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INTERNATIONAL STANDARD

AMENDMENT 1

Quartz crystal units of assessed quality –
Part 1: Generic specification

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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FOREWORD

This amendment has been prepared by IEC technical committee 49: Piezoelectric, dielectric and electrostatic devices and associated materials for frequency control, selection and detection.

The text of this amendment is based on the following documents:

FDIS	Report on voting
49/1254/FDIS	49/1259/RVD

Full information on the voting for the approval of this amendment can be found in the report on voting indicated in the above table.

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

1.2 Normative references

Add the following reference to the existing list of normative references:

IEC 61760-1:2006, *Surface mounting technology – Part 1: Standard method for the specification of surface mounting components (SMDs)*

4.9 Endurance test procedure

Replace Subclause 4.9 with the following new content:

4.9 Endurance test procedure

4.9.1 Standard aging test for production verification

4.9.1.1 Purpose

This test is usable for the statistical verification of aging performance in the production process.

4.9.1.2 Procedure

– Take sample from the production lot.

– Initial measurement of f_s and R_1 at (25 ± 2) °C.

– Store in oven at T_{oven} = (+85 ± 3) °C.

– Take and record additional measurements after 1 day and at least three more times at time intervals recommended in Annex A.

– For the measurement, remove the crystals from oven, and store at room temperature for 1 h, avoiding temperature shocks. Measurement of f_s and R_1 at (25 ± 2) °C in accordance with IEC 60444-5 or equivalent.

– Final measurement of f_s and R_1 at (25 ± 2) °C after 30 days.

4.9.1.3 Evaluation

The difference between the highest and lowest frequency measurement shall not exceed the specified value. The resistance R_1 shall never exceed the specified maximum values.

4.9.2 Accelerated aging

4.9.2.1 Purpose

For special applications, an accelerated aging procedure at higher temperatures is applied to shorten the verification time and/or to gain performance data at higher operating temperatures.

4.9.2.2 Procedure

The procedure is as in 4.9.1, except that the preferred oven temperature is T_{oven} = +105 °C, +125 °C or +150 °C. This temperature has to be lower or equal to the specified maximum storage temperature.

The ratio between the storage time at 25 °C and the storage time at an elevated temperature T_{oven} to achieve the same amount of frequency aging is called "time acceleration factor" (TAF). This factor depends on the design of the crystal unit and on the production process. It can be determined experimentally as described in Annex A, or taken from experience with structurally similar crystals, or can be mutually agreed between the manufacturer and the user.

If the time acceleration factor TAF is not otherwise specified, the following approach is recommended.

Applying Arrhenius's law, the time acceleration factor TAF is related to the activation energy E_a (in eV) by the following equation:

$$\mathrm{TAF} = e^{\frac{E_a \cdot \left(\frac{1}{T_{ref}} - \frac{1}{T_{oven}} \right)}{k}}$$

where

k is Boltzmann's constant ($k \approx 8{,}617 \times 10^{-5}$ eV/K), and the temperatures are given in K.

Published experimental results (see [6] and [7]) show that the activation energy E_a is decreasing over time, i.e. the acceleration factor becomes lower with the aging time. Furthermore, E_a varies between the different crystals and oscillators, depending on frequency, package size, resonator design and production processes. The observed values of E_a were between > 0,1 eV and < 1 eV.

A common assumption is TAF = 12 for T_{oven} = +85 °C, i.e. 30 days (1 month) aging at 85 °C are considered to be equivalent to 365 days (12 months) aging at 25 °C, which corresponds to an activation energy E_a of 0,38 eV.

With this value of E_a, the time acceleration factor for other aging temperatures can be calculated. Table 5 below shows the time acceleration factor TAF and the number of days N_d equivalent to 365 days at 25 °C.

Table 5 – Time acceleration factors for E_a = 0,38 eV

T_{oven} °C	TAF	N_d days
+25	1	365
+85	12	30
+105	23	16
+125	41	9
+150	79	5

Other time acceleration factors may be agreed between the manufacturer and the user based on their own reliability calculations.

4.9.2.3 Evaluation

The evaluation is as in 4.9.1.

4.9.3 Reference aging test

4.9.3.1 Purpose

This procedure is used for higher confidence level. This method should be used for high-precision crystals and as reference method in case of dispute.

4.9.3.2 Procedure

See Annex A.

4.9.3.3 Evaluation

The test data of the series resonance frequency f_s is subjected to the data fitting procedure.

The frequency measurement data $f_i(t)$ shall be fitted using the method of least squares of the following function (logarithmic fit):

$$\left[\frac{\Delta f(t)}{f_{init}}\right] = a_0 + a_1 \times \ln(a_2 \times t + 1)$$

where

$\Delta f(t)$ is the frequency difference of the crystal t days after the start of the aging cycle and the initial frequency f_{init} measured after the stabilization time t_{stab} (the time origin for measurements analysis shall be the beginning of the stabilization period).

The coefficients a_0, a_1 and a_2 are constants to be determined from the least squares fit.