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Pages 1 to 31

**EVALUATION TEST PROGRAMME FOR  
DISCRETE MICROWAVE SEMICONDUCTORS**

**ESA/SCC Basic Specification No. 2265010**



**space components  
coordination group**

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ISSUE 1

**DOCUMENTATION CHANGE NOTICE**

Rev. Letter	Rev. Date	Reference	CHANGE Item	Approved DCR No.
'A'	Feb. '94	P1. Cover Page P2. DCN P3. Table of Contents P5. Para. 2.2 P7. Paras. 5.2 to 5.6 P8. Paras. 5.7 and 5.8 Paras. 5.10 and 5.11	: Amended as relevant : Reference to ESA PSS-01-702 added : Text related to GaAs devices deleted : Text related to GaAs devices deleted : New Para. on Materials and Finishes; former Para. 5.10 renumbered 5.11 and amended; former Para. 5.11 deleted	None None None 221052 21062 21062 221052 / 21062 / 23605
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**1. PURPOSE**

The purpose of this specification is to establish the procedure to be followed in the evaluation of Silicon (Si) and Gallium Arsenide (GaAs) microwave semiconductors for space application and thereby to anticipate, as far as possible, component behaviour during qualification testing. Therefore, the aim of such testing shall be to overstress specific characteristics of the component concerned with a view to the detection of possible failure modes. The evaluation shall also include the susceptibility of the component to ESD damage and radiation. Additionally, a detailed construction analysis shall be performed to detect any design and construction defects which may affect the reliability of the component and to facilitate failure analysis activities.

**2. APPLICABLE DOCUMENTS**

The following documents form part of, and shall be read in conjunction with, this specification.

**2.1 ESA/SCC SPECIFICATIONS**

No. 5010, Discrete Microwave Semiconductor Components.

No. 20400, Internal Visual Inspection.

No. 20500, External Visual Inspection.

No. 20900, Radiographic Inspection.

No. 22900, Total Dose Steady-State Irradiation Test Method.

No. 23800, Electrostatic Discharge Sensitivity Test Method.

Unless otherwise stated herein, reference within the text of this specification to "the Detail Specification" shall mean the relevant ESA/SCC Detail Specification.

**2.2 OTHER (REFERENCE) DOCUMENTS**

ESA PSS-01-702, A Thermal Vacuum Test for the Screening of Space Materials.

IEC Publication No. 68 - Basic Environmental Testing Procedures.

MIL-STD-750 - Test Methods and Procedures for Semiconductor Devices.

MIL-STD-883 - Test Methods and Procedures for Microelectronics.



**3. PROCEDURE**

**For Si devices** : Standard components shall be selected from a homogeneous lot at the Manufacturer to be evaluated.

**For GaAs devices** : Standard components shall be selected from more than one lot but no more than 3 lots at the Manufacturer to be evaluated to form a homogeneous sample. This requirement may be reviewed on a case by case basis.

These components shall not have been submitted to any screening or burn-in, but must have been manufactured in conformity with high reliability practice and an established Process Identification Document (P.I.D.) or an identifiable process which shall form the basis for a P.I.D..

The tests specified in the programme shall be performed in the sequence shown in Charts IA or IB. All results shall be recorded and failed components submitted to a failure analysis. Probable failure modes and mechanisms shall be determined. The evaluation test programme shall be performed, under the supervision of the Qualifying Space Agency (QSA) for whom the evaluation of the component concerned is required, by the Manufacturer or at a test laboratory approved by the QSA.

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#### 4. TEST PROGRAMME SEQUENCE AND SAMPLE DISTRIBUTION

##### 4.1 SELECTION OF COMPONENTS FOR EVALUATION TESTING

The number of components chosen for evaluation testing shall depend upon whether a single component type or a family of parts is evaluated and the number of component types chosen to represent the family.

**For Si devices** : Not less than 55 specimens shall be used for each test programme.

**For GaAs devices** : Not less than 74 specimens shall be used for each test programme.

The component types chosen to represent a family shall cover the range of components to be evaluated and be representative of the different package and pin configurations under consideration. They shall also be the most suitable for highlighting those characteristics and parameters that are pertinent to an investigation into failure modes and weaknesses.

The samples selection shall be as specified by, or as agreed with, the QSA.

The above mentioned quantity shall be submitted to the full evaluation procedure whenever a new technology has been applied to the components concerned, where there is insufficient experience in their production.

##### 4.2 DETAIL SPECIFICATION

Should a Detail Specification for the device(s) to be evaluated not exist, the Manufacturer shall prepare such a document in accordance with the established ESA/SCC format and submit it to the appropriate QSA for review. This shall then serve as a basis for the ordering and testing of the relevant components.

##### 4.3 INSPECTION RIGHTS

The QSA reserves the right to inspect at any time the components processed for evaluation purposes. The Manufacturer shall notify the QSA at least 3 working days in advance of the date of internal visual inspection (see Para. 4.4).

##### 4.4 CONTROL DURING FABRICATION

The components shall be produced as defined in Para 3 above. Internal visual inspections shall be performed by the Manufacturer on the lot to be tested to the extent that this forms part of the Manufacturer's standard procedures. Progress of the components shall be observed closely and recorded together with failure causes of any rejects. A chart showing the numbers in/out and failure cause for each fabrication stage shall be submitted to the QSA.

#### 5. INSPECTION

##### 5.1 GENERAL

The components shall be checked to verify their suitability for the Evaluation Test Programme. Defects or deviations from the established ESA/SCC requirements may invalidate the evaluation. For each measurement or inspection performed, the results shall be summarised in terms of quantity tested, quantity passed and quantity rejected. If devices are rejected, the reason shall be clearly identified.

**5.2 DIMENSIONS**

All devices shall be inspected in accordance with Figure 2 of the Detail Specification (go-no-go). Where gauges exist for performance of measurements, these may be used. Rejected components shall be replaced.

**5.3 WEIGHT**

All devices shall be weighed. Any devices that exceed the weight defined in the Detail Specification shall be rejected. Rejected components shall be replaced.

**5.4 ELECTRICAL PARAMETERS (100%)**

These measurements shall be performed on all components in accordance with Table 2 of the Detail Specification at an ambient temperature of  $+22 \pm 3$  °C. (go-no-go).

Rejected components shall be replaced.

**5.5 EXTERNAL VISUAL INSPECTION (100%)**

All devices shall be inspected in accordance with ESA/SCC Basic Specification No 20500.

Rejected components shall be replaced.

**5.6 PARTICLE IMPACT NOISE DETECTION (PIND) (100%)****(a) Applicability**

This test is only applicable to devices with a cavity.

**(b) Procedure**

All devices shall be tested in accordance with the requirements of ESA/SCC Generic Specification No. 5010, Para. 9.7.

Rejected components shall be replaced.

**5.7 RADIOGRAPHIC INSPECTION (100%)**

All devices shall be inspected in accordance with ESA/SCC Basic Specification No 20900. Additional axes to those specified in the ancillary specification of ESA/SCC Basic Specification No. 20900 may be radiographed if, by so doing, it is possible to observe any faults.

Rejected components shall be replaced.



**5.8 HERMETICITY (100%)****5.8.1 Penetrant Dye Test****(a) Applicability**

This test is only applicable to glass cavity devices .

**(b) Procedure**

The test shall be performed on all devices in accordance with the requirements of MIL-STD-750, Method 1071, Test Condition 'E'.

Rejected components shall be replaced.

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#### 5.8.2 Seal Test

##### (a) **Applicability**

This test is only applicable to devices with a cavity.

##### (b) **Procedure**

Fine and gross leak tests shall be performed on all components in accordance with the requirements of ESA/SCC Generic Specification No. 5010, Para. 9.8.

Rejected components shall be replaced.

#### 5.9 MARKING AND SERIALISATION (100%)

All components shall be marked and serialised in accordance with the standard procedures of the Manufacturer concerned.

**For GaAs devices** : Traceability of the different lots shall be possible.



#### 5.10 MATERIALS AND FINISHES

All non-metallic materials and finishes, that are not within a hermetically sealed enclosure, of the components specified herein shall be tested in accordance with ESA PSS-01-702 to verify its outgassing requirements, unless relevant data is available.

#### 5.11 COMPLETION OF INSPECTION

At the completion of inspection, a formal review shall be conducted of the quantity and type of reject encountered and an assessment made of the probability of a satisfactory Evaluation if pursued to the conclusion of the test programme. If sufficient confidence cannot be established at this time, work on the Evaluation Lot should be terminated.



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## 6. INITIAL MEASUREMENTS

### 6.1 INITIAL ELECTRICAL MEASUREMENTS

These measurements shall be performed in accordance with Tables 2 and 3 of the relevant Detail Specifications. All characteristics shall be recorded against serial numbers.

### 6.2 THERMAL ANALYSIS - FOR GaAs DEVICES ONLY

This test could be destructive and shall be performed on 5 devices. The purpose of this test is to investigate thermal resistivity/conductivity and "hot-spot".

For low power devices (output power at 1dB compression less than 20dBm), MIL-STD-750, Method 31XX shall be applied in order to determine thermal conductivity/resistivity at nominal junction temperature and at the highest junction temperature applied during endurance life test.

For power devices (output power at 1dB compression equal to or more than 20dBm), measurements shall be performed and "hot-spot" and thermal conductivity/resistivity under nominal RF conditions shall be evaluated.

### 6.3 SPECIFIC DYNAMIC MEASUREMENTS - FOR GaAs DEVICES ONLY

These measurements shall be performed on 5 components. The purpose of these tests is to evaluate parasitic effects affecting the operation of GaAs devices. These tests shall be agreed between the QSA and the Manufacturer.

These tests are mainly:

- For power FET's, gate and drain lag effects.
- For low noise FET's, transconductance and output conductance.
- For diodes, pulse measurement.



Two of the devices shall be placed in Group 1 of Chart I B, the three others shall be placed equally under accelerated electrical endurance tests (Group 2A of Chart I B). It could be useful to perform these measurements after ageing tests in order to analyse any degradations which could occur.

## 7. EVALUATION TEST PROGRAMME

### 7.1 GENERAL

The evaluation tests shall be performed as specified in Charts IA for Si devices and IB for GaAs devices. Para. 7.2 details the requirements for Si devices and Para. 7.3 details the requirements for GaAs devices. The components shall be randomly divided into groups and their associated subgroups in the proportions indicated in Charts IA or IB. When a family of components is under investigation, the variations within that family must be represented in each group/subgroup.

All failed components shall be analysed. The depth of analysis shall depend upon the circumstances in which failure occurred and upon whether useful information may be gained. As a minimum, the failure mode shall be determined in each case.

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- For Si devices** :
- The Subgroup 2A tests of Chart I A shall be completed and the results analysed before the Subgroup 3B tests of Chart I A are commenced.
  - Components not failing catastrophically, i.e. those displaying out-of-tolerance electrical parameters, shall not be removed from the test sequence but monitored to observe degradation trends.

## 7.2 EVALUATION TEST PROGRAMME FOR Si DEVICES (CHART I A)

### 7.2.1 Group 1 - Control Group

This group shall be retained for comparison purposes. Whenever electrical measurements are made on any devices under test, these devices shall also be measured.

### 7.2.2 Group 2 - Destructive Tests

#### 7.2.2.1 General

This group shall be randomly divided into 5 subgroups in the proportions indicated in Chart I A.

#### 7.2.2.2 Subgroup 2A - Step-Stress Tests

##### 7.2.2.2.1 General

This subgroup shall be randomly divided into 2 further subgroups in the proportions indicated in Chart I A. The step-stress sequence shall be terminated when 50% (rounded up) of the specimens have been destroyed, unless practical reasons prevent this.

##### 7.2.2.2.2 Determination of Thermal Resistance/Conductivity

###### (a) **Applicability**

This test is not applicable to devices that are thermally self limiting, e.g., Gunn diodes.

###### (b) **Procedure**



MIL-STD-750, Method 31xx, as applicable.

##### 7.2.2.2.3 Parameters To Be Measured During Step-Stress Tests

During step-stress tests, electrical measurements shall be made in accordance with Table 4 of the Detail Specification. Should Table 4 of the Detail Specification not be established, the parameters to be measured shall be selected from Table 2 of the Detail Specification. In the case of doubt as to the applicability of any Table 2 parameter, the parameter shall be measured. At the termination of the step-stress sequences any surviving devices shall have their thermal resistance/conductivity measured as specified in Para. 7.2.2.2.2.

##### 7.2.2.2.4 Subgroup 2A(i) - Temperature Step-Stress Test

The tests in this subgroup shall be performed as specified in Chart II. Electrical measurements shall be made as defined in Para. 7.2.2.2.3 above. The starting temperature (which will be no higher than the maximum operating temperature as defined in the Detail Specification) and the temperature steps (with a maximum step of 25°C) to be employed will be decided by the QSA.

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#### 7.2.2.2.5 Subgroup 2A(ii) - Power Step-Stress Test

##### (a) **Applicability**

This test is only applicable to devices where operation on circuits requiring transfer and dissipation of significant and/or varying levels of power is an intended feature of their design. The QSA shall review the component type and technology to determine the applicability of the test.

##### (b) **Procedure**

The tests in this subgroup shall be performed as specified in Chart III. Electrical measurements shall be made as defined in Para. 7.2.2.2.3 above. The starting power (which will be no higher than the maximum rated power as defined in the Detail Specification) and the power steps (with a maximum step of 20%) to be employed will be decided by the QSA.

#### 7.2.2.2.6 Analysis of Subgroup 2A

The analysis of Subgroup 2A shall be presented to the QSA in a graphical form, supported by the actual results, as follows:

- The number of functional failures shall be plotted against each temperature or power level (if applicable) applied. The cumulative failure rate shall also be plotted.
- The parameters (as defined in 7.2.2.2.3 above) shall be monitored, recorded and plotted against time for each temperature or power level (if applicable) applied, as appropriate.
- The average drift of the parameters at each temperature or power level applied shall be plotted against temperature or power (if applicable) as appropriate.

The analysis of the results of Subgroup 2A(i and ii (if applicable)) shall be used to determine the most effective temperatures and power (if applicable) for the accelerated electrical endurance test (Subgroup 3B).

#### 7.2.2.3 Subgroup 2B - Radiation Tests

In accordance with the requirements of ESA/SCC Basic Specification No. 22900.

#### 7.2.2.4 Subgroup 2C - Construction Analysis

##### 7.2.2.4.1 Internal Water Vapour Content

##### (a) **Applicability**



This test is not applicable to glass devices or to devices without a cavity.

##### (b) **Procedure**

MIL-STD-883, Method 1018, Procedure 1.

##### 7.2.2.4.2 Opening

The devices shall be opened using a technique which does not contaminate the internal structure or in any way impair the ability to observe defects.

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#### 7.2.2.4.3 Internal Visual Inspection

Each device shall be visually inspected in accordance with ESA/SCC Basic Specification No. 20400. Photographs shall be taken as follows:-

- (a) An overall photograph of the opened device.
- (b) An overall photograph of the die.
- (c) Photographs of any anomalies found.

#### 7.2.2.4.4 Scanning Electron Microscope (SEM) Inspection (as applicable)

This inspection shall include, but shall not necessarily be limited to, examination of the following:-

- (a) Detailed examination of any anomalies identified by the internal visual inspection (Para. 7.2.2.4.3 above). Photographs shall be taken of the above.
- (b) Low magnification (up to 500X) shall be used to assess:-
  - (i) Clearance of bond wires at the die edge.
  - (ii) Quality of bonding at the die.
  - (iii) Quality of bonding at the post.

Photographs shall be taken of the above.

- (c) High magnification (greater than 500X) shall be used to assess:-
  - (i) Metallisation coverage and consistency at steps.
  - (ii) Metallisation coverage at contact windows, bonding pads, etc....

Photographs shall be taken of the above.

In the case of devices with a glassivated surface, this examination shall first be attempted through the glassivation.



If the resolution is inadequate, the glassivation shall be removed. This step must be postponed until the bond strength (Para 7.2.2.4.5) test has been performed.

#### 7.2.2.4.5 Bond Strength Test (if applicable)

In accordance with the requirements of the ESA/SCC Generic Specification No. 5010, Para 9.2.3.

#### 7.2.2.4.6 Die Shear Test (if applicable)

In accordance with the requirements of the ESA/SCC Generic Specification No. 5010, Para. 9.2.4.

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#### 7.2.2.4.7 Microsectioning

##### (a) **Glassivation Layer Integrity (if applicable)**

In accordance with the requirements of MIL-STD-883, Method 2021.

##### (b) **Mounting**

The device(s) shall be mounted on a carrier or in a transparent thermosetting resin. This shall have a curing temperature below the maximum storage temperature of the device(s). The resin shall be evacuated after mixing and after the device has been mounted in the uncured resin.

##### (c) **Microsectioning**

The device(s) shall be ground and polished to achieve a surface finish of a least 0.1 micron.

To improve definition and detail, chemical etches shall be used to highlight junction definition, metallographic features, etc.... The following, not exhaustive, features shall be assessed:-

- (i) Diffusion and oxide characteristics.
- (ii) Metal/semiconductor interfaces.
- (iii) Metal/metal interfaces.
- (iv) Plating thickness and consistency on posts and pins.

Photographs shall be taken of the above.

#### 7.2.2.5 Subgroup 2D - Package Tests

##### 7.2.2.5.1 General

The devices in this subgroup shall be divided between Paras. 7.2.2.5.2, 7.2.2.5.3 and 7.2.2.5.4 in the ratio 2:2:1. Any devices from Para. 7.2.2.5.2 or 7.2.2.5.3 that have not been destroyed shall then be subjected to Para. 7.2.2.5.4.

##### 7.2.2.5.2 Thermal Tests

##### (a) **Applicability**

These tests must be performed on electrically good devices.

##### (b) **Procedure**

##### (i) Thermal Shock

All devices shall be submitted to the test in accordance with ESA/SCC Generic Specification No. 5010, Para. 9.5.2 - 50 cycles instead of 5 cycles (100 cycles instead of 10 cycles for glass encapsulated devices).

##### (ii) Seal Test

All devices shall be subjected to the tests in accordance with Para. 5.8.

##### (iii) Electrical Measurements

These measurements shall be made in accordance with Table 2 of the Detail Specification.



##### (iv) Moisture Resistance

##### - Applicability

This test is only applicable to glass non-cavity devices.

##### - Procedure

In accordance with the requirements of ESA/SCC Generic Specification No. 5010, Para. 9.16.

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(v) Seal Test

All devices shall be subjected to the tests in accordance with Para. 5.8.

(vi) Electrical Measurements

These measurements shall be made in accordance with Table 2 of the Detail Specification.

7.2.2.5.3 Mechanical Tests

(a) **Tests that Must Be Performed on Electrically Good Devices**

(i) Shock

All devices shall be subjected to the test in accordance with ESA/SCC Generic Specification No. 5010, Para. 9.13 - 50 shocks instead of 5 shocks.

(ii) Seal Test

All devices shall be subjected to the tests in accordance with Para. 5.8.

(iii) Electrical Measurements

These measurements shall be made in accordance with Table 2 of the Detail Specification.

(iv) Vibration

All devices shall be subjected to the test in accordance with ESA/SCC Generic Specification No. 5010, Para. 9.14 - 120 sweeps (total) instead of 12 sweeps (total).

(v) Seal Test

All devices shall be subjected to the tests in accordance with Para. 5.8.

(vi) Electrical Measurements

These measurements shall be made in accordance with Table 2 of the Detail Specification.

(b) **Tests That Can Be Performed On Electrical Rejects**

(i) Solderability (if applicable)

All devices shall be subjected to the test in accordance with ESA/SCC Generic Specification No. 5010, Para. 9.17.

(ii) Permanence of Marking

All devices shall be subjected to the test in accordance with ESA/SCC Generic Specification No. 5010, Para. 9.18.

7.2.2.5.4 Resistance to Soldering Heat

(a) **Applicability**

This test must be performed on electrically good devices.

(b) **Procedure**

In accordance with the requirements of IEC Publication No.68-2-20, Test 'Tb', Method 1A with no thermal screen or flux for  $10 \pm 1s$  or MIL-STD-750, Method 2031. Following each cycle, electrical measurements shall be performed in accordance with Table 2 (go-no-go) of the Detail Specification and a hermeticity test shall be performed in accordance with Para. 5.8. The test shall be repeated until the device has failed or 5 cycles have been performed, whichever is the sooner.

7.2.2.6 Subgroup 2E - Electrical Tests

7.2.2.6.1 General

The components in this subgroup shall be randomly divided between those tests that are performed.



#### 7.2.2.6.2 Electrostatic Discharge Sensitivity (ESDS) Test

ESD testing shall be performed in accordance with the requirements of ESA/SCC Basic Specification No. 23800. If the component under examination is not categorised into one of the three classes listed, then the component shall be termed "unclassified".

#### 7.2.2.6.3 Characterisation

##### (a) **Safe Operating Area**

###### (i) Applicability

This test is only applicable to devices where operation in circuits requiring transfer and dissipation of significant and/or varying levels of power is an intended feature of their design. The QSA shall review the component type and technology to determine the applicability of the test.

###### (ii) Procedure

In accordance with the requirements of MIL-STD-750, Method 3051, 3052, 3053 or 3474, as applicable.

##### (b) **Current Limits**

The design of each device under investigation shall be examined to ensure that no part of the device carries more than the maximum current defined by the technology or process design rules.

##### (c) **Breakdown Voltages**

in accordance with the requirements of MIL-STD-750, Method 3001, 3011, 3026, 3401, 3403, 3407, 4021 or 4022, as applicable.

### 7.2.3 Group 3 - Endurance Tests

#### 7.2.3.1 General

This group shall be randomly divided into 3 subgroups in the proportions indicated in Chart I A.

#### 7.2.3.2 Subgroup 3A - High Temperature Reverse Bias (HTRB) Test

Unless otherwise specified in the Detail Specification, all devices shall be subjected to the test in accordance with ESA/SCC Generic Specification No. 5010, Para. 9.21.

#### 7.2.3.3 Subgroup 3B - Accelerated Electrical Endurance Test

This group shall be randomly divided into 3 subgroups in the proportions indicated in Chart I A. The applicable tests shall not be performed until the Subgroup 2A tests have been completed and analysed, and 3 test conditions selected. The tests in this group shall be performed as specified in Chart IV.

The temperatures T1, T2 and T3 shall be chosen such that within approximately 1000, 500 and 168 hours, the parameter(s) defined in Para. 7.2.2.2.3 above can be expected to have drifted to an extreme of the permitted range. A common applied power (if applicable) also determined from the Subgroup 2A tests, shall be used. If the power step-stress test was not performed, the devices shall be operated at their maximum rated dissipation. Intermediate electrical measurements shall be performed in accordance with Para. 7.2.2.2.3 above at the following times:

T <sub>1</sub> (1000 hrs)	T <sub>2</sub> (500 hrs)	T <sub>3</sub> (168 hrs)
168 (+24 -0) hrs	168 (+24 -0) hrs	168 (+24 -0) hrs
500 (+24 -0) hrs	500 (+24 -0) hrs	-
1 000 (+24 -0) hrs	-	-

Failed components shall be removed for analysis as specified in Para. 7.1.

7.2.3.4 Subgroup 3C - Extended Burn-in Test

The devices shall be tested for 1000 hours at the conditions defined in the Detail Specification for burn-in. Intermediate electrical measurements shall be performed in accordance with Para. 7.2.2.2.3 above at the following times: 168(+24-0) hrs, 500(+24-0) hrs and 1 000 (+24 -0) hrs. If the conditions determined for the 1 000 hour subgroup in 7.2.3.3 above are identical to those defined for burn-in, this test shall not be performed.

7.2.4 Group 4 - Reserve

Should any additional tests be considered necessary, the devices in this subgroup shall be used.

7.3 EVALUATION TEST PROGRAMME FOR GaAs DEVICES (CHART I B)

7.3.1 Group 1 - Control Group

This group shall consist of 5 devices. Electrical measurements shall be performed on the 5 components in accordance with Table 3 of the Detail Specification. These devices are to be retained as a reference and may be used for verifying the test setup prior to making electrical or RF measurements on devices from the various other groups in the evaluation. At least 2 devices of this group shall be tested for specific dynamic measurements.

7.3.2 Group 2 - Ageing Tests

7.3.2.1 General

This group shall be randomly divided into two subgroups in the proportions indicated in Chart IB .

7.3.2.2 Group 2A, Accelerated Electrical Endurance Test

7.3.2.2.1 Selection of the Components

This group shall consist of 36 components, divided into three subgroups as specified in Chart IB. In these tests, junction temperature shall not exceed 225°C and the tests shall be performed up to 4000 hours or 50% of defects.

7.3.2.2.2 Test Conditions

Unless otherwise specified, the test sequence shall be in accordance with Chart IV and the relevant Detail Specification. As a general guideline, the following conditions shall be applicable:

- Test 1, T<sub>j</sub> = 175°C, bias condition 1
- Test 2, T<sub>j</sub> = 225°C, bias condition 1
- Test 3, T<sub>j</sub> = 225°C, bias condition 2





Unless otherwise specified, bias condition 1, shall be the most stringent biasing in order to investigate the effect of high electrical fields.

Unless otherwise specified, bias condition 2, shall be the most stringent biasing in order to investigate the effect of high current density.

#### 7.3.2.2.3 Intermediate or Final Electrical Measurements

These measurements shall be performed to define the parameters listed in Table 6 of the relevant Detail Specification as well as any additional parameters, depending on the technology applied, as specified in the evaluation contract. The intermediate or final electrical measurements shall include RF measurements. Intermediate electrical measurements shall be performed at the following times:  $48 \pm 8$  hrs,  $168 \pm 24$  hrs,  $500 \pm 24$  hrs,  $1000 \pm 24$  hrs and every  $1000 \pm 24$  hrs until completion of the test.

#### 7.3.2.2.4 Failure Analysis

Devices under test showing signs of failure shall be removed for investigation before the failure becomes catastrophic. It may not be necessary for the devices to be removed from test as soon as they exceed the failure criteria.

Failure criteria shall be based on either DC or RF parameters depending of the technology. This shall be considered on a case by case basis.

#### 7.3.2.2.5 Analysis of Subgroup 2A

The results of analysis of Subgroup 2A shall be presented to the QSA as follows:

- Functional failures shall be recorded on graphs for each subgroup together with the quantity of failures.
- Dispersion and drift of the different parameters listed in Table 6 of the Detail Specification.
- Initial, intermediate and final electrical measurements plotted for each intermediate time.
- Influence of the biasing on the life of the device.
- Evaluated activation energy and Arrhenius constant law if data are sufficient.

#### 7.3.2.3 Subgroup 2B - Temperature Storage Tests

##### 7.3.2.3.1 Selection of Components

This group shall consist of 12 components, divided into two subgroups as specified in Chart I B. These tests shall be performed in order to evaluate high activation energy. Temperature shall not exceed  $300^{\circ}\text{C}$  and tests shall be performed up to 1000 hours or 50% of defects.

##### 7.3.2.3.2 Test Conditions

Unless otherwise specified, the test sequence shall be in accordance with Chart IV and the relevant Detail Specification. Devices shall be stored at 2 different temperatures T1 and T2.

##### 7.3.2.3.3 Intermediate or Final Electrical Measurements (See Chart IV)

See Para. 7.3.2.2.3.

**7.3.2.3.4 Failure Analysis**

See Para. 7.3.2.2.4.

**7.3.2.3.5 Analysis of Subgroup 2B**

See Para. 7.3.2.2.5 (Influence of the biasing is not applicable).

**7.3.3 Group 3 - Destructive Tests**

This group shall be randomly divided into three subgroups as specified in Chart I B.

**7.3.3.1 Subgroup 3A - Radiation Testing and Construction Analysis****7.3.3.1.1 Radiation Analysis**

The purpose of this test is to investigate the device sensitivity to radiation. 6 devices shall be submitted to radiation analysis in accordance with ESA/SCC Basic Specification No. 22900 using an electron source. Devices shall be measured at the end of the test and one week after.

**7.3.3.1.2 Construction Analysis**

This test shall be performed on the devices which have been submitted to radiation analysis. They shall be divided randomly into 3 further subgroups.

**7.3.3.1.2.1 Internal Water Vapour Content.****(a) Applicability**

This test is not applicable to glass devices or to devices without a cavity.

**(b) Procedure**

This test shall be performed on 2 devices, in accordance with the requirements of MIL-STD-883, Method 1018, Procedure 1.

**7.3.3.1.2.2 Opening**

6 devices shall be opened using a technique which does not contaminate the internal structure or in any way impair the ability to observe defects.

**7.3.3.1.2.3 Internal Visual Inspection**

Each device shall be visually inspected in accordance with ESA/SCC Basic Specification No. 20400. Photographs shall be taken as follows:

- (a) An overall photograph of the opened device.
- (b) An overall photograph of the die
- (c) Photographs of any anomalies found.

**7.3.3.1.2.4 Scanning Electron Microscope (SEM) Inspection**

This test shall be performed on 2 devices. This inspection shall include, but shall not be necessary be limited to, examination of the following:

- (a) Detailed examination of any anomalies identified by the internal visual inspection (Para. 7.3.3.1.2.3 above). Photographs shall be taken of the above.



(b) Low magnification (up to 500X) shall be used to assess:

- (i) Clearance of bond wires at the die edge.
- (ii) Quality of bonding at the die.
- (iii) Quality of bonding at the post.

Photographs shall be taken of the above.

(c) High magnification (greater than 500X) shall be used to assess, when applicable.

- (i) Mesa.
- (ii) Passivation.
- (iii) Access zone.
- (iv) Gate definition.
- (v) Metallisation coverage and consistency at steps.
- (vi) Metallisation coverage at contact windows, bonding pads, etc....

Photographs shall be taken of the above.

In the case of devices with a glassivated surface this examination shall first be attempted through the glassivation.

If the resolution is inadequate, the glassivation shall be removed. This step must be postponed until the bond strength (Para 7.3.3.1.2.5) test has been performed.

#### 7.3.3.1.2.5 Bond Strength Test

This test shall be performed on the device which has submitted the SEM analysis. The test shall be in accordance with ESA/SCC Generic Specification No. 5010, Para 9.2.3.

#### 7.3.3.1.2.6 Die Shear Test

This test shall be performed on 2 devices in accordance with the requirements of ESA/SCC Generic Specification No. 5010, Para. 9.2.4.

#### 7.3.3.1.2.7 Microsectioning

This test shall be performed on 2 devices.

##### (a) **Glassivation Layer Integrity**

In accordance with the requirements of MIL-STD-883, Method 2021.

##### (b) **Mounting**

The device(s) shall be mounted on a carrier or in a transparent thermosetting resin. This shall have a curing temperature below the maximum storage temperature of the device(s). The resin shall be evacuated after mixing and after the device has been mounted in the uncured resin.

##### (c) **Microsectioning**

The device(s) shall be ground and polished to achieve a surface finish of a least 0.1 micron.

To improve definition and detail, chemical etches shall be used to highlight junction definition, metallographic features, etc.... The following, not exhaustive, features shall be assessed:



- (i) Device structure, epitaxial interfaces.
- (ii) Passivation.
- (iii) Metal/semiconductors interfaces.
- (iv) Metal/metal interfaces.

Photographs shall be taken of the above.

#### 7.3.3.2 Group 3B - ESD Testing

ESD testing shall be performed on 5 devices in accordance with the requirements of ESA/SCC Basic Specification No. 23800. If the component under examination is not categorised into one of the 3 classes listed, then the component shall be termed "unclassified".

#### 7.3.3.3 Subgroup 3C - Package Tests

##### 7.3.3.3.1 General

The devices in this subgroup shall be divided between Paras. 7.3.3.3.2, 7.3.3.3.3 and 7.3.3.3.4 in the ratio 2:2:1. Any devices from Para. 7.3.3.3.2 or 7.3.3.3.3 that have not been destroyed shall then be subjected to Para. 7.3.3.3.4.

##### 7.3.3.3.2 Thermal Tests

###### (a) **Applicability**

These tests must be performed on electrically good devices.

###### (b) **Procedure**

###### (i) Thermal Shock

All devices shall be submitted to the test in accordance with ESA/SCC Generic Specification No. 5010, Para. 9.5.2 - 50 cycles instead of 5 cycles (100 cycles instead of 10 cycles for glass encapsulated devices).

###### (ii) Seal Test

All devices shall be subjected to the tests in accordance with Para. 5.8.

###### (iii) Electrical Measurements

These measurements shall be made in accordance with Table 2 of the Detail Specification.

###### (iv) Moisture Resistance

###### - Applicability

This test is only applicable to glass non-cavity devices.

###### - Procedure



In accordance with the requirements of ESA/SCC Generic Specification No. 5010, Para. 9.16.

###### (v) Seal Test

All devices shall be subjected to the test in accordance with Para. 5.8.

###### (vi) Electrical Measurements

These measurements shall be made in accordance with Table 2 of the Detail Specification.

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#### 7.3.3.3.3 Mechanical Tests

##### (a) Tests that Must Be Performed on Electrically Good Devices

###### (i) Shock

All devices shall be subjected to the test in accordance with ESA/SCC Generic Specification No. 5010, Para. 9.13 - 50 shocks instead of 5 shocks.

###### (ii) Seal Test

All devices shall be subjected to the tests in accordance with Para. 5.8.

###### (iii) Electrical Measurements

These measurements shall be made in accordance with Table 2 of the Detail Specification.

###### (iv) Vibration

All devices shall be subjected to the test in accordance with ESA/SCC Generic Specification No. 5010, Para. 9.14 - 120 sweeps (total) instead of 12 sweeps (total).

###### (v) Seal Test

All devices shall be subjected to the tests in accordance with Para. 5.8.

###### (vi) Electrical Measurements

These measurements shall be made in accordance with Table 2 of the Detail Specification.

##### (b) Tests That Can Be Performed On Electrical Rejects

###### (i) Solderability (if applicable)

All devices shall be subjected to the test in accordance with ESA/SCC Generic Specification No. 5010, Para. 9.17.

###### (ii) Permanence of Marking

All devices shall be subjected to the test in accordance with ESA/SCC Generic Specification No. 5010, Para. 9.18.

#### 7.3.3.3.4 Resistance to Soldering Heat

##### (a) **Applicability**

This test must be performed on electrically good devices.

##### (b) **Procedure**

In accordance with the requirements of IEC Publication No.68-2-20, Test 'Tb', Method 1A with no thermal screen or flux for  $10 \pm 1$ s or MIL-STD-750, Method 2031. Following each cycle, electrical measurements shall be performed in accordance with Table 2 (go-no-go) of the Detail Specification and a hermeticity test shall be performed in accordance with Para. 5.8. The test shall be repeated until the device has failed or 5 cycles have been performed, whichever is the sooner.

**8. DATA DOCUMENTATION****8.1 GENERAL REQUIREMENTS**

An evaluation test report shall be established. This shall comprise the following:

FOR ALL TYPES OF DEVICES	
(a) Cover sheet (or sheets). (b) List of equipment (testing and measuring). (c) List of test references. (d) Sample identification. (e) Production data. (f) Inspection data. (g) Initial electrical measurements. (h) Group 1 - Control group data. (i) Thermal resistance/conductivity data.	
FOR SILICON DEVICES	FOR GaAs DEVICES
(j) Subgroup 2A(i) - Temperature step-stress test data. (k) Subgroup 2A(ii) - Power step-stress test data (if applicable). (l) Subgroup 2B - Radiation tests data. (m) Subgroup 2C - Construction analysis data. (n) Subgroup 2D - Package tests data. (o) Subgroup 2E - Electrical tests data. (p) Subgroup 3A - High Temperature Reverse Bias (HTRB) test data (if applicable). (q) Subgroup 3B - Accelerated electrical endurance test data. (r) Subgroup 3C - Extended burn-in test data. (s) Group 4 - Reserve data (if applicable). (t) Summary of results and conclusions.	(j) Subgroup 2A(i) - Electrical endurance test, temperature 1, bias 1. (k) Subgroup 2A(ii) - Electrical endurance test, temperature 2, bias 1. (l) Subgroup 2A(iii) - Electrical endurance test, temperature 2, bias 2. (m) Subgroup 2B(i) - Temperature storage test, temperature 1. (n) Subgroup 2B(ii) - Temperature storage test, temperature 2. (o) Subgroup 3A(i) - Radiation tests data. (p) Subgroup 3A(ii) - Construction analysis data. (q) Subgroup 3B - ESD test data. (r) Subgroup 3C - Package test data. (s) Summary of results and conclusions.

All items listed shall be grouped, preferably as subpackages, and for identification purposes, each page shall include the following information:

- Manufacturer's/test house's name.
- Lot identification.
- Date of establishment of the document.
- Page number.

**8.2 COVER SHEET (S)**

The cover sheet (or sheets) of the evaluation test report shall include as a minimum:

- (a) Reference to this document, including issue and date.
- (b) Component type and number.
- (c) Lot identification.
- (d) Manufacturer's/test house's name and address.
- (e) Location of the Manufacturing plant/test house.
- (f) Signature on behalf of the Manufacturer/test house.
- (g) Total number of pages of the evaluation test report.

**8.3 LIST OF EQUIPMENT USED**

A list of equipment used for tests and measurements shall be included in the evaluation test report. Where applicable, this list shall contain the inventory number, Manufacturer's type number, serial number, calibration status data, etc. This list shall indicate for which tests such equipment was used.

**8.4 LIST OF TEST REFERENCES**

This list shall include all references or codes which are necessary to correlate the test data provided with the applicable tests.

**8.5 SAMPLE IDENTIFICATION (PARA 4.1)**

This shall identify the criteria used for the selection of the particular components used for the tests, when evaluating a range of components by means of representative samples.

**8.6 PRODUCTION DATA (PARA 4.4)**

The progress of the components through the normal manufacturing processes shall be documented. The components failing a particular process shall be detailed, together with the reason for their removal.

**8.7 INSPECTION DATA (PARA.5)**

The number of components subjected to each test shall be identified together with the number and reason for any rejects. Radiographs of any failed components shall be presented.

**8.8 INITIAL MEASUREMENTS DATA (PARA. 6)****8.8.1 Initial Electrical Measurements Data (Para. 6.1)**

All data shall be recorded against serial numbers. A histogram of the device parameters shall be produced.

**8.8.2 Thermal Analysis Data - For GaAs Devices only (Para. 6.2)**

All data shall be recorded against serial number. "Hot spot" picture shall be delivered for power devices.

**8.8.3 Specific Dynamic Measurements Data - For GaAs Devices only (Para. 6.3)**

All data shall be recorded against serial number.

**8.9 GROUP 1 - CONTROL GROUP DATA (PARA. 7.2.1 OR 7.3.1)**

All data shall be recorded against serial number.

**8.10 SPECIFIC DATA DOCUMENTATION FOR Si DEVICES****8.10.1 Subgroup 2A - Step-Stress Tests Data****8.10.1.1 Thermal Resistance/Conductivity Data (Para. 7.2.2.2.2)**

All data shall be recorded against serial numbers.

**8.10.1.2 Subgroup 2A(i) - Temperature Step-Stress Test Data (Para. 7.2.2.2.4)**

All data shall be recorded against serial numbers. This shall include:

- (a) Starting temperature.
- (b) Temperature steps.
- (c) Electrical measurements tabulated for each step.
- (d) Graphical output as defined in Para. 7.2.2.2.6.
- (e) Analysis of any failed components as defined in Para. 7.1.
- (f) Thermal resistance/conductivity measurements from surviving devices.

**8.10.1.3 Subgroup 2A(ii) - Power Step-Stress Test Data (Para. 7.2.2.2.5) (if applicable)**

All data shall be recorded against serial numbers. This shall include:

- (a) Starting temperature.
- (b) Power steps.
- (c) Electrical measurements tabulated for each step.
- (d) Graphical output as defined in Para. 7.2.2.2.6.
- (e) Analysis of any failed components as defined in Para. 7.1.
- (f) Thermal resistance/conductivity measurements from surviving devices.

**8.10.2 Subgroup 2B - Radiation Tests Data (Para. 7.2.2.3)**

All data shall be recorded against serial numbers. This shall include:

- (a) Total dose steady-state test data.

**8.10.3 Subgroup 2C - Construction Analysis Data (Para. 7.2.2.4)**

All data shall be recorded against serial numbers. This shall include:

- (a) Internal water vapour content data.
- (b) Photographs.
- (c) SEM photographs.
- (d) Results of bond strength test.
- (e) Results of die shear test.
- (f) Glassivation layer integrity test data (if applicable)
- (g) Microsectioning photographs.



**8.10.4 Subgroup 2D - Package Tests Data (Para. 7.2.2.5)**

All data shall be recorded against serial numbers. This shall include:

- (a) Thermal tests data.
- (b) Mechanical tests data.
- (c) Resistance to soldering heat test data.

**8.10.5 Subgroup 2E - Electrical Tests Data (Para. 7.2.2.6)**

All data shall be recorded against serial numbers. This shall include:

- (a) ESDS test data.
- (b) Characterisation data.

**8.10.6 Group 3 - Endurance Tests Data****8.10.6.1 Subgroup 3A - High Temperature Reverse Bias (HTRB) Test Data (Para. 7.2.3.2) (if applicable)**

All data shall be recorded against serial numbers.

**8.10.6.2 Subgroup 3B - Accelerated Electrical Endurance Test Data ( Para. 7.2.3.3)**

All data shall be recorded against serial numbers. This shall include:

- (a) Temperatures  $T_1$ ,  $T_2$  and  $T_3$  chosen.
- (b) Power chosen (if applicable).
- (c) Electrical measurements tabulated and plotted for each intermediate time as defined in Para. 7.2.3.3.
- (d) Drift values referred to the initial electrical measurements (Para. 6.1).
- (e) Analysis of any failed components as defined in Para. 7.1.

**8.10.6.3 Subgroup 3C - Extended Burn-in Test Data (Para. 7.2.3.4)**

All data shall be recorded against serial numbers.

**8.10.7 Group 4 - Reserve Data (Para. 7.2.4) (if applicable)**

All data shall be recorded against serial numbers.

**8.11 SPECIFIC DATA DOCUMENTATION FOR GaAs DEVICES****8.11.1 Group 2 - Ageing Tests****8.11.1.1 Subgroups 2A (i),(ii),(iii) - Accelerated Electrical Endurance tests data (Para 7.3.2.2)**

All data shall be recorded against serial number. This shall include:

- (a) Temperatures  $T_1$  and  $T_2$ .
- (b) Initial, intermediate and final electrical measurements, and plotted for each intermediate time as defined in Para. 7.3.2.2.3.
- (c) Dispersion and drift values referred to the initial electrical measurements (Para. 6.1)
- (d) Analysis of any failed components as defined in Para. 7.3.2.2.4.

**8.11.1.2 Subgroups 2B (i),(ii) - Temperature Storage Tests (Para. 7.3.2.3)**

All data shall be recorded against serial number. This shall include:-

- (a) Temperatures  $T_1$  and  $T_2$ .
- (b) Initial, intermediate and final electrical measurements, and plotted for each intermediate time as defined in Para. 7.3.2.3.3.
- (c) Dispersion and drift values referred to the initial electrical measurements (Para. 6.1).
- (d) Analysis of any failed components as defined in Para. 7.3.2.3.4.

**8.11.2 Group 3 - Destructive Tests.****8.11.2.1 Subgroup 3A - Radiation Tests Data**

All data shall be recorded against serial number. This shall include:

- (a) Total dose steady-state test data.
- (b) Conditions and equipments.

**8.11.2.2 Subgroup 3A - Construction Analysis Data**

All data shall be recorded against serial number. This shall include:

- (a) Internal water vapour content data.
- (b) Photographs.
- (c) SEM photographs.
- (e) Results of die shear test.
- (d) Results of bond strength test.
- (f) Glassivation layer integrity test data (if applicable).
- (g) Microsectioning photographs.

**8.11.2.3 Subgroup 3B - ESD Test Data**

All data shall be recorded against serial numbers. This shall include:

- (a) Conditions and equipments.
- (b) Results of ESD tests.

**8.11.2.4 Subgroup 3C - Package Tests Data**

All data shall be recorded against serial numbers. This shall include:

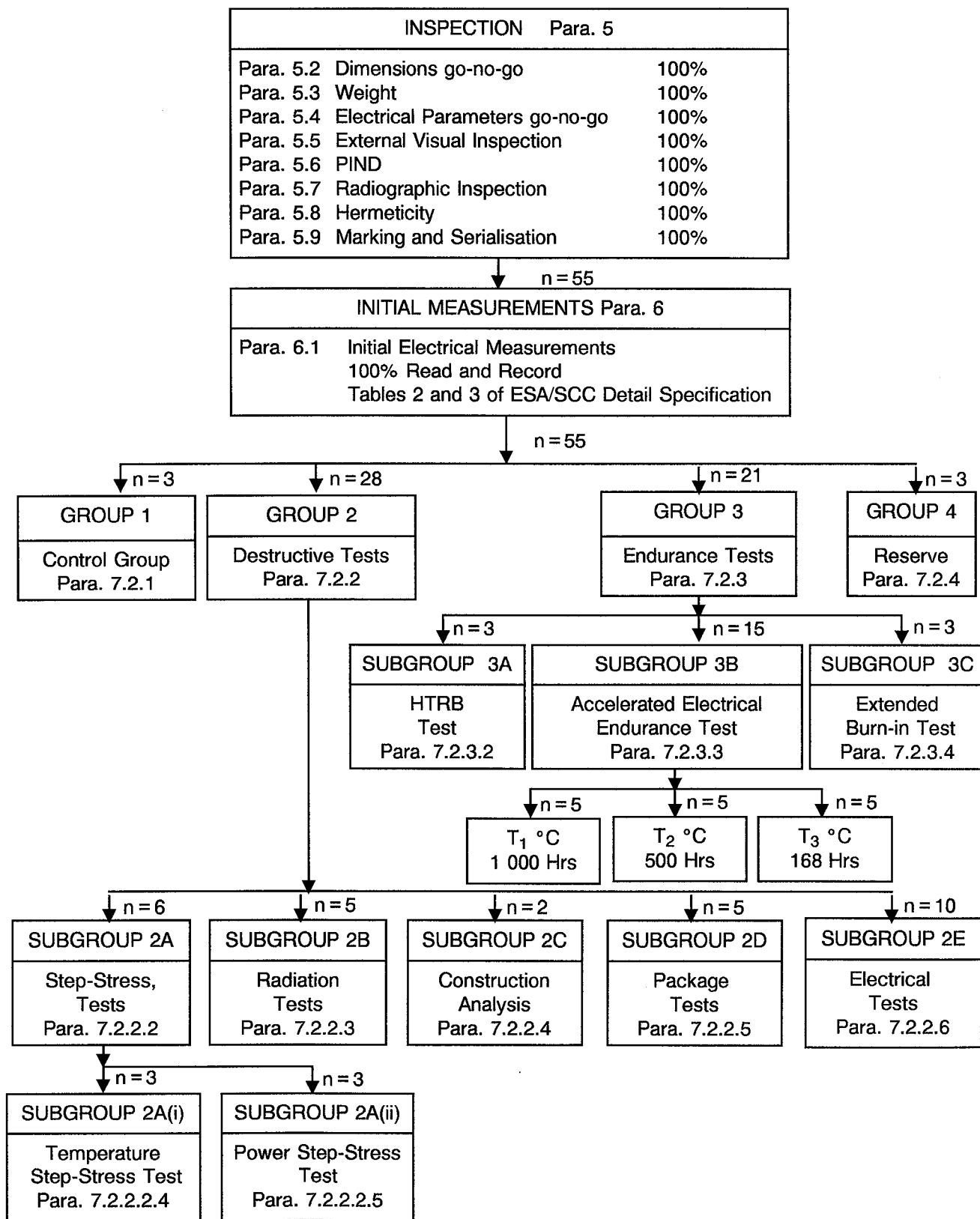
- (a) Fine leak tests data.
- (b) Gross leak tests data.

**8.12 SUMMARY OF RESULTS AND CONCLUSIONS**

The above shall be briefly reviewed, indicating the success or otherwise of the evaluation test programme. Any production screens that need to be introduced into the P.I.D. shall be outlined.

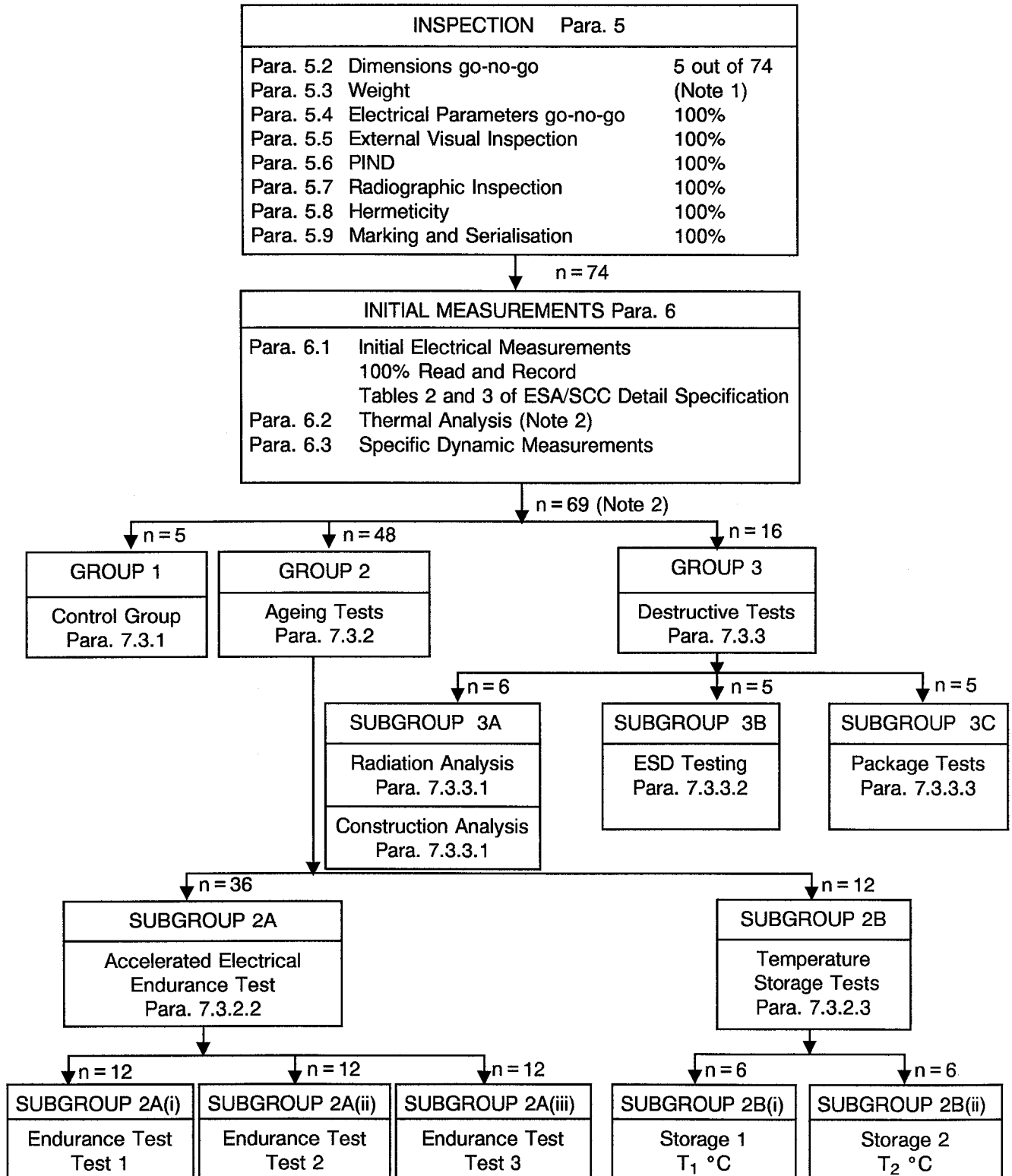


**CHART I A - EVALUATION TEST PROGRAMME FOR SI DEVICES**



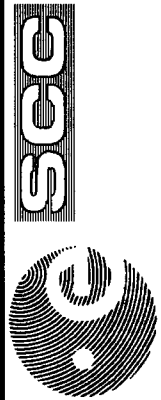


**CHART I B - EVALUATION TEST PROGRAMME FOR GaAs DEVICES**

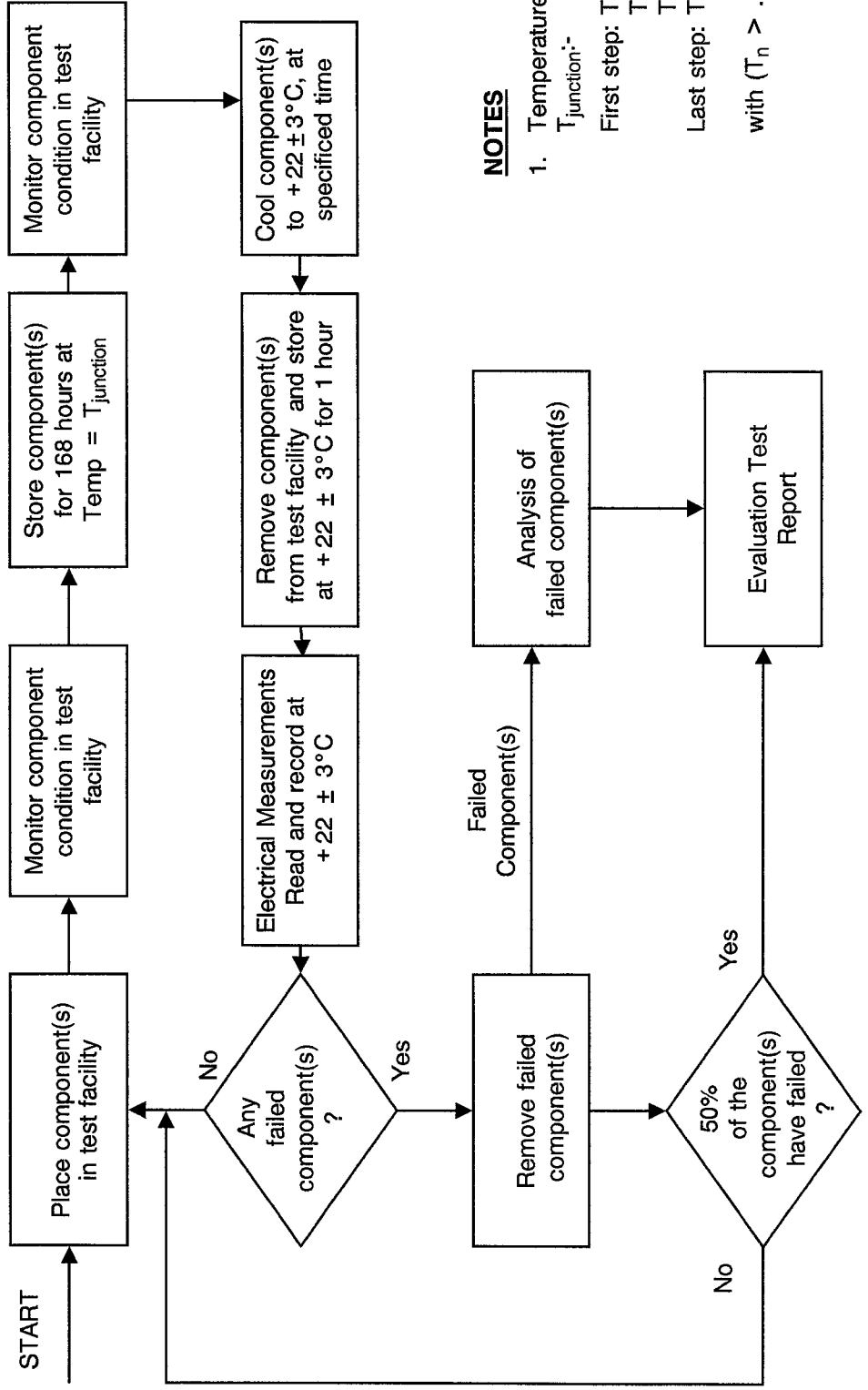


**NOTES**

1. For detailed requirements, see Para. 5.3.
2. 5 devices out of the initial 74 devices could be destructed in thermal analysis.



**CHART II - TEMPERATURE STEP-STRESS SEQUENCE - FOR SI DEVICES ONLY**



**NOTES**

- Temperature steps with  $T_{\text{junction}}$ :-  
 First step:  $T_0$  ( $^{\circ}\text{C}$ )  
 $T_1$  ( $^{\circ}\text{C}$ )  
 $T_2$  ( $^{\circ}\text{C}$ )  
 Last step:  $T_n$  ( $^{\circ}\text{C}$ )  
 with  $(T_n > \dots T_2 > T_1 > T_0)$

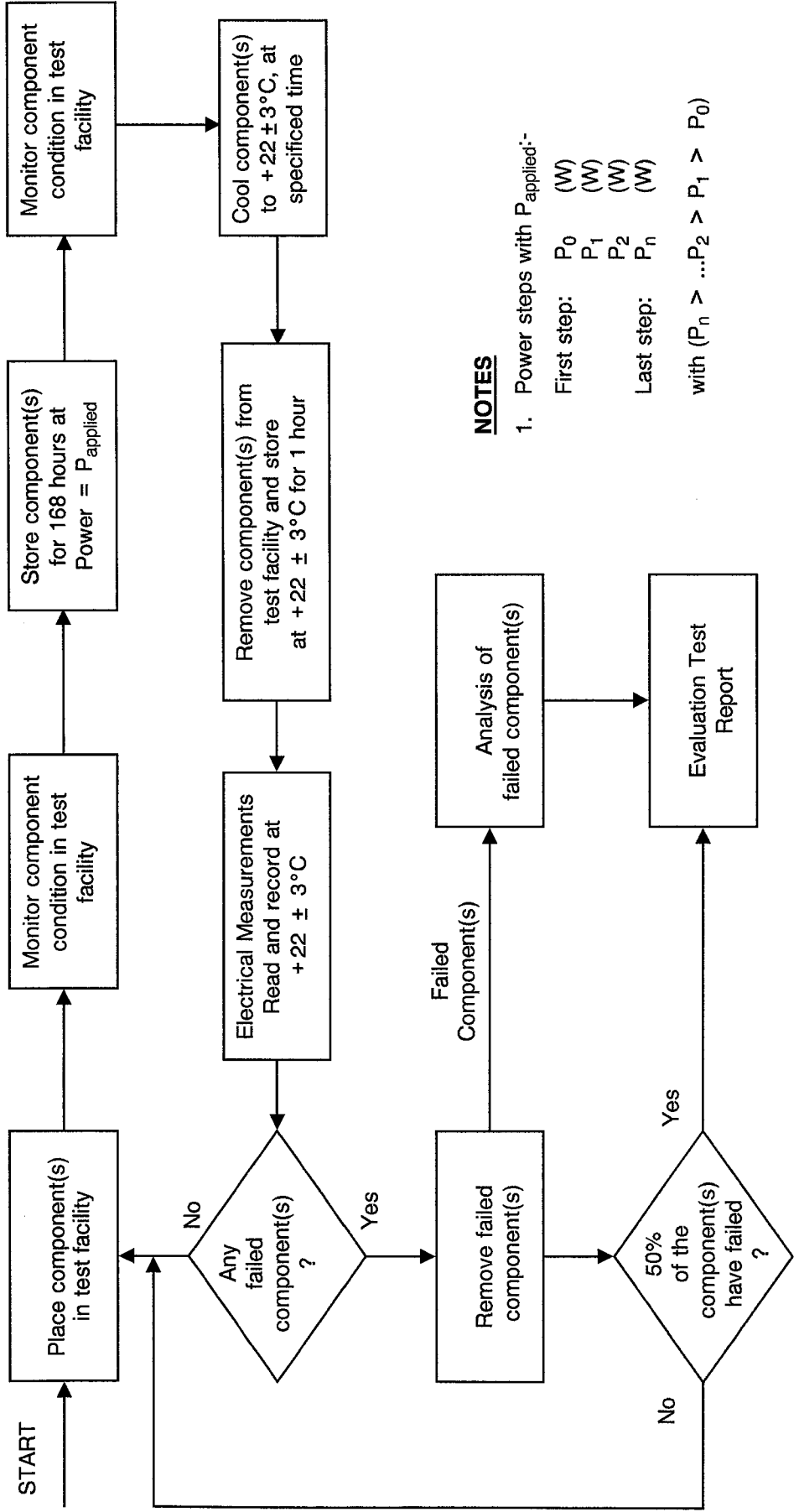


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**CHART III - POWER STEP-STRESS SEQUENCE - FOR SI DEVICES ONLY**



**NOTES**

1. Power steps with  $P_{\text{applied}}$ :-

- First step:  $P_0$  (W)
- $P_1$  (W)
- $P_2$  (W)
- Last step:  $P_n$  (W)

with  $(P_n > \dots P_2 > P_1 > P_0)$



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**CHART IV - ACCELERATED ELECTRICAL ENDURANCE TEST**

