



**REPORT TITLE : TECHNICAL SPECIFICATION OF  
MAIN HYDRAULIC PUMP**

**PROJECT-VARIANT: LCA AF Mk2**

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**AIRCRAFT RESEARCH & DESIGN CENTRE  
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## RELEASE RECORD TABLE

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## TECHNICAL SPECIFICATION OF MAIN HYDRAULIC PUMP - LCA AF Mk2

### 1 Introduction:

This document defines technical specification of hydraulic pump for LCA Airforce Mk2 (LCA AF Mk2) aircraft. The pump shall be designed as per the SAE AS19692 REV. A for a 280 bar (4060 psi), Type II aircraft hydraulic system conforming to and defined as per the SAE AS5440A and in accordance with SAE AS8775.

### 2 Applicable documents:

Relevant and applicable portions of the regulations & standards listed below shall be considered & satisfied as a part of Design, Manufacture & Testing of the hydraulic pump.

- SAE AS5440A : Hydraulic system Design
- SAE AS19692 REV. A : Variable flow hydraulic Pumps
- SAE AS8775 : Hydraulic System Components
- MIL-STD-810H : Environmental Test Methods
- MIL-PRF-5606J : Hydraulic Fluid - Petroleum based
- MIL-PRF-83282D : Hydraulic Fluid - Fire Resistant Hydrocarbon Based
- MIL-PRF-87257C : Hydraulic Fluid - Fire Resistant; Low temperature, Synthetic Hydrocarbon based
- MIL-G-5514G : Packing, Installation and Gland Design
- NAS 1638 : Cleanliness requirements for Hydraulic Systems
- MIL-STD-704D : Aircraft electric power characteristics
- MIL-STD-461C/G / 462D : Electromagnetic Interface
- MIL-STD-2073-1E : Standard Practice for Military Packaging
- MIL-DTL-38999 : Connector, Electrical, circular, Miniature, High Density, Quick Disconnect
- ISO 7320 : Hydraulic ports Interface
- DEF STAN 00-970/Issue-01: Design and Airworthiness Requirements dated 12/12/1983 for Service Aircraft
- ADA/QA&SEG/3723/ E-map: Environmental map of LCA AF Mk 2 /854/2020, Issue-I, Dt: Jan 2020
- ADA/LCA AF Mk2/Scatter : MoM on Scatter Factor of Mechanical LRUs Factor/ MoM/01 Dt: 23/09/2020

**Note:** For standards not covered in the above list relevant military specifications are applicable and latest revision of above standards are applicable.

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### 3 Description of system:

LCA AF Mk2 hydraulic system is a 280 bar (4060 psi), Type II hydraulic system. The services operated are Flight controls, Landing Gear and Wheel brakes etc. The hydraulic pump continuously provide the hydraulic power to servo actuators, operated by digital fly-by-wire flight control system (FCS), run the hydraulic motor driven generators throughout the flight. Occasionally the other services such as airbrakes are operated. The landing gears operation, wheel brake operation and the nose wheel steering operation happen during the taxiing roll, landing and take-off phase. Accumulator is used in the power system for FCS and suction pressure is ensured through the use of self-pressurized bootstrap reservoir, which gets pressurized by the system pressure itself. There are two independent systems in the LCA AF Mk2 aircraft and each system is to be powered by one hydraulic pump.

### 4 General pump characteristics and requirements:

- |      |   |  |
|------|---|--|
| 4.1  | Rated discharge pressure (at zero flow) | : 280 <sup>+6</sup> bar                              |
| 4.2  | Full flow pressure                      | : 270 <sup>+5</sup> bar                              |
| 4.3  | Rated inlet pressure                    | : 5 <sup>-0.5</sup> bar (abs)                        |
| 4.4  | Minimum Inlet pressure                  | : 2 bar (abs)  |
| 4.5  | Maximum Inlet pressure                  | : 11.35 bar (abs)                                    |
| 4.6  | Over pressure                           | : 340 bar  |
| 4.7  | System Relief valve setting             | : 312 to 320 bar (Crack open)<br>340 Bar (Full Flow) |
| 4.8  | Maximum transient pressure              | : 135% of rated discharge pressure<br>@ zero flow    |
| 4.9  | Rated case drain pressure               | : 15 <sup>+1</sup> bar                               |
| 4.10 | Maximum transient case drain pressure   | : 35 bar   |
| 4.11 | Minimum Efficiency                      | : 0.85 or 85%  |
| 4.12 | Case drain flow                         | : 6 lpm (max)  |
| 4.13 | Rated inlet temperature                 | : 115 °C   |
| 4.14 | Maximum fluid temperature at the outlet | : 135 °C   |
| 4.15 | Minimum fluid temperature at the inlet  | : -54 °C   |
| 4.16 | Operating temperature range             | : -40 °C to +135 °C                                  |
| 4.17 | Storage Temperature                     | : -55 °C to +71 °C.                                  |
| 4.18 | Nominal ambient temperature             | : 40 °C  |
| 4.19 | Drive Flange Temperature (max)          | : 135 °C   |
| 4.20 | Rated delivery/ flow                    | : 110 <sup>+5</sup> lpm                              |

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- 4.21 Rated speed : 6000 rpm
- 4.22 System Fluid contamination level : NAS 1638 class 7 (or) better
- 4.23 Proof Pressure
- Pressure (Delivery) : 420 bar
- Suction (Inlet) : 15 bar
- Case Drain : 53 bar
- 4.24 Burst Pressure
- High pressure side : 700 bar
- Suction side : 25 bar
- Case pressure side : 88 bar
- 4.25 Duration of continuous operation : 10 hours minimum
- 4.26 Hydraulic Fluid : MIL-PRF-5606J/MIL-PRF-83282D/  
MIL-PRF-87257C / DEF STAN 91.48  
Issue 1 / AIR 3520A / GOST 6794  
or equivalent.
- 4.27 Pump characteristics : Refer Figure-1
- Note:** Although pump rated output flow is 110 lpm, there should be provision for growth potential of at least 10% of over rated delivery / flow.
- 4.28 Pump Envelope : As per Figure-2
- Note:** Deviations from the dimensions in Figure-2 will be accepted based on installation study. Vendor shall supply the CAD model of the pump along with RFQ for the same.

## 5 Performance requirements:

### 5.1 Operating Input:

- 5.1.1 Drive power source: Aircraft Mounted Accessory Gear Box (AMAGB) driven by the engine PTO shaft.
- 5.1.2 Drive speed
- 5.1.2.1 Rated Speed : 6000 RPM
- 5.1.2.2 Over speed : 6900 RPM
- 5.1.2.3 Idle Speed : 4200 RPM
- 5.1.2.4 Minimum speed above which the discharge Flow or pressure is normal : To be specified by vendor
- 5.1.3 Type of Hydraulic Reservoir : Self pressurized "Boot Strap"

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Note : Pump speed will be varying from idle speed to rated speed based upon engine throttle position. Vendor shall ensure that resonance frequency doesn't fall in this speed range.

## 5.2 Operating Feedback:

### 5.2.1 Number of Accumulators in the system:

One Accumulator of 2 lts swept volume and pre charge nitrogen pressure of  $140 \pm 15$  bar.

### 5.2.2 Discharge flow (pressure) filtration:

15 microns Absolute, flow capacity 120 lpm, with no bypass

### 5.2.3 Maximum allowable Pressure fluctuation under steady state condition:

$\pm 21$  Bar as per para 3.3.12 of SAE AS19692 REV. A. Volume from Discharge port up to the first NRV in the system is around 149 cc (for RH system) and around 117 cc (for LH system). Also it is to be noted that a flexible hose and pipe will be installed between the pump discharge port and the first NRV.

### 5.2.4 Seepage of fluid past the rotary shaft end: Not exceeding 2 cc per hour.

## 5.3 Variable delivery control:

Pump shall incorporate delivery control means which will act to increase the delivery of the pump from zero to its maximum full flow value for any given operating speed as the discharge pressure is reduced from rated discharge pressure to maximum full flow pressure and vice versa.

### 5.4 Response time: 0.050 seconds (max)

### 5.5 Stability: Refer 3.3.13.2 of SAE AS19692 REV. A

## 5.6 Depressurization:

Pump shall have depressurization feature to reduce the pump power extraction during engine start/relight. This shall be controlled by external electric signal/automatically. Electric connector shall be compatible with MIL-DTL-38999 series.

Depressurization mode will be active for pump speed < 50 %.

Pressure output during depressurization shall preferably be 50 bar/vendor to specify this value.

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## 5.7 Endurance Test:

A sample pump shall complete 2000 hours endurance test as outlined in para 4.3.2.1.10 of SAE AS19692 REV. A

### For Depressurization valve:

36000 cycles to be conducted at different fluid temperature as given below,

50 cycles at -40 Deg C

26950 cycles at 107 Deg C

9000 cycles at 135 Deg C

**Qualification methodology:** Actual Test.

**Note:** The above number of cycles is applicable if endurance and impulse are carried on same unit.

## 5.8 Life:

5.8.1 Mean Time Between Overhaul : 2000 hrs (min)/ 15 years

5.8.2 Total Technical life : Preferably, on condition or 6000 hrs /40 years, whichever is earlier.

5.8.3 Mean Time Between Failure : 23270 hrs (min)

5.8.4 Qualification methodology : Reliability Analysis and prediction  
(Based on testing of Impulse Fatigue and Endurance tests)

The vendor shall indicate the MTTR of the component wherever applicable. The component shall conform to MIL-STD 785B (Reliability program for systems and equipment development and production). The vendor shall provide FMECA of the component carried out as per MIL-STD-1629A.

## 5.9 Impulse Test:

Sl. No.	cycles	Port	Impulse Cycle (bar)	No. Cycles	Remarks
1	Start- stop	Delivery port	0 - 280 -0	26,250*	---
2		Suction Port	0- 12 - 0	26,250*	---
3	Case impulse	Case drain port	0- 35-0	26,250*	---
4	Transient	Delivery port	280-378-280	2,00,000	---

**Note:** \*1.The number of cycles in sl.no 1,2 and 3 is applicable if endurance and impulse are carried on same unit.

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2. Impulse cycles shall be carried out as per Figure.3 of SAE ARP 1383C at cycling rate of 1 - 3 Hz

**Qualification methodology:** Actual Test.

#### 5.10 Dry Run Test:

Pump shall be tested for dry run capability (Closing the fluid supply to pump) at 5600 rpm. During the test,

5.10.1. If temperature of the pump exceeds 200° C record the run duration and may continue the test till failure (as specified in para 5.10.2) or limit total test duration to 60 minutes whichever is earlier.

5.10.2. The pump shall not create external sparks or explode or disintegrate to cause FOD. The pump shall collapse through any other fail-safe mechanism such as rupture of the external or internal drive shaft / seizure / jamming etc.

5.10.3. In case of any failure during dry run test, record the run duration and type of failure.

**Qualification methodology:** Actual Test.

#### 5.11 Prognostics:

It is preferred that the pump design shall incorporate latest prognostic tools / sensors which would help to predict the remaining life of the pump or would warn the maintenance crew about a future failure. The sensors shall be calibrated and proper software shall be provided which would enable to predict the remaining life or warn of a future failure. The software, if any provided shall be provided with the latest issues and also the vendor shall undertake to upgrade the same as and when a revision takes place.

### 6 Electrical requirements:

#### 6.1 Electrical Supply:

Nominal Voltage	: 28 V DC
Normal Steady State Voltage	: 22 to 29 V DC
Abnormal Steady State Voltage	: 20 to 31.5 V DC
Emergency Voltage	: 16 to 29 V DC
Starting voltage	: 12 to 29 VDC

The unit shall operate on nominal 28 V DC supply and vendor shall carry out power supply test in compliance with MIL-STD-704D as given below to characterize the impact on aircraft electrical power at the input terminals of electrical utilization equipment.

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## DC Power supply checks:

Steady state characteristics	Limits
Steady state voltage	22.0 to 29.0 Volts
Distortion factor	0.035 maximum
Distortion spectrum	Fig. 9 of MIL-STD-704D
Ripple amplitude	1.5 Volts maximum
Transient characteristics	Limits
Voltage transient	Fig. 10 of MIL-STD-704D

## Power Supply Test for utilization equipment

### 28 VDC utilization equipment – MIL-STD-704D compliance tests

Test Method	Description	Limit
<b>Normal, Aircraft Electrical Operation</b>		
LDC101	Load Measurements	Inrush Current, Load (VA), Current Distortion Factor & Current Spectrum limits are unique to each equipment and to be defined in equipment specification.
<b>Abnormal, Aircraft Electrical Operation</b>		
LDC301	Abnormal Steady State Limits for Voltage	20 -31.5 V
<b>Emergency, Aircraft Electrical Operation</b>		
LDC401	Emergency Limits for Voltage	<b>Emergency State Voltage limits:</b> 16 -29 V
<b>Starting, Aircraft Electrical Operation</b>		
LDC501	Starting Voltage Transients	12 - 29 V • Steady state to Transient level: 1 msec • Transient level to Steady state: 30 sec
<b>Power Failure, Aircraft Electrical Operation</b>		
LDC602	Polarity Reversal	Polarity Reversal should not cause damage

## 6.2 Electrical connector

Socket type / Receptacle type MIL-DTL-38999 series III. The mating Connectors, back shells and accessories (if any) also be supplied along with the unit.

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### 6.3 Insulation resistance

Greater than or equal to 50 mega ohm at 500 VDC. Insulation resistance shall be carried as part of QTP (Qualification Test Procedure) and ATP (Acceptance test procedure) of all deliverables.

### 6.4 Bonding resistance

Bonding to be less than or equal to 2.5 milli ohm with reference to mounting flange. All mounting holes of LRU are conductive coated to enable proper bonding during installation on aircraft for protection against lightening and static charging.

In order to meet the requirement, vendor may also provide provision to connect bonding braid if required.

### 6.5 Transient Suppressor

Unit shall have provision to suppress any electrical transients during the operation.

### 6.6 Di-electric withstand capacity

The unit should withstand di-electric voltage of more than 500 V AC at 50 or 60 Hz for a period of 60 seconds at +135 °C between the solenoid terminal and casing. There should not be any break down of insulation.

### 6.7 Electromagnetic interface

All the electrical components used in the pump shall meet the EMI & EMC requirements as per specification CE102 and RS103 as per MIL-STD-461G/462D and CE07 as per MIL-STD-461C/462D. Conduct the tests as per table given below.

Sl. No.	Method of Test	Tests	Frequency Range
1	CE 102	Conducted Emission, Power and interconnecting Leads (Narrowband & Broadband)	10kHz-10MHz (Ref Fig 7)
2	CE 07	Conducted Emissions , Transients, spikes, Time Domain	--
3	RS 103	Radiated Susceptibility, Electric Field.	2 MHz to 40 GHz E- Field :200 V/m

**Table. EMI/EMC test for Main Pump**

#### Qualification methodology: Actual Test

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## 7 Environmental requirements:

Environmental conditions as applicable for hydraulic pump LCA AF Mk2 are detailed below. In general requirements specified in MIL-STD-810H and Environmental map of LCA AF Mk2 to be satisfied wherever applicable.

### 7.1 Temperature (Ref: MIL-STD-810H, Method 502.4, Procedure I&II):

As per Annexure-II of Environmental map of LCA AF Mk2, ADA/QA&SEG/ 3723/E-map/854/2020, Issue '1', Dt: Jan 2020, as applicable to Hydraulic system equipment. (Same is reproduced below)

#### 7.1.1 High temperature storage cum operating (Ref: MIL-STD 810H, Method 501.7): (Ref. Figure-3)

**Severity:** From 35°C to 71°C diurnal cycles.

**Duration:** 7 cycles.

**Remarks:** Carryout operational check at the maximum temperature of 71°C for the test item after allowing stabilization during 1st, 4th & 7th cycle as per profile.

**Qualification methodology:** Actual Test /Similarity

#### 7.1.2 High Temperature test applicable to mechanical system equipment:

Soak the equipment at 135 °C and stabilize for 2 hours. Actuate the component at this temperature for at least 2 times. Perform leakage test after each actuation.

**Qualification methodology:** Actual Test /Similarity

#### 7.1.3 Low Temperature: As per Para 4.3.2.1.9 of SAE AS19692 REV. A.

**Qualification methodology:** Actual Test

### 7.2 Altitude (Ref: MIL-STD-810H, Method 500.6 Procedure II):

60,000 ft (18km), As per Sl.No.4 Annexure-I of Environmental map of LCA AF Mk2, ADA/QA&SEG/ 3723/E-map/854/2020, Issue '1', Dt: Jan 2020. (Same is reproduced below)

**Severity:** Pressure corresponding to 60,000 ± 100 ft (18 km) altitude  
(54 mm of Hg)

**Duration:** One-hour soak (Operational) followed by a single operational test

**Remarks:** Rate of change of altitude ≈ 150 m/sec (or 12.5 mm Hg/s) with positive chamber temperature (+25°C)

**Qualification methodology:** Actual Test /Similarity.

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### 7.3 Thermal shock (Ref:MIL-STD-810H, Method 503.7 Procedure I-C):

As part of the qualification testing, the pump shall be subjected to the thermal shock test as per Para 4.3.2.1.9.1 of SAE AS19692 REV. A and also as per the requirements laid out in the Requirements laid out in the Environmental Map of LCA AF Mk2, ADA/QA&SEG/ 3723/E-map/854/2020, Issue '1', Dt: Jan 2020. (Same is reproduced below)

**Severity:** Stabilize at  $T_1 = -55^{\circ}\text{C}$  soak for 1 hour. Transfer and stabilize at  $T_2 = +71^{\circ}\text{C}$  and soak it for 1 hour. Transfer it to  $T_1 = -55^{\circ}\text{C}$  for 1 hour. This constitutes 1 cycle (Refer figure 8).

**Duration :** 3 Cycles.

**Remarks :** Equipment shall be in non-operating condition. Transfer from low temperature to high temperature chamber and vice versa shall be effected within 1 Minute.

**Qualification methodology:** Actual Test /Similarity

**Acceptance Criteria:**

There shall be no signs of performance deterioration (Indicated by functional test), or any sign of physical degradation after the test.

### 7.4 Vibration (Ref:MIL-STD-810H, Method 514.8, Procedure I):

(Ref Figure-2 for mounting and x,y,z direction)

Pumps shall be capable of withstanding vibrations excited by the driving means. For design and test purposes, torsional vibration excited by the driving means shall be considered negligible. The pump shall meet the requirements of MIL-STD-810H and environmental map of LCA AF Mk2. The moving parts shall be inherently balanced and shall not vibrate in the manner as to cause failure of any part of the pump at speeds up to 120% of the rated speed. As part of the qualification testing the pump shall be subjected to the functional vibration test as per Para 4.3.2.1.8 of SAE AS19692 REV. A and also as per the requirements laid out in the Requirements laid out in the Environmental Map of LCA AF Mk2, ADA/QA&SEG/ 3723/E-map/854/2020, Issue '1', Dt: Jan 2020. (Sl.No.21 for Random vibration and Sl.No.20. for Sinusoidal vibration of Annexure-I) (Same is reproduced below).

#### 7.4.1 Random vibration:

**Severity:** Random vibration level from 15 Hz to 2000 Hz as per the power spectral density given in Figure-4.

**Duration:** 1 hour /axis in all three axes.

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**Remarks:** The equipment shall be operational and performance shall be monitored during the test. Any test interruptions due to failure of vibration system, recover the system and continue the vibration test from test point of failure.

**Qualification methodology:** Actual Test

#### 7.4.2 Sinusoidal vibration:

**Severity:** Limited to resonance search tests from 5 Hz to 2000 Hz at 1'g'

**Duration:** Limited to duration of frequency sweep 5 Hz to 2000 Hz

Number of axes : 3

Number of sweeps : 3 sweeps/axis

**Remarks:** This test shall be conducted before and after conduct of Random vibration tests with equipment in off state. No resonance shall be observed for equipment up to 200 Hz.

**Note:** If the resonance frequency is less than 200 Hz, the unit shall be dwelled for 15 minutes, as applicable, at each resonance frequency.

**Qualification methodology:** Actual Test.

#### Note:

1. The equipment shall be operational during this test and pump shall be pressurized and depressurized at least one cycle and flow is cycled from zero to 50% rated flow for at least 5 times/minute with a valve response time of 0.5 sec as per Para. 4.3.2.1.8.5 of SAE AS19692 REV. A.
2. During the test pump shall be operational.
3. If the depressurizing valve is not mounted along any of the axis shown in Figure-2, additional vibration test to be carried such that direction of vibration shall be parallel to electrical depressurizing valve.

#### 7.5 Acceleration (Ref: MIL-STD-810H, Method 513.8, Procedure II and I):

As per Sl. No. 19 (a) & 19 (b) Annexure-I of Environmental map of LCA AF Mk2, ADA/QA&SEG/ 3723/E-map/854/2020, Issue '1', Dt: Jan 2020.

(Same is reproduced below) (Ref Figure-2 for mounting and x,y,z direction):

##### 7.5.1 Functional:

**Severity:** 10 'g' in all 6 directions.

**Duration:** 1 min along each direction in all axes.

**Remarks:** Equipment shall be operational during this test.

**Qualification methodology:** Actual Test.

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### 7.5.2 Structural:

**Severity:** 15 'g' in all 6 directions.

**Duration:** 1 min along each direction.

**Remarks:** Equipment shall be non-operational during this test.

**Qualification methodology:** Actual Test.

### 7.6 Shock (Ref: MIL-STD-810H, Method 516.8):

As per Sl. No. 22 of Annexure-I of Environmental map of LCA AF Mk2, ADA/QA&SEG/ 3723/E-map/854/2020 Issue '1', Dt: Jan 2020. (Same is reproduced below) (Ref Figure-2 for mounting and x,y,z direction):

#### 7.6.1 Functional:

**Severity:** 20 'g' Saw tooth (or 15 'g' half sine), 11 ms pulse.

**Duration:** 3 Shocks in each of orthogonal axis.

**Remarks:** The equipment shall be operational and monitored during this test.

**Qualification methodology:** Actual Test.

#### 7.6.2 Transit Drop:

**Severity:** Height of drop 122 cm.

**Duration:** 26 drops (1 drop/each face, edge and corner).

**Remarks:** The equipment shall be kept in its normal packed condition in transit case (In which it is intended to transit and stored) during this test. The transit boxes shall meet the requirements as per the applicable Military standards.

**Qualification methodology:** Actual Test.

#### 7.6.3 Bench handling:

**Severity:** Raise one edge by 10 cm or 45° whichever is less and dropped in wooden bench.

**Duration:** 4 drops on each face.

**Remarks:** The equipment shall be in unpacked condition during these tests.

**Qualification methodology:** Actual Test.

### 7.7 Humidity (Ref: MIL-STD-810H, Method 506.6, Procedure III):

As per Sl.No.12 of Annexure-I of Environmental map of LCA AF Mk2, ADA/QA&SEG/ 3723/E-map/854/2020, Issue '1', Dt: Jan 2020. (Same is reproduced below).

**Severity:** Temperature 30°C to 60°C, RH 85 to 95%, Temperature, humidity and

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diurnal cycle (Same is reproduced in Figure-6).

**Duration:** 10 cycles.

**Qualification methodology:** Actual Test / Similarity.

**Acceptance Criteria:**

Carry out functional check at the end of 1<sup>st</sup>, 5<sup>th</sup> and 10<sup>th</sup> cycle. Functional checks after the test to be carried out within recovery period. There shall be no signs of performance deterioration (Indicated by functional test of the unit).

#### 7.8 Fungus (Ref: MIL-STD-810H, 508.8):

As per SI.No.13 of Annexure-I of Environmental map of LCA AF Mk2, ADA/QA&SEG/3723/E-map/854/2020, Issue '1', Dt: Jan 2020. (Same is reproduced below).

**Severity:** The spore suspension shall be prepared using fungi as specified in Table-1 (Alternatively, fungi as per JSS55555 can be used).

**Duration:** Wet the entire surface of test item with spore suspension in 10 min. Incubation period 28 days at 30 Deg C and 95% RH.

**Remarks:**

- 7.8.1 This test can be carried out on representative samples of parts used in the equipment. Alternatively, if material analysis reveals that none of the fungus nutrient materials listed in Table-1 is used then the test can be dispensed with.
- 7.8.2 Fungal growth be verified on the cotton strips every 7th day during the 28 days test duration.
- 7.8.3 Post verification of the functionality, visual inspection shall be carried out after 4 hours after removal from the chamber taking into account the human safety requirements.
- 7.8.4 Interruptions due to test setup failure within 7 days shall entail or necessitate restart of the test cycle on the equipment. However, for beyond 7 days recover, the test setup and continue the test from the point of failure.

**Qualification methodology:** Actual Test / Analysis / Similarity

**Acceptance Criteria:**

There shall be no significant visible surface deterioration or other defects due to the fungus test which would be detrimental to normal operation of the unit.

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Sl. No.	Name of culture
1	Aspergillus Flavus
2	Trichoderma Virens
3	Talaromyces Pinophilus (Pencillium Funiculosum )
4	Chaetomium Globosum
5	Aspergillus brasiliensis (Aspergillus Niger)

**Table-1 (List of Fungi for culture preparation)**

### 7.9 Salt Fog (Ref: MIL-STD-810H, Method 509.7):

As per Sl. No. 14 of Annexure-I of Environmental map of LCA AF Mk2, ADA/QA&SEG/3723/E-map/854/2020, Issue '1', Dt: Jan 2020. (Same is reproduced below).

**Severity:** Salt solution of  $5 \pm 1\%$  concentrations. Ambient temperature  $35 \pm 2^\circ\text{C}$ . Ensure the fallout is between 1 and 3 ml/80 cm<sup>2</sup>/hr with a pH between 6.5 and 7.2.

24 hrs exposure & 24 hrs drying constitute one cycle.

**Duration:** 2 cycles (96 hours).

**Remarks:** 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% of impurities. Drying shall be at prevailing ambient conditions.

**Qualification methodology:** Actual Test/Similarity.

#### **Acceptance Criteria:**

There shall be no evidence of any corrosion during visual examination. The equipment shall be subjected to satisfactory functional test after the Test.

### 7.10 Blowing Dust :

(Ref: MIL-STD-810H, Method 510.7, Procedure I or JSS 55555):

As per Sl. No. 15 (b) of Annexure-I of Environmental map of LCA AF Mk2, ADA/QA&SEG/ 3723/E-map/854/2020, Issue '1', Dt: Jan 2020. (Same is reproduced below).

**Severity:** Blowing Dust, Air Velocity 1.5 m/s to 8.9 m/s, RH  $\leq$  30%, Dust Concentration  $10.6 \pm 7 \text{ g/m}^3$  ( $0.3 \pm 0.2 \text{ g/ft}^3$ ).

**Duration:** 6 hours at  $23^\circ \text{C}$  and 6 hours at  $65^\circ \text{C}$ .

**Remarks:** If unscheduled test interruption occurs, carryout the visual examination and continue the tests from the point of interruption after ensuring enough stabilizing conditions are achieved.

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**Qualification methodology:** Actual Test / Similarity.

#### 7.11 Fluid contamination test (Ref: MIL-STD-810H, Method 504.3):

As per Sl.No.16 of Annexure-I of Environmental map of LCA AF Mk2, ADA/QA&SEG/3723/E-map/854/2020, Issue '1', Dt: Jan 2020. (Same is reproduced below)

**Severity:** Test temperature  $71^{\circ}\text{C} \pm 3^{\circ}\text{C}$ .

**Test Fluids:**

- (a) Fuel Jet A-1(IS1571) / JP-8(MIL-T-83133) / JP-5(MIL-T-5624) / AVTUR (DEF-Stan 91-91/5-2).
- (b) Hydraulic fluid: MIL-PRF-5606.
- (c) Lub oil mixtures: MIL-PRF-23699 Rev G Class C/I.
- (d) Soap water: MIL-PRF-83937D, type IV.

**Duration:** 7 days / test fluid (On representative sample for all equipment).

**Qualification methodology:** Actual Test /Analysis/Similarity.

**Acceptance Criteria:**

There shall be no significant visible surface deterioration.

#### 7.12 Extreme Contamination:

The hydraulic pump shall not deteriorate in its performance, when it is continuously used with Hydraulic Fluid having contamination level up to Class 8 of NAS 1638 for a prolonged period of time. Safety against any failure of the unit shall be ensured, when the unit is subjected to operation with Hydraulic Fluid having contamination level up to Class10 of NAS 1638 for a limited period of time (2 hours max.). Vendor shall demonstrate the same as a part of Endurance Test.

**Qualification methodology:** Actual Test/similarity

#### 7.13 Combined temperature, humidity and altitude:

As per Sl.No.23 of Annexure-I of Environmental map of LCA AF Mk2, ADA/QA&SEG/3723/E-map/854/2020, Issue '1', Dt: Jan 2020. (Same is reproduced below), (Ref. Figure-5)

**Severity:** As per theTable-2

**Duration:**10 cycles.

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Table-2

Time In hours *	T / °C	Altitude (Km)	Humidity %	Supplemental cooling Air / liquid			Equipment ON / OFF ( hr )
				Temp	Mass flow rate	Humidity	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
0-1.2 ± 10 %	-55	Ground		-55	M (Min)		ON (0.5-1.2 hrs)
1.2-2.0 ± 10 %	47	Ground	95%	47	M (Min)	95%	OFF
2.0-2.8 ± 10 %	-55	15		-55	M (Min)		ON
2.8-4.8 ± 10 %	47	Ground	95%	47	M (Min)	95%	ON
4.8-9.2 ± 10 %	71	Ground		71	M (Max)		ON ( 5.0 hrs onwards )
9.2-10 ± 10 %	71- 20	15		71-20	M (Max)		ON
10-12 ± 10 %	20	10		20	M (Max)		ON

\* The amount of time to ramp temperature is dependent upon the test facility change rate and shall not exceed 5 °C/min.

#### Notes :

- LRUs shall be electrically powered ON, along with supplementary cooling as per the profiles indicated above.
- LRUs, which are conduction cooled (without supplementary cooling), shall follow the above electrical power ON profiles
- In case the supply of supplementary cooling air is not feasible, the LRU functionality shall be verified as per the power ON schedule/profile above. Subsequent to verifying of the unit functionality at that instant for short duration, the LRU can be switched off.

**Qualification methodology:** Actual Test / Similarity.

#### 7.14 Rain drip test (Ref: MIL-STD-810H, Method 506.6 Procedure III)

Sl. No. 11 of Annexure 1 of Environmental map of LCA AF Mk2, ADA/QA&SEG/3723/E-map/854/2020, Issue '1', Dt: Jan 2020. (Same is reproduced below)

**Severity :** Volume flow rate 250 to 280 lit/m<sup>2</sup>/hour. Droplet size > 4.5 mm  
Dispenser placed approximately 1 meter above equipment.

**Duration:** Drip for 30 min followed by operating for 1hr (Configuration as installed on the A/C).

**Qualification methodology:** Actual Test / Similarity.

**Remarks:** The unit shall be subject to visual internal inspection by removing adequate & sufficient covers/panels for the equipment for evidence of water penetration by collecting the accumulated water by using syringe. There shall be no immediate effect of water on the operation of the material.

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### Acceptance Criteria

There shall be no significant visible surface deterioration or other defects due to the rain drip which would be detrimental to normal operation of the unit.

## 8 Installation requirements:

8.1 **Dimensions:** As per Figure-2

8.2 **Weight:** 9.5 Kg (max)

8.3 **Direction of rotation:** CCW Looking from Drive Shaft end

8.4 **Drive coupling:**

A replaceable part of the pump assembly, incorporating a shear section shall be interposed between the pump drive and AMAGB drive shaft by which the pump to be driven and coupling shall be retained positively. Type of lubrication required to be specified.

Preferably, provision for sensor installation to capture vibration frequency of the pump to be provided by the vendor.

8.5 Starting torque of the pump shall be less than 100 Nm. Vendor should provide the graph (Speed (N2) Vs Torque).

8.6 Vendor should provide the graph of Outlet Pressure Vs Flow rate & RPM.

8.7 ISO TC 20/ISO 1971-1975 / RS623 / Nominal spigot diameter of 3.5 inch for mounting with 'V' Band Clamp (Ref Figure-2).

8.8 **Lubrication oil:** As per MIL-PRF-23699 Rev G Class C/I.

8.9 **Lubrication:** Except for the coupling shaft spline, the hydraulic pump shall be self-lubricated with no provisions for lubrication other than the circulating fluid.

8.10 Oil leakage out of the drive pad shall be less than 2 cc/hour.

8.11 **Ports:**

8.11.1 Ports shall conform to the following (Ref Figure-2):

Suction: ISO 7320-25 (MJ 33 x 1.5 to suit 25 dia OD tube)

Pressure: ISO 7320-16 (MJ 22 x 1.5 to suit 16 dia OD tube)

Case drain: ISO 7320-06 (MJ 12 x 1.25 to suit 06 dia OD tube)

8.11.2 Port markings: Inlet, outlet, and case drain ports shall be identified in accordance with MIL-STD-130N on each pump with clear and permanent markings.

8.11.3 Structural strength: Ports and housing should withstand 2.5 times nominal torque wrench loads for attachment /removal of fittings.

**Note:** The ports shall be designed for fitment of straight adaptor with provision for

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fitment of banjo type of fitting if necessary during installation studies.

- 8.12 **Drive shaft seal:** ID =  $82.15 \pm 0.5$ ; CS =  $3.5 \pm 0.1$ ; compatibility with Gear Box oil as per para 8.8 (Mil standard equivalent part number of the O-ring is M83248-1-236). Drive shaft seal shall be supplied along with the pump and spares, 2 Nos for each pump.

## 9 Detail requirements:

**Materials:** Materials and processes used in the manufacturing of the pump shall be of high quality, corrosion resistant or suitably protected of high strength to weight ratio suitable for the purpose and shall conform to applicable government specification. Any other material used must be compatible with the specified hydraulic fluid and have the approval of HAL.

**Seals:** Seals used in the construction of the pump shall be in accordance with MIL-R-83248C or equivalent.

## 10 Storage and shelf life:

Vendor shall furnish the storage and maintenance requirements for the equipment. Minimum storage life should be more than 10 years. No maintenance/periodic exercising shall preferably be called for during the storage period, vendor should specify periodic checks during the storage if any.

## 11 Maintainability & testability:

### 11.1 General Requirements:

Vendor shall ensure that the Periodic Visual Inspection (external leakage etc.) and Periodic Hydraulic Oil Contamination checks are the only preventive maintenance requirements for the hydraulic pump. There shall be no scheduled removals until TBO. Vendor shall specify Periodic Inspection Interval, Servicing Requirements and TBO schedule. Vendor shall also provide the following maintenance details as a part of Technical Manuals.

- Corrective maintenance details and time
- Off-aircraft maintenance details and time
- Bleeding procedure of pump
- Depot maintenance details
- Field & Stores handling procedure
- Trouble Shooting.

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## 11.2 Special Requirements:

In addition, Description & Operation Manual, Illustrated Parts Catalogue (IPC), Component Maintenance Manual (CMM), servicing & Overhaul Manual, Storage Manual, etc., details of field & depot maintenance levels, time required, training requirements for maintenance personnel, test equipment & special tools required if any etc., assistance in defect investigation, are to be indicated and supplied by the vendor. Necessary initial training for HAL's engineers / mechanics /inspectors has to be provided by the hydraulic pump vendor.

## 11.3 Reliability & Flight Safety:

Reliability of hydraulic pump shall be initially estimated through Failure Mode Effect & Criticality Analysis (FMECA) in terms of Mean Time Between Failures (MTBF) based on the data of similar existing units and components used. FMECA, criticality analysis & Reliability Prediction report are to be submitted by vendor to support estimated Reliability of hydraulic pump. Subsequent to qualification testing Reliability values shall be revised, based on problems / defects / failures encountered during qualification testing and revised FMECA & Reliability Report to be resubmitted to HAL.

Failure Mode Effect & Criticality Analysis as well as the Reliability Establishment Analysis of the hydraulic pump along with supporting documents shall be prepared / compiled by vendor and submitted to support the established Hydraulic pump reliability.

## 12 General test requirements & classifications:

The vendor shall show compliance of hydraulic pump with the respective applicable MIL & SAE specification as specified in para 2 and generate a compliance matrix. All the required Qualification, Certification and Environmental Tests shall be conducted on the hydraulic pump in accordance with the specific requirements detailed in this specification and compliance shall be provided by the Vendor. These tests shall also conform to requirements of Hydraulic Units applicable for 280 bar Class (4060 psi), Type-II System requirements of SAE AS5440A, Hydraulic System Component Requirements SAE AS8775 Standards. For all the Environmental Tests, Vendor shall show compliance to the stringent of Military (MIL-STD-810H) and to the Environmental map of LCA AF Mk2, ADA/QA&SEG/3723/E-map/854/2020, Issue '1', Dt: Jan 2020. Any deviations or additional tests shall be concurred by mutual discussions. Hydraulic pump vendor shall prepare & provide their Acceptance & Qualification Test Program Plan and schedule to HAL for concurrence prior to actual tests. These Test Plan

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& Schedules will be studied by HAL & Indian Certification Agencies and joint concurrence will be provided.

The Hydraulic Pump Testing shall be classified into three types:

- Production Acceptance Tests (SOP & Performance Tests on Each Unit)
- Qualification Tests (Type Certification Tests on Qualification Units)
- Reliability Qualification Tests (On embodiment of Modification in service)

### 12.1 Production Acceptance Tests:

Production Acceptance Tests (PAT) shall be conducted on each & every pump for the purpose of ensuring Quality Control w.r.t. Standard of Preparation (SOP) and Performance of hydraulic pump against performance parameters specified in this Technical Specification & associated standards. The vendor shall submit production Acceptance Tests (PAT) schedule to HAL for co-ordination and acceptance.

### 12.2 Qualification Tests:

In general, the test procedures and conditions called in quality assurance provisions of relevant MIL standards (Para 4.3.2 of SAE AS19692 REV. A and Environmental tests as per Para 7 of this specification along with other tests like impulse, dry run etc.,) shall be taken as the basis to formulate qualification / reliability test procedures and conditions against which LCA AF MK2 hydraulic pump is intended to be qualified. The vendor shall actually test, qualification sample pumps and submit the results to HAL. All major parameters that would in a way govern the performance and safety of the aircraft hydraulic system shall be demonstrated by actual tests only. Similarity results and statements shall be avoided. The vendor with his experience of designing similar pumps may submit similarity of design and performance to HAL. In case any test requirements are being cleared on Similarity basis, the same shall be accompanied by Design Statement, along with supporting documents and similar test results, for prior acceptance by HAL & Indian Certification Authorities. However, the final decision to accept the particular test based on similarity statement or to go for an actual test rests totally with HAL and the Indian Certifying Authorities. HAL with an Indian team may participate to witness the qualification tests and vendor shall co-operate for the same.

### 12.3 Reliability Qualification Tests (On embodiment of Modification in service):

These are tests that are required to be conducted to ensure the reliability of the units after incorporating modifications. The requirement for modification may arise out of failures during the agreed qualification tests or during the service usage of the component on the aircraft.

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### 13 Required documentation:

All the documents of LCA AF MK2 hydraulic pump shall be prepared by Vendor in English Language only. Soft Copies (in Adobe PDF or MS Word Format) and Hard Copies (3 sets) of all the following Documents shall be supplied to HAL. All the Live Documents shall be periodically updated by Vendor on a yearly basis and Amendments shall be supplied to HAL.

3D CAD Model (Preferably in CATIA V5 version 19) shall be given by the vendor for HAL for preparation of Installation Drawing & to perform required interference study of the installation on Aircraft, in addition, 2D Assembly & Installation Drawings shall be supplied in AutoCAD (Release 2000) format along with 3 sets of hard copies. All Technical Documents shall be supplied in soft copies MS-Word & Adobe-PDF formats in addition to signed & released hard copies.

The following documents shall be supplied in ENGLISH language only.

- 1) Description of the hydraulic pump with its salient features and operational details.
- 2) Relevant assembly, Sub-Assembly and installation drawings with sectional details wherever necessary, hydraulic and electrical schematics wherever applicable.
- 3) Polar moment of inertia
- 4) Performance details.
- 5) Reliability values and maintainability requirements including failure mode effects and criticality analysis.
- 6) Stress reports.
- 7) Overhaul schedules.
- 8) Mean Time Between Failure (MTBF) value should be provided.
- 9) Qualification and certification test records with test schedules and test results. The complete type record consisting of certificate of design, type test schedule, test report record of failures, defects and modification, analysis and summary approved by the appropriate authority shall be submitted prior to shipment of prototype units.
- 10) Airworthiness/relevant certification issued by appropriate agency to be provided.
- 11) The qualification test procedure report shall be supplied.
- 12) Production Acceptance Test (PAT) or Acceptance test procedure (ATP) report shall be supplied.
- 13) Acceptance test report (ATR) shall be supplied with each unit.

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- 14) Record of similar applications and reliability reports preferably to be provided.
- 15) Declaration of design and performance for the Hydraulic pump.
- 16) Compliance matrix indicating the specification requirement and compliance with details of how the compliance is achieved. Statements such as "complied", or "as per your requirements" Shall be avoided.
- 17) Certificate of Conformity (COC).
- 18) Certificate of Design (COD).
- 19) Relevant Technical and maintenance manuals.
- 20) Complete list of Pump parts indicating its effect on environmental and safety hazard.
- 21) Component Maintenance Manual (CMM) as per S1000D including 3D animation for assembly and disassembly.
- 22) Failure history or performance feedback to be provided if the unit being supplied is a common off the shelf item.
- 23) Design document of the Pump.
- 24) Pump disposal procedure / manual.
- 25) Mathematical model of pump or black box model of the pump in Amesim / Matlab format preferably to be provided.

## 14 Qualification / Type approval:

The unit shall be tested and qualified for use in military aircraft application as per the guide lines of the SAE AS19692 REV. A and SAE AS8775 standards. Qualification testing shall have prior approval of ARDC, HAL through submitting Qualification program plan.

The vendor shall help HAL in obtaining the flight clearance from the certifying agency. Any documents/tests which are required for obtaining the certification omitted here may become a requirement at a later stage. The vendor shall support HAL for the same. It is to be understood that the vendor is also equally responsible for obtaining the flight clearance of the unit from the certifying agencies.

The vendor shall provide detailed justification of his design/actual performance/ test results to support the compliance to the requirements as laid down in the technical specification and also the relevant SAE AS / MIL standards.

The unit offered should be of the current design and in case, vendor intends to phase out or replace with a superior unit for any reason including obsolescence, vendor should take responsibility for offering an alternate system at no extra cost.

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## 15 Components and assembly:

All the necessary technical details, General Assembly & Installation Drawings of pump along with Hydraulic Scheme Diagrams shall be supplied to HAL. Concurrence shall be taken for items with development and qualification requirements. Mounting & Hydraulic Interfaces of the Main Pump shall be as required by HAL.

## 16 Product support:

The proposals should include an assurance of maintenance and spares supports for the products during the next 40 years the aircraft is expected to be in service.

The following documents are to be made available.

- Maintenance and servicing manual. The manual shall also include trouble shooting, extent of first line and second line servicing, overhaul and repair instructions, storage instructions etc.
- Spare parts catalogue.
- List of special tools and equipment required for servicing of the unit.
- Regular service bulletins.
- Assistance in defect investigation.
- Training of engineers/mechanics/inspectors in the maintenance, servicing and inspection of the components.
- Supply of cut section models/training aid kits/video cassettes etc.

## 17 Ergonomics & Accessibility:

Easy accessibility shall be provided to mount the Main Pump Assembly on the Aircraft and to connect Hydraulic lines using standard tools.

## 18 Other requirements:

All other functional requirements that are not covered in the above paragraphs can be suitably assumed based on standards, existing usage and subsequently submitted to HAL for acceptance.

## 19 Attenuator:

From the system design point of view, as such a need for an attenuator does not exist. The high pressure system volume up to the first check valve for the LH and RH pump installations is as per Para 5.2.3. The vendor shall endeavor to reduce the pulsations in the pump itself and make all efforts to avoid the use of attenuator. However, if the requirement of

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such a device is mandatory, preferably it shall be a part of the pump. The vendor shall technically justify the requirement of this.

If incorporation of the attenuator is not possible in the pump, the vendor shall propose different types of attenuators such as In-line, Tee type etc., to HAL to study its installation in the delivery line of the pump.

The total responsibility of such an attenuator qualified for usage in military aircraft hydraulic system of 280 bar (As described in para 1 and 3) with interfaces to mate with ISO standard connections shall rest with the pump vendor. The attenuator, if required, shall be supplied by the vendor along with the pump with all the relevant applicable documents as listed in para 13. The weight of the attenuator if required shall be included as a part of the dry weight of the pump as given in para 8.2.

AGM (PUR)

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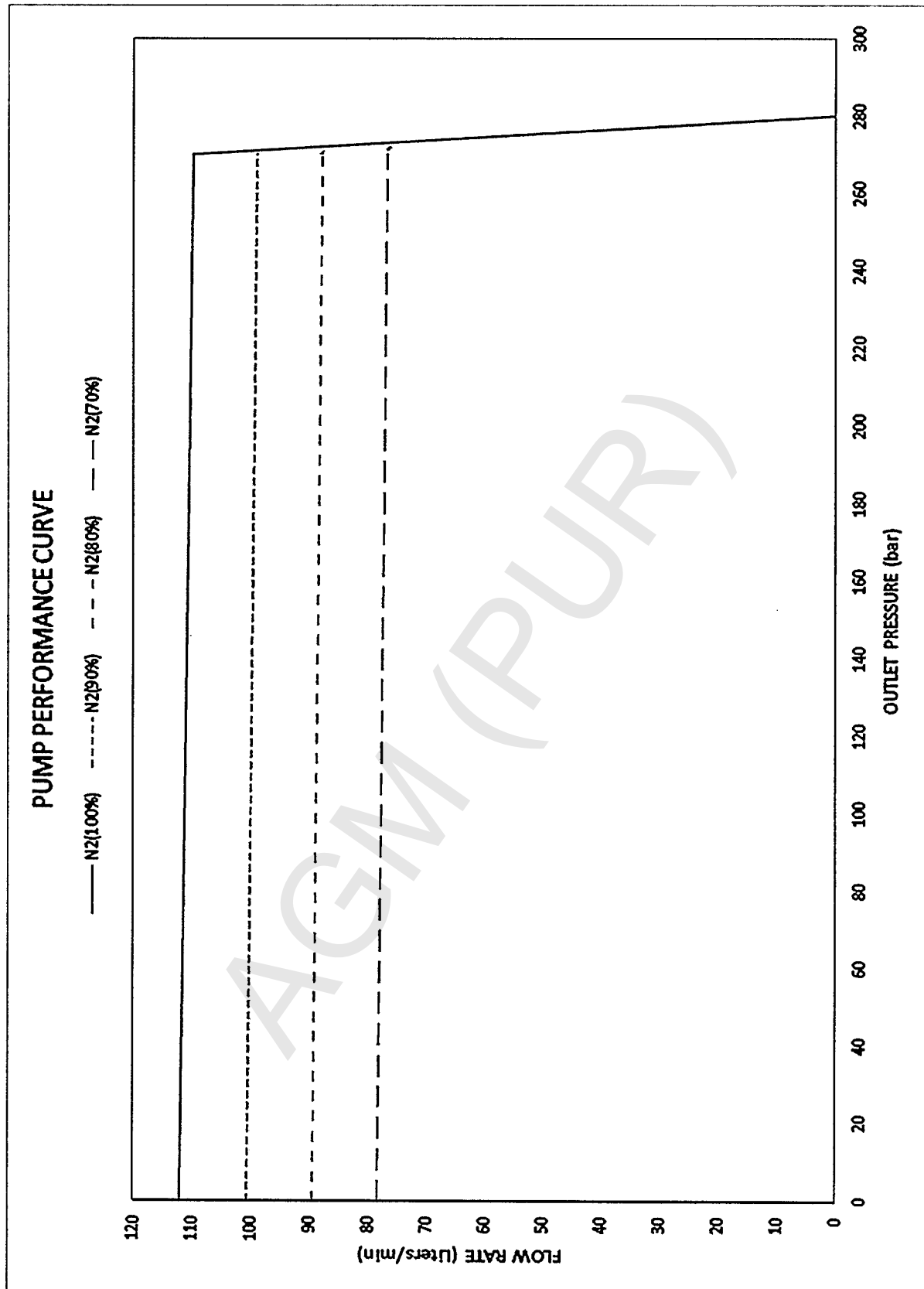
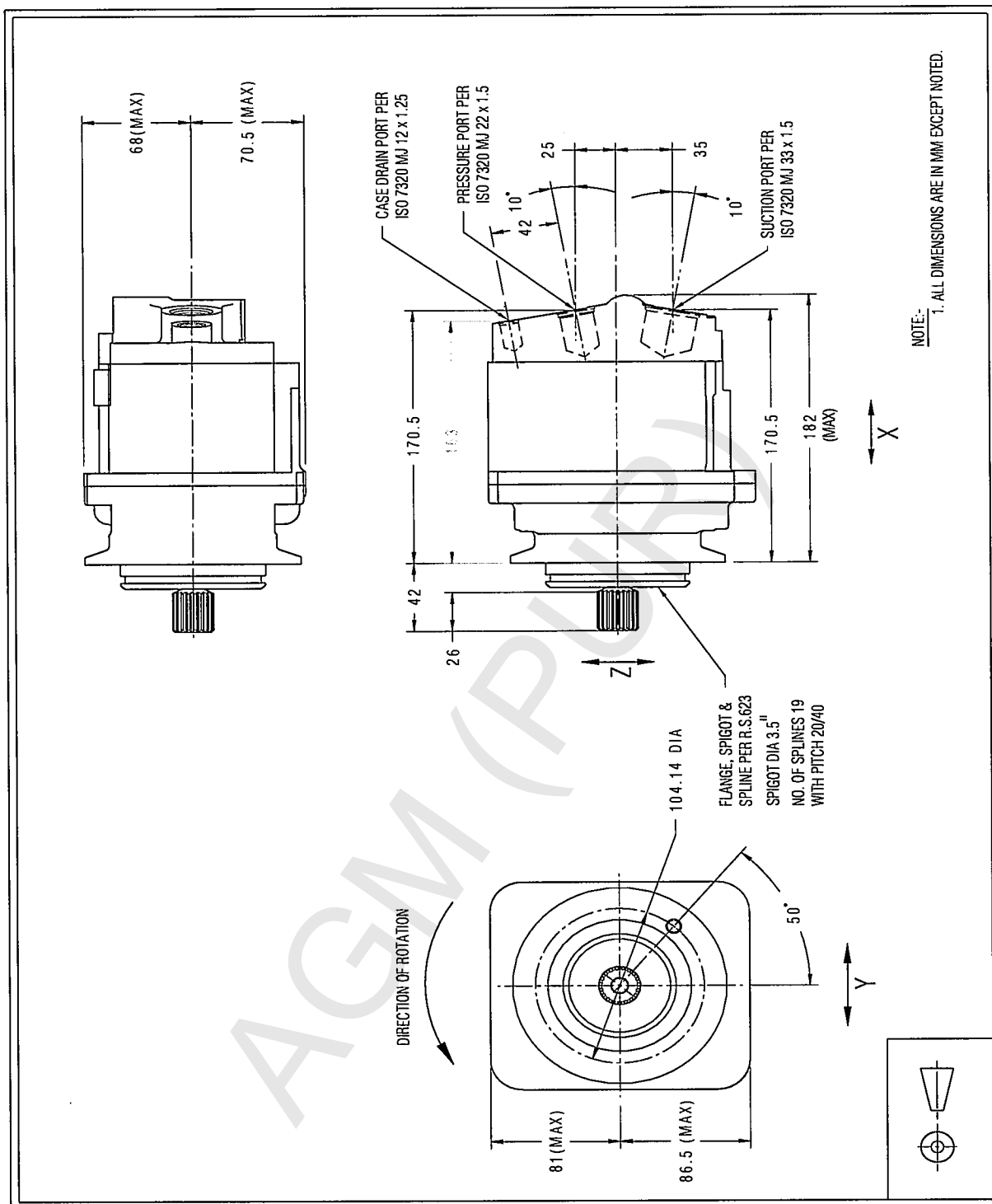


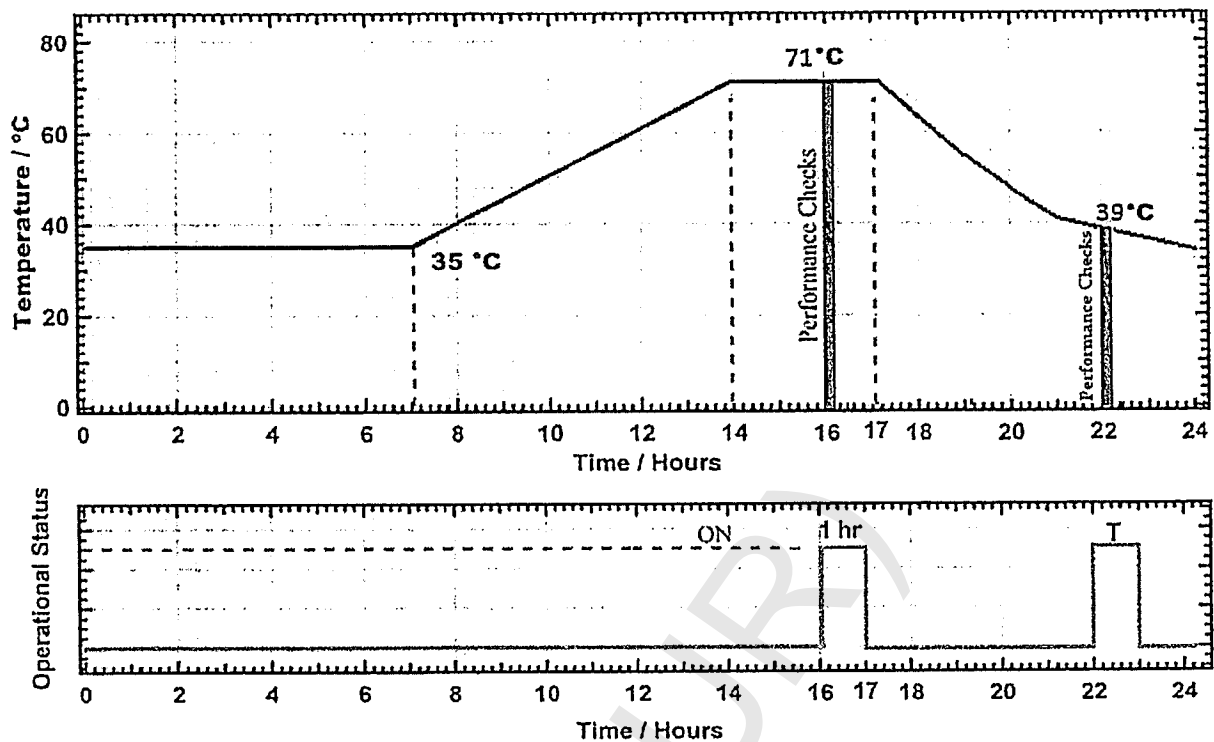
Figure-1: Pump Characteristics

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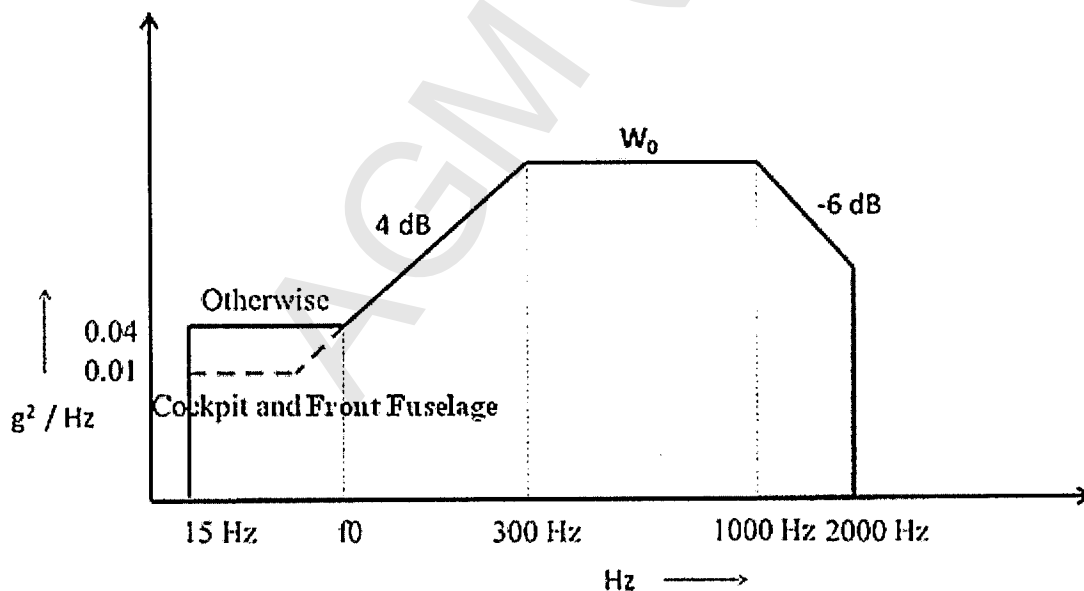
**Figure-2: Envelope and Installation Requirements**

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T: Duration for performance checks depends on LRUs as applicable.

Figure-3: High Temperature – Storage cum Operating (Diurnal Cycle)

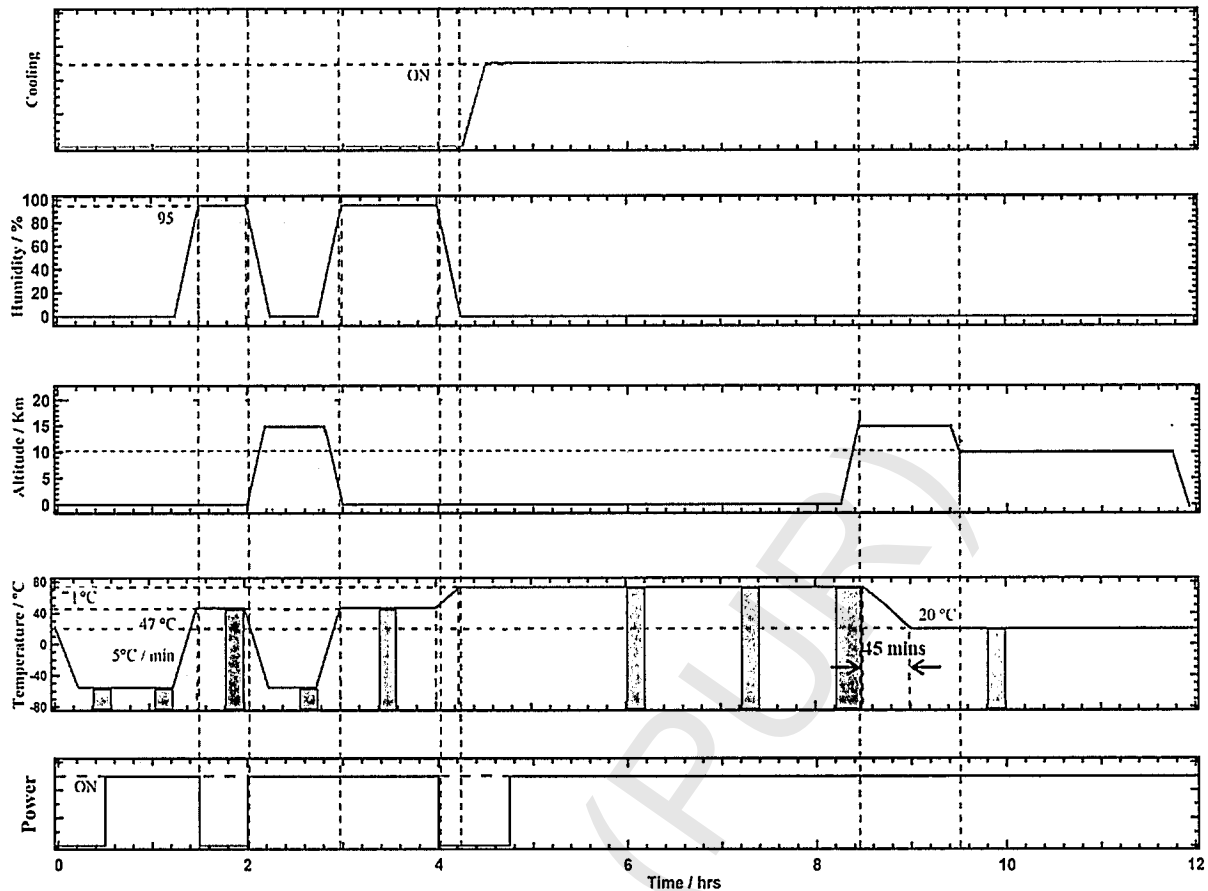


$$\text{PSD } (W_0) = 0.04 \text{ g}^2/\text{Hz}$$

Figure-4: Random Vibration Spectrum Profile (for Equipments)

**Note:** Follow the profile given as “Other wise”,  $f_0$  value is not applicable for this.

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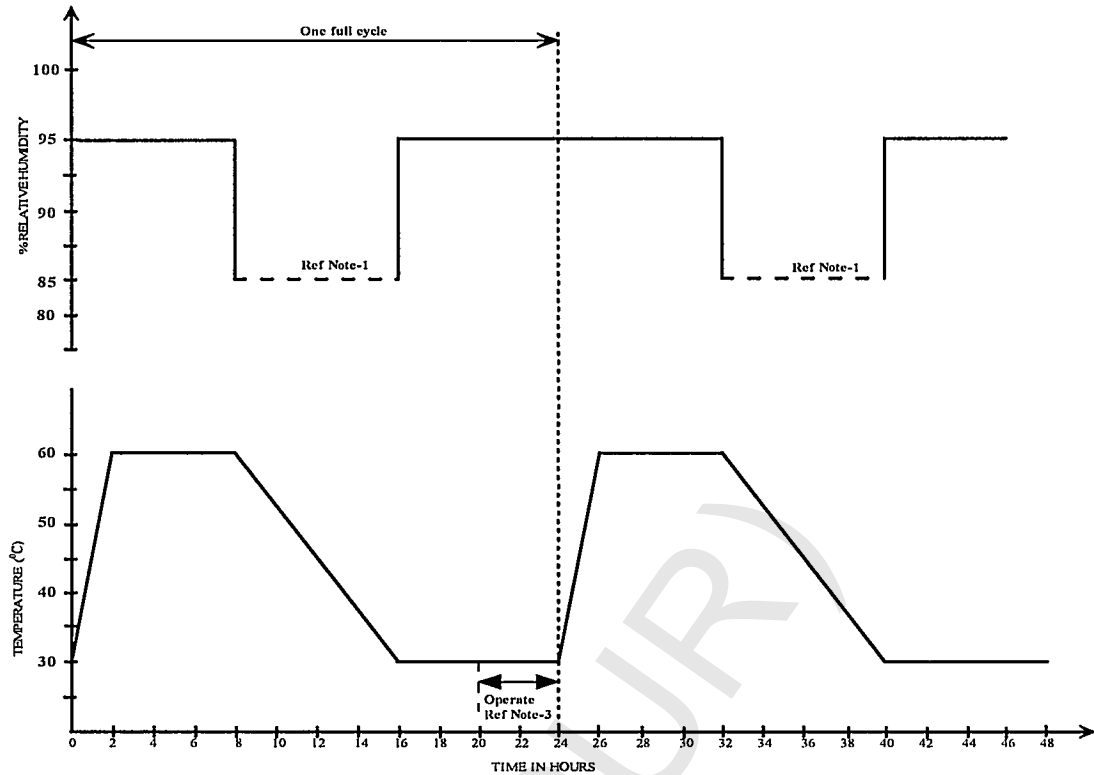


#### Notes :

- LRUs shall be electrically powered ON, along with supplementary cooling as per the profiles indicated above.
- LRUs, which are conduction cooled (without supplementary cooling), shall follow the above electrical power ON profiles
- In case the supply of cooling air is not feasible, the LRU functionality shall be verified as per the power ON schedule/profile above. Subsequent to verifying of the unit functionality at that instant for short duration, the LRU can be switched off.

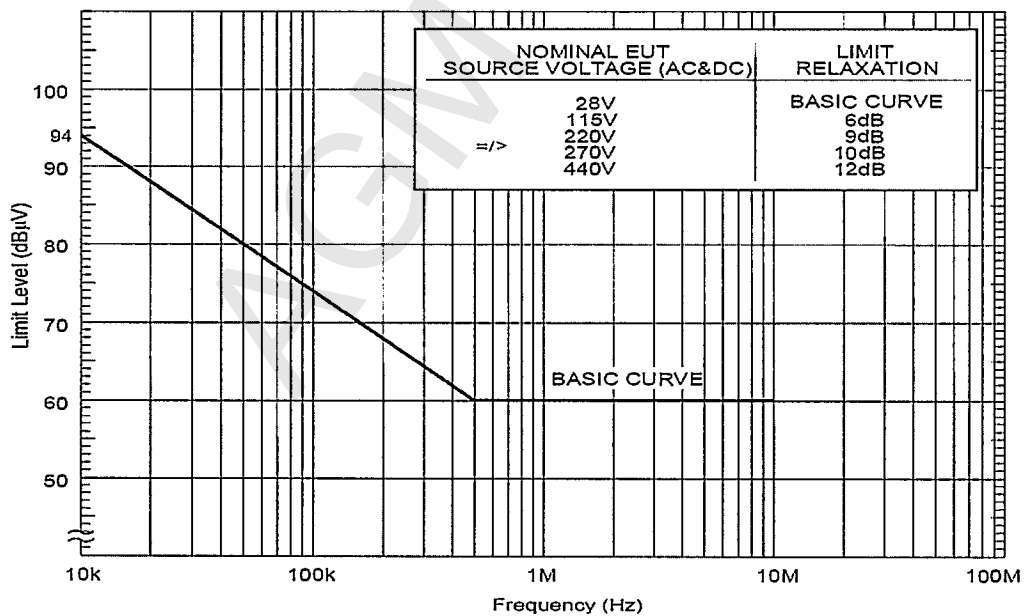
**Figure-5: Combined Altitude, Humidity and Temperature Test**

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Note: Relative humidity maintained above 85% during temperature drops

**Figure-6: Diurnal Cycle for Temperature – Humidity**



**Figure-7: Limit for CE102 (EUT power leads, AC and DC)**

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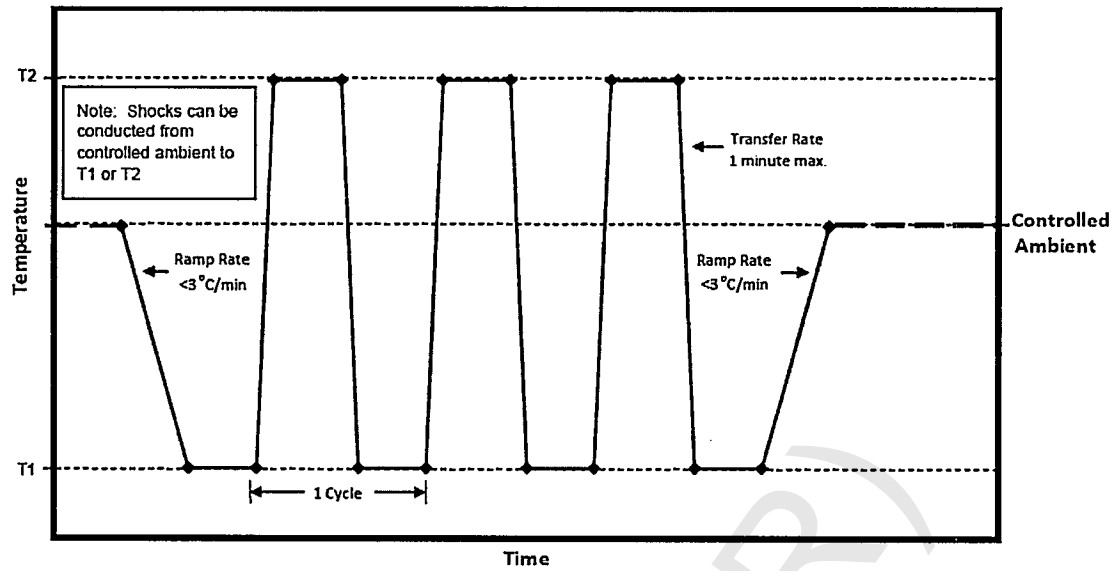


Figure-8:Thermal shock profile

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