EVALUATION TEST PROGRAMME GUIDELINES

FOR

LASER DIODE MODULES

ESCC Basic Specification No. 23201

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1 PURPOSE

The purpose of this guideline document is to recommend an approach and pertinent requirements for the evaluation of laser diode modules for use in space applications.

2 SCOPE

2.1 GENERAL

This Evaluation Test Programme Guideline defines the accelerated testing required to overstress specific characteristics of laser diodes in order to detect possible failure modes. It also defines the minimum content of a constructional analysis to detect any design and/or construction defects which may affect reliability and which may support failure analysis activities.

2.2 APPLICABILITY

This Evaluation Test Programme Guideline is applicable to laser diode modules with hermetic and non-hermetic packages. It is also applicable to any optical fibres, fibre-optic cables or optical connectors which form part of the laser diode module's fibre/cable attachment. When the module includes non-evaluated fibre optics or other internal elements (e.g. integrated circuits, thermoelectric coolers or photo diodes), the Evaluation Test Programme shall be complemented with suitable tests based on applicable ESCC basic and ancillary specifications.

3 RELATED DOCUMENTS

3.1 APPLICABLE DOCUMENTS

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

No. 5000	Discrete Semiconductor Components, Hermetically Sealed.
No. 20400	Internal Visual Inspection.
No. 20500	External Visual Inspection.
No. 20900	Radiographic Inspection of Electronic Components.
No. 21300	Terms, Definitions, Abbreviations, Symbols and Units.
No. 22900	Total Dose Steady-State Irradiation Test Method.
No. 23800	Electrostatic Discharge Sensitivity Test Method.
No. 24800	Resistance to Solvents of Marking, Materials and Finishes.
No. 25200	Application of Scanning Acoustic Microscopy to Plastic Encapsulated Devices.

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

3.2 REFERENCE DOCUMENTS

ECSS-Q-ST-70	Materials, mechanical parts and processes.
ECSS-Q-ST-70-02	Thermal vacuum outgassing test for the screening of space materials.
ECSS-Q-ST-70-21	Flammability testing for the screening of space materials.
ECSS-Q-ST-70-29	Determination of offgassing products from materials and assembled articles to be used in a manned space vehicle crew compartment.
IEC 61300	Fibre optic interconnecting devices and passive components - Basic test and measurement procedures.
MIL-STD-883	Test Method Standard, Microcircuits.
MIL-STD-202	Test Method Standard, Electronic and Electrical Component Parts.

4 TERMS, DEFINITIONS, ABBREVIATIONS, SYMBOLS AND UNITS

The terms, definitions, abbreviations, symbols and units specified in ESCC Basic Specification No. 21300 shall apply. In addition the following definitions shall apply:

Hermetic Package:	A component package which by design or construction is able to pass a seal test.
Non-Hermetic Package:	A component package which by design or construction is unable to pass a seal test.

5 INTRODUCTION

The tests specified in this Evaluation Test Programme shall be performed in the sequence shown in Chart I. All results shall be recorded, and all failed laser diodes shall be submitted to failure analysis where probable failure modes and mechanisms shall be determined.

The evaluation testing shall be performed under the supervision of the customer/user for whom the evaluation of the laser diode is required. The evaluation testing may be performed by either the Manufacturer or a test house, under the supervision and responsibility of the manufacturer, and approved by the customer/user.

6 REQUIREMENTS

6.1 SELECTION OF LASER DIODES FOR EVALUATION TESTING

Standard laser diodes shall be selected from homogenous lots from the manufacturers to be evaluated. These components shall not have been submitted to any screening but must have been manufactured and assembled into laser diodes in conformity with high reliability practice and established procedures. The sub-elements that form the laser diode shall also be from homogenous lots and also be fully traceable.

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

The component types chosen to represent a family shall cover the range of components to be evaluated and be representative of the different 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.

6.1.1 Preliminary Assembly Evaluation

Preliminary assembly evaluation activities shall be carried out during the design phase. The objective is to identify the weakest point, or points, of a given component assembly in the early stages of the development process, thus enabling the possibility of modifying the package design and/or the assembly processes before the formal evaluation is carried out.

The main requirements are:

– to assess the technological limits related to the assembly processes.
– to identify, as early as possible, potential technology problems without impacting directly on the schedule of the overall evaluation.
– to improve the assembly of the final device based on the results obtained.
– to optimise the formal Evaluation Test Programme.

6.1.2 Detail Specification

Should a detail specification for the laser diode to be evaluated not exist, the Manufacturer shall prepare such a document in accordance with the established ESCC format and submit it to the customer/user for provisional approval. This Detail Specification shall then serve as a basis for the ordering and testing of the laser diodes.

6.1.3 Inspection Rights

The customer/user reserves the right at any time to inspect the laser diodes being processed for evaluation purposes.

6.1.4 Control During Fabrication

Pre-assembly visual inspections shall be performed on the lot to be evaluated and this requirement shall form part of the Manufacturer’s standard procedure. The Manufacturer shall notify the customer/user at least three working days in advance of the date of this inspection.

Progress of the laser diodes’ manufacture shall be observed, closely monitored and recorded. A chart showing the numbers in/out and cause for rejection of any failures (every failure shall be explained) during each fabrication stage shall be submitted to the customer/user, along with a failure analysis of any rejects at each stage.

6.2 100% INSPECTION

Every lot of laser diodes shall be inspected on a 100% basis to verify their suitability for the Evaluation Test Programme. Defects or deviations from the established ESCC 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 any items are rejected, the reason shall be clearly identified.

6.2.1 Dimensions

The basic outline (L x W x H) plus lead/terminal dimensions of each laser diode shall be measured in accordance with the Detail Specification and the results recorded, together with any non-conformances. Rejected laser diodes shall be replaced.

6.2.2 Weight

All laser diodes shall be weighed to an accuracy of 0.1g. Any laser diodes which exceed the maximum weight specified in the Detail Specification shall be replaced.

6.2.3 Initial Electro-Optical Measurements

All laser diodes shall be measured in accordance with the Detail Specification at an ambient temperature of +22 ±3ºC (go-no-go). Rejected laser diodes shall be replaced.

6.2.4 External Visual Inspection

All devices shall be inspected in accordance with ESCC Basic Specification No. 20500. Rejected laser diodes shall be replaced.

6.2.5 Particle Impact Noise Detection (PIND)

If applicable, all laser diodes shall be subjected to PIND in accordance with MIL-STD-883 Test Method 2020, Condition A. Rejected laser diodes shall be replaced.

6.2.6 Hermeticity

If applicable, fine and gross leak tests shall be performed on all laser diodes in accordance with MIL-STD-883 Test Method 1014, Conditions A and C. Rejected laser diodes shall be replaced.

Hermeticity assessment for very low leak rate (critical for small packages) shall be measured by RGA when standard fine leak test cannot be applied. The main steps of the method are:

1. Define the required helium leak rate (this may be done theoretically based on the quantity of contaminants, such as oxygen or water, that are acceptable at both the start and end of life).
2. Define the He bombing conditions (pressure and duration) that lead to a quantity of helium inside the package that could be easily detected by RGA (typically 1500 ppmv).
3. Carry out the He bombing and RGA test. If the helium content measured by RGA is greater than 1500 ppmv, the leak rate is higher than the acceptable value.

6.2.7 Marking and Serialisation

In order to guarantee traceability all laser diodes shall be permanently marked and serialised in accordance with the Manufacturer's standard procedures.

6.2.8 Materials and Finishes

All non-metallic materials and finishes of the laser diodes specified herein shall be tested in accordance with ECSS-Q-ST-70-02, to verify their outgassing requirements, unless relevant data is available.

The use of epoxy in an enclosed volume presents the potential for reliability problems. The outgassing of solvents, extenders and reaction by-products from the epoxy after the package is sealed can cause degradation either through condensation and/or chemical reaction. Careful qualification of the epoxy and the cure cycle and continuous lot-to-lot control effort could reduce or eliminate these concerns.

In addition, all laser diodes specified herein shall meet the flammability requirements outlined in ECSS-Q-ST-70-21 and the outgassing requirements outlined in ECSS-Q-ST-70-29.

6.2.9 Completion of Inspection

The completion of inspection shall result in a batch of laser diodes that have been verified as to their suitability for the Evaluation Test Programme, i.e. each laser diode has satisfied the requirements of Paras. 6.2.1 through 6.2.8.

6.3 ELECTRO-OPTICAL MEASUREMENTS

Electro-optical measurements shall be made on a randomly selected sample of laser diodes as shown in Chart I. Measurements shall be made in accordance with Electrical Measurements at Room, High and Low Temperatures in the Detail Specification at the test temperatures specified in the Detail Specification. All results shall be recorded against serial numbers. Any laser diodes which fail one (or more) electro-optical measurements shall be replaced.

6.4 EVALUATION TESTING

Evaluation testing shall be performed as specified in Chart I and the following sub-paragraphs.

All failed laser diode samples shall be analysed. The depth of analysis shall depend on 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. Samples not failing catastrophically, e.g. those displaying out of tolerance electro-optical parameters, shall not be removed from the test sequence but monitored to observe degradation trends.

6.4.1 Group 1 - Control Group (2 samples)

The laser diode samples of this group shall be retained for comparison purposes. Whenever measurements are made on any samples under test, these samples shall also be measured.

6.4.2 Group 2 - Destructive Tests (37 samples)

6.4.2.1 Subgroup 2A - Step-Stress Tests (6 samples)

Unless otherwise specified, the step-stress sequences performed in this Subgroup shall only be terminated when all the test samples have failed catastrophically. Optical output power shall be measured and recorded throughout the test. Measurements shall be made as defined in the Detail Specification.

6.4.2.1.1 Determination of Thermal Resistance (6 samples)

Determination of Thermal Resistance shall be performed using the Manufacturer’s test method and the Detail Specification limit applied.

6.4.2.1.2 Temperature Step-Stress Tests (3 samples)

- High Temperature Step-Stress Test (2 samples)

  This test shall be performed as specified in Chart II. Test shall continue until the samples fail unless practical reasons prevent this.

- Low Temperature Step-Stress Test (1 sample)

  This test shall be performed as specified in Chart II. Test shall continue until the sample fails unless practical reasons prevent this.

6.4.2.1.3 Power Step-Stress Test (3 samples)

This test shall be performed as specified in Chart III. Test shall continue until the samples fail catastrophically unless practical reasons prevent this.

6.4.2.1.4 Measurements after each Step-Stress Sequence

Electro-optical measurements shall be performed on the samples and, where applicable, parameter drift values calculated after each step-stress sequence. The measurements and limits shall be defined in the Detail Specification.

6.4.2.1.5 Analysis of Subgroup 2A

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

- The number of failures shall be plotted against time for each temperature or power level applied. The sequential failure occurrence shall also be recorded.
- The optical output power shall be monitored, recorded and plotted against time for each temperature or power level applied.
- The average drift of the optical output power at each temperature or power level applied shall be plotted against temperature.
- Failure shall be according to Detail Specification limits.

The analysis of the results shall be used to determine the most efficient temperature and power for accelerated endurance testing.

6.4.2.2 Subgroup 2B - Constructional Analysis (4 samples)

A constructional analysis shall be performed as follows:

(a) External Visual Inspection in accordance with ESCC Basic Specification No. 20500
(b) Radiographic Inspection in accordance with ESCC Basic Specification No. 20900
(c) Seal Test per MIL-STD-883 Test Method 1014, Conditions A and C (if applicable)
(d) Fibre Attachment Integrity performed on the optical fibre or fibre-optic cable (as applicable), consisting of:
   1. Fibre Pull per IEC 61300-2-4. Changes in insertion loss shall be monitored as described in Para. 9.2 of IEC 61300-2-4. The following information shall be reported for each measurement:
      (i) Results of external visual inspection
      (ii) Optical transmittance changes during the test
   2. Fibre Rotation per IEC 61300-2-5, Torsion

(e) Residual Gas Analysis per MIL-STD-883 Test Method 1018 (if applicable). All results shall be documented. Sealing lot traceability shall be available and consulted in case of failure.
(f) Internal Visual Inspection per ESCC Basic Specification No. 20400 and the Manufacturer's specification for Internal Visual inspection. Dimensions of all components shall be checked for compliance with the Detail Specification. As a minimum, the following photographs shall be taken:
   1. An overall photograph of an opened component
   2. Photographs of any anomalies found, with magnification where appropriate

(g) Microsection at both assembly and semiconductor level. All findings shall be photo documented.
(h) Scanning Electron Microscope inspection to include, but not be limited to, examination of the following:
   1. Detailed examination of any anomalies identified by the internal visual inspection
   2. Clearance of bond wires
   3. Quality of wire bonds
   4. Microsection inspection including assessment of coating and die attach quality

The four steps above shall be photo documented.

(i) Bond pull as per MIL-STD-883 Test Method 2011
- Test condition C or D for thermo-compression, ultrasonic or wedge bonding.
- Test condition F for flip-chip bonding.
- Test condition G or H for beam lead bonding.

(j) Die shear MIL-STD-883 Test Method 2019 or 2027.
The same test samples submitted to Bond Strength shall be used. Individual separation forces and categories shall be recorded.

(k) Terminal strength as per MIL-STD-883 Test Method 2004 Condition A

(l) Material Analysis shall be performed to confirm that the laser diode materials comply with the material specifications given in the Detail Specification. Prohibited materials are listed in ECSS-Q-ST-70.

(m) Outgassing shall be tested in accordance with ECSS-Q-ST-70-02 to verify all non-metallic materials and finishes of the laser diodes meet the outgassing requirements, unless relevant data is available.

(n) Scanning Acoustic Microscopy per ESCC Basic Specification No. 25200.

6.4.2.3 Subgroup 2C - Irradiation (6 samples)

6.4.2.3.1 Displacement Damage (DD) (3 samples)

DD Radiation Testing shall be performed in accordance with the requirements set out in the detailed ETP for each specific laser diode.

6.4.2.3.2 Total Ionising Dose (TID) (3 samples)

TID Radiation Testing shall be performed in accordance with ESCC Basic Specification No. 22900.

6.4.2.4 Subgroup 2D - Environmental Tests (16 samples)

On completion of each of the following tests, the samples shall undergo fine and gross leak testing (if applicable), external and/or internal visual examination (as applicable) and electro-optical measurements, in accordance with the Detail Specification, to identify any damage caused as a result of that test.

6.4.2.4.1 Random Vibration Testing (3 samples)

Random Vibration shall be performed per MIL-STD-202 Test Method 214 and the following:

A random vibration generator shall be used to vibrate the samples according to the Power Spectral Density 20-2000Hz 30g(rms), or up to the limit stated in the Detail Specification, in which case additional steps shall be added. This shall be applied along each of three orthogonal directions for a period of 7.5 minutes each. Optical output power shall be monitored throughout the test. Resonance frequency sweep shall be performed before and after the test.

On completion of the test sequence the samples shall undergo fine and gross leak testing (if applicable),external and/or internal visual examination (as applicable) and electro-optical measurements, in accordance with the Detail Specification, to identify any damage caused as a result of the vibration test.

The samples shall then be subjected to Mechanical Shock.

6.4.2.4.2 Mechanical Shock

Mechanical Shock shall be performed per MIL-STD-883 Test Method 2002 in the following steps:

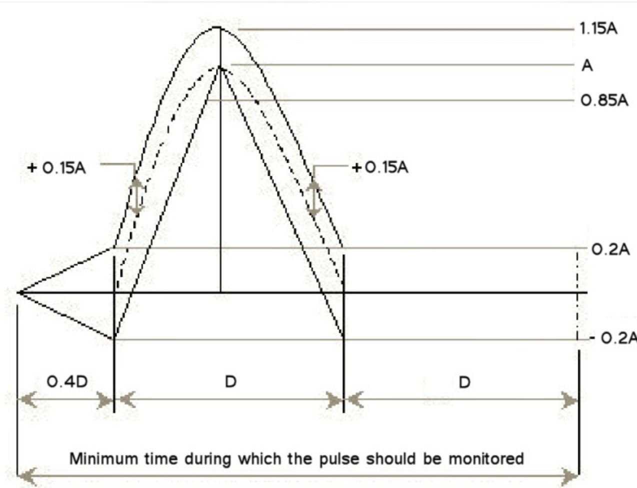
Step 1: 500g (peak), duration = 1ms (Condition A of MIL-STD-883 Test Method 2002)

Step 2: 1500g (peak), duration = 0.5ms (Condition B of MIL-STD-883 Test Method 2002)

Step 3: 3000g (peak), duration = 0.3ms (Condition C of MIL-STD-883 Test Method 2002)

or up to the limit stated in the Detail Specification, in which case additional steps will need to be added. Five shocks shall be applied in each orientation at each step.

The shock generator shall be capable of generating a saw-tooth pulse. Peak acceleration of the nominal pulse, A, and duration of the nominal pulse, D, shall be as specified in the table below.



A	D
75g	11ms
2500g	500µs

The samples are then subjected to five shocks along each of three orthogonal directions for each acceleration level.

On completion of the test sequence the samples shall undergo fine and gross leak testing (if applicable), external and/or internal visual examination (as applicable) and electro-optical measurements, in accordance with the Detail Specification, to identify any damage caused as a result of the mechanical shock test.

6.4.2.4.3 Temperature Cycling (3 samples)

Temperature Cycling shall be performed per MIL-STD-883 Test Method 1010, Condition A with the exception that the high temperature shall be +70 (+10, -0) °C and number of cycles 500.

Measurements of optical output power shall be made throughout the test at every 100th cycle.

On completion of the test, the temperature shall be returned to +22 ± 3°C and the samples removed from the chamber. A visual inspection (external and/or internal, as applicable) shall be carried out to look for any damage or other anomalies, followed by fine and gross leak testing (if applicable) and electro-optical measurements per the Detail Specification.

6.4.2.4.4 Rapid Depressurisation (3 samples)

Rapid Depressurisation is applicable to optical fibre coupled laser diodes only and may be substituted by analysis.

The optical output power of the samples shall be measured before the test and monitored throughout, including during sample transfer.

The samples shall be placed within the thermal vacuum chamber and connected to the optical measuring equipment, outside the chamber, via vacuum feed-throughs.

The chamber pressure is reduced, from atmospheric pressure, until a stable pressure of not more than 1333 Pa is achieved. Pressure shall be reduced in a time of no more than 5 seconds. The chamber shall then be returned to atmospheric pressure.

The samples shall undergo 5 depressurisation cycles.

On completion of the test, the samples shall be removed from the chamber. The dimensions shall be measured and a visual inspection (external and/or internal, as applicable) carried out to look for any damage or other anomalies, followed by electro-optical measurements per the Detail Specification.

6.4.2.4.5 Thermal Vacuum (3 samples)

Thermal Vacuum test is only applicable to laser diodes which cannot be guaranteed as truly hermetic, i.e. that are not expected to contain a specified internal atmosphere after 15 years (or mission life). For laser diodes which have a semi-hermetic package, the seal has to be opened prior to vacuum exposure.

The samples shall be placed within the thermal vacuum chamber and connected to the optical measuring equipment, outside the chamber, via vacuum feed-throughs.

Components shall be subjected to 1000 hours biased life test at a pressure ≤ 1mPa and temperature of +60°C. Optical output power shall be measured throughout the test.

On completion of the test, the samples shall be removed from the chamber. The dimensions shall be measured and a visual inspection (external and/or internal, as applicable) carried out to look for any damage or other anomalies, followed by electro-optical measurements per the Detail Specification.

6.4.2.4.6 Moisture Stress (3 samples)

A Moisture Stress test shall be performed as follows depending on the package.

(a) For Hermetic Package Components
Components shall be subjected to a moisture resistance test followed by a temperature cycling test in accordance with the following conditions:
- Phase 1: Moisture resistance:
  - relative humidity: 85 %
  - ambient temperature: +85 °C
  - no electrical bias
  - duration: 240 hours
- Phase 2: Temperature cycling around dew point
  - cycling between -10ºC and +50ºC under a non-condensing atmosphere
  - rate: 3ºC/minute
  - low temperature and high temperature dwell time: 3 hours
  - number of cycles: 10
  - electrical bias shall be applied.

(b) For Non-Hermetic Package Components
Components shall be subjected to a bake in accordance with the following conditions:
- relative humidity: 70%
- ambient temperature: +70°C
- no electrical bias
- duration: 500 hours

6.4.2.4.7 Low Temperature Storage (1 sample)

Low Temperature Storage consists of 2000 hours un-biased storage at the same low temperature used for Temperature cycling. Electro-optical measurements per the Detail Specification shall be performed prior to and following the test exposure. This test shall only be performed if requested by the customer.

6.4.2.4.8 Solderability (5 samples from previous tests)

Solderability shall be performed in accordance with Para. 8.16 of ESCC Generic Specification No. 5000. Electro-optical rejects may be used for this test. On completion of Solderability the samples shall be subjected to Permanence of Marking.

6.4.2.4.9 Permanence of Marking

Permanence of Marking shall be performed in accordance with ESCC Basic Specification No. 24800.

6.4.2.5 Subgroup 2E - Electro-Optical Tests (5 samples)

6.4.2.5.1 Electrostatic Discharge Sensitivity (ESDS) - Human Body Model (HBM) (3 sample)

ESDS (HBM) testing shall be performed in accordance with ESCC Basic Specification No. 23800 or MIL-STD-883, Test Method 3015.8.

6.4.2.5.2 Catastrophic Optical Damage (COD) Threshold (1 sample)

A “current ramp” is applied to the laser diode under test. The ramp speed (in mA/s) is determined by the Manufacturer’s value of IMAX (in mA) divided by 60 (s).

The optical power is monitored during the current ramping. When the optical power has fallen by more than 50% the current (ICOD) and optical power (PCOD) are measured and recorded.

6.4.2.5.3 Performance in a Vacuum (1 sample)

Electro-optical measurements, as defined in the Detail specification, shall be made in a vacuum environment.

6.4.2.5.4 Characterisation (1 sample)

The main laser characteristics (e.g. LIV, Spectrum data, Near and Far Fields) shall be measured at various temperatures within the operating temperature range as specified in the Detail Specification. The test methods to be used shall be in accordance with the manufacturer's internal practices. On completion of Characterisation the sample shall be subjected to Verification of Performance.

6.4.2.5.5 Verification of Performance

The performance of the device shall be explored over the operating temperature range as specified in the Detail Specification.

6.4.3 Group 3 - Accelerated Endurance Test (24 samples)

The aim of the accelerated endurance testing is to demonstrate that components will not run into wear out mode during mission life time. It shall also provide data for random failure rate calculations.

Prior to performing the endurance test, the samples shall pass screening specified in ESCC No. 5000 and the associated Detail specification.

Accelerated Endurance Test conditions shall be set-up based on data from step-stress and characterisation testing and also from available manufacturer's data. Endurance testing shall be run with one, two or three accelerated levels depending on prior knowledge of acceleration factors.

Normally both temperature and power (including duty cycle/frequency) shall be used for acceleration. Constant power operation is the normal mode, but also constant current operation or a combination of both may apply.

6.4.3.1 Test Conditions

The Accelerated Endurance Test shall be based on the following inputs:

- Mission life or 15 years when the mission life is unknown
- Failure modes and associated acceleration factors
- Activation Energy
- Power Exponent
- Frequency/duty cycle acceleration

In the absence of knowledge of all factors concerning mission life and failure modes the following conditions shall be used:

- Duration 5000 hours or until 50% of devices have failed
- Wavelength stability of ± 5% or better, or as otherwise specified in the Detail Specification
- Maximum rated combination of temperature and power, or performed at three different conditions
- The tests shall be with constant power and failure is defined when the input current is increased by 20%.

6.4.3.2 Monitoring during Test

The following parameters shall be monitored during the Accelerated Endurance Test:

- Voltage
- Temperature
- Current
- Optical output power
- Wavelength

Any other parameters to be measured shall be agreed with the customer according to complexity and need.

6.4.4 Group 4 - Reserve (3 samples)

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

7 DATA DOCUMENTATION

7.1 GENERAL REQUIREMENTS

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

(a) Cover sheet (or sheets)
(b) List of equipment (testing and measuring)
(c) List of test references
(d) Sample identification
(e) Production data
(f) 100% Inspection data
(g) Electro-Optical measurements (read and record) data
(h) Group 1 - Control Group data
(i) Subgroup 2A - Step-Stress Tests data
(j) Subgroup 2B - Constructional Analysis report
(k) Subgroup 2C - Radiation reports
(l) Subgroup 2D - Environmental Tests data
(m) Subgroup 2E - Electro-Optical Tests data
(n) Group 3 - Accelerated Endurance Tests data
(o) List of failed devices by Subgroup (if/as applicable), along with failure analysis where necessary
(p) Summary of results and conclusions
(q) Items (a) to (o) inclusive shall be grouped, preferably as sub-packages, 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

7.2 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) Laser diode 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

7.3 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.

7.4 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.

7.5 SAMPLE IDENTIFICATION

This shall identify the criteria used for the selection of the particular laser diode used for the tests when evaluating a range of components by means of representative samples, or evaluating a capability domain for the manufacture of laser diodes.

7.6 100% INSPECTION DATA

The number of laser diodes subjected to each test shall be identified together with the number and reason for any rejects.

7.7 ELECTRO-OPTICAL MEASUREMENTS

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

7.8 GROUP 1 - CONTROL GROUP DATA

All data shall be recorded against serial numbers.

7.9 GROUP 2 - DESTRUCTIVE TESTS DATA

7.9.1 Subgroup 2A - Step-Stress Tests Data

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

- Starting temperature and power
- Temperature and power steps
- Electro-optical measurements tabulated for each step
- Graphical output as defined in Para. 6.4.2.1.5
- Analysis of any failed laser diodes as defined in Para. 6.4
- Optical output power measurements from all samples

7.9.2 Subgroup 2B - Constructional Analysis

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

- Results of all inspection steps specified in Para. 6.4.2.2
- Photographs as specified within Para. 6.4.2.2 (e.g. Photographs from External Visual inspection, X-ray photographs, SEM photographs, CSAM images)
- Dimensions of the samples

7.10 GROUP 3 - ACCELERATED ENDURANCE TEST DATA

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

- Failure modes and associated acceleration factors used for the test conditions
- All test results
- Failure rate calculations

7.11 FAILURE ANALYSIS REPORTS

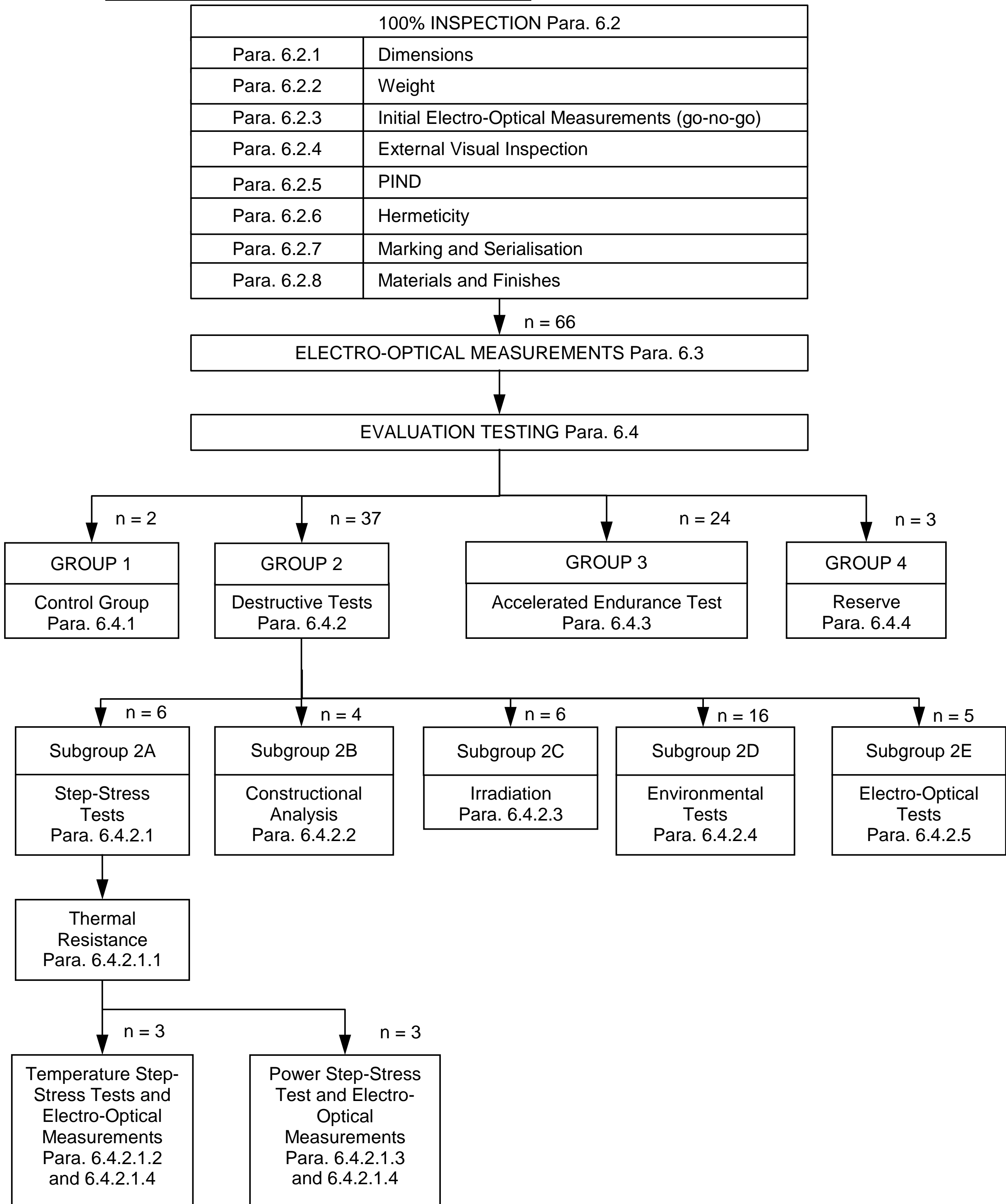
Failure analysis reports shall be part of the data delivery.

7.12 SUMMARY OF THE RESULTS AND CONCLUSIONS

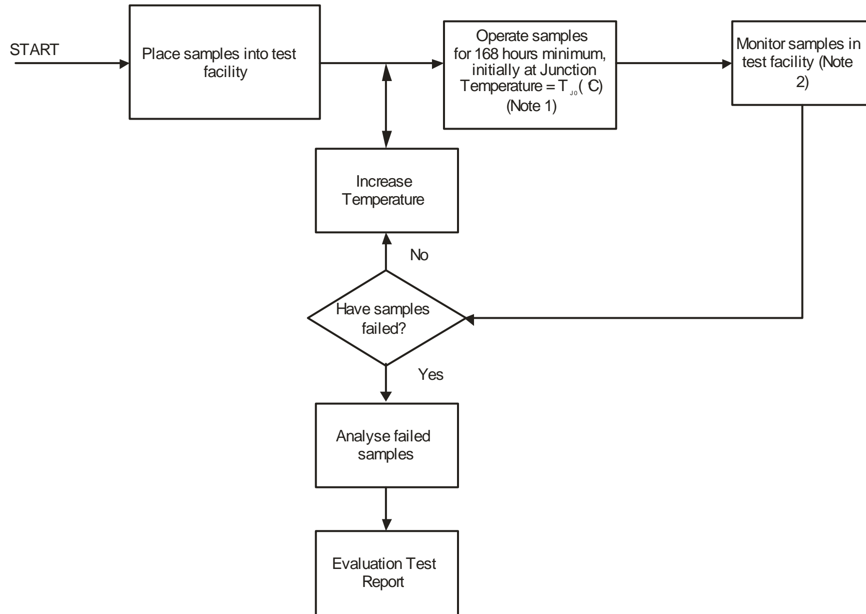
All results and reports produced shall be briefly reviewed and the success or otherwise of the Evaluation Test Programme determined. Any production changes that need to be introduced into the P.I.D. shall be defined.

8 CHARTS

8.1 CHART I - EVALUATION TEST PROGRAMME



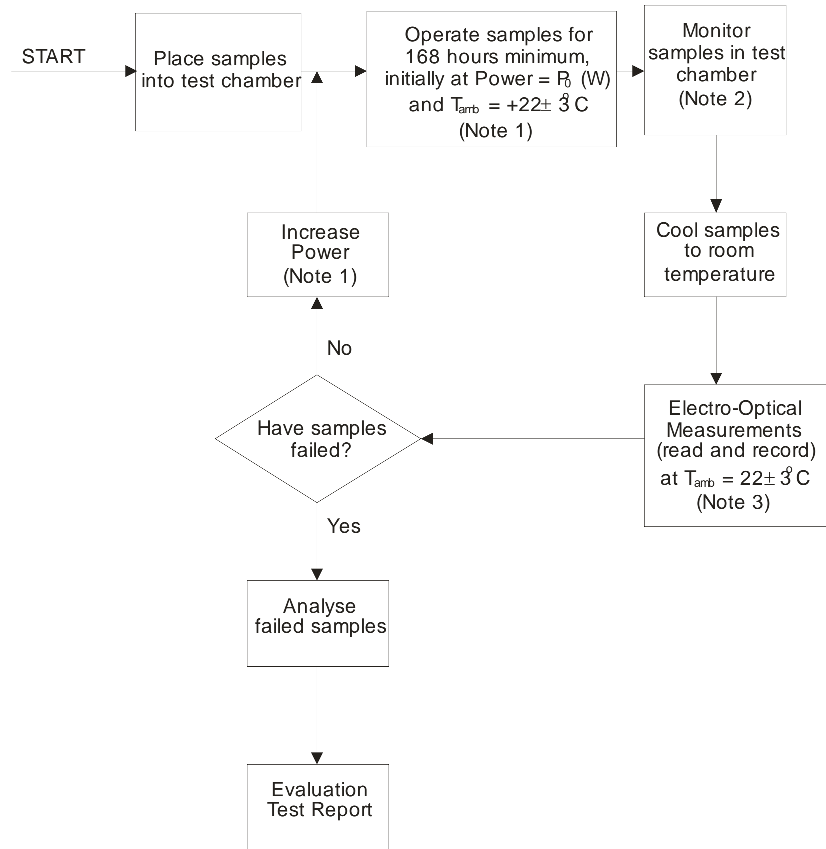
8.2 CHART II - TEMPERATURE STEP-STRESS SEQUENCE



NOTES:

1. Test temperature shall be increased or decreased, as necessary, in equally-spaced steps TJ0, TJ1, TJ2....TJn:
   For High Temperature Step-Stress Test, TJn > ... TJ1 > TJ0.
   For Low Temperature Step-Stress Test, TJn < ... TJ1 < TJ0.
   The actual temperature of each test step shall be discussed and agreed with the Manufacturer prior to commencement of the test.
   Example:
   TJ0 = +120 ±2°C, TJ1 = +125 ±2°C, TJ2 = +130 ±2°C and so on for the High Temperature Step-Stress Test;
   TJ0 = -50 ±2°C, TJ1 = -55±2°C, TJ2 = -60 ±2°C and so on for the Low Temperature Step-Stress Test.
2. Samples may need to be removed from the test chamber for measurements.

8.3 CHART III - POWER STEP-STRESS SEQUENCE



NOTES:

1. Power shall be increased in equally-spaced steps P0, P1, P2....Pn. The actual power of each test step shall be discussed and agreed with the Manufacturer prior to commencement of the test.
   Example:
   P0 = 150mW (±5%), P1 = 200mW (±5%), P2 = 250mW (±5%) and so on.
2. Samples may need to be removed from the test chamber for measurements.
3. The electro-optical measurements to be made are specified in the Detail Specification.