and repeat the steps ‘c’ & ‘d’.
e. Visually inspect the EUT
f. After completing the Physical inspection, perform the performance check as per the ATP Document and Record the Results.

Acceptance Criteria:

At the end of the test, Visually Examine the Unit and Perform the performance check as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51). ECU should not have any degradation in performance.

1.12 FUNGUS (MOLD GROWTH) TEST

Test Purpose:

This test is to determine the resistance of the EUT to fungi and the adverse effects by fungi under the conditions favorable for their developments viz. high humidity, warm atmosphere and presence of inorganic salts.

This test is carried out on representative samples of parts used in equipment. Alternatively, if material analysis reveals that the material is not a nutrient to any fungus listed in table below, then this test can be dispensed with.

Test Severity:

- As per MIL- 810F Method-508.5
- The ECU Chassis is exposed to the conditions of fungus and mold growth. The ECU chassis is fabricated from AL 6061 T6 with chromate conversion and PU paint on the external surface. Also it contains gaskets and O rings of silicon rubber material.
- Hence representative samples of the above materials shall be studied by test or alternatively material analysis will be presented.
- Wet the entire surface of test item with spore suspension for 10 min. Incubation period 28 days at 30°C, 95% RH
- Following types of fungus will be utilized- Aspergillus flavus or Aspergillus versicolor or Penicillium funiculosum
- This test can be carried out on representative samples of parts used in equipment. Alternatively, this test can be carried out as per JSS55555.

Test Procedure:

Preparation for incubation-

a. Assure the condition of the items to be tested is similar to their condition as delivered by the manufacturer or customer for use, or as otherwise specified. Accomplish any cleaning of the test item at least 72 hours before the beginning of the fungus test to allow for evaporation of volatile materials.

b. Install the test item in the chamber or cabinet on suitable fixtures, and remove any covers.
c. Hold the test item in the test chamber at 30 °C and a RH of at least 95 percent for at least four hours immediately before inoculation.
d. Inoculate the test item and the cotton fabric chamber control items with the mixed fungus spore suspension by spraying the suspension on the control items and on and into the test item(s) (if not permanently or hermetically sealed) in the form of a fine mist from an atomizer or nebulizer. Ensure personnel with appropriate knowledge of the test item are available to aid in exposing its interior surfaces for inoculation.
e. In order for air to penetrate, replace the covers of the test items without tightening the fasteners.
f. Start incubation immediately following the inoculation.
g. NOTE: In spraying the test and control items with composite spore suspension, cover all external and internal surfaces that are exposed during use or maintenance. If the surfaces are non-wetting, spray until drops begin to form on them.

Incubation of the test item -

h. Except as noted in Step 2 below, incubate the test items at constant temperature and humidity conditions of 30 °C and a relative humidity of at least 95 percent for the test duration (28 days).
i. After 7 days, inspect the growth on the control cotton strips to verify the environmental conditions in the chamber are suitable for growth. At this time, verify that at least 90 percent of the surface area of each test strip located at the level of the test item is covered by fungus. If it is not, repeat the entire test with the adjustments of the chamber required to produce conditions suitable for growth. Leave the control strips in the chamber for the duration of the test.
j. If the cotton strips show satisfactory fungus growth after 7 days, continue the test for the required period from the time of inoculation as specified in the test plan. If there is no increase in fungus growth on the cotton strips at the end of the test as compared to the 7-day results, the test is invalid.

Inspection -

At the end of the incubation period, inspect the test item immediately. If possible, inspect the item within the chamber. If the inspection is conducted outside of the chamber and is not completed in 1 hour, return the test item to the test chamber or to a similar humid environment for a minimum of 2 hours. Except for hermetically sealed materiel, open the test item enclosure and examine both the interior and exterior of the test item. Record the results of the inspection.

Acceptance Criteria:

The representative test samples of EUT shall not undergo any degradation or fungus growth during and after test.

1.13 RAIN DRIP TEST

Test Purpose:

This test is to determine the effectiveness of protective covers to shield the EUT and its capability to satisfy the performance requirement after exposure to rain drip.

Test Severity:

- Volume flow rate 250 to 280 lit/m2/Hour.
- Duration: 15 min.
- Dispenser placed approximately 1 meter above equipment.
- Procedure as per MIL-STD-810F, Method 506.4 Procedure II

Test Procedure:

a. Perform functional Check on EUT as per as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51).
b. The EUT while being under the laboratory atmospheric conditions shall be introduced into the rain drip test chamber, the latter also being under the same conditions.
- EUT shall then be exposed to rain drip test for 15 min at a water fall rate of 250 to 280 lit/m2/Hour.

c. from a height of 1 meter and unit shall be non-operational.
d. After completion of the test, the EUT shall then be removed from the chamber and shall be allowed to remain under standard conditions for a period of 2 Hours.
e. Carryout functional checks on the EUT as per ATP

Acceptance Criteria:

At the end of the test, Visually Examine the Unit and Perform the performance check as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51). ECU should not have any degradation in performance.

1.14 BLOWING DUST TEST

Test Purpose:

This test is to evaluate the ability of material to resist the effects of dust that may obstruct openings, penetrate into cracks, crevices, bearings and joints.

The test item configuration should be as similar to the condition during actual use.

Test Conditions:

- Temperature: 23^0C
- RH: 30 %
- Air Velocity: 1.5m/s to 8.9m/s
- Dust Concentration: 10.6 ± 0.7 grams/m3
- Material of Dust: Silicon Dioxide or China Clay
- Duration: 6 hr. at 23^0C
- Orientation: As installed in the pod shell.
- Procedure: MIL-810F Method-510.4 Procedure-I

Test Procedure:

a. Perform functional Check on EUT as given in the ATP Document
b. With the EUT in the chamber, adjust the test section temperature to 55ºC and the air velocity to 1.5m/s to 8.9m/s. Adjust the Test section relative humidity to less than 30% and maintain it throughout the test.
c. Adjust the dust feed control for a dust concentration of 10.6 ± 0.7grams/m^3
d. Maintain the conditions of Steps ‘b’ and ‘c’ for 6 hrs.
e. Stop the dust feed. Reduce the Test section air velocity to 1.5m/s approximately and adjust the temperature to 55ºC
f. Maintain the Step ‘e’ condition for 1 Hrs. following test temperature stabilization.
g. Adjust the Air velocity to that used in step ‘b’ and restart the dust feed to maintain the dust concentration as in step ‘c’.
h. Continue the exposure for at least 6 hrs.
i. Allow the UUT to return to standard ambient conditions, and the dust to settle.

j. Remove accumulated dust from the UUT by brushing, wiping or shaking, taking card to avoid introduction of additional dust or disturbing any which may have already entered the UUT. Do not remove dust by either air blast or vacuum cleaning unless these methods are likely to be used in service.
k. Perform the performance check in accordance with the approved ATP document and Record the Results.

Acceptance Criteria:

At the end of the test, Visually Examine the Unit and Perform the performance check as per Annexure II of ATP Doc (ATP DARE/MED/041/REP/HW-2.0/51). ECU should not have any degradation in performance.

1.15 FLUID CONTAMINATION TEST

Test Purpose:

This test is to determine the ability of EUT towards contamination of Fluids.

Test Conditions:

- As per MIL-810F Method-504.1
- The fluid which the components can be exposed to during its service is OJ LENA 65 also known as NYCOSOL 51. Same will be used for the test.
- The ECU Chassis is exposed to the fluid. ECU is fabricated from AL 6061 T6 with Chromate conversion and PU paint on the external surface. Also it contains gaskets and O-rings of silicon rubber material.
- Test duration: 7 days'/test fluid.
- This test can be carried out on representative samples of parts used in equipment

Test Procedure:

The representative samples will be dipped in the OJ Fuel DERD, Hydraulic fluid MIL-H-5606E, Lub oil mixture to DERD 2497/MIL-L-7808, Soap Water.

- This condition of exposure shall be maintained for 8 hours and at the end, test items shall be visually examined for any deterioration (cracking, swelling of rubber, paint or coating removal or degradation)

Acceptance Criteria:

- Samples shall be free from cracks or coating or surface finish damages post the exposure.

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CHAPTER -1

GENERAL INSTRUCTION TO TENDERERS

1.1. DESPATCH INSTRUCTION:

i) The General Conditions of Contract form part of the Tender specifications. **All pages of the tender documents shall be duly signed, stamped and submitted along with the offer in token of complete acceptance thereof.** The information furnished shall be complete by itself. The tenderer is required to furnish all the details and other documents as required in the following pages.

ii) Tenderers are advised to study all the tender documents carefully. Any submission of tender by the tenderer shall be deemed to have been done after careful study and examination of the tender documents and with the full understanding of the implications thereof. Should the tenderers have any doubt about the meaning of any portion of the Tender Specification or find discrepancies or omissions in the drawings or the tender documents issued are incomplete or shall require clarification on any of the technical aspect, the scope of work etc., they shall at once, contact the authority inviting the tender well in time (so as not to affect last date of submission) for clarification before the submission of the tender. Tenderer's request for clarifications shall be with reference to Sections and Clause numbers given in the tender documents. The specifications and terms and conditions shall be deemed to have been accepted by the tenderer in his offer. Non compliance with any of the requirements and instructions of the tender enquiry may result in the rejection of the tender.

iii) Integrity pact (IP) shall be applicable for all tenders / contracts if indicated in NIT. This integrity pact shall be issued as part of the Tender documents and shall be returned by the bidder along with Techno-commercial bid duly filled, signed and stamped by the authorized signatory who signs the bid. Only those vendors / bidders who have entered into such an IP with BHEL shall be considered qualified to participate in the bidding. Entering into this pact shall be a preliminary qualification

1.2. SUBMISSION OF TENDERS:

1.2.1 The tenderers must submit their tenders as per instructions in the NIT

1.2.2 Tenders submitted by post shall be sent by 'REGISTERED POST ACKNOWLEDGEMENT DUE / by COURIER' and shall be posted with due allowance for any postal/courier delays. BHEL takes no responsibility for delay, loss or non-receipt of tenders sent by post/courier. **The tenders received after the specified time of their submission are treated as 'Late Tenders' and shall not be considered under any circumstances.** Offers received by Fax/Email/Internet shall be considered as per terms of NIT.

1.2.3 Tenders shall be opened by authorised Officers of BHEL at the place, time and date as specified in the NIT, in the presence of such of those tenderers or their authorised representatives who may be present

1.2.4 Tenderers whose bids are found techno commercially qualified shall be informed the date and time of opening of the Price Bids and such Tenderers may depute their representatives to witness the opening of the price bids. BHEL's decision in this regard shall be final and binding.

1.2.5 Before submission of Offer, the tenderers are advised to inspect the site of work and the environments and be well acquainted with the actual working and other prevalent conditions, facilities available, position of material and labour, means of transport and access to Site, accommodation, etc. No claim will be entertained later on the grounds of lack of knowledge of any of these conditions.

1.3. LANGUAGE:

1.3.1 The tenderer shall quote the rates in English language and international numerals. These rates shall be entered in figures as well as in words. For the purpose of the tenders, the metric system of units shall be used.

1.3.2 All entries in the tender shall either be typed or written legibly in ink. Erasing and over-writing is not permitted and may render such tenders liable for rejection. All cancellations and insertions shall be duly attested by the tenderer.

1.4 PRICE DISCREPANCY:

1.4.1 **Conventional (Manual) Price Bid opening**: In the case of price bid opening without resorting to Reverse Auction, if there are differences between the rates given by the tenderer in words and figures or in amount worked out by him, the following procedure for evaluation and award shall be followed:

i) When there is a difference between the rates in figures and in words, the rates which corresponds to the amounts worked out by the contractor, shall be taken as correct

ii) When the amount of an item is not worked out by the contractor or it does not correspond with the rate written either in figure or in words, then the rate quoted by the contractor in words shall be taken as correct

iii) When the rate quoted by the contractor in figures and words tallies but the amount is not worked out correctly, the rate quoted by the contractor shall be taken as correct and not the amount.

iv) In case of lump sum price, if there is any difference between the amount in figures and in words, the amount quoted by the bidder in words shall be taken as correct.

v) In case of omission in quoting any rate for one or more items, the evaluation shall be done considering the highest quoted rate obtained against the respective items by other tenderers for the subject tender. If the tenderer becomes L-1, the notional rates for the omission items shall be the lowest rates quoted for the respective items by the other tenderers against the respective omission items for the subject job and the 'Total quoted price (loaded for omissions)' shall be arrived at. However, the overall price remaining the same as quoted originally, the rates for all the items in the 'Total quoted price (loaded for omissions)' shall be reduced item wise in proportion to the ratio of 'Original' total price and the 'Total quoted price (loaded for omissions)''.

vi) The 'Final Total Amount' shall be arrived at after considering the amounts worked out in line with 'i' to 'iv' above.

1.4.2 **Reverse Auction**: In case of Reverse Auction, the successful bidder shall undertake to execute the work as per overall price offered by him during the Reverse Auction process. In case of omission of rates, the procedure shall be as per 'Guidelines for Reverse Auction' enclosed.

1.5. QUALIFICATION OF TENDERERS:

i) Only tenderers who have previous experience in the work of the nature and description detailed in the Notice Inviting Tender and/or tender specification are expected to quote for this work duly detailing their experience along with offer.

ii) Offers from tenderers who do not have proven and established experience in the field shall not be considered

iii) Offers from tenderers who are under suspension (banned) by any Unit/Region/Division of BHEL shall not be considered.

iv) Offers from tenderers who do not comply with the latest guidelines of Ministry/Commissions of Govt. of India shall not be considered.

1.6. EVALUATION OF BIDS:

i) Techno-commercial Bids submitted by the tenderer will be opened first and evaluated for fulfilling the Pre-Qualification criteria and other conditions in NIT/Tender documents, based on documentary evidences submitted along with the offer

ii) In case the same qualifying experience is claimed by more than one agency, then the agency who has executed the work as per documentary evidence submitted shall only be qualified. Scope of qualifying work should be totally with the agency who has executed and in case it is only labour + consumables without T&P, then the responsibility of execution is assigned to the first agency and not to the agency who has executed only as labour supply contractor. Further, BHEL reserves the right to ask for further proofs including submission of TDS certificates for the said job

iii) In case the qualifying experience is claimed by private organizations based on Work Order and completion certificates from another private organization, BHEL reserves the right to ask for further proofs including submission of TDS certificates for the said job

iv) Assessing Bidder Capacity for executing the current tender shall be as per Notice Inviting Tender

v) Price Bids of shortlisted bidders shall only be opened either through the conventional price bid opening or through electronic Reverse Auction, at the discretion of BHEL

vi) Price Bids of unqualified bidders shall not be opened. After release of Letter of Intent / Work Order, the un-opened bids (including price bids) shall be returned to respective bidder along with reasons for not opening the bid.

1.7. DATA TO BE ENCLOSED:

Full information shall be given by the tenderer in respect of the following. Non-submission of this information may lead to rejection of the offer.

i) **INCOME TAX PERMANENT ACCOUNT NUMBER**

Certified copies of Permanent Account Numbers as allotted by Income Tax Department for the Company/Firm/Individual Partners, etc. shall be furnished along with tender.

ii) **GSTIN REGISTRATION NUMBER**

Certified copies of GSTIN Numbers for the Company/Firm/Individual Partners, etc. shall be furnished along with tender

iii) **ORGANIZATION CHART**

The organization chart of the tenderer's organization, including the names, addresses and contact information of the Directors/Partners shall be furnished along with the offer.

An attested copy of the Power of Attorney, in case the tender is signed by an individual other than the sole proprietor

iv) **IN CASE OF INDIVIDUAL TENDERER:**

His / her full name, address and place & nature of business.

v) **IN CASE OF PARTNERSHIP FIRM**

The names of all the partners and their addresses, A copy of the partnership deed/instrument of partnership dully certified by the Notary Public shall be enclosed.

vi) **IN CASE OF COMPANIES:**

a. Date and place of registration including date of commencement certificate in case of Public Companies (certified copies of Memorandum and articles of Association are also to be furnished).

b. Nature of business carried on by the Company and the provisions of the Memorandum relating thereof.

1.8. AUTHORISATION AND ATTESTATION:

Tenders shall be signed by a person duly authorized/empowered to do so. An attested copy of the Power of Attorney, in case the tender is signed by an individual other than the sole proprietor shall be submitted along with the tenders

1.9. EARNEST MONEY DEPOSIT:

Not Applicable

1.10. SECURITY DEPOSIT / PERFORMANCE SECURITY:

A. Security deposit means the security provided by the contractor towards fulfilment of any obligations in terms of the provisions of the contract.

B. The total amount of the security deposit will be **5 %** of the contract value.

C. <u>Modes of Deposit</u>:

The required amount of Security Deposit of **5%** of the contract value may be accepted in the following forms:

a) Cash (as permissible under the extant Income Tax Act)

b) Local Cheques of Scheduled Banks (subject to realization)/ Pay Order/ Demand Draft/ Electronic Fund Transfer in favour of BHEL.

c) Bank Guarantee from Scheduled Banks/ Public Financial Institutions as defined in the company's act. The bank guarantee format should have the approval of BHEL.

d) Fixed Deposit Receipt issued by Scheduled Banks/ Public Financial Institutions as defined in the company's act (FDR should be in the name of the contractor, a/c BHEL.

e) Securities available from Indian Post offices such as National Savings Certificates, Kisan Vikas Patras etc. (held in the name of Contractor furnishing the security and duly endorsed/ hypothecated/ pledged, as applicable, in favour of BHEL)

(**Note:** BHEL will not be liable or responsible in any manner for the collection of interest or renewal of the documents or in any other matter connected therewith)

f) Insurance Surety Bonds

D. **<u>Collection of Security deposit</u>**:

At least 50% of the required Security Deposit, including the EMD, should be collected before start of the work. Balance of the Security Deposit can be collected by deducting 10% of the gross amount progressively from each of the running bills of the Contractor till the total amount of the required Security Deposit is collected.

In case of delay in submission of performance security, enhanced performance security which would include interest (Repo rate + 4%) for the delayed period, shall be submitted by the bidder.

If the value of work done at any time exceeds the contract value, the amount of Security Deposit shall be correspondingly enhanced and the additional Security Deposit shall be immediately deposited by the Contractor or recovered from payment/s due to the Contractor.

The recoveries made from running bills (cash deduction towards balance SD amount) can be released against submission of equivalent Bank Guarantee in acceptable form, but only once, before completion of work, with the approval of the authority competent to award the work.

(**Note:** In case of (a) small value contracts not exceeding Rs. 20 lakhs or (b) SAS jobs, work can be started before the required Security Deposit is collected. However, payment can be released only after collection/ recovery of initial 50% Security Deposit).

E. Security deposit shall be released to the contractor upon fulfilment of contractual obligations as per the terms of the contract.

F. The security deposit shall not carry any interest.

G. Bidder agrees to submit performance security required for execution of the contract within the time period mentioned.

1.10.1 The validity of Bank Guarantees towards Security Deposit shall be initially up to the completion period as stipulated in the Letter of Intent/Award + 3 months, and the same shall be kept valid by proper renewal till the acceptance of Final Bills of the Contractor, by BHEL

1.10.2 BHEL reserves the right of forfeiture of Security Deposit in addition to other claims and penalties in the event of the Contractor's failure to fulfil any of the contractual obligations or in the event of termination of contract as per terms and conditions of contract. BHEL reserves the right to set off the Security Deposit against any claims of other contracts with BHEL.

1.11. RETURN OF SECURITY DEPOSIT:

Security Deposit shall be refunded/Bank Guarantee(s) released to the Contractor along with the 'Final Bill' after deducting all expenses/ other amounts due to BHEL under the contract / other contracts entered into with them by BHEL.

1.12. BANK GUARANTEE:

Where ever Bank Guarantees are to be furnished/ submitted by the contractor, the following shall be complied with

i) Bank Guarantees shall be from Scheduled Banks/ Public Financial Institutions as recommended by BHEL time to time.

ii) The Bank Guarantees shall be as per prescribed formats of BHEL.

iii) It is the responsibility of the bidder to get the Bank Guarantees revalidated/extended for the required period (subject to a minimum period of six months), as per the advice of BHEL Engineer-in-Charge / Site Engineer / Construction Manager. BHEL shall not be liable for issue of any reminders regarding expiry of the Bank Guarantees.

iv) In case extension/further extensions of any Bank Guarantees are not required, the bidders shall ensure that the same is explicitly endorsed by the Engineer-in-Charge / Construction Manager and submitted to the BHEL Visakhapatnam.

v) In case the Bank Guarantees are not extended before the expiry date, BHEL reserves the right to invoke the same by informing the concerned Bank in writing, without any advance notice/communication to the concerned bidder.

vi) Bidders to note that any corrections to Bank Guarantees shall be done by the issuing Bank, only through an amendment in an appropriate non judicial stamp paper.

vii) The Original Bank Guarantee shall be sent directly by the Bank to BHEL under Registered Post (Acknowledgement Due), addressed to the Finance Bills, BHEL, HPVP, Visakhapatnam – 530012

1.13. VALIDITY OF OFFER:

The rates in the Tender shall be kept open for acceptance for a minimum period of **THREE MONTHS** from latest due date of offer submission (including extension, if any). In case BHEL (Bharat Heavy Electricals Ltd) calls for negotiations, such negotiations shall not amount to cancellation or withdrawal of the original offer which shall be binding on the tenderers.

1.14. EXECUTION OF CONTRACT AGREEMENT:

The successful tenderer's responsibility under this contract commences from the date of issue of the Letter of Intent / Work Order by Bharat Heavy Electricals Limited. The Tenderer shall submit an unqualified acceptance to the Letter of Intent/Work order within the period stipulated therein.

The successful tenderer shall be required to execute an agreement in the prescribed form, with BHEL, within a reasonable time after the acceptance of the Letter of Intent/Work Order, and in any case before releasing the first running bill. The contract agreement shall be signed by a person duly authorized/empowered by the tenderer. The expenses for preparation of agreement document shall be borne by Contractor.

1.15. REJECTION OF TENDER AND OTHER CONDITIONS:

1.15.1 The acceptance of tender will rest with BHEL which does not bind itself to accept the lowest tender or any tender and reserves to itself full rights for the following without assigning any reasons whatsoever:

a. To reject any or all of the tenders.

b. To split up the work amongst two or more tenderers as per NIT

c. To award the work in part if specified in NIT

d. In case of either of the contingencies stated in (b) and (c) above, the time for completion as stipulated in the tender shall be applicable.

1.15.2 Conditional tenders, unsolicited tenders, tender which are incomplete or not in the form specified or defective or have been materially altered or not in accordance with the tender conditions, specifications etc., are liable to be rejected.

1.15.3 Tenders are liable to be rejected in case of unsatisfactory performance of the tenderer with BHEL or tenderer under suspension (hold/banning /delisted) by any unit / region / division of BHEL or tenderers who do not comply with the latest guidelines of Ministry/Commissions of Govt. of India. BHEL reserves the right to reject a bidder in case it is observed that they are overloaded and may not be in a position to execute this job'. The decision of BHEL will be final in this regard.

1.15.4 If a tenderer who is a proprietor expires after the submission of his tender or after the acceptance of his tender, BHEL may at their discretion, cancel such tender. If a partner of a firm expires after the submission of tender or after the acceptance of the tender, BHEL may then cancel such tender at their discretion, unless the firm retains its character.

1.15.5 BHEL will not be bound by any Power of Attorney granted by changes in the composition of the firm made subsequent to the execution of the contract. They may, however, recognize such power of Attorney and changes after obtaining proper legal advice, the cost of which will be chargeable to the contractor concerned.

1.15.6 If the tenderer deliberately gives wrong information in his tender, BHEL reserves the right to reject such tender at any stage or to cancel the contract if awarded and forfeit the Earnest Money/Security Deposit/any other money due.

1.15.7 Canvassing in any form in connection with the tenders submitted by the Tenderer shall make his offer liable to rejection.

1.15.8 In case the Proprietor, Partner or Director of the Company/Firm submitting the Tender, has any relative or relation employed in BHEL, the authority inviting the Tender shall be informed of the fact as per specified format, along with the Offer. Failing to do so, BHEL may, at its sole discretion, reject the tender or cancel the contract and forfeit the Earnest Money/Security Deposit.

1.15.9 The successful tenderer should not sub-contract part or complete work detailed in the tender specification undertaken by him without written permission of BHEL's Construction Manager/Site-in-charge / Engineer-in-Charge. The tenderer is solely responsible to BHEL for the work awarded to him.

1.15.10 The Tender submitted by a techno commercially qualified tenderer shall become the property of BHEL who shall be under no obligation to return the same to the bidder. However unopened price bids and late tenders shall be returned to the bidders.

1.15.11 Unsolicited discount received after the due date and time of Bid Submission shall not be considered for evaluation. However, if the party who has submitted the unsolicited discount/rebate becomes the L-I party, then the awarded price i.e. contract value shall be worked out after considering the discount so offered.

1.15.12 BHEL shall not be liable for any expenses incurred by the bidder in the preparation of the tender irrespective of whether the tender is accepted or not.

1.16. EMD EXEMPTION FOR MSME VENDORS: Not Applicable

1.17. FRAUD PREVENTION POLICY:

The bidder along with its associate/collaborators/sub-contractors/sub-vendors/consultants/ service providers shall strictly adhere to BHEL Fraud Prevention Policy displayed on BHEL website http://www.bhel.com and shall immediately bring to the notice of BHEL management about any fraud or suspected fraud as soon as it comes to their notice

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CHAPTER-II

2.1 IDEFINITIONS:

In these general conditions of contract, the following terms shall have the meaning hereby assigned to them except where the context otherwise requires: -

(a) The "CONTRACT" means the documents forming the tender and acceptance thereof together with all the documents referred to therein including General and Special conditions of contract, CPWD specifications Vol. I to VII as amended up to date and the drawings. All the documents as applicable taken together shall be deemed to form one contract and shall be complementary to one another.

(b) The "TENDER DOCUMENT" means the form of tender as applicable General and Special Conditions of contract, and the specifications and/or drawings as given to contractors for the purpose of preparing their tender including "Notice Inviting Tender".

(c)The "WORK" means the work described in the tender documents in individual work order and/ or accompanying drawings and specifications as may be issued from time to time to the contractor by the Engineer-in-Charge in writing the power conferred upon them, including all modifications or additional works and obligations to be carried out either at the site or in factory, workshop or any other place as may be essentially required for the performance of the work.

(d) The "SITE" means the land and/ or other place on into or through which the work is to be executed under the contract or any adjacent land, part or structure which may be allotted to or used for the purpose of carrying out the contract.

(e) The "CONTRACTOR" means the individual firm or company whether incorporated or not, undertaking the work and shall include the legal personal representatives of such individuals or the person(s) composing the firm or company and the permitted assigns of such individuals or firm or company.

(f) The abbreviations "SE/ Dy. Mgr/ Mgr./ Sr. Mgr/ DGM/ Sr. DGM/ AGM/ GM" means Senior Engineer/ Deputy Manager/ Manager/ Senior Manager/ Deputy General Manager/ Sr. Dy. General Manager / Additional General Manager / General Manager respectively who will direct the contract.

(g) The "ENGINEER-IN-CHARGE " means the Engineer/ Sr. Engineer or any other executive deputed by BHEL to supervise the work or part of the work on behalf of the First Party.

(h) Accepting authority: As per BHEL Delegation of Power

(i) "APPROVED" means the approval of directions of the Sr. Manager/ Manager/ Dy. Manager or person deputed by them for the particular purpose.

"Bharat Heavy Electricals Limited" hereinafter referred to as BHEL shall mean the Head of the contracting / Outsourcing department / Other Administrator or other Administrative Officers of the said Company including the Engineer-in-Charge, Sr. Manager or other executive deputed by BHEL is authorized to invite tenders and enter into contract for works on behalf of the Company. BHEL means the Bharat Heavy Electricals Limited/ HPVP plant of the said Company at Visakhapatnam.

(j) In the case of percentage rate contract, "Contractor's percentage" shall if the context so permits means the uniform percentage tendered by the contractor and accepted by the Accepting Officer and expression "Contract Rates" shall refer to rates in the Schedule of Quantities & Rates (SOQR).

(k) The "CONTRACT SUM" means the sum accepted or the sum calculated in accordance with the prices accepted in tender and/ or the Contract rate as applicable to the contractor for the entire execution and full completion of the work.

(l) The "FINAL SUM" means the actual amount payable under the contract by BHEL to the contractor for the entire execution and full completion of the work.

(m) The "TIME OF COMPLETION" is the date or dates for completion of the work or any part of the work as set out in or ascertained in accordance with the individual work or the tender documents or any subsequent amendments thereto.

(n) A "WEEK" means seven days without regard to the number of hours worked in any day in that week.

(o) A"DAY" means a day of 24 (twenty-four) hours irrespective of the number of hours worked or not worked in that day.

(p) A "WORK DAY" means day other than that prescribed by the Negotiable Instruments Act, as being a holiday and consists of the number of hours of labour as commonly recognized by good employers in the trade, in the district where the work is carried out or as laid in the BHEL Rules and Regulations.

(q) "DEVIATION ORDER" means any order given by the Engineer-in-Charge to effect an alteration, addition or deduction, which does not radically affect the scope and nature of the contract.

(r) "EMERGENCY WORK " means any urgent measures which in the opinion of the Engineer-in-Charge become necessary during the progress of the work to obviate any risk of accident or failure or which become necessary for security.

(s) "PROVISIONAL SUM" or "PROVISIONAL LUMPSUM" means a lump sum included by the BHEL in the work for which details are not available at the time of inviting tender.

(t) "PROVISIONAL ITEMS" means items for which approximate quantities have been included in the tender documents.

SCOPE OF WORK

2.2 HEADING OF THE CONDITIONS:

The heading to these conditions shall not affect the interpretation thereof. The decision of BHEL regarding interpretation of any of terms and conditions set forth in this agreement shall be final and binding on the contractor

2.3 CONTRACT DOCUMENTS:

The accepting officer shall furnish to the contractor on demand, two copies of the signed drawings and schedule, and copies of all other relevant documents and specifications and the Engineer in- charge or his representative shall have, at all reasonable times, access to them.

2.4 WORKS TO BE CARRIED OUT:

The contractor shall, except as provided under schedule include all labour, materials, tools, plant, equipment & transport which may be required in preparation for, and in the entire execution and full completion of work. Schedule shall be deemed to have prepared in accordance with good practice and recognized principles & unless otherwise stated the descriptions given therein shall be held to include rate on materials, carriage, and cartage, lead, return of empties, hoisting, setting, fitting in position and all other labour necessary in and for the entire execution and full completion aforesaid. Any error in description or in quantity in schedule or any omission there from shall not vitiate the contract or release the contractor from the execution of the whole or any part of the work comprised there in accordance to the drawings and material workmanship but the articles or materials specified may be obtained from any other firm subject to the prior written approval of the Unit Head of the First Party.

In case of any discrepancy between schedule, the specification and/ or the drawings, the Accepting Officer shall be the deciding authority as to which shall prevail and his decision shall be final and conclusive. If neither drawings nor specifications contain any mention of minor details of construction, which in the opinion of the Accepting Officer are essentially as are reasonably and obviously and fairly intended for the satisfactory completion of the work, whose decision shall be final and conclusive. Such details shall be provided by the contractor without any extra cost as if they were specifically mentioned and shall be deemed to be included in the contract. The contractor shall be deemed to have satisfied himself as to the nature of site, local facilities of access and all matters affecting the execution and completion of the work. No extra charges consequent on any misunderstanding in these respects or otherwise will be allowed by the First Party.

2.5 DEVIATIONS:

The contractor shall not make any alteration and addition to or omission from the work as described in the tender documents except in pursuance of the written instructions of the Engineer-in-Charge. No such DEVIATION from the work described in the tender documents shall be valid unless the same has been specifically confirmed in writing.

The Accepting Officer may deviate, either by way of addition or deduction from the work so described provided that the contract sum thereby carried on the whole, by not more than the percentage set out in the tender documents. The value, of all additions and deductions will be added to or deducted from the contract sum. Whenever the Accepting Officer intends to exercise such a right, his intention shall specify the deviations, which are to be made on the lump sum assessment or the proposed basis of payment, the extra items allowed, if any, and the date for completion of entire contract. Any objection by the contractor to any matter consisting the order shall be notified by him in writing to Engineer-in-Charge within seven days from the date of such order, but under no circumstance shall the work be stopped (unless so ordered by the Engineer-in-Charge) owing to such difference or controversy that may arise from such an objection by the contractor. The Contractor shall be deemed to have accepted the order and the conditions stated therein. In the event of the contractor failing to agree with Engineer-in-Charge regarding the terms of proposed deviation, the objection shall be referred to the Accepting Officer or officer authorized by Accepting Officer whose decision shall be binding on the contractor.

2.6 TIME:

Time is the essence of the contract and is specified in the tender document or in each individual work order.

As soon as possible after the contract is let or any substantial work order is placed and before the work is to begin, the Engineer-in-Charge and the contractor shall (if so required by the Engineer-in-Charge) agree a time and progress chart for completion of the work within the scheduled time. The chart in the work order shall have the completion date of the individual items thereof and/ or the contract or order as a whole. It shall indicate the forecast of the dates for commencement and completion of the various processes or sequences of the work, and shall be amended as may be required by agreement between Engineer-in-Charge and contractor writing the limitations of time imposed in the tender document or order.

In the absence of any specific time and progress chart to be agreed to between the contractor and Engineer-in-Charge , the contractor shall ensure and maintain, uninterrupted progress of the work such that the entire work shall be completed within the time imposed in the tender documents or order and the proportion of work that shall be completed up to any time in relation to the entire work to be done under the contract or order shall not be less than the proportion that the time elapsed bears to the total time of completion provided in the tender documents or order. The contractor shall suspend the execution of the work or any part or parts thereof whenever called upon in writing by the Engineer-in-Charge. The contractor will be allowed an extension of time for completion limited to not less than the period of suspension but no other claim in respect for compensation or otherwise whatsoever will be admitted. Time may also be extended to allow for alteration of work made by the deviation order as may be decided upon by the Engineer-in-Charge in consultation with the contractor.

2.7 STORE AND MATERIALS:

The contractor shall, at his own expense, supply all stores and material required for the contract other than free issue materials provided by BHEL at the rates detailed therein subject to their availability at the place of issue indicated therein. All stores and materials to be supplied by the contractor shall be of the best kind as described in the specification and the contractor shall ensure that the stores and materials so comply with the specifications. The contractor shall, at his own expense and without delay, supply samples of stores and materials proposed to be used in the execution of the work for the approval of Engineer-in-Charge, who may reject all stores and materials not corresponding either in quantity or character to the approved samples. The stores and materials so rejected shall be duly replaced by the Contractor in time to ensure completion of the work as scheduled and the rejected stores/ materials shall also be replaced by him at his own cost and effort.

In case of stores and material provided by BHEL, the contractor shall bear the cost of loading, transporting to site, unloading, storing under cover and as required, assembling and jointing the several parts together as necessary and incorporating fixing these stores and materials in the work including all preparatory work of whatever description that may be required, and returning empty cases or containers to the place of issue without any extra charge.

2.8 DELAY AND TIME EXTENSION:

If in the opinion of Engineer-in-Charge the work is delayed by any one or more of the following:

1) By reason of abnormally bad weather,

2) By reason of serious loss or damage by fire,

3) By reason of civil commotion, local combination of worker, strike or lockout, affecting any of the trades employed on the work,

4) By delay on the part of the agency or tradesmen engaged by B.H.E.L./ HPVP in executing work not performing part of this contractor,

5) Earthquake & floods

6) Busy of nation

7) Riots

8) Non-availability of stores which are responsibility of BHEL etc. the same shall be covered under force majeure.

9) Any Other Reason.

By reason of any other cause, which in the absolute discretion of the Engineer-in-Charge (when he is the accepting officer of the contract), is beyond the contractor control. When in such case(s) the accepting officer, on recommendation of the Engineer-in-Charge (or higher authority) to be specified in this regard, may make fair and reasonable extension in the completion date of the individual items of work of the contract as a whole. Such extension, which will be communicated to the contractor by the Engineer-in-Charge in writing, but shall nevertheless use constantly his best endeavour to prevent or make good the delay and shall do all that may be reasonably required to the satisfaction of the Engineer-in-Charge to proceed with the work. The delay caused on this account may be waived by the Accepting Officer on merit, based on the written request of the Contractor.

2.9 PATENT RIGHTS:

The contractor shall fully indemnify BHEL or the agent servant or employees or BHEL against any action, claim or proceeding to infringement or the use of any patent or design or any alleged patent or design rights, and shall pay any royalties which may be payable in respect of article or part thereof included in the contract. In the event of any claims being made or action against BHEL in respect of any of the matters aforesaid, the contractor shall immediately be notified thereof for taking necessary action provided that the payment of indemnity shall not apply when such infringement has taken place, in complying with the specific direction issued by BHEL but the contractor shall pay any royalties payable in respect of any such use.

2.10 TAXES & DUTIES:

All charges on account of taxes and/or duties on materials obtained for the work (excluding materials provided by BHEL) shall be as per Notice of Inviting tender.

2.11 ROYALTIES:

Royalties fixed from time to time as per prevalent local rules will be recovered for materials, after which the contractor may be allowed to remove from quarries situated on land, which is in the charge of BHEL authorities.

2.12 PLANT:

The contractor, shall at his own expense, supply all tools plants and equipment (herein after referred to as T & P) required for the execution of the contract, as specified in the tender documents.

2.13 ASSIGNMENT OR TRANSFER OF CONTRACT:

The contractor shall not without prior written approval of the accepting officer, assign or transfer the contract or any part thereof or any share, or interest wherein to any other person. No sum of money which may become payable under the contract shall be payable to any person other than the contractor without prior written approval of Accepting Officer to the assignment or transfer of such money.

SUB CONTRACT: The contractor shall not sub-contract any portion of the contract without the prior written approval of the Accepting Officer.

2.14 LAWS GOVERNING THE CONTRACT:

BHEL reserves the right to take penal action as deemed fit if any information provided by the vender / contractor is found to be incorrect. This contract shall be governed by the Indian Laws for the time being in force.

2.15 COMPLIANCE TO REGULATION AND BYE LAWS:

The contractor shall conform to the provisions of any statute relating to the work and regulations and bye-laws of any local authority and of any water and lighting companies or undertakings with whom/whose systems the work is proposed to be connected. Before making any variation from the drawings or specifications so as to necessitate for such connections the contractor shall give notice to Engineer-in-Charge specifying the variations proposed to be made and the reasons thereof. Until he has received instructions from the Engineer-in-Charge in respect thereof, the contractor required shall be bound to give all notice by statute regulations or bye-laws as aforesaid and to pay all fees and taxes payable to any authority in respect thereof.

PERFORMANCE OF THE CONTRACT

2.16 ORDERS UNDER THE CONTRACT:

All orders, notices etc. to be given under the contract shall be in writing, typescript or printed and if sent by registered post to the address given in tender of the contractor, shall be deemed to have been on the date when in ordinary course they would have been delivered to him. The contractor shall carry out without delay all orders given to him.

2.17 ADMISSION TO THE SITE:

The contractor shall not enter on (other than for inspection purpose) or take possession of the site unless permitted to do so by Engineer-in-Charge. The portions of the site to be occupied by the contractor shall be clearly defined and marked on the site plan, and the contractor will not on any account be allowed to extend his operations beyond these areas.

The contractor shall be provided if necessary or required at site, temporary access thereto and shall modify and maintain the same as required from time to time. He shall take out and clear away and access route when no longer required, restoring the area to its original condition. The Engineer-in-Charge shall have power to execute other works whether or not connected with the work in contract agreement on the site contemporaneously with the execution of the original work and the contractor shall give reasonable facilities for this purpose.

BHEL reserves the right of taking over, at any times any portion of the site which they may require and the contractor shall at his own expense clear such portion forthwith. The photographs of the site of work or any part therein shall be taken, published or otherwise circulated with the prior approval of Engineer-in-Charge.

No such approval shall, however, exempt the contractor from complying with any statutory provision in regard to the taking and publication of such photograph. No such approval shall, however, exempt the contractor or shall give him the right to entry to the site at all time. The Engineer-in-Charge shall have the power to exclude from the site any person of the Contractor whose admission thereto may in his opinion be undesirable for any reason whatsoever.

2.18 CONTRACTORS SUPERVISORS:

The contractor shall either himself supervise the execution of the contract or shall appoint competent agent approved by the Engineer-in-Charge to act in his stead.

The contractor shall employ such Agent having at least DEGREE of BACHELOR of Engineering from a recognized University for contract value exceeding rupees ten lacs, or having at least a diploma in engineering from a recognized college for contract value exceeding Rs.5 lacs but not exceeding Rs ten lacs. The employment of any agent as aforesaid shall not be necessary if the contractor himself is in possession of recognized technical qualification and is in opinion of the Engineer-in-Charge, capable of receiving instructions of the Engineer-in-Charge and for execution of the works to the full satisfaction of the Engineer-in-Charge. If the contractor fails to appoint a suitable Engineer/ agent as aforesaid, the Engineer-in-Charge shall have full power to suspend the execution of work and stop payment of any advance that may become due until such date till a suitable Engineer/ agent is appointed and the contractor shall be held responsible for the delay caused to the work and no extension of time on this account shall be given to him as stipulated in condition mentioned above.

Orders given to contractor's agent shall be considered to have the same force as if they had been given to the contractor himself.

The contractor or his accredited agent shall attend whenever required and without making any claim for doing so, either to the office of the Engineer-in-Charge or the work site to receive instructions. The Engineer-in-Charge shall have full power and without assigning any reason, to require the contractor immediately and cease to employ in connection with this contract any agent, servant or employee whose continued employment is, in his opinion, undesirable. The contractor shall not be allowed any compensation on this account.

2.19 LABOUR LAWS TO BE COMPLIED WITH BY THE CONTRACTOR:

The contractor shall employ labour in sufficient number to maintain the required rate of progress and of quality required to ensure workmanship of the degree required by the specifications and to the satisfaction of the Engineer-in-Charge.

Contractor shall decide the number of employees to be deployed for execution of the work awarded to him and he or his authorized representative will be solely entitled to dictate such workers about the manner of carrying out the work as per the prescribed specifications and quality plan.

Contractor to ensure that the employees deployed in the premises of BHEL are physically and mentally fit and do not have any criminal record. Such employees should possess requisite skill, proficiency, qualification, experience etc. Contractor to provide employment card / identity with photograph duly verified and attested by the contractor to his employees. Contractor to indicate the name of the proprietary/ partnership firm/ company, place of work, contract no. and duration of validity of card. Contractor will be responsible for good conduct of his employees. In case of any misconduct / misbehaviour by any employee, the contractor will replace such employee(s) immediately.

BHEL shall have the privity of the contract with the contractor only and will give instructions to the contractor or his authorized representatives. BHEL will have nothing to do or be concerned with the employment of employees working for the contractor. The relationship between BHEL and the contractor will be that of independent entities and nothing herein contained will amount to joint venture, partnership or an employer employee relationship.

The contractor shall obtain a valid labour licence under the Contract Labour (R&A) Act 1970, and the Contract Labour (Regulation and Abolition) Central Rules 1971, before the commencement of the work, and continue to have a valid licence until the completion of work. The contractor shall also abide by the provisions of the Child Labour (Prohibition and Regulation) Act 1986. The relevant statutory provisions of the State Government of Andhra Pradesh shall also be applicable in toto. The contractor shall observe provisions of the Factories Act in respect of working hours, holidays, rest intervals, leaves and overtime to his employees. No work shall be done on second/ third shift, overtime, Sundays or on other declared holidays without written permission from BHEL.

Any failure to fulfil this requirement shall attract the penal provisions of the Contract arising out of the resultant non-execution of the work.

Payment of wages:

The contractor shall pay to labour employed by him either directly or through sub-contractors, in accordance with the provisions of the Contract Labour (Regulations and Abolition) Act 1970 and the Contact Labour (Regulation and Abolition) Central Rules 1971 or Minimum Wages Act wherever applicable, including the relevant statutory provisions of the State Government. The contractor shall ensure payment of wages to the Contract labour employed by him latest by 7th of the following month. The above payments shall be verified by the departmental supervisor under his name and designation.

II. In respect of all labour directly or indirectly employed in the works for performance of the contractor's part of this contract, the Contractor shall comply with or cause to be complied with the BHEL's Contractor's Labour Regulations made by BHEL from

time to time or as per the provisions of the Contract Labour (Regulations and Abolition) Act 1970 and the Contact Labour (Regulation and Abolition) Central Rules 1971 and Minimum Wages Act wherever applicable.

III. (A) The Engineer-in-Charge concerned shall have the right to deduct from the moneys due to the contractor any sum required or estimated to be required for making good the loss suffered by a worker or workforce by reason of non-fulfilment of the conditions of the contract for the benefit of the workers, non-payment of wages or of deductions made from his or their wages which are not justified by their terms of the contract or non-observance of the regulations.

B) Under the provisions of Minimum Wages (Central) Rules 1950, the contractor is bound to allow to the labours directly or indirectly employed in the works one-day rest for 6 days continuous work and pay wages at the same rates as for duty. In the event of default, the Engineer-in-Charge shall have the right to deduct the sum or sums not paid on account of wages for weekly holidays to any labour and pay the same to the persons entitled thereto from any money due to the contractor by the Engineer-in-Charge concerned.

IV. The contractor shall duly comply with the provisions of the Payment of wages Act-1936, Minimum Wages Act 1948, Employees liability Act-1938, Workmen's compensation Act-1923, Industrial Disputes Act 1947, Maternity Benefits Act 1961, EPF and MP Act 1952, Payment of Gratuity Act 1972, Income tax Act, Service Tax Act, Employees State Insurance Act, Payment of Bonus Act 1967 etc. and the Contract Labour (Regulations and Abolition) Act 1970, or the modifications thereof or any other laws relating thereto and the rules made there under from time to time.

a) Contractor must ensure payment of PF, pension dues under EPF and MP Act 1952 to the RPFC.

b) Contractor must ensure payment of ESI contribution under ESI Act 1948 and provide ESI membership No. / Card of each employee.

c) Contractor shall produce proof of deductions as well as remittances of PF, Pension, ESI contribution; administrative charges etc. wherever applicable and shall maintain proper records. Contractor to issue wage slip to his employees.

d) The contractor shall furnish proper returns to the concerned statutory authorities like PF etc. and also provide a copy of the same to BHEL.

e) In case of non compliance of any of the labour laws e.g. payment of minimum wages to his employees or remittance of contribution to the concerned authorities etc., the contractor shall be responsible for all the expenses /liability occurring/ accruing on BHEL because of this including expenditure of legal proceedings. All such expenses shall be recoverable from the contractor from any of his running contracts / security deposit / other dues with BHEL or from any contract entered with BHEL thereafter.

f) Payment of bonus under the Payment of Bonus Act, payment of Gratuity under the Gratuity Act and retrenchment compensation under act will be the sole responsibility of contractor.

g) Contractor shall pay minimum wages as applicable from time to time including leave with wages to their workers as per rules /act.

h) Contractor will give three National Holidays to his workers.

V. The contractor shall indemnify and keep BHEL indemnified against statutory payments to be made under for due observance of the laws aforesaid as well as the BHEL contractor's Labour Regulations without prejudice to his rights to claim indemnity from his sub-contractors not affecting BHEL under any event or statutory violation by the contractor.

VI. The laws aforesaid shall be deemed to be part of this contact and any breach thereof shall be deemed to be a breach of the contract.

VII. Whatever is the minimum wage for the time being, such wage shall be paid by the contractor to the workmen directly without any intervention of jamadar and that jamadar shall not be entitled to deduct or recover any amount from the minimum wage payable to the workmen and by way of commission or otherwise.

VIII. The contractor shall ensure that no amount by way of commission or otherwise is deducted or recovered by that jamadar from the wages of workmen engaged by him in the work premises of BHEL.

IX. All the registers and records shall be preserved in original for a period of 3 years from the passing of final bill and shall be produced on demand before any officer, inspector, etc. of the Government/ BHEL.

In respect of all labours directly or indirectly employed in the work of the performance of the contractor's part of the contract, the contractor shall its own expenses arrange for the safety provisions as per BHEL safety clause framed from time to time and shall its own expense provide for all facilities in connection therewith. In case the contractor fails to make arrangement and provide necessary facilities aforesaid the Engineer-in-Charge shall be at liberty to make arrangement and provide facilities as aforesaid and recover in full the costs incurred in that behalf from the contractor.

Should it appear to the Engineer-in-Charge that the contractor is not properly observing and complying with the provisions of the BHEL Contractor's Labour Regulations and Model Rules and the Contact Labour (Regulation and Abolition) Central

Rules 1971, for the protection of health and sanitary arrangements for the workmen employed by the contractor, (hereinafter referred as "the said Rules") the Engineer-in-Charge shall have the power to give notice in writing to the contractor requiring that the said rules be complied with and the amenities prescribed therein be provided to the workmen within a reasonable time to be specified in the notice. If the contractor shall fail within the period specified in the notice to comply with and/observe the said Rules and to provide the amenities to the workmen as aforesaid, the Engineer-in-Charge shall have the power to provide amenities herein before mentioned at the cost of the contractor.

The Engineer-In charge may require the contractor to dismiss or remove from the site of the work any person or persons in the contractor's employee upon the work who may be incompetent or misconduct himself and the contractor shall forthwith comply with such requirements.

It shall be the responsibility of the contractor to see that the building under construction is not occupied by anybody unauthorized during construction, and is handed over to the Engineer-in-charge with vacant possession of complete building. If such building though completed is occupied illegally, then the Engineer-in-charge shall have the option to refuse to accept the said building/ buildings in that position.

However, the Engineer-in-charge, through a notice, may require the contractor to remove the illegal occupation any time on or before construction and delivery. The contractor will be liable for all payments to be made under the law and for the observance of the regulations aforesaid without prejudice to his right to claim indemnity from his subcontractor.

2.20 ACCOMMODATION FOR LABOUR:

The contractor shall during the progress of the work, provide, erect and maintain at his own expense and approved standards and scales, all necessary temporary living and sanitary accommodation required for his work people on the site, in connection with the execution of the work and also arrange for supply of wholesome drinking water for his work people.

The planning, sitting, layout and erection of these temporary buildings shall be approved by the Engineer-in-Charge and the whole of such temporary accommodation shall at all times during the progress of the work be kept tidy and in clean sanitary conditions to the entire satisfaction of the Engineer-in-Charge and at the contractor's expenses. The contractor shall confirm generally to the sanitary requirements of the local medical and health authority and at all times with such precautions that may be necessary to prevent soil pollution of the site.

On completion of the work all such temporary buildings shall be cleaned away, all rubbish burnt, excrete or other disposal pits or trenches filled and effectively sealed off and the whole of the site left clean and tidy to the entire satisfaction of the Engineer-in-Charge and at the contractors expense.

2.21 ANTI MALARIAL PRECAUTION:

The contractor shall at his own expenses, conform to all anti-malarial instruction given to him by the Engineer-in-Charge including filling up of borrow pits, if any.

2.22 CONSERVANCY:

The contractor shall at his own expenses, carry out all instructions issued to him by Engineer-in-Charge to effect a proper disposal to night soil and other conservation work in respect of the contractors work people or his employees on the site.

The contractor will bear the cost of any charges levied by the local authority for the execution of such work on his behalf.

2.23 NUISANCE:

The contractor shall not at any time do, cause or permit any nuisance on the site or do anything which may cause unnecessary disturbance or inconvenience to the owners, tenants or occupier of other properties near the site and to the public generally and shall secure the efficient protection of streams and water ways against pollution.

2.24 WATER & ELECTRICITY:

Water and electricity shall be supplied to the contractor by the department subject to the following conditions:

a) One/ two source of supply of water/ electricity points, to be decided by Engineer-in-Charge, shall be provided by BHEL. However, contractor shall have to make their own arrangement for laying of pipelines/ connection from the main source of supply for working at site.

b) Department do not guarantee to maintain uninterrupted supply of water/ electricity and it will be incumbent on the contractor to make alternative arrangement for proper supply of the same at their own cost in the event of any break down in the government water/ electricity mains so that the progress of work is not held up for the want of the same. No claim of damage or refund will be entertained on account of such break down.

c) In case of non-availability of above facilities at work place, contractor has to make his own arrangements at his cost or as mentioned in the NIT.

2.25 TEMPORARY WORKSHOPS STORES etc.:

The contractor shall, during the progress of work, provide, erect and maintain at his own expense all necessary temporary work-shops, stores, offices etc. required for the proper and efficient execution of work. The planning, sitting and execution of these buildings/ works shall have the approval of the Engineer-in-Charge and the contractor shall at all times keep them tidy in a clean and sanitary condition to the entire satisfaction of the Engineer In-charge.

2.26 STORES AND MATERIALS ON SITE:

All stores and materials for the work are to be deposited by the contractor only in places to be indicated by the Engineer-in-Charge, where in accordance with the contract, stipulations certain stores and materials (for incorporation in the work) are to be issued to the contractor by BHEL as detailed.

BHEL free issue items will be so issued only to the extent required for the actual completion of the work as stipulated in the contract. The decision of Engineer—in-Charge / Head of the department regarding the quantities to be issued as above shall be final and binding on the contractor. For any excess quantities consumed on the work, the cost will be recovered from the contractor at punitive rates, which will be as mentioned in Schedule “B”.

As regard issue of material and stores to be issued to the contractor by BHEL, the contractor shall give the Engineer-in-Charge reasonable notice in writing of his requirement of such stores/ materials and on the approval of his demand being notified to him, he shall make immediate arrangement for drawing the same. Such stores and materials shall be transported by the contractor at his own expense direct from the place of issue to the site of work with the prior written approval, obtained from the Engineer-in-Charge to take them to a store or work shop or elsewhere. BHEL officers connected with the contract shall have the power at any time to inspect and examine any stores or at any factory or workshop or other place where material intended to be used in or on the workshop, or other places such stores or materials are being fabricated or manufactured, or at any place where the same are lying and the contractor shall give necessary facilities for such inspection and examination.

The Engineer-in-Charge shall be entitled to have tests made of any stores or materials supplied by the contractor who shall provide at his own expense all facilities which the Engineer-in-Charge may require for this purpose. If at the discretion of Engineer-in-Charge, independent expert is employed to make any such test, his charges shall be borne by the contractor only, if the test disclosed that the said stores or materials are not in accordance with the provisions of the contract.

Should the Engineer-in-Charge consider at any time during the construction or reconstruction or prior to the expiry of the maintenance period that the stores or materials provided by the contractor are unsound or of a quality inferior to the constructed or otherwise and not in accordance with the contract (in respect whereof the decision of the Engineer-in-Charge shall be final and conclusive). The contractor shall on demand in writing from the Engineer-in-Charge specifying the stores or materials complained or notwithstanding that the same may have been inadvertently passed, certified and paid for, forthwith remove the stores or materials so specified and provide other proper and suitable stores or materials at his own expense to the entire satisfaction of Engineer-in-Charge and in the event of his failing to do so within a period to be specified by Engineer-in-Charge in his demand aforesaid, the Engineer-in-Charge may replace with others, the stores or materials complained of, at the risk and expense in all respect of the contractor.

The liability of the contractor under this condition shall not extend beyond the maintenance period aforesaid except as regard stores or materials, which the Engineer-in-Charge shall have previously given, notice to the contractor to replace that. (Maintenance period for any work under this organization will be TWELVE MONTHS from the date of actual completion of the particular work and handing over to BHEL in the case of building works and SIX MONTHS for all other works.).

All stores and materials brought to the site shall become and remains the property of BHEL and shall not be removed from the site without the prior written approval of the Engineer-in-Charge. However, when the work is finally completed, the contractor shall at his own expense forthwith remove from the site surplus stores and materials originally supplied by him and upon such removal the same shall revert and become the property of the fixing in the work and which after making due allowance for the reasonable wear and tear/ or waste have not on completion of the works been so incorporated or fixed, shall be returned by the contractor at his own expense to the place of issue.

Credit for surplus stores and/ or material returned by the contractor to BHEL will be given to him at a price, based on the prevailing market rate but not exceeding that at which the said stores and materials were originally issued to him but due consideration shall be given to the allowance claimed by BHEL, in respect of any depreciation or damage suffered by the stores and / or materials while in the custody of the contractor regarding which the decision of Engineer-in-Charge shall be final and conclusive.

If in the opinion of the Engineer-in-Charge (which will be final and conclusive) any stores supplied by the BHEL have either during progress of work or after completion of work but under the custody of the contractor, become damaged to such an extent that they cannot be usefully utilized either in the same work or in other work, the Engineer-in-Charge shall not accept

the stores and in the event of his so rejecting, the contractor shall be charged for the said stores at a rate fixed by the accepting officer. The contractor shall not be entitled to any claim whatsoever on this account.

2.27 TOOLS AND PLANTS ON SITE:

All tools, plants and equipment brought to site shall become the property of the BHEL and shall not be removed from the site without the prior written approval of the Engineer-in-Charge. When the work is finally completed or contract is terminated for reasons other than the default of the contractor, the contractor shall forthwith remove from the site all tools, plants and equipments (other than those as may have been provided by BHEL) and upon such removal the same shall become the property of the contractor.

2.28 STATEMENT OF HIRE CHARGES:

A monthly detailed statement of the hire charges incurred in respect of BHEL tools, plants, equipment etc. shall be given to the contractor by the Engineer-in-Charge.

2.29 PRECAUTIONS AGAINST RISK:

The contractor shall be responsible for providing at his own expense, for all precautions to prevent loss or damage from any and all risk and to minimize the amount of any such loss or damage and for necessary steps to be taken for the said purpose until the works have been handed over complete in all respect to the Engineer In-charge.

The contractor shall provide all watchmen necessary for the protection of site, the work, the materials, tools, plants, equipment and anything else lying in the site during the progress of work. He shall solely be responsible for and shall take all responsible and proper steps for protecting, securing and watching all and/ or about the work and the site which may be dangerous to any person whatsoever.

2.30 NOTICES AND FEES:

The contractor shall give all notices required by any statutory provisions or by the regulations and/ or bye-laws or any local authority and/ or of any public service, company or authority affected by the work or with those systems if the same are or will be contracted. The contractor shall pay and indemnify BHEL against any fees and charges demandable by law under such Acts, Regulations and/ or bye-laws in respect of the work and shall make and supply all drawings and plans required in connection with any such notice.

2.31 SETTING OUT OF THE WORK & PROTECTING/ MAINTAINING SIGNALS & MARKS:

The Engineer-in-Charge shall supply dimensions, drawings, levels and other information necessary to enable the contractor to set out the work. The contractor shall at his own expense set out accurately according to the drawings, figures and dimensions there, on all the work in the contract and any extras or additions thereto and shall be solely responsible for their being so set out and executed. All bench marks, pegs, signals on surface, alignment stones, mile stones and all similar marks whether putting by BHEL authorities for the purpose of checking the contractor's work in the tenure of the contractor, be put under the care of the contractor who shall, at his own expense take all proper and responsible precautions and care to preserve and maintain them in their true position. In the event of these marks being disturbed or obliterated by accident or due to any other cause whatsoever the same may, if deemed necessary, be replaced by Engineer-in-Charge / Head of the department to the contractor's expense and the cost thereof deducted from any money thereon or/ after becoming due to the contractor.

Where requested by the contractor, the level mark, centre line and chain age pegs corresponding to those as shown on the drawings, will be pointed out to the contractor on the ground but all bench marks or chain age pegs additional to these shown on the drawing shall be provided by the contractor at his expense.

2.32 SITE DRAINAGE:

All water that may accumulate on the site during the progress of the work or in trenches and excavations shall be removed by the contractor to the entire satisfaction of the Engineer-in-Charge at his own expense.

2.33 EXCAVATION RELICS etc.:

Material of any kinds obtained from excavation on the site shall remain the property of BHEL and shall be disposed off as the Engineer-in-Charge directs. All gold, silver, oil and other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar items which may be found on at/upon the site shall be the property of the BHEL.

2.34 FOUNDATIONS:

The contractor shall not lay any foundation until the excavations for the same have been examined and approved in writing by the Engineer-in-Charge.

2.35 COVERING OF WORK:

The contractor shall give reasonable notices in writing to the Engineer-in-Charge whenever any work is to be permanently covered or cancelled, whether by earth or other means so that it can finally be inspected or measured if necessary. In default of doing so the contractor shall, if required by the Engineer-in-Charge uncover such work at his own expense.

2.36 APPROVAL OF WORKS BY STAGES:

All work embracing more than one process shall be subject to examination and approval at each stage and the contractor shall give due notice in writing to the Engineer-in-Charge when each stage is ready. In default of such notice being received, the Engineer-in-Charge shall be entitled to approve the quality and extent thereof at any time he may choose and in the event of any dispute, the decision of the Engineer-in-Charge thereon shall be final and conclusive.

2.37 EXECUTION OF WORK:

The work shall be executed in a workman like manner and to the satisfaction in all respect of the Engineer-in-Charge. The Engineer-in-Charge will communicate or confirm his instruction to the contractor in respect of the execution of the work in a "WORK SITE ORDER BOOK " maintained at his office and the contractor shall visit this office, daily and shall conform receipt of such instructions by signing the relevant entries in this book. Such entries will rank as order notices in writing within the intent and meaning of these conditions.

2.38 RESPONSIBILITY FOR BUILDINGS:

In the event of any building or part of any building being handed over to the contractor for execution of work thereto under provisions of the contract, he shall give a written receipt for all fixtures, glasses etc. and shall be required to make good at his own expense all damage resulting from whatsoever cause while in his charge and on completion of the work to deliver up the said building or part thereof in a clean stage complete in every particular to the entire satisfaction of the Engineer-in-Charge.

2.39 INSPECTION OF WORKS:

BHEL Officers / BHEL representatives concerned with the contract shall have power at any time in respect and examine any part of the work and the contractor shall provide such facilities as may be required for such inspection and examination. Should the Engineer-in-Charge consider at any time during the construction or reconstruction or prior to the expiry of maintenance period, that any work has been executed with unsound, imperfect or unskilled workmanship or of a quality inferior to that contracted for or not otherwise in accordance with the contract, in respect whereof the decision of the Engineer-in-Charge shall be final and conclusive. The contractor shall on demand in writing from the Engineer-in-Charge specifying the fault notwithstanding that the same may have been inadvertently passed, certified and paid for, forthwith rectify or remove and reconstruct, the work so specified, in whole or in part as the case may be, require at his own risk and expense to the entire satisfaction of Engineer-in-Charge, who may accept the work at reduced rate if deemed fit. However, the liability of the contractor under this condition shall not extend beyond the maintenance period except as regard workmanship, which the Engineer-in-Charge should have previously given notice to the contractor to rectify.

2.40 DAMAGE AND LOSS TO PRIVATE PROPERTY AND INJURY TO WORKS:

The contractor shall at his own expense reinstate and make good to the satisfaction of the Engineer-in-Charge and pay compensation for any injury, loss or damage caused to any property or right what so ever including property or/ and rights of BHEL (or agent /servants/any outsider or employees of BHEL) and the injury, loss or damage arising out of or in any way in connection with the execution or purported execution of the contract and further the contractor shall indemnify BHEL, against all claims enforceable against BHEL) or which would be so enforceable against BHEL were BHEL a private person in respect of any such injury (including injury resulting in death, loss or damage to any person whatsoever or property, including all claims which may arise under Workman's Compensation Act or otherwise.

2.41 COMPLETION:

The works shall be completed to the entire satisfaction of the Engineer In-charge and in accordance with contractor's forecast of time and progress where operative and that, all unused stores and materials, tools, plant, equipment, temporary buildings and things shall be removed and the site and work cleared of rubbish and all waste material and delivered up clean and tidy to the satisfactions of the Engineer In-charge at the contractor's expense on or before the scheduled date of completion. BHEL shall have power to take over from the contractor from time to time such section of work as have been completed to the satisfaction of the Engineer In-charge. The Engineer-in-Charge shall certify to the state of the work at the end of the maintenance period where applicable.

2.42 COMPENSATION AS LIQUIDATED DAMAGES FOR DELAY:

If the contractor fails to complete and clear the site on or before the scheduled date of completion or does not achieve the progress as set out under the caption "TIME " in clause 2.6 of these General Conditions, he shall without prejudice to any other right or remedy on BHEL on account of such breach, be liable to pay as compensation as liquidated damage an amount

equal to 0.50 percentage of the total contract sum for every week (7 days) of extension sought beyond the scheduled date of completion of the contract provided always that the total amount of compensation as liquidated damages to be paid under this condition shall not exceed 10% of the contract sum. Such amount may be adjusted or set off against any sum payable to the contractor under this or any other contract. If delay is for 8 days, it will be counted as delay for 2 weeks for liquidated damages. In case any penalty is to be levied at any stage during the progress of work, reference shall be made to the clause as mentioned in special condition of tender.

2.43 CANCELLATION OF CONTRACT FOR CORRUPT ACTS:

The Accepting Officer, whose decision shall be final and conclusive, shall without prejudice to any other right or remedy which shall have accrued or shall accrue thereafter, BHEL cancel the contract if any of the following cases and the contractor shall be liable to pay to BHEL for any loss or damage relating from any such cancellation to the same extent as provided in the case of cancellation of defaults.

If the contractor---

a) Offer to give or agree to give to any person in BHEL service, any gift or consideration of any kind as an inducement or reward for doing or forbearing to do for having done or for borne to do any act in relation to obtaining or execution of this or any other contract for BHEL service

OR

b) Enter into a contract with BHEL in connection with which commission has been paid or agreed to be paid by him or with his knowledge, unless the particulars of any such commission and the terms of payment thereof have previously been disclosed in writing to the Accepting Officer.

OR

c) Obtain a contract with BHEL as a result of ring tendering or by non-bearing methods or competitive tendering without first disclosing the fact in writing to the Accepting Officer.

OR

d) Steel or misuse of any property of BHEL either by himself or through his workmen within his knowledge or convince.

2.44 CANCELLATION OF CONTRACT DUE TO INSOLVENCY, ASSIGNMENT OR TRANSFER OR SUBLETTING OF CONTRACT:

The Accepting Officer, without prejudice to any other right or remedy, which shall have accrued or shall accrue thereafter to BHEL, shall cancel the contract in any of the following cases:

If the contractor -----

a) Being an individual or if a firm, or any partner thereof shall at any time to be adjudged bankrupt or having a receiving order or order for administration of his estate made against him or shall take any proceedings for liquidation or composition under any Bankruptcy Act for the time being enforce or make any connivance or assignment or makes unauthorized or illegal arrangement for the benefit of his creditors or propose to do so, or if any application be made under any bankruptcy and for the time being in force for the sequestration of his estate or if a trust deed be granted by him on behalf of his creditors,

OR

b) Being a company, shall pass a resolution or the court shall make an order for the liquidation of its affairs, or a receiver or Manager on behalf of the debenture holders shall be appointed or circumstances shall arise which entitle the court of debenture holders to appoint a receiver or Manager.

OR

c) Assigns, sublets or attempts to assign, transfer or sublet any portion of the work without the prior written approval of the Accepting Officer,

Whenever the Accepting Officer exercises his authority to cancel the contract under this condition, he may complete the work by any means at the contractor's risk and expense, provided that, in the event of the cost of completion (as certified by Engineer-in-Charge, which is final and conclusive) being less than the contract cost the advantage shall accrue to the BHEL, and that if the cost of completion exceeds the money due to the contractor under the contract, the contractor shall either pay the excess amount ordered by the Engineer-in-Charge or the same shall be recovered from the contractor by other means

In case BHEL completes the work under the provisions of this condition, the cost of such completion to be taken into account in determining the excess cost to be charged to the contractor under this condition shall consist of the cost of materials purchased and/ or labour provided by BHEL with an addition of such percentage to cover superintendence and establishment charges as may be decided by the DGM / GM, whose decision shall be final and conclusive.

2.45 CANCELLATION OF CONTRACT IN PART OR IN FULL FOR CONTRACTOR'S DEFAULT:

If the contractor—

a) Makes default in commencing the work within a reasonable time from the date of handing over of the site and continues in that state after a reasonable notice from the Engineer-in-Charge.

OR

b) In the opinion of the Engineer-in-Charge at any time, whether before or after the date or extended date for completion, makes default in proceeding with the work with due diligence and continues in that state after reasonable notice from Engineer-in-Charge.

OR

b) Fails to complete the work, without prejudice to any other right or remedy which shall have accrued, or shall accrue thereafter to BHEL contract.

OR

c) Fails to comply with any of the terms and conditions of the contract after reasonable notice in writing with order properly issued.

OR

d) Fails to complete the work, work order, and items of work with individual dates for completion and clear the site on or before the date of completion, or if fails to achieve the conditions of contract, the Accepting Officer, may without prejudice to any other right or remedy which shall have accrued or shall accrue thereafter or do only such work order or items of work in default from the contract at the expense and cost of the contractor. Whenever the Accepting Officer exercises his authority to cancel the contract as a whole or in part under this condition, he may complete the work as a whole or part to under this contract, the contractor shall either pay the excess amount ordered by Engineer-in-Charge or the same shall be recovered from the contractor by other means.

In case of BHEL completes the work or any part thereof under the provisions of this condition, the cost of such completion to be taken into account in determining the excess cost to be charged to the contractor under this condition, shall consist of the materials purchased and/ or labour provided by BHEL with an addition of such percentage to cover superintendence and establishment charges as may be decided by the DGM whose decision shall be final and conclusive.

In the event of termination of contract for any reason whatsoever, the contractor shall withdraw all his employees from the establishment of BHEL. In case contractor decides to terminate services of his employees he should settle all terminal dues including retrenchment compensation.

2.46 TERMINATION OF CONTRACT DUE TO DEATH:

Without prejudice to any of the rights or remedies under this contract, if the contractor dies, the Accepting Officer shall have the option of terminating the contract without compensation to the contractor authorized survivors.

2.47 SPECIAL POWERS OF TERMINATION:

If at any time after the acceptance of the tender, BHEL shall for any reason whatsoever not require the whole or any part of the work, to be carried out, the Engineer-in-Charge shall give notice in writing of the fact to the contractor, who shall have no claim to any payment of compensation or otherwise, howsoever on account of any profit or advantage which he might have derived from the execution of the work in full but which he did not derive in consequence of the foreclosing of the work.

The contractor shall be paid at contract rates for the full amount of the work executed including such additional work i.e., cleaning of site etc. as may be rendered necessary by the said foreclosing. He shall also be allowed a reasonable payment (as decided by the Accepting Officer) for any expenses sustained on account of labour and material collected but which could not be utilized on the work as verified by the Engineer-in-Charge but the contractor shall not have any claim for compensation on account of any alterations having been made in the original specifications, drawings, designs and instructions involving and curtailment of the work as originally contemplated.

2.48 FAIR WAGE:

Refer clause 2.19 of General terms and conditions of Contract**.**

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CHAPTER-III
VALUATION AND PAYMENT

3.1 RECORDS AND MEASUREMENTS:

All items having a financial value shall be entered in the BHEL Measurement book so that a complete record is obtained on all work performed under the contract.

Measurement shall be carried out as per unit mentioned in the bill of quantity (price-bid).

The measurements shall be taken jointly by any person or persons duly authorized on the part of the BHEL and the contractor.

The Engineer-in-Charge shall give reasonable notice in writing to the contractor of appointments for measurements.

The contractor shall without extra charge, provide assistance with appliance and other things necessary for measurements.

The contractor shall bear all the cost of measurement of his work.

Measurements shall be entered in the BHEL measurement book and signed and dated by both parties each day on the site on completion of measurement. If the contractor objects to any of the measurement recorded on behalf of BHEL in the Measurement Book or against the item or items objected to, and such note shall be signed and dated by both parties engaged in taking the measurements.

If as a result of such objection it becomes necessary to remeasure the work wholly or in part, the expense of such measurement shall be borne by the party requiring the measurement to be retaken provided that net error found by this remeasurement amount to less than 5 % (five percent) of the value as recorded by the first measurement.

If the contractor's representative fails to attend when required, the Engineer-in-Charge shall have power to proceed by himself to take measurements, and in that case these measurements shall be accepted by the contractor as final.

The contractor shall once in every month, submit to the Engineer with a copy to the concerned Engineer-in-Charge details of his claims for the work done by him up to and including the previous month which are not covered by his contract agreement in any of the following respects: -

a) Deviation from the item and specification provided in the contract documents.

b) Extra items / new items of the work.

c) Quantities in excess of those provided in the contract agreement.

d) Items in respect of which rates have not been settled, in addition furnish a clear certificate to the effect that the claims submitted by him as aforesaid cover all his claims and that no further claims shall be raised by him in respect of the work done up to and including the period under report.

3.2 FINAL BILLS:

As soon as possible after the completion of the work to the satisfaction of the Engineer-in-charge, the contractor shall forward a certified final account on BHEL forms in duplicate. It shall be accompanied with all abstracts; vouchers etc. in support thereof and shall be prepared, in the manner prescribed by the Engineer-in-Charge. No claims will be entertained after the receipt of the final bills.

The contractor shall be entitled to be paid the final sum less the value of payments already made on account subject to certification to the final bill by the Engineer-in-Charge. No charge shall be allowed to the contractor on account of the preparation of the final bills.

3.3 PAYMENTS OF BILLS:

The payment of final bill will be made only after successful proving. All payments to be made to the contractor under this contract shall be through online payment i.e., RTGS/ NEFT within a reasonable time after the certification by the Engineer-in-Charge.

3.4 RECOVERY FROM THE CONTRACTOR:

Whenever under the contract any sum of money shall be recoverable from or payable to the contractor, the same may be deducted from any sum then due or which at any time thereafter may become due to the contractor under the contract or under any other contract with BHEL or from his security deposit, or he shall pay the claim on demand.

3.5 POST TECHNICAL AUDIT OF WORK & BILLS:

BHEL reserves the right to carry out a post payment audit and technical examination of the work and bill including all supporting vouchers, abstracts etc. and to enforce recovery of any sums becoming due as a result thereof in the manner

provided into the proceedings sub-paragraph provided, however, that no such recovery shall be enforced after three years of passing the final bills.

3.6 REFUND OF SECURITY DEPOSIT:

After expiration of the maintenance period, provided always that the contractor shall first have been paid final bill and have rendered a "No Demand" certificate, the security deposit mentioned *shall be released after satisfactory completion of the maintenance period* of the work duly verified by Site In charge. *The maintenance period of work is 3 months from the date of actual completion of work.*

3.7 ARBITRATION:

All disputes between the parties to the contract arising out of or relating to the contractor other than those for which the decision of the Engineer-in-Charge / Accepting Officer or any other person is by the contract expressed to be final and conclusive, shall after written notice by either party to the contract, the other party be referred to the sole arbitration of Unit Head or any other officer of BHEL in his sole discretion unless the parties otherwise agree, such reference shall not take place until after the completion, alleged completion or abandonment of the work or the determination of the contract. The venue of arbitration proceedings will be at Visakhapatnam. The arbitrator shall have the power to extend, from time to time, the time for making his award with the consent of the parties. The award of the Arbitrator shall be final, conclusive and binding on both the parties to the contract. Any matter arising out of or in connection with the agreement shall be under jurisdiction of Visakhapatnam court. The Head of HPVP Unit of BHEL, Visakhapatnam shall appoint the Arbitrator. No person other than a person so appointed shall act as Arbitrator.

3.8 IMPLEMENTATION OF PROVISION OF THE APPRENTICE ACT:

Contractor shall comply with the provisions of Apprentice Act-1961, and the Rules and Orders issued there under from time to time. If he fails to do so his failure will be a breach of the contract and the Accepting Authority may, in his discretion cancel the contract. The contractor shall also be liable for any pecuniary liability arising on account of any violation by him of the provision of the Act.

3.9 SAFETY AND SECURITY:

1. BHEL reserves the right to take penal action as deemed fit if any information provided by the vender / contractor is found to be incorrect.

2. Other safety related conditions:

a) The contractor shall ensure proper safety of all the workmen, materials, plant and belonging to him or to BHEL or to others, working at or near the site. The contractor shall also be responsible for provision of all safety notices and safety equipment required both by the relevant legislation and the Engineer-in-charge as he may deem necessary.

b) The contractor shall adopt adequate safety measures and use of protective clothing by all the workmen at site/work place whether engaged or not in actual of work or supervision thereof. The contractor shall ensure that the workmen on site use safety belt, gloves, helmets, masks etc. as are necessary for their safety.

c) The contractor shall be responsible for safety arrangements of all equipment used in connection with the execution of the work and shall ensure employment of only trained person to operate the equipment. Only tested equipment, tools, wires, ropes etc. shall be used and shall periodically be tested to the satisfaction of the BHEL. All test certificates shall be made available to the BHEL at site as and when required.

d) The contractor shall ensure provision and maintenance of lights, guards, fencing with gates and watching when and where necessary or required by the BHEL or by any one duly constituted authority for the protection of the work and / or for the safety and convenience of the public or others.

e) The contractor shall take adequate safety precautions for prevention of accidents at site. The contractor shall also ensure that their employees / workmen comply with the statutory safety rules and regulations as and also those laid down by BHEL from time to time.

f) The contractor shall provide at his cost necessary watch and ward force as may be approved by the BHEL to ensure security and safety of all buildings, structures, equipments and materials under their custody at the site of work.

g) The contractor shall abide by all security regulations at site by the BHEL from time to time. The contractor shall provide identify badges to their personnel and workmen, which must be properly displayed by them at site.

h) In order to facilitate issue of exit gate permits by the BHEL for materials and equipments either during execution or the maintenance period, the CONTRACTOR shall submit to the BHEL list of construction / erection equipment etc. and / or other materials that shall be taken by them inside the site from time to time. Such movement of materials, equipment, tools, tackles etc. shall be subject to certification by the Engineer-in-Charge.

i) The contractor and his personnel / workmen shall be subject to security check by BHEL's own security force or Central Industrial Security Force if engaged by the BHEL for the overall protection of the project.

j) The contractor shall not allow any visitors on the works except with the written permission of the BHEL.

k) From the commencement to the completion of work, the contractor shall take full responsibility for the care of the work, constructional plant and equipment and all temporary works and in case any damage or loss shall happen to the work, constructional plant and equipment or to plant temporary work from any cause whatsoever, the contractor shall at his own cost replace or repair and make good the same.

l) The contractor will notify well in advance to the Engineer-in-charge of his intention to bring to site any container filled with liquid or gaseous fuel explosive or petroleum substance or such chemicals, which may involve hazards. The Engineer-in-charge shall have the right to prescribe the conditions under which such containers are to be stored, handled and used during the performance of the works and the contractor shall strictly adhere to and comply with such instructions. The Engineer-in-charge shall have to right at his sole discretion to inspect any such container or such construction plant / equipment, for which material in the container is required to be used and if in his opinion, its use is not safe, he may forbid its use. No claim due to such prohibition shall be entertained by BHEL nor shall BHEL entertain any claim of the contractor towards additional safety provisions/ conditions to be provided for/ constructed as per Engineer-in-Charge instructions compliance to statutory in respect of such conditions will be the sole responsibility of the contractor.

m) Further any such decision of the Engineer-in-Charge shall not in any way absolve the contractor of his responsibilities for safety provisions and in case, use of such a container or entry thereof into the site area is forbidden by Engineer-in-Charge without any cost implications to BHEL or extension of work schedule.

n) Where it is necessary to provide and/ or store petroleum products or petroleum mixtures and explosive, the contractor shall be responsible for carrying out such provision and / or storage in accordance with the rules and regulations laid down in Petroleum Act 1934, Explosives Act 1948 and Petroleum and Calcium Carbide Manual published by the Chief Inspector of Explosives of India. All such storage shall have prior approval of the Engineer-in-charge. In case, any approval is necessary from the Chief Inspector (Explosives) or other statutory authorities, the contractor shall be responsible for obtaining the same.

o) All equipment used in construction & erection by the contractor shall meet Indian/ International Standards and where such standards do not exist, contractor shall ensure these to be absolutely safe. All equipment shall be strictly operated and maintained by the contractor in accordance with manufacturer's operation manual and safety instructions and as per guide lines/ rules of BHEL in this regard.

p) Periodical examination and all tests for all lifting/ hoisting equipment and tackles shall be carried out in accordance with the relevant provisions of Factories Act 1948, Indian Electricity Rules 1910 and associated Law/ Rules in force from time to time. A register of such examinations and tests shall be promptly produced as and when desired by Engineer-in-charge or Safety Officer.

q) Contractor shall provide suitable safety equipment of prescribed standard to all employees and workmen according to the need at his own cost as may be directed by Engineer-in-charge who will also have the right to examine these safety equipments to determine their suitability, reliability, acceptability and adoptability.

r) The contractor shall provide safe working conditions to all workmen and employees at the site including safe means of access, railings, stairs, ladders, scaffolding, safety belts etc. the scaffoldings shall be erected under the control and supervision of an experienced and competent person.

s) The contractor shall not interfere with or disturb electric fuses, wiring and other electrical equipment belonging to BHEL or other contractors under any circumstances whatsoever, unless specially permitted in writing by BHEL to handle such fuses, wiring or electrical equipment.

Before the contractor connects any electrical appliances to any plug or socket belonging to the other contractor or BHEL, he shall:

i) Satisfy the Engineer-in-charge that the appliance is in good working condition.

ii) Inform the Engineer-in-charge of the maximum current rating voltage and phases of the appliances.

iii) Obtain permission of the Engineer-in-charge detailing the sockets to which the appliances may be connected.

The Engineer-in-charge will not grant permission to connect until he is satisfied that:

i) The appliance is in good condition and is fitted with a suitable plug.

ii) The appliance is fitted with suitable cable having two earth conductors, one of which shall be an earthed metal sheet surrounding the cores.

iii) No electrical cable in use by the contractor will be disturbed without prior permission. No weight of any description will be imposed on any cable and no ladder or similar equipment will rest against or attached to it.

iv) No repair work shall be carried out on any live equipment, the equipment must be declared safe by the Engineer-in-charge and a permit to work shall be issued by Engineer-in-charge before any repair work is carried out by the contractor. While working on electric lines/ equipment whether alive or dead suitable type and sufficient quantity of tools will have to be provided by contractor to electricians/ workmen/ officers.

t) The contractor shall employ necessary number of qualified full time electricians/ electrical supervisors to maintain his temporary electrical installations.

u) In case any accident occurs during the construction/ erection or other associated activities undertaken by the contractor thereby causing any minor or major or fatal injury to his employees due to reason whatsoever, it shall be the responsibility of the contractor to promptly inform the same to BHEL Engineer-in-Charge in prescribed from. The contractor will be responsible for all pecuniary liability if any under such circumstances.

v) The Engineer-In charge and Safety Officer shall have the right at his sole discretion to stop the work, if in his opinion, the work is being carried out in such a way that it may cause accidents and endanger the safety of the person and/ or property and/ or equipments. In such cases, the contractor shall also be informed in writing about the nature of hazards and possible injury/ accident and he shall remove the shortcomings promptly. The contractor after stopping the specific work can, if felt necessary, appeal against the order of stoppage of work to the respective General Manager within 3 days of such stoppage of work and decision of GM in this respect shall be conclusive and binding on the contractor.

w) Notwithstanding anything contrary to this, in the event of his workmen, the contractor shall be required to fill Injury Report and submit to the Shop Manager/ Engineer-in-Charge of BHEL immediately and ensure due compliance of Workmen Compensation Act 1923 and Rules made there under.

x) The contractor shall not be entitled to any damages/ compensation for stoppage of work due to safety reasons as provided above and the period of such stoppage of work will not necessarily be taken as an extension of time for completion of work and will not be the ground for waiver of levy of liquidated damages.

y) The contractor shall follow and comply with all BHEL safety rules, relevant provision of applicable law pertaining to the safety of workmen, plant and equipment as may be prescribed from time to time without any demur protest or contest or reservation. In case of any unconformity between statutory requirement and BHEL Safety Rules referred above, the later shall be binding on the contractor unless the statutory provisions are more stringent.

z) If the contractor fails in providing safe working environment as per the statutory requirements and / or BHEL Safety Rules or continue to work even after being instructed to stop the work by Engineer-in-charge or Safety Officer as provided above, the contractor shall promptly pay to BHEL, on demand, compensation at the rate of Rs. 500/- per day or part thereof till instructions are complied with and so certified by Engineer-in-charge/ Safety Officer. However, in case of accident taking place causing death/ injury to any individual the statutory provisions shall apply in addition to compensation mentioned in this para; and the contractor will be solely liable on account of this.

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ANNEXURE – III

Ref: OS/SC/2024-25/76/43 **Date: 10.08.2024**

Sub: Contract for conducting Qualification Tests (QT) on 1 Unit of Liquid Cooling System (2KW Module) for R&D, BHEL-HPVP, Visakhapatnam – Reg

ACCEPTANCE TO TENDER TERMS & CONDITIONS

I / We hereby confirm that the Tender documents, all Annexures etc. have been studied in detail and we have fully understood the scope of work.

I / We accept to all the **Terms and Conditions** of the Tender Enquiry and the prices quoted are in accordance with the same.

I / We accept to offer valid for a period of **3 months** from the last date for tender submission.

I / We give our acceptance to participate in **Reverse Auction** in case BHEL decides to go for reverse auction for this tender.

Tender documents duly signed on all the pages by the Owner / authorized representative of the bidder are attached herewith.

SIGNATURE OF THE TENDERER WITH SEAL

ANNEXURE- IV

Ref: OS/SC/2024-25/76/43 **Date: 10.08.2024**

CONTRACTOR INFORMATION

Sl. No.	Particulars	To be Filled by Bidder
01.	Name of the Contractor	
02.	Nature of Firm / Concern (Proprietor/Partnership/Pvt. Limited/Public Ltd.) Note: In case of partnership concern, please enclose photo copies of the partnership deed	
03.	Full address	
04.	Name of the Proprietor/Partner	
05.	Name of the Person(s) and designation authorized for signing the contract/dealing with BHEL	
06.	Telephone No. of the firm	
07.	Fax No.	
08.	Mobile No.	
09.	E-mail ID	
10.	HSN Code./ SAC Code	
11.	Organizational structure with name and designation	

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ANNEXURE- V

Ref: OS/SC/2024-25/76/43 **Date: 10.08.2024**

CHECK LIST

Sl. No.	Particulars	Document Enclosed (Yes / No)	Document No
01.	Name of the Contractor		
02.	Tender Document Signed & Stamped		
03.	GSTIN Registration Certificate		
04.	PAN Number		
05.	HSN / SAC Code		
06.	Income Tax Returns for last 3 years		
07.	Profit & Loss account and Balance Sheet certified by the Practicing Chartered Accountant for the last 3 years		
08.	Work orders & Job Completion Certificates in similar works as mentioned in eligibility criteria.		
09.	Documentary evidence of Local office address at Visakhapatnam, Andhra Pradesh		
10.	MSE - Valid Udyam Registration Certificate (if any)		

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ANNEXURE – NEFT

ACCEPTANCE FOR ELECTRONIC FUND TRANSFER / RTGS / NEFT TRANSFER

01	NAME & ADDRESS OF THE SUPPLIER / SUBCONTRACTOR	
02	VENDOR CODE ASSIGNED BY BHEL-HPVP LTD	

DETAILS OF BANK ACCOUNT

03	NAME & ADDRESS OF THE BANK	
04	NAME OF THE BRANCH	
05	BRANCH CODE	
06	MICR CODE	
07	ACCOUNT NUMBER	
08	TYPE OF ACCOUNT	
09	BENEFICIARY'S NAME	
10	IFSC CODE OF THE BRANCH	
11	EMAIL ID	
12	TELEPHONE / MOBILE NUMBER	

CERTIFICATE

I / We here by agree to receive the payments due from M/s Bharat Heavy Electricals Ltd., by the National Electronic Fund Transfer / or RTGS Transfer mode by credit to my / our above-mentioned Bank account. I / We also agree that payments made to the above-mentioned account are a valid discharge of the liability of M/s Bharat Heavy Electricals Ltd. I / We also agree to bear the applicable Bank charges for the above mode of transfer. A copy of the Cheque leaf/ cancelled Cheque leaf of the above account is sent herewith.

(Authorized Signatories with Name & Seal)

BANKER'S CERTIFICATION

We confirm that we are enabled for receiving RTGS and NEFT credits and we further confirm that the account number of _____ _____ (name of account holder), the signature of authorized signatory and the MICR and IFSC codes of our branch mentioned above are correct.

Place: Bank Manager / Officer

Date: Signature with Bank stamp and Name seal

FORWARDED TO ACCOUNTS DEPARTMENT / CASH SECTION

We confirm the above details are verified with the records available with us

Signature of BHEL Official with Name & Seal

Operating the contract / Services

ANNEXURE- GST

GST COMPLIANCE FOR INDIGENOUS SUPPLIERS / CONTRACTORS

1. In Response to Tenders for Indigenous supplier will be entertained only if the vendor has a valid GSTIN which should be clearly mentioned in the offer. If any specific exemption is available, a declaration with due supporting documents need to be furnished for considering the offer.
2. Supplier shall mention their GSTIN in all their invoices and invoices shall be in the format as specified/prescribed under GST laws. Invoices shall necessarily contain Invoice number (in case of multiple numbering system is being followed for billing like SAP invoice no, commercial invoice no etc., then the Invoice No which is linked/uploaded in GSTN network shall be clearly indicated), item description as per P0, Quantity, Rate, Value, applicable taxes with nomenclature (like IGST, SGST, CGST & UTGST) separately, HSN/ SAC Code, etc.
3. All invoices shall bear the HSN Code for each item separately (Harmonized System of Nomenclature)/ SAC code (Services Accounting Code).
4. A declaration to the effect that all invoice particulars are/were uploaded in the GSTN network/ portal & all tax liability as per GST rules and regulations have been and will be discharged, shall be mentioned in the invoice. If not mentioned in the invoice, a separate declaration shall be submitted as per the requirement of BHEL.
5. All documents like Test Certificate, LR copy, Guarantee/Warrantee certificate, work completion certificate, any other document mentioned in PO, shall be sent along with the vehicle/consignment where ever applicable. For all consignments received within the calendar month, input credit will be availed within that month in line with monthly returns filing cycle. In case of any discrepancy in the document or non-submission of documents mentioned in the PO, then BHEL will not be able to accept or account the material, in such case availing of tax credit will be deferred to next month or so.
6. In case of discrepancy in the data uploaded by supplier in the GSTN portal or in case of any shortages or rejection in the supply, then BHEL will not be able to avail the tax credit and will notify the supplier of the same. Supplier has to rectify the data discrepancy in the GSTN portal or issue credit note (details to be uploaded in GSTN portal) for the shortages or rejections in the suppliers, within the calendar month notified by BHEL.
7. For any such delay in availing of tax credit for reasons attributable to supplier (as mentioned above), interest (calculated @ SBI Base Rate + 6%) along with penalty if any will be deducted for the delayed period i.e. from the month of receipt till the month tax credit is availed, from the running bills.
8. Under GST regime, BHEL has to discharge GST liability on LD recovered from suppliers/ contractors. Hence applicable GST shall also be recoverable from suppliers/contractors on LD amount. For this Debit note will be issued by BHEL indicating the respective supply invoice number.
9. This is to inform that GST portion of invoice, shall be released only upon Vendor declaring such invoice in his GSTR-1 and receipt of goods and Tax invoice by BHEL and Confirmation of payment of GST thereon by vendor on GSTN portal. Alternatively, BG of appropriate value may be obtained from vendor which shall be valid At least one month after the confirmation of date of payment of GST by vendor on GSTN portal and receipt of Tax invoice and receipt of goods, whichever is later. Above is subject to receipt of goods/service and tax invoice thereof along with vendor declaring invoice in his return and paying GST within timeline prescribed for availing ITC by BHEL.
10. That in case vendor delays Declaring such invoice in his return and GST credit availed by BHEL is denied or reversed subsequently as per GST law, GST amount paid by BHEL towards such ITC reversal as per GST law shall be recoverable from vendor/contractor along with interest levied/ leviable on BHEL.

Note: The above will be followed strictly for Processing vendor payments to ensure GST Compliance.

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ANNEXURE- VI

BHARAT HEAVY ELECTRICALS LIMITED
HEAVY PLATES & VESSELS PLANT
VISAKHAPATNAM – 530 012

PRICE BID
PART-II

NAME OF WORK: : Contract for conducting Qualification Tests (QT) on 1 Unit of Liquid Cooling System (2KW Module) for R&D, BHEL- HPVP, Visakhapatnam – Reg

Tender Enquiry No: OS/SC/2024-25/76/43, Date: 10.08.2024

SCHEDULE OF QUANTITIES & RATES (SOQR)

SL. NO	DESCRIPTION OF WORK	UNIT	QTY.	TOTAL AMOUNT in ₹
1	Qualification Tests (QT) on 1 Unit of Liquid Cooling System (2KW Module) for R&D, BHEL- HPVP, Visakhapatnam as per scope of work (Annexure-I) (All 31 tests are included)	Lump sum	**1**	
2.	**GST @ 18% on Total Amount**			₹_____
3	**Total Amount including GST in ₹**			₹_____

Total Amount in Words:

NOTE:

1) **The prices shall remain fixed and firm for an entire period of contract & No additional payment shall be made to contractor over and above the quoted price.**
2) GST as applicable shall be paid by contractor and same shall be reimbursed on submission of proof of payment.

SIGNATURE OF THE TENDERER WITH SEAL