Bharat Heavy Electricals Limited
Heavy Plates & Vessels Plant
Visakhapatnam – 530 012,
Andhra Pradesh, INDIA.

Tel. : +91(0) 891 288 1515/1345
E-mail : rameshsnvs@bhel.in &
dgs@bhel.in

NOTICE INVITING TENDER

Ref: OS/SC/2024-25/161/105 **Date: 05.02.2025**

Sub: Service Contract to conduct qualification test of Pump Modules of BHEL-HPVP, Visakhapatnam – Reg.

Tenders are invited under **two 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	LAST DATE FOR RECEIPT OF TENDER
01	Service Contract to conduct qualification test of Pump Modules of BHEL-HPVP, Visakhapatnam	15.02.2025, thru GEM 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 2024 should be at least. **₹11.12** Lakhs. In case annual turnover for FY 2023-24 is not finalized or ITR is not submitted by the contractor, Avg. annual turnover during the last 3 years ending 31st March 2023 shall be considered.

Tenderer should enclose PAN, GSTIN registration no., Income tax returns for last three years (AY-2022-23, 2023-24 & 2024-25/2021-22), 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 the last 7 years ending **31st Jan 2025** as given below: -

(a) Three similar completed works costing not less than the amount equal to **₹14.83** Lakh each.

OR

(b) Two similar completed works costing not less than the amount equal to **₹ 18.54** Lakh each.

OR

(c) One similar completed work costing not less than the amount equal to **₹29.66** Lakh.

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 Pump Modules or Similar Systems in Airborne Application for aerospace industry 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) **Vendor should have Test facilities to carry out at least any 10 tests out of total tests as specified at Annexure-I at the vendor works. Proof is to be produced.**

V) **Un-priced PO copy and work completion certificate issued by end user/ customer duly mentioning total executed value or priced PO copy and work completion certificate shall be submitted along with the bid as part of PQC (Pre-Qualification Compliance) for testing.**

VI) **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.**

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Ref: OS/SC/2024-25/161/105 **Date: 05.02.2025**

2. SCOPE OF THE WORK

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

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. CONTRACT PERIOD:

Contract is valid for a period of **One Year** from date of work order or intimation by R & D department, whichever is later.

Completion Period:

The total duration of all the qualification tests will be 20 weeks from the receipt of unit from BHEL

5. INSPECTION:

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

6. EARNEST MONEY DEPOSIT: Not Applicable

7. 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.

C. **Modes of Deposit:**

The required amount of Security Deposit i.e. **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.

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.

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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.**

8. 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.

9. 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%.

10. 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.

11. PAYMENT TERMS:

100% 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 (for RA Bills)/ WAM 07 (for Final Bill) duly filled & signed

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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.

12. PRICE SCHEDULE, TAXES & DUTIES:

a. Prices shall be quoted as per the price schedule attached to the tender (Annexure-VI).

b. The quoted prices shall be inclusive of GST as applicable as on due date of tender submission. However, GST as applicable shall be payable by vendor & 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. REVERSE AUCTION:

Reverse Action will be conducted thru GeM Portal.

14. VALIDITY OF THE OFFER:

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

15. 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 and overhead charges shall be charged to the contractor. Risk & Cost will be implemented as per STANDARD OPERATING PROCEDURE FOR IMPLEMENTATION OF RISK & COST of BHEL.

16. GENERAL:

a) **Bidders shall confirm their acceptance to all the terms & conditions of the tender enquiry.** Any deviation to the tender terms & conditions is 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, 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 document and all other relevant documents in detail for understanding the scope of supply and the processes involved before submission of their offer.

For any clarifications required on this tender document, scope of supply, mode of operation etc., the bidders shall depute their authorized representatives to BHEL-HPVP, Visakhapatnam with prior intimation to get clarifications from concerned authorities between 09:00 AM to 04:00 PM.

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

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

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)	Test Procedures	

PART - II: PRICE BID

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

17. **TENDER SUBMISSION:**

a. The Bid shall be submitted in two parts through GeM portal along with the following documents:

a) All page of tender document duly signed & stamped.
b) Income tax returns for last 3 year,
c) Experience Certificates (Work Order & Job completion certificate) in line with eligibility criteria.
d) Copy of GSTIN Registration Certificate.
e) Copy of PAN.
f) Valid Udyam registration Copy
g) **Documentary Proof of Test facilities of at least any 10 tests at the vendor works.**
h) Any other documents mentioned in the tender

Offers received in any other form will not be accepted.
Note: All pages of tender documents and the various supporting documents enclosed by the bidder should be signed on all pages with company seal.

b. The Bids shall be submitted in two parts through GEM portal before submission time.
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.

18. **OPENING OF TENDERS:**

The bid will be opened **in GEM Portal at prescribed Date & Time**

19. 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.

***

SCOPE OF WORK

The scope of testing is specified below:

1. Vendor shall perform qualification tests (QT) as specified in table 1 of this specification on 1 no. of module as per Document No: QTP/0PM4502000 & Version No.: 00, Date of Issue: 23-01-2024 within 20 weeks from date of PO.
2. The bidder should have experience of performing similar tests in Airborne Application for aerospace industry in last 5 years from the tender issue date.
   Un-priced PO copy or 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 equipment provided by BHEL in vendor's test facility. All machines, fixtures (except fixture for vibration test), materials, instruments, manpower, Accessories, tools and tackles, any other items required for testing shall be arranged by vendor.
   Fixture for vibration test will be provided by BHEL. **All other fixtures 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. However, the following are in BHEL scope.
   a. Handing over of equipment to vendor stores from BHEL stores before start of first test.
   b. Collection of equipment from Vendor Stores after completion of all tests.
7. Vendor shall comply all the conditions of Annexure-1 of AS9100.
8. The functional test to be carried out by vendor after every test. BHEL will supply the rig for functional test.
9. BHEL will provide the case for Transit Drop test.
10. 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.
11. Vendor shall inform to BHEL 2 weeks in advance about the schedule of the test. BHEL, ADA & DGAQA personal will witness the testing. Necessary entry passes shall be arranged by vendor in case the test is being carried out at another facility.
12. The Dimensional Details of test sample is specified below.

a. Pump Module: 320 x 315 x 116.5 mm – ~13.5kg (Dry)

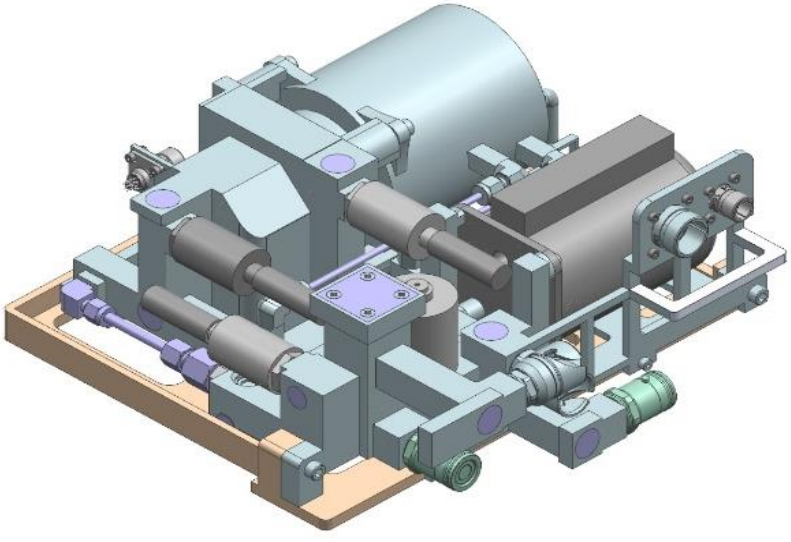

Figure:1 Typical Model of Module

Contd…2

ANNEXURE I

Ref: OS/SC/2024-25/161/105 **Date: 05.02.2025**

13. BHEL will provide Document No: QTP/0PM4502000 & Version No.: 00, Date of Issue: 23-01-2024 the following final approved documents along with PO.
    Document No: QTP/0PM4502000 & Version No.: 00, Date of Issue: 23-01-2024

    For tender purpose, interested parties may obtain above document form Mr. S Mandal, DGM (R&D) / Satish D (Manager)
    Email: smandal@bhel.in / satishd@bhel.in, Ph: 0891 288 1195 / 1149.
14. The following power and load source shall be used by vendor during testing as a minimum.
    a. Operating Voltage: 200V
    b. Load Current: 1.4A 3Phase
    c. No. of Power Cables: 4 Wire and 400Hz.
15. Interconnecting cables (for the CS114, CS115 & CS116) which are required for testing shall be arranged by vendor.
16. The vendor must submit the test plan before conducting the tests.
17. **The total duration of all the qualification tests will be 20 weeks from the receipt of unit from BHEL.**
18. Scope of transportation: Transportation of Test unit from BHEL to Vendor works will be in BHEL scope and after the completion of tests, transportation of the unit from vendor works to BHEL Visakhapatnam will be in vendor scope.
19. **Fixtures manufactured by vendor for conducting tests shall be returned to BHEL after completion of all tests along with vibration test fixture provided by BHEL. Transportation cost for returning of test fixtures to BHEL-HPVP, Visakhapatnam shall be borne by vendor only.**
20. **Insurance for damage / theft in vendors work or their sub vendors work shall be borne by vendor.**
21. List of Tests to be conducted on Module:

Sl. No	Name of Test
1	Burn in Test
2	Altitude Test
3	High Temperature Storage Cum Operational Test
4	Low Temperature Storage Test
5	Low Temperature Operating Test
6	Thermal Shock Test
7	Rain Drip Test
8	Humidity Test
9	Fungus (Mould Growth) Direct Effect Test
10	Salt Fog Test
11	Fluid Contamination Test
12	Dust Test
13	Acceleration Test (Structural)
14	Vibration Test
15	Mechanical Shock Test
16	Transit Drop Test
17	Bench Handling Test
18	Gunfire Vibration Test
19	EMI / EMC Tests
20	Power Supply Test
21	Dielectric Withstanding Voltage Test

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ANNEXURE I

Ref: OS/SC/2024-25/161/105 **Date: 05.02.2025**

Please Refer:

QUALIFICATION TEST PROCEDURE DOCUMENT FOR PUMP MODULE USED IN LIQUID COOLING SYSTEM (LCS) OF LCA AF Mk2.

Document Number: QTP/0PM4502000 & Version No.: 00

Date of Issue: 23-01-2024

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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, i.e. **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 after deducting all expenses/ other amounts due to BHEL under the contract / other contracts entered into with them by BHEL after the maintenance period of 2 months or on closure of contract whichever is later.

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/2024-25/161/105 **Date: 05.02.2025**

Sub: Service Contract to conduct qualification test of Pump Modules of 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 Bidder with Company Seal

ANNEXURE- IV

Ref: OS/SC/2024-25/161/105 **Date: 05.02.2025**

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	

***

ANNEXURE- V

Ref: OS/SC/2024-25/161/105 **Date: 05.02.2025**

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 Proof of Test facilities of at least any 10 tests at the vendor works		
10.	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		
11	Udyam Registration Certificate		

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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:

Service Contract to conduct qualification test for Pump Module **(Quantity-One)** of BHEL-HPVP, Visakhapatnam – Reg

Tender Enquiry No.: OS/SC/2024-25/161/105, Date: 05.02.2025

SCHEDULE OF QUANTITIES & RATES

SL No	Description of work	Unit	Total Amount in ₹
1	Burn in Test	Lump Sum	12,000.00
2	Altitude Test	Lump Sum	22,750.00
3	High Temperature Storage Cum Operational Test	Lump Sum	1,42,800.00
4	Low Temperature Storage Test	Lump Sum	12,000.00
5	Low Temperature Operating Test	Lump Sum	12,000.00
6	Thermal Shock Test	Lump Sum	21,000.00
7	Rain Drip Test	Lump Sum	55,000.00
8	Humidity Test	Lump Sum	2,04,000.00
9	Fungus (Mould Growth) Direct Effect Test	Lump Sum	80,000.00
10	Salt Fog Test	Lump Sum	62,400.00
11	Fluid Contamination Test	Lump Sum	8,25,000.00
12	Dust Test	Lump Sum	30,000.00
13	Acceleration Test (Structural)	Lump Sum	1,30,000.00
14	Vibration Test	Lump Sum	1,10,000.00
15	Mechanical Shock Test	Lump Sum	70,000.00
16	Transit Drop Test	Lump Sum	30,000.00
17	Bench Handling Test	Lump Sum	30,000.00
18	Gunfire Vibration Test	Lump Sum	45,000.00
19	EMI / EMC Tests	Lump Sum	4,24,000.00
20	Power Supply Test	Lump Sum	7,10,000.00
21	Dielectric Withstanding Voltage Test	Lump Sum	20,000.00

ANNEXURE- VI

NAME OF WORK:

Service Contract to conduct qualification test of Pump Modules of BHEL-HPVP, Visakhapatnam

Tender Enquiry No.: OS/SC/2024-25/161/105, Date: 05.02.2025

Sl. No	Description of work	Unit	Total Amount in ₹
22	Functionality test charges, fixture charges, Transportation charges	Lump Sum	6,60,000.00
23	**Total Amount**		**37,07,950.00**
24	**Discount / increase on total amount sl. No. 23 (- or + ____ %)**		
25	**Total Amount after discount / increase (Sl. No. 23 ± 24)**		
26	**GST @ 18% on Total amount at Sl. No. 25**		
27	**Total Amount Including GST (Sl. No. 25 + 26)** **(This amount is to be quoted in GeM Portal)**		

Total Amount in Words:

NOTE:

1) **Price break-up of Sl. No. 22 (Functionality test charges, fixture charges, Transportation charges) is to be mentioned separately.**
2) **Work is to be carried out at Vendor works. Sending & receiving of Items/ Equipment for testing to vendor works are in the scope of BHEL-HPVP, Visakhapatnam.**
3) **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) **Fixtures manufactured by vendor for conducting tests shall be returned to BHEL after completion of all tests along with vibration test fixture provided by BHEL. Transportation cost for returning of test fixtures to BHEL-HPVP, Visakhapatnam shall be borne by vendor only.**
5) **Insurance for damage / theft in vendors work or their sub vendors work shall be borne by vendor**
6) **The quoted prices shall be fixed & firm without any escalation during the entire period of contract and till completion of the work.**
7) **L1 shall be evaluated based on quoted total price at Sl. No: 27.**
8) The quantity indicated in the schedule is indicative only and may increase/ decrease or be deleted but total value of contract will not exceed the awarded value, unless otherwise order is amended. However, payment shall be made for the actual quantities executed only.
9) **After L1 evaluation, discount/ increase shall be applied pro-rata basis on each SOQR line of item.**
10) GST as applicable shall be payable by the contractor and same will be reimbursed by BHEL as per Annexure - GST.

Signature of the Tenderer with Company Seal

ACCEPTANCE TEST PROCEDURE

FOR

PUMP MODULE USED IN

LIQUID COOLING SYSTEM (LCS)

OF LCA AF Mk2

(Part No.: 0-PM-45-02000)

Bharat Heavy Electricals Ltd.
Corporate R&D, Vikas Nagar,
Hyderabad - 500042

Aeronautical Development Agency (ADA)
PB No. 1718, Vimanapura Post,
Bangalore - 560017

Document Control Data Sheet

Document Number	ATP/0PM4502000	**Date**	23-01-2024
REV. No	00		
No. of Pages	14		
Title	**Acceptance Test Procedure (ATP) for Pump Module used in Liquid Cooling System (LCS) of LCA AF Mk2**		
Originating Group/Orgn.	BHEL Corporate R&D, Hyderabad		
Abstract	The ATP document provides details of tests to be carried out on the Pump Module after manufacturing the unit for acceptance of the unit		

Bharat Heavy Electricals Limited	**Aeronautical Development Agency (ADA), Bangalore**
Prepared: B. Sireesha Sireesha Baile, Dy. Manager, Corp. R & D, Hyderabad	Rep, GS Dte Ajay Kashyap Sc-'D'
Checked: Sougat Mandal, Sr. Manager, HPVP, Visakhapatnam	Technology Director (QA&SEG) Arvind Kuldeep Scientist - E
Reviewed: A.K. Mandal - AGM Quality, HPVP, Visakhapatnam	Technology Director (GS)

Approved

(ANURAG BASAK, TD-A)

RD, RCMA (A/C-R&D)

Record of Amendments

Rev No.	Issue Date	Brief Description of Amendment	Affected Pages

Distribution List

BHEL	Aeronautical Development Agency (ADA)	Certifying Agencies
AGM (Quality),BHEL Corporate R&D, Hyderabad	TD (GS)	RCMA (A/C-R&D)
HPVP, Visakhapatnam	TD (QA&SEG)	DGAQA

Contents

1. Introduction

The Liquid Cooling System (LCS) is used for maintaining the coolant temperature less than 41^0C while entering the heat loads. The Pump Module of the LCS circulates 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 Pump Module 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 Pump Module Part No. 0-PM-45-02000 developed by M/s BHEL-Corporate R&D, Hyderabad meeting the requirement of Technical Specification No. ADA:GS:ECS:Mk2:LCS:001, Issue:01 dated 21-12-2021 and CDR, Document No. ADA/LCS/22-23/CDR/001, Revision No.: 01, Dt. 17-06-2022.

3. Applicable Documents

ADA, Bangalore Technical Specification for the Pump Module used in Liquid Cooling System (LCS) OF LCA AF Mk2, ADA:GS:ECS:Mk2:LCS:001, Issue:01 dt.21-12-2021.

4. Test Centre & Sampling

All Acceptance Tests described in this document shall be carried out at the test facility at BHEL Corporate R&D/ HPVP Visakhapatnam/ Accredited Labs after manufacture of each Pump Module Unit.

5. Inspection/Certification Authority

All Acceptance Tests shall be witnessed and inspected by BHEL-Quality, QASEG representative from ADA and representative from DG-AQA, Hyderabad in accordance with the requirements and procedures specified in this document for each unit of the Pump Module. The test report shall be submitted to ADA, Bangalore along with each unit of the Pump Module.

6. Test Environment

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

7. Acceptance Test Sequence

The following Acceptance Tests shall be performed on the Pump Module 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 Pump Module.

Table-1: Acceptance test sequence

Sequence	Name of Test
1	Visual Examination
2	Dimension & Weight Check
3	Physical Interface Checks (Mechanical & Electrical)
4	Proof Pressure Check
5	Accumulator Check
6	Pressure Relief Valve Check
7	Functionality Check
8	Final Inspection

8. Acceptance Test Details:

8.1 Visual Examination:

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

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

Table-2: Major assembly/Sub assembly/ Components details

Sl. No.	Major sub assembly	Part No.	Serial No.	Result
1	Monoblock Assembly			
2	Tray			
3	Pump			
4	Motor			
5	Accumulator			

6	Solenoid Valve			
7	Pressure Sensors			
8	Pressure Relief Valve			
9	Filter			
10	Signal & Power Connectors			
11	Quick Disconnect Couplings (QDCs)			

Test / Check Performed By:	**Witnessed by:**		
BHEL	**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

Table-3: Name Plate/Engraving details

Sl. No.	**Action**	**Expected result**	**Observed value**	**Remarks**
1	Part No.	--------		
2	Sl. No.	--		
3	Dry Weight	13.1 + 0.2 Kg		
4	Manufacturing Year	---		
5	Version No.	---		

Test / Check Performed By:	**Witnessed by:**		
BHEL	**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

8.2 Dimension & Weight Check:

i. Measure the dry weight of the Pump Module using a weighing machine.

ii. Measure the overall dimensions of the Pump Module and document as per the Table -5 given below.

Table-5: Weight & Overall Dimensions of Pump Module assembly with Tray

Sl. No.	Action	Expected value	Observed value	Remarks
a	Dry weight of unit	13.1 + 0.2 Kg		
b	Length (mm)	330 (max)		
c	Width (mm)	322.5 (max)		
d	Height (mm)	116.5 (max)		

Test / Check Performed By:	Witnessed by:		
BHEL	**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

8.3 Physical Interface Checks (Mechanical & Electrical):

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

a) Confirm location of QDCs and genders of Quick disconnect couplings (QDCs).
b) Confirm location and gender of the Signal connector and Power connector.
c) Continuity test shall be conducted for Electrical loom. Ensure the loom is qualified for airborne applications.
d) Carry out Megger Test (Insulation Test) for the Pump motor and record the observations as per Table -6 given below.
e) Carry out Bonding resistance Test for the Pump module and record the observations as per Table -6 given below.

Table-6: Megger & bonding resistance test report

Sl. No.	Action	Expected result	Observed value	Remarks
1	Measure phase resistance to ground @ 500 V DC (Megger Test)	> 50M ohms		
2	Measure Bonding resistance	< 2.5 milli ohms		
Test / Check Performed By:		**Witnessed by:**		
BHEL		**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

8.4 Break-in Run Test

The Pump Module will be initially run under low load condition which will be gradually increased to full load condition. This test shall be performed by gradually increasing the speed from 0 RPM (Pump Module OFF condition) to 12000 RPM (Pump Module ON condition & operating at full load) in four stages i.e., 3000 RPM, 6600 RPM, 9000 RPM and 12000 RPM.

8.5 Startup Test

The pump module shall be directly started at full load (maximum flow and maximum pressure) condition for this test and record the observations as per Table -7 given below.

Table-7: Startup Test Report

Sl. No.	Action	Expected result	Observed value	Remarks
1	Measure Startup Time	< 3 seconds		
2	Measure Startup Current	< 15 Amps		
Test / Check Performed By:		**Witnessed by:**		
BHEL		**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

8.6 Proof Pressure Check

The proof pressure checks shall be carried out using a manually operated external hydraulic pump as per the procedure given below. Results are to be documented in Table-7.

a) Pressurize the Pump Module with a help of charging equipment. Ethylene Glycol Water Mixture (65:35) or Nycosol-51 can be used for pressurizing the Pump module.
b) Ensure that all the components of Pump module are connected properly to monoblock. The Pressure relief valve should be removed and the port should be plugged before carrying out the test.
c) Slowly pressurise unit to maximum 12.75 (- 0.5 Tolerance) bar (g) (~ 1.5 times the operating Pressure) and isolate the pump module from the pressure source.
d) Keep the pump module isolated from the pressure source and monitor the pressure for 3 minutes.
e) Slowly reduce the pressure inside the pump module to atmospheric pressure.

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

Table-7: Proof pressure check

Sl. No.	Test	Observations	Remarks
1	Proof pressure test		

Test / Check Performed By:	Witnessed by:		
BHEL	**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

8.7 Accumulator Check:

a) Ensure that accumulator level sensor is connected to a multimeter / Data Logger to measure the voltage.
b) When the circuit pressure is zero, measure the output voltage of level sensor.
c) Connect pressure source to inlet port of pump module 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 8.5 ± 0.5 bar gauge and measure the output voltage from level sensor.
e) Slowly reduce the pressure to 1 ± 0.3 bar gauge. Measure the output voltage from level sensor.

f) Slowly reduce the pressure inside the Pump Module to zero. Measure the output voltage of level sensor.

Table -8: Level sensor output

Sl. No.	Action	Level sensor output (Volts)	Observed value (Volts)	Remarks
1	Liquid Pressure : 0 + 0.2 bar gauge	0.6* ± 0.4		
2	Liquid Pressure : 1 ± 0.3 bar gauge	2.5* ± 0.4		
3	Liquid Pressure : 8.5 ± 0.5 bar gauge	4.3* ± 0.4		
4	Liquid Pressure : 1 ± 0.3 bar gauge	2.5* ± 0.4		
5	Liquid Pressure : 0 + 0.2 bar gauge	0.6* ± 0.4		

Test / Check Performed By:	Witnessed by:		
BHEL	**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

* These values need to be confirmed by OEM, post testing of Accumulator

8.8 Pressure relief valve check

Ensure the pump module is charged with the operating coolant (EGW mixture) into the pump module. Keep the coolant charging equipment connected.

a) Remove the pressure relief valve outlet pipe from the pump module.
b) Increase pressure in the pump module gradually to 8.5 ± 0.5 bar 'g' (operating pressure).
c) There should be no leakage through the Pressure relief valve.
d) Increase the pressure to 12.75 + 0.5 bar 'g' and check if the PRV has cracked and started leaking.
e) Decrease the pressure to ≤ 12 bar 'g' 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.

Table -9: Pressure Relief valve

Sl. No.	Test	Observations	Remarks
1	Pressure relief valve check @8.5 ± 0.5 bar 'g'		
2	Pressure relief valve check greater than @12.75 + 0.5 bar 'g'		
3	Pressure relief valve check ≤ 12 bar 'g'		

Test / Check Performed By:	Witnessed by:		
BHEL	**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

Note: The Pump Module should also be subjected to Pressure Relief Valve Check once after the completion of all Qualification Tests.

8.9 Functionality Check

8.9.1 Functional Test Procedure:

a) The functional test should be carried out by connecting the Pump module to the demonstrational test set up.

b) Charge the unit along with full circuit with Ethylene glycol - water mixture (Nycosol-51) up to 1 ± 0.3 bar gauge pressure. The pressure reading can be obtained from either of the three Pressure sensors. The charging shall be carried out with external charging unit.

c) Ensure that the Solenoid valve is in switched OFF condition, with the help of electrical switch.

d) Switch 'ON' the pump and adjust the 'control valve' on the demonstrational test setup such that the discharge pressure is 8.5 ± 0.5 bar gauge.

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

i. Measure the flow rate of the pump and coolant temperature with the help of flow meter and temperature sensor mounted on the demonstrational test setup respectively.

ii. Power and current measurement shall be taken with the help of Power analyzer. The power consumption of the pump module in the Solenoid Switched 'OFF' condition (normal mode) should be within 1062 VA max.

iii. The Coolant Discharge pressure and suction pressure shall be measured with the help of sensors mounted on Pump Module.

iv. Switch 'OFF' the pump.

v. The level sensor reading shall be taken with multimeter / Data logger.

f) Now, switch 'ON' Solenoid valve manually with the help of electrical switch.

g) Repeat steps (d) to (e) and Record the readings as per Table -10 and Switch 'OFF' the pump. The power Consumption of the Pump Module in the Solenoid Switched 'ON' condition should be within 780 VA max.

Acceptance Criteria:

Observed readings shall be within the ranges provided below –

Unit Sl. No.:
Date:

a) Flow rate: 12 LPM (± 1.2 LPM)

b) Discharge Pressure: 8.5 ± 0.5 bar (g)

c) Suction Pressure: 1± 0.3 bar (g)

d) Maximum Power consumption: 1062 VA (normal mode) & 780 VA (degraded mode)

e) Coolant temperature: Ambient temperature ± 10°C

Table -10: Test Data sheet

Time	Discharge pressure (bar gauge)	Suction Pressure (bar gauge)	Coolant Flow Rate (LPM)	Coolant Temperature (°C)	Power Consumption (VA)	Accumulator Level Sensor reading (V)	Solenoid valve (By Pass)	Remarks
							OFF	
							ON	

Test / Check Performed By:	**Witnessed by:**		
BHEL	**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

8.10 Final Inspection:

Pump Module shall be inspected visually. There should be no mechanical damage and leakage in the unit and should be recorded in Table – 11.

Table-11: Final inspection

Sl. No.	Test	Observations	Remarks
1	Final inspection – Mechanical Damage		
2	Final inspection - Leakage		

Test / Check Performed By:	Witnessed by:		
BHEL	**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

Document Number: QTP/0PM4502000

Version No. : 00

Date of Issue: 23-01-2024

QUALIFICATION TEST PROCEDURE DOCUMENT

FOR

PUMP MODULE USED IN

LIQUID COOLING SYSTEM (LCS)

OF LCA AF Mk2

(Part No.: 0-PM-45-02000)

Bharat Heavy Electricals Ltd.

Aeronautical Development Agency (ADA)
PB No. 1718, Vimanapura Post,
Bangalore - 560017

Document Control Data Sheet

Document Number	QTP/0PM4502000	**Date**	23-01-2024
REV. No	00	No. of Pages	87
Title	**Qualification Test Procedure (QTP) for Pump Module used in Liquid Cooling System (LCS) of LCA AF Mk2**		
Originating Group/Orgn.	Bharat Heavy Electricals Limited		
Abstract	The QTP document provides details of tests to be carried out on the Pump Module after manufacturing for acceptance of the unit.		

Bharat Heavy Electricals Limited	**Aeronautical Development Agency (ADA), Bangalore**
Prepared: **Sireesha Baile, Dy. Manager** **Corporate R & D, Hyderabad**	Rep, GS Dte Sc-'D'
Checked: **SOUGAT MANDAL, Sr. Manager** **HPVP, Visakhapatnam**	Technology Director (QA&SEG) Arvind Kuldeep Scientist - E
Reviewed: A.K. Mandal - AGM **Quality, HPVP, Visakhapatnam**	Technology Director (GS)

(ANURAG BASAK)
TD-'A'

Approved

RD, RCMA (A/C-R&D)

Record of Amendments

Rev No.	Issue Date	Brief Description of Amendment	Affected Pages
00	**23-01-2024**	**New Document**	

Distribution List

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HPVP, Visakhapatnam	TD (QA&SEG)	DGAQA

Table of Contents

1 Introduction

1.1 Purpose & Scope

The purpose of the document is to provide the test procedures for Qualification Testing of Pump Module.

1.2 Overview of Item

The Liquid Cooling System (LCS) is used for maintaining the coolant temperature less than 41^0C while entering the heat loads. The Pump Module 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 Pump Module when the liquid is circulated at the desired flow rate as per the technical specifications of the unit.

1.3 Reference Document

1.3.1 Project Documents

I. ADA, Bangalore Technical Specification for the Pump Module used in Liquid Cooling System (LCS) OF LCA AF Mk2, ADA:GS: ECS: Mk2: LCS:001, Issue:01 dt.21-12-2021
II. ATP for Pump Module used in LCS, ATP/0PM4502000 dt.23-01-2024
III. Environmental Map of LCA AF Mk2, ADA/QA&SEG/3723/E-Map/854/2020, Issue-01, Dt Jan 2020.

1.3.2 Standards

a) MIL-STD-704F – Aircraft Electric Power Characteristics
b) MIL Handbook 704 - Guidance for Test Procedures for Demonstration of Utilization Equipment Compliance to Aircraft Electrical Power Characteristics
c) MIL – STD-810 H - Environmental Engineering Considerations and Laboratory tests
d) MIL – STD – 704D - Electrical Power, Aircraft, characteristics and utilization
e) MIL – STD – 461G - Requirements for the control of electromagnetic interference characteristics of sub systems and equipment
f) MIL-STD-464A - Electromagnetic Environmental Effects Requirements for Systems
g) MIL-E-38453A - Environmental Control, Environmental Protection and Engine bleed air systems

1.4 Abbreviations

Table 1: Abbreviations used in the document	
LCU/PM	Liquid Circulation Unit/Pump module
EMI EMC	Electromagnetic inductance – Electro Magnetic Conductance
EUT	Equipment Under Test
QTP	Qualification Test Procedure
LDC	Low Direct Current
TAC	Three Phase Alternating Current
DGAQA	Directorate General of Aeronautical Quality Assurance
DI	Defect Investigation

2 Initial Performance Tests

2.1 Test Setup, Visual Examination and Performance Checks

After each QT (Environmental, EMI-EMC and Power supply tests), the functionality of the EUT has to be established. Fig. 1 shows the pump module with the test rig. The following checks have to be carried out to test the functionality:

1. Visual Examination before and after Environmental, EMI-EMC and Power Supply Tests.
2. Performance Checks with Solenoid valve in switch off condition after Environmental, EMI-EMC and Power Supply Tests.

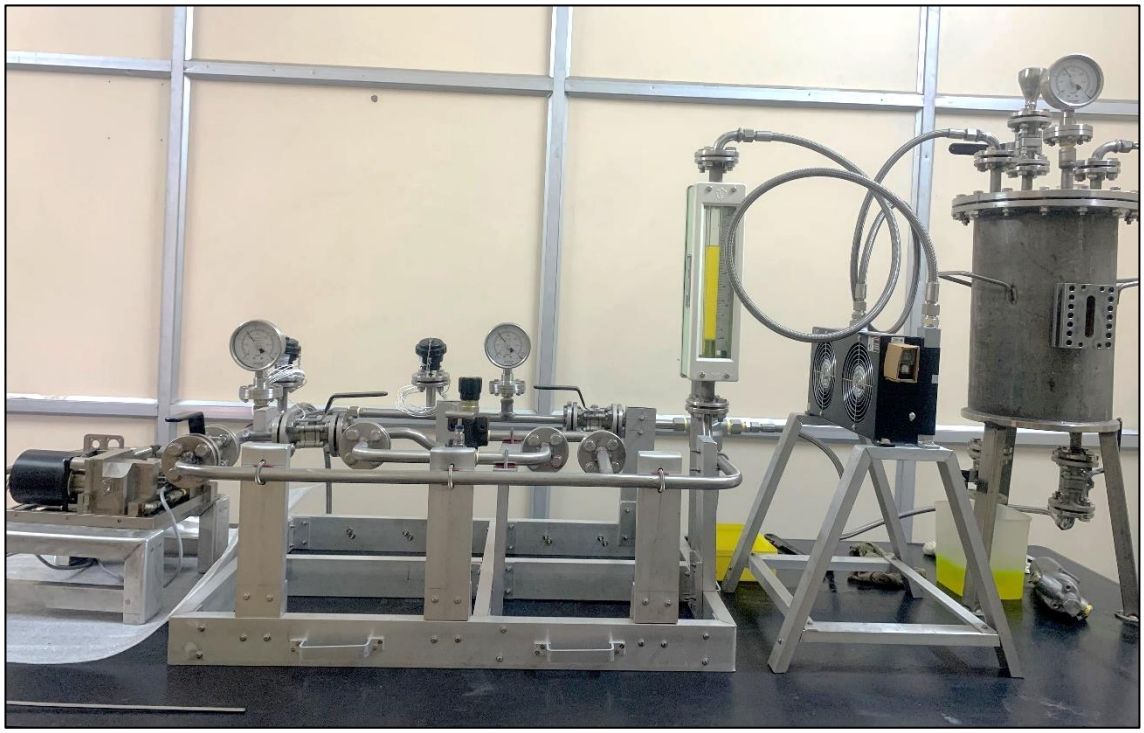


Figure 1. Pump module with the test rig

2.2 Visual Examination

Visually examine all the components/sub-assemblies (refer table-2) for corrosion and visual external damage like paint peel-off etc., (refer section 9.1 in ATP).

Table 2: Major assembly/Sub assembly/ Components details

Sl. No.	Major sub assembly	Part No.	Serial No.	Result
1	Monoblock Assembly			
2	Tray			
3	Pump			
4	Motor			
5	Accumulator			
6	Solenoid Valve			

7	Pressure Sensors			
8	Check Valve			
9	Filter			
10	Signal & Power Connectors			
11	Quick Disconnect Couplings (QDCs)			

Test / Check Performed By:	**Witnessed by:**		
BHEL	**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

2.3 Performance Checks

a) The functional test should be carried out by connecting the Pump module to the demonstrational test set up.

b) Charge the unit along with full circuit with Ethylene glycol - water mixture (Nycosol-51) up to 1 ± 0.3 bar gauge pressure. The pressure reading can be obtained from either of the three Pressure sensors. The charging shall be carried out with external charging unit.

c) Ensure that the Solenoid valve is in switched OFF condition, with the help of electrical switch.

d) Switch 'ON' the pump and adjust the 'control valve' on the demonstrational test setup such that the discharge pressure is 8.5 ± 0.5 bar gauge.

e) Readings shall be taken as mentioned below and shall be documented in Table-3.

i. Measure the flow rate of the pump and coolant temperature with the help of flow meter and temperature sensor mounted on the demonstrational test setup respectively.

ii. Power and current measurement shall be taken with the help of Power analyzer. The power consumption of the pump module in the Solenoid Switched 'OFF' condition (normal mode) should be within 1062 VA max.

iii. The Coolant Discharge pressure and suction pressure shall be measured with the help of sensors mounted on Pump Module.

iv. Switch 'OFF' the pump.

v. The level sensor reading shall be taken with multimeter / Data logger.

f) Now, switch 'ON' Solenoid valve manually with the help of electrical switch.

g) Repeat steps (d) to (e) and Record the readings as per Table 3 and Switch 'OFF' the pump. The power Consumption of the Pump Module in the Solenoid Switched 'ON' condition should be within 780 VA max.

Acceptance Criteria:

Observed readings shall be within the ranges provided below –

a) Flow rate: 12 (± 1.2 LPM)

b) Discharge Pressure: 8.5 ± 0.5 bar

c) Suction Pressure: 1± 0.3 bar

d) Maximum Power consumption: 1062 (normal mode) & 780 (degraded mode)

e) Coolant temperature: Ambient temperature ± 10°C

Unit Sl. No.:
Date:

Table 3: Test Data sheet

Time	Discharge pressure (bar gauge)	Suction Pressure (bar gauge)	Coolant Flow Rate (LPM)	Coolant Temperature (°C)	Power Consumption (VA)	Accumulator Level Sensor reading (V)	Solenoid valve (By Pass)	Remarks
							OFF	
							ON	

Test / Check Performed By:	**Witnessed by:**		
BHEL	**ADA (GS)**	**ADA (QA & SEG)**	**DGAQA**

3 QUALIFICATION TESTS

Table-4: Qualification Tests Report matrix

Sl. No.	Para	Name of Test	QT1	QT2
1	2.0	Initial Performance Tests,	√	√
2	3.1	Burn In Test	√	
3	3.2	Altitude Test	√	
4	3.3	High Temperature Storage Cum Operational Test	√	
5	3.4	Low Temperature Storage Test	√	
6	3.5	Low Temperature Operating Test	√	
7	3.6	Thermal Shock Test	√	
8	3.7	Rain Drip Test	√	
9	3.8	Humidity Test	√	
10	3.9	Fungus (Mould Growth) Direct Effect Test	√	
11	3.10	Salt Fog Test	√	
12	3.11	Fluid Contamination Test	√	
13	3.12	Dust Test	√	
14	3.13	Acceleration Test (Structural)	√	
15	3.14	Vibration Test	√	
16	3.15	Mechanical Shock Test	√	
17	3.16	Transit Drop Test	√	
18	3.17	Bench Handling Test	√	
19	3.18	Gunfire Vibration Test	√	
21	4.0	EMI / EMC Tests	√	
22	5.0	Power Supply Test	√	
23	6.0	Dielectric Withstanding Voltage Test	√	
24	7.0	Endurance Test		√
25	8.0	Burst Pressure Test		√

3.1 Burn In Test

Test Specification / Severity

EUT must be continuously operating for 8 hours

Purpose

This test is done on EUT to determine the effects of continuous operation.

Test Setup

Demonstrational test setup used for functional testing shall be used.

Test Procedure:

a) Start the Burn in test.
b) if required to maintain near ambient temperatures switch on heat exchanger
c) After completion of Test, conduct the visual inspection and performance check as given in para 2.3 (points 'a' to 'e') and record the results.

Pass/Fail Criteria:

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

3.2 Altitude Test

Severity

60,000 ft (18km) Altitude

Rate of Altitude change ≤ 150 m/sec.

Duration: 1 hour

Purpose

This test is to determine that the material can withstand and/or operate in low pressure environment.

Test Procedure

a. With the EUT in its operational configuration, adjust the chamber air pressure as per the above severity.

b. Operational check is carried out once on EUT during last 30min of cycle. In Operational check, only monitor whether the EUT is working or not (Monitor suction and discharge pressure)

c. Adjust the chamber air to standard ambient conditions at the rate specified.

d. Visually examine the EUT to the extent possible.

Remarks: Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

Pass/Fail Criteria

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

3.3 High Temperature Storage cum Operational Test

Severity :

From 35°C to 71°C, Duration 7 cycles, 24 Hrs each cycles as per profile given in Fig 2.

Purpose :

This test is to determine the effects of high temperature conditions on material safety, integrity and performance.

Test Procedure:

a) Place the EUT in its operational configuration
b) Adjust the chamber environment to the test condition and maintain for the specified time.
c) Expose the EUT to the temperature conditions of the storage cycle for at least 7 cycles (24 Hrs cycle). Record the thermal response of the EUT.
d) EUT shall be subjected to 1 hour power ON tests (during 16^{th} to 17^{th} hour of testing) in the 1^{st}, 4^{th} and 7^{th} Cycle at 71°C after the storage of EUT for 2hours (during 14^{th} to 16^{th} hour of test) at 71°C. Operational check is carried out once on EUT during the one hour power ON test (during 16^{th} to 17^{th} hour of testing) at 71°C in the 1^{st}, 4^{th} and 7^{th} Cycle. In Operational check, only monitor whether the EUT is working or not (Monitor suction and discharge pressure). The EUT shall be left powered ON post completion of the operational check till the end of 1 hour (16^{th} to 17^{th} hour of testing) of power ON requirement in 1^{st}, 4^{th} and 7^{th} Cycle of testing.

Remarks: Perform functional Check with Solenoid valve switch OFF on EUT as given in the para 2.3 (points ‘a’ to ‘e’) after test.

Pass/Fail Criteria:

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

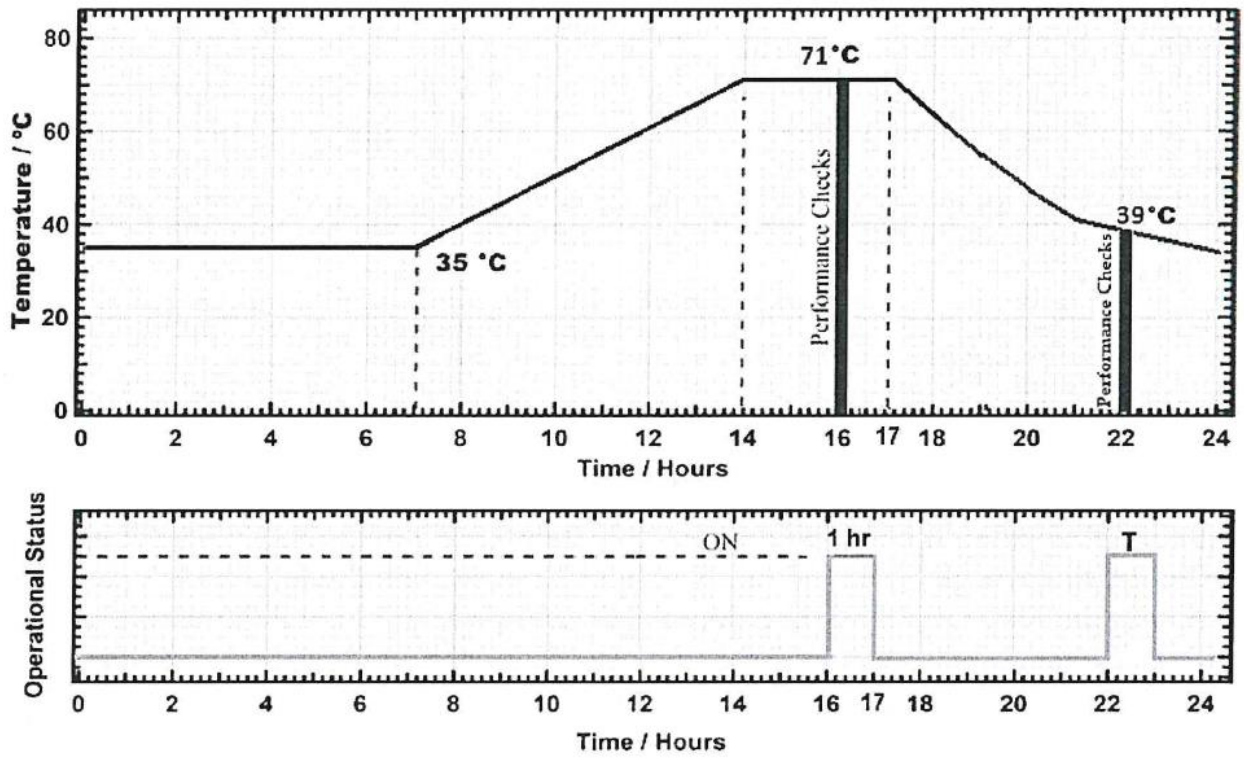


Figure 2. High Temp Storage cum Operation Test Profile

3.4 Low Temperature Storage

Severity

Ambient to -55°C-$_{2°C}$, Duration 4 hours, one cycle.

Purpose

This test is to determine how low temperature conditions during storage effects material safety, integrity and performance.

Test Procedure

Storage:

- Place the EUT in its Operational configuration in the chamber
- Adjust the chamber environment to -55°C-$_{2°C}$, Duration 4 hours.
- After completion of Test, Remove the unit from the chamber.
- Conduct a visual examination.

Remarks:

a) Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

b) Low Temperature storage test (Para 3.4) will be immediately followed by the Low Temperature Operating Test (Para 3.5).

Pass/Fail Criteria

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

3.5 Low Temperature Operating

Severity

Ambient to -40°C-$_{2^{\circ}C}$, Duration 2 hours, one cycle.

Purpose

This test is to determine how low temperature conditions during operation effects the material safety, integrity and performance.

Test Procedure

a. **Operation:**

- Place the EUT in its Operational configuration in the chamber
- Adjust the chamber environment to **-40-$_2$°C** but with the rate of change of temperature being not greater than 3°C/min. Soak EUT for a duration 2 hours at -40°C post temperature stabilization.
- Operational check is carried out once on EUT with the EUT still at -40°C. In Operational check, only monitor whether the EUT is working or not (Monitor suction and discharge pressure). The EUT should be capable of cold start at -40°C within warm up time of two minutes.
- After completion of Test, Remove the unit from the chamber.
- Conduct a visual examination.

Remarks:

a) Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.
b) Low Temperature Operating test (Para 3.5) will be performed immediately after the completion of Low Temperature Storage Test (Para 3.4).

Pass/Fail Criteria

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

3.6 Thermal Shock Test

Severity

Profile as per Fig. 3.
$-55°C$ to $+71°C$

Purpose

This test is to determine that the material can withstand and/or operate in thermal shock condition.

Test Procedure

a. With the EUT in its operational configuration subject the pump module to thermal shock as per the profile given in Fig. 3.
b. Stabilize the unit at T1 = $-55°C^{+0}_{-2°C}$ soak for 1 hour.
c. Transfer and stabilize at T2 = $+71°C^{+2°C}_{-0}$ and soak it for 1 hour.
d. Transfer it to T1 = $-55°C^{+0}_{-2°C}$ for 1 hour. This constitutes 1 cycle.
e. Repeat for total 3 cycles. The transfer between the chambers shall not take more than 1 minutes.
f. Visually examine the EUT to the extent possible.

Remarks: Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

Pass/Fail Criteria

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

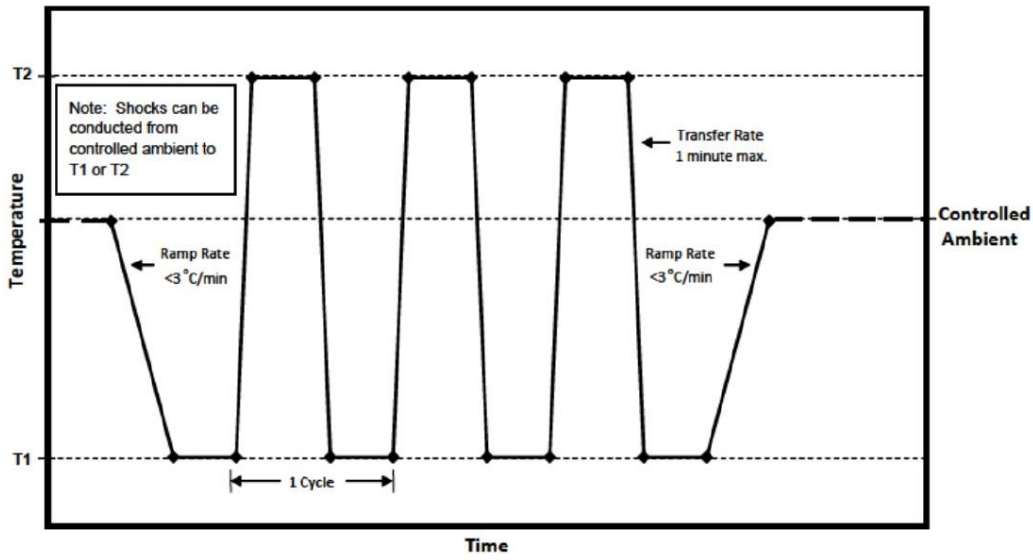


Figure 3. Thermal Shock Test Profile

3.7 Rain Drip Test

Severity

Droplet size > 4.5mm

Volume flow rate 250 to 280 l/m2/hr

30 minutes.

Purpose

This test is to determine that the material can withstand and/or operate in Rain Drip conditions.

Test Procedure

a. Blank all the ports of the unit and carry out the rain drip test for 30 minutes with volume flow rate between 250 to 280 l/m2/hr and Droplet size > 4.5mm, through a dispenser kept approximately 1 meter above the test unit.
b. Visually examine the EUT to the extent possible.

Remarks : Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

Pass/Fail Criteria

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

3.8 Humidity Test

Purpose

This test is to determine that the material can withstand and/or operate in different operating humidity environment.

Test Procedure

a) Subject the test unit to Humidity profile as per Figure 4.
b) Install the test unit in a suitable chamber. Repeat the procedure for 10 cycles.
c) Adjust the chamber temperature and humidity conditions to room conditions and allow the test unit to stabilize.
d) Visually examine the EUT to the extent possible

Remarks:

a) At the end of 1st, 5th and 10th cycle of humidity test, Operational check is carried out on EUT. In Operational check, monitor whether the EUT is working or not (Monitor suction and discharge pressure).
b) The functional checks to be carried out within the recovery period (as per para 2.3).
c) If the functional check requires the chamber to be open or the EUT to be removed from the chamber, and the check cannot be completed in 30minutes, in order to prevent unrealistic drying, recondition the EUT at 30°C±2°C and 95% RH for one hour, and then continue the checkout. Extend the test time for that cycle by one hour. Continue this sequence until the checkout has been completed.
d) If the operational check is conducted in the chamber, and extends beyond the 4-hour period indicated in Figure below, do not proceed to the next cycle until the operation check is completed. Once the check has been completed resume the test.

Pass/Fail Criteria

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

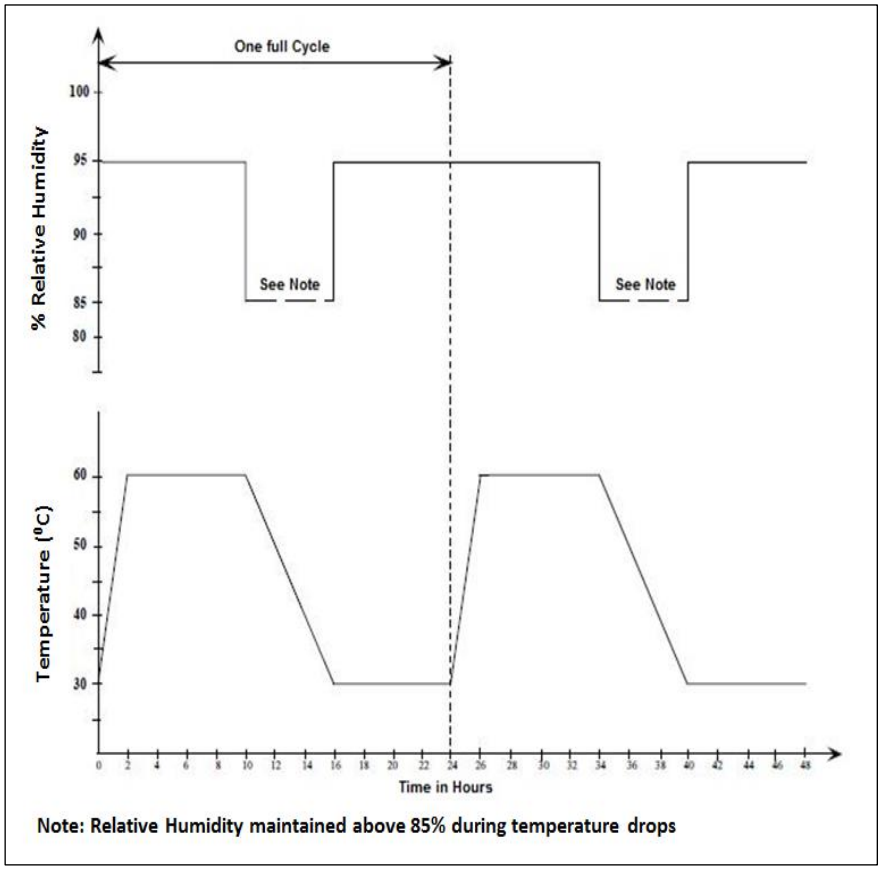


Figure: 4 Diurnal Cycle for Temperature-Humidity

3.9 Fungus (Mould Growth) Direct Effect Test

Purpose

This test is to check the direct effect of Fungus (Mould Growth) on the pump module.

Test Procedure

a. Wet the entire surface of the test unit with Fungi spore (consisting of Aspergillus Flavus, Trichoderma Virens, Talaromyces Pinophilus (Pencillium Funiculosum), Chaetomium Globosum, Aspergillus brasiliensis (Aspergillus Niger) or (alternatively fungi as per JSS 55555)) in 10 minutes.
b) Adjust the temperature to 30 °C and humidity to 95% RH (or as specified in JSS55555) and allow an incubation period of 28 days.
c) After completion of the above test, visually examine the EUT to the extent possible.

Remarks : Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

Pass/Fail Criteria

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

3.10 Salt Fog Test

Purpose

This test is to determine that the material can withstand and/or operate in situations of Salt Fog environment.

Test Procedure

a. Expose the test unit to salt fog of 5±1% concentration for a period of 24 hours followed by 24 hours of drying. This constitutes one cycle.

b. The drying shall be at controlled condition of 35±2°C and humidity of 90 to 95% RH. The composition of salt for preparation of solution shall be with sodium chloride containing not greater than 0.1% sodium iodide and not greater than 0.5% other impurities.

c. Repeat the above steps (a) and (b) for 2 cycles.

d. Visually examine the EUT to the extent possible.

Remarks : Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

Pass/Fail Criteria

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

3.11 Fluid Contamination Test

Purpose

This test is to determine that the material can withstand and/or operate in situations of Fluid Contamination.

Test Procedure

a. Expose the test unit to test fluids with 7 days per fluid (total 28 days) at 71±3°C.

b. The test fluids used shall be

- **i.** Fuel Jet A-1 (ISI 571 / JP-8 MIL-T-83133 / JP-5 MIL-T-5624) / AVTUR (DEF-Stan 91-91/5-2),
- **ii.** Hydraulic fluid MIL - H - 5606,
- **iii.** Lubrication oil mixers MIL-PRF-23699 Rev. G Class C/I, and
- **iv.** Soap water MIL-PRF-87937D, type IV.

c. Visually examine the EUT to the extent possible.

Remarks : Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

Pass/Fail Criteria

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

3.12 Dust Test

Purpose

This test is to determine that the material can withstand and/or operate in situations of dust exposed environment.

Test Procedure

a. Expose the test units to blowing dust with concentrations of 10.6±7 gm/m3 at velocity of 1.5 to 8.9 m/s and RH ≤30% for 6 hrs at 23°C and 6 hrs at 65°C (or as per JSS55555).

b. The orientation of the unit shall be changed at 90 minutes time interval.

c. Visually examine the EUT to the extent possible.

Remarks : Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

Pass/Fail Criteria

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

3.13 Acceleration Test (Structural)

Severity

Fore and aft: 15g

Lateral left and right: 15g

Up and down: 15g

Test Duration 1.0 (ONE) minute exposure after the specified 'g' level is reached on each axes

Unit in Power OFF Condition

Purpose

This test is to determine will the EUT structurally withstands the loads induced by in-service acceleration.

Test Procedure:

a. Install the EUT

b. 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.

c. Stop the centrifuge and inspect the test item.

d. Repeat steps ‘a’ to ‘c’ for the five remaining directions.

e. Upon completing the tests in the six test directions, carryout Functional test and inspect is carried out on EUT. Record the results.

Remarks : EUT is in OFF condition during shock test

Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points ‘a’ to ‘e’) after test.

Pass/Fail Criteria

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

3.14 Vibration Test

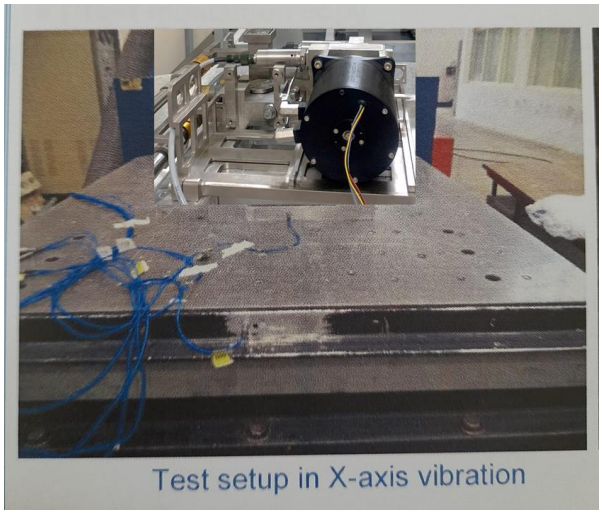


Figure 5: Location of accelerometers on EUT

Test Specification / Severity

As per MIL-STD-810 H Procedure I Method 514.8

As per profile given in Figure 6 in all 3 mutually perpendicular axes. Duration: 1 Hr per axis

Purpose

This test is done on EUT to determine the effects of vibration with regard to safety, integrity and performance during ground and flight operations.

Test Procedure:

Prior to the vibration test, the test unit along with the test fixture shall be subjected to resonance search test (sinusoidal): Subject the unit to resonance sweep through the frequency range 5 to 2000 Hz at 1g for a number of 3 sweeps/axis along all 3 axes. This test shall be conducted before and after conduct of Random vibration tests with equipment in OFF state. There shall be no resonance observed up to 200 Hz. If the resonance frequency is less than 200 Hz, the unit shall be dwelled for 15 minutes, as applicable, at each resonance frequency.

a. Fix the EUT on to the Vibration Table using a suitable Fixture.

b. Set the Vibration Test level as defined in Fig. 6.

c. Repeat the steps 'a' to 'b' for remaining 2 axes.

d. After completion of Test, conduct the visual inspection and performance check as given in para 3.3(points 'a' to 'e') and record the results.

Remarks :

- ✓ During vibration, the Unit is in Power On condition and Performance parameters should be monitored.

Pass/Fail Criteria:

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

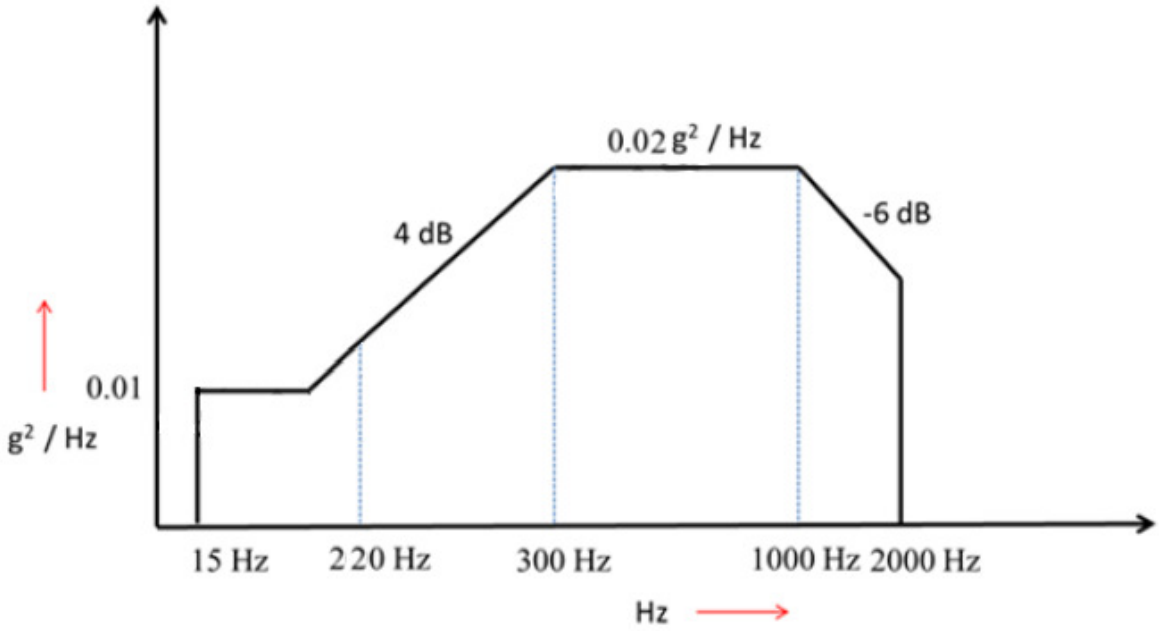


Figure 6. Vibration Test Profile

3.15 Mechanical Shock Test

Severity

20g saw tooth for 11ms or 15g half sine for 11ms

No. of Shocks: 3 Shocks per axis on each of 6 directions.

Total 18 Shocks

Purpose

This test is to ensure that EUT can physically and functionally withstand dynamic shock stresses without any performance degradation or malfunctions.

Test Procedure

a. Install the EUT on to the Shock Table

b. Subject the EUT to the Test shock input.

c. Record necessary data to show that the shock met or exceeded desired Test levels within the specified tolerance.

d. Repeat steps 'a' to 'c' three times for each orthogonal test axis.

e. Document the test sequence.

Remarks **: EUT is in ON condition during shock test**

Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

Pass/Fail Criteria

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

3.16 Transit Drop Test

Purpose

This test is to determine that the Pump Module can withstand accidental drops.

Test Procedure

a. The unit in packed condition (condition in which it will be transited or stored) shall be dropped (26times) from a height of 122cm such that one drop is performed on each face, edge and corner.

b. Visually examine the EUT to the extent possible.

Remarks : Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

Pass/Fail Criteria

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

3.17 Bench Handling Test

Purpose

This test is to determine that the Pump Module can withstand accidental drops when handling.

Test Procedure

a. The unit's edge shall be raised by 10cm or 45° whichever is less and shall be dropped (4 drops on each face) on an wooden bench in unpacked condition, such that one drop is performed by raising one edge of that bottom face and the other three drops by raising the remaining three edges of that face. Test shall be repeated for the remaining faces of the EUT.

b. Visually examine the EUT to the extent possible.

Remarks : Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

Pass/Fail Criteria

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

3.18 Gunfire Vibration Test

Severity

Test spectrum: Frequency range 20Hz to 2000 Hz. Raise up to 250Hz @6dB/octave. PSD of 0.034 g2 / Hz between 250Hz to 1250Hz and then falling off @ 6 dB/octave to 2000 Hz. Profile as per Fig. 7.

The total duration of test is **7 minutes** along each axis

The EUT is under turned "ON" condition and subjected to functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e').

Purpose

This test is to determine that the Pump module can operate in different operating Vibration environment as in situations of Gunfire.

Test Procedure

a. Fix the EUT on to the Vibration Table using a suitable Fixture.

b. Set the Vibration Test level as defined in the spectrum shown in Fig. 7.

c. Repeat the steps 'a' to 'b' for remaining 2 orthogonal axes.

d. After completion of Test, conduct the visual inspection.

Remarks :

- ✓ During vibration, the Unit is in Power ON condition and functional Check with Solenoid valve switch OFF on EUT shall be carried out as given in the Para 2.3 (points 'a' to 'e').

Pass/Fail Criteria:

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

F_1(Hz)	F_2(Hz)	T (g^2 / Hz)	P_1 (g^2 / Hz)	P_2(g^2 / Hz)
25	50	0.034	0.0036	0.004

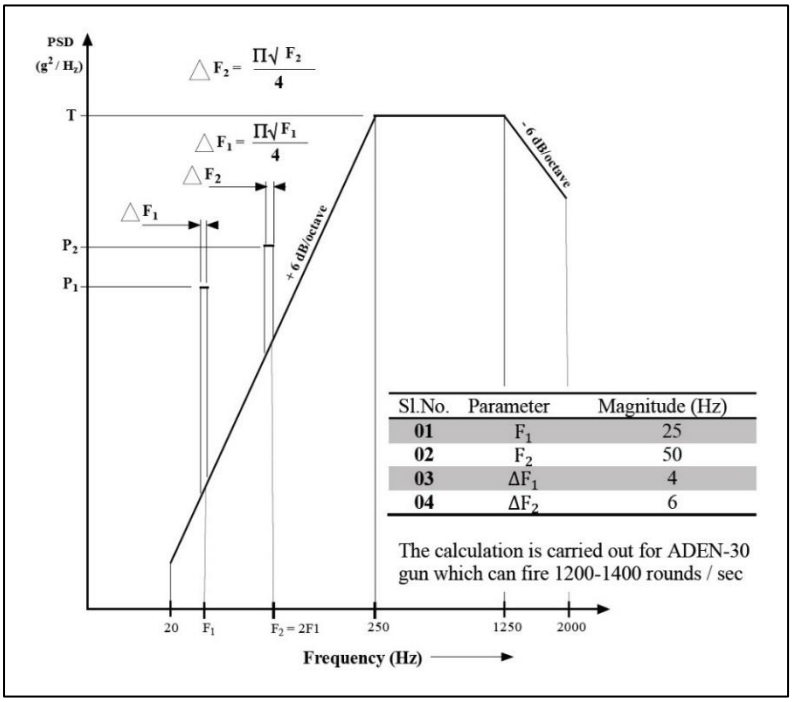


Figure 7: Gunfire Induced Vibration Spectrum

4 EMI/EMC Tests

EMI/EMC tests are performed as per the specifications in the below table 6 and Procedures given in MIL-STD-461G. EMI/EMC tests has to be performed as per the following table:

Table 5: List of EMI/EMC Tests

Sl. No.	Method of Tests	Tests	Frequency Range & Test curve
1	CE 102	Conducted Emission, Power Leads	10 KHz-10 MHz
2	CE 07	Conducted Emissions, Power Leads, Spikes, Time Domain	
3	CS 101	Conducted Susceptibility, Power Leads	30 Hz - 150KHz (Voltage), Limit Curve-2
4	CS 114	Conducted Susceptibility, Bulk Cable Injection	10 KHz-200 MHz, Curve-5
5	CS 115	Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation	
6	CS 116	Conducted Susceptibility, damped sinusoidal transients, cables and power leads	Imax =5A 10kHz to 100MHz
7	CS 118	Conducted Susceptibility, Personnel Borne Electrostatic Discharge	
8	RE 102	Radiated Emission, Electric Field	10 KHz-18 GHz
9	RS 103	Radiated Susceptibility, Electric Field	2 MHz to 40 GHz, Electric Field 60 V/m

4.1 Product Configuration – EMI/EMC Perspective

Figure 8, shows the System Interface with connector details.

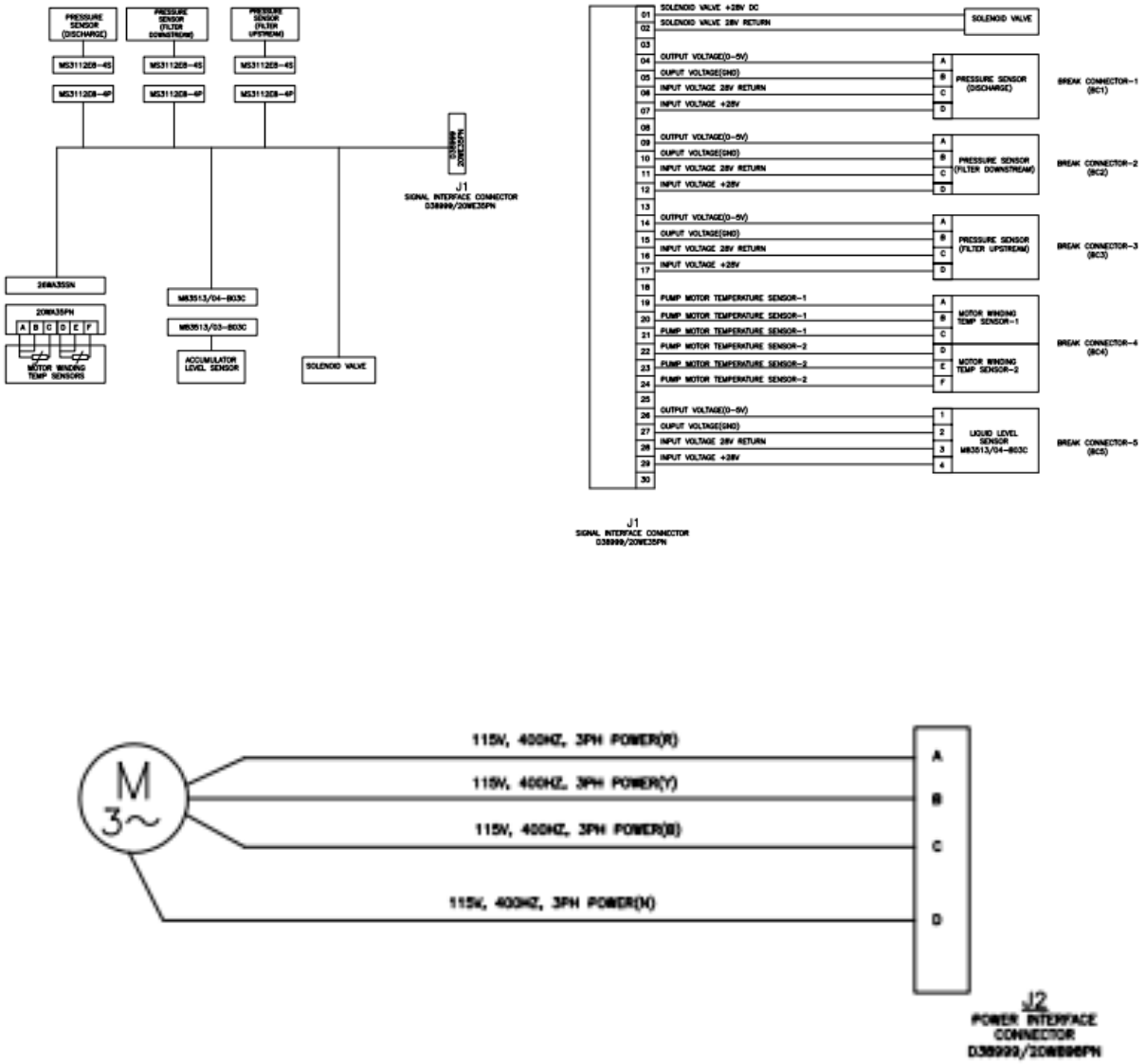


Figure 8: System connector with interface details

Figure 9 gives the connector pin-out diagram

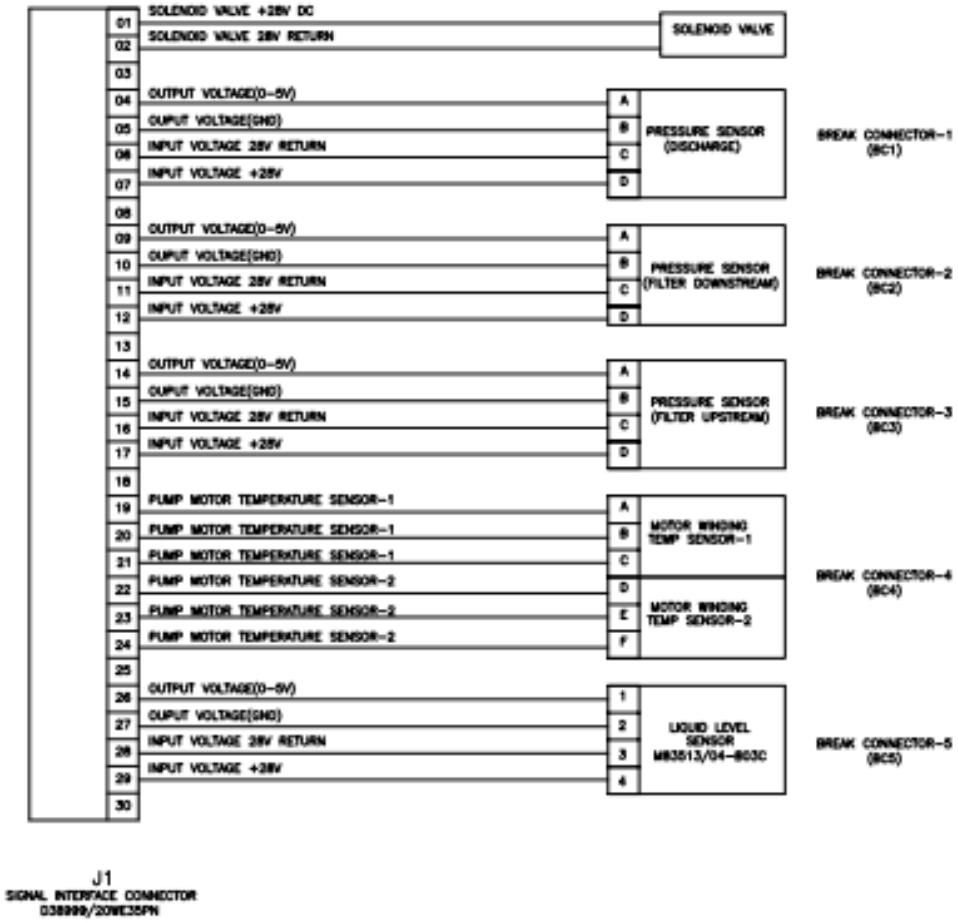


Figure 9: Connector Pin out Diagram

The following table 7 gives the pin-out details:

Table 6: Pin-out details

Connector Name	**Pin number**	**Signal**	**Wire type including shielding**
D38999/26WE35SN	1-29	DC	22 AWG
D38999/26WB98SN	A-C	AC 3 phase	20 AWG

4.2 EMI/EMC general requirements

The test equipment and the test chamber shall meet the general requirements given in Chapter-4 of Mil-Std-461 E/F. The overall test setup shall be per figure below

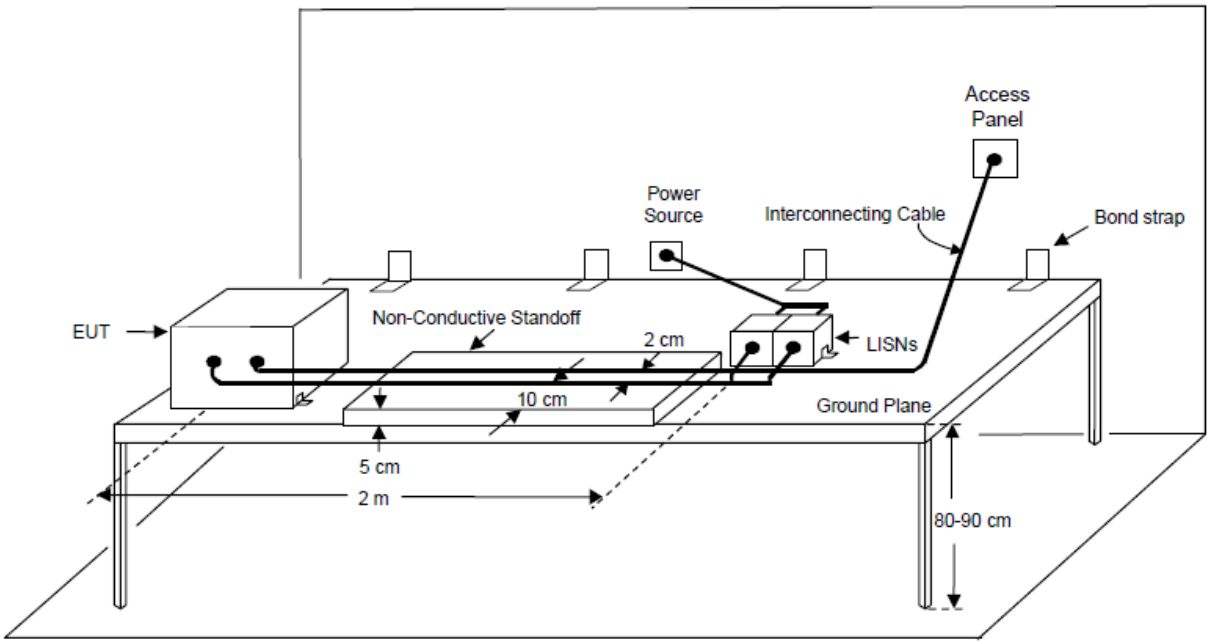


Figure 10: Connector Pin out Diagram

4.2.1 Tolerances

The general tolerances shall be

- Distance: ±5%
- Frequency: ±2%
- Amplitude, measurement receiver: ±2 dB
- Amplitude, measurement system (includes measurement receivers, transducers, cables, and so forth): ±3 dB
- Time (waveforms): ±5%
- Resistors: ±5%
- Capacitors: ±20%

4.2.2 Test Conditions

Ground plane: The EUT shall be installed on a ground plane that simulates the actual installation.

Bonding of EUT: Only the provisions included in the design of the EUT shall be used to bond units such as equipment case and mounting bases together, or to the ground plane. When bonding straps are required, they shall be identical to those specified in the installation drawings.

Orientation of EUTs: EUTs shall be oriented such that surfaces which produce maximum radiated emissions and respond most readily to radiated signals face the measurement antennas.

Table 7

Test Name	Face/Direction of Maximum Radiation
Radiated Emission	
Radiated Susceptibility	

Electrical cable assemblies shall simulate actual installation and usage. Shielded cables or shielded leads (including power leads and wire grounds) within cables shall be as per aircraft ICD. The list of cables used during testing are as follows:

Table 8: List of cables

Cable Name/Identification	Description	Cable Length
Power Cable	3 Phase AC power to Motor	2 m
Signal Cable	DC power for excitation of Solenoid valve, Pressure sensors, hall effect sensor	2 m

Interconnecting leads and cables: Individual leads shall be grouped into cables in the same manner as in the actual installation. Total interconnecting cable lengths in the setup shall be the same as in the actual platform installation. If a cable is longer than 10 meters, at least 10 meters shall be included. When cable lengths are not specified for the installation; cables shall be sufficiently long to satisfy the conditions specified below. At least the first 2 meters (except for cables which are shorter in the actual installation) of each interconnecting cable associated with each enclosure of the EUT shall be run parallel to the front boundary of the setup. Remaining cable lengths shall be routed to the back of the setup and shall be placed in a zigzagged arrangement. When the setup includes more than one cable, individual cables shall be separated by 2 centimeters measured from their outer circumference. For bench top setups using ground planes, the cable closest to the front boundary shall be placed 10 centimeters from the front edge of the ground plane. All cables shall be supported 5 centimeters above the ground plane.

Electrical and mechanical interfaces: All electrical input and output interfaces shall be terminated with either the actual equipment from the platform installation or loads which simulate the electrical properties (impedance, grounding, balance, and so forth) present in the actual installation. Signal inputs shall be applied to all applicable electrical interfaces to exercise EUT circuitry.

Operation of EUT: During emission measurements, the EUT shall be placed in an operating mode which produces maximum emissions. During susceptibility testing, the EUT shall be placed in its most susceptible operating mode. For EUTs with several available modes (including software controlled operational modes), a sufficient number of modes shall be tested for emissions and susceptibility such that all circuitry is evaluated.

Susceptibility monitoring: The EUT shall be monitored during susceptibility testing for indications of degradation or malfunction. This monitoring is normally accomplished through the use of built-in-test (BIT), visual displays, aural outputs, and other measurements of signal outputs and interfaces operational check during testing of

Frequency scanning: For susceptibility measurements, the entire frequency range for each applicable test shall be scanned. For swept frequency susceptibility testing, frequency scan rates and frequency step sizes of signal sources shall not exceed the values listed in Table 9 below.

Table 9: Frequency scanning

Frequency Range	Analog Scans Maximum Scan Rates	Stepped Scans Maximum Step Size
30 Hz - 1 MHz	0.0333f_o/sec	0.05 f_o
1 MHz - 30 MHz	0.00667 f_o/sec	0.01 f_o
30 MHz - 1 GHz	0.00333 f_o/sec	0.005 f_o
1 GHz - 8 GHz	0.000667 f_o/sec	0.001 f_o
8 GHz - 40 GHz	0.000333 f_o/sec	0.0005 f_o

4.3 EMI/EMC Test Procedure

4.3.1 Conducted Emission (CE-102)

Severity

Power and interconnecting leads (10 KHz to 10MHz)

Purpose

This test is used to verify the electromagnetic emissions from the EUT do not exceed the specified limits for power input leads including returns.

CE-102 Limits

Conducted emissions on power leads shall not exceed the applicable values shown on Fig. 12 basic curve.

Test Setup

Make the Test setup as shown in the Fig. 11.

Test Procedure:

a) Calibrate the Test equipment

b) Connect the measurement receive to the 20 dB attenuator on the signal output port of the LISN.

c) Make the Test setup and Power ON the EUT.

d) Select an appropriate lead for testing.

e) Scan the measurement receiver over the applicable frequency range, using the bandwidths and minimum measurement times.

Repeat the above steps ‘d’ & ‘e‘ for each power lead.

Remarks : Monitor performance parameters while EUT is under test**.** Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points ‘a’ to ‘e’) after test.

Pass/Fail Criteria:

Measured emission pattern for power lines and return lines are below the limit line.

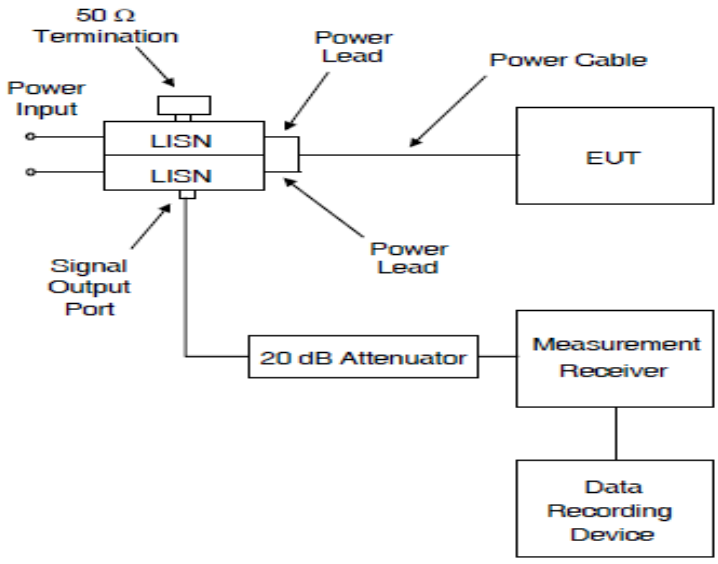


Figure 11: CE-102 Test configuration

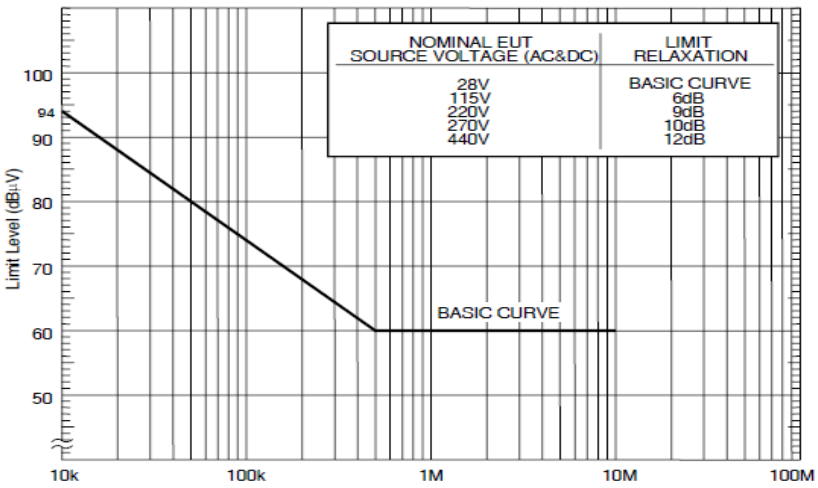


Figure 12: CE-102 Test Limit (*Refer Basic Curve*)

4.3.2 Conducted Emissions, Power Leads, Spikes, Time Domain (CE - 07)

CE07 (Conducted Emissions, Power Leads, Spikes, Time Domain) is applicable as per **MIL- STD-461C.**

Severity

Conducted switching spikes of less than 50 µsec in duration shall not exceed ±50% of nominal rms voltage.

Purpose / Applicability

This test is applicable for AC and DC leads, which obtain power from or provide power to other equipment or subsystems.

CS-07 Limits:

Conducted switching spikes of less than 50 µsec in duration shall not exceed

a) ±50% of nominal rms voltage in case of AC leads and
b) ±50%, -150% of nominal line voltage in case of DC leads as applicable

Conducted switching spikes equal to or greater than 50 µsec in duration shall meet the transient requirements of MIL-STD-704D. Spike duration is the time interval between 50% amplitude point on the transient leading edge and the 50% amplitude point on the transient trailing edge. High frequency ringing superimposed on the pulse leading or trailing edges should be ignored.

Based on the intended environment the limit of the test can be modified to ±50% of the nominal value of the AC and DC line voltage

Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points ‘a’ to ‘e’) after test.

4.3.3 Conducted Susceptibility (CS-101)

Severity

Power leads (30Hz to 50KHz)

Purpose

This test is used to verify ability of the EUT to withstand signals coupled on input power leads.

CS-101 Limits:

Applicable limit line for voltage is shown in Fig. 14, curve 2. Applicable limit line for Power is shown in Fig.15.

Test Setup

Make the Test setup as shown in the Fig. 13.

Test Procedure:

a. Calibrate the Test equipment.

b. Make the Test setup and Power ON the EUT.

c. Set the signal generator to the lowest test frequency. Increase the signal level until the required voltage or power level is reached on the power lead.

d. While maintaining at least the required signal level, scan through the required frequency range as given in section 4.2.

e. Susceptibility evaluation

- Monitor the EUT for degradation of performance.

- If susceptibility is noted, determine the threshold level in accordance with fig. 14 and verify that it is above the limit.

f. Repeat the above steps ‘c’ to ‘e‘ for each power lead.

g. Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points ‘a’ to ‘e’) after test.

Pass/Fail Criteria:

Shall not exhibit any malfunction, degradation of performance beyond the given tolerance values (refer section 2.3).

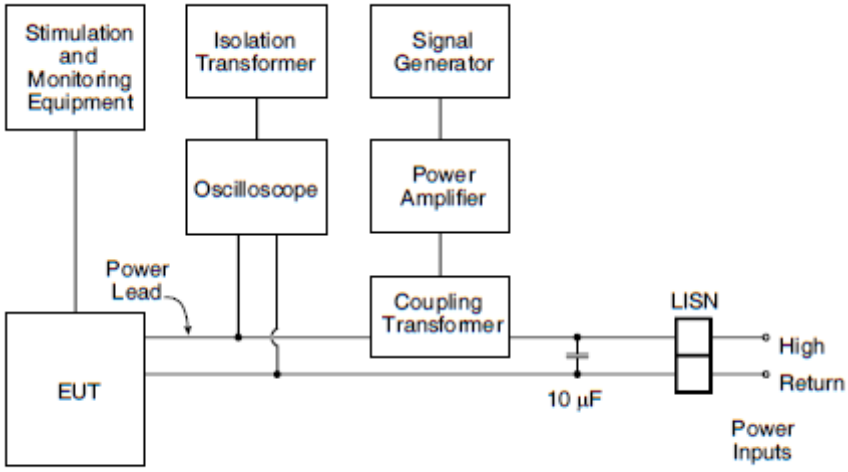


Figure 13. CS-101 Signal Injection

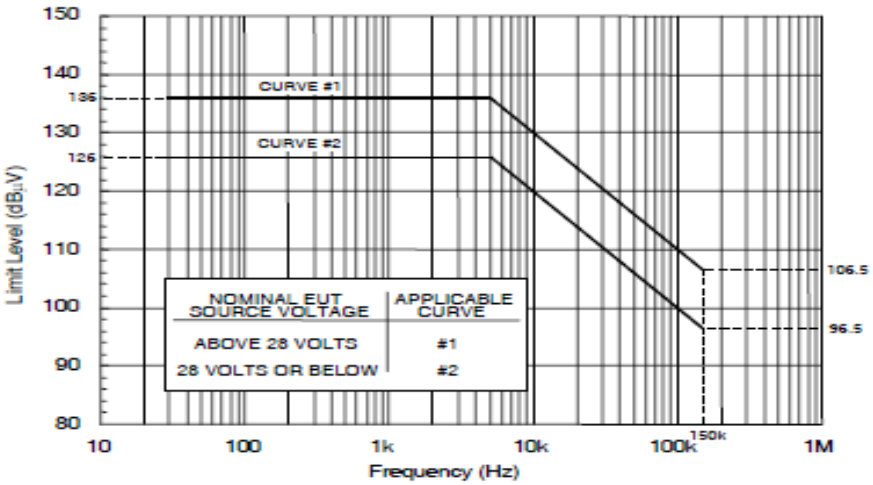


Figure 14. CS-101 Voltage Limit (*Refer Curve-2).*

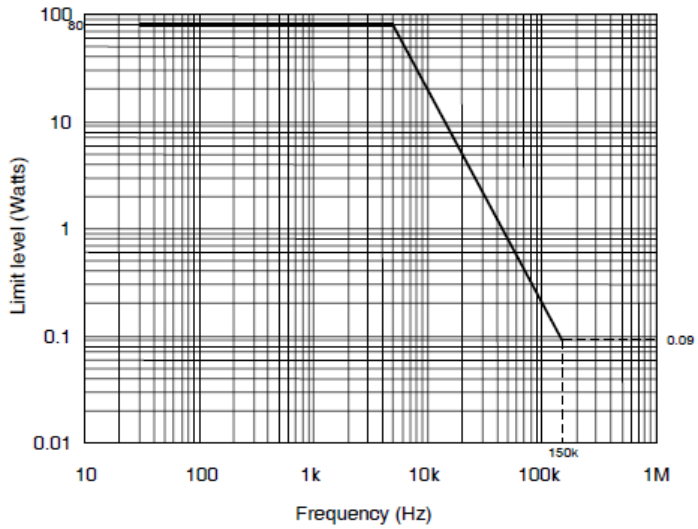


Figure 15. CS-101 Power Limit

4.3.4 Conducted Susceptibility (CS-114)

Severity

Bulk Cable, 10KHz to 200 MHz

Purpose

This test is used to verify the ability of the EUT to withstand RF signals coupled on to EUT associated cables.

CS-114 Limits

Applicable limit is shown in Fig. 17, curve 5.

Test Setup

Make the Test setup as shown in the Fig. 16.

Test Procedure:

a. Calibrate the Test equipment.

b. Make the Test setup.

c. Place the injection and monitor probes around a cable bundle interfacing with an EUT connector.

d. Locate the monitor probe 5cm from the connector. If the overall length of the connector and back shell exceeds 5cm, position the monitor probe as close to the connector's back shell as possible.

e. Position the injection probe 5cm from the monitor probe.

f. Power ON the EUT.

g. Susceptibility Evaluation

- Set the signal generator to 10KHz with 1KHz pulse modulation, 50% duty cycle.

- Apply the forward power level determined to the injection probe while monitoring the induced current.

- Scan the required frequency range while maintaining the forward power level at the calibration level determined or the maximum current level for the applicable limit, whichever is less stringent.

- Monitor the EUT for degradation of performance during testing.

- Whenever susceptibility is noted, determine the threshold level in accordance and verify that it is above the applicable requirement.

Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points ‘a’ to ‘e’) after test.

Pass/Fail Criteria

The EUT shall not exhibit any malfunction, degradation of performance during the test.

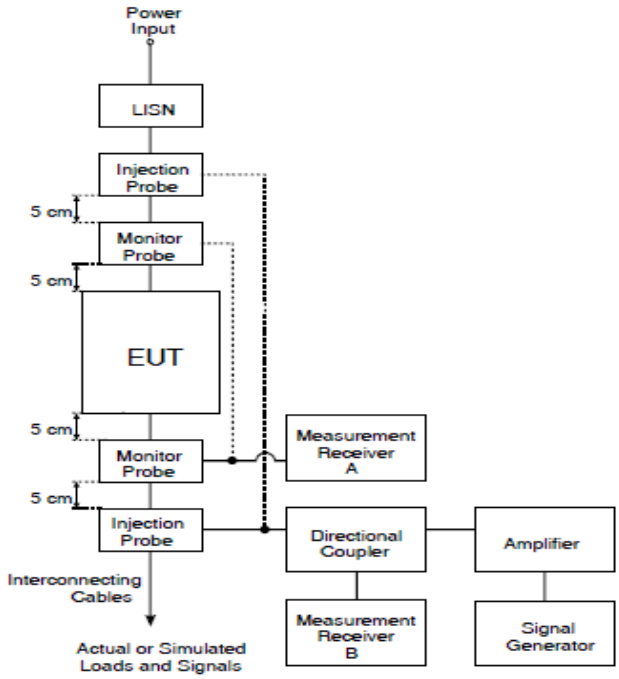


Figure 16. CS-114 Bulk Cable Injection

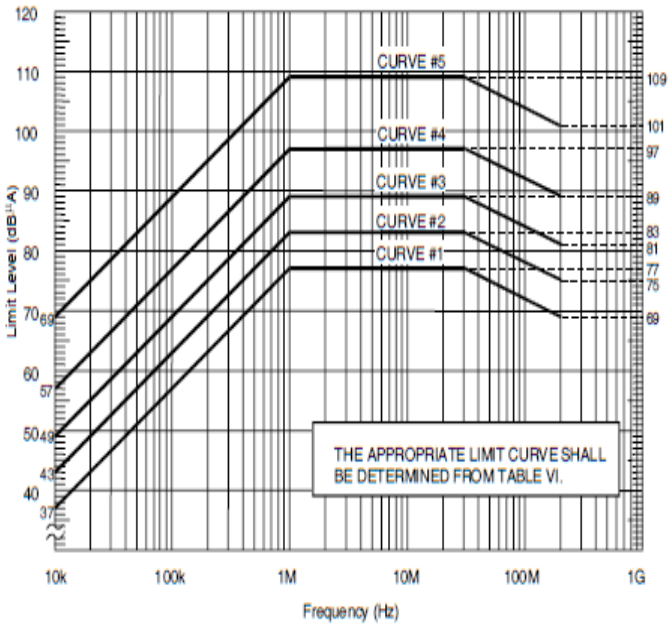


Figure 17. CS-114 Test Limit (*Refer Curve-5)*

4.3.5 Conducted Susceptibility (CS-115)

Severity

Bulk Cable, impulse excitation

Purpose

This test is used to verify the ability of the EUT to withstand impulse signals coupled on to EUT associated cables.

CS-115 Limits

Applicable limit is shown in Fig. 19

Test Setup

Make the Test setup as shown in the Fig. 18.

Test Procedure:

a. Calibrate the Test equipment.

b. Make the Test setup.

c. Place the injection and monitor probes around a cable bundle interfacing with an EUT connector.

d. Locate the monitor probe 5cm from the connector. If the overall length of the connector and back shell exceeds 5cm, position the monitor probe as close to the connector's back shell as possible.

e. Position the injection probe 5cm from the monitor probe.

f. Power ON the EUT.

g. Susceptibility Evaluation

- Adjust the pulse generator, as a minimum, for the amplitude setting determined.
- Apply the test signal at the pulse repetition rate and for the duration specified in the requirement.
- Monitor the EUT for degradation of performance during testing.
- Whenever susceptibility is noted, determine the threshold level and verify that it is above the limit.
- Record the peak current induced in the cable as indicated on the oscilloscope.
- Repeat the above step 'g' on each cable bundle interfacing with each electrical connector on the EUT.

Remarks: Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points ‘a’ to ‘e’) after test.

Pass/Fail Criteria:

The EUT shall not exhibit any malfunction, degradation of performance during the test.

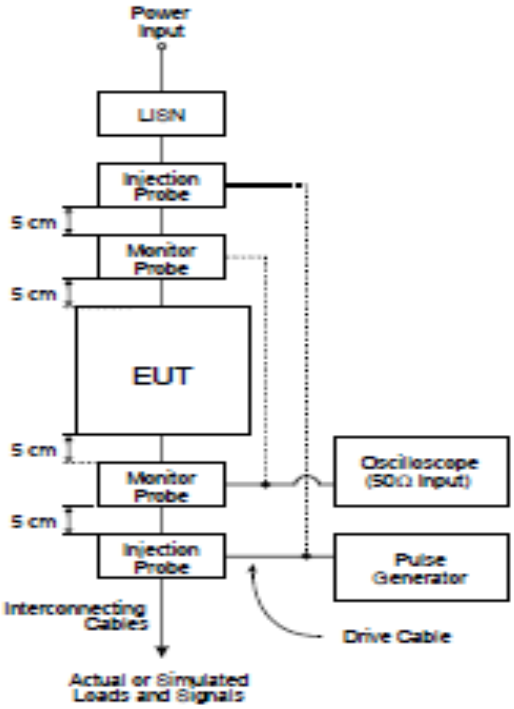


Figure 18. CS-115 Bulk Cable Injection

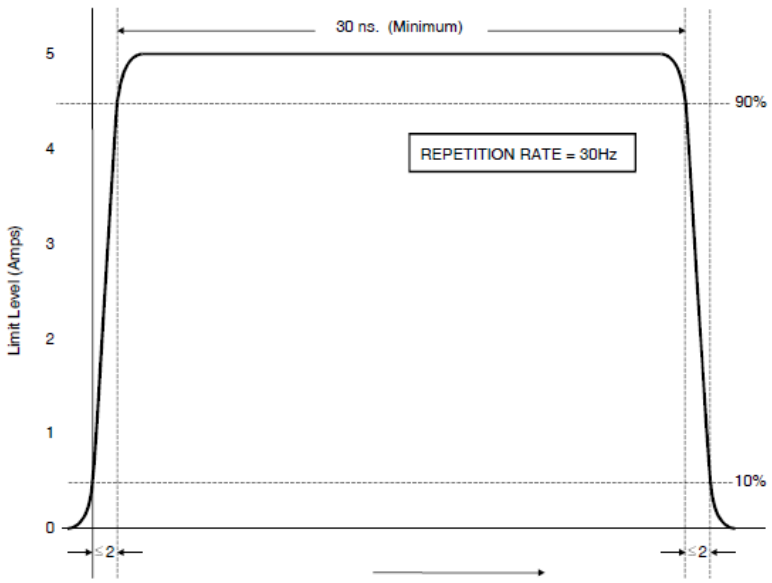


Figure 19. CS-115 signal characteristics

4.3.6 Conducted Susceptibility (CS-116)

Severity

Damped Sinusoidal Transients, Cables and Power Leads (10KHz to 100 MHz)

Purpose

This test is used to verify the ability of the EUT to withstand Damped sinusoidal transients coupled on to EUT associated cables and power leads.

CS-116 Limits:

The test will be performed at six frequencies viz. 10KHz, 100KHz, 1MHz, 10MHz, 30MHz and 100MHz. Applicable current limit is shown in Fig. 21 (Imax-5A).

Test Setup

Make the Test setup as shown in the Fig. 20.

Test Procedure:

a. Calibrate the Test equipment.

b. Make the Test setup.

c. Using the EUT Test setup on each cable bundle interfacing with each connector on the EUT including complete power cables. Also perform test on each individual high side power lead.

d. Power ON the EUT.

e. Set the damped sine generator to a test frequency.

f. Apply the test signals to each cable or power lead on the EUT sequentially. Slowly increase the damped sine-wave generator output level to provide the specified current, but not exceeding the pre-calibrated generator output level. Record the peak current obtained.

g. Monitor the EUT for degradation of performance.

h. If susceptibility is noted, determine the threshold level and verify that it is above the specified requirements.

i. Repeat the steps ‘e’ to ‘h’ for each test frequency as specified in the requirement.

j. Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points ‘a’ to ‘e’) after test.

Pass/Fail Criteria:

The EUT shall not exhibit any malfunction, degradation of performance during the test.

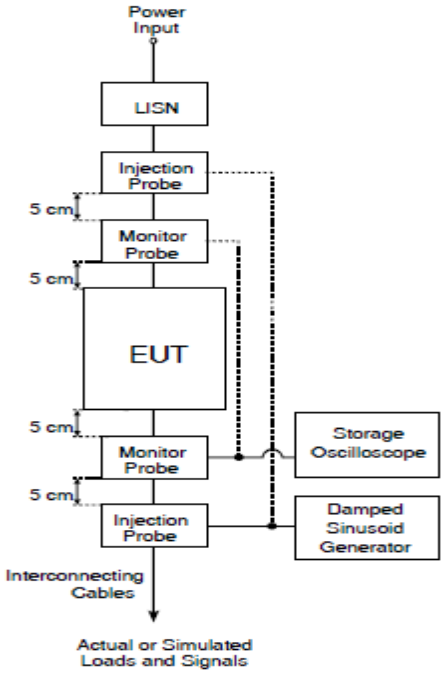
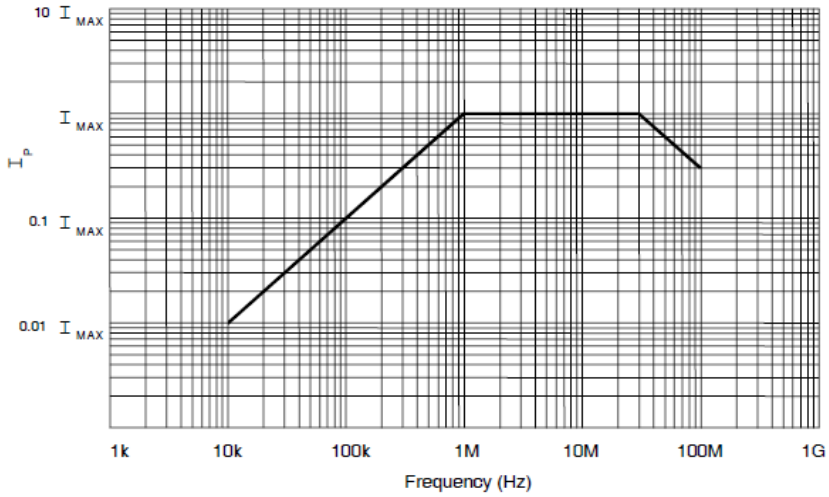


Figure 20. CS-116 Setup for Bulk Cable Injection of damped sinusoidal transients



Imax = 5 A **Figure 21. CS-116 Limit**

4.3.7 Conducted Susceptibility, Personnel Borne Electrostatic Discharge (CS118)

CS118 (Conducted Susceptibility, Personnel Borne Electrostatic Discharge) is applicable as per **MIL- STD-461G.**

CS118 Applicability

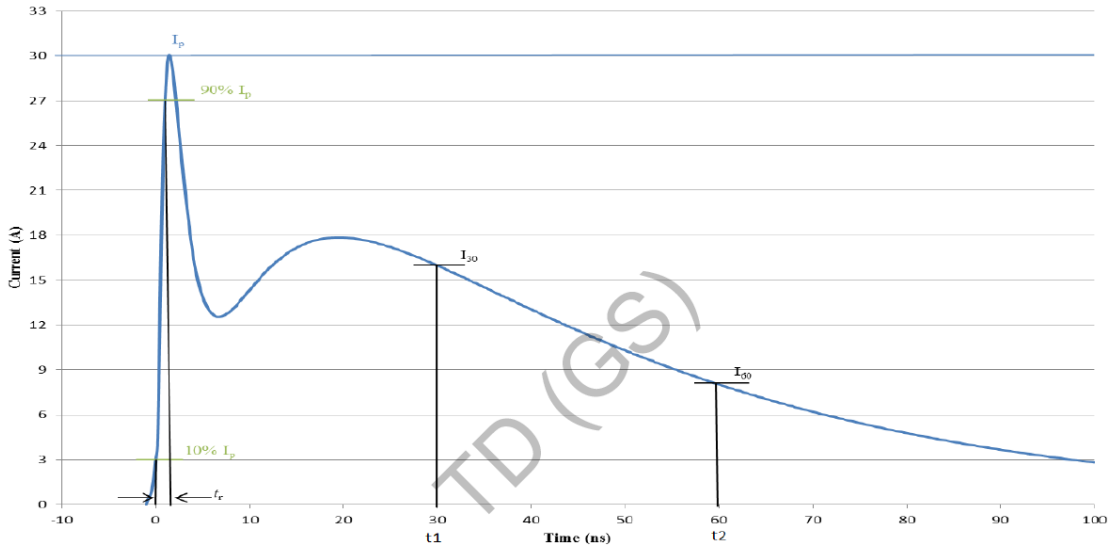
Objective of this test is to verify the ability of the EUT to withstand personnel borne electrostatic discharge (ESD) in a powered-up configuration. This requirement is applicable to electrical, electronic, and electromechanical subsystems and equipment that have a man-machine interface.

CS118 Limits

The equipment shall not exhibit any malfunction, degradation of performance, or deviation from specified indications, beyond the tolerances indicated in ATP document (refer 9.8.1 point 'a' to 'e'), when subjected to the Electro-Static Discharge (ESD) test level of ±8kV. Contact discharge at 8kV is required for conductive surfaces as shown in Figure 22. Air discharge is applicable when contact discharge cannot be applied.

The electrostatic discharges shall be applied to those points and surfaces of the EUT which are accessible to the operator/installer during normal use. Test points to be considered shall include the locations as applicable for given equipment under test:

- Any conductive or non-conductive points in the control or keyboard area.
- Any other point of human contact such as switches, knobs, buttons,
- indicators LEDs, seams slots, grilles, connector shells and other accessible areas.
- As a minimum, each face/side of the equipment shall be included as test point.



Displayed Voltage (KV)	First Peak Current, ±15% (A)	Rise time (ns) (Note-1)	Current I_1, ±30% (A) at t_1 = 30 ns	Current I_2 ±30% (A) at t_2 = 60 ns
±8	30	$0.6 \leq t_r \leq 1.0$	16	8
Note-1: Rise time is defined as the time from 10% to 90% of the peak value of the current waveform.				

Figure 22. CS118 – Contact Discharge current waveform at 8kV

Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test.

4.3.8 Radiated Emission (RE-102)

Severity

Electric Field (10KHz to 18GHz)

Purpose

This test is used to verify the electric field emissions from the EUT and its associated cables do not exceed specified requirements.

RE-102 Limits

Electric field emissions shall not be radiated in excess of the levels shown in Fig. 24 (RE-102 Limit (Refer Fixed wing internal, <25m Nose to Tail).

Test Setup

Make the Test setup as shown in the Fig. 23.

Test Procedure:

a. Calibrate the Test equipment.

b. Make the Test setup.

c. Using the measurement path of Fig. 23, perform the following evaluation for each antenna to demonstrate that there is electrical continuity through the antenna.

d. Power ON the EUT.

e. Using the measurement path of Fig. 23, determine the radiated emission from the EUT and its associated cabling.

- Scan the measurement receiver for each applicable frequency range, using the bandwidths and minimum measurement times.
- Above 30MHz, orient the antennas for both horizontally and vertically polarized fields.
- Take measurements for each antenna position.

f. Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points ‘a’ to ‘e’) after test.

Pass/Fail Criteria:

The measured emission pattern is below the limit line.

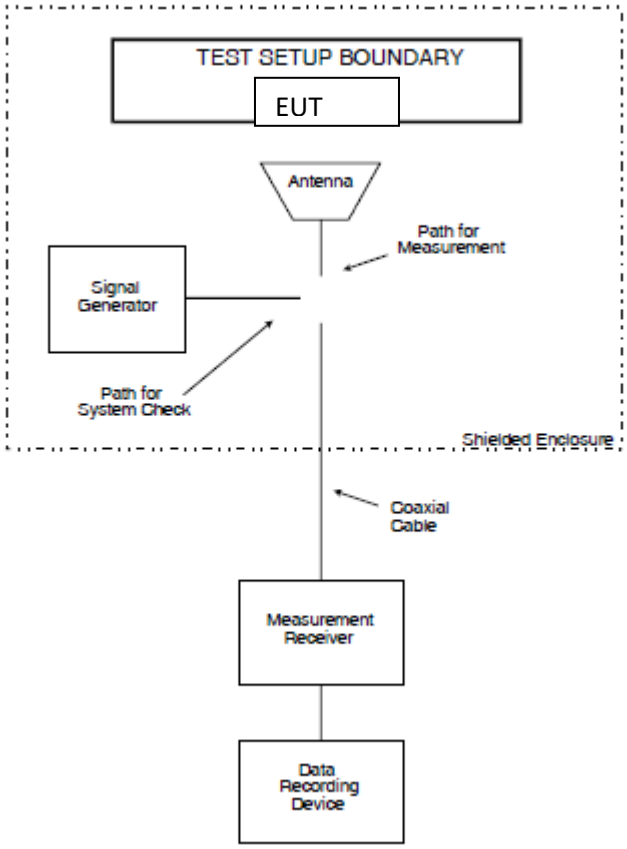


Figure 23. RE-102 Test Setup

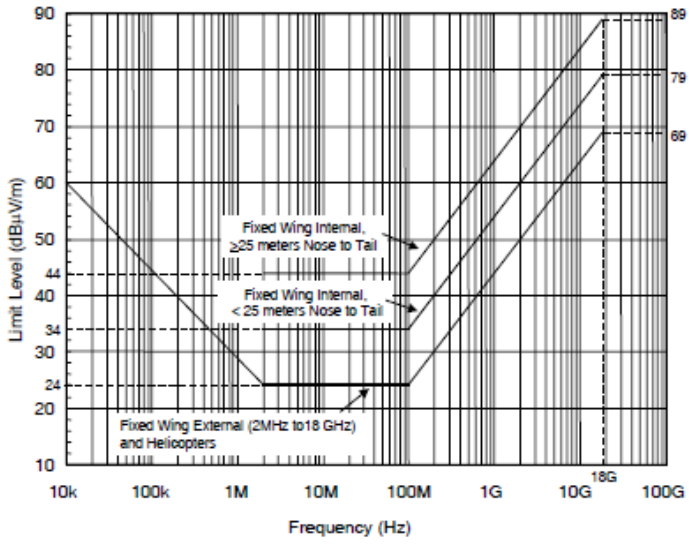


Figure 24. RE-102 Limit (*Refer Fixed wing internal, <25m Nose to Tail*)

4.3.9 Radiated Susceptibility (RS-103)

Severity

Electric field (2MHz to 40 GHz) 60 V/m

Purpose

This test is used to verify the ability of the EUT and associated cabling to withstand electric fields.

RS-103 Limits

The EUT shall not exhibit any malfunction, degradation of performance while subjected to the radiated electric field in the range of 2MHz to 40GHz.

Test Setup

Make the Test setup as shown in the Fig25.

Test Procedure:

a. Calibrate the Test equipment.

b. Make the Test setup and Power ON the EUT.

c. E-Field sensor procedure

- Set the signal source to 1KHz pulse modulation, 50% duty cycle and using appropriate amplifier and transmit antenna, establish an electric field at the test start frequency. Gradually increase the electric field level until it reaches the applicable limit.

- Scan the required frequency range in accordance with the rates and duration. Monitor EUT performance for susceptibility effects.

d. Receive antenna procedure

- Remove the receive antenna and reposition the EUT.

- Set the signal source to 1KHz pulse modulation, 50% duty cycle. Using an appropriate amplifier and transmit antenna, establish an electric field at the test start frequency. Gradually increase the input power level until it corresponds the applicable level recorded during the calibration routine.

- Scan the required frequency range in accordance with the rates and durations specified, while assuring the correct transmitter input power is adjusted in accordance with the calibration data collected. Constantly monitor the EUT for conditions.

e. If susceptibility is noted, determine the threshold level and verify that it is above the limit.

f. Perform testing over the required frequency range 2MHz to 40GHz.

g. Repeat the above for each transmit antenna position.

h. Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points ‘a’ to ‘e’) after test.

Pass/Fail Criteria

The EUT shall not exhibit any malfunction, degradation of performance.

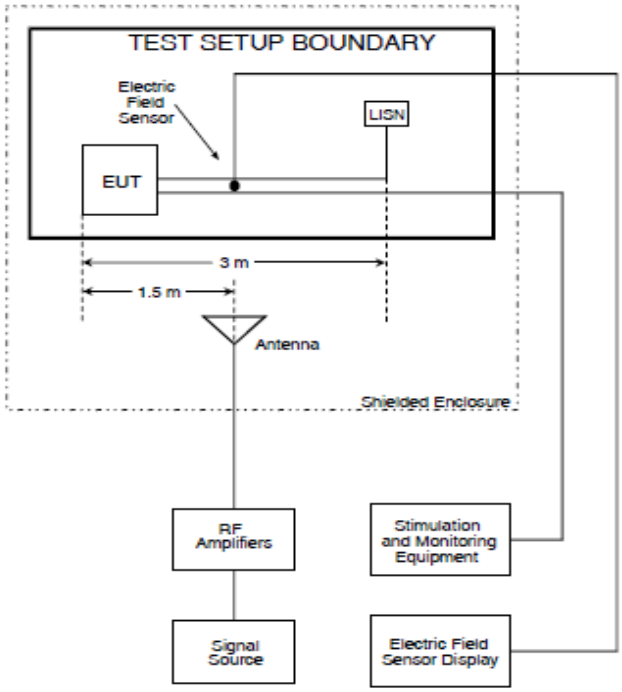


Figure 25. RS-103 Test Setup configuration

Freq Range	Limit Level (Volt/Meter)
2MHz- 1 GHz	40
1 GHz- 3 GHz	60
3 GHz-40 GHz	60

Table 10: RS-103 Limits

4.3.10 Electrostatic Discharge

The Pump Module shall not be adversely affected when exposed to 15 kV ESD waveform in RTCA/DO-160E, Section 25.

4.3.11 Bonding & Grounding

The Pump Module shall provide necessary electrical bonding to protect personnel from the hazardous effects of static charge. The Pump Module shall provide electrical shock and fault current

hazard protection. The Pump Module shall provide necessary electrical bonding to ensure compliance with the E3 requirements. The Pump Module shall comply with the bonding requirements of MIL-STD-464A.

5 POWER SUPPLY TESTS

Purpose: The purpose of these tests is to ensure that the EUT is compatible to the aircraft power supply as per MIL 704 D.

5.1 Low Direct Current Tests

The unit shall be subjected to the following Low Direct Current tests as per MIL 704 D.

LDC 101 : Load Measurements Test
LDC 102 : Steady State Voltage Test
LDC 103 : Voltage Distortion Test
LDC 104 : Total Ripple Test
LDC 105 : Normal Voltage Transients
LDC 301 : Abnormal Steady State Voltage Test
LDC 302 : Abnormal Voltage Transients
LDC 401 : Emergency Steady State Voltage Test
LDC 602 : Polarity Reversal Test

5.1.1 LDC 101 – Load Measurements Test

Purpose: This test is used to verify the load limits, inrush current limits, current distortion factor and current spectrum limits that are unique to each equipment and may be required to be defined in the equipment performance specification document.

Remarks: Perform functional Check with Solenoid valve switch ON on EUT as given in the para 2.3 after test.

Pass / **Fail Criteria:** The EUT is considered to have passed if the utilization equipment is within the load limits, inrush current limits, the current distortion limit, and the current spectrum limits specified in the utilization equipment performance specification document. The load limits, inrush current limits, the current distortion limit, and the current spectrum limits are not specified in MIL-STD-704 D and are unique to each equipment. The utilization equipment must not suffer damage or cause an unsafe condition.

5.1.2 LDC 102 – Steady State Voltage Test

Severity:

Voltage NLSS : 22VDC

Voltage NHSS : 29VDC

Purpose: This test is used to verify that EUT operates and maintains specified performance when provided with input power with steady state voltage levels.

Test Setup: Make the test setup as given in figure 26 below

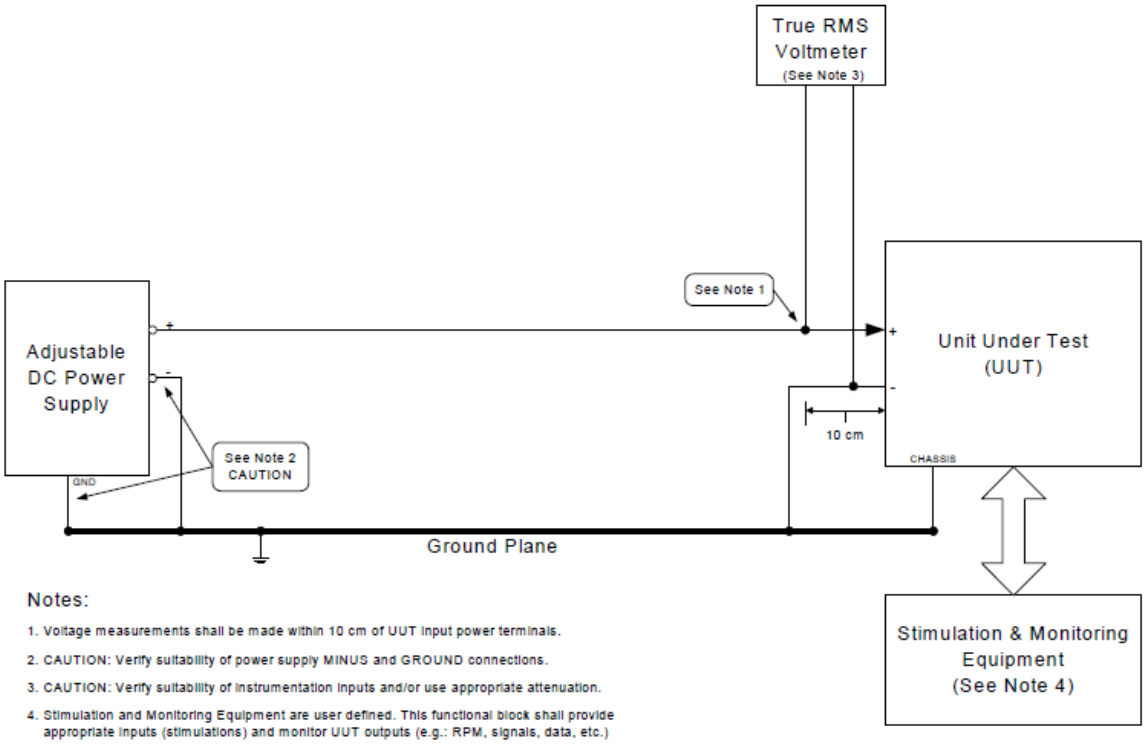


Figure 26: Normal operation – steady state limits for voltage

Test Procedure*:*

a) Make the test setup and power 'ON' the EUT with steady state voltage of + 28V (Nominal).

b) Set the input power supply voltage to the EUT to +22V (Normal Low Steady State).

c) After stabilizing the input power, conduct functional check (degraded mode) with Solenoid valve switched on. The performance parameters in degraded mode are, Flow: 5 to 7 lpm, differential pressure across Pump: 2.5 to 4 bar.

d) Keep the unit in power ON condition for minimum of 30 minutes. Monitor the EUT performance (degraded mode) during entire duration.

e) Restart the EUT at +22V (NLSS) to verify that EUT can be restarted. After restart, conduct functional check with Solenoid valve switched on (degraded mode).

f) Repeat c) through f) for input power supply voltage of +29V (Normal High Steady State)

g) After completion of above test, set the input voltage to +28V (nominal) and carry the functional check with Solenoid valve switch ON on EUT as given in Para 2.3.

Remarks: This test is Not applicable, if equipment design caters continuous (at least 30min) operation from 16 to 31.5 V DC.

Pass / Fail Criteria: The EUT is considered to be passed if EUT operates and maintains specified degraded performance for input power of steady state voltage.

5.1.3 LDC 103 – Voltage Distortion Test

Purpose: This test is used to verify that EUT operates and maintains specified performance when subjected to voltage distortion of frequencies and amplitudes as specified in Table 11 below:

Table 11: Test conditions for voltage distortion spectrum

Test Condition	Frequency of Voltage Distortion	MIL-STD-704A Amplitude of Voltage Distortion Voltage rms	MIL-STD-704B, C, & D Amplitude of Voltage Distortion Voltage rms	MIL-STD-704E & F Amplitude of Voltage Distortion Voltage rms
A	10 Hz	0.900 Vrms	0.100 Vrms	0.100 Vrms
B	25 Hz	0.900 Vrms	0.158 Vrms	0.158 Vrms
C	50 Hz	0.400 Vrms	0.200 Vrms	0.223 Vrms
D	60 Hz	0.320 Vrms	0.224 Vrms	0.245 Vrms
E	250 Hz	0.320 Vrms	0.398 Vrms	0.500 Vrms
F	1 kHz	0.790 Vrms	0.707 Vrms	1.000 Vrms
G	1.7 kHz	1.000 Vrms	0.891 Vrms	1.000 Vrms
H	2 kHz	1.000 Vrms	1.000 Vrms	1.000 Vrms
I	5 kHz	1.000 Vrms	0.316 Vrms	1.000 Vrms
J	6.5 kHz	1.000 Vrms	0.707 Vrms	0.707 Vrms
K	10 kHz	0.400 Vrms	0.125 Vrms	0.500 Vrms

Test Setup: Make the test setup as given below in figure 27.

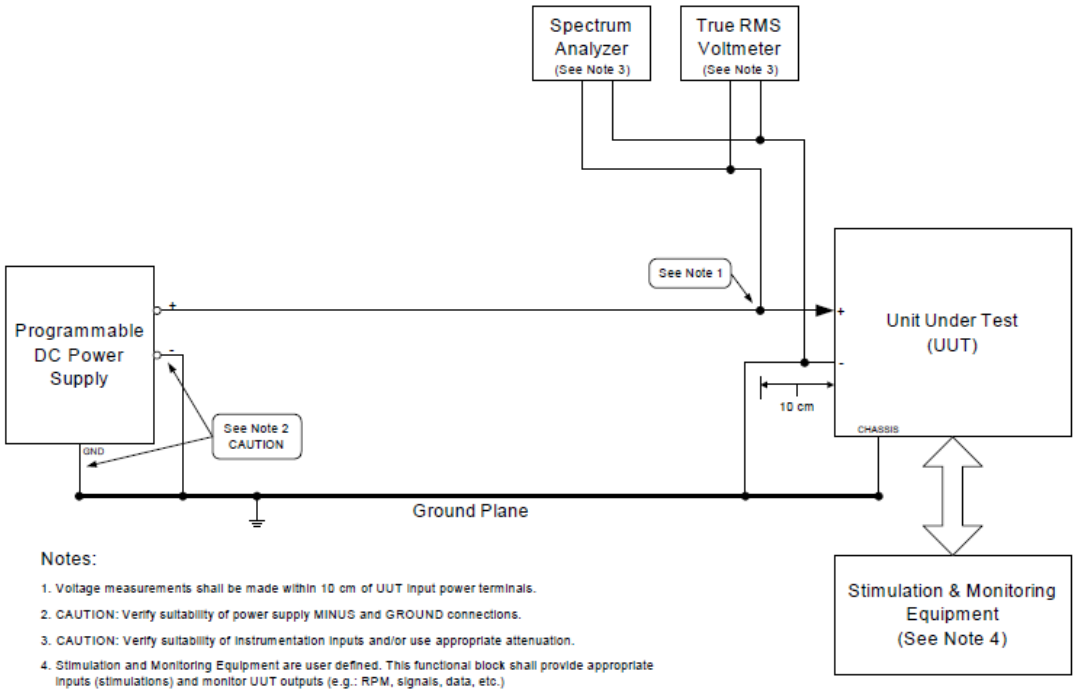


Figure 27: Normal operation – voltage distortion spectrum (10 Hz and 25 Hz)

Test Procedure:

a) Make the test setup and power 'ON' the EUT with steady state voltage of +28V (Nominal).

b) Switch off the EUT after function check and switch on the EUT with solenoid valve switched on condition.

c) Set the amplitude of input voltage distortion to 0.1Vrms with 10 Hz rate over steady state DC voltage of +28V.

d) Keep this input distortion for 5 minutes and monitor the EUT degraded mode performance.

e) Repeat c) through d) for the various setting as given in the table above.

f) After completion of above test, set the input voltage to +28V DC without voltage distortion and carry functional Check with Solenoid valve switch ON on EUT as given in Para 2.3.

Pass / Fail criteria: The EUT is considered to be passed if EUT operates and maintains specified functional performance in degraded mode when subjected to voltage distortion as specified in the MIL standard 704E.

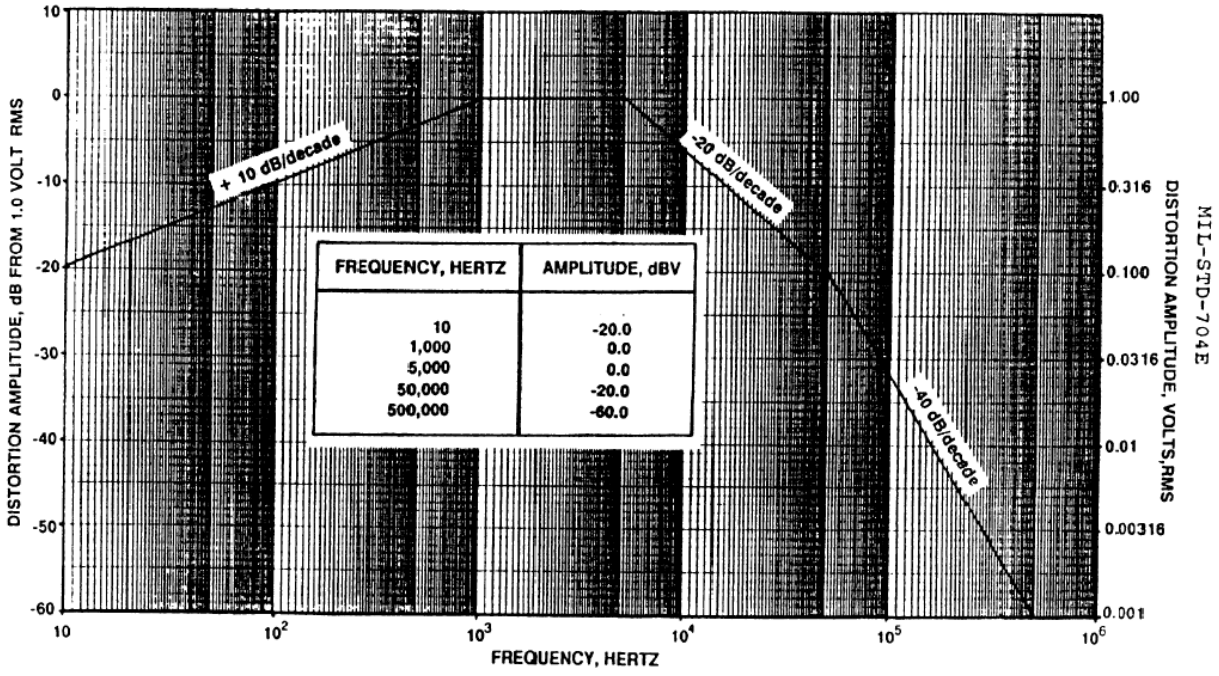


Figure 28: Maximum distortion spectrum for 28 volts DC system

5.1.4 LDC 104 – Total Ripple Test

Purpose: This test is used to verify that the EUT operates and maintains specified performance when subjected to voltage having a ripple of 1.5V peak to peak as specified in table below

Test Setup: Make the test setup as given in figure 29 below

Test Procedure:

a) Make the test setup and power 'ON' the EUT with steady state voltage of +28V (nominal).

b) Calibrate the test system to produce waveforms for test conditions as in table below with the help of equivalent resistive load.

c) Set the programmable power supply to the setting recorded during the calibration procedure of Setting –A.

Table 12: Ripple frequency and amplitude

Test Condition	Ripple Frequency Components	MIL-STD-704A Amplitude of Ripple Component Vrms	MIL-STD-704B, C, D, E, & F Vrms
A	1200 Hz	1.00 Vrms	0.80 Vrms
	2400 Hz	0.20 Vrms	0.16 Vrms
	3600 Hz	0.33 Vrms	0.26 Vrms
	4800 Hz	0.10 Vrms	0.08 Vrms
	6000 Hz	0.16 Vrms	0.13 Vrms
	7200 Hz	0.05 Vrms	0.04 Vrms
	8400 Hz	0.08 Vrms	0.06 Vrms
B	2400 Hz	0.80 Vrms	0.80 Vrms
	4800 Hz	0.16 Vrms	0.16 Vrms
	7200 Hz	0.26 Vrms	0.26 Vrms
	9600 Hz	0.08 Vrms	0.08 Vrms
	12000 Hz	0.13 Vrms	0.13 Vrms
	14400 Hz	0.04 Vrms	0.04 Vrms
	16800 Hz	0.06 Vrms	0.06 Vrms

d) Power 'ON' the EUT with solenoid valve switch on. Conduct the functional test (Degraded mode performance) of the EUT and record the test results. Keep the unit in power 'ON' condition continuously for minimum 30 minutes.

e) Measure and record the DC ripple frequency and amplitude during the test.

f) Repeat d) through f) for other test settings as in table above.

g) For each test condition, record the frequency and amplitude of ripple voltage, time duration at test condition, and the degraded performance of the EUT in the table above.

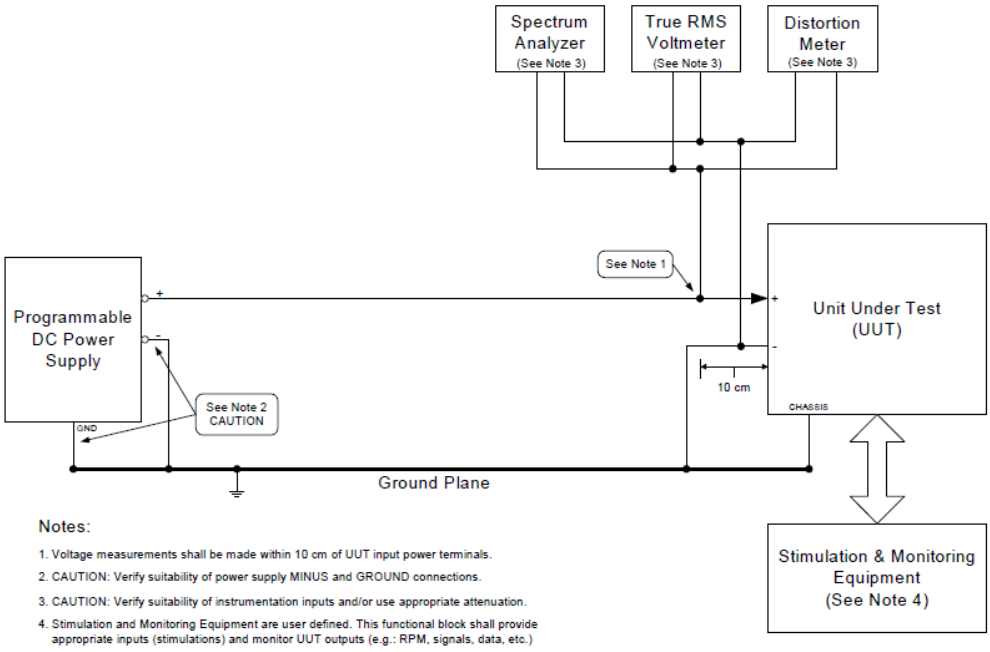


Figure 29: Normal operation – total ripple

h) After completion of above test, set the input voltage to +28V DC without ripple voltage and carry functional Check with Solenoid valve switch ON on EUT as given in Para 2.3.

Pass/Fail Criteria: The EUT is considered to be passed of EUT operates and maintains specified functional performance (Degraded mode) when subjected to voltage having a ripple of 1.5V peak to average.

5.1.5 LDC 105 – Normal Voltage Transients

Purpose: This test is used to verify that EUT operates and maintains specified performance when subjected to normal voltage transients (under voltage, over voltage and combined transients) as per profile given below:

Test Setup: Make the test setup as given figure 31:

Test Procedure:

a) Make the test setup and power 'ON' the EUT with steady state voltage of +28V (nominal)

b) Switch off the EUT after function check and switch on the EUT with solenoid valve switched on condition.

c) Subject the EUT to voltage transients for each of test condition AA through RR as listed in table 13.

d) For test condition EE and JJ, perform three over-voltage transients of 50V for 10 milliseconds separated by 0.5 seconds each.

e) For test condition MM and PP, perform three under-voltage transients of 18V for 10 milliseconds separated by 0.5 seconds each.

f) Repeat each of the test condition 5 times.

g) Monitor the degraded mode performance of unit during the transients.

h) After the power is returned to ambient, carry out the functional test at the end of each transient test.

i) After the completion of all transient tests as listed in table, inject the repetitive voltage transient to EUT.

j) Program the power supply to provide a continually repeating voltage transient that decreases from 28.5V to 18 V in 2.5 millisecond, then increases to 45V over 30 milliseconds, then decreases to 28.5V over 2.5 milliseconds. The voltage transient is repeated every 0.5 seconds.

k) Conduct the repetitive voltage transient on the EUT for 30 minutes.

l) For each test condition, record the steady state voltage and voltage transient, time duration at voltage transient and monitor degraded mode performance of the EUT.

m) After completion of above test, set the input voltage to +28V DC without any transient and conduct the functional Check with Solenoid valve switch ON on EUT, as given in Para 2.3.

Pass/Fail criteria: The EUT is considered to be passed if EUT operates and maintains specified degraded mode performance when subjected to normal voltage transients.

Table 13: Test conditions for MIL-STD-704B, C, D, E and F normal voltage transients

Test Condition	Steady State Voltage Vdc	Time From Steady State Voltage to Voltage Transient Level milliseconds	Voltage Transient Level Vdc	Duration at Voltage Transient Level milliseconds	Time From Voltage Transient Level to Steady State Voltage milliseconds
Overvoltage Transients					
AA	29 Vdc	< 1 msec	50 Vdc	12.5 msec	< 1 msec
BB	29 Vdc	< 1 msec	50 Vdc	12.5 msec	70 msec
CC	29 Vdc	< 1 msec	40 Vdc	45 msec	< 1 msec
DD	29 Vdc	< 1 msec	40 Vdc	45 msec	37.5 msec
EE	29 Vdc	< 1 msec	50 Vdc (3 times)	10 msec Every 0.5 msec	< 1 msec
FF	22 Vdc	< 1 msec	50 Vdc	12.5 msec	< 1 msec
GG	22 Vdc	< 1 msec	50 Vdc	12.5 msec	95 msec
HH	22 Vdc	< 1 msec	40 Vdc	45 msec	< 1 msec
II	22 Vdc	< 1 msec	40 Vdc	45 msec	62.5 msec
JJ	22 Vdc	< 1 msec	50 Vdc (3 times)	10 msec Every 0.5 msec	< 1 msec
Undervoltage Transients					
KK	29 Vdc	< 1 msec	18 Vdc	15 msec	< 1 msec
LL	29 Vdc	< 1 msec	18 Vdc	15 msec	234 msec
MM	29 Vdc	< 1 msec	18 Vdc (3 times)	10 msec Every 0.5 sec	< 1 msec
NN	22 Vdc	< 1 msec	18 Vdc	15 msec	< 1 msec
OO	22 Vdc	< 1 msec	18 Vdc	15 msec	85 msec
PP	22 Vdc	< 1 msec	18 Vdc (3 times)	10 msec Every 0.5 sec	< 1 msec
Combined Transient					
QQ	29 Vdc then	< 1 msec < 1 msec	18 Vdc 50Vdc	10 msec 12.5 msec	< 1 msec 70 msec
RR	22 Vdc then	< 1 msec < 1 msec	18 Vdc 50Vdc	10 msec 12.5 msec	< 1 msec 62.5 msec

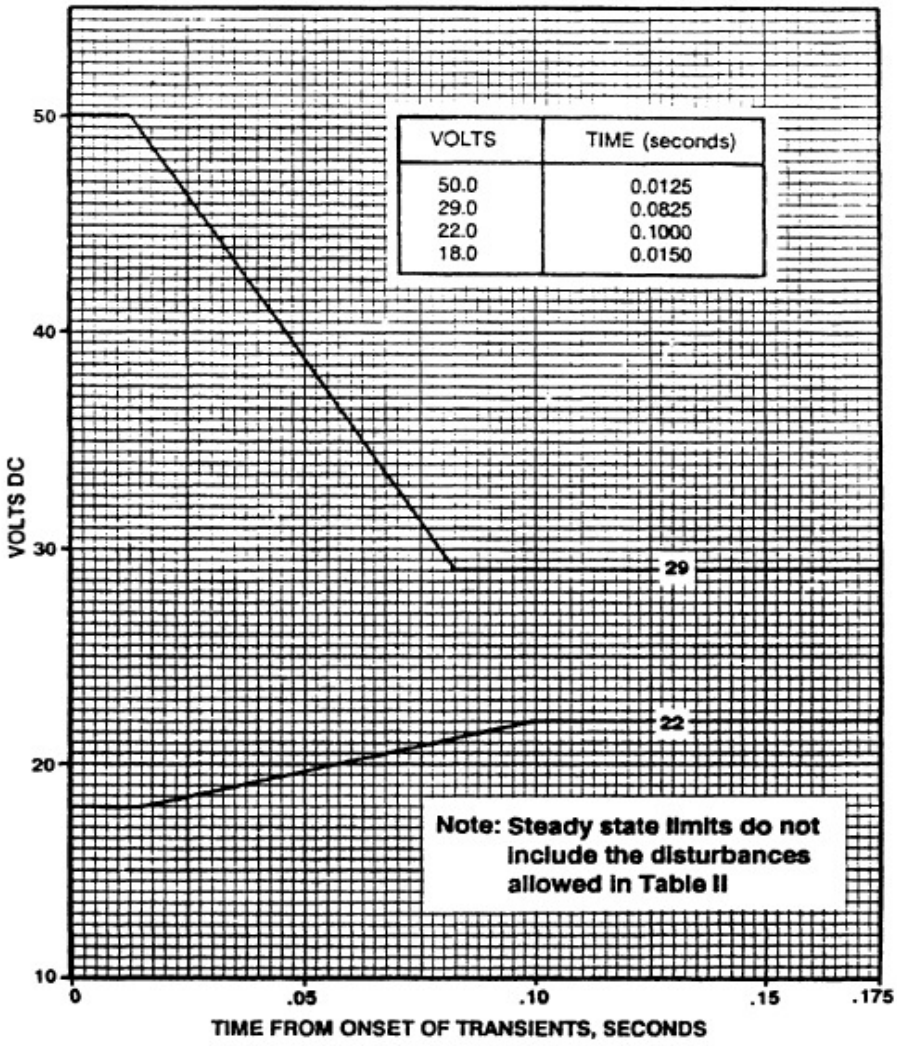


Figure 30: Envelope of normal voltage transient for 28 volts DC system

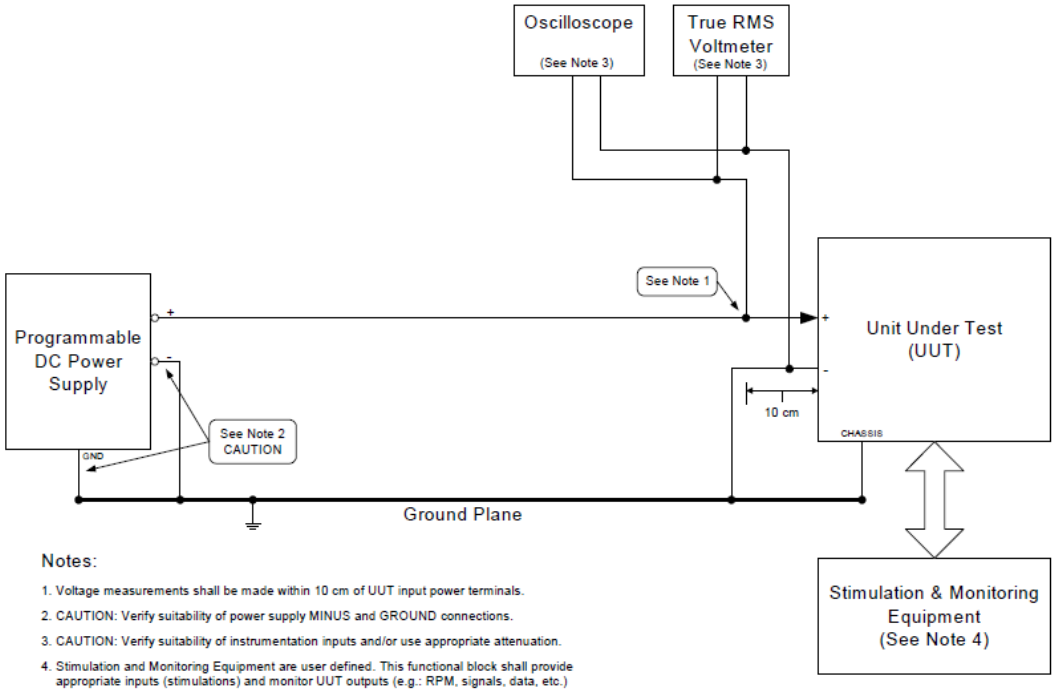


Figure 31: Normal operation – normal voltage transients

5.1.6 LDC 301 – Abnormal Steady State Voltage Test

Severity:

Abnormal limits for steady state voltage as per MIL-STD-704D is

Voltage ALSS: 20.0 VDC

Voltage AHSS: 31.5 VDC

Purpose: This test is used to verify that EUT operates and maintains specified performance when provide with input power with abnormal steady state levels.

Test Setup: Make the test setup as per figure 32

Test Procedure:

a) Make the test setup and power 'ON' the EUT with steady state voltage of +28V.

b) Switch off the EUT after functional check and switch on the EUT with solenoid valve switched on condition.

c) Set the input power supply voltage to the EUT to +20V.

d) After stabilizing the input power, conduct functional test (Degraded mode) on EUT and record the test results

e) Keep the unit in power 'ON' condition for minimum of 30 minutes. Monitor the EUT degraded mode performance during entire duration

f) Restart the EUT at +20V to verify that EUT can be restarted. After restart, monitor the degraded mode performance on EUT.

g) Repeat d) through f) for input power supply voltage of +32 V

h) After completion of above test, set the input voltage to +28V and conduct the functional Check with Solenoid valve switch ON on EUT, as given in Para 2.3.

Remarks: This test is Not applicable, if equipment design caters continuous (at least 30min) operation from 16 to 31.5 V DC.

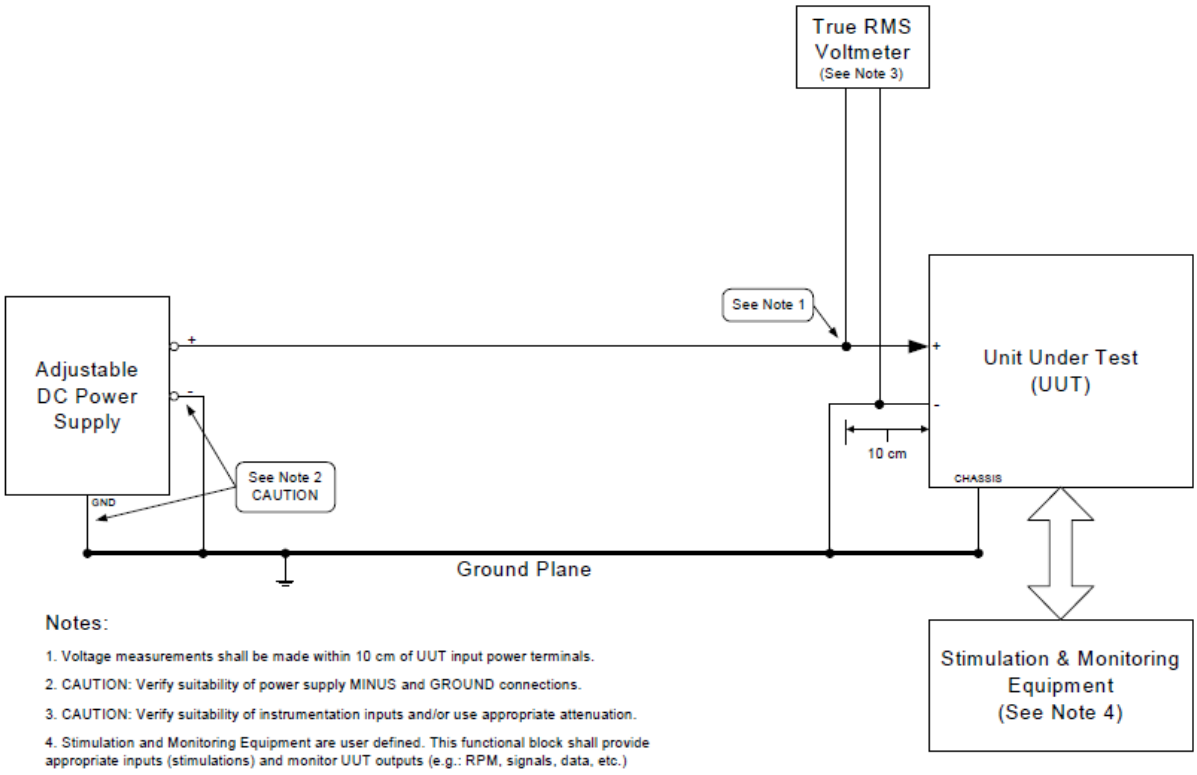


Figure 32: Abnormal operation – steady state limits for voltage

Pass/fail criteria: The EUT is considered to be passed if EUT operates and maintains specified degraded mode performance for input power of abnormal steady state voltage.

5.1.7 LDC 302 – Abnormal voltage transients

Purpose: This test is used to verify that EUT operates and maintains specified performance when subjected to abnormal voltage transients (under voltage, overvoltage and combined transients) as per profile given below: -

Test Setup: Make the test setup as given in figure 34 below

Test Procedure:

a) Make the test setup and power 'ON' the EUT with steady state voltage of +28V.

b) Switch off the EUT after functional check and switch on the EUT with solenoid valve switched on condition.

c) Subject the EUT to voltage transient for each of test condition AA through NN as listed in table 14.

d) For test condition CC and FF, perform three over-voltage transients of 50V for 45 milliseconds every 0.5 seconds each

e) For test condition II and LL, perform three under-voltage transients of 7V Vdc for 45 milliseconds every 0.5 second each

f) Repeat each of the test condition 5 times. Monitor the degraded mode performance of unit during the transient

g) After the power is returned to ambient, monitor the degraded mode performance at the end of each transient test.

h) For each test condition, record the steady state voltage and voltage transient, time duration at voltage transient level and degraded mode performance of the EUT.

i) After completion of above test, set the input voltage to +28V DC without any transient and

j) Conduct the functional Check with Solenoid valve switch ON on EUT, as given in Para 2.3.

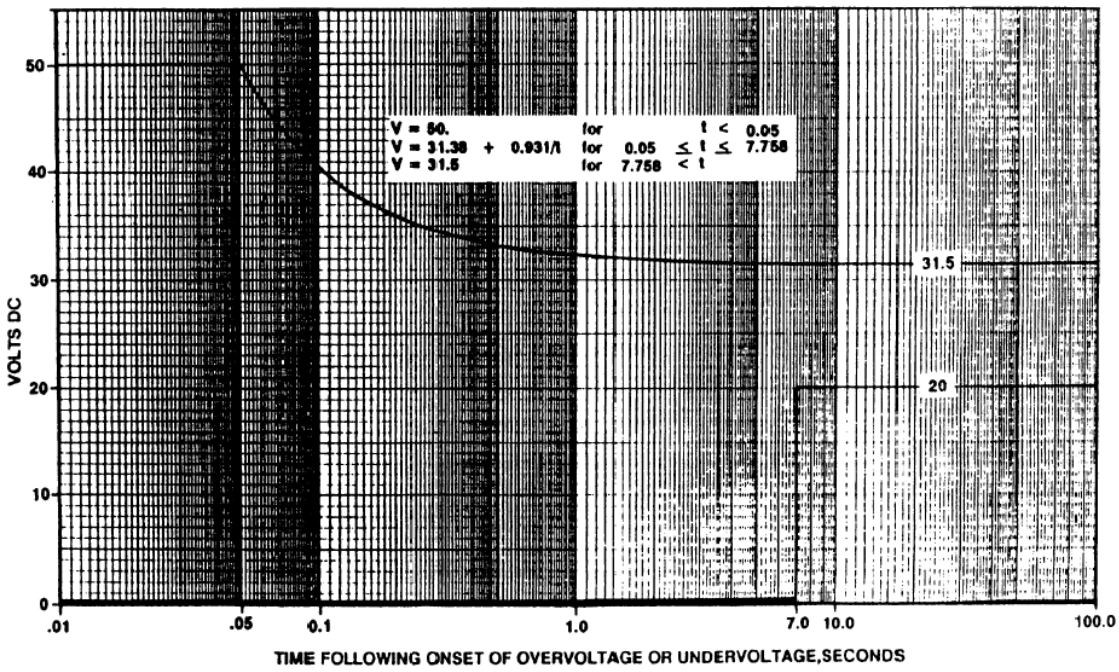


Figure 33: Limits for DC overvoltage or under voltage for 28 volts DC system

Table 14: Test condition for MIL-STD-704D abnormal voltage transients

Test Condition	Steady State Voltage Vdc	Time From Steady State Voltage to Voltage Transient Level milliseconds	Voltage Transient Level Vdc	Duration at Voltage Transient Level	Time From Voltage Transient Level to Steady State Voltage or Next Voltage Level
Overvoltage Transients					
AA	29 Vdc	< 1 msec	50 Vdc	45 msec	< 1 msec
BB	29 Vdc	< 1 msec	50 Vdc	45 msec	15 msec
		then	45 Vdc	decreasing	30 msec
		then	40 Vdc	decreasing	60 msec
		then	35 Vdc	decreasing	4.85 sec
		then	30 Vdc	decreasing	1 sec
		then	29 Vdc		
CC	29 Vdc	< 1 msec	50 Vdc (3 times)	45 msec Every 0.5 sec	< 1 msec
DD	22 Vdc	< 1 msec	50 Vdc	45 msec	< 1 msec
EE	22 Vdc	< 1 msec	50 Vdc	45 msec	15 msec
		then	45 Vdc	decreasing	30 msec
		then	40 Vdc	decreasing	60 msec
		then	35 Vdc	decreasing	4.85 sec
		then	30 Vdc	decreasing	8 sec
		then	22 Vdc		
FF	22 Vdc	< 1 msec	50 Vdc (3 times)	45 msec Every 0.5 sec	< 1 msec
Undervoltage Transients					
GG	29 Vdc	< 1 msec	7 Vdc	45 msec	< 1 msec
HH	29 Vdc	< 1 msec	7 Vdc	45 msec	15 msec
		then	12 Vdc	increasing	30 msec
		then	17 Vdc	increasing	60 msec
		then	22 Vdc	increasing	4.85 sec
		then	28 Vdc	increasing	1 sec
		then	29 Vdc		
II	29 Vdc	< 1 msec	7 Vdc (3 times)	45 msec Every 0.5 sec	< 1 msec
JJ	22 Vdc	< 1 msec	7 Vdc	45 msec	< 1 msec
KK	22 Vdc	< 1 msec	7 Vdc	45 msec	15 msec
		then	12 Vdc	increasing	30 msec
		then	17 Vdc	increasing	60 msec
		then	22 Vdc		
LL	22 Vdc	< 1 msec	7 Vdc (3 times)	45 msec Every 0.5 sec	< 1 msec
Combined Transient					
MM	29 Vdc	< 1 msec < 1 msec	7 Vdc then 50Vdc	10 msec 45 msec	< 1 msec 15 msec
		then	45 Vdc	decreasing	30 msec
		then	40 Vdc	decreasing	60 msec
		then	35 Vdc	decreasing	4.85 sec
		then	30 Vdc	decreasing	1 sec
		then	29 Vdc		
NN	22 Vdc	< 1 msec < 1 msec	7 Vdc then 50Vdc	10 msec 45 msec	< 1 msec 15 msec
		then	45 Vdc	decreasing	30 msec
		then	40 Vdc	decreasing	60 msec
		then	35 Vdc	decreasing	4.85 sec
		then	30 Vdc	decreasing	8 sec
		then	22 Vdc		

Pass/fail criteria: The EUT is considered to be passed if EUT operates and maintains specified functional performance as per ATP document when subjected to abnormal voltage transients.

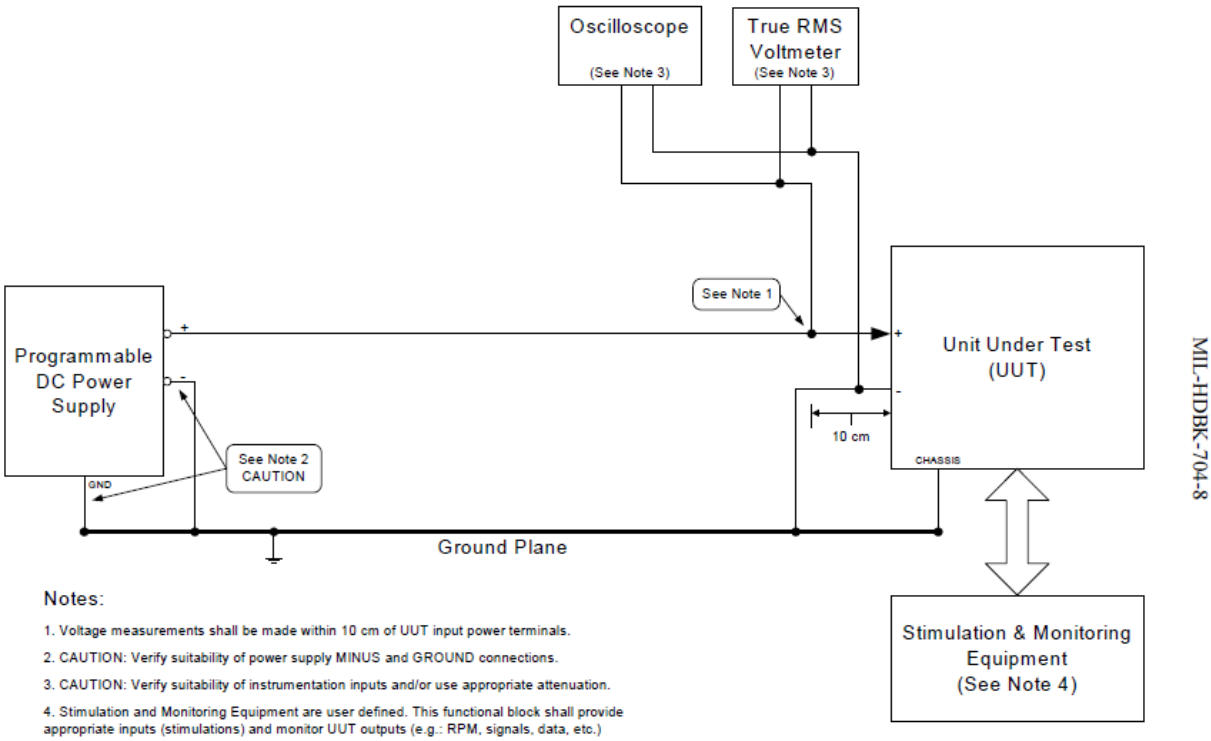


Figure 34: Abnormal operation – abnormal voltage transients

5.1.8 LDC 401 – Emergency Steady State Voltage Test

Severity: Emergency limits for steady state voltage as per MIL-STE-704D is

Voltage ELSS: 16.0 VDC

Voltage EHSS: 29.0 VDC

Purpose: The test is used to verify that EUT operates and maintains specified performance when provided with input power with emergency steady state levels.

Test Setup: Make the test setup as given in figure 35

Test Procedure:

a) Make the test setup and power 'ON' the EUT with steady state voltage of +28V.

b) Switch off the EUT after functional check and switch on the EUT with solenoid valve switched on condition.

c) Set the input power supply voltage to the EUT to +16V

d) After stabilizing the input power, conduct functional test (Degraded mode) on EUT and record the test results.

e) Keep the unit in power ON condition for minimum of 30 minutes. Monitor the EUT degraded mode performance during entire duration.

f) Restart the EUT at +20V to verify that EUT can be restarted. After restart, conduct the functional test (degraded mode) on EUT and record the test results.

g) Repeat d) through g) for input power supply voltage of +29V.

h) After completion of above test, set the input voltage to +28V and conduct the functional Check with Solenoid valve switch ON on EUT, as given in Para 2.3.

Remarks: This test is Not applicable, if equipment design caters continuous (at least 30min) operation from 16 to 31.5 V DC.

Pass / fail criteria: The EUT is considered to be passed if EUT operates and maintains specified degraded mode performance for input power of emergency steady state voltage level.

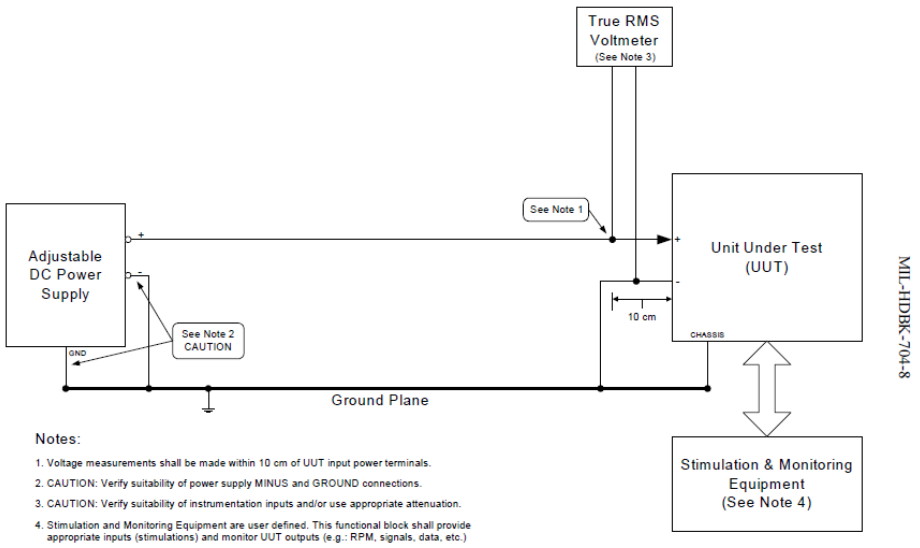


Figure 35: Emergency operation – steady state limits for voltage

5.1.9 LDC 602 – Polarity Reversal Test

Severity: Polarity reversal should not cause any damage to the EUT

Purpose: The test is used to verify that EUT is not damaged by phase reversal or a positive physical means is employed to prevent phase reversal.

Remarks: Perform functional Check with Solenoid valve switch ON on EUT as given in the para 2.3 after test.

Pass / fail criteria: The EUT is considered to be passed if EUT is not damaged and does not cause an unsafe condition when the positive and negative connection are reversed.

5.2 Three phase Power Supply Tests

Purpose: The purpose of these tests is to ensure that EUT is compatible to the aircraft power supply as per MIL STD 704D.

Following Power Supply Tests to be carried out on EUT. All the functional/performance tests shall be conducted with solenoid valve switched off condition (refer section 9.8.1 point 'a' to 'e' of ATP) and functional/performance parameters corresponds to the same.

- Tests on 3 Phase, 400 Hz , 115V AC (As per MIL-HDBK-704-3)
  a. TAC101 : Three Phase Load and Current Harmonic Measurements
  b. TAC102 : Steady State Limits for Voltage (Including Unbalance) and Frequency
  c. TAC103 : Voltage Phase Difference
  d. TAC109 : Normal Voltage Transients
  e. TAC110 : Normal Frequency Transients
  f. TAC301 : Abnormal Limits for Voltage and Frequency
  g. TAC302 : Abnormal Voltage Transients (Overvoltage/Under voltage)
  h. TAC303 : Abnormal Frequency Transients (Over frequency/Under frequency)
  i. TAC401 : Emergency limits for Voltage and Frequency
  j. TAC602 : One Phase and Two Phase Power Failures
  k. TAC603 : Phase Reversal

Details of each test are provided below,

5.2.1 TAC 101 – Steady State Voltage Test

Purpose: This test is used to verify that three phase, 115 Volt, 400 Hz power utilization equipment utilizes only 115 Volt line-to-neutral power, current inrush is within limits, has balanced power, the power factor is within limits, and does not use half-wave rectification for the applicable MIL-STD-704D. Additionally, this test procedure is used to verify that the utilization equipment current waveform is within total current distortion and current spectrum (current distortion vs. frequency) limits defined in the utilization equipment performance specification document.

Test Condition: The Test conditions for Three Phase Load and Current Harmonic Measurements Test TAC 101 are indicated below.

i.	Inrush Current	: 300 Percent for loads >3kVA
ii.	Power Factor	: 0.85 Lagging to Unity for Loads >500VA and No Leading Power Factor for >100VA
iii.	Rectification Restriction	: No Half – Wave Rectification
iv.	Percent Unbalanced Load	: Figure 36 given below or 3.33% for Loads >30kVA

Remarks: Perform functional Check with Solenoid valve switch OFF on EUT as given in the para 2.3 (points 'a' to 'e') after test.

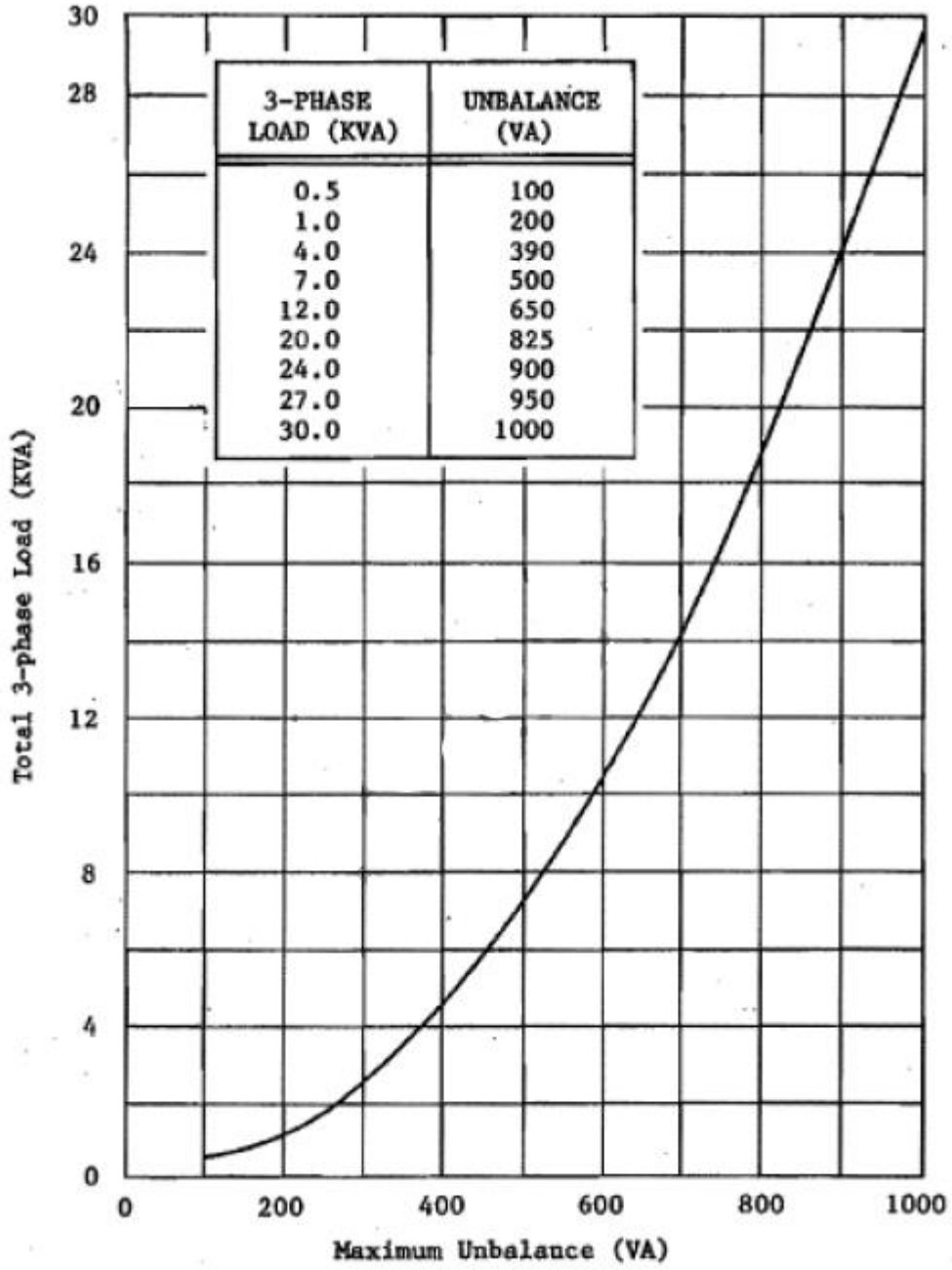


Figure 36: Load Unbalance Limit for AC Three – Phase Utilization Equipment
(Figure – 1 of MIL-STD-704)

Pass Fail Criteria: The utilization equipment is considered to have passed if the utilization equipment utilize only 115 Volt line-to-neutral power, is within current inrush limits, is within the balanced load limits, is within the power factor limits, and does not use half-wave rectification for the applicable MIL-STD-704D and as noted in Test Conditions above. If required by the utilization equipment performance specification document, the utilization equipment current waveform must be within the total current distortion and current spectrum limits defined in the utilization equipment performance specification document. The utilization equipment must not suffer damage or cause an unsafe condition.

5.2.2 TAC 102 – Steady State Voltage Test

Purpose: This test procedure is used to verify that three phase, 115 Volt, 400 Hz power utilization equipment operates and maintains specified performance when provided power with voltage and frequency at the Normal Low Steady State (NLSS) limits and the Normal High Steady State (NHSS) limits as specified in the applicable edition(s) of MIL-STD-704D

Test Condition: The normal limits for steady state voltage, voltage unbalance, and frequency are provided below. Test conditions for steady state limits for voltage and frequency are also indicated below.

Table 15: MIL-STD-704 normal limits for steady state voltage, voltage unbalance, and frequency (TAC 102-I)

Normal Limit	704A	704B	704C	704D	704E	704F
Voltage NLSS	108 V	108 V	108 V	108 V	108 V	108 V
Voltage NHSS	118 V	118 V	118 V	118 V	118 V	118 V
Voltage Unbalance	3.0V	3.0V	3.0V	3.0V	3.0V	3.0V
Frequency NLSS	380 Hz	395 Hz (380 Hz)1/	393 Hz	393 Hz	393 Hz	393 Hz
Frequency NHSS	420 Hz	405 Hz (420 Hz)1/	407 Hz	407 Hz	407 Hz	407 Hz

1/ Normal steady state frequency limits for MIL-STD-704B for helicopters is 400 ±20 Hz.

Table 16: Test conditions for steady state limits for voltage and frequency (TAC 102-II)

Test Condition	Voltage	Frequency
Balanced Voltages		
A	Nominal Voltage	Nominal Frequency
B	Nominal Voltage	NLSS Frequency
C	Nominal Voltage	NHSS Frequency
D	NLSS Voltage	Nominal Frequency
E	NLSS Voltage	NLSS Frequency
F	NLSS Voltage	NHSS Frequency
G	NHSS Voltage	Nominal Frequency
H	NHSS Voltage	NLSS Frequency
I	NHSS Voltage	NHSS Frequency
Unbalanced Voltages		
J	Van NLSS Voltage Vbn NLSS Voltage+3.0V Vcn NLSS Voltage+3.0V	Nominal Frequency
K	Van NHSS Voltage Vbn NHSS Voltage-3.0V Vcn NHSS Voltage-3.0V	Nominal Frequency

Test Setup: Make the test setup as given in figure 37

Test Procedure:

With the power source off, install the EUT and the stimulation and monitoring equipment into the test setup of figure TAC102-1. Turn on the power source and adjust the voltage to the nominal steady state voltage of 115 Vrms (line-to-neutral) and adjust the frequency to the nominal steady state frequency of 400 Hz. Energize the EUT. Allow sufficient time for the EUT to warm up. Conduct the functional Check.

For each test condition A through K noted in table TAC102-II, the EUT must remain for a length of time that confirms the utilization equipment can continuously operate at the steady state voltage and frequency limits and should be not less than thirty (30) minutes. Test conditions A through I are three phase balanced voltages. Test conditions J and K are unbalanced voltage conditions. At each test condition monitor the performance parameters of the EUT according to the utilization equipment performance test procedures to verify that the EUT is providing specified performance for normal aircraft electrical conditions. For each test condition shutdown, the EUT and verify that the EUT can be re-started. After re-start conduct a performance test of the EUT according to the utilization equipment performance test procedures to verify that the EUT is providing specified performance for normal aircraft electrical conditions. Record the voltages, frequency, time duration at test condition, successful/unsuccessful re-start and the performance of the EUT for each test condition in the data sheet shown in table TAC102-III. Repeat for each mode of operation of the EUT.

After all test conditions are complete, adjust the voltage to the nominal steady state voltage of 115 Vrms (line-to-neutral) and adjust the frequency to the nominal steady state frequency of 400 Hz. Conduct a performance test of the EUT to confirm that the EUT has not suffered damage and is providing specified performance for normal aircraft electrical conditions.

Remarks: This test is Not applicable, if equipment design caters continuous (at least 30min) operation from 100 - 125 V AC, 360 – 440 Hz.

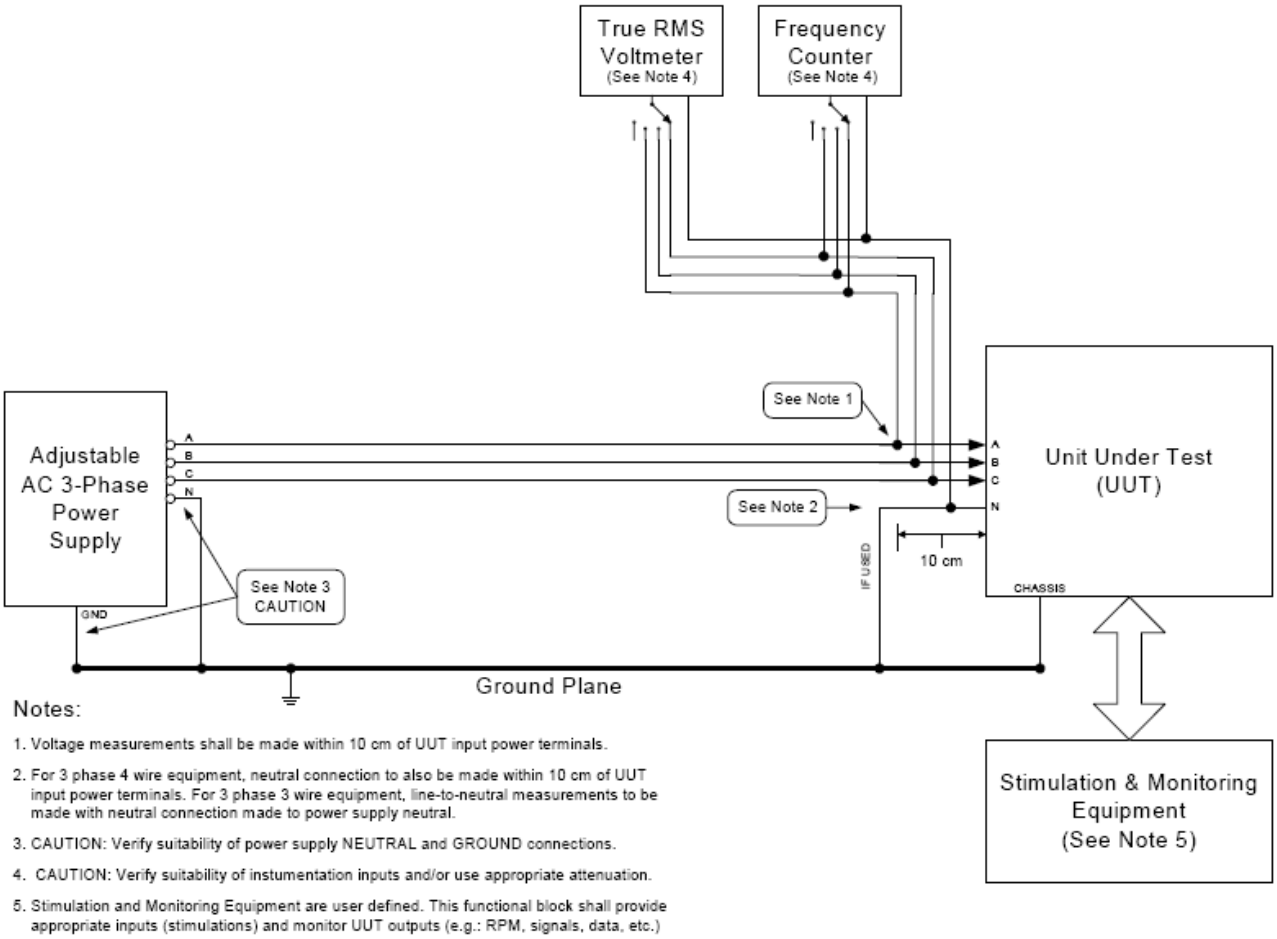


Figure 37: Test Set up for TAC 102, Steady State Limits for Voltage (Including Unbalance) and Frequency

Pass Fail Criteria: The utilization equipment is considered to have passed if the utilization equipment operates and maintains performance for normal aircraft electrical conditions when supplied input power of voltage and frequency at the specified normal steady state limits of the applicable edition(s) of MIL-STD-704 and as noted in table TAC102-I. The utilization equipment must maintain specified performance for a length of time that confirms the utilization equipment can continuously operate at the steady state voltage and frequency limits and should be, not less than thirty (30) minutes for each of the test conditions. The utilization equipment must demonstrate re-start at the steady state voltage and frequency limits. The utilization equipment must not suffer damage or cause an unsafe condition.

Test Results:

Record the Test results as per the sample data sheet provided below.

Table 17- Sample Data sheet for TAC-102 Steady State Limit for Voltage and Frequency (TAC 102-III)

Test Condition	Parameters							Performance
	Phase	Voltage		Frequency		Time Duration at Test Condition	Re-Start (Yes/No)	Pass/Fail
A	A		V_{rms}		Hz	min		
	B		V_{rms}					
	C		V_{rms}					
B	A		V_{rms}		Hz	min		
	B		V_{rms}					
	C		V_{rms}					
C	A		V_{rms}		Hz	min		
	B		V_{rms}					
	C		V_{rms}					
	A		V_{rms}		Hz	min		
	B		V_{rms}					
	C		V_{rms}					
	A		V_{rms}		Hz	min		
	B		V_{rms}					
	C		V_{rms}					
J	A		V_{rms}		Hz	min		
	B		V_{rms}					
	C		V_{rms}					
K	A		V_{rms}		Hz	min		
	B		V_{rms}					
	C		V_{rms}					

5.2.3 TAC 103 – Voltage Phase Difference

Purpose: This test procedure is used to verify that three phase, 115 Volt, 400 Hz power utilization equipment operates and maintains specified performance when provided voltages having phase angles within the limits specified in the applicable edition(s) of MIL-STD-704 D

Test Condition: Test Conditions for the test are provided below,

Table 18: Test conditions for voltage phase difference (TAC 103-II)

Test Condition	Voltage Phase Angle Van	Voltage Phase Angle Vbn	Voltage Phase Angle Vcn
A	0°	116°	240°
B	0°	124°	240°

Test Set Up: Test setup for the test are provided below in figure 38,

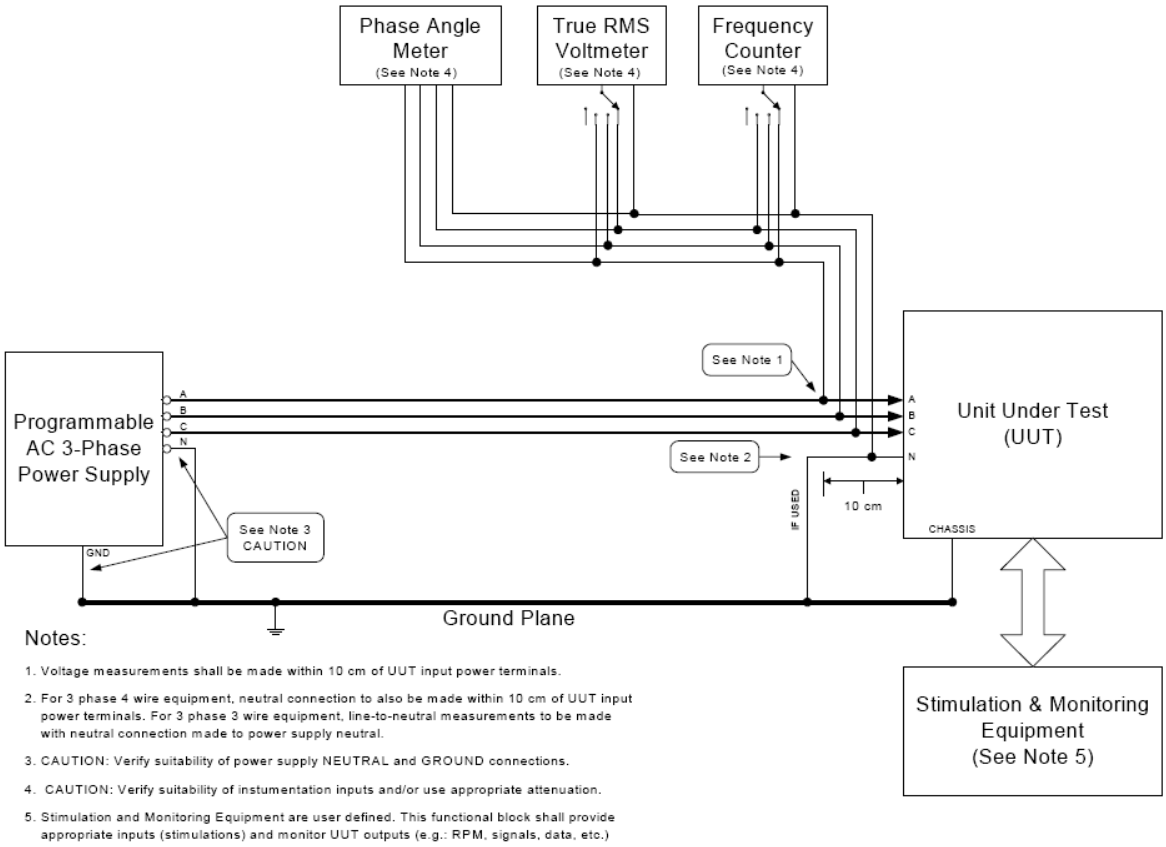


Figure 38: Test Set up for TAC 103-1

Test Procedure: With the power source off, install the EUT and the stimulation and monitoring equipment into the test setup of figure TAC103-1. Turn on the power source and adjust the voltage to the nominal steady state voltage of 115 Vrms (line-to-neutral) and adjust the frequency to the nominal steady state frequency of 400 Hz. Energize the EUT. Allow sufficient time for the EUT to warm up. Conduct a performance test of the EUT to verify that the EUT is providing specified performance for normal aircraft electrical conditions. For each test condition A and B noted in table TAC103-II, the EUT must remain for a length of time that confirms the utilization equipment can continuously operate with voltage phase differences and should be, not less than thirty (30) minutes. The phase angles are referenced to Van. At each test condition conduct a performance test of the EUT to verify that the EUT is providing specified performance for normal aircraft electrical conditions. Record the voltages, frequency, phase angles, time duration at test condition, and the performance of the EUT for each test condition in the data sheet shown in table TAC103-III. Repeat for each mode of operation of the EUT. After all test conditions are complete, adjust the voltage to the nominal steady state voltage of 115 Vrms (line-to-neutral) and adjust the frequency to the nominal steady state frequency of 400 Hz. Adjust the phase angles to Van 0^{o}, Vbn 120^{o}, and Vcn 240^{o}. Conduct a performance test of the EUT to confirm that the EUT has not suffered damage and is providing specified performance for normal aircraft electrical conditions.

Pass Fail Criteria: The utilization equipment is considered to have passed if the utilization equipment operates and maintains performance for normal aircraft electrical conditions when provided voltages having phase angles at the limits of the applicable edition(s) of MIL-STD-704 and as noted in table TAC103-III. The utilization equipment must maintain specified performance for a

length of time that confirms the utilization equipment can continuously operate and should be not less than thirty (30) minutes for each of the test conditions. The utilization equipment must not suffer damage or cause an unsafe condition

Test Record: Record the test results as per the sample data sheet provided below,

Table 19: Sample data sheet for TAC103 voltage phase difference (TAC 103-III)

Test Condition	Parameters										Performance
	Phase	Voltage		Frequency		Phase Angle			Time Duration at Test Condition		Pass/Fail
A	A		V_{rms}		Hz	Van		°		min	
	B		V_{rms}			Vbn		°			
	C		V_{rms}			Vcn		°			
B	A		V_{rms}		Hz	Van		°		min	
	B		V_{rms}			Vbn		°			
	C		V_{rms}			Vcn		°			

5.2.4 TAC 109- Normal Voltage Transients

Purpose: This test procedure is used to verify that three phase, 115 Volt, 400 Hz power utilization equipment operates and maintains specified performance when subjected to normal voltage transients as specified in the applicable edition(s) of MIL-STD-704 D.

Test Level: Test conditions for the test are provided below,

Table 20: Test conditions for MIL-STD-704B, C, D, E and F normal voltage transients (TAC 109-III)

Test Condition	Time From Steady State Voltage to Voltage Transient Level milliseconds	Voltage Transient Level Vrms	Duration at Voltage Transient Level milliseconds	Time From Voltage Transient Level to Steady State Voltage milliseconds
Overvoltage Transients				
AA	< 1.25 msec	140 Vrms	60 msec	< 1.25 msec
BB	< 1.25 msec	140 Vrms	60 msec	25 msec
CC	< 1.25 msec	160 Vrms	34 msec	< 1.25 msec
DD	< 1.25 msec	160 Vrms	34 msec	52 msec
EE	< 1.25 msec	180 Vrms	10 msec	< 1.25 msec
FF	< 1.25 msec	180 Vrms	10 msec	77 msec
GG	< 1.25 msec	180 Vrms (3 times)	10 msec every 0.5 sec	< 1.25 msec
Undervoltage Transients				
HH	< 1.25 msec	90 Vrms	35 msec	< 1.25 msec
II	< 1.25 msec	90 Vrms	35 msec	45 msec
JJ	< 1.25 msec	80 Vrms	10 msec	< 1.25 msec
KK	< 1.25 msec	80 Vrms	10 msec	70 msec
LL	< 1.25 msec	80 Vrms (3 times)	10 msec every 0.5 sec	< 1.25 msec
Combined Transient				
MM	< 1.25 msec then < 1.25 msec	80 Vrms 180 Vrms	10 msec 10 msec	< 1.25 msec 77 msec

Test Set Up: Test set up is indicated in the figure 39 below

Test Procedure:

a) **Procedure for Normal Voltage Transient:** The EUT must be subjected to the voltage transients for each test condition AA through MM noted in table TAC109-III. The voltage must increase or decrease from steady state voltage to the voltage transient level within ½ cycle (1.25 milliseconds). The voltage must remain at the voltage transient level for the duration noted in table TAC109-III. The voltage must return to steady state over the time duration noted in table TAC109-III. For test condition GG, three overvoltage transients of 180 Vrms for 10 milliseconds are performed, separated by 0.5 seconds. For test condition LL, three under voltage transients of 80 Vrms for 10 milliseconds are performed, separated by 0.5 seconds. For test condition MM, an undervoltage transient of 80 Vrms for 10 milliseconds is immediately followed by an overvoltage transient of 180 Vrms for 10 milliseconds and the voltage returns to steady state over the time duration noted. For each test condition, monitor the performance of the EUT during the voltage transient to verify that the EUT is providing specified performance for normal aircraft electrical conditions. Repeat each test condition 5 times. After the power returns to normal steady state limits, conduct a performance test of the EUT to verify that the EUT is providing specified performance for normal aircraft.

b) **Procedure for Repetitive Normal Voltage Transient:** Program the power supply to provide a continually repeating voltage transient that decreases from 115 Vrms to 90 Vrms in 2.5 msec, then increases to 140 Vrms over 50 msec, then decreases to 115 Vrms over 5.0 msec. The voltage transient is repeated every 0.5 seconds, see figure 40 (TAC109-2). The EUT must be subjected to the repetitive voltage transient for a length of time that confirms the utilization equipment can continuously operate and should be not less than thirty (30) minutes. Conduct a performance test of the EUT to verify that the EUT is providing specified performance for normal aircraft electrical conditions. Record the steady state voltages, steady state frequency, high voltage transient level, low voltage transient level, oscilloscope trace, time duration at test condition, and the performance of the EUT in the data sheet shown in table TAC109-V. Repeat for each mode of operation of the EUT. After all test conditions are complete, adjust the voltage to the nominal steady state voltage of 115 Vrms (line-to-neutral) and adjust the frequency to the nominal steady state frequency of 400 Hz. Conduct a performance test of the EUT to confirm that the EUT has not suffered damage and is providing specified performance for normal aircraft electrical conditions.

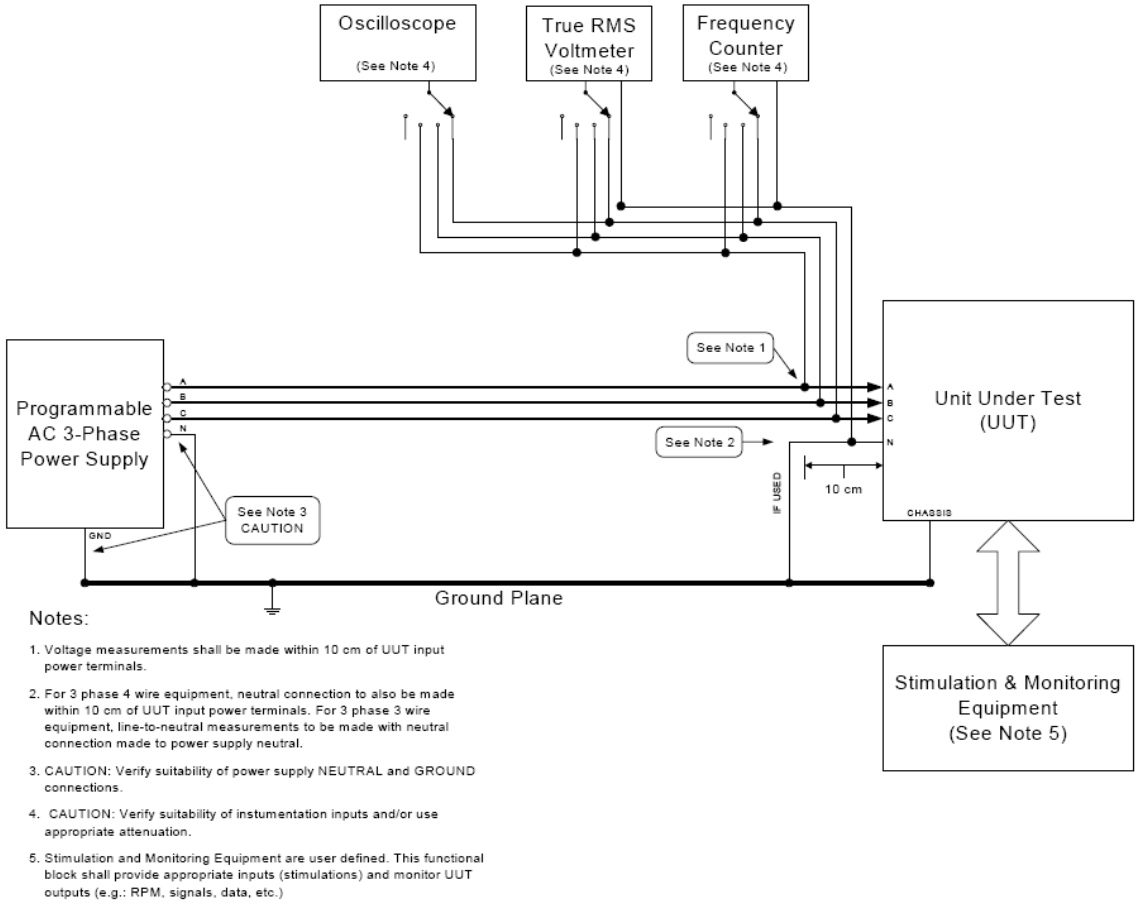


Figure 39: Test Set up for TAC 109

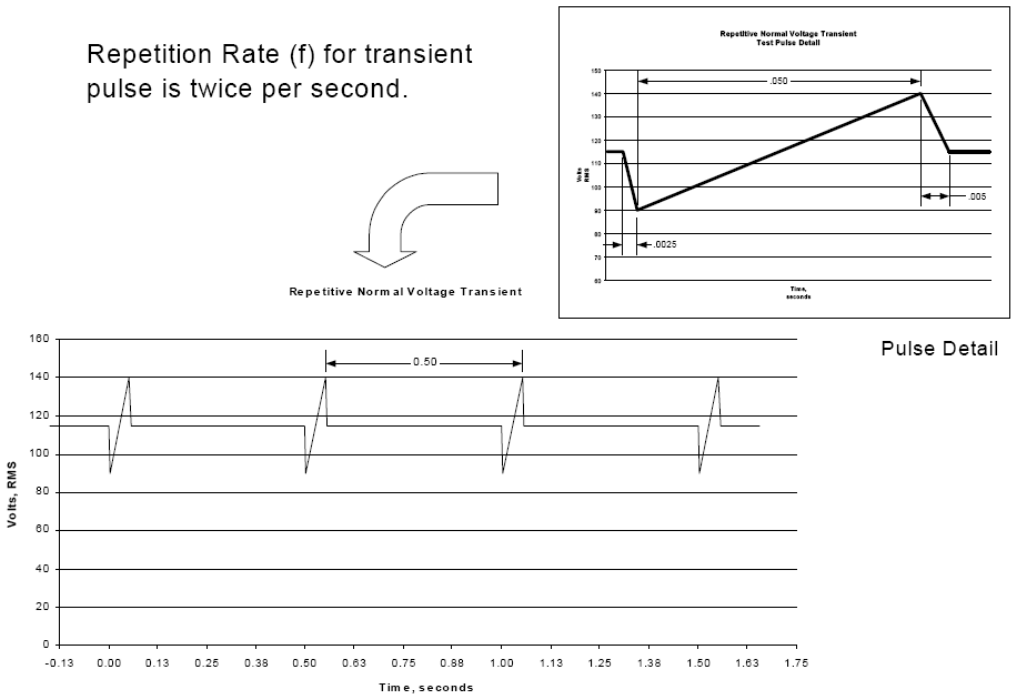


Figure 40: TAC 109-2 Repetitive Normal Voltage Transients

Pass / Fail Criteria: After all test conditions are complete, adjust the voltage to the nominal steady state voltage of 115 Vrms (line-to-neutral) and adjust the frequency to the nominal steady state frequency of 400 Hz. Conduct a performance test of the EUT to confirm that the EUT has not suffered damage and is providing specified performance for normal aircraft electrical conditions

Test Record: Record the test results as per the specified format provided below.

Table 21: Sample data sheet for TAC109 normal voltage transients for MIL-STD-704B, C, D, E & F (TAC 109-V)

Test Condition	Parameters												Performance
	Phase	Steady State Voltage		Steady State Frequency		Voltage Transient		Time at Voltage Transient Level		Oscilloscope Trace			Pass/Fail
AA	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
BB	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
CC	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
DD	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
EE	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
FF	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
GG	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
HH	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
II	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
JJ	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
KK	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
LL	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
MM	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
	A						V_{rms}		msec				
	B						V_{rms}		msec				
	C						V_{rms}		msec				
Repetitive Transient	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace	V_{rms} vs. Time		
	B		V_{rms}				V_{rms}		msec				
	C		V_{rms}				V_{rms}		msec				
	A						V_{rms}		msec				
	B						V_{rms}		msec				
	C						V_{rms}		msec				
	Time duration at test condition											min	

5.2.5 TAC-110 Normal Frequency Transients

Purpose: This test procedure is used to verify that three phase, 115 Volt, 400 Hz power utilization equipment operates and maintains specified performance when subjected to normal frequency transients as specified in the applicable edition(s) of MIL-STD-704

Test Conditions: Test conditions for the test are specified below,

Table 22: Test conditions for MIL-STD-704B, C, D, and F normal frequency transients (TAC 110-III)

Test Condition	Time From Steady State Frequency to Frequency Transient Level milliseconds	Frequency Transient Level Hz	Duration at Frequency Transient Level	Time From Frequency Transient Level to Steady State Frequency milliseconds
Overfrequency Transients				
AA	40 msec	410 Hz	10 seconds	40 msec
BB	80 msec	420 Hz	5 seconds	80 msec
CC	100 msec	425 Hz	1 seconds	100 msec
DD	100 msec then 10 msec then 20 msec	425 Hz 420 Hz 410 Hz	1 seconds 4 seconds 5 seconds	10 msec 20 msec 40 msec
Underfrequency Transients				
EE	40 msec	390 Hz	10 seconds	40 msec
FF	80 msec	380 Hz	5 seconds	80 msec
GG	100 msec	375 Hz	1 seconds	100 msec
HH	100 msec then 10 msec then 20 msec	375 Hz 380 Hz 390 Hz	1 seconds 4 seconds 5 seconds	10 msec 20 msec 40 msec
Combined Transient				
II	100 msec then 100 msec	375 Hz 425 Hz	1 seconds 1 seconds	100 msec 100 msec

Test Set Up: Test set up is indicated in the figure 40, same as the test setup for TAC 109

Test Procedure: The EUT must be subjected to the frequency transients for each test condition AA through II noted in table TAC110-III. The frequency must increase or decrease from steady state frequency to the frequency transient level over the duration noted; the frequency must remain at the frequency transient level for the duration noted; and the frequency must return from the frequency transient level over the duration noted. For test condition II, an under frequency transient of 375 Hz is immediately followed by an over frequency transient of 425 Hz. For each test condition, monitoring the performance of the EUT during the frequency transient to verify that the EUT is providing specified performance for normal aircraft electrical conditions. Repeat each test condition 5 times. After the power returns to normal steady state limits, conduct a performance test of the EUT to verify that the EUT is providing specified performance for normal aircraft electrical conditions. Record the steady state voltages, steady state frequency, frequency transient level, time at frequency transient, oscilloscope trace (Hz vs. time), and the performance of the EUT for each test condition in the data sheet shown in table TAC110-V. Repeat for each mode of operation of the EUT.

Pass/ Fail Criteria: After all test conditions are complete, adjust the voltage to the nominal steady state voltage of 115 Vrms (line-to-neutral) and adjust the frequency to the nominal steady state frequency of 400 Hz. Conduct a performance test of the EUT to confirm that the EUT has not suffered damage and is providing specified performance for normal aircraft electrical conditions.

Test Records: Record the test results as per the table provided below,

Table 23: Sample data sheet for TAC110 normal voltage transients for MIL-STD-704B, C, D, E & F (TAC110-V)

Test Condition	Parameters											Performance
	Phase	Voltage		Frequency		Frequency Transient		Time at Frequency Transient Level		Oscilloscope Trace		Pass/Fail
AA	A		V_{rms}		Hz		Hz		sec	Attach Trace	Hz vs. Time	
	B		V_{rms}									
	C		V_{rms}									
BB	A		V_{rms}		Hz		Hz		sec	Attach Trace	Hz vs. Time	
	B		V_{rms}									
	C		V_{rms}									
CC	A		V_{rms}		Hz		Hz		sec	Attach Trace	Hz vs. Time	
	B		V_{rms}									
	C		V_{rms}									
DD	A		V_{rms}		Hz		Hz		sec	Attach Trace	Hz vs. Time	
	B		V_{rms}									
	C		V_{rms}									
EE	A		V_{rms}		Hz		Hz		sec	Attach Trace	Hz vs. Time	
	B		V_{rms}									
	C		V_{rms}									
FF	A		V_{rms}		Hz		Hz		sec	Attach Trace	Hz vs. Time	
	B		V_{rms}									
	C		V_{rms}									
GG	A		V_{rms}		Hz		Hz		sec	Attach Trace	Hz vs. Time	
	B		V_{rms}									
	C		V_{rms}									
HH	A		V_{rms}		Hz		Hz		sec	Attach Trace	Hz vs. Time	
	B		V_{rms}									
	C		V_{rms}									
II	A		V_{rms}		Hz		Hz		sec	Attach Trace	Hz vs. Time	
	B		V_{rms}									
	C		V_{rms}									
							Hz		sec			

5.2.6 TAC-301: Abnormal Limits for Voltage and Frequency

Purpose: This test procedure is used to verify that three phase, 115 Volt, 400 Hz power utilization equipment operates and maintains specified performance when provided power with voltage and frequency at the Abnormal Low Steady State (ALSS) limits and the Abnormal High Steady State (AHSS) limits as specified in the applicable edition(s) of MIL-STD-704 D.

Test Levels: Test levels and test conditions are provided below,

Table 24: MIL-STD-704 abnormal limits for steady state voltage and frequency (TAC 301-I)

Abnormal Limit	704A	704B	704C	704D	704E	704F
Voltage ALSS	102 V	100 V	100 V	100 V	100 V	100 V
Voltage AHSS	124 V	125 V	125 V	125 V	125 V	125 V
Frequency ALSS	370 Hz	375 Hz	380 Hz	375 Hz	380 Hz	380 Hz
Frequency AHSS	430 Hz	425 Hz	420 Hz	425 Hz	420 Hz	420 Hz

Table 25: Test conditions for abnormal steady state limits for voltage and frequency (TAC 301-II)

Test Condition	Voltage	Frequency
A	Nominal Voltage	ALSS Frequency
B	Nominal Voltage	AHSS Frequency
C	ALSS Voltage	Nominal Frequency
D	ALSS Voltage	ALSS Frequency
E	ALSS Voltage	AHSS Frequency
F	AHSS Voltage	Nominal Frequency
G	AHSS Voltage	ALSS Frequency
H	AHSS Voltage	AHSS Frequency

Test Set Up: Test set up is indicated in the below figure 41

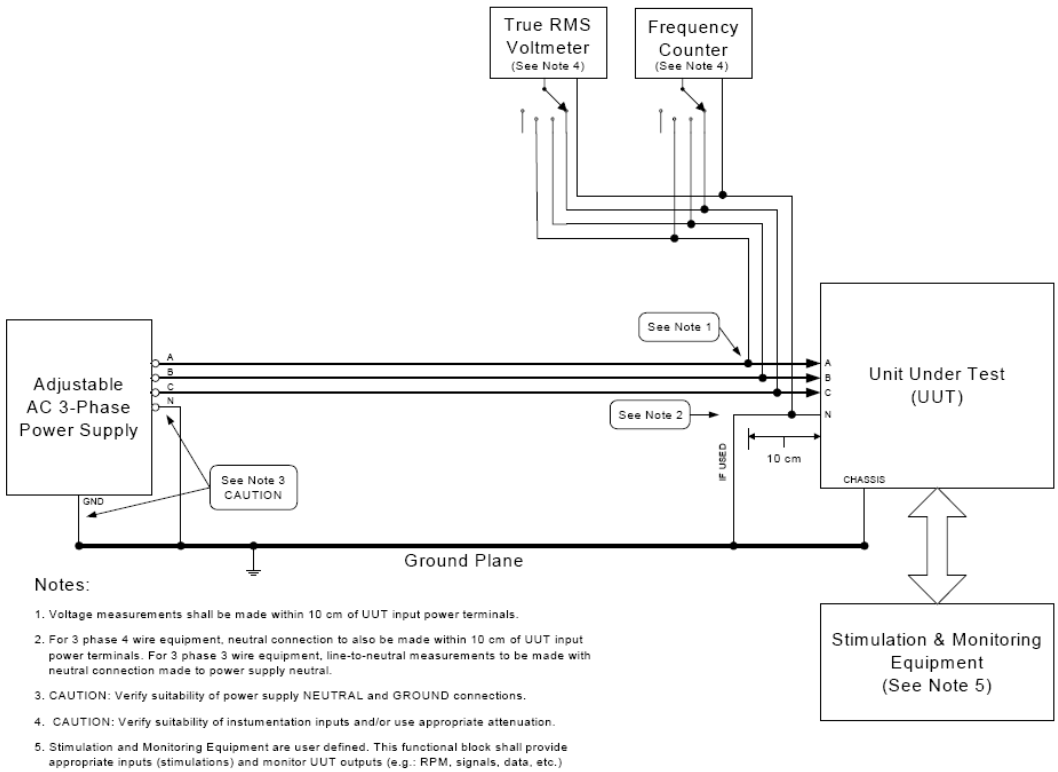


Figure 41: Test Set up for TAC 301

Test Procedure: With the power source off, install the EUT and the stimulation and monitoring equipment into the test setup of figure TAC301-1. Turn on the power source and adjust the voltage to the nominal steady state voltage of 115 Vrms (line-to-neutral) and adjust the frequency to the nominal steady state frequency of 400 Hz. Energize the EUT. Allow sufficient time for the EUT to warm up. Conduct a performance test of the EUT to verify that the EUT is providing specified performance for normal aircraft electrical conditions. For each test condition A through H noted in table TAC301-II, the EUT must remain for a length of time that confirms the utilization equipment can perform as specified at the abnormal steady state voltage and frequency limits and should be not less than thirty (30) minutes. At each test condition conduct a performance test of the EUT to verify that the EUT is providing specified performance for abnormal aircraft electrical conditions. For each test condition shut down the EUT and verify that the EUT can be re-started. After re-start, conduct a performance test of the EUT to verify that the EUT is providing specified performance for abnormal aircraft electrical conditions. Adjust the voltage to the nominal steady state voltage of 115 Vrms and adjust the frequency to the nominal steady state frequency of 400 Hz. Conduct a performance test of the EUT to confirm that the EUT has automatically returned to the performance specified for normal aircraft electrical conditions, and has not suffered damage. Record the voltages, frequency, time duration at test condition, successful/unsuccessful re-start and the performance of the EUT for each test condition in the data sheet shown in table TAC301-III. Repeat for each mode of operation of the EUT. After all test conditions are complete, adjust the voltage to the nominal steady state voltage of 115 Vrms (line-to-neutral) and adjust the frequency to the nominal steady state frequency of 400 Hz. Conduct a performance test of the EUT to confirm that the EUT has not suffered damage and is providing specified performance for normal aircraft electrical conditions.

Remarks: This test is Not applicable, if equipment design caters continuous (at least 30min) operation from 100 - 125 V AC, 360 – 440 Hz.

Pass / **Fail Criteria:** The utilization equipment is considered to have passed if the utilization equipment operates and maintains performance as specified in the utilization equipment performance specification document for abnormal aircraft electrical conditions when supplied input power of voltage and frequency at the specified abnormal steady state limits of the applicable edition(s) of MIL-STD-704 and as noted in table TAC301-I. The utilization equipment must maintain specified performance for a length of time that confirms the utilization equipment can continuously operate at the abnormal steady state voltage and frequency limits and should be not less than thirty (30) minutes for each of the test conditions. Unless otherwise specified in the utilization equipment performance specification document, the utilization equipment must demonstrate re-start at the abnormal steady state voltage and frequency limits. Unless otherwise specified in the utilization equipment performance specification document, the utilization equipment must automatically return to the performance specified for normal aircraft electrical conditions when the power returns to within normal limits. The utilization equipment must not suffer damage or cause an unsafe condition.

Test Record: Test Results should be recorded as per the table provided below,

Table 26: Sample data sheet for TAC301abnormal steady state limits for voltage and frequency (TAC 301-III)

Test Condition	Parameter							Performance
	Phase	Voltage		Frequency		Time Duration at Test Condition		Pass/Fail
A	A		V_{rms}		Hz		min	
	B		V_{rms}					
	C		V_{rms}					
B	A		V_{rms}		Hz		min	
	B		V_{rms}					
	C		V_{rms}					
C	A		V_{rms}		Hz		min	
	B		V_{rms}					
	C		V_{rms}					
D	A		V_{rms}		Hz		min	
	B		V_{rms}					
	C		V_{rms}					
E	A		V_{rms}		Hz		min	
	B		V_{rms}					
	C		V_{rms}					
F	A		V_{rms}		Hz		min	
	B		V_{rms}					
	C		V_{rms}					
G	A		V_{rms}		Hz		min	
	B		V_{rms}					
	C		V_{rms}					
H	A		V_{rms}		Hz		min	
	B		V_{rms}					
	C		V_{rms}					

5.2.7 TAC-302: Abnormal Voltage Transients

Purpose: This test procedure is used to verify that three phase, 115 Volt, 400 Hz power utilization equipment operates and maintains specified performance when subjected to abnormal voltage transients as specified in the applicable edition(s) of MIL-STD-704.

Test Levels: Test levels for the test are provided below,

Table 27: Test conditions for MIL-STD-704B, C, D, E, and F abnormal voltage transients (TAC 302-III)

Test Condition	Time From Steady State Voltage to Voltage Transient Level milliseconds	Voltage Transient Level Vrms	Duration at Voltage Transient Level milliseconds	Time From Voltage Transient Level to Steady State Voltage or Next Voltage Level
Undervoltage Transients				
HH	< 1.25 msec	85 Vrms	180 msec	< 1.25 msec
II	< 1.25 msec	85 Vrms	180 msec	87 msec
	then	90 Vrms	increasing	253 msec
	then	95 Vrms	increasing	6.41 sec
	then	100 Vrms	increasing	>10 sec
		115 Vrms		
JJ	< 1.25 msec	66 Vrms	78 msec	< 1.25 msec
KK	< 1.25 msec	65 Vrms	78 msec	31 msec
	then	75 Vrms	increasing	71 msec
	then	85 Vrms	increasing	87 msec
	then	90 Vrms	increasing	253 msec
	then	95 Vrms	increasing	6.41 sec
	then	100 Vrms	increasing	>10 sec
		115 Vrms		
LL	< 1.25 msec	45 Vrms	50 msec	< 1.25 msec
MM	< 1.25 msec	45 Vrms	50 msec	11 msec
	then	55 Vrms	increasing	17 msec
	then	65 Vrms	increasing	31 msec
	then	75 Vrms	increasing	71 msec
	then	85 Vrms	increasing	87 msec
	then	90 Vrms	increasing	253 msec
	then	95 Vrms	increasing	6.41 sec
	then	100 Vrms	increasing	>10 sec
		115 Vrms		
NN	< 1.25 msec	45 Vrms (3 times)	20 msec every 0.5 sec	< 1.25 msec
Combined Transient				
OO	< 1.25 msec	45 Vrms then	20 msec	< 1.25 msec
	< 1.25 msec	180 Vrms	50 msec	11 msec
	then	170 Vrms	decreasing	17 msec
	then	160 Vrms	decreasing	31 msec
	then	150 Vrms	decreasing	71 msec
	then	140 Vrms	decreasing	87 msec
	then	135 Vrms	decreasing	253 msec
	then	130 Vrms	decreasing	6.41 sec
	then	125 Vrms	decreasing	>10 sec
		115 Vrms		

Test Set Up: Test set up is indicated in the below figure 42

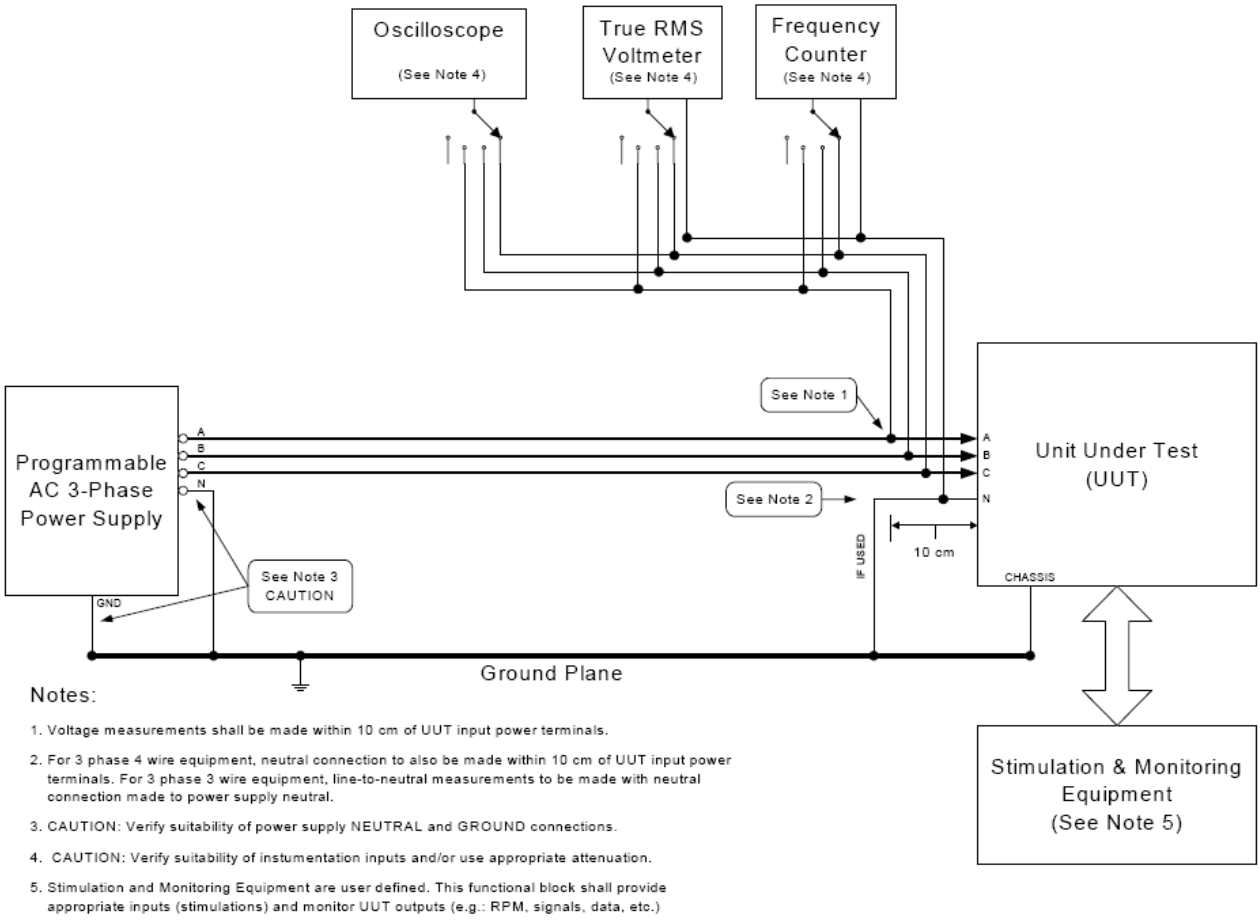


Figure 42: Test Set up for TAC 302

Test Procedure: The EUT must be subjected to the voltage transients for each test condition AA through OO noted in table TAC302-III. The voltage must increase or decrease from steady state voltage to the voltage transient level within ½ cycle (1.25 milliseconds). The voltage must remain at the voltage transient level for the duration noted in table TAC302-III. The voltage must return to steady state over the time duration noted in table TAC303-III. For test condition GG, three over-voltage transients of 180 Vrms for 20 milliseconds are performed, separated by 0.5 seconds. For test condition NN, three under-voltage transients of 45 Vrms for 20 milliseconds are performed, separated by 0.5 seconds. For test condition OO, an under-voltage transient of 45 Vrms for 20 milliseconds is immediately followed by an overvoltage transient of 180 Vrms for 50 milliseconds and the voltage returns to steady state over the time duration noted. For each test condition, monitor the performance of the EUT during the voltage transient to verify that the EUT is providing specified performance for abnormal aircraft electrical conditions. Repeat each test condition 5 times. After the power returns to normal limits, conduct a performance test of the EUT to verify that the EUT automatically returns to specified performance for normal aircraft electrical conditions when the power returns to within normal limits, and has not suffered damage. Record the steady state voltages, steady state frequency, voltage transient level, time duration at voltage transient,

oscilloscope trace, and the performance of the EUT for each test condition in the data sheet shown in table TAC302-V. Repeat for each mode of operation of the EUT.

Pass/ Fail Criteria: The utilization equipment is considered to have passed if the utilization equipment operates and maintains performance for abnormal aircraft electrical conditions when subjected to voltage transients within the abnormal limits of the applicable edition(s) of MIL-STD-704D and as noted in Figure 43. Unless otherwise specified in the utilization equipment performance specification document, the utilization equipment must automatically return to the performance specified for normal aircraft electrical conditions when the power returns to within normal limits. The utilization equipment must not suffer damage or cause an unsafe condition.

Test Records: Record the test results as per the format provided below,

Table 28: Sample data sheet for TAC302 abnormal voltage transients for MIL-STD-704B, C, D, E & F (TAC 302-V)

Test Condition	Parameters										Performance
	Phase	Steady State Voltage		Steady State Frequency		Voltage Transient		Time at Voltage Transient Level		Oscilloscope Trace	Pass/Fail
AA	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace V_{rms} vs. Time	
	B		V_{rms}				V_{rms}		msec		
	C		V_{rms}				V_{rms}		msec		
BB	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace V_{rms} vs. Time	
	B		V_{rms}				V_{rms}		msec		
	C		V_{rms}				V_{rms}		msec		
CC	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace V_{rms} vs. Time	
	B		V_{rms}				V_{rms}		msec		
	C		V_{rms}				V_{rms}		msec		
DD	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace V_{rms} vs. Time	
	B		V_{rms}				V_{rms}		msec		
	C		V_{rms}				V_{rms}		msec		
EE	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace V_{rms} vs. Time	
	B		V_{rms}				V_{rms}		msec		
	C		V_{rms}				V_{rms}		msec		
FF	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace V_{rms} vs. Time	
	B		V_{rms}				V_{rms}		msec		
	C		V_{rms}				V_{rms}		msec		
GG	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace V_{rms} vs. Time	
	B		V_{rms}				V_{rms}		msec		
	C		V_{rms}				V_{rms}		msec		
NN	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace V_{rms} vs. Time	
	B		V_{rms}				V_{rms}		msec		
	C		V_{rms}				V_{rms}		msec		
OO	A		V_{rms}		Hz		V_{rms}		msec	Attach Trace V_{rms} vs. Time	
	B		V_{rms}				V_{rms}		msec		
	C		V_{rms}				V_{rms}		msec		
	A						V_{rms}		msec		
	B						V_{rms}		msec		
	C						V_{rms}		msec		

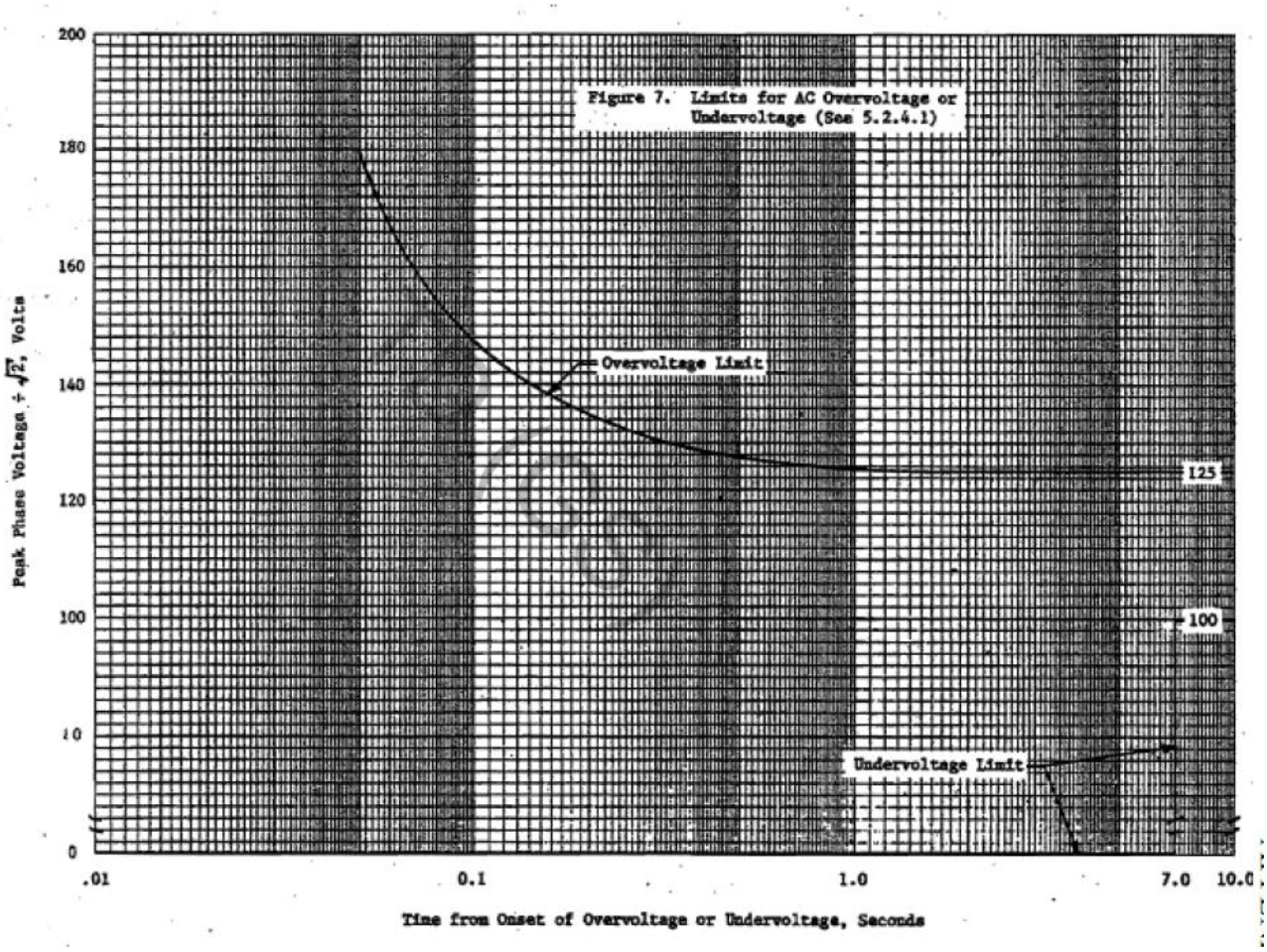


Figure 43: Envelope of abnormal AC Frequency Transient
(Figure-7 of MIL-STD-704D)

5.2.8 TAC 303 Abnormal Frequency Transients

Purpose: This test procedure is used to verify that three phase, 115 Volt, 400 Hz power utilization equipment operates and maintains specified performance when subjected to abnormal frequency transients as specified in the applicable edition(s) of MIL-STD-704

Test Level: Test conditions for the abnormal frequency transients are provided below in table 29, and the Limits of abnormal frequency transients are given in below figure 44.

Table 29: Test conditions for MIL-STD-704B, C, D, E, and F abnormal voltage transients (TAC 303-III)

Test Condition	Time From Steady State Frequency to Frequency Transient Level milliseconds	Frequency Transient Level Hz	Duration at Frequency Transient Level	Time From Frequency Transient Level to Steady State Frequency milliseconds
Overfrequency Transients				
AA	160 msec	480 Hz	½ cycle	160 msec
BB	160 msec	480 Hz	4.78 seconds	160 msec
Underfrequency Transients				
CC	160 msec	320 Hz	½ cycle	160 msec
DD	160 msec	320 Hz	4.78 seconds	160 msec
Combined Transient				
EE	160 msec 160 msec	320 Hz then 480 Hz	½ cycle ½ cycle	160 msec 160 msec

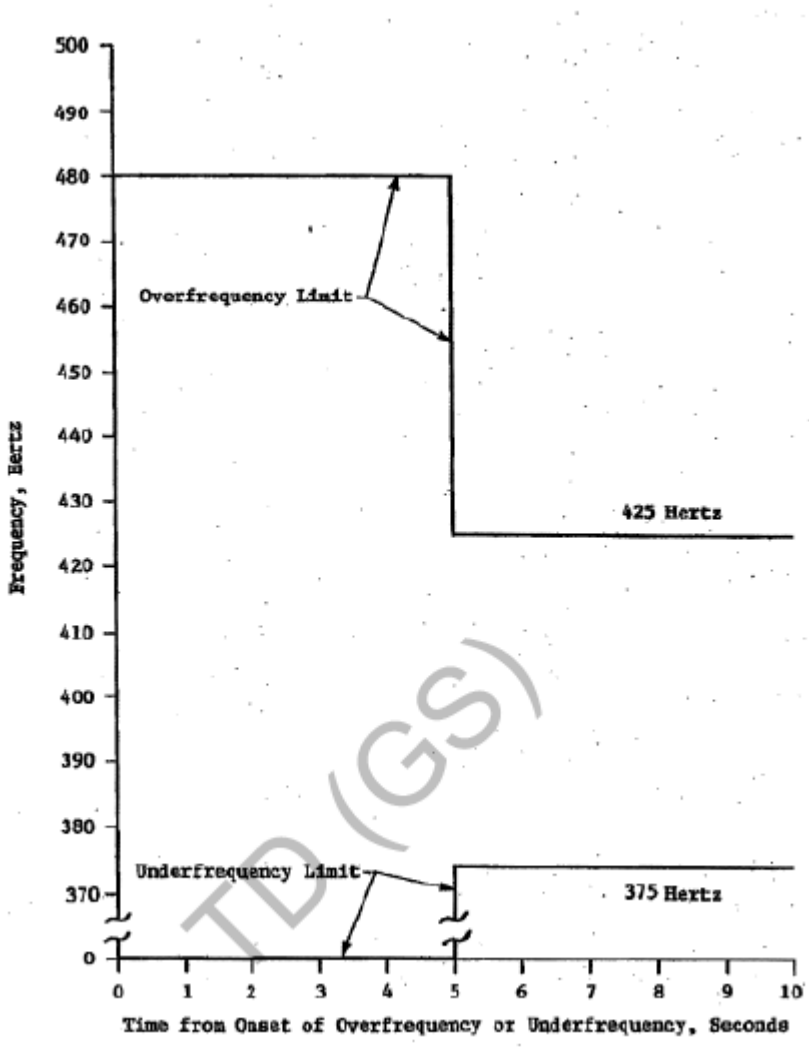


Figure 44: Limits of AC over frequency or Under frequency (Figure-8 of MIL-STD-704D)

Test set up: Test set up is indicated in Fig provided below in figure 45,

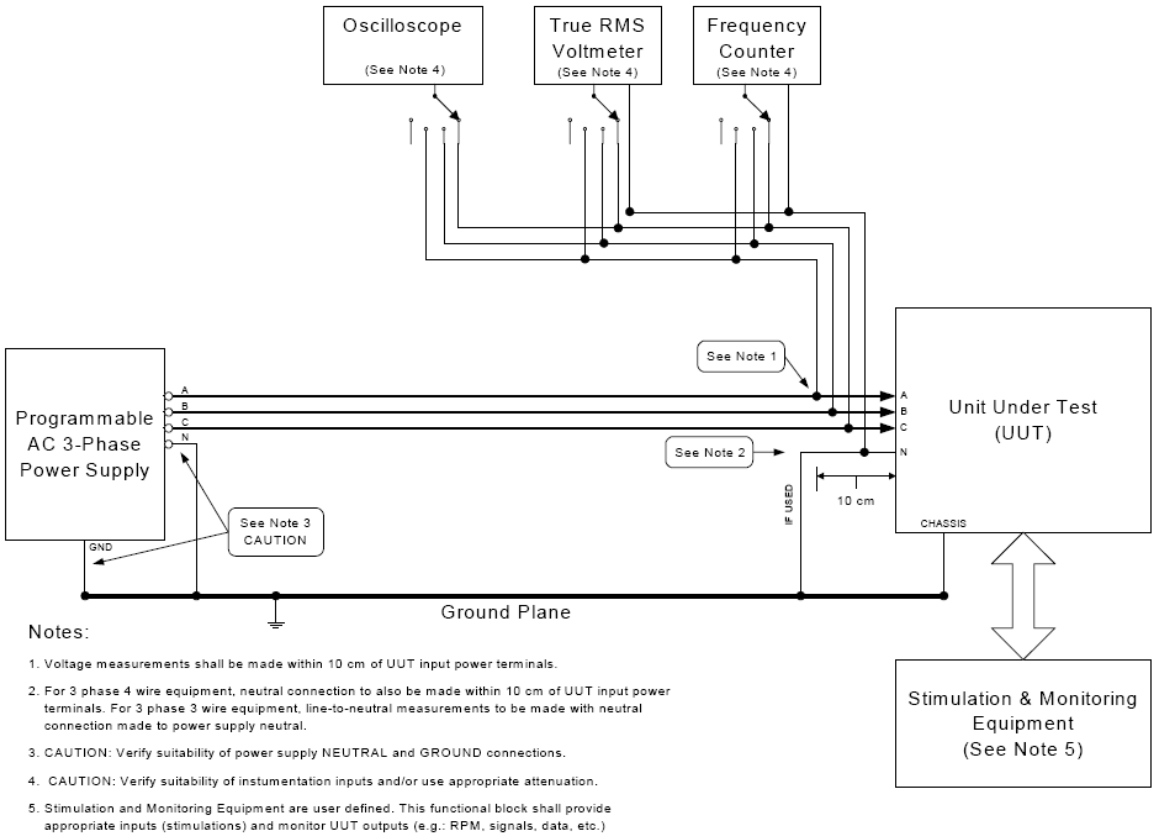


Figure 45: Test Set up for TAC 303

Test Procedure: The EUT must be subjected to the frequency transients for each test condition AA through EE noted in table TAC303-III. The frequency must increase or decrease from steady state frequency to the frequency transient level over the duration noted; the frequency must remain at the frequency transient level for the duration noted; and the frequency must return from the frequency transient level over the duration noted. For test condition EE, an under frequency transient of 320 Hz is immediately followed by an over frequency transient of 480 Hz. For each test condition, monitor the performance of the EUT during the frequency transient to verify that the EUT is providing specified performance for abnormal aircraft electrical conditions. Repeat each test condition 5 times. After the power returns to normal limits, conduct a performance test of the EUT to verify that the EUT is providing specified performance for normal aircraft electrical conditions, and has not suffered damage. Record the steady state voltages, steady state frequency, frequency transient level, time at frequency transient, oscilloscope trace (Hz vs. time), and the performance of the EUT for each test condition in the data sheet shown in table TAC303-V. Repeat for each mode of operation of the EUT.

Pass/ Fail Criteria: The utilization equipment is considered to have passed if the utilization equipment operates and maintains performance as specified in the utilization equipment performance specification document for abnormal aircraft electrical conditions when subjected to voltage transients within the abnormal limits of the applicable edition(s) of MIL-STD-704 and within the limits of figure 43. Unless otherwise specified in the utilization equipment performance

specification document, the utilization equipment must automatically return to the performance specified for normal aircraft electrical conditions when the power returns to within normal limits. The utilization equipment must not suffer damage or cause an unsafe condition.

Test Records: Record the test results as per the format provided below,

Table 30: Sample data sheet for TAC303 abnormal frequency transients for MIL-STD-704D (TAC 302-V)

Test Condition	Parameters												Performance
	Phase	Steady State Voltage		Steady State Frequency		Frequency Transient		Time at Frequency Transient Level		Oscilloscope Trace			Pass/Fail
AA	A		V_{rms}		Hz		Hz		msec	Attach Trace	Hz vs. Time		
	B		V_{rms}										
	C		V_{rms}										
BB	A		V_{rms}		Hz		Hz		sec	Attach Trace	Hz vs. Time		
	B		V_{rms}										
	C		V_{rms}										
CC	A		V_{rms}		Hz		Hz		msec	Attach Trace	Hz vs. Time		
	B		V_{rms}										
	C		V_{rms}										
DD	A		V_{rms}		Hz		Hz		sec	Attach Trace	Hz vs. Time		
	B		V_{rms}										
	C		V_{rms}										
EE	A		V_{rms}		Hz		Hz		msec	Attach Trace	Hz vs. Time		
	B		V_{rms}										
	C		V_{rms}										
							Hz		msec				

5.2.9 TAC 401 Emergency Limits for Voltage and Frequency

Purpose: This test procedure is used to verify that three phase, 115 Volt, 400 Hz power utilization equipment operates and maintains specified performance when provided power with voltage and frequency at that the Emergency Low Steady State (ELSS) limits and the Emergency High Steady State (EHSS) limits as specified in the applicable MIL-STD-704 D.

Test Level: The emergency test limits for steady state voltage and frequency are given below.

Voltage ELSS : 104 V

Voltage EHSS : 122 V

Frequency ELSS : 360 Hz

Frequency EHSS : 440 Hz

The test conditions for emergency steady state limits for voltage and frequency are given in the below table 31

Table 31: Test conditions for emergency steady state limits for voltage and frequency (TAC 401-II)

Test Condition	Voltage	Frequency
A	Nominal Voltage	ELSS Frequency
B	Nominal Voltage	EHSS Frequency
C	ELSS Voltage	Nominal Frequency
D	ELSS Voltage	ELSS Frequency
E	ELSS Voltage	EHSS Frequency
F	EHSS Voltage	Nominal Frequency
G	EHSS Voltage	ELSS Frequency
H	EHSS Voltage	EHSS Frequency

Remarks:

a) This test is Not applicable, if equipment design caters continuous (at least 30min) operation from 100 - 125 V AC, 360 – 440 Hz.
b) Perform functional Check with Solenoid valve switch OFF on EUT as given in the para 2.3 (points 'a' to 'e') after test.

Pass/ Fail Criteria: The utilization equipment is considered to have passed if the utilization equipment operates and maintains performance as specified in the utilization equipment performance specification document for emergency aircraft electrical conditions when supplied input power of voltage and frequency at the specified emergency steady state limits of the applicable MIL-STD-704D and as noted in table TAC401-I. The utilization equipment must maintain specified performance for a length of time that confirms the utilization equipment can continuously operate at the emergency steady state voltage and frequency limits and should be, not less than thirty (30) minutes for each of the test conditions. Unless otherwise specified in the utilization equipment performance specification document, the utilization equipment must demonstrate re-start at the emergency steady state voltage and frequency limits. Unless otherwise specified in the utilization equipment performance specification document, the utilization must automatically return to the performance specified for normal aircraft electrical conditions when the power returns to within normal limits. The utilization equipment must not suffer damage or cause an unsafe condition.

5.2.10 TAC 602 One Phase and Two Phase Power Failures

Purpose: This test procedure is used to verify that three phase, 115 Volt, 400 Hz power utilization equipment operates and maintains specified performance when subjected to one and two phase power failures (7 seconds and indefinitely) as specified in the applicable edition(s) of MIL-STD-704

Test Level: The power failure limits of TAC 602 are 7seconds and indefinitely as per the Figure 43 - Envelope of abnormal AC Frequency Transient (Figure-7 of MIL-STD-704D).

Test conditions for the abnormal frequency transients are provided below in table 29.

Table 31: Test conditions one and two phase power failures (TAC 602-II)

Test Condition	Phases	Duration of Power Failure
One Phase Power Failure		
A	Phase A	7 seconds
B	Phase B	7 seconds
C	Phase C	7 seconds
D	Phase A	Indefinitely
E	Phase B	Indefinitely
F	Phase C	Indefinitely
Two Phase Power Failures		
G	Phase A & B	7 seconds
H	Phase B & C	7 seconds
I	Phase A & B	Indefinitely
J	Phase B & C	Indefinitely

Remarks: Perform functional Check with Solenoid valve switch OFF on EUT as given in the para 2.3 (points 'a' to 'e') after test.

Pass/ Fail Criteria: The utilization equipment is considered to have passed if the utilization equipment operates and maintains performance as specified in the utilization equipment performance specification document for power failure aircraft electrical conditions when subjected to power failures as specified by the applicable edition(s) of MIL-STD-704 and as noted in table TAC602-I. The utilization equipment must maintain the specified performance during one and two phase power failures. The utilization equipment must maintain specified performance for a length of time that confirms the utilization equipment can continuously operate with one and two phase power failures and should be not less than thirty (30) minutes for each of the test conditions. Unless otherwise specified in the utilization equipment performance specification document, the utilization equipment must automatically return to the performance specified for normal aircraft electrical conditions when the power returns to within normal limits. The utilization equipment must not suffer damage or cause an unsafe condition.

5.2.11 TAC 603 Phase Reversal (Three Phase)

Purpose: This test procedure is used to verify that three phase, 115 Volt, 400 Hz power utilization equipment is not damaged by phase reversal or a positive physical means is employed to prevent phase reversal.

Test Severity: Phase Reversal should not cause damage

Remarks: Perform functional Check with Solenoid valve switch OFF on EUT as given in the para 2.3 (points 'a' to 'e') after test.

Pass/ Fail Criteria: The utilization equipment is considered to have passed if the utilization equipment is not damaged and does not cause an unsafe condition when the input phase sequence is reversed. A positive physical means to prevent phase sequence reversal may be used to fulfill this requirement.

6 Dielectric Withstanding Voltage Test

Purpose

This test is to determine that the Pump Module can withstand dielectric voltage of 1500 V AC with 50/60 Hz Frequency for a single time.

Test Procedure

a. Set the breakdown tester to test Voltage of 1500 V AC with 50/60 Hz Frequency.

b. The voltage shall be increased gradually from 0 to 1500 Volts within 5 secs and shall be maintained for a period of 60 seconds.

c. The unit shall not show any evidence of break down and there shall not be any leakage current.

d. If test is repeated, use 50% of the initial voltage as test voltage (750 V).

Remarks : This Test shall be conducted only once on one of the qualification test units. Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test

Pass/Fail Criteria

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

7 Endurance Test

Purpose

This test is to determine that the Pump Module can withstand continuous operation and operate throughout its life determined.

Test Procedure

a. Pump should be tested for continuous operation of 10 hrs per day with full load.

b. Test to be carried out for total 6000 hours at fully operational condition.

c. Visually examine the EUT to the extent possible.

Remarks : This Test is carried out on one of the qualification test units. Perform functional Check with Solenoid valve switch OFF on EUT as given in the Para 2.3 (points 'a' to 'e') after test

Pass/Fail Criteria

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

8 Burst Pressure Test

Purpose

This test is to determine that the Monoblock can withstand maximum pressure condition without failure.

Test Procedure

The Burst pressure checks shall be carried out using the and as per the procedure given below. Results are to be documented in Table-30:

a) Pressurize the Monoblock with a help of charging equipment. Ethylene Glycol Water Mixture (65:35) or Nycosol-51 can be used for pressurizing the Pump module.
b) Ensure that all the ports of Monoblock are closed.
c) Slowly pressurise unit to 21.25 bar g (2.5 times the operating Pressure) and Isolate the Monoblock from the pressure source.
d) Keep the pump module isolated from the pressure source and monitor the pressure for 3 minutes.
e) Slowly reduce the pressure to atmospheric pressure.

Acceptance criteria – There should be no leakage, no crack or any other physical damage in the Monoblock.

Table 30: Burst pressure check

Sl. No.	Test	Observations	Pass/Fail
1	Burst pressure test		