

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Fixed capacitors for use in electronic equipment –
Part 21: Sectional specification – Fixed surface mount multilayer capacitors of
ceramic dielectric, Class 1**

**Condensateurs fixes utilisés dans les équipements électroniques –
Partie 21: Spécification intermédiaire – Condensateurs multicouches fixes à
diélectriques en céramique pour montage en surface, de Classe 1**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2011 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Fixed capacitors for use in electronic equipment –
Part 21: Sectional specification – Fixed surface mount multilayer capacitors of
ceramic dielectric, Class 1**

**Condensateurs fixes utilisés dans les équipements électroniques –
Partie 21: Spécification intermédiaire – Condensateurs multicouches fixes à
diélectriques en céramique pour montage en surface, de Classe 1**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

W

CONTENTS

FOREWORD.....	5
1 General.....	7
1.1 Scope.....	7
1.2 Object.....	7
1.3 Normative references.....	7
1.4 Information to be given in a detail specification.....	7
1.4.1 Outline drawing and dimensions.....	8
1.4.2 Mounting.....	8
1.4.3 Rating and characteristics.....	8
1.4.4 Marking.....	9
1.5 Terms and definitions.....	9
1.6 Marking.....	10
1.6.1 Information for marking.....	10
1.6.2 Marking on the body.....	10
1.6.3 Requirements for marking.....	10
1.6.4 Marking of the packaging.....	10
1.6.5 Additional marking.....	10
2 Preferred ratings and characteristics.....	10
2.1 Preferred characteristics.....	10
2.1.1 Preferred climatic categories.....	10
2.2 Preferred values of ratings.....	11
2.2.1 Rated temperature (T_R).....	11
2.2.2 Rated voltage (U_R).....	11
2.2.3 Category voltage (U_C).....	11
2.2.4 Preferred values of nominal capacitance and associated tolerance values.....	11
2.2.5 Temperature coefficient (α).....	12
2.2.6 Dimensions.....	14
3 Quality assessment procedures.....	14
3.1 Primary stage of manufacture.....	14
3.2 Structurally similar components.....	14
3.3 Certified records of released lots.....	14
3.4 Qualification approval.....	14
3.4.1 Qualification approval on the basis of the fixed sample size procedures.....	14
3.4.2 Tests.....	15
3.5 Quality conformance inspection.....	19
3.5.1 Formation of inspection lots.....	19
3.5.2 Schedule.....	20
3.5.3 Delayed delivery.....	20
3.5.4 Assessment levels.....	20
4 Test and measurement procedures.....	21
4.1 Preliminary drying.....	21
4.2 Measuring conditions.....	22
4.3 Mounting.....	22
4.4 Visual examination and check of dimensions.....	22
4.4.1 Visual examination.....	22

4.4.2	Requirements	22
4.5	Electrical tests.....	24
4.5.1	Capacitance	24
4.5.2	Tangent of loss angle ($\tan \delta$)	24
4.5.3	Insulation resistance.....	24
4.5.4	Voltage proof.....	25
4.6	Temperature coefficient (α) and temperature cycle drift.....	26
4.6.1	Preliminary drying.....	26
4.6.2	Measuring conditions.....	26
4.6.3	Requirements	26
4.7	Shear test	26
4.8	Substrate bending test	27
4.8.1	Initial measurement	27
4.8.2	Final inspection	27
4.9	Resistance to soldering heat	27
4.9.1	Initial measurement	27
4.9.2	Test conditions	27
4.9.3	Recovery	28
4.9.4	Final inspection, measurements and requirements	28
4.10	Solderability	29
4.10.1	Test conditions	29
4.10.2	Recovery	30
4.10.3	Final inspection, measurements and requirements	30
4.11	Rapid change of temperature	30
4.11.1	Initial measurement	30
4.11.2	Number of cycles	30
4.11.3	Recovery	30
4.11.4	Final inspection, measurements and requirements	30
4.12	Climatic sequence.....	31
4.12.1	Initial measurement.....	31
4.12.2	Dry heat	31
4.12.3	Damp heat, cyclic, Test Db, first cycle	31
4.12.4	Cold	31
4.12.5	Damp heat, cyclic, Test Db, remaining cycles	31
4.12.6	Final inspection, measurements and requirements	31
4.13	Damp heat, steady state.....	32
4.13.1	Initial measurement	32
4.13.2	Conditions of test	32
4.13.3	Recovery	33
4.13.4	Final inspection, measurements and requirements	33
4.14	Endurance.....	33
4.14.1	Initial measurement	33
4.14.2	Conditions of test	33
4.14.3	Recovery	34
4.14.4	Final inspection, measurements and requirements	34
4.15	Robustness of terminations (only for capacitors with strip termination)	34
4.15.1	Test conditions	34
4.15.2	Final inspection and requirements	34
4.16	Component solvent resistance (if required).....	35

4.17 Solvent resistance of the marking (if required).....	35
4.18 Accelerated damp heat, steady state (if required).....	35
4.18.1 Initial measurement.....	35
4.18.2 Conditioning.....	35
4.18.3 Recovery.....	36
4.18.4 Final measurements.....	36
Annex A (normative) Guidance for the specification and coding of dimensions of fixed surface mount multilayer capacitors of ceramic dielectric, Class 1.....	37
Annex B (informative) Combination of temperature coefficient and tolerance for the reference temperature of 25 °C.....	38
Bibliography.....	39
Figure 1 – Fault: crack or fissure.....	22
Figure 2 – Fault: crack or fissure.....	22
Figure 3 – Separation or delamination.....	23
Figure 4 – Exposed electrodes.....	23
Figure 5 – Principal faces.....	23
Figure 6 – Reflow temperature profile.....	28
Figure A.1 – Dimensions.....	37
Table 1 – Preferred tolerance on nominal capacitance.....	11
Table 2 – Nominal temperature coefficient and tolerance.....	12
Table 3 – Combination of temperature coefficient and tolerance.....	13
Table 4 – Fixed sample size test plan for qualification approval – Assessment level EZ.....	16
Table 5 – Tests schedule for qualification approval.....	17
Table 6a – Lot-by-lot inspection.....	21
Table 6b – Periodic tests.....	21
Table 7 – Tangent of loss angle limits.....	24
Table 8 – Test voltages.....	26
Table 9 – Temperature cyclic drift limits.....	26
Table 10 – Reflow temperature profiles for Sn-Ag-Cu alloy.....	28
Table 11 – Maximum capacitance change.....	29
Table 12 – Maximum capacitance change.....	31
Table 13 – Number of damp heat cycles.....	31
Table 14 – Final inspection measurements and requirements.....	32
Table 15 – Test conditions for damp heat, steady state.....	32
Table 16 – Final inspection measurements and requirements.....	33
Table 17 – Endurance test conditions ($U_C = U_R$).....	33
Table 18 – Endurance test conditions ($U_C \neq U_R$).....	34
Table 19 – Final inspection measurements and requirements.....	34
Table 20 – Initial requirements.....	35
Table 21 – Conditioning.....	35
Table B.1 – Combination of temperature coefficient and tolerance for the reference temperature of 25 °C.....	38

INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –**Part 21: Sectional specification –
Fixed surface mount multilayer capacitors
of ceramic dielectric, Class 1**

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 itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 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 60384-21 has been prepared by IEC technical committee 40: Capacitors and resistors for electronic equipment.

This second edition cancels and replaces the first edition published in 2004 and contains the following significant technical changes with respect to the previous edition:

- The test voltage of $1,2 U_R$ at $U_R \geq 1\,000\text{ V}$ has been added in 4.5.4 Voltage proof.
- Detail test conditions have been added in 4.7 Shear test and 4.8 Substrate bending test.
- Test conditions applying lead free solder alloy (Sn-Ag-Cu) have been included in 4.9 Resistance to soldering heat and 4.10 Solderability.
- A selection of the test conditions according to marketing needs have been stated in 4.13 Damp heat, steady state.
- The dimensions of 0402 M in Annex A have been added.

- The code of the temperature coefficient and the tolerance of capacitance for the reference temperature of 25 °C have been added, see Annex B.

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

FDIS	Report on voting
40/2127/FDIS	40/2140/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.

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

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

The committee has decided that the contents of this publication will remain unchanged until the stability 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.

<https://standards.iteh.ai/catalog/standards/sist/7779cae-0497-4acc-b6de-0b091c25391b/iec-60384-21-2011>

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 21: Sectional specification – Fixed surface mount multilayer capacitors of ceramic dielectric, Class 1

1 General

1.1 Scope

This part of IEC 60384 is applicable to fixed unencapsulated surface mount multilayer capacitors of ceramic dielectric, Class 1, for use in electronic equipment. These capacitors have metallized connecting pads or soldering strips and are intended to be mounted on printed boards, or directly onto substrates for hybrid circuits.

Capacitors for electromagnetic interference suppression are not included, but are covered by IEC 60384-14.

1.2 Object

The object of this standard is to prescribe preferred ratings and characteristics and to select from IEC 60384-1 the appropriate quality assessment procedures, tests and measuring methods and to give general performance requirements for this type of capacitor. Test severities and requirements prescribed in detail specifications referring to this sectional specification should be of equal or higher performance level, lower performance levels are not permitted.

1.3 Normative references

The following reference 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 60063:1963, *Preferred number series for resistors and capacitors*
Amendment 1 (1967)
Amendment 2 (1977)

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-58:2004, *Environmental testing – Part 2-58: Tests – Test Td – Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60384-1:2008, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 61193-2:2007, *Quality assessment systems – Part 2: Selection and use of sampling plans for inspection of electronic components and packages*

ISO 3:1973, *Preferred numbers – Series of preferred numbers*

1.4 Information to be given in a detail specification

The detail specification 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.

NOTE The information given in 1.4.1 may, be presented in tabular form if more convenient.

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

There shall be an illustration of the capacitors as an aid to easy recognition and for comparison of the capacitors with others.

Dimensions and their associated tolerances, which affect interchangeability and mounting, shall be given in the detail specification. All dimensions shall preferably be stated in millimetres, however, when the original dimensions are given in inches, the converted metric dimensions in millimetres shall be added.

Normally the numerical values shall be given for the length, width and height of the body. When necessary, for example when a number of items (sizes and capacitance/voltage ranges) 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 capacitors.

1.4.2 Mounting

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

1.4.3 Rating 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 Nominal capacitance range

See 2.2.4.1.

NOTE When products approved to the detail specification have different ranges, the following statement should be added: "The range of capacitance values available in each voltage range is given in the register of approvals, available for example on the website www.iecq.org."

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, severity and requirements applicable for the solderability and the resistance to soldering heat tests.

1.4.4 Marking

The detail specification shall specify the content of the marking on the capacitor and on the package. Deviations from 1.6 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

fixed capacitors, ceramic dielectric, Class 1

capacitor specially designed and suited for resonant circuit application where low losses and high stability of capacitance are essential or where a precisely defined temperature coefficient is required, for example for compensating temperature effects in the circuit

NOTE The ceramic dielectric is defined by its rated temperature coefficient (α).

1.5.3

subclass

for a given nominal temperature coefficient, the subclass is defined by the tolerance on the temperature coefficient (see Table 2)

NOTE The nominal temperature coefficient value and its tolerance refer to the temperature interval of +20 °C to +85 °C, but because in practice TC curves are not strictly linear, it is necessary to define limiting capacitance deviation ($\Delta C/C$) for other temperatures (see Table 3).

1.5.4

category temperature range

range of ambient temperatures for which the capacitor has been designed to operate continuously; this is given by the lower and upper category temperature

1.5.5

rated temperature

T_R

maximum ambient temperature at which the rated voltage may be continuously applied

1.5.6

rated d.c. voltage

U_R

maximum d.c. voltage which may be applied continuously to a capacitor at any temperature between the lower category temperature and the rated temperature

NOTE Maximum d.c. voltage is the sum of the d.c. voltage and peak a.c. voltage or peak pulse voltage applied to the capacitor.

1.5.7

category voltage

U_C

maximum voltage which may be applied continuously to a capacitor at its upper category temperature

1.6 Marking

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

1.6.1 Information for marking

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:

- nominal capacitance;
- rated voltage (d.c. voltage may be indicated by the symbol $\overline{\text{---}}$ or $\underline{\text{---}}$);
- tolerance on nominal capacitance;
- temperature coefficient and its tolerance as applicable (according to 2.2.5);
- year and month (or week) of manufacture;
- manufacturer's name or trade mark;
- climatic category;
- manufacturer's type designation;
- reference to the detail specification.

1.6.2 Marking on the body

These capacitors are generally not marked on the body. If some markings can be applied, they shall be clearly marked with as many as possible of the above items as is considered useful. Any duplication of information in the marking on the capacitor should be avoided.

1.6.3 Requirements for marking

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

1.6.4 Marking of the packaging

The packaging containing the capacitor(s) shall be clearly marked with all the information listed in 1.6.1.

1.6.5 Additional marking

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 the detail specification shall preferably be selected from the following.

2.1.1 Preferred climatic categories

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

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

- lower category temperature: -55 °C , -40 °C , -25 °C , -10 °C and $+10\text{ °C}$;
- upper category temperature: $+70\text{ °C}$, $+85\text{ °C}$, $+100\text{ °C}$, $+125\text{ °C}$ and $+150\text{ °C}$;
- duration of the damp heat, steady state test (40 °C , 93 % RH): 4, 10, 21 and 56 days.

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

NOTE The resistance to humidity resulting from the above climatic category is for the capacitors in their unmounted state. The climatic performance of the capacitors after mounting is greatly influenced by the mounting substrate, the mounting method (see 4.3) and the final coating.

2.2 Preferred values of ratings

2.2.1 Rated temperature (T_R)

For capacitors covered by this sectional specification, the rated temperature is equal to the upper category temperature, unless the upper category temperature exceeds 125 °C.

2.2.2 Rated voltage (U_R)

The preferred values of the rated voltage are the values of the R5 series of ISO 3. If other values are needed they shall be chosen from the R10 series.

The sum of the d.c. voltage and the peak a.c. voltage or the peak-to-peak a.c. voltage, whichever is the greater, applied to the capacitor shall not exceed the rated voltage. The value of the peak a.c. voltage shall not exceed the value determined by the permissible reactive power.

2.2.3 Category voltage (U_C)

When the rated temperature is defined as the upper category temperature, the category voltage is equal to the rated voltage as defined in IEC 60384-1, 2.2.5. If the upper category temperature exceeds 125 °C, or the rated voltages exceed 500 V, the category voltage shall be given in the detail specification.

2.2.4 Preferred values of nominal capacitance and associated tolerance values

2.2.4.1 Preferred values of nominal capacitance

Nominal capacitance values shall be taken from the series of IEC 60063; the E6, E12 and E24 series are preferred.

2.2.4.2 Preferred tolerance on nominal capacitance

See Table 1.

Table 1 – Preferred tolerance on nominal capacitance

Preferred series	Tolerance			
	$C_N \geq 10$ pF	Letter code	$C_N < 10$ pF	Letter code
E6	±20 %	M	±2 pF	G
E12	±10 %	K	±1 pF	F
E24	±5 %	J	±0,5 pF	D
	±2 %	G	±0,25 pF	C
	±1 %	F	±0,1 pF	B

2.2.5 Temperature coefficient (α)

2.2.5.1 Nominal temperature coefficient and tolerance

Table 2 shows the preferred nominal temperature coefficients and the associated tolerances, expressed in parts per million per degree Kelvin ($10^{-6}/K$), and the corresponding subclasses and codes.

The detail specification shall specify for each temperature coefficient the minimum value of capacitance for which the given tolerance of temperature coefficient may be varied, considering the accuracy of the method of capacitance measurement specified.

For values of capacitance lower than this minimum value:

- a) the detail specification shall specify a multiplying factor for the tolerance on α , as well as the permissible changes of capacitance at the lower and upper category temperature;
- b) special methods of measurement may be necessary and if required shall be tested in the detail specification.

Table 2 – Nominal temperature coefficient and tolerance

Nominal temperature coefficient ($10^{-6}/K$)	Tolerance on temperature coefficient ($10^{-6}/K$)	Subclass	Letter code for	
			α	Tolerance
<u>+100</u>	± 30	1B	A	G
<u>0</u>	± 30	1B	C	G
<u>-33</u>	± 30	1B	H	G
<u>-75</u>	± 30	1B	L	G
<u>-150</u>	± 30	1B	P	G
<u>-220</u>	± 30	1B	R	G
<u>-330</u>	± 60	1B	S	H
<u>-470</u>	± 60	1B	T	H
<u>-750</u>	± 120	1B	U	J
<u>-1 000</u>	± 250	1F	Q	K
<u>-1 500</u>	± 250	1F	V	K
$+140 \geq \alpha \geq -1 000$	^a	1C	SL	-

NOTE 1 Preferred temperature coefficient values (α) are underlined.

NOTE 2 The nominal temperature coefficients and their tolerances are defined using the capacitance change between the temperatures 20 °C and 85 °C.

NOTE 3 A capacitor with a temperature coefficient $0 \times 10^{-6}/K$ and a tolerance on temperature coefficient of $\pm 30 \times 10^{-6}/K$ is designated as a CG capacitor (subclass 1B).

^a This temperature coefficient value is not subject to inspection, since no limits for relative capacitance variation are specified in Table 3.

NOTE See Annex B for the reference temperature of 25 °C as informative guide.

2.2.5.2 Permissible relative variation of capacitance

Table 3 shows for each combination of temperature coefficient and tolerance the permissible relative variation of capacitance expressed in parts per thousand at both the upper and lower category temperatures. Temperature coefficients and tolerances are expressed in parts per million per degree Kelvin ($10^{-6}/K$).

Table 3 – Combination of temperature coefficient and tolerance

		Permissible relative variation in capacitance in parts per 1 000 between 20 °C and given temperature							
		Lower category temperature				Upper category temperature			
α 10 ⁻⁶ /K	Tolerance 10 ⁻⁶ /K	-55 °C	-40 °C	-25 °C	-10 °C	+70 °C	+85 °C	+100 °C	+125 °C
+100	±30(G)	-9,75/ -3,71	-7,80/ -2,96	-5,85/ -2,22	-3,90/ -1,48	3,50/ 6,50	4,55/ 8,45	5,60/ 10,4	7,35/ 13,7
<u>0</u>	±30(G)	-2,25/ 5,45	-1,80/ 4,36	-1,35/ 3,27	-0,90/ 2,18	-1,50/ 1,50	-1,95/ 1,95	-2,40/ 2,40	-3,15/ 3,15
-33	±30(G)	0,225/ 8,47	0,180/ 6,77	0,135/ 5,08	0,090/ 3,39	-3,15/ -0,15	-4,10/ -0,195	-5,04/ -0,240	-6,62/ -0,32
-75	±30(G)	3,38/ 12,3	2,70/ 9,85	2,03/ 7,39	1,35/ 4,92	-5,25/ -2,25	-6,83/ -2,93	-8,40/ -3,60	-11,0/ -4,73
<u>-150</u>	±30(G)	9,00/ 19,2	7,20/ 15,3	5,40/ 11,5	3,60/ 7,67	-9,00/ -6,0	-11,7/ -7,80	-14,4/ -9,60	-18,9/ -12,6
-220	±30(G)	14,3/ 25,6	11,4/ 20,46	8,55/ 15,3	5,70/ 10,2	-12,5/ -9,50	-16,2/ -12,4	-20,0/ -15,2	-26,3/ -20,0
-330	±60(H)	20,3/ 38,4	16,2/ 30,7	12,2/ 23,0	8,10/ 15,4	-19,5/ -13,5	-25,4/ -17,6	-31,2/ -21,6	-41,0/ -28,4
-470	±60(H)	30,8/ 51,2	24,6/ 41,0	18,5/ 30,7	12,3/ 20,5	-26,5/ -20,5	-34,5/ -26,7	-42,4/ -32,8	-55,7/ -43,1
<u>-750</u>	±120(J)	47,3/ 82,3	37,8/ 65,8	28,4/ 49,4	18,9/ 32,9	-43,5/ -31,5	-56,6/ -41,0	-69,6/ -50,4	-91,4/ -66,2
-1 000	±250(K)	56,3/ 117	45,0/ 93,7	33,8/ 70,2	22,5/ 46,8	-62,5/ -37,5	-81,3/ -48,8	-100/ -60,0	-131/ -78,8
-1 500	±250(K)	93,8/ 163	75,0/ 130	56,3/ 97,7	37,5/ 65,1	-87,5/ -62,5	-114/ -81,3	-140/ -100	-184/ -131

When the upper category temperature is above 125 °C, the limits shall be given in the detail specification.

NOTE 1 Preferred temperature coefficient values (α) are underlined.

NOTE 2 The temperature coefficient limits at the temperature range from 20 °C to the upper category temperature are calculated by the nominal temperature coefficients and their tolerances (see formula a) of NOTE 3).

The temperature coefficient limits at the temperature range from 20 °C to -55 °C are calculated by using the formula b) and c) of NOTE 3.

NOTE 3 The capacitance deviations at the lower category temperature are obtained by using following formulas:

- a) upper and lower permissible relative variation in capacitance under upper category temperature:

$$\Delta C/C (10^{-3}) = (\text{nominal temperature coefficient} \pm \text{tolerance on temperature coefficient}^*) \times (\text{upper category temperature} - 20)/1\ 000$$

- b) lower permissible relative variation in capacitance under lower category temperature:

$$\Delta C/C (10^{-3}) = (\text{nominal temperature coefficient} + \text{tolerance on temperature coefficient}^*) \times (\text{lower category temperature} - 20)/1\ 000$$

- c) upper permissible relative variation in capacitance under lower category temperature:

$$\Delta C/C (10^{-3}) = [(-36) - (1,22 \times \text{tolerance on temperature coefficient}^*) + (0,22 \times \text{nominal temperature coefficient} + \text{nominal temperature coefficient}) \times (\text{lower category temperature} - 20)/1\ 000 \text{ where, Tolerance on temperature coefficient}^*: \text{absolute value.}$$