QUALITY DIRECTIVE ON ENVIRONMENTAL STRESS SCREENING (ESS)

भारत सरकार, रक्षा मंत्रालय
वैमानिक गुणवत्ता आश्वासन महानिदेशालय / तकनीकी समन्वय अनुभाग
एच–ब्लाक, नई दिल्ली–110011
GOVERNMENT OF INDIA, MINISTRY OF DEFENCE
DIRECTORATE GENERAL OF AERONAUTICAL QUALITY ASSURANCE
H-BLOCK, NEW DELHI-110011
TEL: 23011783, FAX : 011-23014395
www.dgaeroqa.gov.in, e-mail : hq.dgaqa@nic.in

एम. राजाकन्नू
महानिदेशक

M. Rajakannu
Director General

सत्यमेव जयते

भारत सरकार
रक्षा मंत्रालय
वैमानिक गुणवत्ता आश्वासन महानिदेशालय
एच-ब्लाक, नई दिल्ली-110011

GOVERNMENT OF INDIA
MINISTRY OF DEFENCE
DIRECTORATE GENERAL OF
AERONAUTICAL QUALITY ASSURANCE
H-BLOCK, NEW DELHI-110011
TEL : 23011783 FAX : 011-23014395
email : hq.dgaqa@nic.in

Quality Directive No: 04-03/2015 Date: 14 Aug 2015

PREFACE

1. Manufacturing techniques of Modern Electronics hardware consists of number of individual operations and processes through which defects can be introduced. Some patent defects can be detected through conventional Quality Assurance Processes (Visual & Functional Checks) whereas the latent defects (specially the one which is introduced during the manufacturing processes) are detected only through Environmental Stress Screening (ESS). Inability to find the latent defects by obvious means is the consequences of the increased complexity and density of packing of the modern electronics products.

2. The latent defects must be discovered and corrected before the product leaves the factory otherwise they will show up as product failure in service use with possible serious Military consequences and always with undesirable cost impact.

3. This Quality Directive is issued to specify the procedures for precipitation of the latent defects during manufacture so that the premature failure can be reduced and thus to enhance the reliability of electronics products delivered to the Services.

Place: New Delhi (M Rajakannu)

QUALITY DIRECTIVE ON ENVIRONMENTAL STRESS SCREENING (ESS)

1.0 INTRODUCTION

The requirement of Environmental Stress Screening (ESS) has been envisaged in various Military Standards and Guidelines, the Technical Standing Order (TSO) of HQ DGAQA and Unit Standing Orders (USOs) of the Field Establishments (FEs).

ESS is a vehicle by which the latent defects are accelerated to early failures in the factory, resulting in precipitation of infant failures of bath-tub curve.

The ESS can be viewed as a production tool & extension of QC inspection & testing processes during manufacturing and required to be applied on each of the production equipment to precipitate the latent defects.

The ESS is not a pass fail criteria and the failure during ESS shall be welcomed to introduce the remedial action so that the equipment is free from premature failures during the use by Services.

Although the various field establishments dealing with electronics LRUs have already implemented the ESS in the Acceptance Test Procedures (ATPs)/Production Acceptance Tests (PATs), there is a need to incorporate a uniform ESS procedure in the ATPs & PATs.

2.0 SCOPE

The procedures specified in this document are applicable on indigenous Subassemblies & LRUs of airborne & Ground Equipment including Test Rigs for Electronics equipment.

3.0 OBJECTIVE

To implement a uniform ESS procedure to be followed by all DGAQA Field Establishments (FEs) so that the product delivered to the Services are free from infant failures.

4.0 BACKGROUND

Process of ESS has been standardized as application of Thermal Cycling (TC) and Random Vibration (RV). There have been the following two approaches of ESS as per Military Standards:

(a) **Basic Approach**:
There are two basis approaches to the application of stress screens. *In one approach, the Government explicitly specifies the screens, screening parameters to be used and failure free periods*. Another approach is to have the contractor propose a screening program and is subjected to the approval of the Government. The first one is established approach since long through CEMILAC/RCMA & DGAQA and a uniform implementation of this approach is required as per MIL-HDBK-2164A, CEMILAC Joint Airworthiness Standard (01/2007), CEMILAC Directive 14/2015, JSG 0613 of MoD, applicable as on date. This approach specifies the minimum Thermal Cycling of 33½ Hrs, including 10 cycles of which last three are Defect Free and the duration of one cycle is 3 Hrs 20 minutes minimum with the temperature extremes as per operational temperature specification of the equipment being screened.

(b) **Quantitative Approach** :
Detailed mathematical calculations requiring various inputs from database such as **packing density, defect density, precipitation efficiency (PE), thermal analysis etc. and component level specs of huge no. of components. The data being needed for a systematic quantitative approach to ESS application is not fully developed**. *It requires the temperature extremes of component specs which is very much higher than the operating temperature of the equipment*. In this approach, PE above 95% (should be case for Defence Equipment) can only be reached through the higher temperature extremes with higher rate of change of temperature and more no. of cycles. However, if we increase the temperature extremes and rate of change of temperature further, the no. of temperature cycles can be reduced. It may be noted that testing any LRU beyond its spec limits does not stand to any logic unless it is proved.

It has been noticed that in some cases an approach which is mix of both basic approach & quantitative approach is being followed. The less duration and less no. of cycles (applicable for extremes of components specs of quantitative approach) have been adopted with extremes of LRU specs (applicable for basic approach) which is always lower than the component level specs. This mix approach is not acceptable as it may not serve the very purpose of ESS. Hence either Basic or Quantitative approach may be followed in true spirit for the PE of more than 95%. The scenario is appended below:

Sl. No.	Difference of Temp extremes (ΔT) - ºC	Temp rate of Change ºC/Min	Number of Cycles	Precipitation Efficiency (PE)	Remarks
1	100	5	6	74.96%	Dwell time corresponds to stabilization of the temp of components to max safe value as per component specification
2	100	5	10	90.05%	
3	100	10	10	98.83%	
4	100	5	12	93.73%	
5	100	5	14	96.05%	
6	*120	5	10	92.37%	
7	*120	10	10	99.30%	
8	*140	5	10	94.05%	
9	*140	10	10	99.56%	

* Generally applicable for Industrial Components

Normally it is observed that 80% of defects are susceptible to detection during thermal screening & remaining 20% during Random Vibration (RV). More importance to be given to thermal screening.

The major differences between both the above approaches are as follows:

Sl. No.	Parameter	Basic Approach	Quantitative Approach
1.	Applicable Standards	MIL HDBK 2164A/JSG 0613/ CEMILAC JAS 01/2007 and CEMILAC Directive 14/2015	MIL HDBK 344
2.	Temp extremes	Lower (Equipment Specs)	Much Higher (Component Specs)
3.	No. of Cycles	Fixed (10)	Variables from 2 to 30 as per desired PE
4.	Dwell Time	variable, minimum 3 Hrs 20 minutes for one cycle (90 minutes at each extreme)	Variable, is a function of the difference in the thermal masses of the items being screened.
5.	Rate of change	5 ºC/min or 10 ºC/min	5 ºC/min to 40 ºC/min as per desired PE
6.	Total duration	40 Hrs/33 ½ Hrs	Variable as per above
7.	Vibration	0.04g2/Hz(6.06 g_{rms}) for a selected band of frequencies for 15 minutes (5 mins/axis) as per Fig 'A'	Variable, 0.5 to 10 g_{rms} for 5 to 600 minutes on susceptible axis

5.0 THE DIRECTIVE

5.1 The following test procedure shall be performed in the given sequence:

(a) Functional Check Carry out the Functional Check of the equipment as per the ATP/PAT. Results are to be recorded.

(b) Initial -Vibration The equipment shall be subjected to Random Vibration profile as per **Fig 'A'** on all three axes. The duration of Random Vibration shall be 5 minutes per axis. The equipment should be switched ON during vibration and key performance parameters of the equipment are to be monitored. The failures, if any, shall be recorded and analyzed for the corrective action.

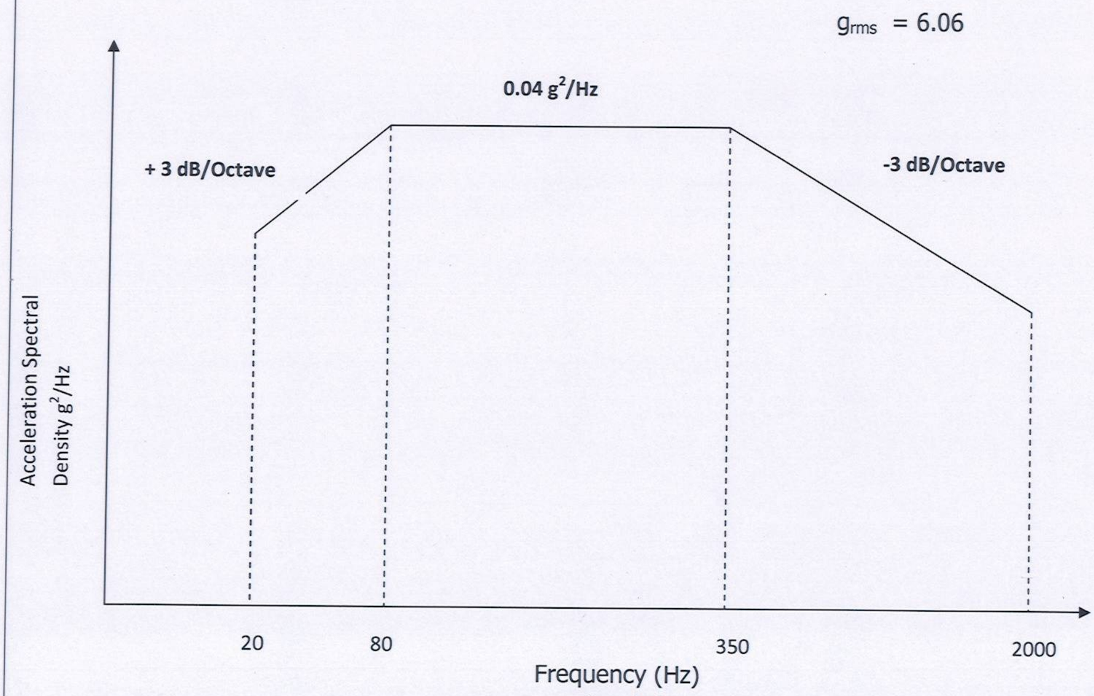

Fig - 'A'

(c) Thermal Cycling After Random Vibration, the equipment shall be subjected to the minimum 10 nos. of thermal cycling for Ambient Cooled equipment as per **Fig 'B'** and minimum 12 nos. of thermal cycling for Supplementary Cooled equipment as per **Fig 'C'**. The duration of one cycle shall be 3 Hrs 20 minutes. The rate of temperature change shall be 10°C/minute. The equipment shall be switched ON & OFF as depicted in the figures. The key performance parameters of the equipment are to be monitored during full switch ON period of the equipment. The failures, if any, shall be recorded and analyzed for the corrective action. The Environmental chamber generated graphical record of the thermal cycling shall be available. Last three thermal Cycles should be fault free. The extremes of the temperature will be governed by the specification of the equipment.

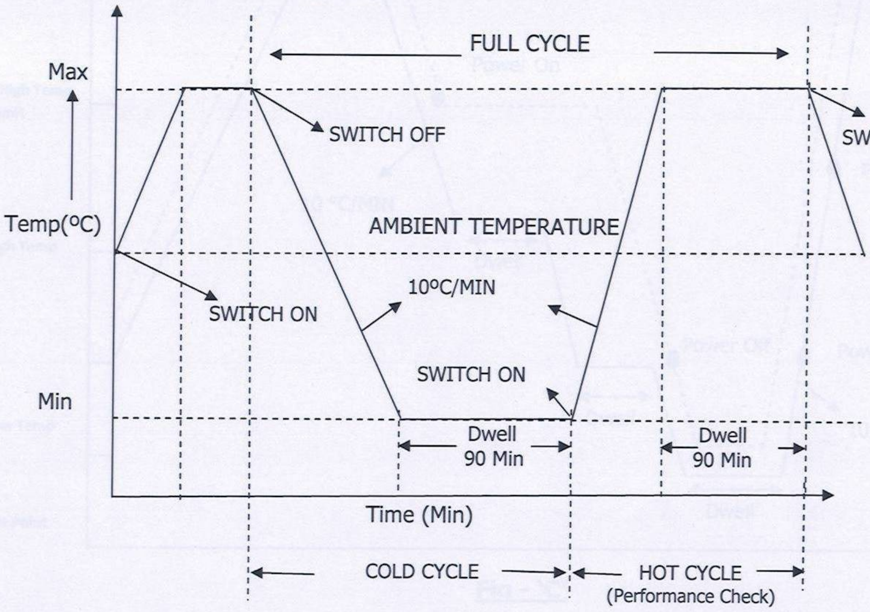

Fig – 'B'

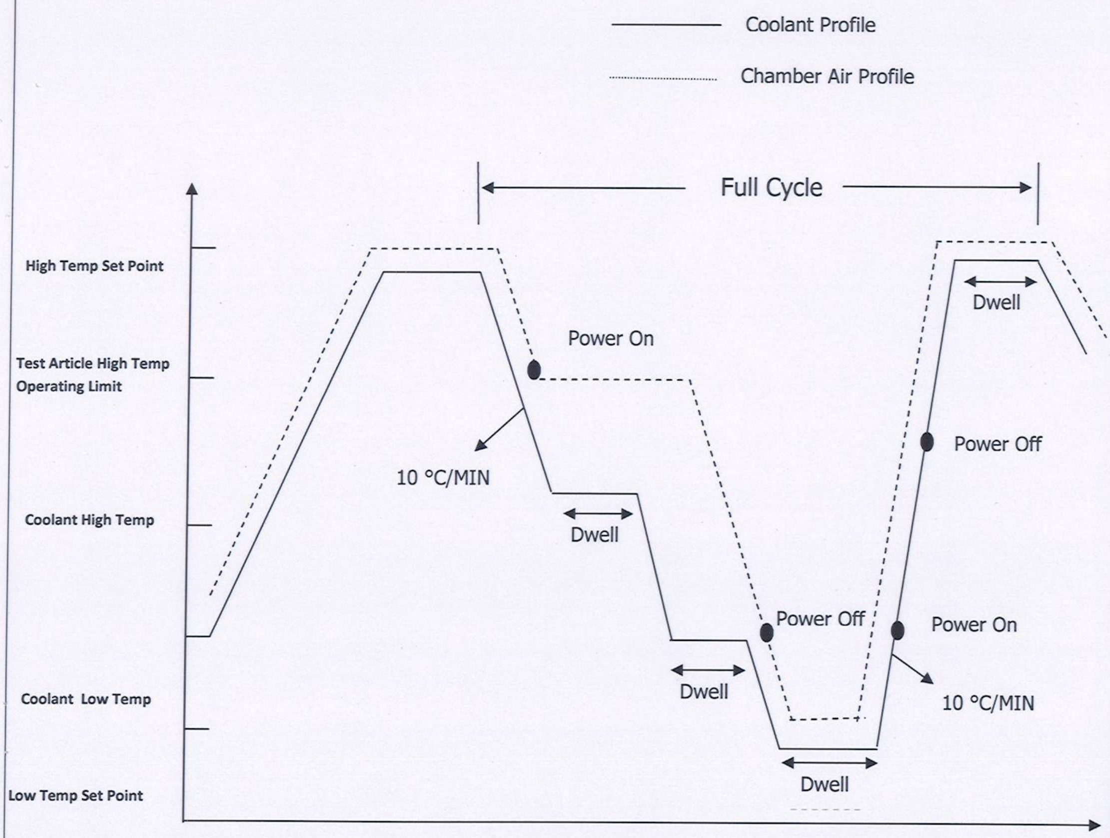

Fig - 'C'

The higher rate of temperature change and more no. of thermal cycles have been found more effective in precipitating the latent defects. Based on the thermal survey of the equipment, the thermal cycling profile can be tailored for decrease in the dwell time and increase in the no. of cycles or vice-versa, keeping the total duration of thermal cycling to 33 Hrs (minimum) for Ambient Cooled equipment and 38 Hrs (minimum) for Supplementary Cooled equipment.

(d) Final Vibration The equipment shall undergo through Random Vibration profile as per **Fig 'A'** above on all the three axes. The duration of Random Vibration shall be 5 minutes per axis. The equipment should be switched ON during vibration and key performance parameters of the equipment are to be monitored. The failures, if any, shall be recorded and analyzed for the corrective action.

(e) Functional Check Carry out the Functional Check of the equipment as per ATP/PAT. Results are to be recorded.

6.0 CONCLUSION

A sincere effort of Field Establishments of DGAQA is required to ensure that the above procedures of the Directive are incorporated in all the ATPs/PATs being followed during production of all electronics LRUs of airborne and Ground applications. Under the provisions of DDPMAS 2002, suggestions shall also be given to CEMILAC/RCMA to incorporate these procedures in the QTP & ATP for airborne equipment during Design & Development.