



QUARTZ CRYSTAL UNITS
ESCC Generic Specification No. 3501

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1 INTRODUCTION

1.1 SCOPE

This specification defines the general requirements for the qualification approval, procurement, including lot acceptance testing, and delivery of Quartz Crystal Units 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. [20900](#), Radiographic Inspection.
- 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. 115-1, Fixed Resistors for use in Electronic Equipment.

IEC Publication No. 302, Standard Definitions and Methods of Measurement for Piezoelectric Vibrators operating over the Frequency Range up to 30MHz.

IEC Publication No. 410, Sampling Plans and Procedures for Inspection by Attributes, or IEC Publication No. 444, Measurements of Quartz Crystal Unit Parameters by Zero Phase Technique in a Π -Network.

MIL-STD-105, Sampling Procedures and Tables for Inspection by Attributes.

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

[MIL-STD-883](#), Test Methods and Procedures for Micro-electronics.

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. In addition, the following abbreviations are used:

- XO = Clock crystal oscillator.
TCXO = Temperature compensated crystal oscillator.
VCXO = Voltage controlled crystal oscillator.
OCXO = Ovenised crystal oscillator.

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 reserves the right to monitor any of the tests and inspections scheduled in the applicable specifications.

4.1.5 Pre-encapsulation Inspection

The Manufacturer shall notify the Orderer at least 2 working weeks before the commencement of pre-encapsulation inspection.

The Orderer shall indicate whether or not he intends to witness the inspection.

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

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.

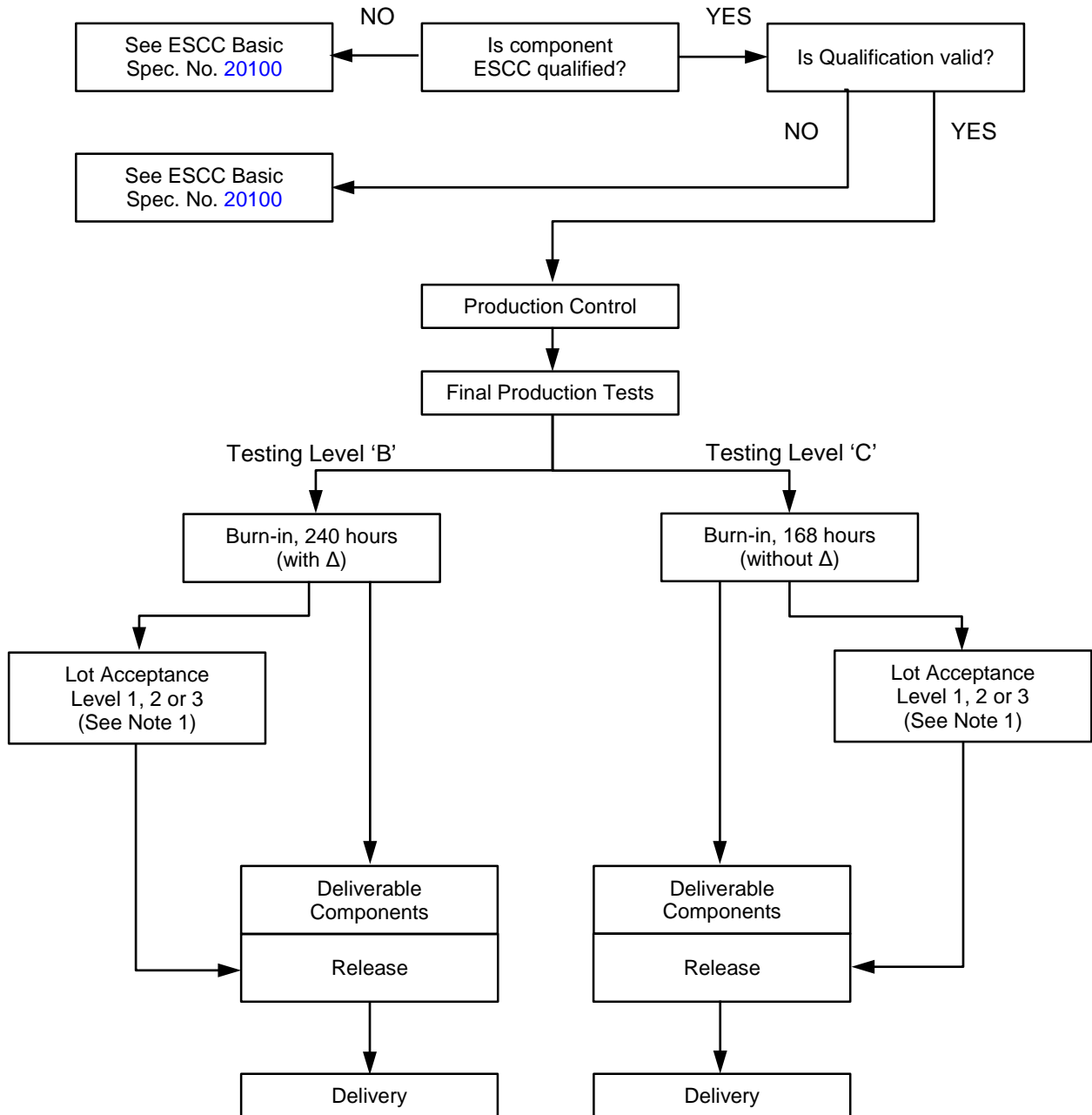
Components procured from sources which are not ESCC qualified, provided that they fully comply with the procurement requirements of this specification and the Detail Specification, may bear the ESCC marking **with the exception of the ESA symbol.**

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.

CHART I – TESTING LEVELS



NOTES

1. When applicable.

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](#), Para's 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.

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 testing level 'B' shall be subjected to a total burn-in period of 240 hours and components of testing level 'C' to a total burn-in period of 168 hours.

7.1.2 Data Points

For components of testing level 'B', undergoing a total burn-in period of 240 hours, the data points for parameter drift measurements shall be 0 hours (initial) 240 (+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 10% (rounded upwards to the nearest whole number) or 2 pieces (whichever is the greater) 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 or MIL-STD-105 and the applicable AQL as specified in the Detail Specification, is exceeded.

In the case where an LTPD to MIL-STD-414 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 41 components shall be submitted to qualification testing (Chart IV). The distribution within the sample shall be as follows:

- 1/3 of the lot at the lower end of the frequency range to be qualified.
- 1/3 of the lot near the middle of the frequency range to be qualified.
- 1/3 of the lot at the upper end of the frequency range to be qualified.

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 solderability and robustness of termination tests are considered to be destructive and therefore components so tested shall not form part of the delivery lot. Post-burn-in electrical rejects may be used for these tests.
- (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 non-destructive and therefore components (of testing level 'B' or 'C') so tested may 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, robustness of terminations, 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.

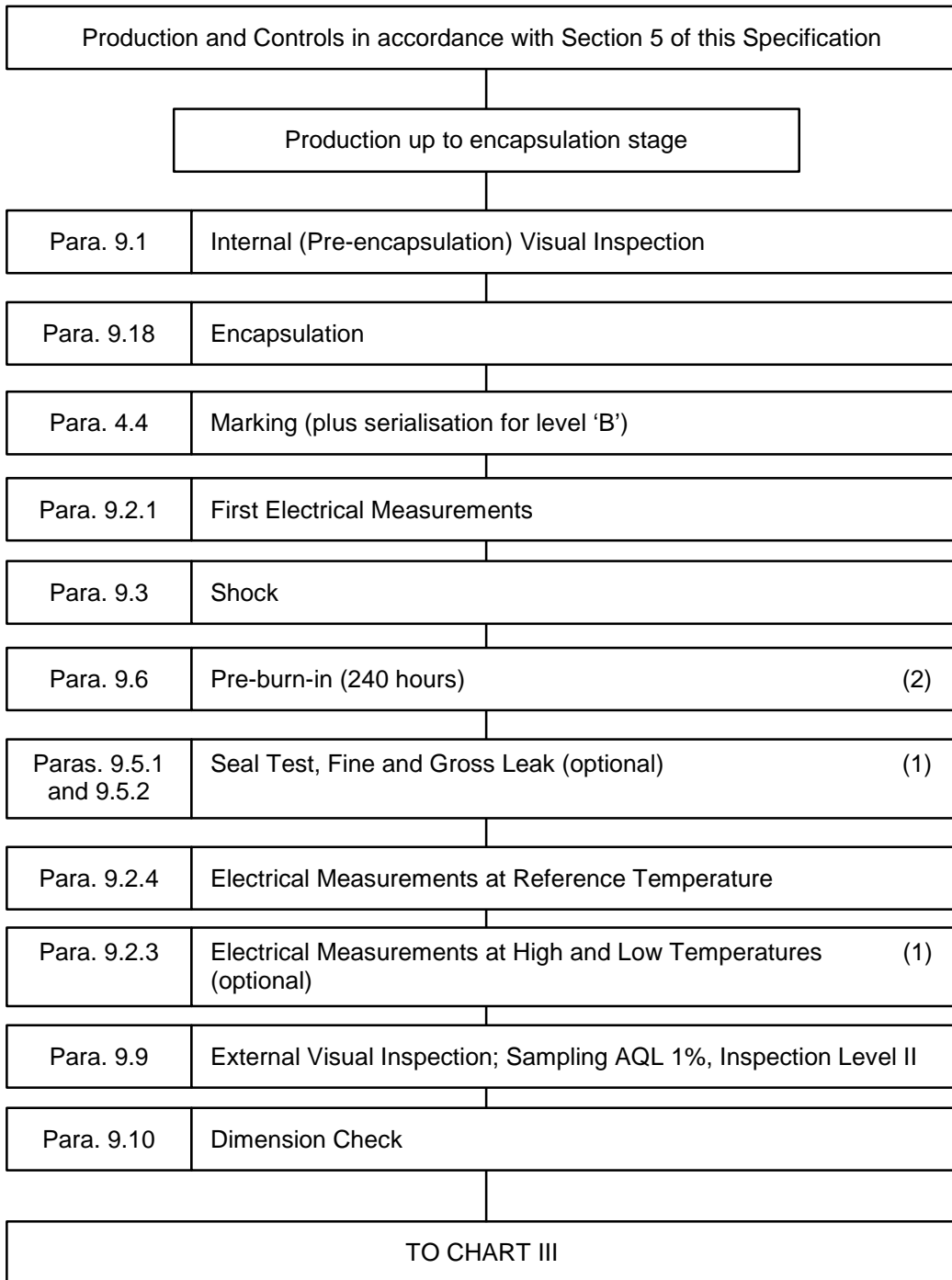
In the case of lot failure, the Manufacturer shall act in accordance with Para. 4.3.1 of this specification.

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



NOTES

1. The performance of these tests is left to the Manufacturer's discretion.
2. May be performed at any point in this chart.

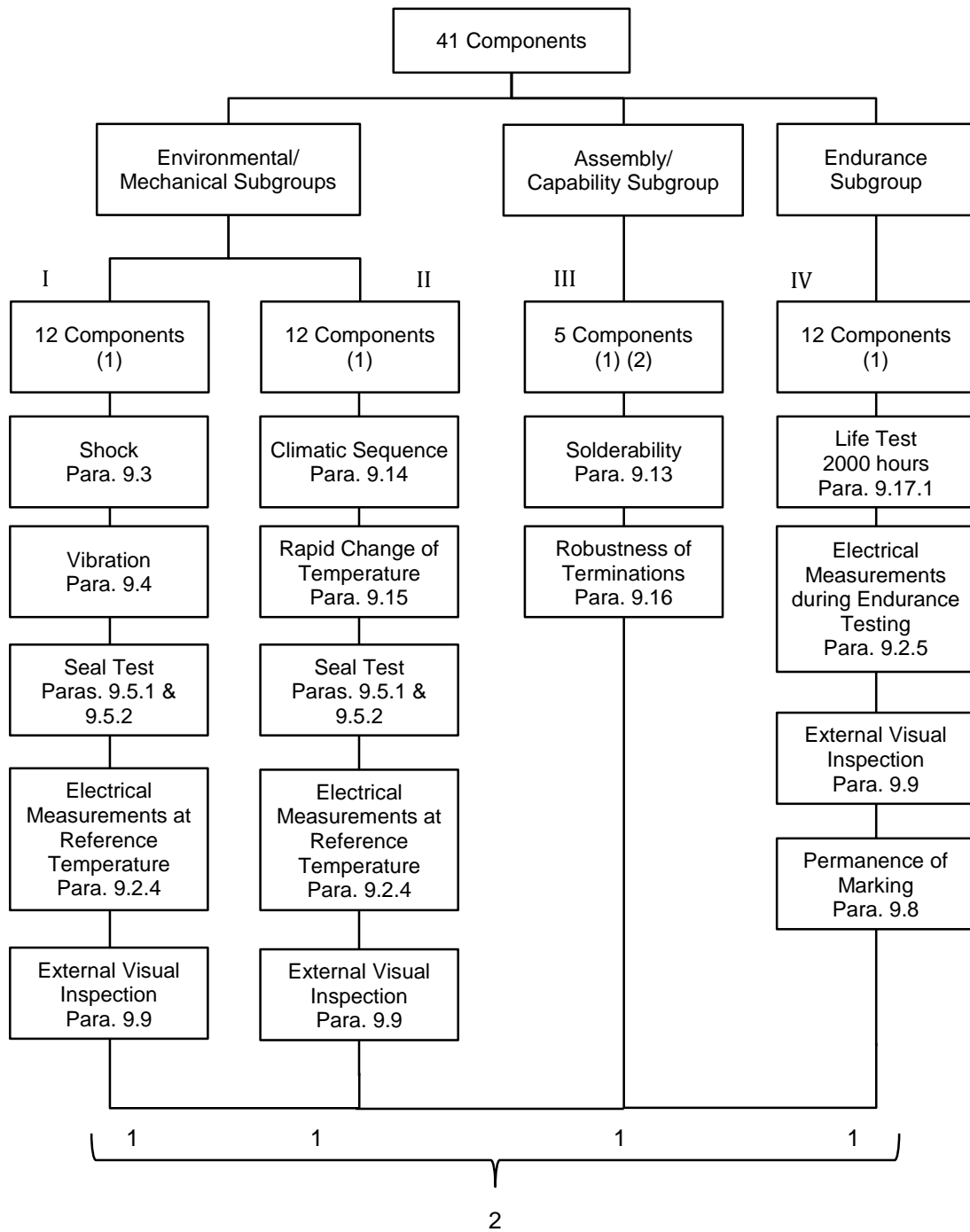
CHART III – BURN-IN AND ELECTRICAL MEASUREMENTS

Components from Final Production Tests		Testing Levels	
		B	C
Para. 9.2.2	Parameter Drift Value, Initial Measurements	X	-
Para. 7.1.1	Burn-in 240 hours (Level 'B') 168 hours (Level 'C')	X	X
Para. 9.2.2	Parameter Drift Value, Final Measurements	X	-
Para. 9.2.4	Electrical Measurements at Reference Temperature (1)	X	X
Para. 9.2.3	Electrical Measurements at High and Low Temperatures	X	X
Para. 9.11	Radiographic Inspection (2) (3) (4)	X	-
Paras. 9.5.1 and 9.5.2	Seal Test, Fine and Gross Leak (3)	X	X
Para. 9.9	External Visual Inspection	X	X
Para. 7.4	Check for Lot Failure	X	X
TO CHART IV OR V			

NOTES

1. The measurements of parameters for the purpose of drift value measurements need not be repeated for electrical measurements at reference temperature.
2. Radiographic Inspection may be performed at any point during the test sequence shown in this Chart.
3. Radiographic Inspection and Seal Test rejects not to be counted for lot failure.
4. Unless otherwise specified in the Detail Specification.

CHART IV – QUALIFICATION TESTS

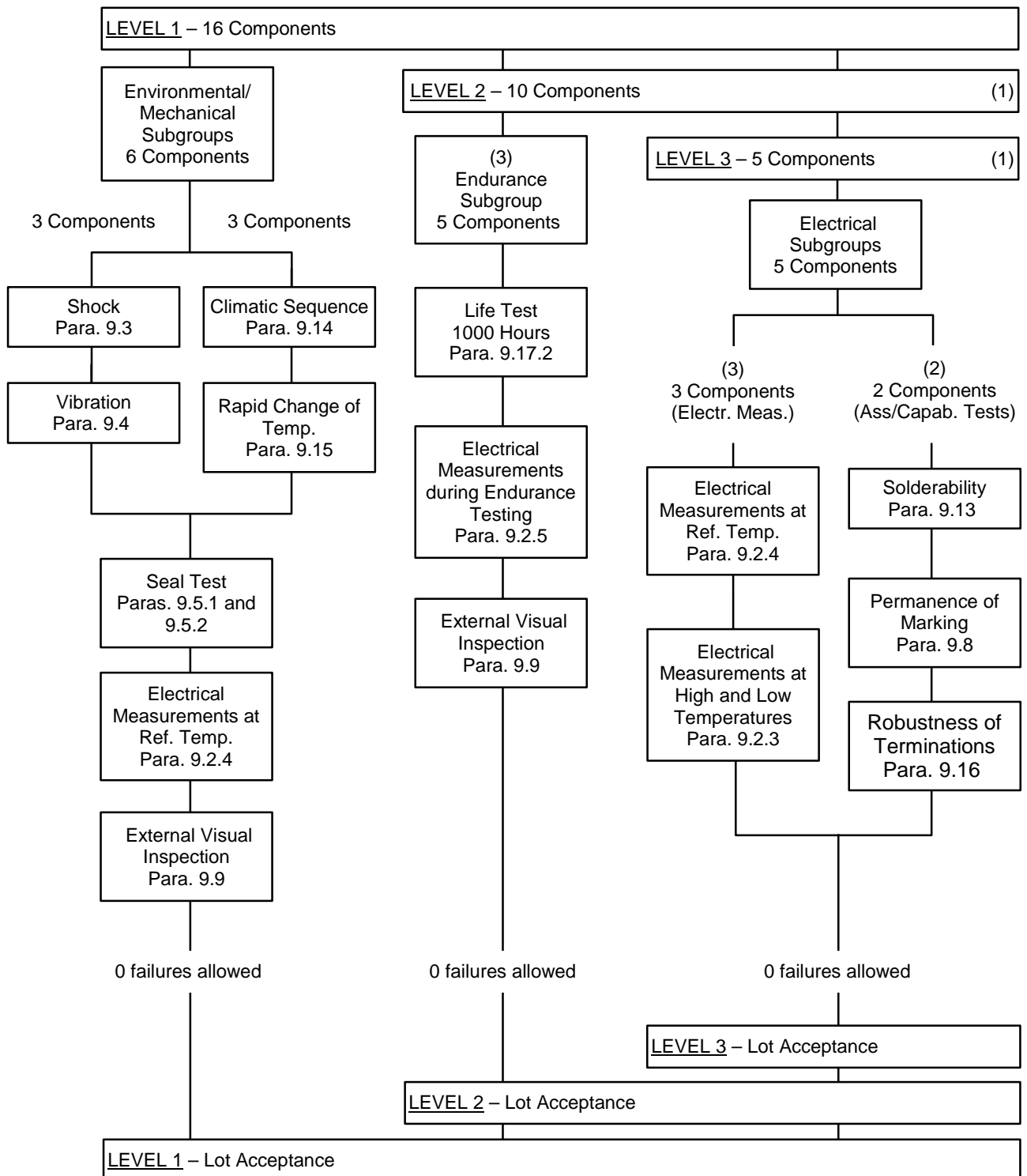


Total allowable number of failed components: 2

NOTES

1. For distribution within the subgroups, see Para. 8.1.2.
2. Post-burn-in electrical rejects may be used for these tests.

CHART V – LOT ACCEPTANCE TESTS



NOTES

1. For distribution within the subgroups, see Para. 8.2.2.
2. Post-burn-in electrical rejects may be used for these tests.
3. The tests in this subgroup are considered to be non-destructive and therefore components so tested may form part of the delivery lot.

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 INTERNAL VISUAL INSPECTION

In accordance with ESCC Basic Specification No. [20400](#).

9.2 ELECTRICAL MEASUREMENTS

9.2.1 General and First Electrical Measurements

Unless otherwise stated in this specification or the Detail Specification, all electrical measurements shall be performed in accordance with the following documents:

- IEC Publication No. 302 and/or
- IEC Publication No. 444, or
- A demonstrated and agreed equivalent method.

The first electrical measurements shall comprise the measurement of resonance frequency and resonance resistance in accordance with Paras. 9.2.1.1 and 9.2.1.2.

9.2.1.1 *Measurement of Resonance Frequency and Resonance Resistance*

(a) At the Reference Temperature

Measurement of resonance frequency and resonance resistance shall be performed at the reference temperature (T_0) and the rated drive level (P_0) $\pm 20\%$.

The resonance frequency may be either f_r or f_L and the measurements are respectively:

$f_r(T_0, P_0)$ or $f_L(T_0, P_0)$.

For resonance frequency f_r :

$$f_r = \frac{1}{2\pi} \sqrt{L_1 C_1}$$

For load resonance frequency f_L :

$$f_L = \frac{1}{2\pi} \sqrt{L_1 C_1 (C_0 + C_L) / (C_1 + C_0 + C_L)}$$

The resonance resistance may be either R_r or R_L and the measurements are respectively:

$R_r(T_0, P_0)$ or $R_L(T_0, P_0)$.

In the case of measurement of f_L and R_L , the value of the load capacitance (C_L) shall be checked at a frequency close to the resonance frequency of the crystal unit under test and the accuracy of the frequency measurement shall be better than 1×10^{-6} .

(b) As a Variation with Drive Level

When required by the Detail Specification, the measurements shall be performed at Drive Levels P_{S1} and P_{S2} as specified in (a) above.

9.2.1.2 *Measurement of Resonance Frequency and Resonance Resistance as a Function of Temperature*

Measurement of resonance frequency and resonance resistance shall be performed at the maximum drive level specified ($P_{S2} \pm 20\%$) or at rated drive level ($P_O \pm 20\%$) when P_{S2} is not specified, over the operating temperature range specified in Table 1(a) of the Detail Specification in accordance with Para. 9.2.1.1.

Starting with the crystal unit at an extreme of the operating temperature range, the frequency and resonance resistance (see Para. 9.2.1.1) shall be measured over the operating temperature range specified at discrete temperature intervals of not greater than 1.5°C , allowing the crystal unit to reach thermal equilibrium at each measurement temperature.

When the intended application is TCXO, VCXO or OCXO the maximum deviation ($\Delta f/f$) of each measurement of resonance frequency to the least squares fit to 4th order polynomial shall not be more than $\pm 1 \times 10^{-6}$, and the difference (Δf) between two consecutive measurements shall not be more than 5×10^{-7} .

When the intended application is OCXO, there shall be no peak in the frequency over the reference temperature range specified in Table 1(a) of the Detail Specification.

9.2.1.3 *Measurement of Motional Capacitance and Motional Inductance*

The measurement of motional capacitance (C_1) and motional inductance (L_1) shall be performed at reference temperature (T_O) and rated drive level (P_O) using one of the following methods:

(a) Load Capacitance Method

The motional capacitance and inductance shall be determined by firstly measuring resonance frequency without load capacitance and again using one or more load capacitances (C_L) connected successively in series with the crystal unit in accordance with IEC Publication No. 302, Clause 2.3.2.

N.B.

The load capacitance values shall be measured at a frequency close to the resonance frequency.

(b) Phase Offset Method

The motional capacitance shall be determined from the measured values of resonance frequency, two frequencies lying on both sides of the impedance curve with a given phase difference (Ψ) equal in magnitude and opposite in sign, and the resonance resistance, in accordance with IEC Publication No. 444-2, Clause 4.

The motional inductance shall be determined from the measured values above using the following formula:

$$L_1 = \frac{(R_r + R_\Pi) \text{tg} \Psi}{2\pi \Delta f}$$

Where: f = the difference between the two measured offset frequencies.

R_r = resonance resistance of the crystal unit. R_Π = resistance of the Π -network.

9.2.1.4 *Measurement of Static Capacitance*

The static capacitance (C_O) of each crystal unit shall be the mean value of the capacitance measured equidistant above and below resonance frequency and sufficiently far removed from the resonance frequency to be independent of any response.

9.2.1.5 Unwanted Responses

Unwanted responses shall be scanned over the frequency range specified in Table 1(a) of the Detail Specification with the conditions specified in Para. 9.2.1.1 to determine all responses within the range. The following shall apply:

- (a) Zero Phase Resonance
The resonance resistance (R_p) shall be measured in the same manner as the main resonance resistance.
- (b) Non-Zero Phase Resonance
The frequency shall be adjusted to obtain the minimum impedance corresponding to the resonance considered.

V_{BS} is the output voltage with the crystal unit in circuit and Ψ the phase difference between the input and output of the Π -network. V_{BC} is the output voltage when the crystal unit is short circuited. The minimum impedance value is calculated from the formula:

$$|Z_P| = R_{\Pi} \left[\sqrt{\left(\frac{V_{BC}}{V_{BS}}\right)^2 - \sin^2 \varnothing} - \cos \varnothing \right]$$

Where: R_{Π} = resistance of the Π -network.

\varnothing = the phase displacement between terminals of the crystal.

9.2.1.6 Insulation Resistance

The insulation resistance shall be measured with a direct voltage of $20 \pm 1V$ during 60 ± 5 seconds, or less if stable conditions are obtained, between:

- (a) Terminations
- (b) Terminations connected together and metal parts of the case, if any.

The measured value shall not be less than that specified in the Detail Specification.

N.B.

Voltagess other than $20 \pm 1V$ may be applied providing correlation can be established.

9.2.1.7 Quality Factor

The quality factor, Q , is calculated from previous measurements by:

$$\frac{1}{2}\pi f_r R_r C_1 \text{ or } 2\pi f_r R_r L_1 / R_r$$

The quality factor shall be determined using the largest value of R_r measured in the temperature range specified. R_L shall be calculated from R_r using the following equation:

$$R_L = R_r(1 + C_0/C_L)^2.$$

9.2.2 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.

9.2.3 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.

9.2.4 Electrical Measurements at Reference Temperature

For components of testing levels 'B' and 'C', the measurement 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.

9.2.5 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 number and the parameter drift calculated, if required.

9.3 SHOCK

9.3.1 Mounting

The specimen shall be fixed to the shock machine, either directly or by means of a fixture as specified below. Mounting fixtures shall be such as to enable the specimen to be subjected to the shocks along 3 mutually perpendicular axes in turn, as defined in Figure 2 of the Detail Specification, which should be chosen so that faults are most likely to be revealed. If the component is provided with specific mounting means, these shall be used as prescribed in the Detail Specification and any additional restraining straps should be avoided.

Unless otherwise specified, components not provided with specific mounting means shall be clamped on both the body and leads (leads shall be clamped at 10 ± 1 mm from the body). Care shall be taken to avoid pinching the leads. For non-leaded SMDs, the components shall be clamped on the body.

9.3.2 Procedure

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

DURING CHART II

- Shape of the shock pulse: half sine.
- Peak acceleration: 490m/s^2 (50g).
- Duration of the pulse: 6ms.
- Non-operating conditions.
- Number of shocks: 3 (1 shock along the 3 mutually perpendicular axes of the test specimen).

DURING CHARTS IV AND V

- Shape of the shock pulse: half sine.
- Peak acceleration: 980m/s² (100g).
- Duration of the pulse: 6ms.
- Non-operating conditions.
- Number of shocks: 18 (3 shocks in each of the 2 directions along the 3 mutually perpendicular axes of the test specimen).
- Before and after the shock test, the resonance frequency and resonance resistance shall be measured as specified in Para. 9.2.1.1. Any changes in resonance frequency and resonance resistance shall not exceed the limits specified in Table 6 of the Detail Specification.

9.4 VIBRATION**9.4.1 Mounting**

The specimen shall be fixed to the vibration generator, either directly or by means of a fixture as specified below. Mounting fixtures shall be such as to enable the specimen to be vibrated along 3 mutually perpendicular axes in turn, which should be chosen so that faults are most likely to be revealed. If the component is provided with specific mounting means, these shall be used as prescribed in the Detail Specification and any additional restraining straps should be avoided.

Unless otherwise specified, components not provided with specific mounting means shall be clamped on both the body and leads (leads shall be clamped at 10 ± 1 mm from the body). Care shall be taken to avoid pinching the leads. For non-leaded SMDs, the components shall be clamped on the body.

9.4.2 Procedure

The crystal units shall be subjected to Test 'Fe' of IEC Publication No. 68-2-6, Clause 8.2.1. The following details shall apply:

- Frequency range: 10 to 2000Hz.
- Displacement amplitude: 1.5mm peak from 10Hz to cross-over.
- Acceleration amplitude: 196m/s² (20g) from cross-over to 2000Hz.
- Duration: 10 cycles in each axis.
- Axes of vibration: 3 mutually perpendicular.
- Sweep rate: 1 octave/minute.
- Before and after the vibration test, resonance frequency and resonance resistance shall be measured as specified in Para. 9.2.1.1. Any changes in resonance frequency and resonance resistance shall not exceed the limits specified in Table 6 of the Detail Specification.

9.5 SEAL TEST

9.5.1 Fine Leak

The crystal units shall be subjected to Test 'Qk', Method 1 of IEC Publication No. 68-2-17, Severity 1000 hours. Unless otherwise stated in the Detail Specification, immersion pressure shall not exceed 4 bars.

9.5.2 Gross Leak (if applicable)

The crystal units shall be subjected to Test 'Qc', Method 1 of IEC Publication No. 68-2-17. (Units sealed under vacuum shall not be tested).

9.6 PRE-BURN-IN

The following details shall apply:

- (a) Duration: 240 (+48 -0) hours.
- (b) Conditions: Table 5 of the Detail Specification.
- (c) Electrical Measurements: None.

9.7 NOT USED.

9.8 PERMANENCE OF MARKING

In accordance with ESCC Basic Specification No. [24800](#).

9.9 EXTERNAL VISUAL INSPECTION

In accordance with ESCC Basic Specification No. [20500](#).

9.10 DIMENSION CHECK

In accordance with ESCC Basic Specification No. [20500](#) and the Detail Specification. To be performed on 5 samples only.

If 1 failure occurs, the complete lot shall be checked.

9.11 RADIOGRAPHIC INSPECTION

In accordance with ESCC Basic Specification No. [20900](#).

9.12 NOT USED.

9.13 SOLDERABILITY

The crystal units shall be subjected to Test 'Ta' of IEC Publication No. 68-2-20 using the solder bath method (Method 1); with the terminations immersed up to the minimum soldering distance from the case as defined in Table 1(b) of the Detail Specification, or the solder globule method (Method 3); with the soldering time defined in the Detail Specification.

Unless otherwise stated in the Detail Specification the first method shall be used. For surface mount crystal units only the part of the termination designed to be soldered shall be tested. When neither of the 2 specified methods are practicable the soldering iron method (Method 2) shall be used with soldering iron size A.

9.14 CLIMATIC SEQUENCE

9.14.1 Dry Heat

9.14.1.1 *Initial Measurements*

The resonance frequency and resonance resistance shall be measured as specified in Para. 9.2.1.1.

9.14.1.2 *Procedure*

The crystal units shall be subjected to Test 'Ba' of IEC Publication No. 68-2-2 for 16 hours at the maximum storage temperature defined in the Detail Specification.

9.14.1.3 *Final Measurements*

After the test, the resonance frequency and resonance resistance shall be measured as specified in Para. 9.2.1.1. Variations in resonance frequency and resonance resistance shall not exceed the values specified in Table 6 of the Detail Specification.

9.14.2 Damp Heat (Accelerated), First Cycle

Unless otherwise specified in the Detail Specification, the crystal units shall be subjected to Test 'Db', Severity (b), Variant (2), of IEC Publication No. 68-2-30, for 1 cycle of 24 hours. After recovery, the crystal units shall be immediately subjected to the Cold Test.

9.14.3 Cold Test

9.14.3.1 *Procedure*

The crystal units shall be subjected to Test 'Aa' of IEC Publication No. 68-2-1 for 2 hours at the minimum storage temperature defined in the Detail Specification.

9.14.3.2 *Final Measurements*

After the test, the resonance frequency and resonance resistance shall be measured as specified in Para. 9.2.1.1. Variations in resonance frequency and resonance resistance compared to the values measured in Para. 9.14.1.3 shall not exceed the values specified in Table 6 of the Detail Specification.

9.14.4 Damp Heat (Accelerated), Remaining Cycles

9.14.4.1 *Procedure*

The crystal units shall be subjected to Test 'Db', Severity (b), Variant (2), of IEC Publication No. 68-2-30 for 6 cycles of 24 hours.

9.14.4.2 *Final Measurements*

After the test, the resonance frequency and resonance resistance shall be measured as specified in Para. 9.2.1.1. Variations in resonance frequency and resonance resistance compared to the values measured in Para. 9.14.3.2 shall not exceed the values specified in Table 6 of the Detail Specification.

In addition, the insulation resistance shall be measured as specified in Para. 9.2.1.6 and the value shall not be less than that specified in Table 6 of the Detail Specification.

9.15 RAPID CHANGE OF TEMPERATURE

The crystal units shall be subjected to Test 'Na' of IEC Publication No. 68-2-14. The following details shall apply:

- (a) Number of Cycles: 10
- (b) Temperature Extremes: At the storage temperatures specified in Table 1(b) of the Detail Specification.
- (c) Duration of the Exposures: 15 minutes.
- (d) Duration of Change-over Time: ≤ 30 seconds.
- (e) Minimum Duration of Recovery: 2 hours.
- (f) Final Measurements

After the recovery period, the resonance frequency and resonance resistance shall be measured as specified in Para. 9.2.1.1. Variations in resonance frequency and resonance resistance compared to the values measured in Para. 9.14.4.2 shall not exceed the values specified in Table 6 of the Detail Specification.

9.16 ROBUSTNESS OF TERMINATIONS

9.16.1 Leaded Crystal Units

9.16.1.1 *Tensile Strength*

The crystal units shall be subjected to Test 'Ua' of IEC Publication No. 68-2-21.

9.16.1.2 *Bending*

- (a) Undercut Pin Terminations

The body or base of the crystal unit shall be held or clamped by any convenient means. A bending tool suitable for the specific enclosure shall be used to engage that segment of the pin terminals which is beyond the undercut portion.

To ensure that bending will occur primarily at the undercut portion, a plate with two clearance holes for the pins may be placed over the pins. Its thickness may be such that it permits inclusion of part of the undercut section of the pins.

The pins shall be bent by the tool through $15 \pm 2^\circ$ in 1 direction and then through $30 \pm 2^\circ$ in the opposite direction, followed by a bend of $15 \pm 2^\circ$ for return to the starting position. The bending rate shall be approximately 3 seconds per bend in each direction.

(b) Wire Terminations

The crystal units shall be subjected to Test 'Ub' of IEC Publication No. 68-2-21. 3 consecutive bends shall be performed with a load equal to half the load specified for the tensile strength test.

9.16.1.3 *Visual Examination*

After each of the tests specified in Paras. 9.16.1 and 9.16.2, the crystal units shall be visually examined. There shall be no visible damage, but cracks in the coating of the crystal units, extending down to the wire, are permitted.

9.16.2 Non-leaded Crystal Units

9.16.2.1 *Mounting*

Mounting shall be performed as specified in Para. 9.19.

9.16.2.2 *Adhesion*

9.16.2.2.1 Initial measurements

The resonance frequency shall be measured as specified in Para. 9.2.1.1.

9.16.2.2.2 Procedure

Surface mount devices shall be tested in accordance with [MIL-STD-883 Method 2019](#), Shear Test, with a force of 20N.

9.16.2.2.3 Final measurements

The components shall be measured in the mounted state. The change in frequency compared to the value measured in accordance with Para. 9.16.2.2.1 shall not exceed the limit prescribed in Table 6 of the Detail Specification.

9.16.2.2.4 Visual examination

The components shall be visually examined (approximately 10X magnification). There shall be no sign of damage, cracking, lifting, or dry solder joints.

9.17 LIFE TEST

9.17.1 Life Test during Qualification Testing

Surface mount devices shall be mounted as prescribed in Para. 9.19.

(a) Duration: 2000 hours.

(b) Conditions: The test shall be performed as a high temperature storage test at a temperature of +105 (+0 -5) °C.

(c) Intermediate and End Data Points

Measurements at intermediate and end data points shall be made in accordance with Table 6 of the Detail Specification at 0, 500 ±48, 1000 ±48 and 2000 ±48 hours.

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

9.17.2 Life Test During Lot Acceptance Testing

Surface mount devices shall be mounted as prescribed in Para. 9.19.

(a) Duration: 1000 hours.

(b) Conditions: Table 5 of the Detail Specification.

(c) Intermediate and End Data Points

Measurements at intermediate and end data points shall be made in accordance with Table 6 of the Detail Specification at 0, 500 \pm 48 and 1000 \pm 48 hours.

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

9.18 ENCAPSULATION

In accordance with the Process Identification Document (PID).

9.19 SURFACE MOUNT DEVICE MOUNTING

Surface mount devices shall be mounted on a suitable substrate in accordance with IEC Publication No. 155-1, Clause 4.31.3.

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 Paras. 7.3 and 8.4) and failure analysis report (see Para. 8.4).
- (j) Certificate of Conformity.
- (k) Radiographic inspection photographs.

Items (a) to (k) 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:

- Internal Visual Inspection (Para. 9.1).
- First electrical measurements (Para. 9.2.1).
- Shock (Para. 9.3).
- Pre-Burn-in (Para. 9.6).
- Seal test (Fine and Gross Leak) (Para. 9.5) (when applicable).
- Electrical measurements at reference temperature (Para. 9.2.4).
- Electrical measurements at high and low temperatures (Para. 9.2.3) (when applicable).
- External visual inspection (Para. 9.9).
- Dimension check (Para. 9.10).

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) 240 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.
- (g) Photographs from radiographic inspection, including those of reject components.

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 Tables 2, 3 and 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 (0.060)	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 (0.082)	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 (0.058)	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 (16.8)	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 (2.8)	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 (6.3)	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)	899 (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)	1898 (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)	3048 (0.33)	4265 (0.239)	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)	1662 (0.76)	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)	884 (1.53)	1296 (1.02)	1728 (0.77)	2591 (0.52)	3702 (0.358)	5193 (0.256)	8638 (0.153)	12957 (0.102)	17278 (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)	1363 (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)
25	65 (27.0)	109 (16.1)	163 (10.8)	217 (8.08)	328 (5.38)	468 (3.76)	652 (2.69)	1086 (1.61)	1629 (1.08)	2173 (0.907)	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 (CONTINUED)

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 a 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.

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.