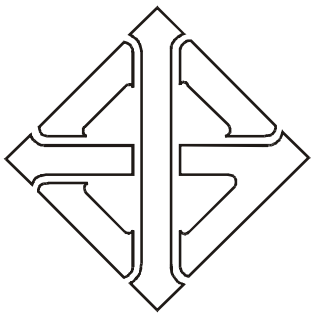

มาตรฐานผลิตภัณฑ์อุตสาหกรรม

THAI INDUSTRIAL STANDARD

มอก. 1929 เล่ม 1 – 2552

IEC 60874 – 1(1999 – 07)

ขั้วต่อสำหรับใยแก้วและสายเคเบิ้ลใยแก้ว

เล่ม 1 ข้อกำหนดร่วม

CONNECTORS FOR OPTICAL FIBRES AND CABLES

PART 1: GENERIC SPECIFICATION

สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม

กระทรวงอุตสาหกรรม

ICS 33.180.20

ISBN 978-616-231-242-7

มาตรฐานผลิตภัณฑ์อุตสาหกรรม
ข้วต่อสำหรับใยแก้วและสายเคเบิ้ลใยแก้ว
เล่ม 1 ข้อกำหนดร่วม

มอก. 1929 เล่ม 1– 2552

สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม
กระทรวงอุตสาหกรรม ถนนพระรามที่ 6 กรุงเทพฯ 10400
โทรศัพท์ 02 202 3300

ประกาศในราชกิจจานุเบกษา ฉบับประกาศและงานทั่วไป เล่ม 127 ตอนพิเศษ 32ง
วันที่ 11 มีนาคม พุทธศักราช 2553

มาตรฐานผลิตภัณฑ์อุตสาหกรรมขั้วต่อสำหรับใยแก้วและสายเคเบิ้ลใยแก้ว เล่ม 1 ข้อกำหนดร่วม ได้ประกาศใช้ครั้งแรกโดยรับ IEC 874-1 (1993) Connectors for optical fibers and cables Part1: Generic Specification มาใช้ในระดับเหมือนกันทุกประการ (Identical) โดยใช้ IEC ฉบับภาษาอังกฤษเป็นหลัก โดยประกาศในราชกิจจานุเบกษา ฉบับประกาศทั่วไป เล่มที่118 ตอนที่ 62ง วันที่ 2 สิงหาคม พุทธศักราช 2544

เนื่องจาก IEC ได้แก้ไขปรับปรุงมาตรฐาน IEC 874-1 (1993) เป็น IEC 60874-1 (1999) จึงได้ยกเลิกมาตรฐานเดิมและกำหนดมาตรฐานใหม่โดยรับ IEC 60874-1 (1999) Connectors for optical fibres and cables Part 1: Generic Specification มาใช้ในระดับเหมือนกันทุกประการโดยใช้มาตรฐาน IEC ฉบับภาษาอังกฤษเป็นหลัก

คณะกรรมการมาตรฐานผลิตภัณฑ์อุตสาหกรรมได้พิจารณามาตรฐานนี้แล้ว เห็นสมควรเสนอรัฐมนตรีประกาศตามมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511

ประกาศกระทรวงอุตสาหกรรม

ฉบับที่ 4097 (พ.ศ. 2552)

ออกตามความในพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม

พ.ศ. 2511

เรื่อง ยกเลิกและกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม

ขั้วต่อสำหรับใยแก้วและสายเคเบิ้ลใยแก้ว

เล่ม 1 ข้อกำหนดร่วม

โดยที่เป็นการสมควรปรับปรุงมาตรฐานผลิตภัณฑ์อุตสาหกรรม ขั้วต่อสำหรับใยแก้วและสายเคเบิ้ลใยแก้ว เล่ม 1 ข้อกำหนดร่วม มาตรฐานเลขที่ มอก.1929 เล่ม 1-2542

อาศัยอำนาจตามความในมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511 รัฐมนตรีว่าการกระทรวงอุตสาหกรรมออกประกาศยกเลิกประกาศกระทรวงอุตสาหกรรม ฉบับที่ 2819 (พ.ศ.2544) ออกตามความในพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ.2511 เรื่อง กำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม ขั้วต่อสำหรับใยแก้วและสายเคเบิ้ลใยแก้ว เล่ม 1 ข้อกำหนดร่วม ลงวันที่ 2 เมษายน พ.ศ.2544 และออกประกาศกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม ขั้วต่อสำหรับใยแก้วและสายเคเบิ้ลใยแก้ว เล่ม 1 ข้อกำหนดร่วม มาตรฐานเลขที่ มอก.1929 เล่ม 1-2552 ขึ้นใหม่ ดังมีรายละเอียดต่อท้ายประกาศนี้

ทั้งนี้ให้มีผลตั้งแต่วันถัดจากวันที่ประกาศในราชกิจจานุเบกษา เป็นต้นไป

ประกาศ ณ วันที่ 14 กันยายน พ.ศ. 2552

ชาญชัย ชัยรุ่งเรือง

รัฐมนตรีว่าการกระทรวงอุตสาหกรรม

มาตรฐานผลิตภัณฑ์อุตสาหกรรม
ขั้วต่อสำหรับใยแก้วและสายเคเบิ้ลใยแก้ว
เล่ม 1 ข้อกำหนดร่วม

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นโดยรับ IEC 60874-1 (1999) Connectors for optical fibres and cables Part 1: Generic Specification มาใช้ในระดับเหมือนกันทุกประการ (identical) โดยใช้ IEC ฉบับภาษาอังกฤษเป็นหลัก

มาตรฐานผลิตภัณฑ์อุตสาหกรรม IEC 60874 ส่วนนี้ ประยุกต์ใช้กับชุดขั้วต่อสำหรับใยแก้วและส่วนประกอบแยกเดี่ยว เช่น เต้าปรับ เต้าเสียบ เต้ารับ สำหรับต่อสายใยแก้วและสายเคเบิลใยแก้วทุกชนิด ทุกขนาด และทุกโครงสร้าง และยังรวมถึง

- ข้อกำหนดของชุดขั้วต่อ
- ขั้นตอนการประเมินคุณภาพ

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้ยังไม่รวมถึงขั้นตอนการดำเนินการทดสอบและการวัด ซึ่งจะไปกล่าวถึงใน IEC61300-1, IEC61300-2 และ IEC61300-3

รายละเอียดให้เป็นไปตาม IEC 60874-1 (1999)

IEC Central office
3, rue de Varembé,
CH-1211 Geneva 20
Switzerland
E-mail : inmail@iec.ch
Web : www.iec.ch

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 3: Sectional specification: Surface mount fixed tantalum electrolytic capacitors with manganese dioxide solid electrolyte

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60384-3 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This third edition cancels and replaces the second edition published in 1989 and constitutes a minor revision related to tables, figures and references.

This bilingual version, published in 2008-06, corresponds to the English version.

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

FDIS	Report on voting
40/1771/FDIS	40/1789/RVD

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

The French version of this standard has not been voted upon.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The QC numbers that appear on the front cover of this publication are the specification numbers in the IEC Quality Assessment System for Electronic Components (IECQ).

The list of all the parts of the IEC 60384 series, under the general title *Fixed capacitors for use in electronic equipment*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site 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.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 3: Sectional specification: Surface mount fixed tantalum electrolytic capacitors with manganese dioxide solid electrolyte

1 General

1.1 Scope

This specification applies to surface mount tantalum solid electrolyte capacitors. These capacitors are primarily intended to be mounted directly onto substrates for hybrid circuits or onto printed boards.

The following two styles are considered:

– Style 1: protected capacitors;
– Style 2: unprotected capacitors.

1.2 Object

The object of this standard is to prescribe preferred ratings and characteristics and to select from IEC 60384-1:1999, the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor.

1.3 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60062, *Marking codes for resistors and capacitors (only available in English)*

IEC 60063, *Preferred number series for resistors and capacitors*

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 60384-1:1999, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

ISO 3, *Preferred numbers – Series of preferred numbers*

1.4 Information to be given in a detail specification

Detail specifications shall be derived from the relevant blank detail specification.

Detail specifications shall not specify requirements inferior to those of the generic, sectional or blank detail specification. When more severe requirements are included, they shall be listed in 1.9 of the detail specification and indicated in the test schedules, for example, by an asterisk.

The following information shall be given in each detail specification and the values quoted shall preferably be selected from those given in the appropriate clause of this sectional specification.

1.4.1 Outline drawing and dimensions

The detail specification shall give an illustration of the capacitor as an aid to easy recognition and for comparison of the capacitor with others. Dimensions and their associated tolerances, which affect interchangeability and mounting, shall be given. All dimensions are to be stated in mm.

NOTE The information given in 1.4.1 may for convenience be presented in tabular form.

Normally, the numerical values shall be given for the length, width and height of the body. When necessary, for example, when a number of case sizes are covered by a detail specification, the dimensions and their associated tolerances shall be placed in a table below the drawing.

When the configuration is other than described above, the detail specification shall state such dimensional information as will adequately describe the capacitor.

1.4.2 Mounting

The detail specification shall give guidance on methods of mounting for normal use. Mounting for test and measurement purposes (if required) shall be in accordance with 4.3.

1.4.3 Ratings and characteristics

The ratings and characteristics shall be in accordance with the relevant clauses of this specification, together with the following.

1.4.3.1 Rated capacitance range

See 2.2.1.

NOTE When products approved to the detail specification have different ranges, the following statement should be added: "The range of values available in each voltage range is given in the qualified products list (QPL).”.

1.4.3.2 Particular characteristics

Additional characteristics may be listed, when they are considered necessary, to specify adequately the component for design and application purposes.

1.4.3.3 Soldering

The detail specification shall prescribe the test methods, severities and requirements applicable for the solderability test and the resistance to soldering heat test.

1.4.4 Marking

The detail specification shall specify the content of the marking on the capacitor and on the package. Deviations from 1.5 of this sectional specification shall be specifically stated.

1.5 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60384-1, as well as the following, apply.

1.5.1
surface mount capacitor
capacitor whose small dimensions and nature or shape of terminations make it suitable for surface mounting in hybrid circuits and on printed boards

1.5.2
rated voltage
U_R
See 2.2.16 of IEC 60384-1

NOTE 1 The sum of the d.c. voltage and the peak a.c. voltage applied to the capacitor should not exceed the rated voltage.

NOTE 2 For short periods, however, the rated voltage may be exceeded (see 2.2.5 and 4.14).

1.5.3
Class 1
capacitor with low dielectric losses and high stability of capacitance; Ta powders with low volumetric capacitance values are used

1.5.4
Class 2
capacitor with a dielectric of medium range volumetric capacitance for applications where low losses and high stability of capacitance are not of major importance

1.5.5
Class 3
capacitor with a dielectric of high volumetric capacitance for applications where small size and high capacitance values are essential, and higher losses and less stability of capacitance can be tolerated

1.6 Marking

See 2.4 of IEC 60384-1, with the following details.

1.6.1 The information given in the marking is normally selected from the following list; the relative importance of each item is indicated by its position in the list:

a) polarity of the terminations (unless identified by the construction);

b) rated capacitance, in clear or coded form;

c) rated voltage, in clear or coded form, (d.c. voltage may be indicated by the symbol (⎓ or ———);

d) tolerance on rated capacitance;

e) style (in accordance with 1.1);

f) year and month (or week) of manufacture;

g) manufacturer's name or trade mark;

i) climatic category;

j) manufacturer's type designation;

k) reference to the detail specification.

1.6.2 Surface mount capacitors are generally not marked on the body. If some marking can be applied, they shall be clearly marked with as many as possible of the above items as is considered useful. Designation of polarity is a mandatory item. Any duplication of information in the marking on the capacitor should be avoided. Where space does not permit the marking of the capacitor in accordance with IEC 60062 the following code may be used.

a) Capacitance coding

The rated capacitance value in picofarad is given by the following digit and letter code.

Letter	Value
A	1,0
C	1,2
E	1,5
G	1,8
J	2,2
L	2,7
N	3,3
Q	3,9
S	4,7
U	5,6
W	6,8
Y	8,2

Digit	Multiplier
9	10^{-1}
0	10^{0}
1	10^{1}
2	10^{2}
3	10^{3}
4	10^{4}
5	10^{5}
6	10^{6}
7	10^{7}
8	10^{8}

b) Voltage coding

For code letters for marking, see the detail specification.

1.6.3 Any marking shall be legible and not easily smeared or removed by rubbing with the finger.

1.6.4 The package containing the capacitor(s) shall be clearly marked with all the information listed in 1.5.1, except polarity, unless this is applicable to the method of packing.

1.6.5 Any additional marking shall be so applied that no confusion can arise.

2 Preferred ratings and characteristics

2.1 Preferred characteristics

The values given in detail specifications shall preferably be selected from the following.

2.1.1 Preferred climatic categories

The capacitors covered by this specification are classified into climatic categories according to the general rules given in IEC 60068-1.

The lower and upper category temperature and the duration of the damp heat, steady state test shall be chosen from the following.

Lower category temperature:	–55 °C.
Upper category temperature:	+85 °C and +125 °C.
Duration of the damp heat, steady state test:	Style 1: 21 and 56 days Style 2: --

The severities for the cold and dry heat tests are the lower and upper category temperatures respectively.

2.2 Preferred values of ratings

2.2.1 Rated capacitance (C_R)

Preferred values of rated capacitance are 1,0 – 1,5 – 2,2 – 3,3 – 4,7 – 6,8 and their decimal multiples.

These values conform to the E6 series of preferred values given in IEC 60063.

2.2.2 Tolerance on rated capacitance

The preferred tolerances on the rated capacitance are ± 10 % and ± 20 %.

2.2.3 Rated voltage (U_R)

The preferred values of rated direct voltages taken from the R5 series of ISO 3 are:

1,0 – 1,6 – 2,0 – 2,5 – 3,5 – 4,0 – 5,0 – 6,3 and their decimal multiples.

If other values are required they shall preferably be chosen from the R10 series.

2.2.4 Category voltage (U_C)

For capacitors having an upper category temperature of 125 °C, category voltages are given in Table 1.

Table 1 – Category voltages

U_R V	2,5	4	6,3	10	16	25	40	63	100
U_C V	1,6	2,5	4,0	6,3	10	16	25	40	63

2.2.5 Surge voltage

The surge voltage shall be 1,3× the rated or 1,3× the category voltage, rounded off to the nearest volt.

2.2.6 Rated temperature

The standard value of the rated temperature is 85 °C.

2.2.7 Requirements for Class 1, Class 2 and Class 3

The detail specification shall provide performance requirements for the capacitance drift values.

Maximum values for the dissipation factor (tan δ)

Class 1 ≤ 0,08

Class 2 ≤ 0,12

Class 3 ≤ 0,24

NOTE The requirements depend on the type of powder, the rated voltage and the case size of capacitors. See the following examples for typical combinations of case size, capacitance and rated voltage.

Class	3216-18* size	6,3 V; 10 µF	Ta powder (µFV/g)
Class 1	6,3 V 15µF	3216-18*	< 30 000
Class 2	6,3 V 33µF	2012-12*	< 70 000
Class 3	6,3 V 68µF	1608-09*	< 100 000

Size code structure (3D) *LW-H*

where

L is the nominal dimension in units of 0,1 mm;

W is the nominal dimension in units of 0,1 mm;

H is the maximum dimension in units of 0,1 mm.

3 Quality assessment procedures

3.1 Primary stage of manufacture

The primary stage of manufacture is the forming of the tantalum oxide dielectric.

3.2 Structurally similar components

Capacitors considered as being structurally similar are capacitors produced with similar processes and materials, though they may be of different case sizes and values.

3.3 Certified records of released lots

The information required in 3.9 of IEC 60384-1 shall be made available when prescribed in the detail specification and when requested by a purchaser. After the endurance test, the parameters for which variables information is required are the capacitance change, tan δ and the leakage current.

3.4 Qualification approval

The procedures for qualification approval testing are given in 3.5 of IEC 60384-1.

The schedule to be used for qualification approval testing on the basis of lot-by-lot and periodic tests is given in 3.5 of this specification. The procedure using a fixed sample size schedule is given in 3.4.1 and 3.4.2.

3.4.1 Sampling

The fixed sample size procedure is described in 3.5.3b) of IEC 60384-1. The sample shall be representative of the range of capacitors for which approval is sought. This may or may not be the complete range covered by the detail specification. The sample shall consist of specimens having the lowest and highest voltages and, for these voltages, the smallest and largest case size. When there are more than four case sizes an intermediate case size shall also be tested. In each of these case size/voltage combinations (values), the highest capacitance shall be chosen. Thus, for the approval of a range, testing is required of either four or six values. When the range consists of less than four values, the number of specimens to be tested shall be that required for four values.

Spare specimens are permitted as follows:

Two (for six values) or three (for four values) per value, which may be used as replacements for specimens which are non-conforming because of incidents not attributable to the manufacturer.

The numbers given in Group 0 assume that all groups are applicable. If this is not so, the numbers may be reduced accordingly.

When additional groups are introduced into the qualification approval test schedule, the number of specimens required for Group 0 shall be increased by the same number as that required for the additional groups.

Table A.1 gives the number of samples to be tested in each group or subgroup together with the permissible number of non-conforming items for qualification approval tests.

3.4.2 Tests

The complete series of tests for selected assessment level given in Tables A.1 to A.3 and the test schedule given in Annex B are required for the approval of capacitors covered by one detail specification. The tests of each group shall be carried out in the order given.

The whole sample shall be subjected to the tests of Group 0 and then divided for the other groups.

Non-conforming specimens found during the tests of Group 0 shall not be used for the other groups.

"One non-conforming item" is counted when a capacitor has not satisfied the whole or a part of the tests of a group.

Approval is granted when the number of non-conforming items does not exceed the specified number of permissible non-conforming items for each group or subgroup and the total number of permissible non-conforming items.

NOTE 1 Tables A.1 and B.1 together form the fixed sample size test schedule. Annex A includes the details for sampling and the permissible non-conforming items for the different tests or groups of tests, whereas Annex B, together with the details of tests contained in Clause 4, gives a complete summary of test conditions and performance requirements indicating where, for example for the test method or conditions of test, a choice should be made in the detail specification.

NOTE 2 The conditions of test and performance requirements for the fixed sample size test schedule should be identical to those prescribed in the detail specification for quality conformance inspection.

3.5 Quality conformance inspection

3.5.1 Formation of inspection lots

3.5.1.1 Groups A and B inspection

These tests shall be carried out on a lot-by-lot basis according to test plan for selected assessment level in Table A.2.

A manufacturer may aggregate the current production into inspection lots subject to the following safeguards:

1) the inspection lot shall consist of structurally similar capacitors (see 3.2);

2a) the sample tested shall be representative of the values and dimensions contained in the inspection lot:

- in relation to their number;
- with a minimum of five of any one value;

2b) if there are less than five of any one value in the sample, the basis for the drawing of samples shall be agreed between the manufacturer and the National Supervising Inspectorate.

3.5.1.2 Group C inspection

These tests shall be carried out on a periodic basis according to the test plan for selected assessment level given in Table A.3.

Samples shall be representative of the current production of the specified periods and shall be divided into small, medium and high sizes. In order to cover the range of approvals in any period, one voltage shall be tested from each group of sizes. In subsequent periods other sizes and/or voltage ratings in production shall be tested with the aim of covering the whole range of approval.

3.5.2 Test schedule

The test schedule for qualification approval is given in Annex B.

3.5.3 Delayed delivery

When, according to the procedures of 3.10 of IEC 60384-1, re-inspection has to be made, solderability, capacitance and leakage current shall be checked as specified in Group A and B inspection.

3.5.4 Assessment levels

The assessment level(s) given in the blank detail specification shall preferably be selected from Tables A.2 to A.3.

4 Test and measurement procedures

This clause supplements the information given in Clause 4 of IEC 60384-1.

4.1 Preliminary drying

If prescribed in the detail specification for Style 2 capacitors, the conditions given in 4.3 of IEC 60384-1 apply.

4.2 Measuring conditions

Capacitors of Style 2 shall be measured at a relative humidity of 25 % to 75 % maximum.

4.3 Mounting

See 4.33 of IEC 60384-1.

4.3.1 Mounting conditions

The detail specification shall specify the soldering process to be used.

4.3.2 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and meet the requirements of Annex B.

4.4 Visual examination and check of dimensions

See 4.4 of IEC 60384-1, with the following details.

4.4.1 Visual examination

Visual examination shall be carried out with suitable equipment with approximately 10× magnification and lighting appropriate to the specimen under test and the quality level required.

NOTE The operator should have facilities available for incident or transmitted illumination as well as an appropriate measuring facility.

4.4.2 Requirements

The capacitors shall be examined to verify that the materials, design, construction, physical dimensions and workmanship are in accordance with the applicable requirements given in the detail specification.

4.5 Electrical tests

4.5.1 Leakage current

See 4.9 of IEC 60384-1, with the following details.

4.5.1.1 Measuring conditions

The rated voltage shall be applied across the capacitor and its protective resistor. The protective resistor shall have a value of 1 000 Ω.

4.5.1.2 Requirement

The leakage current at 20 °C shall not exceed 0,02 $C_R U_R$ μA/(μF×V) or 1 μA, whichever is the greater.

4.5.2 Capacitance

See 4.7 of IEC 60384-1, with the following details.

4.5.2.1 Measuring conditions

The capacitance shall be measured at a frequency of 100 Hz or 120 Hz, as specified in the detail specification. The peak alternating voltage actually applied across the capacitor terminations shall not exceed 0,5 V a.c. r.m.s.

A d.c. bias voltage of

– 1,1 V to 1,5 V for types with a rated voltage of ≤2,5 V
– 2,1 V to 2,5 V for types with a rated voltage of >2,5 V

may be applied during the measurement.

The inaccuracy of the measuring instruments shall not exceed ±2 % of the specified limit, whether this is given as an absolute value or as a change of capacitance.

NOTE Measurement without a polarizing voltage is optional.

4.5.2.2 Requirement

The capacitance shall correspond with the rated value taking into account the tolerance.

4.5.3 Tangent of loss angle (tan δ)

See 4.8.1 of IEC 60384-1, with the following details.

4.5.3.1 Measuring conditions

The measurement shall be made under the conditions of 4.5.2. The inaccuracy of the measuring equipment shall not exceed 0,01 absolute value.

4.5.3.2 Requirement

The tangent of loss angle (at 20 °C) shall not exceed the limits specified in the detail specification.

4.5.4 **Impedance** (if applicable)

See 4.10 of IEC 60384-1, with the following details.

4.5.4.1 Measuring conditions

The ambient temperature shall be (20 ± 2) °C. The a.c. value of the measuring voltage shall not exceed 0,5 V a.c. r.m.s. The frequency of the measuring voltage shall be 100 kHz.

The error of measurement shall not exceed ±10 % of the requirement.

4.5.4.2 Requirement

The impedance shall meet the requirements of the detail specification.

4.5.5 **Equivalent series resistance (ESR)** (if required by the detail specification)

See 4.8.2 of IEC 60384-1, with the following details.

4.5.5.1 Measuring conditions

The ambient temperature shall be (20 ± 2) °C. The a.c. value of the measuring voltage shall not exceed 0,5 V a.c. r.m.s. A d.c. bias voltage of 2,1 V to 2,5 V may be applied during the measurement. The frequency of the measuring voltage shall be 100 kHz.

The error of measurement shall not exceed 10 % of the requirement.

4.5.5.2 Requirements

The ESR shall meet the requirements of the detail specification.

4.6 Resistance to soldering heat

See 4.14 of IEC 60384-1, with the following details.

4.6.1 Initial measurement

The capacitance and the tangent of loss angle shall be measured according to 4.5.2 or 4.5.3.

4.6.2 Test conditions

The detail specification shall prescribe the test method and the test conditions.

a) Solder bath method
   Immersion attitude
   Temperature and immersion time
b) Reflow method
   Reflow temperature profile

4.6.3 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the following requirements.

Under normal lighting and approximately 10× magnification there shall be no signs of damage such as cracks.

The capacitance and tangent of loss angle shall be measured. They shall not exceed the limits specified in the detail specification.

4.7 Solderability

See 4.15 of IEC 60384-1, with the following details.

4.7.1 Test conditions

The detail specification shall prescribe the test method and the test conditions.

a) Solder bath method

   Temperature and immersion time

b) Reflow method

   Reflow temperature profile

4.7.2 Final inspection, measurements and requirements

The capacitor shall then be visually examined under normal lighting and approximately 10× magnification. There shall be no signs of damage.

The areas and edges to be examined as defined in the detail specification shall be covered with a smooth and bright solder coating with no more than a small amount of scattered imperfections such as pinholes or un-wetted or de-wetted areas. These imperfections shall not be concentrated in one area.

4.8 Shear test

See 4.34 of IEC 60384-1.

4.8.1 Initial requirements

Not required (see Group 3).

4.8.2 Final measurements and requirements

The capacitors shall be visually examined and measured and meet the requirements of Annex B.

4.9 Substrate bending test

Not applicable to surface mounting capacitors which, according to their detail specification, shall only be mounted on alumina substrates.

See 4.35 of IEC 60384-1, with the following details.

4.9.1 Initial measurements

Not required (see Group 3).

4.9.2 Test conditions

The detail specification shall prescribe the amount of deflection and the number of bends.

4.9.3 Final measurements and requirements

The capacitors shall be visually examined and measured and meet the requirements of Annex B.

4.10 Rapid change of temperature

See 4.16 of IEC 60384-1, with the following details.

4.10.1 Initial measurement

Not required (see Group 3)

4.10.2 Conditioning

The capacitors shall be subjected to test Na for 5 cycles. The duration of the exposure at each temperature limit shall be 30 min. The recovery period shall be 1 h to 2 h.

4.10.3 Final measurements and requirements

After recovery the capacitors shall be measured and shall meet the requirements shown in Annex B.

4.11 Climatic sequence (applicable to Style 1 capacitors only)

See 4.21 of IEC 60384-1, with the following details.

4.11.1 Initial measurement

Not required.

4.11.2 Dry heat

See 4.21.2 of IEC 60384-1.

4.11.3 Damp heat, cyclic, test Db, first cycle

See 4.21.3 of IEC 60384-1.

4.11.4 Cold

See 4.21.4 of IEC 60384-1.

4.11.5 Damp heat, cyclic, test Db, remaining cycles

See 4.21.6 of IEC 60384-1.

4.11.5.1 Recovery

1 h to 2 h.

4.11.6 Final inspection, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the requirements shown in Annex B.

4.12 Damp heat, steady state (applicable to Style 1 capacitors only)

See 4.22 of IEC 60384-1, with the following details.

The capacitors shall be mounted according to 4.3.

4.12.1 Initial measurement

Not required (see Group 3).

4.12.2 Conditions of test

No voltage shall be applied.

4.12.3 Final inspection, measurements and requirements

After recovery for 1 h to 2 h, the capacitors shall be visually examined and measured and shall meet the requirements shown in Annex B.

4.13 Characteristics at high and low temperature

See 4.29 of IEC 60384-1, with the following details.

The capacitors shall be mounted according to 4.3.

4.13.1 Measurements and requirements

The capacitors shall be measured and shall meet the requirements shown in Annex B.

4.14 Surge

See 4.26 of IEC 60384-1, with the following details.

4.14.1 Test procedure

The capacitors shall be subjected to 1 000 cycles each consisting of a charge as described below, followed by a discharge period of 5 min 30 s.

A voltage, equal to the surge voltage, shall be applied during 30 s through a resistor with a value so that the total resistance in series with the capacitor and voltage source is 1 000 Ω ± 100 Ω.

The test shall be made at the following temperatures.

Table 2 – Test temperatures

Upper category temperature	Test temperature
85 °C	All specimens at upper category temperature
125 °C	50 % of the specimens at 85 °C and the remaining 50 % at the upper category temperature

Each surge voltage cycle shall be performed in such a manner that the capacitor is discharged through the resistor of approximately 1 000 Ω at the end of the 30 s application.

The test shall be terminated on the discharge portion of the cycle.

4.14.2 Final measurements and requirements

The capacitors shall be measured and shall meet the requirements given in Annex B.

4.15 Endurance

See 4.23 of IEC 60384-1, with the following details.

The capacitors shall be mounted according to 4.3.

4.15.1 Initial measurement

Not required (see Group 3).

4.15.2 Conditions of test

Duration:	2 000 h
Test temperature:	Upper category temperature.
Applied voltage:	Category voltage, unless otherwise specified in the detail specification

NOTE When the category voltage and/or temperatures is/are different from the rated voltage and/or temperatures, the sample tested is divided into two parts and submitted to the rated and category voltages and temperatures respectively.

The test voltage shall be applied gradually (not less than 2 min but not more than 5 min) either by a slow build-up of voltage or through a resistor which shall be shorted out within 5 min. The impedance of the voltage source seen from the terminations of each capacitor shall not exceed 3 Ω.

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

4.15.3 Final inspection, measurements and requirements

After recovery for 1 h to 2 h, the capacitors shall be visually examined and measured and shall meet the requirements shown in Annex B.

4.16 **Reverse voltage** (if required by the detail specification)

4.16.1 Initial measurement

Not required (see Group 3).

4.16.2 Conditions of test

The capacitors shall be subjected to the conditions under a) followed by the conditions under b).

a)	Test temperature:	Upper category temperature
	Applied voltage:	3 V d.c. or 10 % of the rated voltage, whichever is less, in the reverse polarity direction, unless otherwise specified in the detail specification
	Duration:	125 h

b)	Test temperature:	Upper category temperature
	Applied voltage:	Direct voltage equal to the category voltage in the forward polarity direction
	Duration:	125 h

4.16.3 Final measurements and requirements

After recovery, the capacitors shall be visually examined and measured and shall meet the requirements given in Annex B.

4.17 Component solvent resistance (if required by the detail specification)

See 4.31 of IEC 60384-1.

4.18 Solvent resistance of the marking (if required by the detail specification)

See 4.32 of IEC 60384-1.

4.19 High surge current (if required by the detail specification)

According to 4.39 of IEC 60384-1, with the following details.

4.19.1 Initial measurements

Not required.

4.19.2 Final measurements and requirements

Final measurements and requirements are those for the subsequent tests in Group 0 or in the blank detail specification in Group A, as appropriate.

Annex A
(normative)

Test plans for assessment level EZ

Table A.1 – Test plan for qualification approval – Assessment level EZ

Group	Clause number and test[a]		Number of specimens (n) and acceptance criteria (c)		
			n[d]	c	c total
0	4.19	High surge current (if required by the detail specification)			
	4.4	Visual examination			
	4.4	Dimensions	124	0	
	4.5.1	Leakage current			
	4.5.2	Capacitance			
	4.5.3	Tangent of loss angle			
	4.5.4	Impedance[c]	16		
	4.5.5	Equivalent series resistance[c]			
		Spare specimens			
1A	4.6	Resistance to soldering heat	12	0	0
	4.17	Component solvent resistance[c]			
1B	4.7	Solderability	12	0	
	4.18	Solvent resistance of the marking[c]			
2	4.9	Substrate bending test[e]	12	0	0
3	4.3	Mounting[b]			
	4.4	Visual examination			
	4.5.1	Leakage current			
	4.5.2	Capacitance	88	0	
	4.5.3	Tangent of loss angle			
	4.5.4	Impedance[c]			
	4.5.5	Equivalent series resistance[c]			
3.1	4.8	Shear (adhesion) test	20	0	
	4.10	Rapid change of temperature			
	4.11	Climatic sequence (Style 1 only)			
3.2	4.12	Damp heat steady state (Style 1 only)	20	0	0
3.3	4.15	Endurance	20	0	
3.4	4.13	Characteristics at high and low temperature	12	0	
3.5A	4.14	Surge voltage	8	0	
3.5B	4.16	Reverse voltage[c]	8	0	

[a] Refers to Clause 4 of this specification.

[b] The specimens found to be non-conforming after mounting shall not be taken into account when calculating the permitted non-conforming items for the following tests. They should be replaced by spare capacitors.

[c] If required by the detail specification.

[d] For capacitance/voltage combinations, see 3.4.1.

[e] Not applicable to surface mounting capacitors which according to their detail specification shall be mounted on alumina substrates.

Table A.2 – Test plan for quality conformance inspection – Lot-by-lot tests – Assessment level EZ

Group	Clause number and test[a]		Inspection level *IL*	Sample size *n*	Acceptance number *c*
A0	4.19	High surge current (if required by the detail specification)		100 %[b]	
	4.5.1	Leakage current			
	4.5.2	Capacitance			
	4.5.3	Tangent of loss angle			
	4.5.4	Impedance[e]			
	4.5.5	Equivalent series resistance[e]			
A1	4.4	Visual examination	S3	[d]	0
	4.4	Dimensions[c]			
B1	4.7	Solderability	S3	[d]	0
	4.18	Solvent resistance of the marking[e]			

[a] Refers to Clause 4 of this specification.

[b] 100 % testing shall be followed by re-inspection by sampling in order to monitor outgoing quality level by non-conforming items per million. The sampling level shall be established by the manufacturer. The calculation of ppm values shall be made in accordance with CECC 00 014 counting any parametric failure as a non-conforming item. In the case where one or more non-conforming items occur in a lot, this lot shall be rejected.

[c] This test may be replaced by in-production testing, if the manufacturer installs SPC on dimensional measurements or other mechanisms to avoid parts exceeding the limits.

[d] Number to be tested: Sample size as directly allotted to the code letter for ***IL*** in Table 2A of IEC 60410 (single sampling plan for normal inspection).

[e] If required by the detail specification.

Table A.3 – Test plan for quality conformance inspection – Periodic tests – Assessment level EZ

Group	Clause number and test[a]		Periodicity (months)	Total sample size *n*	Acceptance number *c*
C1	4.6 4.17	Resistance to soldering heat Component solvent resistance[d]	3	12	0
C2	4.9	Substrate bending test[e]	3	12	0
C3	4.3 4.4 4.5.1 4.5.2 4.5.3 4.5.4 4.5.5	Mounting[c] Visual examination Leakage current Capacitance Tangent of loss angle Impedance[d] Equivalent series resistance[d]	3	78 [b]	0
C3.1	4.8 4.10 4.11	Shear test Rapid change of temperature Climatic sequence (Style 1 only)	6	18	0
C3.2	4.12	Damp heat steady state (Style 1 only)	6	9	0
C3.3	4.15	Endurance	3	24	0
C3.4	4.13	Characteristics at high and low temperature	6	15	0
C3.5A	4.14	Surge voltage	12	6	0
C3.5B	4.16	Reverse voltage[d]	12	6	0

[a] Refers to Clause 4 of this specification.

[b] The values of these measurements serve as initial measurements for the tests of Group 3.

[c] The specimens found to be non-conforming after mounting shall not be taken into account when calculating the permitted non-conforming items for the following tests. They shall be replaced by spare capacitors.

[d] If required by the detail specification.

[e] Not applicable to surface mounting capacitors which according to their detail specification shall be mounted on alumina substrates.

Annex B
(normative)

Test schedule for assessment level EZ

Table B.1 – Test schedule for qualification approval – Assessment level EZ

Clause number and test[a]		Conditions of test[a]	*n* and *c*[b]	Performance requirements[a]
Group 0		**Non-destructive**	See Table A.1	
4.19	High surge current (if required by the detail specification)			
4.4	Visual examination			As in 4.4.2 Marking legible and as specified in the detail specification
4.4	Dimensions (detail)			See detail specification (Table 1)
4.5.1	Leakage current	Protective resistor: 1 000 Ω		≤ 0,02 $C_R U_R$ μA/(μFxV) or ≤ 1 μA whichever is the greater
4.5.2	Capacitance	Frequency: ... Hz[d] Bias: ... V[d, e]		Within specified tolerance See detail specification
4.5.3	Tangent of loss angle	Frequency: ... Hz[d] Bias: ... V[d, e]		Class 1 ≤ 0,08 Class 2 ≤ 0,12 Class 3 ≤ 0,24
4.5.4	Impedance[d]	Frequency: 100 kHz		See detail specification
4.5.5	Equivalent series resistance[d]	Frequency: 100 kHz		See detail specification
Group 1A		**Destructive**	See Table A.1	
4.6.1	Initial measurements	Capacitance Tangent of loss angle		
4.6	4.6 Resistance to soldering heat	Attitude: ...[d]		
4.17	Component solvent resistance[d]	Solvent: ...[d] Solvent temperature: ...[d] Method 2 Recovery: ...[d]		See detail specification
4.6.3	Final measurements	Visual examination		As in 4.6.3
		Capacitance		See detail specification
		Tangent of loss angle		See detail specification
The explanation of footnotes to tables is given at the end of Table B.1.				

Table B.1 *(continued)*

Clause number and test[a]		Conditions of test[a]	*n* and *c*[b]	Performance requirements[a]
Group 1B		**Destructive**	See Table A.1	
4.7	Solderability	Temperature: ... [d] Time: ... [d]		
4.18	Solvent resistance of the marking[e]	Solvent: ...[d] Solvent: temperature: ...[d] Method 1 Rubbing material: cotton wool Recovery: ...[d]		Marking legible
4.7.2	Final measurement	Visual examination		As in 4.7.2
Group 2		**Destructive**	See Table A.1	
4.9	Substrate bending test[c]	Capacitance (with board in bent position) Deflection: ...mm[d] Number of bends: ...[d]		See detail specification
4.9.3	Final measurement	Visual examination		No visible damage
Group 3		**Destructive**	See Table A.1	
4.3	Mounting	Visual examination		No visible damage
		Leakage current		≤ initial limit
		Capacitance		See detail specification
		Tangent of loss angle		≤ initial limit
		Impedance[e]		≤ initial limit
		Equivalent series resistance[e]		See detail specification

Table B.1 *(continued)*

Clause number and test[a]		Conditions of test[a]	*n* and *c*[b]	Performance requirements[a]
Group 3.1		**Destructive**	See Table A.1	
4.8	Shear test	Visual examination		No visible damage
4.10.1	Initial measurements	Not required (see Group 3)		
4.10	Rapid change of temperature	T_A = Lower category temperature T_B = Upper category temperature Five cycles Duration t = 30 min Recovery: 1 h to 2 h		
4.10.3	Final measurements	Leakage current		≤ initial limit
		Capacitance		See detail specification
		Tangent of loss angle		≤ initial limit
4.11	Climatic sequence (Style 1 only)			
4.11.1	Initial measurements	Not required		
4.11.2	Dry heat	Temperature: upper category temperature Duration: 16 h		
4.11.3	Damp heat, cyclic, first cycle			
4.11.4	Cold	Temperature: lower category temperature Duration: 2 h		
4.11.5	Damp heat, cyclic, remaining cycles	Recovery: 1 h to 2 h		
4.11.6	Final measurements	Visual examination		No visible damage Marking legible
		Leakage current		≤ initial limit
		Capacitance		$\lvert\Delta C/C\rvert$ ≤ 10 % of value measured in Group 3
		Tangent of loss angle		≤ 1,2 times initial limit

Table B.1 *(continued)*

Clause number and test[a]		Conditions of test[a]	*n* and *c*[b]	Performance requirements[a]
Group 3.2		**Destructive**	See Table A.1	
4.12	Damp heat, steady state (Style I only)	Recovery: 1 h to 2 h		
4.12.1	Initial measurements	Not required (see Group 3)		
4.12.3	Final measurements	Visual examination		No visible damage Marking legible
		Leakage current		≤ initial limit
		Capacitance		$\lvert\Delta C/C\rvert$ ≤ 10 % of value measured in Group 3
		Tangent of loss angle		≤ 1,2 times initial limit
Group 3.3		**Destructive**	See Table A.1	
4.15	Endurance	Duration: 2 000 h Ambient temperature: ... °C[d] (as applicable) Applied voltage: ...V[d] Recovery: 1 h to 2h		
4.15.1	Initial measurements	Not required (see Group 3)		
4.15.3	Final measurements	Visual examination		No visible damage Marking legible
		Leakage current		≤ 2 times initial limit
		Capacitance		See detail specification
		Tangent of loss angle		≤ 1,5 times initial limit
		Impedance [c] or Equivalent series resistance [c]		See detail specification

Table B.1 *(continued)*

Clause number and test[a]	Conditions of test[a]	n and c[b]	Performance requirements[a]
Group 3.4	**Destructive**	See Table A.1	
4.13 Characteristics at high and low temperature	The capacitors shall be measured at each temperature step		
	Step 1: 20 °C		
	Leakage current		≤ initial limit
	Capacitance		As reference value
	Tangent of loss angle		≤ initial limit
	Step 2: Lower category temperature		
	Capacitance		See detail specification
	Tangent of loss angle		See detail specification
	Step 3: 20 °C		
	Leakage current		≤ initial limit
	Capacitance		$\lvert\Delta C/C\rvert$ ≤ 5 % of value measured in Step 1
	Tangent of loss angle		≤ initial limit
	Step 4: 85 °C		
	Leakage current		≤ 0,2 C_R U_R μA/(μFxV) or ≤ 10 μA whichever is the greater
	Capacitance		See detail specification
	Tangent of loss angle		See detail specification
	Step 5: 125 °C (if applicable)		
	Leakage current		≤ 0,25 C_R U_R μA/(μFxV) or ≤ 12,5 μA whichever is the greater
	Capacitance		See detail specification
	Tangent of loss angle		See detail specification
	Step 6: 20 °C		
	Leakage current Capacitance Tangent of loss angle		As in Step 3

Table B.1 *(continued)*

Clause number and test[a]		Conditions of test[a]	n and c[b]	Performance requirements[a]
Group 3.5A		**Destructive**	See Table A.1	
4.14	Surge voltage	Number of cycles: 1 000 Temperature: ... °C [d] Voltage: 1,3 U_R and/or 1,3 U_C as applicable Protective resistor: (1 000 ± 100) Ω Duration of charge: 30 s Duration of discharge: 5 min 30 s		
	Initial measurements	Not required (see Group 3)		
4.14.2	Final measurements	Leakage current		≤ initial limit
		Capacitance		$\lvert \Delta C/C \rvert$ ≤ 10 % of value measured in Group 3
		Tangent of loss angle		≤ initial limit
Group 3.5B		**Destructive**	See Table A.1	
4.16	Reverse voltage	Duration: 125 h at upper category temperature with a voltage of ... V [d], in reverse polarity direction, followed by 125 h at upper category voltage in forward polarity direction		
4.16.1	Initial measurements	Not required (see Group 3)		
4.16.3	Final measurements	Leakage current		≤ initial limit
		Capacitance		$\lvert \Delta C/C \rvert$ ≤ 10 % of value measured in Group 3
		Tangent of loss angle		≤ 1,15 times initial limit

[a] Refer to Clause 4 of this sectional specification

[b] n = number of specimens, c = acceptance criteria (number of permissible non-conforming items).

[c] Not applicable to surface mounting capacitors which according to their detail specification shall only be mounted on alumina substrates

[d] To be specified in the detail specification

[e] If required in the detail specification