CAPACITORS, CHIP, TANTALUM,

SOLID ELECTROLYTE

ESCC Generic Specification No. 3011

Issue 2	May 2013

Document Custodian: European Space Agency – see https://escies.org

LEGAL DISCLAIMER AND COPYRIGHT

DOCUMENTATION CHANGE NOTICE

(Refer to https://escies.org for ESCC DCR content)

DCR No.	CHANGE DESCRIPTION
772	Specification up issued to incorporate editorial changes per DCR.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 SCOPE

This specification defines the general requirements for the qualification approval, procurement, including lot acceptance testing, and delivery of Capacitors, Chip, Tantalum, Solid Electrolyte for space applications.

This specification contains the appropriate inspection and test schedules and also specifies the data documentation requirements.

1.2 APPLICABILITY

This specification is primarily applicable to the granting of qualification approval to a component in accordance with ESCC Basic Specification No. 20100 and the procurement of such components from qualified Manufacturers.

2 APPLICABLE DOCUMENTS

The following documents form part of, and shall be read in conjunction with, this specification. The relevant issues shall be those in effect on the date of placing the purchase order.

2.1 ESCC SPECIFICATIONS

No. 20100, Requirements for the Qualification of Standard Electronic Components for Space Application.

No. 20400, Internal Visual Inspection.

No. 20500, External Visual Inspection.

No. 20600, Preservation, Packaging and Despatch of ESCC Electronic Components.

No. 21300, Terms, Definitions, Abbreviations, Symbols and Units.

No. 21700, General Requirements for the Marking of ESCC Components.

No. 22800, ESCC Non-conformance Control System.

No. 23500, Lead Materials and Finishes for Components for Space Application.

No. 24600, Minimum Quality System Requirements.

No. 24800, Resistance to Solvents of Marking, Materials and Finishes.

With the exception of ESCC Basic Specifications Nos. 20100, 21700, 22800 and 24600, where Manufacturers' specifications are equivalent to, or more stringent than, the ESCC Basic Specifications listed above, they may be used in place of the latter, subject to the approval of the ESCC Executive.

Such replacements shall be clearly identified in the applicable Process Identification Document (PID) and listed in an appendix to the appropriate Detail Specification.

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

2.2 OTHER (REFERENCE) DOCUMENTS

IEC Publication No. 68, Basic Environmental Testing Procedures.

IEC Publication No. 384, Fixed Capacitors for Use in Electronic Equipment.

IEC Publication No. 410, Sampling Plans and Procedures for Inspection by Attributes.

MIL-STD-414, Sampling Procedures and Tables for Inspection by Variables for Percent Defective.

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

2.3 ORDER OF PRECEDENCE

For the purpose of interpretation and in case of conflict with regard to documentation, the following order of precedence shall apply:

(a) ESCC Detail Specification.
(b) ESCC Generic Specification.
(c) ESCC Basic Specification.
(d) Other documents, if referenced herein.

3 TERMS, DEFINITIONS, ABBREVIATIONS, SYMBOLS AND UNITS

The terms, definitions, abbreviations, symbols and units specified in ESCC Basic Specification No. 21300 shall apply.

4 REQUIREMENTS

4.1 GENERAL

The test requirements for qualification approval of a component shall comprise final production tests (see Chart II), burn-in and electrical measurements to testing level 'B' (see Chart III) and qualification testing (see Chart IV).

The test requirements for procurement of components shall comprise final production tests (Chart II), burn-in and electrical measurements to testing level 'B' or 'C' as required (Chart III) together with, when applicable, a level of lot acceptance testing (see Chart V) to be specified by the Orderer.

If a Manufacturer elects to eliminate a final production test by substituting an in-process control or statistical process control procedure, the Manufacturer is still responsible for delivering components that meet all of the performance, quality and reliability requirements defined in this specification and the Detail Specification.

4.1.1 Specifications

For qualification approval, procurement (including lot acceptance testing) and delivery of components in conformity with this specification, the specifications listed in Section 2 of this document shall apply in total unless otherwise specified herein or in the Detail Specification.

4.1.2 Conditions and Methods of Test

The conditions and methods of test shall be in accordance with this specification, the ESCC Basic Specifications referenced herein and the Detail Specification.

4.1.3 Manufacturer's Responsibility for Performance of Tests and Inspections

The Manufacturer shall be responsible for the performance of tests and inspections required by the applicable specifications. These tests and inspections shall be performed at the plant of the Manufacturer of the components unless it is agreed by the ESCC Executive prior to commencing qualification testing, or procurement, to use an approved external facility.

4.1.4 Inspection Rights

The ESCC Executive (for qualification approval or for a procurement) reserves the right to monitor any of the tests and inspections scheduled in the applicable specifications.

4.2 QUALIFICATION APPROVAL REQUIREMENTS ON A MANUFACTURER

To obtain and maintain the qualification approval of a component, or family of components, a Manufacturer shall satisfy the requirements of ESCC Basic Specification No. 20100.

4.3 DELIVERABLE COMPONENTS

Components delivered to this specification shall be processed and inspected in accordance with the relevant Process Identification Document (PID). Each delivered component shall be traceable to its production lot. Components delivered to this specification shall have completed satisfactorily all tests to the testing level and lot acceptance level specified in the purchase order (see Para. 4.3.2).

ESCC qualified components delivered to this specification shall be produced from lots that are capable of passing all tests, and sequences of tests, that are defined in Charts IV and V. The Manufacturer shall not knowingly supply components that cannot meet this requirement. In the event that, subsequent to delivery and prior to operational use, a component is found to be in a condition such that it could not have passed these tests at the time of manufacture, this shall be grounds for rejection of the delivered lot.

Components failing inspections and tests of the higher testing level (i.e. level 'B') shall not be supplied against any order for components of the lower testing level.

4.3.1 Lot Failure

Lot failure may occur during final production tests (Chart II), burn-in and electrical measurements (Chart III), qualification testing (Chart IV) or lot acceptance testing (Chart V).

Should such failure occur, the non-conformance procedure shall be initiated in accordance with ESCC Basic Specification No. 22800.

Should such failure occur during procurement, the Manufacturer shall notify the Orderer by telex within 2 working days, giving details of the number and mode of failure and the suspected cause.

In the case where qualification approval has been granted to the component, he shall, at the same time by the same means, inform the ESCC Executive in order that the latter may consider its implications.

No further testing shall be performed on the failed components except on instruction from the Orderer. The Orderer shall inform the Manufacturer and the ESCC Executive within 2 working days of receipt of the telex, by the same means, what action shall be taken.

In the case when lot failure occurs during qualification testing, the Manufacturer shall immediately notify the ESCC Executive who will define a course of action to be followed. No further testing shall be performed on the failed components.

4.3.2 Testing and Lot Acceptance Levels

This specification defines 2 levels of testing severity which are designated by the letters 'B' and 'C' (see Chart I) and 3 levels of lot acceptance testing (see Chart V).

The lot acceptance levels are designated 1, 2 and 3 and are comprised of tests as follows:

Level 3 (LA3) - Electrical Subgroup.

Level 2 (LA2) - Endurance Subgroup
plus Electrical Subgroup.

Level 1 (LA1) - Environmental and Mechanical Subgroup
plus Endurance Subgroup
plus Electrical Subgroup.

The required testing level and lot acceptance level shall both be specified in a purchase order.

4.4 MARKING

The following requirements shall be applicable to the packaging only. The components shall not be marked.

All components procured and delivered to this specification from a source qualified according to ESCC Basic Specification No. 20100 shall be marked in accordance with ESCC Basic Specification No. 21700. Thus, they shall bear the ESA symbol to signify their conformance to the ESCC qualification approval requirements and full compliance with the requirements of this specification and the Detail Specification.

Components procured from sources which are not ESCC qualified, provided that they fully comply with the procurement requirements of this specification and the Detail Specification, may bear the ESCC marking **with the exception of the ESA symbol**.

4.5 MATERIALS AND FINISHES

All non-metallic materials and finishes, that are not within a hermetically sealed enclosure, of the components specified herein shall meet the outgassing requirements as outlined in ESA PSS-01-702.

Specific requirements for materials and finishes are specified in the Detail Specification.

5 PRODUCTION CONTROL

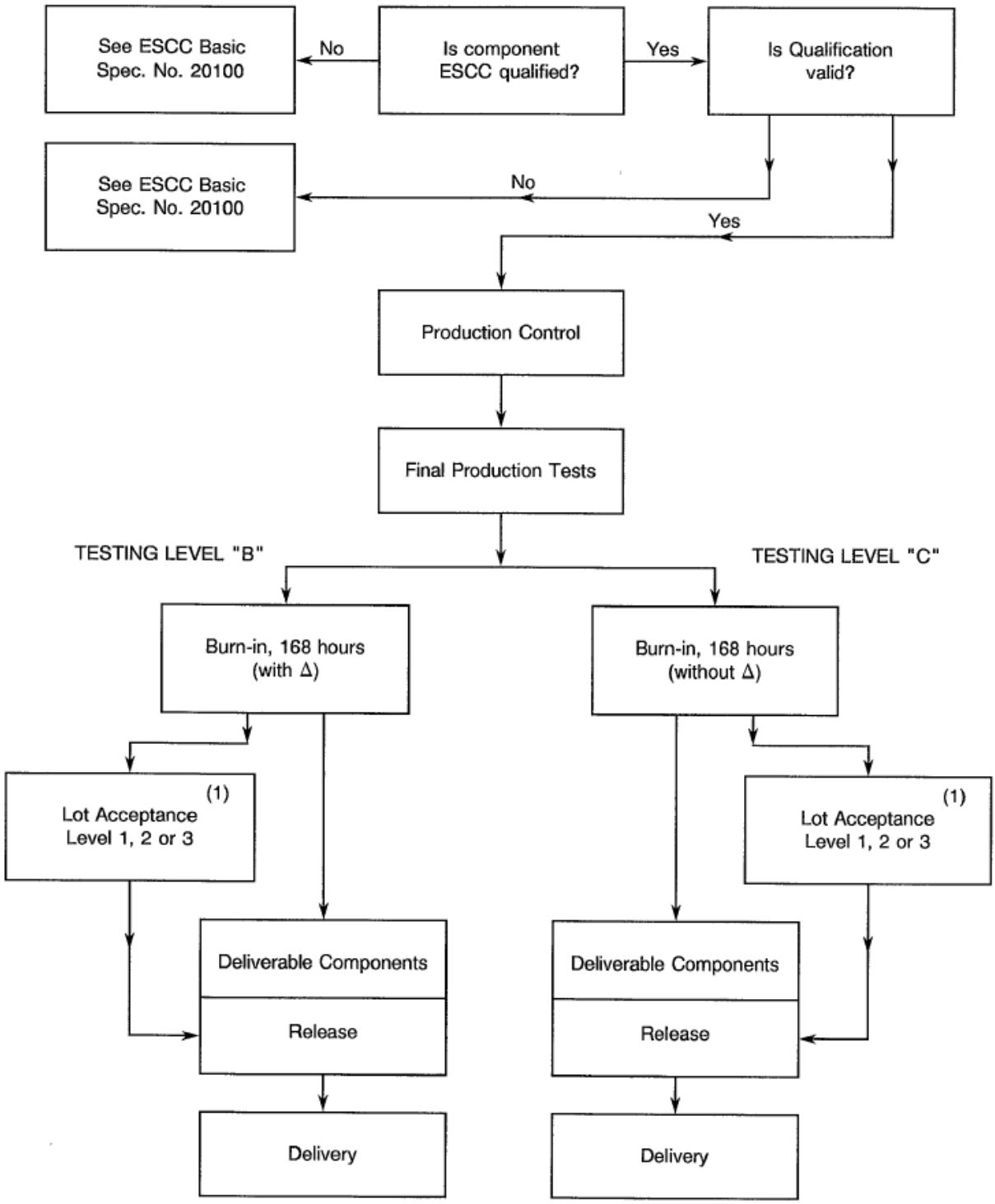
5.1 GENERAL

The minimum requirements for production control, which are equally applicable to procurement, are defined in ESCC Basic Specification No. 20100, Paras. 5.1 and 5.2.

5.2 SPECIAL IN-PROCESS CONTROLS

Where applicable, special in-process controls shall apply as specified in the Detail Specification.

CHART I - TESTING LEVELS



NOTES

1. When applicable.

6 FINAL PRODUCTION TESTS

6.1 GENERAL

Unless otherwise specified in the Detail Specification, all components used for qualification testing and all components for delivery, including those submitted to lot acceptance tests, shall be subjected to tests and inspections in accordance with Chart II.

Unless otherwise specified in the Detail Specification, the tests shall be performed in the order shown.

Any components that do not meet these requirements shall be removed from the lot and at no future time be re-submitted to the requirements of this specification.

6.2 TEST METHODS AND CONDITIONS

The applicable test methods and conditions are specified in the paragraphs referenced in Chart II of this specification.

6.3 DOCUMENTATION

Documentation of final production test data shall be in accordance with the requirements of Para. 10.6 of this specification.

7 BURN-IN AND ELECTRICAL MEASUREMENTS

7.1 GENERAL

Unless otherwise specified in the Detail Specification, all components used for qualification testing and all components for delivery, including those submitted to lot acceptance tests, shall be subjected to tests and inspections in accordance with Chart III.

Unless otherwise specified in the Detail Specification, the tests shall be performed in the order shown.

The applicable test methods and conditions are specified in the paragraphs referenced in Chart III.

Components of testing level 'B' shall be serialised prior to the tests and inspections.

7.1.1 Conditions of Test

The conditions for burn-in shall be as shown in Table 5 of the Detail Specification.

Unless otherwise specified in the Detail Specification, components of both levels 'B' and 'C' shall be subjected to a total burn-in period of 168 hours. For the applicable test methods and procedures, see Para. 9.14.

7.1.2 Data Points

For components of testing level 'B', undergoing a total burn-in period of 168 hours, the data points for parameter drift measurements shall be 0 hours (initial) and 168 (+24 -0) hours (final).

For components of testing level 'C', undergoing a total burn-in of 168 hours, the data point for post burn-in electrical measurements shall be 168 (+24 -0) hours.

7.2 FAILURE CRITERIA

7.2.1 Parameter Drift Failure

The acceptable delta limits are shown in Table 4 of the Detail Specification. A component of testing level 'B' shall be counted as a parameter drift failure if the changes during burn-in are larger than the delta (Δ) values specified.

7.2.2 Parameter Limit Failure

A component shall be counted as a limit failure if one or more parameters exceed the limits shown in Tables 2 or 3 of the Detail Specification.

Any component which exhibits a limit failure prior to the burn-in sequence shall be rejected and not counted when determining lot rejection.

7.2.3 Other Failures

A component shall be counted as a failure in any of the following cases:

- Mechanical failure.
- Handling failure.
- Lost component.

7.3 FAILED COMPONENTS

A component shall be considered as a failed component if it exhibits one or more of the failure modes described in Para. 7.2 of this specification.

7.4 LOT FAILURE

In the case of lot failure, the Manufacturer shall act in accordance with the requirements of Para. 4.3.1 of this specification.

7.4.1 Lot Failure during 100% Testing

If the number of components failed on the basis of the failure criteria described in Para. 7.2 exceeds 5% (rounded upwards to the nearest whole number) of the number of components submitted to burn-in and electrical measurements, the lot shall be considered as failed.

If a lot is composed of groups of components of one family defined in one ESCC Detail Specification, but separately identifiable for any reason, then the lot failure criteria shall apply separately to each identifiable group.

7.4.2 Lot Failure during Sample Testing

A lot shall be considered as failed if the number of allowable failures during sample testing in accordance with General Inspection Level II of IEC Publication No. 410 and the applicable AQL as specified in the Detail Specification, is exceeded.

In the case where an LTPD is specified in the Detail Specification, a lot shall be considered as failed if the number of failures allowed is exceeded (see Annexe I for LTPD Sampling Plan).

If a lot failure occurs in either case, a 100% testing may be performed with the lot failure criteria given in Para. 7.4.1.

7.5 DOCUMENTATION

Data documentation of burn-in and electrical measurements shall be in accordance with Para. 10.7 of this specification.

8 QUALIFICATION APPROVAL AND LOT ACCEPTANCE TESTS

8.1 QUALIFICATION TESTING

8.1.1 General

Qualification testing shall be in accordance with the requirements of Chart IV of this specification. The tests of Chart IV shall be performed on the specified sample, chosen at random from components which have successfully passed the tests in Charts II and III for testing level 'B'. This sample constitutes the qualification test lot.

The qualification test lot is divided into subgroups of tests and all components assigned to a subgroup shall be subjected to all of the tests in that subgroup, in the sequence shown.

The applicable test requirements are detailed in the paragraphs referenced in Chart IV.

The conditions governing qualification testing are given in ESCC Basic Specification No. 20100, Para. 5.3 and, for the extension or renewal of qualification approval, in Paras. 6.3 and 6.4.

8.1.2 Distribution within the Qualification Test Lot

A minimum sample of 108 components shall be submitted to qualification testing (Chart IV). The sample shall consist of test vehicles having the lowest and highest voltages and, for these voltages, the smallest and largest size. If there are more than 4 sizes, an intermediate size shall also be tested. Of each of these size/voltage combinations, the highest capacitance value and, for that value, the tightest tolerance shall be chosen.

Thus, for the qualification approval of a series, testing is required on either 2, 3, 4 or more test vehicles.

Where a series comprises more than 4 test vehicles, the minimum quantity of components per test vehicle must be:

Subgroup 1 - 3 components
Subgroup 2 - 3 components
Subgroup 3 - 3 components
Subgroup 4 - 9 components
Subgroup 5 - 6 components
Subgroup 6 - 3 components

Where a series comprises fewer than 4 test vehicles, the sample shall be evenly distributed between the test vehicles.

The selected distribution shall be agreed with the ESCC Executive.

8.2 LOT ACCEPTANCE TESTING

8.2.1 General

The sample sizes of the 3 lot acceptance levels are specified in Chart V. All components assigned to a subgroup shall be subjected to all of the tests of that subgroup in the sequence shown.

The tests to Chart V shall be performed on the specified sample which shall have been chosen, whenever possible, at random from the proposed delivery lot (but see Para. 8.2.3(b)). The applicable test requirements are detailed in the paragraphs referenced in Chart V.

As a minimum for procurement of non-qualified components, lot acceptance level 3 tests shall apply. For procurement of qualified components, lot acceptance testing shall be performed if specified in a purchase order. Procurement lots ordered with a lot acceptance test level shall be delivered only after successful completion of lot acceptance testing.

8.2.2 Distribution within the Sample for Lot Acceptance Testing

Where a Detail Specification covers a range or series of components that are considered similar, then it may be necessary that the sample for lot acceptance testing be comprised of component types so selected that they adequately represent all of the various mechanical, structural and electrical peculiarities of the procured range or series.

The distribution of the component types will normally vary from procurement to procurement and shall be as specified by the Orderer, following as closely as possible the requirements prescribed in Para. 8.1.2 of this specification.

8.2.3 Lot Acceptance Level 3 Testing (LA3)

Lot acceptance level 3 tests are designated as the electrical subgroup and comprise electrical measurements of characteristics and tests to prove the assembly capability of the component. For LA3 testing, the following requirements and conditions shall apply:

(a) LA3 testing shall be performed by the Manufacturer's quality assurance personnel using dedicated quality assurance equipment whenever possible. LA3 testing shall not be a repetition of routine measurements made by production personnel during final production tests and burn-in and electrical measurements.
(b) When tests to Tables 2 and 3 of the Detail Specification have been performed on a sample basis, then the components for LA3 testing shall be selected from this sample.
(c) The electrical measurements for LA3 are considered to be non-destructive and therefore components so tested may form part of the delivery lot.
(d) The surge voltage and solderability tests are considered to be destructive and therefore components so tested shall not form part of the delivery lot.
(e) When required in the purchase order, the Manufacturer shall notify the Orderer at least 2 working weeks before commencement of LA3 testing. The Orderer shall indicate immediately whether or not he intends to witness the tests.

8.2.4 Lot Acceptance Level 2 Testing (LA2)

Lot acceptance level 2 testing shall comprise the tests for LA3 (electrical subgroup) plus tests on an endurance subgroup. For the electrical subgroup, the requirements and conditions as for LA3 (see Para. 8.2.3) shall apply.

For the endurance subgroup, the following shall apply:

(a) Components of testing level 'C', selected for the endurance subgroup, shall be serialised prior to the tests.

(b) The tests in this subgroup are considered to be destructive and therefore components (of testing level 'B' or 'C') so tested shall not form part of the delivery lot.

8.2.5 Lot Acceptance Level 1 Testing (LA1)

Lot acceptance level 1 testing shall comprise the tests for LA3 (electrical subgroup) and LA2 (endurance subgroup) plus tests on an environmental and mechanical subgroup. For the electrical and endurance subgroups, the requirements and conditions for LA3 (see Para. 8.2.3) and LA2 (see Para. 8.2.4) respectively shall apply.

For the environmental subgroup, the following shall apply:

(a) Components of testing level 'C', selected for the environmental subgroup, shall be serialised prior to the tests.
(b) The tests in this subgroup are considered to be destructive and therefore components (of testing level 'B' or 'C') so tested shall not form part of the delivery lot.

8.3 FAILURE CRITERIA

The following criteria shall apply to qualification testing and to lot acceptance testing.

8.3.1 Environmental and Mechanical Test Failures

The following shall be counted as component failures:

– Components which fail tests for which the pass/fail criteria are inherent in the test method, e.g. solderability, adhesion, etc.

8.3.2 Electrical Failures

The following shall be counted as component failures:

(a) Components which, when subjected to electrical measurements on completion of environmental tests, in accordance with either Table 2 or Table 6, as specified in the Detail Specification, fail one or more the applicable limits.
(b) Components which, when subjected to electrical measurements at intermediate and end-points during endurance testing, in accordance with Table 6 of the Detail Specification, fail one or more of the applicable limits.
(c) Components which, when subjected to measurement of electrical characteristics, in accordance with Tables 2 and 3 of the Detail Specification, fail one or more of the applicable limits.

8.3.3 Other Failures

The following additional failures may also occur during qualification testing or lot acceptance testing:

(a) Components failing to comply with the requirements of ESCC Basic Specification No. 20500.
(b) Lost components.

8.4 FAILED COMPONENTS

A component shall be considered as failed if it exhibits one or more of the failure modes detailed in Para. 8.3 of this specification. The allowable number of failed components per Subgroup, the aggregate failure constraints and the permitted distribution of such failures are shown at the foot of Charts IV and V of this specification.

When requested by the ESCC Executive or the Orderer, failure analysis of failed components shall be performed by the Manufacturer and the results provided.

Failed components from successful lots shall be marked as such and be stored at the Manufacturer's plant for 24 months.

8.5 LOT FAILURE

A lot shall be considered as failed if the allowable number of failures according to Chart IV or V of this specification, as relevant, has been exceeded.

In the case of lot failure, the Manufacturer shall act in accordance with Para. 4.3.1 of this specification.

8.6 DOCUMENTATION

For qualification testing, the qualification test data shall be documented in accordance with the requirements of Para. 10.8 of this specification.

In the case of lot acceptance testing, the data shall be documented in accordance with the requirements of Para. 10.9 of this specification.

CHART II- FINAL PRODUCTION TESTS

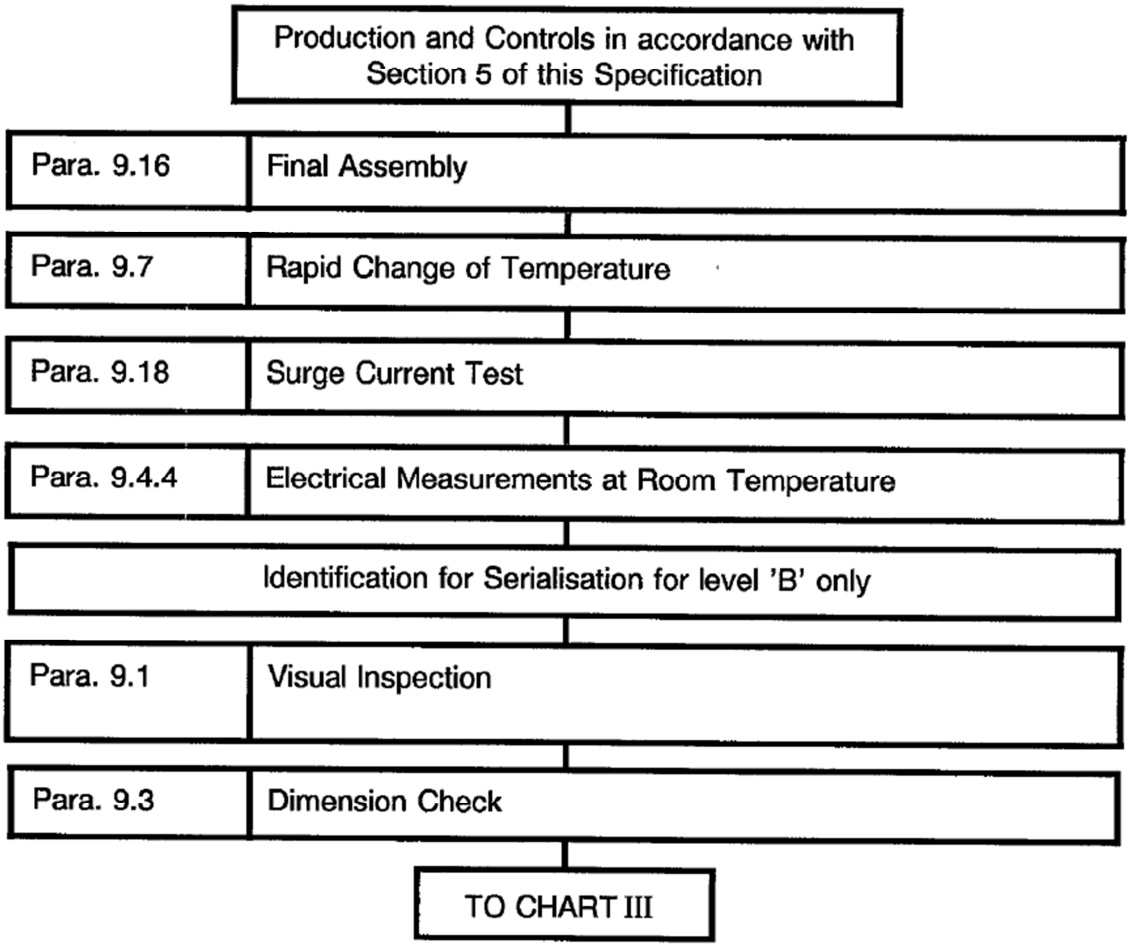
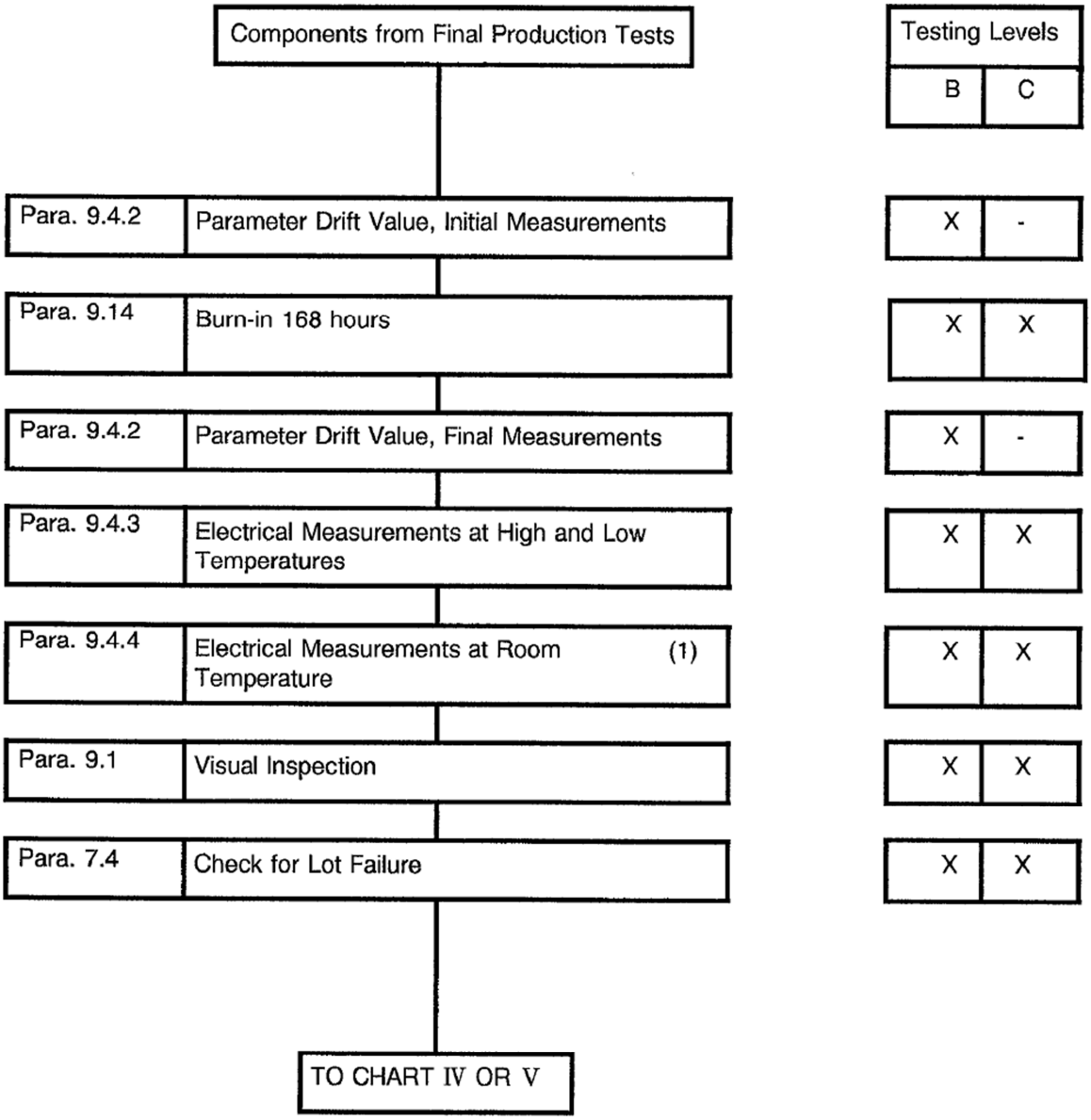


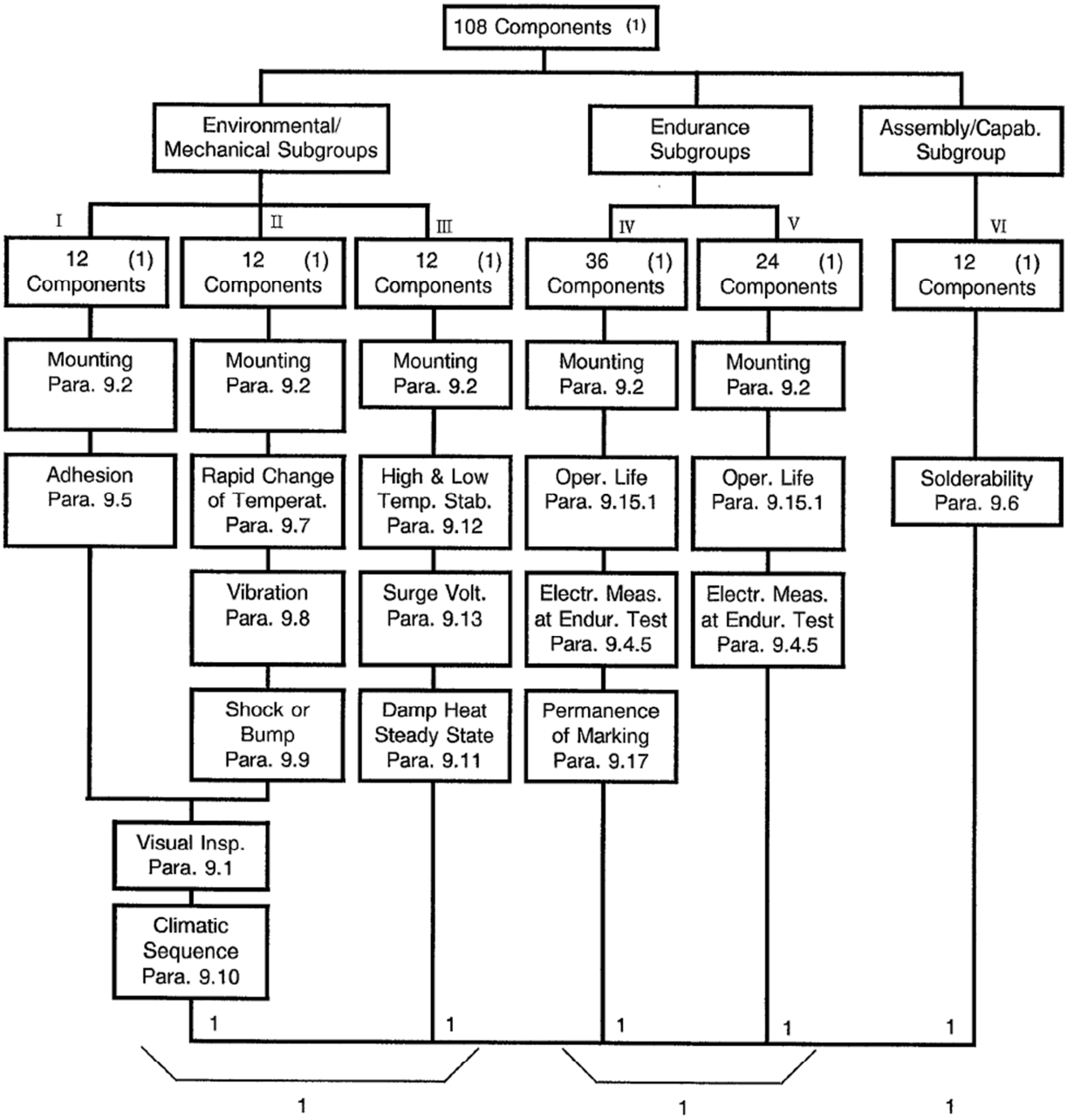
CHART III - BURN-IN AND ELECTRICAL MEASUREMENTS



NOTES

1. The measurements of parameters for the purpose of drift value measurements need not be repeated for electrical measurements at room temperature.

CHART IV- QUALIFICATION TESTS

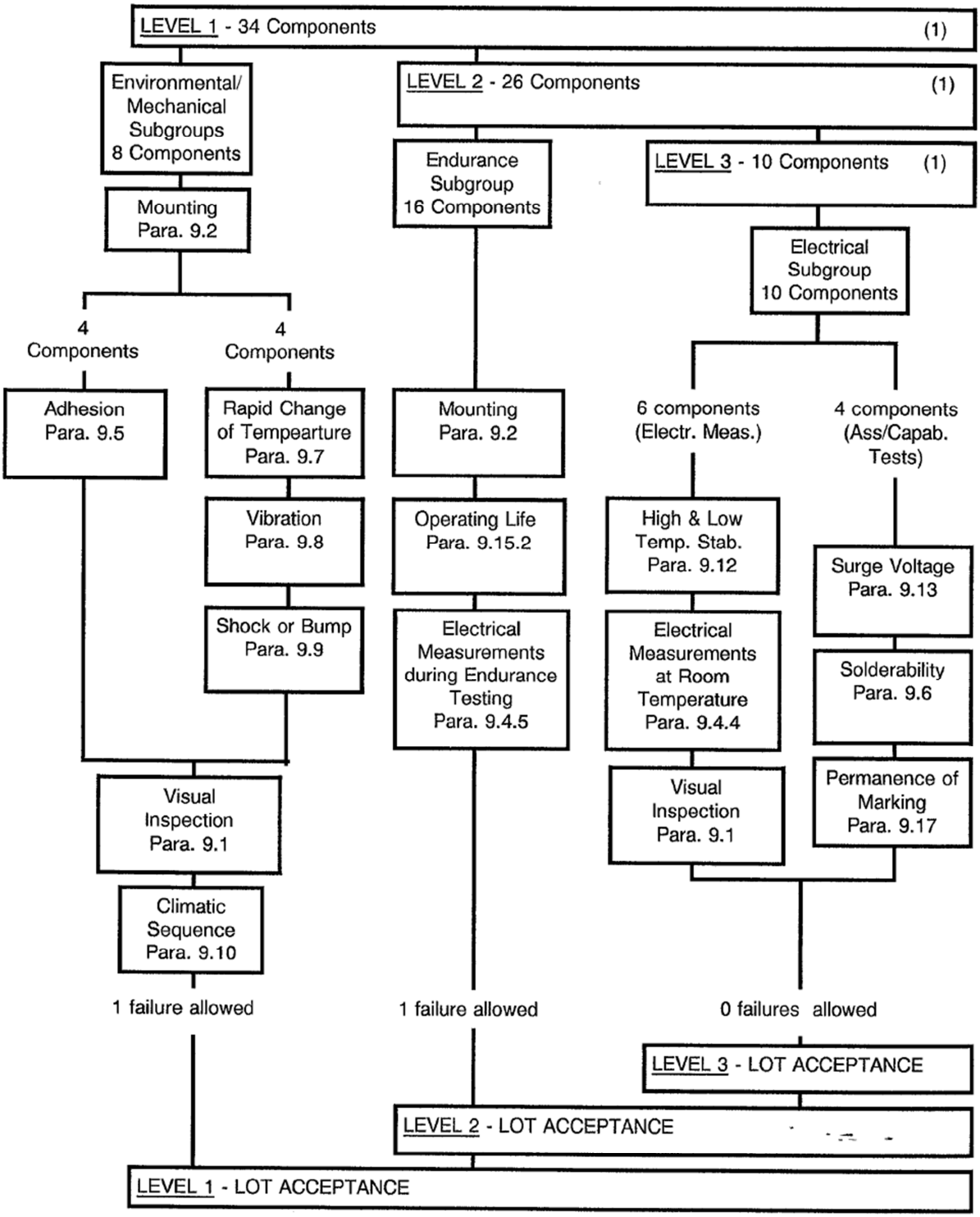


Total allowable number of failed components: 3.

NOTES

1. For distribution within the subgroups, see Para. 8.1.2.

CHART V – LOT ACCEPTANCE TESTS



NOTES

1. For distribution within the subgroups, see Para. 8.2.2.

9 TEST METHODS AND PROCEDURES

If a Manufacturer elects to eliminate or modify a test method or procedure, the Manufacturer is still responsible for delivering components that meet all of the performance, quality and reliability requirements defined in this specification and the Detail Specification.

Documentation supporting the change shall be approved by the ESCC Executive and retained by the Manufacturer. It shall be copied, when requested, to the ESCC Executive.

The change shall be specified in the Detail Specification and in the PID.

9.1 VISUAL INSPECTION

In accordance with ESCC Basic Specification No. 20400.

9.2 MOUNTING ON SUBSTRATES

For all environmental and endurance tests, the capacitors shall be mounted on a suitable substrate in accordance with IEC Publication No. 384-10, Clause 7.6. The substrate material shall not affect the results of any tests or measurements.

The method of mounting will be dependent on capacitor construction, so the substrate will have metallised land areas of proper spacing to permit correct mounting of the capacitors and to allow proper electrical connection to the capacitor terminals. If metallised terminal areas suitable for reflow soldering are provided, the following mounting procedure shall be applicable:

(a) The solder used in preform or paste form shall be silver-bearing (2%) eutectic Sn/Pb solder together with a non-active flux.
(b) The capacitors shall be placed across the metallised land area of the test substrate so as to make contact between chip and substrate land area.
(c) The substrate shall then be placed in, or on, a suitable heat transfer unit (hot plate - tunnel oven - hot gas reflow, etc.). The temperature of the unit shall be maintained at between +215 and +260 °C until the solder melts and reflows forming a homogeneous solder bond, for a period not exceeding the maximum soldering time as defined in the Detail Specification.

NOTES

1. Flux shall be removed by a suitable solvent treatment. All subsequent handling shall be such that contamination is avoided.
2. The mounting operation also comprises the resistance to soldering heat test. Measurements of electrical parameters shall therefore be repeated after the mounting procedure.

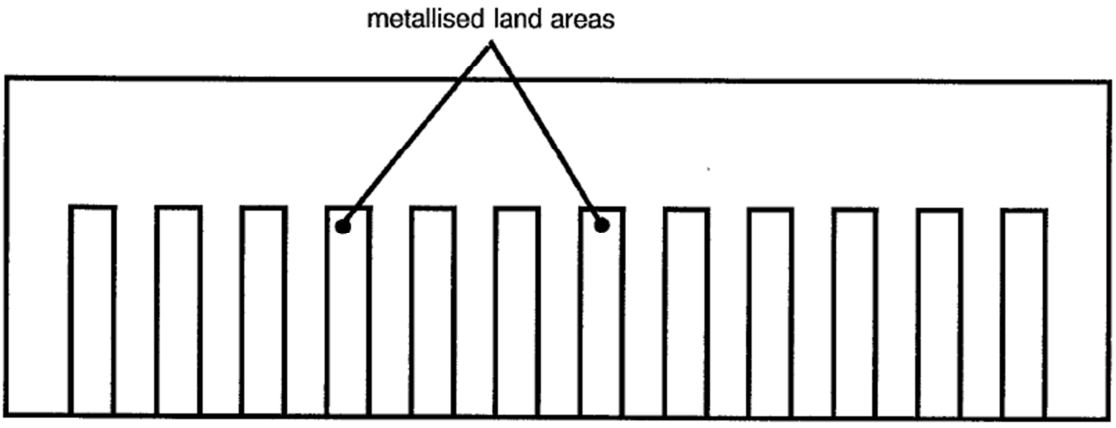
Final Measurement

The capacitance, DC leakage current and dissipation factor shall be measured and shall be within the limits specified in Table 6 of the Detail Specification. The capacitance value measured shall be recorded.

Final Examination

The terminals shall be examined for good tinning as evidenced by the flowing of the solder with wetting of the terminals.

FIGURE I - TYPICAL TEST SUBSTRATE



9.3 DIMENSION CHECK

In accordance with ESCC Basic Specification No. 20500 and the Detail Specification. To be performed on 5 samples per size only. If 1 failure occurs, the complete lot shall be checked.

9.4 ELECTRICAL MEASUREMENTS

9.4.1 General

Electrical measurements and methods shall be as follows.

9.4.1.1 Capacitance

The following details shall apply:

(a) Test frequency: 100±5 or 120±5 Hertz.
(b) Limit of accuracy:
Measurement accuracy shall be within ±2% of the specified limit whether this is given as an absolute value or as a change of capacitance.
(c) Magnitude of polarising voltage:
The maximum DC bias shall be 2.1 to 2.5 Volts for all AC measurements. The magnitude of the AC voltage shall be ≤ 0.5Volts rms.

9.4.1.2 DC Leakage Current

The DC leakage current shall be measured using the DC rated voltage ±2% at the applicable test temperature after a maximum electrification period of 5 minutes. A 1000 Ohm resistor shall be placed in series with the capacitor to limit the charging current. A steady source of power, such as a regulated power supply, shall be used. Measurement accuracy shall be within 0.02µamps.

9.4.1.3 Dissipation Factor

The dissipation factor of each capacitor shall be measured at a frequency of 100±5 or 120±5 Hertz by means of a polarised capacitance bridge. The bridge shall provide a reading accuracy of 0.1% dissipation factor and a measuring accuracy of ±(2% of the measured dissipation factor plus 0.001).

9.4.2 Parameter Drift Value Measurements

At each of the relevant data points for components of testing level 'B', measurements shall be made of all parameters listed in Table 4 of the Detail Specification. All values obtained shall be recorded against serial numbers and the parameter drift calculated.

9.4.3 Electrical Measurements at High and Low Temperatures

For components of testing levels 'B' and 'C', the electrical measurements at high and low temperatures shall be made in accordance with Table 3 of the Detail Specification. Where sample testing is applied, note the requirements of Para. 8.2.3(b). For testing level 'B', all values obtained shall be recorded against serial numbers.

9.4.4 Electrical Measurements at Room Temperature

For components of testing levels 'B' and 'C', the measurements of electrical characteristics shall be made in accordance with Table 2 of the Detail Specification. Where sample testing is applied, note the requirements of Para. 8.2.3(b). For testing level 'B', all values obtained shall be recorded against serial numbers, except during Final Production Tests (Chart II).

9.4.5 Electrical Measurements during Endurance Testing

At each of the relevant data points specified for endurance testing, measurements shall be made of all parameters listed in Table 6 of the Detail Specification. All values obtained shall be recorded against serial numbers and the parameter drift calculated, if required.

9.5 ADHESION

9.5.1 Procedure

A force of 5N shall be applied normal to the line joining the terminations and in a plane parallel to the substrate. The force shall be applied progressively (without any shock) and then be maintained for a period of 10±1 seconds.

9.5.2 Final Examination

There shall be no visual evidence of damage or loosening of the component from the substrate. The capacitance shall be measured as specified in Para. 9.4.1.1 in accordance with Table 6 of the Detail Specification and the value shall be within the specified limits.

9.6 SOLDERABILITY

9.6.1 Procedure

The capacitors shall be subjected to Test 'Ta', Method 1 of IEC Publication No. 68-2-20, using the solder bath method.

The capacitors shall be completely immersed. The temperature shall be +235±5 °C and the duration of immersion 2±0.5 seconds unless otherwise specified in the Detail Specification.

9.6.2 Final Examination

At least 75% of the terminations shall be covered by a smooth solder coating. The remaining 25% may contain small pin-holes or rough spots, but these shall not be concentrated in one area.

When the test procedures have been carried out, the capacitors shall be visually examined. There shall be no evidence of damage.

9.7 RAPID CHANGE OF TEMPERATURE

9.7.1 Initial Measurement

The capacitance shall be measured as specified in Para. 9.4.1.1, or the capacitance value recorded during Para. 9.2, Mounting on Substrates shall be used.

9.7.2 Procedure

The capacitors shall be subjected to Test 'Na' of IEC 68-2-14. The following details shall apply:

- T_A = -55 °C.
- T_B = +125 °C.
- t_1 = 30 minutes.
- t_2 = 1 minute.

Conditioning prior to the first cycle shall be 15 minutes at standard atmospheric conditions as defined in IEC Publication No. 68-1.

9.7.3 Recovery and Final Measurement

The duration of recovery shall be 4 hours minimum at standard atmospheric conditions. After recovery, the capacitors shall be visually examined and there shall be no evidence of corrosion, mechanical damage or obliteration of marking.

The measurements specified in Table 6 of the Detail Specification shall be made and the values shall be within the limits specified.

9.8 VIBRATION

9.8.1 Mounting

The capacitors shall be mounted on a substrate which shall be mechanically connected to the vibration generator either directly or by means of a fixture. Mounting fixtures shall be such that they enable the specimen to be vibrated in 3 mutually perpendicular axes in turn, which should be so chosen that faults are most likely to be revealed.

If external connections, necessary for measuring and supply purposes, are specified in the Detail Specification, they should add the minimum restraint and mass.

9.8.2 Procedure

The substrate shall be subjected to Test 'Fc', Method B4 of IEC Publication No. 68-2-6.

Sweep frequency: 10 - 2000 - 10 Hz.

The entire frequency range of 10 to 2000 Hz and return to 10 Hz shall be traversed in 20 minutes. This cycle shall be performed 12 times in each of the 3 directions (a total of 36 times), so that the motion shall be applied for a total period of approximately 12 hours.

The vibration amplitude shall be 3mm and the relevant frequency shall be set so that an acceleration of 20g is reached.

Unless otherwise stated in the Detail Specification, no potential shall be applied between the terminals of the capacitors under test.

9.8.3 Measurement during Vibration

During the last cycle in each direction, an electrical measurement shall be made to determine intermittent operation, intermittent contacts of 0.5ms or longer duration, arcing or open or short-circuit.

9.8.4 Visual Examination

After vibration, the capacitors shall be visually examined and there shall be no evidence of damage.

9.9 SHOCK OR BUMP

9.9.1 Shock

9.9.1.1 Mounting

The substrate shall be fixed to the shock machine, either directly or by means of a fixture. Mounting fixtures shall enable the specimen to be subjected to shocks along 3 mutually perpendicular axes in turn. When external connections, necessary for measuring and supply purposes, are specified in the Detail Specification, they should add the minimum restraint and mass.

9.9.1.2 Procedure

The capacitors mounted on the substrate shall be subjected to Test 'Ea' of IEC Publication No. 68-2-27. Unless otherwise specified in the Detail Specification, the following conditions shall apply:

- Shape of shock pulse: Half sine.
- Peak acceleration: 50g.
- Duration of pulse: 11ms.
- Number of shocks: 18 (3 shocks in each direction along the 3 mutually perpendicular axes of the test specimen).

9.9.1.3 Visual Examination

After shock, the capacitors shall be visually examined and there shall be no evidence of damage.

9.9.2 Bump

9.9.2.1 Mounting

As specified in Para. 9.9.1.1, the word "shock" to be replaced by "bump".

9.9.2.2 Procedure

The capacitors mounted on a substrate shall be subjected to test 'Eb' of IEC Publication No. 68-2-29. Unless otherwise specified in the Detail Specification, the following conditions shall apply:

- Peak acceleration: 390m/s^2
- Number of bumps: 4000±10

9.9.2.3 Visual Examination

After bump, the capacitors shall be visually examined and there shall be no evidence of damage.

9.10 CLIMATIC SEQUENCE

9.10.1 Initial Measurements

The capacitance value recorded during Para. 9.2, Mounting on Substrates shall be used.

9.10.2 Dry Heat

The capacitors shall be subjected to Test 'Ba' of IEC Publication No. 68-2-2. Duration: 2 hours. Maximum storage temperature as specified in the Detail Specification (Table 1(b)).

While still at the specified high temperature and at the end of the period of high temperature, the measurements specified in Table 6 of the Detail Specification shall be made and the values shall be within the limits specified.

9.10.3 Damp Heat, Accelerated, First Cycle

Unless otherwise specified in the Detail Specification, the capacitors shall be subjected to Test 'Db', Severity b, Variant 2 of IEC Publication No. 68-2-30, 1 cycle. After recovery, the capacitors shall be subjected immediately to the cold test.

9.10.4 Cold Test

The capacitors shall be subjected to Test 'Aa' of IEC Publication No. 68-2-1.

Duration: 2 hours. Minimum storage temperature as specified in the Detail Specification (Table 1(b)).

While still at the specified low temperature and at the end of the period of low temperature, the measurements specified in Table 6 of the Detail Specification shall be made and the values shall be within the specified limits.

9.10.5 Low Air Pressure

The capacitors shall be subjected to Test 'M' of IEC Publication No. 68-2-13 under the following conditions:

- 1 to 2 minutes at 85mbar.
- Temperature: +15 to +35 °C.
- The voltage U_r shall be applied for 1 to 2 minutes immediately after the pressure of 85mbar has been attained.

9.10.6 Damp Heat, Accelerated, Remaining Cycles

The capacitors shall be subjected to Test 'Db' Severity b, Variant 2 of IEC Publication No. 68-2-30, 6 cycles.

9.10.7 Final Measurements

After a recovery period of 1 to 24 hours, the capacitors shall be visually inspected according to ESCC Basic Specification No. 20500.

The measurements specified in Table 6 of the Detail Specification shall be made and the values shall be within the specified limits.

9.11 DAMP HEAT, STEADY STATE

9.11.1 Initial Measurements

The capacitance value recorded during Para. 9.2, Mounting on Substrates shall be used.

9.11.2 Procedure

The capacitors shall be subjected to Test 'Ca' of IEC Publication No. 68-2-3 with no voltage applied unless otherwise specified in the Detail Specification.

Duration shall be as specified in the Detail Specification.

9.11.3 Recovery and Final Measurements

After a recovery period of 6 to 24 ±2 hours, the capacitors shall be visually examined and there shall be no evidence of damage.

The measurements specified in Table 6 of the Detail Specification shall be made and the values shall be within the specified limits.

9.12 HIGH AND LOW TEMPERATURE STABILITY

Electrical Measurements shall be performed as specified in Para 9.4.1 at the temperatures specified hereafter, except that DC leakage current measurements at -55 °C (step 2) are not required.

The capacitors shall be brought to thermal stability at each temperature. Thermal stability will have been reached when no further change in capacitance is observed between 2 successive measurements taken at 15 minute intervals.

Step	Test Temperature (°C)
1	+25±3
2	-55 (+0 -3)
3	+25±3
4	+85 (+4 -0)
5	+125 (+4 -0)
6	+25±3

The thermal stability values shall not exceed the limits/changes specified in Table 3 of the Detail Specification.

9.13 SURGE VOLTAGE

Capacitors shall be subjected to 1000 cycles of the applicable surge voltage specified in Table 1(b) of the Detail Specification. The ambient temperature during cycling shall be +85 °C. Each cycle shall consist of a 30-second surge voltage application, followed by a 30-second discharge period.

Voltage application shall be through a resistor of 33 Ohms of a tolerance of ±5%. Each surge voltage cycle shall be performed in such a manner that the capacitor is shorted terminal to terminal through a copper bar or an equivalent low resistance at the end of the 30-second application. An alternative method of shorting the capacitors is discharge through the same resistance that is used for charging.

After the final cycle, the capacitors shall be stabilised at room temperature and the electrical measurements specified in Para. 9.4.1 shall be performed in accordance with the requirements specified in Table 2 of the Detail Specification.

9.14 BURN-IN

The test shall be conducted in accordance with IEC Publication No. 384-1, Clause 4.23.

9.15 OPERATING LIFE

9.15.1 Operating Life during Qualification Testing

(a) Duration: 2000 hours

(b) Test Temperature

The Test temperatures shall be +85 °C in subgroup IV and +125 °C in subgroup V.

(c) Operating Conditions

Rated DC voltage for the test at +85 °C, or derated voltage for the test at +125 °C, shall be applied gradually (but time not to exceed 5 minutes), either by a slow build-up of the voltage or through a resistor which shall be shorted out within 5 minutes. The voltage shall be applied continuously except for measurement periods. The impedance of the voltage source, as seen from the terminals of each capacitor, shall not exceed 3 Ohms.

Storage batteries or an electronic power supply, capable of supplying at least 1 ampere when a capacitor is shorted, shall be used.

(d) Initial Measurements

The capacitance value recorded during Para. 9.2, Mounting on Substrates shall be used.

DC leakage current and dissipation factor shall be measured as specified in Para. 9.4.1.

(e) Intermediate Data Points

During exposure, DC leakage current (as specified in Para. 9.4.1.2) shall be measured at 0 and 250±48 hours and 1000±48 hours at the applicable high test temperature, according to Table 6 of the Detail Specification.

(f) End Data Points

After the capacitors have been returned to room temperature, they shall be measured at end points according to Table 6 of the Detail Specification at 0 and 2000±48 hours.

In the case where Table 6 specifies "changes", the drift shall always be related to the 0-hour measurement.

(g) Visual Examination

On completion of the operating life tests, the capacitors shall be visually examined. There shall be no evidence of damage.

9.15.2 Operating Life during Lot Acceptance Testing

(a) Duration: 1000 hours.

(b) Test Temperature

The test temperature shall be +85 °C.

(c) Operating Conditions

Rated DC voltage shall be applied gradually (but time not to exceed 5 minutes), either by a slow build-up of the voltage or through a resistor which shall be shorted out within 5 minutes. The voltage shall be applied continuously except for measurement periods. The impedance of the voltage source, as seen from the terminals of each capacitor, shall not exceed 3 Ohms.

Storage batteries or an electronic power supply, capable of supplying at least 1 ampere when a capacitor is shorted, shall be used.

(d) Initial Measurements

The capacitance value recorded during Para. 9.2, Mounting on Substrates shall be used.

DC leakage current and dissipation factor shall be measured as specified in Para. 9.4.1.

(e) Intermediate Data Points

During exposure, DC leakage current (as specified in Para. 9.4.1.2) shall be measured at 0 and 250±48 hours at the applicable high test temperature, according to Table 6 of the Detail Specification.

(f) End Data Points

After the capacitors have been returned to room temperature, they shall be measured at end points according to Table 6 of the Detail Specification at 0 and 1000±48 hours. In the case where Table 6 specifies "changes", the drift shall always be related to the 0-hour measurement.

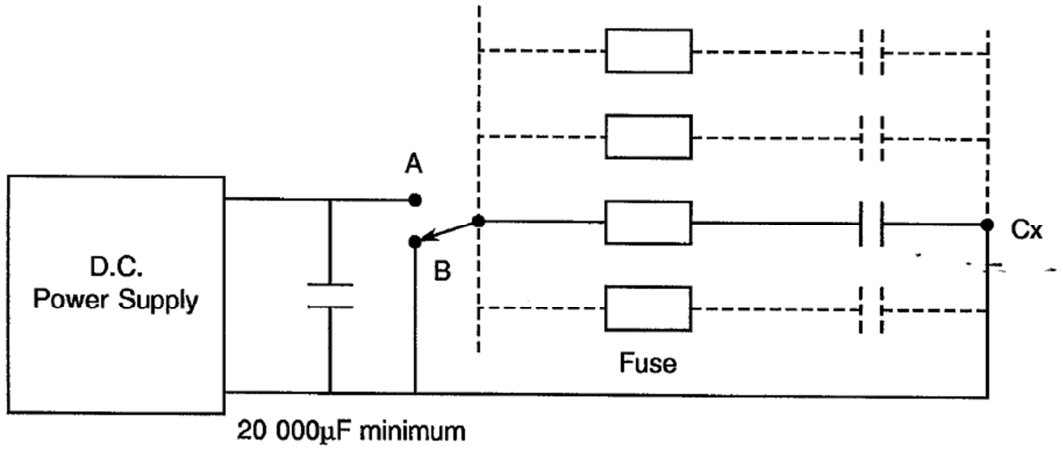
(g) Visual Examination
On completion of the operating life tests, the capacitors shall be visually examined. There shall be no evidence of damage.

9.16 FINAL ASSEMBLY
Final assembly shall be performed in accordance with the Process Identification Document (PID).

9.17 PERMANENCE OF MARKING
In accordance with ESCC Basic Specification No. 24800.

9.18 SURGE CURRENT TEST
A surge current test shall be performed at room temperature as follows:

(a) After rapid change of temperature of Chart II.
(b) Without intermediate electrical measurements between rapid change of temperature and surge current test.
(c) Each capacitor under test shall be submitted to 5 charge/discharge surge current cycles of at least 0.5s per charge and 0.5s per discharge, at the rated voltage of the capacitor under test.
(d) The test circuit shall comply with the following conditions (see Figure below):
- The test shall be performed on an individual capacitor.
- The power supply used for charging the energy storage capacitor bank shall be capable of supplying a regulated DC voltage, variable from 0 to 100V minimum at a 10A minimum current capability.
- The capacitor shall be placed across the DC power supply and shall be continually charged. it shall consist of very low ESR aluminium electrolytic capacitors, connected in parallel, having a capacitance of 20000µF minimum.
- The bank capacitor shall provide, across the capacitor under test, a peak surge current value equal to the test voltage divided per ESR of the capacitor under test plus total circuit resistance. The requirement shall be verified for each test line.
- For calibration, the monitoring of the voltage across a capacitor of 47µF ±10% 35V under test shall demonstrate that the peak voltage across the capacitor during charging is rated voltage ±5% and that 90% of rated voltage is achieved within the first 100µs. This requirement shall be verified for each test line.
- A 30A mercury relay or equivalent shall be used to switch the capacitor under test to the energy bank for charge and into a short-circuit of not more than 0.2Ω maximum for discharge.
- The total resistance of all wiring between the energy source and the capacitor under test, including the mercury relay, the ESR of the capacitor bank and the fuse, shall not exceed 0.5Ω maximum.
- The fuse in the test circuit shall have a rating of not less than 1A and not more than 5A. A fuse shall be placed in series with each capacitor undergoing the test.
- A capacitor under test shall be considered a failure either when the fuse blows or the DC leakage current limit exceeds the nominal value.



10 DATA DOCUMENTATION

10.1 GENERAL

For the qualification approval records and with each component delivery, a data documentation package is required. Depending on the testing level and lot acceptance level specified for the component, this package shall be compiled from:

(a) Cover sheet (or sheets).
(b) List of equipment (testing and measuring).
(c) List of test references.
(d) Special in-process control test data (when required by the Detail Specification).
(e) Final production test data (Chart II) (but see Para. 10.6).
(f) Burn-in and electrical measurement data (Chart III).
(g) Qualification test data (Chart IV).
(h) Lot acceptance test data (Chart V) (when applicable).
(i) Failed components list (see Para's 7.3 and 8.4) and failure analysis report (see Para. 8.4).
(j) Certificate of Conformity.

Items (a) to (j) inclusive shall be grouped, preferably as subpackages and, for identification purposes, each page shall include the following information:

– ESCC Component Number.
– Manufacturer's name.
– Lot identification.
– Date of establishment of the document.
– Page number.

10.1.1 Qualification Approval

In the case of qualification approval, the items listed in Para. 10.1 (a) to (k) less item (h) are required.

10.1.2 Testing Level 'B'

10.1.2.1 Qualified Components

For deliveries of qualified components, the following documentation shall be supplied:-

(a) Cover sheet (if all of the information is not included on the Certificate of Conformity).
(b) Certificate of Conformity (including range of delivered serial numbers).
(c) Attributes record of measurements, tests and inspections performed in Chart II, Chart III (including PDA figure) and Chart V (where applicable).
(d) Failed components list.

10.1.2.2 Unqualified Components

For deliveries of unqualified components, the documentation to be supplied shall be in accordance with Para. 10.1.2.1 plus the following:

(a) Read and record data from Chart III.
(b) Special in-process control data (where applicable).
(c) Failure analysis report on failed components.

10.1.3 Testing Level 'C'

10.1.3.1 Qualified Components

For deliveries of qualified components, the following documentation shall be supplied:

(a) Certificate of Conformity.

10.1.3.2 Unqualified Components

For deliveries of unqualified components, the documentation to be supplied shall be in accordance with Para. 10.1.3.1 plus the following:

(a) Cover sheet (if all of the information is not included on the Certificate of Conformity).
(b) Attributes record of all measurements, tests and inspections performed in Charts II, III and V (when applicable).
(c) Failed components list (including Failure Analysis Report).
(d) Special in-process control data (when applicable).

10.1.4 Data Retention/Data Access

If not delivered, all data shall be retained by the Manufacturer for a minimum of 5 years during which time it shall be available to the ESCC Executive and the Orderer, if requested, for review. The Manufacturer shall deliver variables Data/Reports to the Orderer if required by the Purchase Order.

10.2 COVER SHEET(S)

The cover sheet(s) of the data documentation package shall include as a minimum:

(a) Reference to the Detail Specification, including issue and date.
(b) Reference to the applicable ESCC Generic Specification, including issue and date.
(c) Component type and number.
(d) Lot identification.
(e) Range of delivered serial numbers (for components of testing level 'B').
(f) Number of purchase order.
(g) Information relative to any additions to this specification and/or the Detail Specification.
(h) Manufacturer's name and address.
(i) Location of the manufacturing plant.
(j) Signature on behalf of Manufacturer.
(k) Total number of pages of the data package.

10.3 LIST OF EQUIPMENT USED

A list of equipment used for tests and measurements shall be prepared, if not in accordance with the data given in the Process Identification Document (PID). Where applicable, this list shall contain inventory number, Manufacturer's type number, serial number, etc. This list shall indicate for which tests such equipment was used.

10.4 LIST OF TEST REFERENCES

This list shall include all Manufacturer's references or codes which are necessary to correlate the test data provided with the applicable tests specified in the tables of the Detail Specification.

10.5 SPECIAL IN-PROCESS CONTROL DATA

As specified in the Detail Specification.

10.6 FINAL PRODUCTION TEST DATA (CHART II)

A test result summary shall be compiled showing the total number of components submitted to, and the total number rejected after each of the following tests:

(a)	Rapid Change of Temperature	(Para. 9.7)
(b)	Electrical measurements at room temperature	(Para. 9.4.4)
(c)	Visual inspection	(Para. 9.1)
(d)	Dimension check	(Para. 9.3)

The final production test data shall form an integral part of the data documentation package, but it is not a mandatory requirement that it be delivered with the qualification lot or delivery lot. However, the data package to be delivered shall contain the information as detailed in Paras. 10.1.2 and 10.1.3 or at least shall contain a list of final production tests actually performed and a certification that the data is available for review.

10.7 BURN-IN AND ELECTRICAL MEASUREMENT DATA (CHART III)

10.7.1 Testing Level 'B'

For components of testing level 'B', all data shall refer to the relevant serial numbers. Against these serial numbers, data shall be recorded of the following:

(a) 0-hour measurement for burn-in.
(b) 168 hour measurement for burn-in.
(c) Delta values after burn-in.
(d) Values obtained during measurements at high and low temperatures (Table 3 of the Detail Specification).
(e) Values obtained during measurements of electrical characteristics (Table 2 of the Detail Specification).
(f) Failures during external visual inspection.

10.7.2 Testing Level 'C'

For components of testing level 'C', a test summary (i.e. the total number of components subjected to, and the total number rejected from, each of the tests and inspections) shall be prepared.

10.8 QUALIFICATION TEST DATA (CHART IV)

All data shall be referenced to the relevant serial numbers. Detailed records shall be provided of the components submitted to each test in each of the subgroups and of those rejected. Detailed data shall be provided of all electrical measurements made in accordance with Tables 2 and 6 of the Detail Specification, as and where applicable.

10.9 LOT ACCEPTANCE TEST DATA (CHART V)

10.9.1 Testing Level 'B'

All data shall be referenced to the relevant serial numbers. Detailed records shall be provided of the components submitted to each test in each of the subgroups (as relevant to the lot acceptance level) and of those rejected.

Detailed data shall be provided of all electrical measurements made in accordance with Table 6 of the Detail Specification, as and where applicable.

10.9.2 Testing Level 'C'

A test result summary (i.e. the total number of components submitted to, and the total number rejected from, each of the tests and inspections) as relevant to the lot acceptance level shall be provided.

In the case of lot acceptance 2 testing, all data in respect of electrical measurements made in accordance with Table 6 of the Detail Specification shall be referenced to the relevant serial numbers (see Para. 8.2.4(a)).

In the case of lot acceptance 1 testing, all data in respect of electrical measurements made in accordance with Table 6 of the Detail Specification shall be referenced to the relevant serial numbers (see Para. 8.2.5(a)).

10.10 FAILED COMPONENTS LIST AND FAILURE ANALYSIS REPORT

The failed components list and failure analysis report shall provide full details of:

(a) The reference number and description of the test or measurement performed as defined in this specification and/or the Detail Specification.
(b) The serial number (if applicable) of the failed component.
(c) The failed parameter and the failure mode of the component.
(d) Detailed failure analysis, if requested.

10.11 CERTIFICATE OF CONFORMITY

A Certificate of Conformity shall be established as defined in ESCC Basic Specification No. 20100.

11 DELIVERY

For qualification approval, the disposition of the qualification test lot and its related documentation shall be as specified in ESCC Basic Specification No. 20100 and the relevant paragraphs of Section 10 of this specification.

For procurement, for each order, the items forming the delivery are:

(a) The delivery lot.
(b) The components used for lot acceptance testing, (when applicable), but not forming part of the delivery lot (see Paras. 8.2.3(d), 8.2.4(b) and 8.2.5(b)).
(c) The relevant documentation in accordance with the requirements of Section 10 of this specification.

In the case of a component for which a valid qualification approval is in force, all data of all components submitted to LA1 and LA2 testing shall also be copied, when requested, to the ESCC Executive.

12 PACKAGING AND DESPATCH

The packaging and despatch of components to this specification shall be in accordance with the requirements of ESCC Basic Specification No. 20600.

ANNEXE I

LTPD SAMPLING PLAN LOT SIZES GREATER THAN 200 DEVICES

Minimum size of sample to be tested to assure with a 90% confidence that a lot whose Percent Defective equals the specified LTPD is not accepted (single sample).

Max. Percent Defective (LTPD) or λ	50	30	20	15	10	7	5	3	2	1.5	1	0.7	0.5	0.3	0.2	0.15	0.1
Acceptance Number (c) (r = c + 1)	MINIMUM SAMPLE SIZES (FOR DEVICE-HOURS REQUIRED FOR LIFE TEST, MULTIPLY BY 1000)																
0	5 (1.03)	8 (0.64)	11 (0.46)	15 (0.34)	22 (0.23)	32 (0.16)	45 (0.11)	76 (0.07)	116 (0.04)	153 (0.03)	231 (0.02)	328 (0.02)	461 (0.01)	767 (0.007)	1152 (0.005)	1534 (0.003)	2303 (0.002)
1	8 (4.4)	13 (2.7)	18 (2.0)	25 (1.4)	38 (0.94)	55 (0.65)	77 (0.46)	129 (0.28)	195 (0.18)	258 (0.14)	390 (0.09)	555 (0.06)	778 (0.045)	1296 (0.027)	1946 (0.018)	2592 (0.013)	3891 (0.009)
2	11 (7.4)	18 (4.5)	25 (3.4)	34 (2.24)	52 (1.6)	75 (1.1)	105 (0.78)	176 (0.47)	266 (0.31)	354 (0.23)	533 (0.15)	759 (0.11)	1065 (0.080)	1773 (0.045)	2662 (0.031)	3547 (0.022)	5323 (0.015)
3	13 (10.5)	22 (6.2)	32 (4.4)	43 (3.2)	65 (2.1)	94 (1.5)	132 (1.0)	221 (0.62)	333 (0.41)	444 (0.31)	668 (0.20)	953 (0.14)	1337 (0.10)	2226 (0.062)	3341 (0.041)	4452 (0.031)	6681 (0.018)
4	16 (12.3)	27 (7.3)	38 (5.3)	52 (3.9)	78 (2.6)	113 (1.8)	158 (1.3)	265 (0.75)	398 (0.50)	531 (0.37)	798 (0.25)	1140 (0.17)	1599 (0.12)	2663 (0.074)	3997 (0.049)	5327 (0.037)	7994 (0.025)
5	19 (13.8)	31 (8.4)	45 (6.0)	60 (4.4)	91 (2.9)	131 (2.0)	184 (1.4)	308 (0.85)	462 (0.57)	617 (0.42)	927 (0.28)	1323 (0.20)	1855 (0.14)	3090 (0.085)	4638 (0.056)	6181 (0.042)	9275 (0.028)
6	21 (15.6)	35 (9.4)	51 (6.6)	68 (4.9)	104 (3.2)	149 (2.2)	209 (1.6)	349 (0.94)	528 (0.62)	700 (0.47)	1054 (0.31)	1503 (0.22)	2107 (0.155)	3509 (0.093)	5267 (0.062)	7019 (0.047)	10533 (0.031)
7	24 (16.6)	39 (10.2)	57 (7.2)	77 (5.3)	116 (3.5)	166 (2.4)	234 (1.7)	390 (1.0)	589 (0.67)	783 (0.51)	1178 (0.34)	1680 (0.24)	2355 (0.17)	3922 (0.101)	5886 (0.067)	7845 (0.051)	11771 (0.034)
8	26 (18.1)	43 (10.9)	63 (7.7)	85 (5.6)	128 (3.7)	184 (2.6)	258 (1.8)	431 (1.1)	648 (0.72)	864 (0.54)	1300 (0.36)	1854 (0.25)	2599 (0.18)	4329 (0.108)	6498 (0.072)	8660 (0.054)	12995 (0.036)
9	28 (19.4)	47 (11.5)	69 (8.1)	93 (6.0)	140 (3.9)	201 (2.7)	282 (1.9)	471 (1.2)	709 (0.77)	945 (0.58)	1421 (0.38)	2027 (0.27)	2842 (0.19)	4733 (0.114)	7103 (0.077)	9468 (0.057)	14206 (0.038)
10	31 (19.9)	51 (12.1)	75 (8.4)	100 (6.3)	152 (4.1)	218 (2.9)	306 (2.0)	511 (1.2)	770 (0.80)	1025 (0.60)	1541 (0.40)	2199 (0.28)	3082 (0.20)	5133 (0.120)	7704 (0.080)	10268 (0.060)	15407 (0.040)
11	33 (21.0)	54 (12.8)	83 (8.3)	111 (6.2)	166 (4.2)	238 (2.9)	332 (2.1)	555 (1.2)	832 (0.83)	1109 (0.62)	1664 (0.42)	2378 (0.29)	3323 (0.21)	5546 (0.12)	8319 (0.083)	11092 (0.062)	16638 (0.042)
12	36 (21.4)	59 (13.0)	89 (8.6)	119 (6.5)	178 (4.3)	254 (3.0)	356 (2.2)	594 (1.3)	890 (0.86)	1187 (0.65)	1781 (0.43)	2544 (0.3)	3562 (0.22)	5936 (0.13)	8904 (0.086)	11872 (0.065)	17808 (0.043)
13	38 (22.3)	63 (13.4)	95 (8.9)	126 (6.7)	190 (4.5)	271 (3.1)	379 (2.26)	632 (1.3)	948 (0.89)	1264 (0.67)	1896 (0.44)	2709 (0.31)	3793 (0.22)	6321 (0.134)	9482 (0.089)	12643 (0.067)	18964 (0.045)
14	40 (23.1)	67 (13.8)	101 (9.2)	134 (6.9)	201 (4.6)	288 (3.2)	403 (2.3)	672 (1.4)	1007 (0.92)	1343 (0.69)	2015 (0.46)	2878 (0.32)	4029 (0.23)	6716 (0.138)	10073 (0.092)	13431 (0.069)	20146 (0.046)
15	43 (23.3)	71 (14.1)	107 (9.4)	142 (7.1)	213 (4.7)	305 (3.3)	426 (2.36)	711 (1.41)	1066 (0.94)	1422 (0.71)	2133 (0.47)	3046 (0.33)	4265 (0.235)	7108 (0.141)	10662 (0.094)	14216 (0.070)	21324 (0.047)
16	45 (24.1)	74 (14.0)	112 (9.7)	150 (7.2)	225 (4.8)	321 (3.37)	450 (2.41)	750 (1.44)	1124 (0.96)	1499 (0.72)	2249 (0.48)	3212 (0.337)	4497 (0.241)	7496 (0.144)	11244 (0.096)	14992 (0.072)	22487 (0.048)
17	47 (24.7)	79 (14.7)	118 (9.86)	158 (7.36)	236 (4.93)	338 (3.44)	473 (2.46)	788 (1.48)	1182 (0.98)	1576 (0.74)	2364 (0.49)	3377 (0.344)	4728 (0.246)	7880 (0.148)	11819 (0.098)	15759 (0.074)	23639 (0.049)
18	50 (24.9)	83 (15.0)	124 (10.0)	165 (7.54)	248 (5.02)	354 (3.51)	496 (2.51)	826 (1.51)	1239 (1.0)	1652 (0.75)	2478 (0.50)	3540 (0.351)	4956 (0.251)	8260 (0.151)	12390 (0.100)	16520 (0.075)	24780 (0.050)
19	52 (25.5)	86 (15.4)	130 (10.2)	173 (7.76)	259 (5.12)	370 (3.58)	518 (2.56)	864 (1.53)	1296 (1.02)	1728 (0.77)	2591 (0.52)	3702 (0.358)	5183 (0.256)	8638 (0.153)	12957 (0.102)	17276 (0.077)	25914 (0.051)
20	54 (26.1)	90 (15.6)	135 (10.4)	180 (7.82)	271 (5.19)	386 (3.65)	541 (2.60)	902 (1.56)	1353 (1.04)	1803 (0.78)	2705 (0.52)	3864 (0.364)	5410 (0.260)	9017 (0.156)	13526 (0.104)	18034 (0.078)	27051 (0.052)
26	65 (27.0)	109 (16.1)	163 (10.8)	217 (8.08)	326 (5.38)	466 (3.76)	652 (2.69)	1086 (1.61)	1629 (1.08)	2173 (0.807)	3259 (0.538)	4656 (0.376)	6518 (0.269)	10863 (0.161)	16295 (0.108)	21726 (0.081)	32589 (0.054)

(1) Sample sizes are based upon the Poisson exponential binomial limit.
(2) The minimum quality (approximate AQL) required to accept (on the average) 19 of 20 lots is shown in parentheses for information only.

ANNEXE I

LTPD SAMPLING PLAN LOT SIZES LESS THAN, OR EQUAL TO, 200 DEVICES

C=0

N	10		20		30		40		50		60		80		100		120		150		160		200	
n	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD
2	2.2	65	2.5	66	2.5	67	2.5	67	2.5	67	2.5	68	2.5	68	2.5	68	2.5	68	2.5	68	2.5	68	2.5	68
4	1.2	36	1.2	40	1.2	42	1.2	42	1.3	42	1.3	43	1.3	43	1.3	43	1.3	43	1.3	43	1.3	44	1.3	44
5	1.0	29	1.0	33	1.0	34	1.0	35	1.0	35	1.0	35	1.0	36	1.0	36	1.0	37	1.0	37	1.0	37	1.0	37
8	0.5	15	0.6	20	0.6	22	0.6	23	0.6	23	0.6	23	0.6	24	0.7	24	0.7	24	0.7	24	0.7	24	0.7	25
10			0.4	15	0.5	17	0.5	19	0.5	19	0.5	19	0.5	20	0.5	20	0.5	20	0.5	20	0.5	20	0.5	20
16			0.2	6.9	0.25	10	0.25	11	0.3	11	0.3	12	0.3	12	0.3	13	0.3	13	0.3	13	0.3	13	0.3	13
20					0.2	6.8	0.2	8.0	0.25	8.7	0.25	9.0	0.25	9.4	0.25	10	0.25	10	0.25	10	0.25	10	0.25	11
25					0.15	4.3	0.15	5.7	0.2	6.4	0.2	6.9	0.2	7.4	0.2	7.5	0.2	7.6	0.2	7.7	0.2	7.8	0.2	7.9
32							0.1	3.7	0.1	4.4	0.1	5.0	0.1	5.5	0.1	5.9	0.15	6.0	0.15	6.2	0.15	6.3	0.15	6.3
40									0.1	3.0	0.1	3.4	0.1	4.0	0.1	4.5	0.1	4.6	0.1	4.9	0.1	5.0	0.15	5.0
50											0.1	2.3	0.1	2.9	0.10	3.3	0.10	3.5	0.10	3.7	0.10	3.7	0.10	3.9
64													0.08	1.7	0.08	2.2	0.08	2.5	0.08	2.7	0.08	2.8	0.08	2.9
80															0.07	1.5	0.07	1.7	0.07	2.0	0.07	2.1	0.07	2.2
100																	0.05	1.1	0.05	1.5	0.05	1.5	0.05	1.7
125																			0.04	0.8	0.04	0.9	0.04	1.2
128																			0.04	0.8	0.04	0.9	0.04	1.1
160																							0.03	0.7

C=1

N	10		20		30		40		50		60		80		100		120		150		160		200	
n	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD
2	2.7	95	2.4	95	2.4	95	2.3	95	2.3	95	2.3	95	2.3	95	2.3	95	2.3	95	2.2	95	2.2	95	2.2	95
4	1.5	62	1.2	66	1.2	66	1.1	67	1.1	67	1.0	67	1.0	67	1.0	67	1.0	67	9.8	67	9.7	67	9.7	68
5	1.3	51	1.0	55	8.8	56	8.5	57	8.4	57	8.1	58	7.9	58	7.6	58	7.5	58	7.5	58	7.5	58	7.5	58
8	1.1	28	7.2	35	6.2	38	5.8	38	5.4	39	5.0	39	4.7	39	4.5	39	4.3	39	4.3	40	4.2	40	4.2	40
10			6.2	30	5.0	30	4.6	31	4.2	32	4.2	32	4.2	32	3.9	33	3.5	33	3.3	33	3.3	33	3.3	33
16			5.6	15	4.2	18	3.8	18	3.4	20	3.0	20	2.9	21	2.6	21	2.5	21	2.3	21	2.3	22	2.2	22
20					4.0	13	3.2	15	2.8	16	2.5	16	2.4	16	2.3	16	2.1	17	2.0	17	2.0	17	2.0	18
25					3.8	9.2	3.1	11	2.5	12	2.2	13	2.0	13	1.8	13	1.7	13	1.6	14	1.6	14	1.6	14
32							3.1	7.4	2.4	8.2	2.1	9.0	1.8	9.9	1.6	10	1.5	10.5	1.4	11	1.3	11	1.3	11
40									2.4	5.9	2.1	6.8	1.6	7.6	1.4	7.8	1.3	8.2	1.2	8.3	1.2	8.4	1.2	8.6
50											1.7	4.6	1.4	5.6	1.2	6.1	1.2	6.4	1.0	6.5	0.9	6.7	0.9	6.7
64													1.3	3.8	1.1	4.4	1.0	4.7	0.8	5.0	0.8	5.0	0.7	5.2
80															1.1	3.0	1.0	3.4	0.8	3.7	0.7	3.8	0.6	4.0
100																	0.9	2.5	0.7	2.8	0.7	2.8	0.6	3.0
125																			0.7	1.9	0.7	2.0	0.5	2.2
128																			0.7	1.7	0.7	1.9	0.5	2.2
160																							0.5	1.5

C=2

N	10		20		30		40		50		60		80		100		120		150		160		200	
n	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD	AQL	LTPD
4	3.3	82	2.8	83	2.7	84	2.7	85	2.7	85	2.6	85	2.8	85	2.6	86	2.6	86	2.5	86	2.5	86	2.5	86
5	2.7	69	2.3	73	2.1	74	2.0	74	2.0	74	2.0	75	2.0	75	1.9	75	1.9	75	1.9	75	1.9	75	1.9	75
8	2.2	42	1.5	49	1.4	49	1.3	52	1.3	52	1.3	52	1.2	53	1.2	53	1.2	53	1.1	53	1.1	53	1.1	53
10			1.3	39	1.1	42	1.1	42	1.0	43	1.0	43	9.6	43	9.2	44	9.1	44	8.9	44	8.9	44	8.7	44
16			1.1	2.2	8.6	2.5	6.9	2.7	6.8	2.7	6.4	2.7	6.0	2.8	6.0	2.9	5.9	2.9	5.9	2.9	5.7	2.9	5.5	3.0
20					7.7	1.9	6.2	2.1	5.9	2.2	5.6	2.2	5.1	2.3	4.8	2.3	4.8	2.3	4.8	2.3	4.5	2.4	4.5	2.4
25					7.4	1.3	6.0	1.6	4.9	1.7	4.5	1.7	4.3	1.8	4.1	1.8	3.9	1.8	3.7	1.8	3.7	1.9	3.7	1.9
32							5.5	1.1	4.8	1.2	4.3	1.3	3.6	1.4	3.4	1.4	3.2	1.4	3.0	1.45	3.0	1.5	2.9	1.5
40									4.6	8.9	3.9	9.8	3.1	1.1	2.8	1.2	2.6	1.2	2.4	1.2	2.4	1.2	2.3	1.2
50											3.5	6.9	2.8	8.1	2.4	8.4	2.3	8.6	2.1	9.0	2.1	9.3	2.0	9.5
64													2.6	5.7	2.2	6.2	2.0	6.6	1.8	7.1	1.7	7.1	1.6	7.4
80															2.1	4.5	1.8	4.9	1.6	5.4	1.5	5.4	1.4	5.6
100																	1.8	3.5	1.4	3.9	1.4	4.0	1.2	4.4
125																			1.4	2.8	1.3	2.9	1.1	3.3
128																			1.4	2.6	1.3	2.9	1.1	3.2
160																							1.1	2.3

ANNEXE I

This table gives the AQL and LTPD values associated with certain single sampling plans (Acceptance Number "C", Sample Size "n" and Lot Size "N"). The table has the following features:

(a) Calculations are based upon the hyper-geometric distribution (exact theory) for lot sizes of 200 devices or less.

(b) The AQL of a sampling plan is defined as the interpolated Percent Defective for which there is 0.95 probability of acceptance under the plan. The AQL so defined need not be a realisable Lot Percent Defective for the lot size involved (e.g., 12 percent is not a realisable Percent Defective for a lot size of 20 devices).

(c) The LTPD of a sampling plan is defined as the interpolated Percent Defective for which there is a 0.10 probability of lot acceptance under the plan. The LTPD so defined need not be a realisable Lot Percent Defective for the lot size involved.

(d) The sequence of sample sizes and lot sizes are generated by taking products of preceding numbers in the respective sequences and the numbers 2 and 5.