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Airworthiness Directive

14 / 2015

SAFETY OF FLIGHT TESTS

CENTRE FOR MILITARY AIRWORTHINESS & CERTIFICATION (CEMILAC)

DEFENCE RESEARCH & DEVELOPMENT ORGANIZATION

MINISTRY OF DEFENCE, GOVT OF INDIA

Documentation Page

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Abstract:	Developmental Flight clearance for Avionics equipment is issued for carrying out limited experimental test flights, user evaluations or ferrying flights for the purpose of gathering system data, verifying system operation of newly designed or modified equipment. DDPMAS-2002 (vide Section-III, Chapter-2, Para-11) permits set of tests called Safety of Flight Tests (SOFT) as a route for issue of Developmental Flight Clearance without compromising on safety issues. The Scope of this directive is to provide guidelines for preparing a SOF test schedule for clearing airborne equipment to undertake developmental flight trials.	
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Approved By:	**P Jayapal** **Chief Executive (Airworthiness)** **CEMILAC, DRDO**	
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E-4

Documentation Page

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2-5

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56

Contents

1 Introduction 5
1.1 Purpose 5
1.2 Scope 5
1.3 Applicability 6
1.4 References 6
1.5 Definitions 6
1.6 Acronyms 7
2 Safety of Flight Test Approach 8
2.1 Applying SOFT Approach 8
2.2 Steps for SOFT 9
2.2.1 SOF Test Plan 9
2.2.2 SOF testing 9
2.2.3 SOF Test Report 9
2.3 Documents 9
2.4 SOF Tests 10
2.5 SOF Test Details 10
2.5.1 Initial Visual Examination 10
2.5.2 Performance / Functional Checks 11
2.5.3 Burn-in 11
2.5.4 Environmental Stress Screening (ESS) 11
2.5.5 Power Supply Tests 13
2.5.6 EMI / EMC Tests 13
2.5.7 Environmental Tests 14
2.5.8 Shock Test 17
2.5.9 Acceleration Test (Structural) 18
2.5.10 Other Tests (Only if applicable) 18
2.5.11 Final Visual Examination and Performance / Functional Checks 19
3 Cancellation & Promulgation 23
3.1 Cancellation 23
3.2 Promulgation 23
3.3 Feedback 23

1 Introduction

1.1 Purpose

Developmental Flight clearance for Avionic / Electrical equipment is issued for carrying out limited experimental test flights for the evaluation of the system on the platform or user evaluations or ferrying flights for the purpose of gathering system data or verifying system operation of newly designed or modified equipment. DDPMAS-2002 (vide Section-III, Chapter-2, Para-11) permits set of tests called Safety of Flight Test (SOFT) as a route for issue of Developmental Flight Clearance without compromising on safety issues. This route is increasingly being resorted to in clearing the avionic / electrical equipment due to the following reasons:-

a) Platform level problems / functional shortcomings will be revealed during developmental / prototype flight testing leading to remedial action prior to the costly and time consuming full Qualification Test (QT).

b) Full QT would take a long time before the item is cleared for integration and flight trials.

MIL-Std-1796A defines Safety of Flight Test (SOFT) as "*any test or analysis needed to show that an item will not cause a hazard in the aircraft*". SOFT calls for a set of tests to: -

a) Ensure that the integration and operation of the equipment does not jeopardize the safety of the platform.

b) Verify that the unit will function satisfactorily in the envisaged environment.

The test severity and duration are arrived to meet the period of the flight evaluation.

1.2 Scope

The Scope of this directive is to provide guidelines for preparing a SOF test schedule for clearing airborne **internally mounted** equipment to undertake developmental flight trials.

1.3 Applicability

This directive is applicable from the date of release.

1.4 References

a. Procedure for Design, Development and Production of Military Aircraft and Airborne Stores (DDPMAS) 2002 and DDPMAS-2002 Vol-II, Software Development and Certification
b. MIL-STD-1796A, Avionics Integrity Program (AVIP)
c. Mil-HDBK-344A, Environmental Stress Screening for Electronic Equipment
d. Mil-STD-2164(EC) Environmental Stress Screening Process for Electronic Equipment
e. ADS-71 SP, Standard Practice, Environmental Airworthiness And Qualification Requirements For Electronics, Avionics, And Mission Equipment Installed On Army Aircraft

1.5 Definitions

The definition of terms as applicable for this directive is: -

a. **Safety of Flight Test**:

   Any test or analysis needed to show that an item will not cause a hazard in the aircraft.

b. **Flight Critical Equipment**:

   Anomalies generated by this type equipment would cause immediate or almost immediate loss of aircraft control or unsafe situations with loss of life a likely occurrence.

c. **Safety Critical Equipment**:

   Anomalies generated by this type equipment would cause a safety hazard to personnel or to the aircraft.

d. **Equipment**:

   A general term designating an item or group of items capable of performing a complete function.

e. **Standard of Preparation**:

A set of drawings, data, documents that establish the hardware build standard, Bill of Materials, Processes and software build standard of equipment.

f. **Environmental Stress Screening:**

A series of tests conducted under environmental stresses to disclose weak parts and workmanship defects so that corrective action can be taken.

1.6 Acronyms

a.	CATH	:	Combined Altitude Temperature Humidity
b.	DDPMAS	:	Procedure for Design, Development and Production of Military aircraft and airborne stores
c.	EMC	:	Electromagnetic Compatibility
d.	EMI	:	Electromagnetic Interference
e.	ESS	:	Environmental Stress Screening
f.	JAC	:	Joint Airworthiness Committee
g.	PC	:	Performance Checks
h.	QT	:	Qualification Tests
i.	SOFT	:	Safety of Flight Test
j.	SOP	:	Standard of Preparation
k.	TOH	:	Temperature – Operation High
l.	TOL	:	Temperature – Operation Low
m.	TSH	:	Temperature – Storage High
n.	TSL	:	Temperature – Storage Low

2 Safety of Flight Test Approach

2.1 Applying SOFT Approach

a. The SOFT approach for clearing airborne stores shall be applied only to avionic / electrical equipment which are **not Flight / Safety critical** in nature.

b. One unit shall undergo all the applicable SOF tests. On satisfactory completion of SOF Tests, another unit with same Standard of Preparation (SOP) and manufactured following the same processes shall be subjected to ESS tests and cleared for flight trials. The unit that has undergone SOF test can also be cleared for flight trials. Alternately, the SOF tested unit may be used for the continuation of full QT under the following conditions:

   i. It has not undergone flight trials

   ii. There is no change to the SOP

   iii. QT test profiles are similar to SOF test profiles

c. Not more than three units / aircraft sets shall be cleared for development flight trials. The equipment shall be cleared for maximum of 100 flying hours. Depending on the programme requirements, the number of units and the flying hours may be decided mutually between the contractor and the regulatory authority.

d. To evaluate the cumulative effects of vibration, shock and environments (such as temperature, altitude, humidity), a single unit shall be used. However for EMI / EMC and Power Supply tests, the same unit or another unit with same SOP may be used.

e. This directive shall be used as a guideline for carrying out the SOF tests. The tests may be tailored based on the equipment functionality, operation, platform environment and mounting location / orientation.

f. The test specifications selected for SOFT in this directive are derived from respective MIL standards like MIL-STD-810F, MIL-STD-461E, and

MIL-STD-704E. The higher revisions of these standards may be followed whenever applicable. Moreover, if the program mandates the use of other qualification standards like RTCA DO-160, DEF STAN etc, test specification may be derived accordingly.

g. SOF tests which are carried out to full QT specification may not be repeated during full qualification tests, if there are no changes in SOP.

h. Subsequent use of the units cleared through SOF approach shall be governed by CEMILAC Directive No.92/2005 promulgated vide CEMILAC/5390/TCS dated 23 May 2005 and its further revision / amendments.

2.2 Steps for SOFT

2.2.1 SOF Test Plan

A separate SOF Test plan for avionic / electrical equipment shall be prepared as per the guidelines given below and submitted to CEMILAC / RCMA for approval.

2.2.2 SOF testing

SOF testing shall be carried out as per the approved test plan only. The tests shall be carried out with the concurrence of regulatory authorities. Presence of personnel from CEMILAC / RCMA is not essential but desirable.

2.2.3 SOF Test Report

SOF Test report to be prepared by the contractor / testing agency and duly coordinated by DGAQA / competent QA authority. The DGAQA / competent QA authority certified report to be forwarded to CEMILAC for issue of clearance for flight evaluation.

2.3 Documents

Documents required for the airworthiness certification like Technical Specifications, Hardware/Software SOP, Test Equipment specification/acceptance and any other documents/data as required by the certification authority shall also be provided. The activities and documents for software certification shall be mutually agreed between the contractor and the certification authorities.

2.4 SOF Tests

SOF test consists of the following: -

I. Initial Visual Examination and measurement of weight and physical parameters
II. Performance / Functional checks
III. Burn – in
IV. Environmental Stress Screening (ESS)
V. Power Supply Tests
VI. EMI / EMC Tests
VII. Environmental Tests with Performance / Functional Checks consisting of:
    i. Vibration Test
    ii. Combined Altitude Temperature Humidity (CATH)
    iii. Shock Test
    iv. Acceleration Test (Structural)
    v. Shock Test (Crash Safety)
    vi. Rapid decompression Test
    vii. Explosive Atmosphere
    viii. Gun Fire Vibration

    } Only if applicable

VIII. Final Visual Examination and Performance / Functional Checks

Note-1: The sequence of SOF tests shall be mutually agreed between the designer and certification agency / regulatory authority.

2.5 SOF Test Details

2.5.1 Initial Visual Examination

The equipment shall be inspected for type / part number, serial number etc., and to visually verify compliance to standard workmanship / assembly practices and conformance to drawings. Also weight and physical dimensions shall be measured and recorded.

2.5.2 Performance / Functional Checks

The equipment shall be tested for complete performance / functional checks exercising the software residing in the equipment at nominal power supply voltages at ambient temperature.

Any defects observed during inspection / performance checks shall be recorded and necessary corrective action initiated to eliminate the same.

2.5.3 Burn-in

The equipment shall be kept powered 'ON' continuously for 4 hours at ambient temperature with nominal power supply voltage. Performance Checks are to be carried out during the test. On completion of burn-in, the equipment shall be subjected to visual examination and performance checks.

Note-2: The 4 hours duration has been arrived at by considering the approximate maximum trial duration of single flight of aircrafts and helicopters. This may be tailored for 1.5 times the maximum mission duration.

2.5.4 Environmental Stress Screening (ESS)

ESS tests are performed in order to bring out latent manufacturing defects and enhance reliability. For the thermal cycling the maximum and minimum temperatures (TOH, TOL) limits are those values of temperatures defined by the equipment specifications for operation.

Note-3: The ESS profile given below may be tailored based on MIL-STD-2164(EC) / MIL-HDBK-344A.

2.5.4.1 Vibration

With the Power ON, the equipment shall be exposed to five minutes of random vibrations in all three perpendicular axes prior to and after the thermal cycling. The random vibration spectrum shall be as shown in Figure-1. This profile may be followed for all equipment irrespective of type of platform. Critical parameters shall be monitored during vibration.

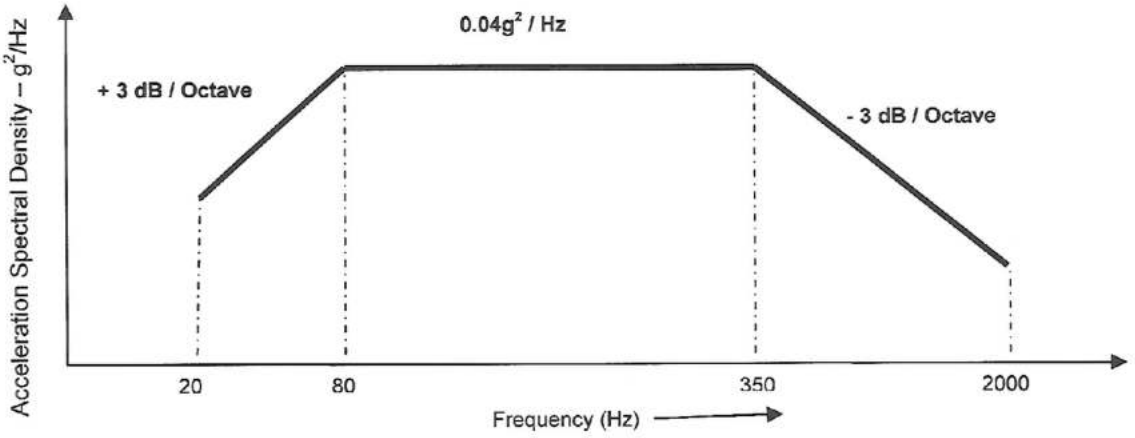


Figure – 1: Vibration Test Profile for ESS

2.5.4.2 Thermal cycling

The unit shall be subjected to 10 thermal cycles. The last three cycles shall be defect free. The temperature cycling profile shall be as shown in Figure-2. Performance checks shall be carried out as indicated in the profile. Necessary warm up time as per technical specification of the equipment shall be considered.

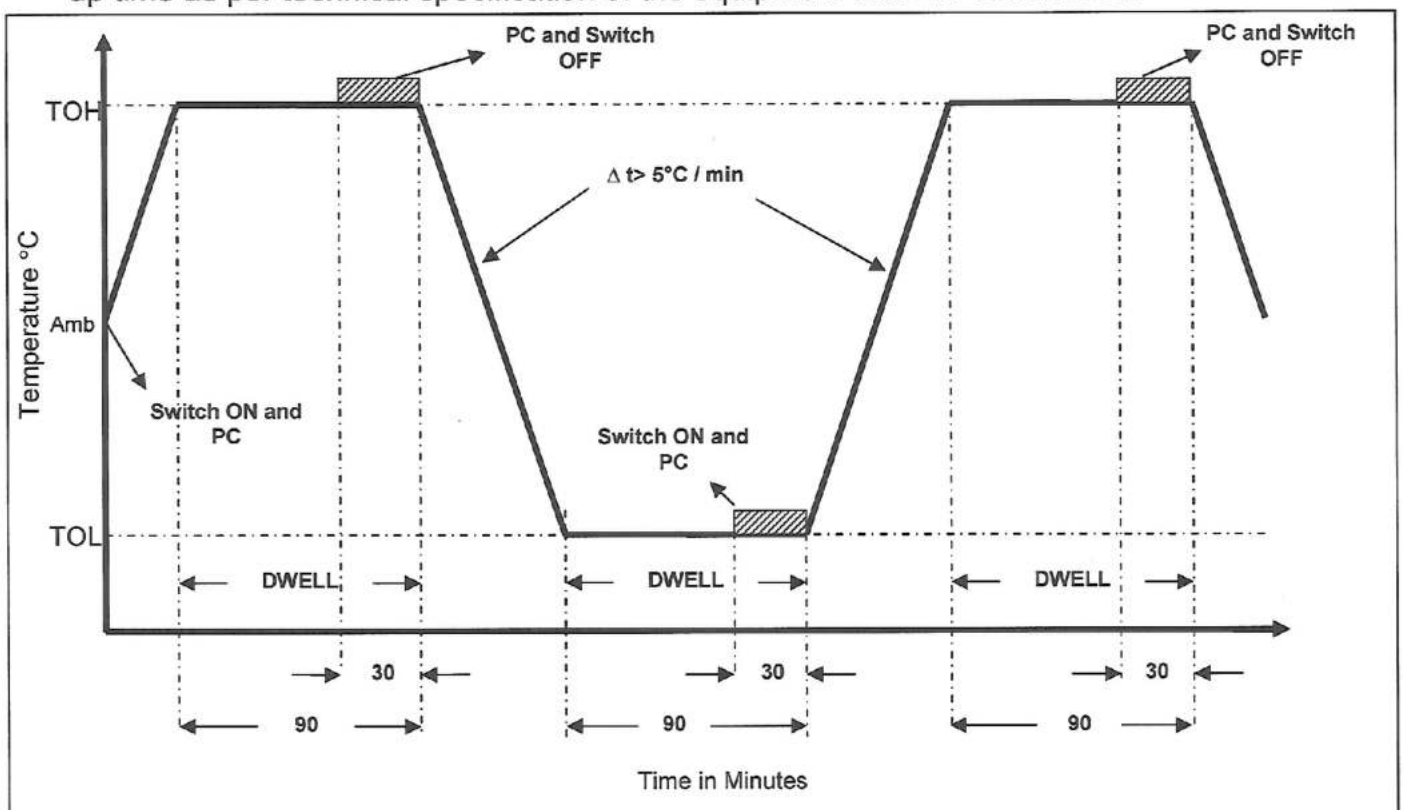


Figure – 2: Thermal Cycling Profile for ESS

On completion of ESS, the equipment shall be subjected to visual examination and performance checks.

2.5.5 Power Supply Tests

All the applicable tests under MIL-STD-704 shall be carried out. Pass / Fail criteria against each test shall be defined based on the equipment performance requirement. If any specific requirements of the platform exist, additional Power supply tests may be included accordingly.

Note-4: If MIL-STD-704 is used, the test procedure shall be as per MIL-HDBK-704.

2.5.6 EMI / EMC Tests

All applicable EMI/EMC tests shall be carried out to verify the compliance of the equipment to MIL-STD-461. Compliance to all the applicable **Conducted and Radiated Emission** tests as shown in Table-1 shall be strictly ensured. Any deviation observed during the **Conducted and Radiated Susceptibility** tests shall be studied for safety issues and attended to. If there are no safety issues then improvements shall be implemented prior to commencing Qualification Tests.

Table-1 : Conducted and Radiated Emission Tests

Type	Test	Description	Frequency Range
Conducted Emission	CE101	Power Leads	30Hz to 10KHz
	CE102	Power Leads	10KHz to 10 MHz
	CE106*	Antenna Terminals	10KHz to 40 GHz
Radiated Emission	RE101	Magnetic Field	30Hz to 100 KHz
	RE102	Electric Field	10KHz to 18 GHz
	RE103*	Antenna Spurious & Harmonic Outputs	10KHz to 40 GHz
* - Either CE106 or RE103 may be carried out as applicable			

Note-5: Test procedure contents may be as per DI-EMCS-80201B and DI-EMCS-80200B for Electromagnetic Interference Test Procedures and Electromagnetic Interference Test Report respectively.

2.5.7 Environmental Tests

2.5.7.1 Vibration Test

This test shall be carried out to verify the capability of equipment to meet the vibration stresses. This test consists of three parts:

i. Initial Resonance Test
ii. Endurance Vibration Test
iii. Final Resonance Test

2.5.7.1.1 Initial Resonance Test

Initial Resonance test shall be carried out as per Table-2. After completion of this test carry out the performance checks.

Table-2 : Resonance Tests

Equipment mounted on **Rotary Wing Platform**	Resonance Search at 0.5g from 5 Hz to 500 Hz with equipment in 'OFF' condition shall be carried out. The test will be conducted with the test item mounted as is in the platform. Record the resonance frequencies (ratio > 2) observed. These frequencies should not coincide with the platform fundamental frequencies and their harmonics.
Equipment mounted on **Fixed Wing Aircraft**	Resonance search at 0.5g from 5 Hz to 2000 Hz with equipment in 'OFF' condition shall be carried out. The test will be conducted with the test item mounted as is in the platform. Record the resonance frequencies (ratio > 2) observed. These frequencies should not coincide with the platform fundamental frequencies and their harmonics.

2.5.7.1.2 Endurance Vibration Test

Vibration endurance test shall be 15 minutes per axis in all three axes.

i. For Rotary wing aircraft the profile shall be as per Figure-3. The values of W_0, W_1, f_x, $A_1 \ldots A_4$ shall be derived from TABLE 514.5C-IV of MIL-STD-810F.
ii. For Fixed wing Propeller aircraft the profile shall be as per Figure-4. The values of L_0, f_x, shall be derived from Table 514.5C-II.of MIL-STD-810F.
iii. For Fixed wing Jet aircraft the profile shall be as per Figure-5.

The equipment shall be kept ON during the endurance vibration test with performance checks. On completion of the vibration test the complete performance checks shall be carried out.

E-17

2.5.7.1.3 Final Resonance Search

Final resonance search (similar to Initial Resonance search) shall be carried out after endurance test, even if there was no resonance found during initial resonance search. Any deviation in the resonances from the initial resonance search or any resonance noticed should be recorded and corrective action taken to eliminate the same. At the end of the vibration test, Visual Examination and Performance Check shall be carried out.

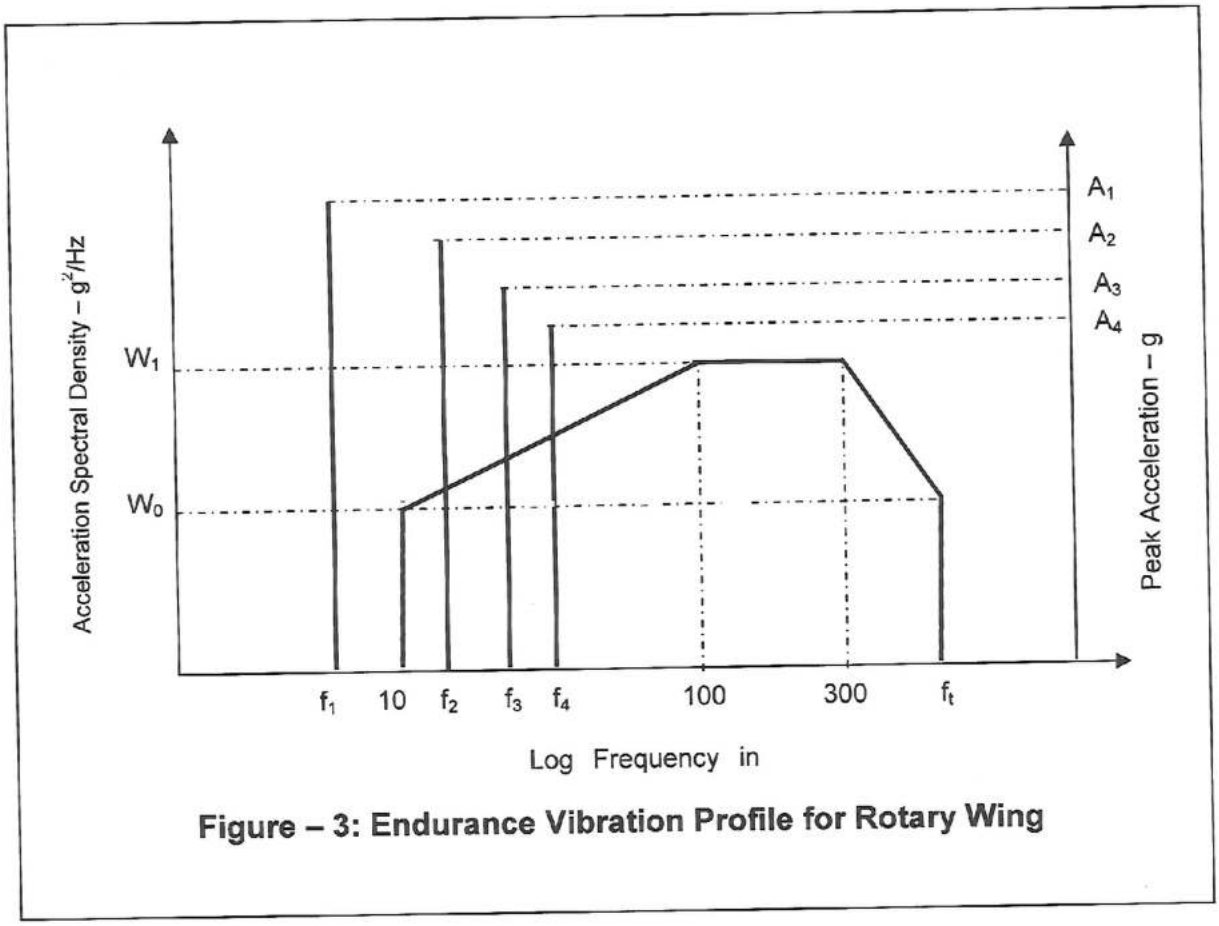


Figure – 3: Endurance Vibration Profile for Rotary Wing

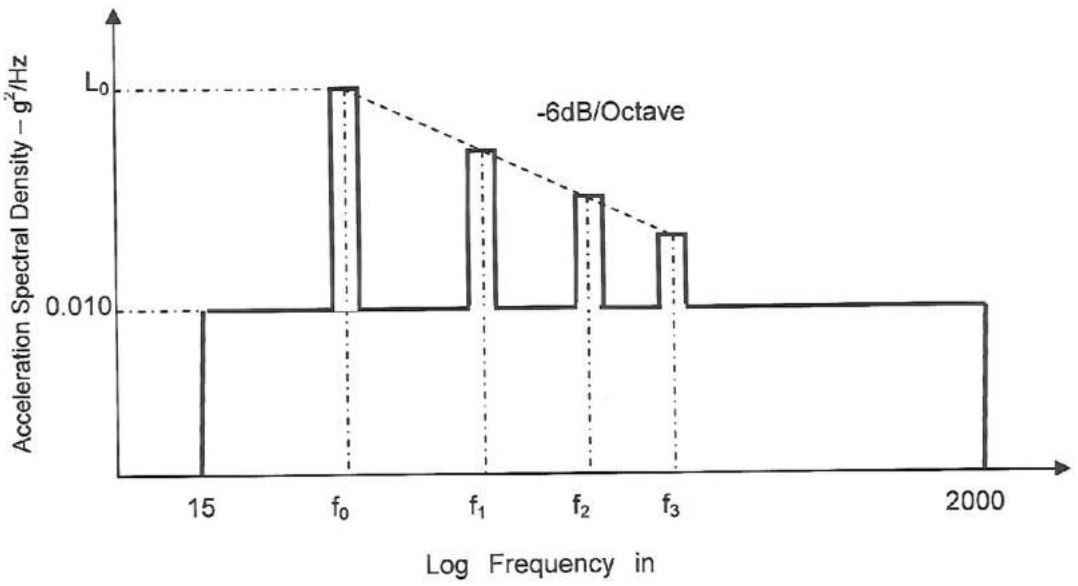


Figure – 4: Endurance Vibration Profile for Fixed Wing Propeller

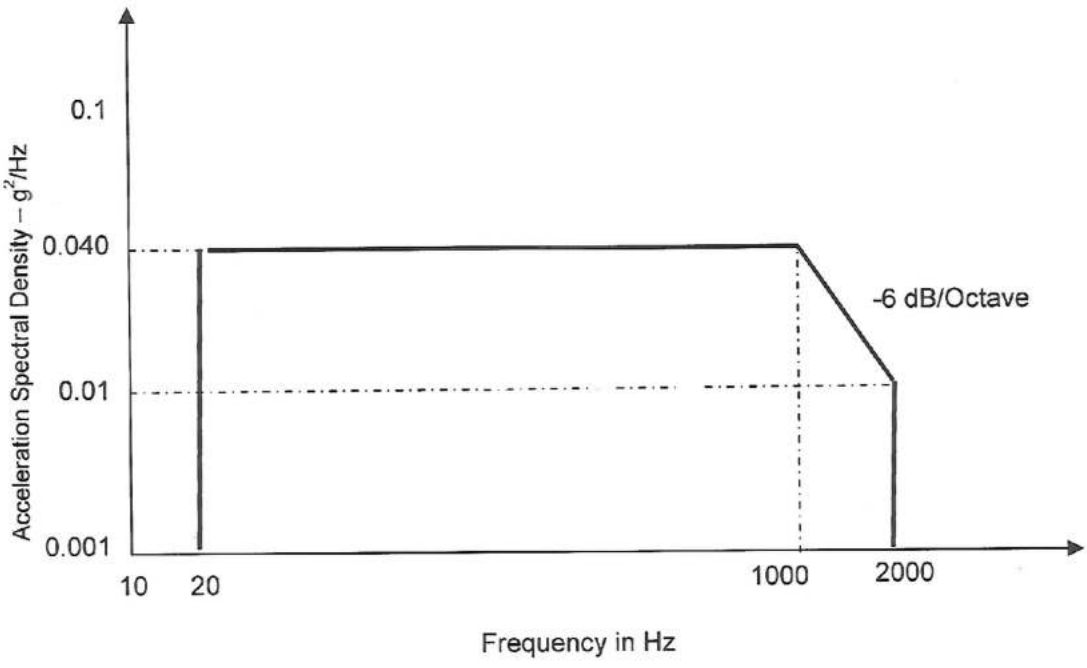


Figure – 5: Endurance Vibration Profile for Fixed Wing Jet Aircraft

2.5.7.2 Combined Altitude Temperature Humidity (CATH) Test

This test shall be carried out to verify the capability of the equipment to meet the combined effect of the temperature, humidity and altitude. The equipment shall be subjected to this combined environment as shown in Figure - 6 below for **01 (one)** cycle. High and Low Temperature (TOH, TOL, TSH, TSL) and Altitude (Max Alt) severity levels shall be decided based on the equipment specification / platform / field data. The equipment shall be powered 'ON' during the test and Performance checks carried out as shown in profile. At the end of the test carry out Visual Examination and Performance Checks.

Note-6: The Combined Temperature / Humidity / Altitude test shown in Figure - 6 is for a typical fighter aircraft. For propeller aircraft/helicopters with very low Rate of Climb/Rate of Descent; the altitude, temperatures may be tailored based on the platform requirements and the requirement of combined high temperature/low pressure may be removed.

Note-7: Though, the combined Temperature / Humidity / Altitude test is the recommended method for avionics equipment, in case of non-availability of CATH facility, then temperature, altitude and humidity tests may be carried out separately as per the profiles given at Figure 7, 8, 9 & 10. (Figure shown constitute one cycle each). 03 such cycles each shall be carried out for high temperature and humidity test. One cycle each shall be carried out for low temperature and altitude test.

2.5.8 Shock Test

This test shall be carried out to verify the capability of the equipment to meet the mechanical shock requirements of the platform. The equipment shall be subjected to three shocks each of 20g saw tooth / 15g half sine pulse of 11 milliseconds duration in all six directions in ON condition. At the end of the shock test Visual Examination and Performance Check shall be carried out. The mounting arrangement / assembly shall be intact and equipment shall perform without degradation.

2.5.9 Acceleration Test (Structural)

This test shall be carried out to verify the capability of the equipment to meet the acceleration (structural) requirements of the platform. The equipment shall be subjected to acceleration in six directions at 'g' levels indicated below in OFF condition for duration of one minute per direction. After test in each direction, visual inspection and performance check shall be carried out. Structural Acceleration test values for a typical fighter aircraft and helicopter shall be as per Table-3.

Table-3: Structural Acceleration (g levels)

Direction [1, 2]	Aircraft (Jet Fighter)[3]	Helicopter
Fore	3.0	4.0
Aft	9.0	4.0
Up	13.5	10.5
Down	4.5	4.5
Lateral left	6.0	6.0
Lateral right	6.0	6.0

[1] - Directions with respect to the aircraft axis.

[2] - If mounting orientation of the equipment in the aircraft is not known, test shall be done at maximum value in all directions.

[3] - For other platforms Refer MIL-STD-810 or actual platform requirements.

2.5.10 Other Tests (Only if applicable)

Based on the platform requirements, mounting locations the following tests may be considered.

2.5.10.1 Shock Test (Crash Safety)

This test shall be carried out on cockpit and cabin mounted equipment to verify the capability of the equipment to withstand the Shock (Crash Safety). A mock-up of the equipment may be used for this test. The equipment shall be subjected to one shock each of 40g saw tooth / 30g half sine pulse of 11 milliseconds duration in all six directions in OFF condition. At the end of the shock test visual Examination shall be carried out. The mounting arrangement / assembly shall be intact.

2.5.10.2 Rapid Decompression Test

This test shall be carried out on equipment mounted in pressurised area such as cockpit / cabin to verify the capability of the equipment to meet the Rapid Decompression due to rapid change in pressure. The pressure variation shall be corresponding to 8,000 ft to the maximum operating altitude within 15 seconds. The chamber pressure shall be held to maximum altitude condition for 10 minutes. The equipment may be kept 'OFF' during the test. At the end of the test, equipment shall be brought to standard ambient atmospheric conditions and Performance Check carried out.

2.5.10.3 Explosive Atmosphere Test

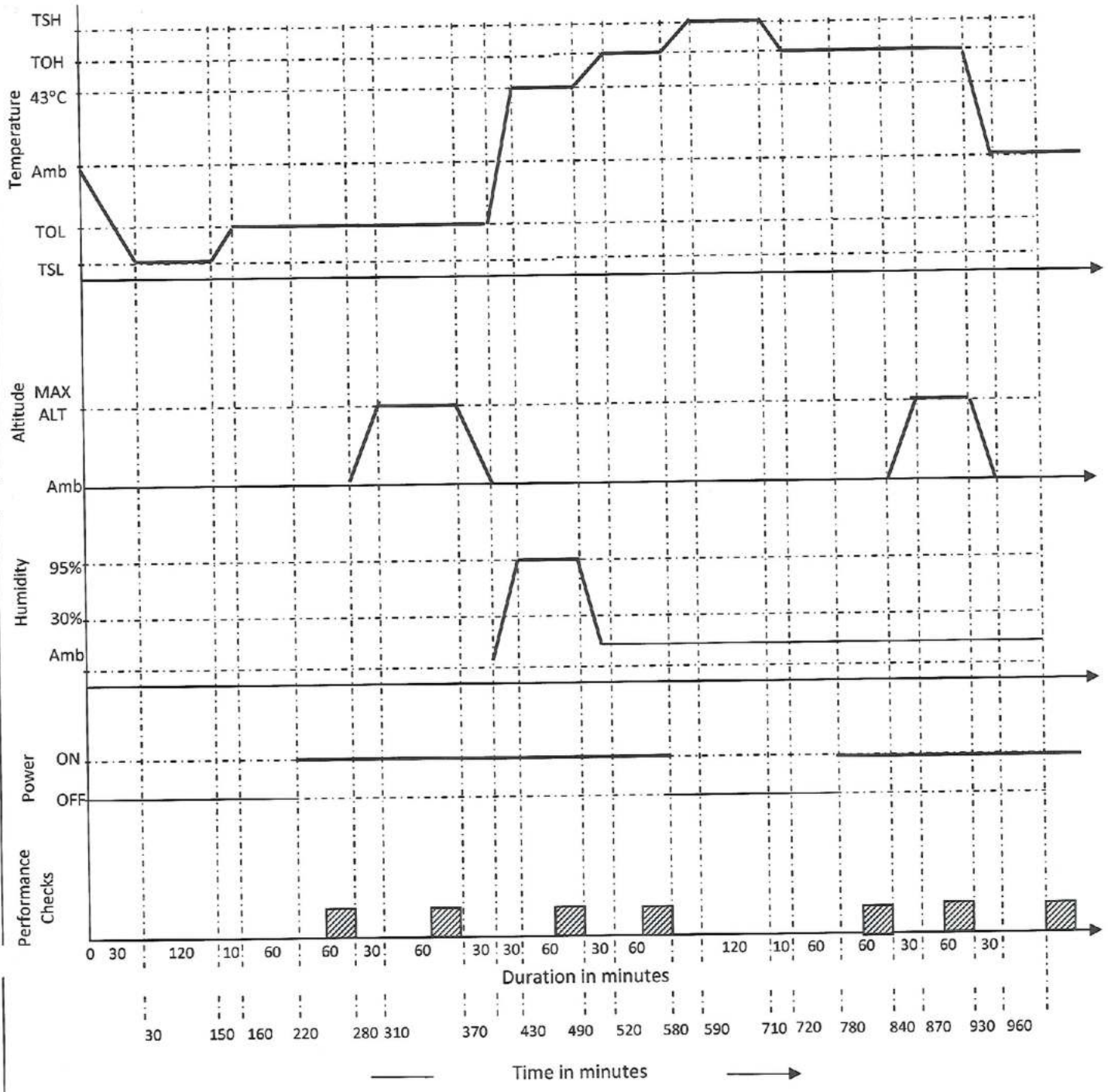
An explosive test shall be carried out to determine the ability of the equipment to either operate in fuel – air atmosphere without causing ignition and / or for verifying containment of an explosive or burning reaction of encased unit. The test may be performed based on Method 511.4 of MIL-STD-810F.

2.5.10.4 Gun Fire Vibration

Gunfire vibration tests are performed to provide a degree of confidence that materiel can physically withstand the transient vibration encountered in operational environments during the firing of a low calibre gun. This test shall be carried out only if the equipment is mounted near to the gun and gun firing is expected during the flight trials for this equipment. The profile may be tailored based on Method 519.5 of MIL-STD-810F. The Gun Fire Vibration Test for SOFT may be carried out on a Mock up unit.

2.5.11 Final Visual Examination and Performance / Functional Checks

At the end of all the Environmental Tests, final visual examination and performance checks shall be carried out.



Note-8: All performance checks during last 30 minutes of the respective condition

Figure – 6: Combined Temperature, Humidity and Altitude Test

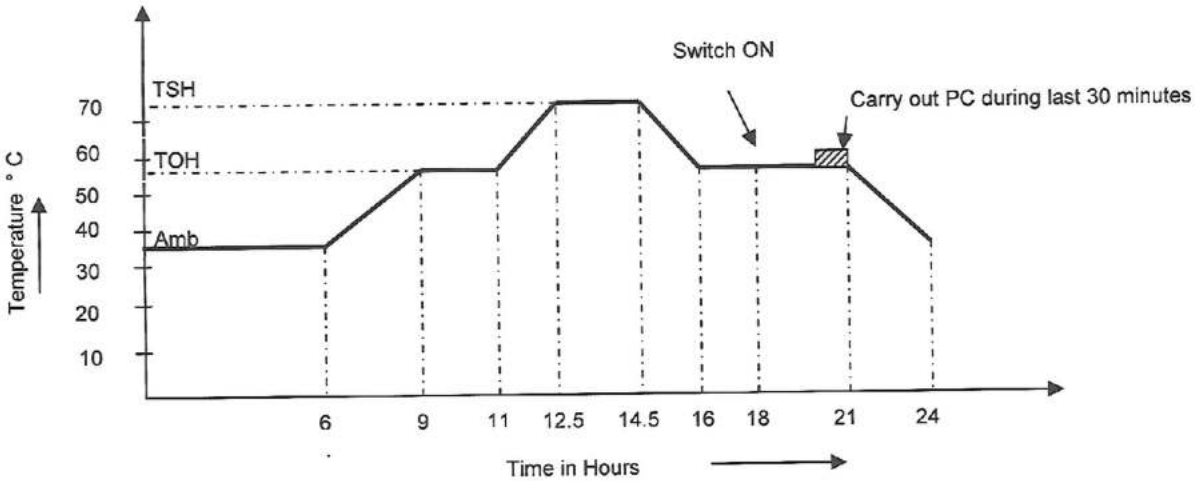


Figure – 7: High Temperature Storage cum Operational Test Profile

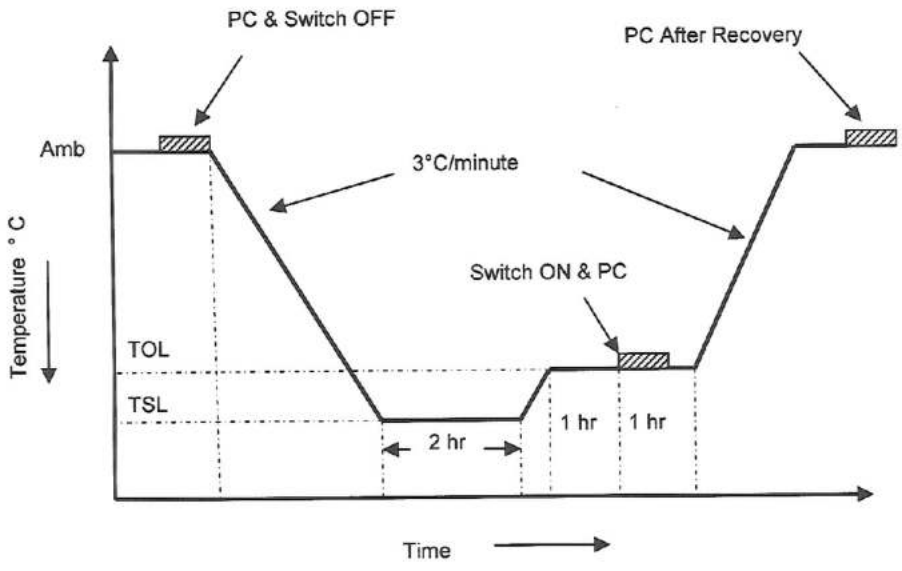


Figure – 8: Low Temperature Storage cum Operational Test Profile

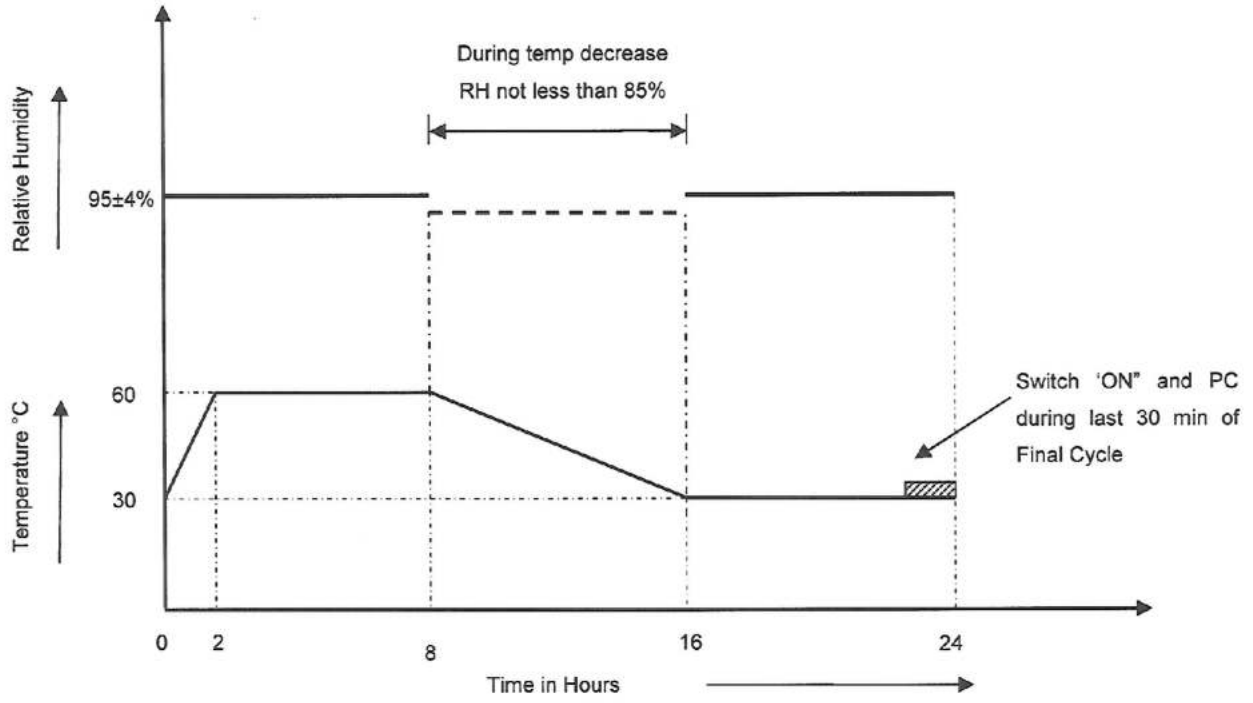


Figure – 9: Humidity Test Profile

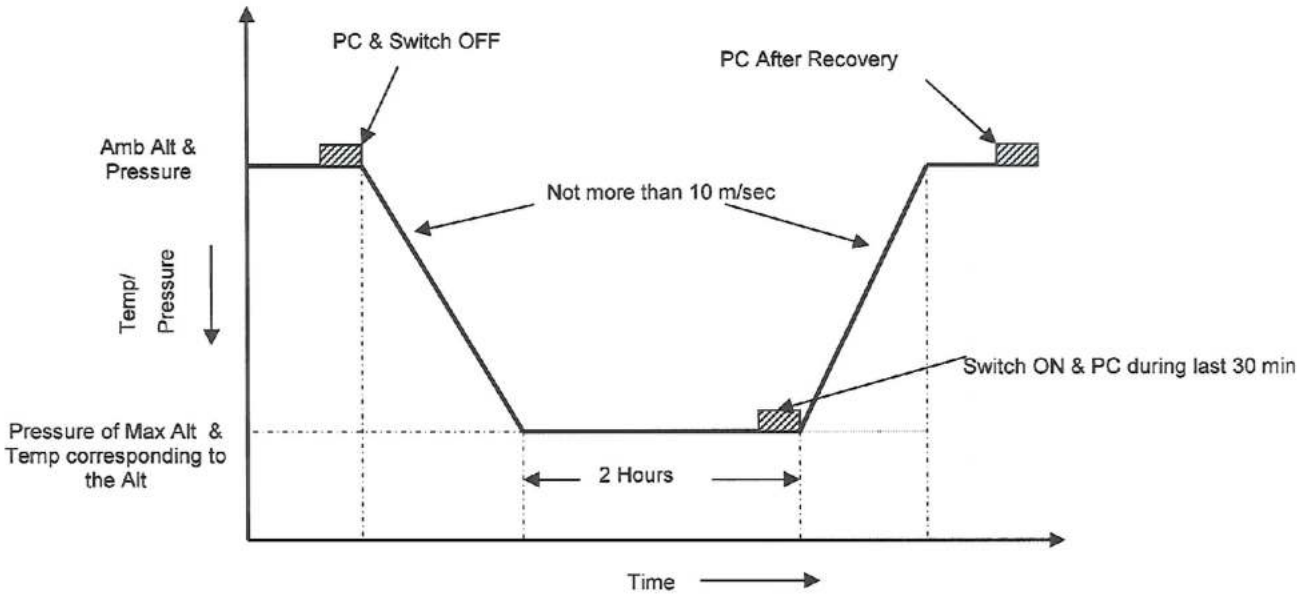


Figure – 10: Altitude Test Profile

E-28

3 Cancellation & Promulgation

3.1 Cancellation

This order cancels and supersedes the following directive:

Safety of Flight Tests CEMILAC Directive 99/2006

3.2 Promulgation

a. The draft directive was circulated for review to all members of Joint Airworthiness Committee (JAC).
b. The directive is released after incorporating relevant comments received from various members.

3.3 Feedback

The feedback, if any, of this directive may please be forwarded to:

Chief Executive (Airworthiness)
CEMILAC, Defence Research & Development Organization
Marathahalli Colony Post
Bangalore-560037.

E-26

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