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INTERNATIONAL STANDARD

colour
inside

Fixed capacitors for use in electronic equipment –
Part 17: Sectional specification – Fixed metallized polypropylene film dielectric AC and pulse capacitors

IEC 60384-17:2019-03 RLV(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 17: Sectional specification – Fixed metallized polypropylene film dielectric AC and pulse capacitors

FOREWORD

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International Standard IEC 60384-17 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 2005. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) all parts of the document have been revised based on the ISO/IEC Directives, Part 2:2016 (seventh edition) and harmonization between other similar kinds of documents;
b) tables and Clause 4 have been revised so as to prevent duplications and contradictions;
c) new damp heat steady-state robustness classes with test conditions have been added in text, in Clause 4 and in Annex A.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
40/2654/FDIS	40/2664/RVD

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

This document 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 document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

The contents of the corrigendum of December 2020 have been included in this copy.

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FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 17: Sectional specification – Fixed metallized polypropylene film dielectric AC and pulse capacitors

1 General

1.1 Scope

This part of IEC 60384 applies to fixed capacitors with metallized electrodes and polypropylene dielectric for use in electronic equipment.

NOTE Capacitors that have mixed ~~foil~~ film and metallized electrodes are also within the scope of this standard.

These capacitors may have "self-healing" properties depending on conditions of use.

Capacitors covered by this specification are mainly intended for use with alternating voltage and/or for pulse applications. The maximum reactive power applicable is 10 000 var and the maximum peak voltage is 3 000 V.

Capacitors for reactive power exceeding 500 var, and to which a maximum peak voltage of 2 500 V at 50 Hz can be applied, are not covered by this document, except when they are the highest part of a range of reactive power mainly situated below 500 var at 50 Hz.

This document is not intended to cover capacitance values higher than 20 μF.

Two performance grades of capacitors are covered, Grade 1 for long-life application and Grade 2 for general application.

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

Capacitors for electrical shock hazard protection (covered by IEC 60065 of IEC technical committee 61) and fluorescent lamp and motor capacitors (covered by IEC 60252-1 and IEC 60252-2 of IEC technical committee 33), and capacitors for use in tubular fluorescent and other discharge lamp circuits (covered by IEC 61048 and IEC 61049 of IEC technical committee 34) are also excluded.

1.2 Object

The object of this document is to prescribe preferred ratings and characteristics and to select from IEC 60384-1:2016, 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 shall be of ~~an~~ equal or higher performance level~~, because~~. Lower performance levels are not permitted.

1.3 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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*

~~IEC 60063:1963, *Preferred number series for resistors and capacitors*~~
~~Amendment 1 (1967)~~
~~Amendment 2 (1977)~~

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60384-1:2016, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 60384-16, *Fixed capacitors for use in electronic equipment – Part 16: Sectional specification: Fixed metallized polypropylene film dielectric d.c. capacitors*

~~IEC 60384-17-1, *Fixed capacitors for use in electronic equipment – Part 17: Blank detail specification: Fixed metallized polypropylene film dielectric a.c. and pulse capacitors. Assessment level E*~~

~~IEC 60410, *sampling plans and procedures for inspection by attributes*~~

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

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

1.4 Information to be given in a detail specification

1.4.1 General

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.

~~NOTE~~ The information given in 1.4.2 may, for convenience, be presented in tabular form.

The information in 1.4.2 to 1.4.4 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.

1.4.2 Outline drawing and dimensions

There shall be 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 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 of the body, the width and height of the body and the wire spacing, or for cylindrical types, the body diameter, and the length and diameter of the terminations. When necessary, for example when a number of items (capacitance values/voltage ranges) are covered by a detail specification, the dimensions and their associated tolerances shall be placed in a table below the drawing.~~

The numerical values of the body shall be given as follows:

– general case: width, length and height;

– for cylindrical body: diameter and length.

The numerical values of the terminals shall be given as follows:

– width or diameter, length and spacing.

When necessary, for example when a number of items (sizes and capacitance ~~values~~/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 capacitor. When the capacitor is not designed for use on printed boards, this shall be clearly stated in the detail specification.

1.4.3 Mounting

The detail specification shall specify the method of mounting to be applied for normal use and for the application of the vibration and the bump or shock tests. The capacitors shall be mounted by their normal means. The design of the capacitor may be such that special mounting fixtures are required in its use. In this case, the detail specification shall describe the mounting fixtures and they shall be used in the application of the vibration and bump or shock tests.

1.4.4 Ratings and characteristics

1.4.4.1 General

The ratings and characteristics shall be in accordance with the ~~relevant~~ clauses of this specification, ~~together with the following~~ including the items as specified in 1.4.4.2 to 1.4.4.5.

1.4.4.2 ~~Rated~~ Nominal 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 IEC QC 001005."~~

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

1.4.4.3 Sinusoidal current (if applicable)

The detail specification shall state the derating curve of the sinusoidal current versus temperature with reference to 70 °C, and the derating curve of the sinusoidal current versus frequency and of the sinusoidal current versus capacitance.

1.4.4.4 Particular characteristics

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

1.4.4.5 Soldering

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

1.4.5 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.~~

The detail specification shall specify the content of the marking on the capacitor and on the packaging. When there are deviations from 1.6, these shall be given in the detail specification.

1.5 Terms and definitions

1.5.1 General

For the purposes of this document, the applicable terms and definitions of IEC 60384-1:2016, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

1.5.2 Performance and stability grades

The performance grade describes the capacitor's ability to function in the intended applications. The stability grade describes capacitance drift in tests.

1.5.2.1
performance grade 1 capacitors
<long-life> capacitors~~ intended~~ for long-life applications with stringent requirements for the electrical parameters

1.5.2.2
performance grade 2 capacitors
<general purpose> capacitors for general application where the stringent requirements~~ of performance~~ for grade 1 capacitors are not necessary

1.5.2.3
stability grade
capacitance drift after climatic and mechanical tests and after endurance tests

Note 1 to entry: The performance grade and the stability grade~~ must~~ shall be noted in the detail specification.

1.5.2.4
performance grade and stability grade combination~~s (if stability grade is required for a.c. and pulse capacitors)~~
designation for combined performance grade and stability grade

Note 1 to entry: ~~see the table below for preferred values.~~ Table 1 shows the preferred combination designations.

Table 1 – Preferred ~~values~~ designations of performance grade and stability grade combinations

Performance grades	Stability grades	Combination designations
1	1	1.1
	2	1.2
2	–	2

The three combinations concern capacitance stability and tan δ values. Distinction in performance of the three combinations is shown in Table 4.

1.5.3 Rated voltages

1.5.3.1 General

~~NOTE~~ The sum of the DC voltage and the peak AC voltage or the peak pulse voltage applied to the capacitor ~~must~~ shall not exceed the rated voltage. The value of the peak AC voltage allowed at different frequencies is under consideration.

1.5.3.2
rated DC voltage
maximum DC voltage that may be applied continuously to a capacitor at the rated temperature

1.5.3.3
rated AC voltage
maximum RMS alternating voltage that may be applied continuously to a capacitor at the rated temperature and at a given frequency

1.5.3.4
rated pulse voltage
peak value of the pulse voltage that may be applied continuously to a capacitor at the rated temperature and at a given frequency

1.5.3.5
rated voltage pulse slope ~~(if applicable)~~
maximum admissible value of the voltage slope $\frac{\mathrm{d}U}{\mathrm{d}t}$ of a pulse at the rated temperature at such a repetition frequency that no significant increase of temperature occurs

Note 1 to entry: The formula for rated voltage pulse slope is $\frac{(\mathrm{d}U)}{(\mathrm{d}t)_\mathrm{R}}$

1.6 Marking

1.6.1 General

See IEC 60384-1:2016, 2.4, with the details given in 1.6.2 to 1.6.5.

1.6.2 Information for marking

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) ~~rated~~ nominal capacitance (in clear or code in accordance with IEC 60062);

b) rated AC and/or pulse voltage (AC voltage may be indicated by the symbol ∼ (IEC 60417-5032-2002-10)) and the corresponding frequency if different from 50 Hz;

c) tolerance on ~~rated~~ nominal capacitance;

d) rated DC voltage (DC voltage may be indicated by the symbol ⎓ or ―― (IEC 60417-5031-2002-10)) (if applicable);
e) rated voltage pulse slope (if applicable);
f) rated current and corresponding frequency (if applicable);
g) year and month (or year and week) of manufacture;
h) manufacturer's name and/or trade mark;
i) climatic category;
j) manufacturer's type designation;
k) reference to the detail specification.

1.6.3 Marking on capacitors

The capacitor shall be clearly marked with a), b) and c) of 1.6.2 with as many as possible of the remaining items as is considered necessary. Any duplication of information in the marking on the capacitor should be avoided.

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

1.6.4 Marking on packaging

The ~~package~~ packaging containing capacitor(s) ~~shall~~ should be clearly marked with all the information listed in 1.6.2 as applicable.

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

2.1.1 General

The values given in detail specifications shall preferably be selected from 2.2.1 to 2.2.8.

2.1.2 Preferred climatic categories

The capacitors covered by this specification are classified into climatic categories in accordance with the general rules given in IEC 60068-1:2013, Annex A.

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 and −10 °C;
- upper category temperature: +70°C, +85 °C, +100 °C, +105 °C, +110 °C and + 125 °C;
- duration of the damp heat, steady-state test: 4 d, 10 d, 21 d and 56 d.

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

If specified in the detail specification, the humidity robustness grade according to Annex A should be given in connection with the climatic category.

2.2 Preferred values of ratings

2.2.1 ~~Rated~~ Nominal capacitance (~~C_{R}~~ C_{N})

Preferred values of ~~rated~~ nominal capacitance are values chosen from the E series of ~~preferred values given in~~ IEC 60063 which are given in Table 2, and their decimal multiples (× 10^n, where n is an integer).

2.2.2 Tolerance~~s~~ on ~~rated~~ nominal capacitance

The preferred tolerances on the ~~rated~~ nominal capacitance are ±20 %; ±10 %; ±5 %; ±2 %; ±1 %.

2.2.3 ~~Rated~~ Nominal capacitance with associated tolerance values

For preferred combinations of capacitance series and tolerances, see Table 2.

Table 2 – Preferred combinations of capacitance series and tolerance

Preferred combinations	
Series	**Tolerances**
E 6	±20 %
E 12	±10 %
E 24	±5 %
E 48	±2 %
E 96	±1 %

2.2.4 Rated AC voltage (U_{RAC} or $U_{\mathrm{R}\sim}$)

The frequency for the rated AC voltage shall be 50 Hz/60 Hz unless the detail specification prescribes a higher frequency.

The preferred values of rated AC voltage (RMS value) shall be chosen from the R10 or R20 series given in ISO 3.

The detail specification shall give the derating curve of the admissible RMS voltage versus temperature (higher than rated temperature) and, if applicable, versus frequency.

2.2.5 Category AC voltage (U_{CAC} or $U_{\mathrm{C}\sim}$)

The category AC voltage is equal to the rated AC voltage U_{RAC} for upper category temperatures up to 85 °C. For an upper category temperature ~~> 85~~ 100 °C, the category AC voltage is 0,7 U_{RAC}. For upper category temperatures > 100 °C, the category AC voltage will be calculated following the slope from U_{RAC} at 85 °C to 0,7 U_{RAC} at 100 °C for each temperature (for example 105 °C, 110 °C or 125 °C).

Figure 1 gives the category AC voltage ratio to rated AC voltage as a function of upper category temperature.

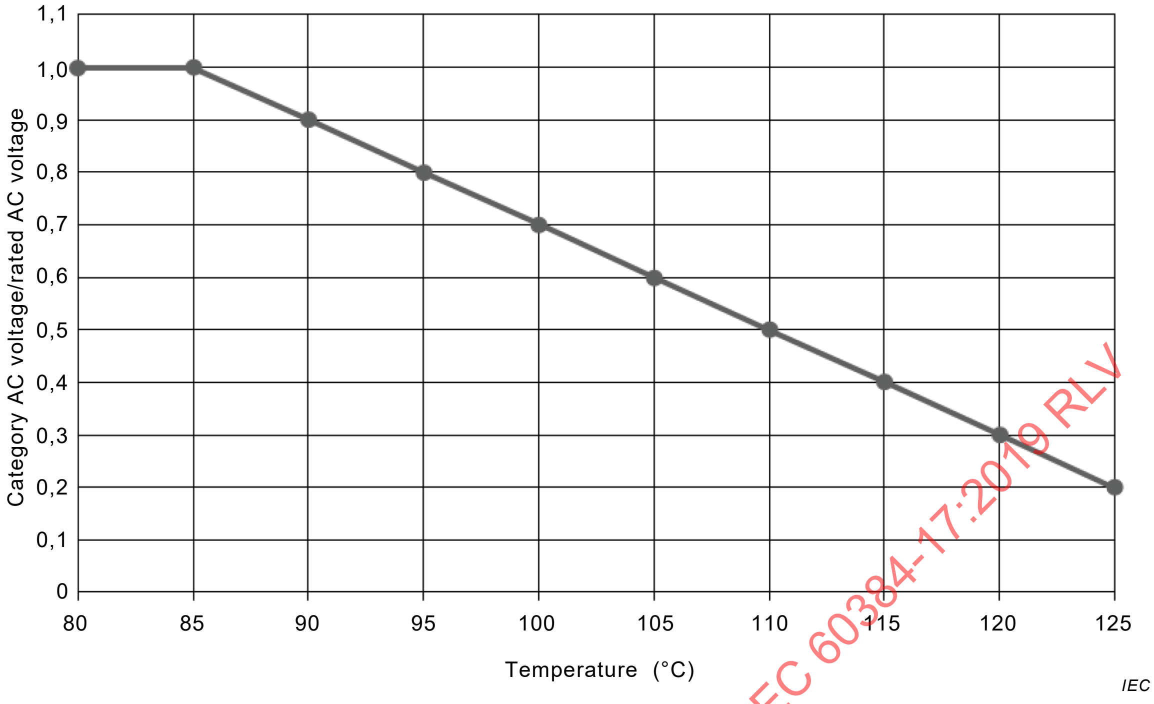

Figure 1 – Category AC voltage/rated AC voltage versus upper category temperature

2.2.6 Rated temperature

The standard value for rated temperature is 85 °C. Except for an upper category temperature of 70 °C, the rated temperature is 70 °C.

NOTE ~~AC rated temperature is 15 °C less than d.c. rated temperature.~~ For DC rated voltage, the rated temperature is 15 °C higher than for AC rated voltage.

2.2.7 Rated AC current (~~when required in the detail specification~~ if required)

The detail specification shall state:

- the frequency;
- the RMS value of the rated AC current applicable at the specified frequency (value chosen from R10 or R20 series);
- the derating curve of the admissible AC current versus ambient temperature.

2.2.8 Rated pulse voltage (if required)

The detail specification shall state:

- voltage pulse slope
- duration of the pulse
- repetition frequency of the pulses

3 Quality assessment procedures

3.1 Primary stage of manufacture

The primary stage of manufacture is the winding of the capacitor element or the equivalent operation.

3.2 Structurally similar components

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

3.3 Certified test records of released lots

The information required in IEC 60384-1:2016, ~~3.9~~ Q.1.5 shall be made available when prescribed in the detail specification and when requested by a purchaser. After the endurance test, the required parameters ~~for which variables information is required~~ are the capacitance ~~change,~~ and tan δ. The insulation resistance is only required by attribute.

3.4 Qualification approval procedures

3.4.1 General

The procedures for qualification approval testing are given in ~~the generic specification~~ IEC 60384-1:2016, ~~3.5~~ Q.2.

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

3.4.2 Qualification approval on the basis of the fixed sample size procedure

3.4.2.1 Sampling

The fixed sample size procedure is described in IEC 60384-1:2016, ~~3.5.3 b)~~ Q.2.4. 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 may be the whole or part of the range given in the detail specification.

The sample shall consist of four specimens having the ~~lowest~~ maximum and ~~highest~~ minimum rated voltages, and, for these voltages, the ~~lowest~~ maximum and ~~highest~~ minimum capacitances. When there are more than four rated voltages, an intermediate voltage shall also be tested. Thus, for the approval of a range, testing is required of either four or six values (capacitance/voltage combinations). When the range consists of ~~less~~ fewer 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 that 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 3 gives the number of samples to be tested ~~in~~ for each group ~~or subgroup together~~ with the permissible number of ~~defectives~~ non-conforming items for qualification approval tests.

3.4.2.2 Tests

The complete series of tests specified in Table 3 and Table 4 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.

Specimens found ~~defective during~~ to be non-conforming in the tests of Group 0 shall not be used for the other groups.

~~"One defective" is counted when a capacitor has not satisfied the whole or a part of the tests of a group.~~

~~The approval is granted when the number of defectives does not exceed the specified number of permissible defectives for each group or subgroup and the total number of permissible defectives.~~

~~NOTE Tables 3 and 4 together form the fixed sample size test schedule, for which Table 3 includes the details for the sampling and permissible defectives for the different tests or groups of tests, whereas Table 4 together with the details of tests contained in Clause 4 gives a complete summary of test conditions and performance requirements and indicates where, for example for the test method or conditions of test a choice has to be made in the detail specification.~~

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

Approval is granted when the number of non-conforming items is zero.

Table 3 and Table 4 together form the fixed sample size test schedule for the qualification approval on the basis of the fixed sample size procedure.

Table 3 gives the number of the samples and permissible non-conforming items for each test and test group.

Table 4 gives a summary of the test conditions and performance requirements, and choices of the test conditions and performance requirements in the detail specification.

The test conditions and performance requirements for the qualification approval on the basis of the fixed sample size procedure should be identical to those for quality conformance inspections given in the detail specification.

~~Table 3 – Sampling plan together with numbers of permissible defectives for qualification approval tests for a.c. and pulse capacitors~~

~~Group No.~~	~~Test~~	~~Subclause of this publication~~	~~Number of specimens (*n*) and number of non-conformances (*c*)~~						
			~~Per value[c]~~	~~For four or less values to be tested[c]~~			~~For six values to be tested[c]~~		
			~~*n*~~	~~4 *n*~~	~~*c*~~	~~*c* total~~	~~6 *n*~~	~~*c*~~	~~*c* total~~
~~0~~	~~Visual examination~~	~~4.1~~							
	~~Marking~~	~~1.6~~							
	~~Dimensions~~	~~4.1~~							
	~~Capacitance~~	~~4.2.2~~	~~29~~	~~116~~	~~2[b]~~		~~174~~	~~3[b]~~	
	~~Tangent of loss angle~~	~~4.2.3~~							
	~~Voltage proof~~	~~4.2.1~~	~~(+5)[e]~~	~~(+20)[e]~~			~~(+30)[e]~~		
	~~Insulation resistance~~	~~4.2.4~~	~~(+5)[e]~~	~~(+20)[e]~~			~~(+30)[e]~~		
	~~Inductance[e]~~	~~4.2.5~~							
	~~Sealing[e]~~								
	~~Spare specimens~~		~~2~~	~~8~~			~~12~~		
~~1A~~	~~Robustness of terminations~~ ~~Resistance to soldering heat~~ ~~Component solvent resistance~~	~~4.3~~ ~~4.4~~ ~~4.14~~	~~3~~	~~12~~	~~1~~		~~18~~	~~1~~	
~~1B~~	~~Solderability~~ ~~Solvent resistance of the marking~~ ~~Rapid change of temperature~~ ~~Vibration~~ ~~Bump or shock[a]~~	~~4.5~~ ~~4.15~~ ~~4.6~~ ~~4.7~~ ~~4.8 or 4.9~~	~~6~~	~~24~~	~~1~~		~~36~~	~~2[b]~~	
~~1~~	~~Climatic sequence~~	~~4.10~~	~~9~~	~~36~~	~~2~~	~~4~~	~~54~~	~~3~~	~~6~~
~~2~~	~~Damp heat, steady state~~	~~4.11~~	~~5~~	~~20~~	~~1~~		~~30~~	~~2[b]~~	
~~3~~	~~Endurance test at 50 Hz/60 HZ alternating voltage~~	~~4.12.1~~	~~10~~	~~40~~	~~3[b]~~		~~60~~	~~4[b]~~	
	~~Endurance test with sinusoidal current or voltage[e]~~	~~4.12.2~~	~~5~~	~~20~~	~~1[b]~~		~~30~~	~~2[b]~~	
	~~Pulse endurance test[e]~~	~~4.12.3~~	~~5~~	~~20~~	~~1[b]~~		~~30~~	~~2[b]~~	
~~4~~	~~Temperature characteristics[e]~~ ~~Charge and discharge[d]~~	~~4,2,6~~ ~~4.13~~	~~5~~	~~20~~	~~1~~		~~30~~	~~2~~	

~~[a] As required in the detail specification.~~

~~[b] Not more than one defective is permitted from any one value.~~

~~[c] Capacitance-voltage combinations, see 3.4.1.~~

~~[d] Not required when pulse endurance test is required.~~

~~[e] If required in the detail specification.~~

Table 3 – Test and sampling plan for qualification approval, assessment level EZ

Group No.	Test	Subclause	Number of specimens (n) and permissible number of non-conforming items (c)			
			Per value[b] n	For four or less values to be tested[b] 4 n	For six values to be tested[b] 6 n	c
0	Visual examination	4.1	29	116	174	0
	Marking	1.6				
	Dimensions	4.1				
	Capacitance	4.2.2				
	Tangent of loss angle	4.2.3				
	Voltage proof	4.2.1				
	Insulation resistance	4.2.4				
	Inductance [d]	4.2.5	(+5)[d]	(+20)[d]	(+30)[d]	
	Sealing [d]	4.16	(+5)[d]	(+20)[d]	(+30)[d]	
	Spare specimens		2	8	12	
1A	Robustness of terminations	4.3	3	12	18	
	Resistance to soldering heat	4.4				
	Component solvent resistance [d]	4.14				
1B	Solderability	4.5	6	24	36	
	Solvent resistance of the marking	4.15				
	Rapid change of temperature	4.6				
	Vibration	4.7				
	Bump or shock [a]	4.8 or 4.9				
1	Climatic sequence	4.10	9	36	54	
2	Damp heat, steady state without voltage	4.11	5	20	30	
	Damp heat, steady state with voltage [d]		(+5)[d]	(+20)[d]	(+30)[d]	
3A	Endurance test at 50 Hz/60 Hz alternating voltage	4.12.1	10	40	60	
3B[e]	Endurance test with sinusoidal current or voltage [d]	4.12.2	(+5)[d]	(+20)[d]	(+30)[d]	
3C[e]	Pulse endurance test [d]	4.12.3	(+5)[d]	(+20)[d]	(+30)[d]	
4	Characteristics depending on temperature [d]	4.2.6	(+5)[d]	(+20)[d]	(+30)[d]	
	Charge and discharge [c]	4.13	5[c]	20[c]	30[c]	

[a] As required in the detail specification.

[b] Capacitance-voltage combinations, see 3.4.2.

[c] Not required when pulse endurance test is required.

[d] If required in the detail specification.

Table 4 – Test schedule for qualification approval *(1 of 8)*

~~**Subclause number and test**~~[a]	~~**D or ND**~~[b]	~~**Conditions of test**~~[a]	~~**Number of specimens (n) and number of permissible non-conformances (c)**~~	~~**Performance requirements**~~[a]
~~**Group 0**~~	~~ND~~		~~See Table 3~~	
~~4.1 Visual examination~~				~~As in 4.1~~ ~~Legible marking and as specified in the detail specification~~
~~4.1 Dimensions (detail)~~				~~See detail specification~~
~~4.2.2 Capacitance~~				~~Within specified tolerance~~
~~4.2.3 Tangent of loss angle (tan δ)~~		~~Frequency: 1 kHz~~		~~As in 4.2.3.2~~
~~4.2.1 Voltage proof~~		~~See detail specification for the method~~		~~No breakdown or flashover~~
~~4.2.4 Insulation resistance~~		~~See detail specification for for the method~~		~~As in 4.2.4.2~~
~~4.2.5 Inductance (if applicable)~~				~~Inductance: ≤... mH (see detail specification)~~
~~Sealing (if applicable)~~		~~See detail specification for the method~~		~~No seepage of impregnant or harmful deformation of the case~~
~~**Group 1A**~~	~~D~~		~~See Table 3~~	
~~4.3.1 Initial measurements~~		~~Capacitance~~ ~~Tangent of loss angle:~~ ~~For $C_R > 1$ µF: at 1 kHz~~ ~~$C_R \leq 1$ µF: at 10 kHz~~		
~~4.3 Robustness of terminations~~		~~Visual examination~~		~~No visible damage~~
~~4.4 Resistance to soldering heat~~		~~No pre-drying~~ ~~See detail specification for the method (1A or 1B)~~		
~~4.14 Component solvent resistance (if applicable)~~		~~Solvent: ...~~ ~~Solvent temperature: ...~~ ~~Method 2~~ ~~Recovery: ...~~		~~See detail specification~~
~~4.4.2 Final measurements~~		~~Visual examination~~		~~No visible damage~~ ~~Legible marking~~
		~~Capacitance~~		~~$\Delta C/C$ for Grade 1.1: ≤1 %~~ ~~Grade 1.2: ≤2 %~~ ~~Grade 2: ≤3 %~~ ~~of value measured in 4.3.1~~
		~~Tangent of loss angle~~		~~Increase of tan δ~~ ~~for $C \leq 1$ µF:~~ ~~for Grade 1.1: ≤0,001~~ ~~Grade 1.2: ≤0,002~~ ~~Grade 2: ≤0,004~~ ~~for $C > 1$ µF: see detail specification, compared to values measured in 4.3.1~~

~~Subclause number and test~~[a]	~~D or ND~~[b]	~~Conditions of test~~[a]	~~Number of specimens (n) and number of permissible non-conformances (c)~~	~~Performance requirements~~[a]
~~Group 1B~~	~~D~~		~~See Table 3~~	
~~4.5 Solderability~~		~~Without ageing~~ ~~See detail specification for the method~~		~~Good tinning as evidenced by free flowing of the solder with wetting of the terminations or solder shall flow within . . . s, as applicable~~
~~4.15 Solvent resistance of the marking (if applicable)~~		~~Solvent: ...~~ ~~Solvent temperature: ...~~ ~~Method 1~~ ~~Rubbing material: cotton wool~~ ~~Recovery: ...~~		~~Legible marking~~
~~4.6.1 Initial measurements~~		~~Capacitance~~ ~~Tangent of loss angle:~~ ~~For $C_R > 1$ µF: at 1 kHz~~ ~~$C_R \le 1$ µF: at 10 kHz~~		
~~4.6 Rapid change of temperature~~		~~T_A = Lower category temperature~~ ~~T_B = Upper category temperature~~ ~~Five cycles~~ ~~Duration t = 30 min~~ ~~Visual examination~~		~~No visible damage~~
~~4.7 Vibration~~		~~For mounting method see detail specification~~ ~~Procedure B4~~ ~~Frequency range: from . . . Hz to . . . Hz~~ ~~Amplitude: 0,75 mm or acceleration 98 m/s^2 (whichever is the less severe)~~ ~~Total duration: 6 h~~		
~~4.7.2 Final inspection~~		~~Visual examination~~		~~No visible damage~~
~~4.8 Bump (or shock, see 4.9)~~		~~For mounting method see detail specification~~ ~~Number of bumps: ...~~ ~~Acceleration: ... m/s^2~~ ~~Duration of pulse: ... ms~~		
~~4.9 Shock (or bump, see 4.8)~~		~~For mounting method see detail specification~~ ~~Number of bumps: ...~~ ~~Acceleration: ... m/s^2~~ ~~Duration of pulse: ... ms~~		
~~4.8.3 or 4.9.3 Final measurements~~		~~Visual examination~~		~~No visible damage~~
		~~Capacitance~~		~~$\Delta C/C$ for Grade 1.1: ≤1 %~~ ~~Grade 1.2: ≤2 %~~ ~~Grade 2: ≤3 %~~ ~~of value measured in 4.6.1~~
		~~Tangent of loss angle~~		~~Increase of tan δ:~~ ~~for $C \le 1$ µF:~~ ~~for Grade 1.1: ≤0,001~~ ~~Grade 1.2: ≤0,002~~ ~~Grade 2: ≤0,004~~ ~~for $C > 1$ µF: see detail specification, compared to values measured in 4.6.1~~
		~~Insulation resistance~~		~~≥50 % of values in 4.2.4.2~~

~~Subclause number and test~~[a]	~~D or ND~~[b]	~~Conditions of test~~[a]	~~Number of specimens (n) and number of permissible non-conformances (c)~~	~~Performance requirements~~[a]
~~**Group 1**~~	~~D~~		~~See Table 3~~	
~~4.10 Climatic sequence~~				
~~4.10.2 Dry heat~~		~~Temperature: upper category temperature~~ ~~Duration: 16 h~~		
~~4.10.3 Damp heat, cyclic, Test Db, first cycle~~				
~~4.10.4 Cold~~		~~Temperature: lower category temperature~~ ~~Duration: 2 h~~		
~~4.10.5 Low air pressure (if required by the detail specification)~~		~~Air pressure: 8 kPa~~		
~~4.10.5.3 Final measurement~~		~~Visual examination~~		~~No permanent breakdown, flashover or harmful deformation of the case~~
~~4.10.6 Damp heat, cyclic, Test Db, remaining cycles~~				
~~4.10.6.2 Final measurement~~		~~Visual examination~~		~~No visible damage~~ ~~Legible marking~~
		~~Capacitance~~		~~$\Delta C/C$ for Grade 1.1: ≤1 %~~ ~~Grade 1.2: ≤3 %~~ ~~Grade 2: ≤5 %~~ ~~of value measured in 4.4.2, 4.8.3 or 4.9.3 as applicable~~
		~~Tangent of loss angle~~		~~Increase of tan δ:~~ ~~for $C \leq 1$ µF:~~ ~~for Grade 1.1: ≤0,0015~~ ~~Grade 1.2: ≤0,003~~ ~~Grade 2: ≤0,005~~ ~~for $C > 1$ µF: see detail specification, compared to values measured in 4.3.1 or 4.6.1 as applicable~~
		~~Insulation resistance~~		~~≥50 % of values in 4.2.4.2~~
~~**Group 2**~~	~~D~~		~~See Table 3~~	
~~4.11 Damp heat, steady state~~				
~~4.11.1 Initial measurements~~		~~Capacitance~~ ~~Tangent of loss angle at 1 kHz~~		
~~4.11.3 Final measurements~~		~~Visual examination~~		~~No visible damage~~ ~~Legible marking~~
		~~Capacitance~~		~~$\Delta C/C$ for Grade 1.1: ≤1 %~~ ~~Grade 1.2: ≤3 %~~ ~~Grade 2: ≤5 %~~ ~~of value measured in 4.11.1~~

~~**Subclause number and test[a]**~~	~~**D or ND [b]**~~	~~**Conditions of test[a]**~~	~~**Number of specimens (n) and number of permissible non-conformances (c)**~~	~~**Performance requirements[a]**~~
~~**Group 2** *(continued)*~~			~~See Table 3~~ ↓	
		~~Tangent of loss angle~~		~~Increase of tan δ:~~ ~~for $C \leq 1$ µF:~~ ~~for Grade 1: ≤0,001~~ ~~Grade 2: ≤0,002~~ ~~for $C > 1$ µF: see detail specification, compared to values measured in 4.11.1~~
		~~Insulation resistance~~		~~≥50 % of values in 4.2.4.2~~
~~**Group 3A**~~	~~D~~		~~See Table 3~~ ↓	
~~4.12.1 Endurance test at 50/60 Hz alternating voltage (if applicable)~~		~~Duration:~~ ~~Grade 1: 2 000 h~~ ~~Grade 2: 1 000 h~~		
~~4.12.1.1 Initial measurements~~		~~Capacitance~~ ~~Tangent of loss angle~~ ~~For $C_R > 1$ µF: at 1 kHz~~ ~~$C_R \leq 1$ µF: at 10 kHz~~		
~~4.12.1.3 Final measurements~~		~~Visual examination~~		~~No visible damage~~ ~~Legible marking~~
		~~Capacitance~~		~~$\Delta C/C$ for Grade 1: ≤5 %~~ ~~Grade 2: ≤10 %~~ ~~of value measured in 4.12.1.1~~
		~~Tangent of loss angle~~		~~Increase of tan δ:~~ ~~for $C \leq 1$ µF:~~ ~~for Grade 1: ≤0,0015~~ ~~Grade 2: ≤0,003~~ ~~for $C > 1$ µF: see detail specification, compared to values measured in 4.12.1.1~~
		~~Insulation resistance~~		~~≥50 % of values in 4.2.4.2~~
~~**Group 3B** [c]~~	~~D~~		~~See Table 3~~ ↓	
~~4.12.2 Endurance test with sinusoidal current or voltage (if applicable)~~		~~Duration:~~ ~~Grade 1: 2 000 h~~ ~~Grade 2: 1 000 h~~ ~~Frequency:... Hz~~		
~~4.12.2.1 Initial measurements~~		~~Capacitance~~ ~~Tangent of loss angle~~ ~~For $C_R > 1$ µF: at 1 kHz~~ ~~$C_R \leq 1$ µF: at 10 kHz~~		
~~4.12.2.3 Final measurements~~		~~Visual examination~~		~~No visible damage~~ ~~Legible marking~~
		~~Capacitance~~		~~$\Delta C/C$ for Grade 1: ≤5 %~~ ~~Grade 2: ≤10 %~~ ~~of value measured in 4.12.2.1~~

~~Subclause number and test[a]~~	~~D or ND[b]~~	~~Conditions of test[a]~~	~~Number of specimens (n) and number of permissible non-conformances (c)~~	~~Performance requirements[a]~~
~~Group 3B[c] *(continued)*~~			~~See Table 3~~ ↓	
		~~Tangent of loss angle~~		~~Increase of tan δ:~~ ~~for $C \leq 1$ µF:~~ ~~for Grade 1: ≤0,0015~~ ~~Grade 2: ≤0,003~~ ~~for $C > 1$ µF: see detail specification, compared to values measured in 4.12.2.1~~
		~~Insulation resistance~~		~~≥50 % of values in 4.2.4.2~~
~~Group 3C[c]~~	~~D~~		~~See Table 3~~ ↓	
~~4.12.3 Pulse endurance test (if applicable)~~		~~Duration:~~ ~~Grade 1: 2 000 h~~ ~~Grade 2: 1 000 h~~ ~~Pulse repetition rate: … Hz~~ ~~Discharge time constant: as in 4.12.3.2~~ ~~Applied peak voltage: equal to the rated peak voltage (see detail specification)~~		
~~4.12.3.1 Initial measurements~~		~~Capacitance~~ ~~Tangent of loss angle:~~ ~~For $C_R > 1$ µF: at 1 kHz~~ ~~$C_R \leq 1$ µF: at 10 kHz~~		
~~4.12.3.3 Final measurements~~		~~Visual examination~~		~~No visible damage~~ ~~Legible marking~~
		~~Capacitance~~		~~$\Delta C/C$ for Grade 1: ≤5 %~~ ~~Grade 2: ≤10 %~~ ~~of value measured in 4.12.3.1~~
		~~Tangent of loss angle~~		~~Increase of tan δ:~~ ~~for $C \leq 1$ µF:~~ ~~for Grade 1: ≤0,0015~~ ~~Grade 2: ≤0,003~~ ~~for $C > 1$ µF: see detail specification, compared to values measured in 4.12.3.1~~
		~~Insulation resistance~~		~~≥50 % of values in 4.2.4.2~~
~~Group 4~~	~~D~~		~~See Table 3~~ ↓	
~~4.2.6 Characteristics depending on temperature (if applicable)~~		~~Capacitance~~		~~As in 4.2.6~~
		~~Insulation resistance~~		~~As in 4.2.6~~
~~4.13 Charge and discharge (not applicable when pulse endurance test is required)~~				

~~**Subclause number and test**~~[a]	~~**D or ND**~~[b]	~~**Conditions of test**~~[a]	~~**Number of specimens (n) and number of permissible non-conformances (c)**~~	~~**Performance requirements**~~[a]
~~**Group 4** *(continued)*~~				
~~4.13.1 Initial measurements~~		~~Capacitance~~ ~~Tangent of loss angle:~~ ~~for C_R > 1 µF: at 1 kHz~~ ~~C_R ≤ 1 µF: at 10 kHz~~ ~~Duration of charge: . . . s~~ ~~Duration of discharge: . . . s~~	~~See Table 3~~	
~~4.13.3 Final measurements~~		~~Capacitance~~	↓	~~$\Delta C/C$ for Grade 1.1: ≤1 %~~ ~~Grade 1.2: ≤3 %~~ ~~Grade 2: ≤5 %~~ ~~of value measured in 4.13.1~~
		~~Tangent of loss angle~~	↓	~~Increase of tan δ:~~ ~~for C ≤ 1 µF:~~ ~~for Grade 1: ≤0,003~~ ~~Grade 2: ≤0,005~~ ~~for C > 1 µF: see detail specification, compared to values measured in 4.13.1~~
		~~Insulation resistance~~	↓	~~≥50 % of values in 4.2.4.2~~

[a] ~~Subclause numbers of test and performance requirements refer to Clause 4 of this specification.~~

[b] ~~In this table: D = destructive ; ND = non-destructive.~~

[c] ~~The detail specification may additionally prescribe either or both endurance tests.~~

Subclause number, test and inspection items[a]	D or ND[b]	Conditions of test and measurements[a]	Number of specimens (n) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 0	ND		See Table 3	
4.1 Visual examination		See 4.1.2		Legible marking and as specified in the detail specification
4.1 Dimensions (detail)		See 4.1.2		See detail specification
4.2.2 Capacitance		See 4.2.2.2		Within specified tolerance
4.2.3 Tangent of loss angle (tan δ)		See 4.2.3.2 and 4.2.3.4		See 4.2.3.3 and 4.2.3.5
4.2.1 Voltage proof, either				
4.2.1.2 DC test, or		See 4.2.1.2.2		See 4.2.1.4
AC test		See 4.2.1.3.2		See 4.2.1.4
See detail specification for the test				
4.2.4 Insulation resistance		See 4.2.4.2		See 4.2.4.3
4.2.5 Inductance [d]		See 4.2.5		See detail specification
4.16 Sealing [d]		See detail specification for the method		No seepage of impregnant or harmful deformation of the case
Group 1A	D		See Table 3	
4.3 Robustness of terminations		See IEC 60384-1:2016, 4.13		
4.3.2 Initial inspections				
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		≤ initial limit
4.3.3 Final inspections				
Visual examination		See 4.1.2		no visible damage
Capacitance		See 4.2.2.2		See detail specification
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		See detail specification
4.4 Resistance to soldering heat		See IEC 60384-1:2016, 4.14 See 4.4.3 and detail specification for the method (1 or 2), and the duration of the test		
4.14 Component solvent resistance [d]		See IEC 60384-1:2016, 4.31		See detail specification
4.4.5 Final inspections and measurements				
Visual examination		See 4.4.5		No visible damage
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1.1: ≤ 1 % Grade 1.2: ≤ 2 % Grade 2: ≤ 3 % of value measured in 4.3.2

Table 4 *(2 of 8)*

Subclause number, test and inspection items[a]	**D or ND[b]**	**Conditions of test and measurements[a]**	**Number of specimens (n) and number of permissible non-conforming items (c)**	**Performance requirements[a]**
Group 1A *(continued)*	D		See Table 3	
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ for $C_N \le 1$ µF: for Grade 1.1: ≤ 0,001 Grade 1.2: ≤ 0,002 Grade 2: ≤ 0,004 of values measured in 4.3.2 for $C_N > 1$ µF: see detail specification[c]
Group 1B	D		See Table 3	
4.5 Solderability		See 4.5.2. See detail specification for the method		
4.5.3 Final inspections				
Visual examination				See 4.5.3
4.15 Solvent resistance of the marking [d]		See IEC 60384-1:2016, 4.32.1		Legible marking
4.6 Rapid change of temperature		See 4.6.3 between T_A and T_B T_A = Lower category temperature T_B = Upper category temperature		
4.6.2 Initial inspections				
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		≤ initial limit
Visual inspection				
4.6.4 Final inspections				
Visual examination		See 4.1.2		No visible damage
Capacitance		See 4.2.2.2		See detail specification
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		See detail specification
4.7 Vibration		See 4.7.3 See detail specification for the frequency range		
4.7.4 Final inspections				
Visual examination		See 4.1.2		No visible damage
4.8 Bump (or shock, see 4.9) [d]		See 4.8.3		
4.9 Shock (or bump, see 4.8)[d]		See 4.9.3 See detail specification for mounting method and severities		

Table 4 *(3 of 8)*

Subclause number, test and inspection items[a]	**D or ND**[b]	**Conditions of test and measurements**[a]	**Number of specimens (n) and number of permissible non-conforming items (c)**	**Performance requirements**[a]
Group 1B *(continued)*.				
4.8.5 or 4.9.5 Final inspections and measurements				
Visual examination		See 4.1.2		No visible damage
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1.1: ≤ 1 % Grade 1.2: ≤ 2 % Grade 2: ≤ 3 % of value measured in 4.6.2
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \leq 1$ µF: for Grade 1.1: ≤ 0,001 Grade 1.2: ≤ 0,002 Grade 2: ≤ 0,004 for $C_N > 1$ µF: see detail specification, compared to values measured in 4.6.2[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3
Group 1	D		See Table 3	
4.10 Climatic sequence				
4.10.2 Initial inspections				
Visual examination		See 4.1.2		No visible damage
Capacitance [e]		See 4.2.2.2		See detail specification
Tangent of loss angle [e]		See 4.2.3.2 and 4.2.3.4		See detail specification
Insulation resistance [e]		See 4.2.4.3		See detail specification
4.10.3 Dry heat		See IEC 60384-1:2016, 4.21.3		
4.10.4 Damp heat, cyclic, Test Db, first cycle		See IEC 60384-1:2016, 4.21.4		
4.10.5 Cold		See IEC 60384-1:2016, 4.21.5		
4.10.6 Low air pressure [d]		See 4.10.6.2		
4.10.6.3 Final inspections				
Visual examination		See 4.1.2		No permanent breakdown, flashover or harmful deformation of the case
4.10.7 Damp heat, cyclic, Test Db, remaining cycles		See 4.10.7.2		
4.10.7.3 Recovery [d]		See 4.10.7.3		
4.10.7.4 Final inspections				

Table 4 *(4 of 8)*

Subclause number, test and inspection items[a]	**D or ND**[b]	**Conditions of test and measurements**[a]	**Number of specimens (n) and number of permissible non-conforming items (c)**	**Performance requirements**[a]
Group 1 *(Continued)*				
4.10.7.4 Final inspections				
Visual examination		See 4.1.2		No visible damage Legible marking
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1.1: ≤ 1 % Grade 1.2: ≤ 3 % Grade 2: ≤ 5 % of value applied in 4.10.2
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \leq 1$ µF: for Grade 1.1: ≤ 0,0015 Grade 1.2: ≤ 0,003 Grade 2: ≤ 0,005 for $C_N > 1$ µF: see detail specification[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3
Group 2	D		See Table 3	
4.11 Damp heat, steady state		See 4.11.3		
4.11.2 Initial inspections		See 4.11.2		
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		≤ initial limit
4.11.3 Test conditions		a) Without voltage b) If the detail specification so specifies, two sets of samples of equal size shall be prepared, one set to be tested without voltage and one set with rated voltage applied		
4.11.4 Recovery[d]		See 4.11.4		
4.11.5 Final inspections				
Visual examination		See 4.1.2		No visible damage Legible marking
Capacitance		See 4.2.2.2		a) Test without voltage $\lvert\Delta C/C\rvert$ for Grade 1.1: ≤ 1 % Grade 1.2: ≤ 3 % Grade 2: ≤ 5 % of value measured in 4.11.2

Table 4 *(5 of 8)*

Subclause number, test and inspection items[a]	D or ND[b]	Conditions of test and measurements[a]	Number of specimens (n) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 2 *(Continued)*				b) Test with rated voltage Minimum requirements according to Annex A $|\Delta C/C|$ for Grade 1.1: ≤ 2 % Grade 1.2: ≤ 6 % Grade 2: ≤ 10 % of value measured in 4.11.2 See detail specification for more stringent requirements
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: a) Test without voltage: for $C_N \leq 1$ µF: for Grade 1: ≤0,001 Grade 2: ≤0,002 for $C_N > 1$ µF: see detail specification compared to values measured in 4.11.2[c] b) Test with rated voltage: Minimum requirements according to Annex A: for $C_N \leq 1$ µF: for Grade 1: ≤ 0,002 Grade 2: ≤ 0,004 for $C_N > 1$ µF: see detail specification compared to values measured in 4.11.2[c] See detail specification for more stringent requirements
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3 for both a) and b)

Table 4 *(6 of 8)*

Subclause number, test and inspection items[a]	D or ND[b]	Conditions of test and measurements[a]	Number of specimens (n) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 3A	D		See Table 3	
4.12.2 Endurance test at 50/60 Hz alternating voltage				
4.12.2.1 Initial inspections and measurements		See 4.12.2.1		
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		≤ initial limit
4.12.5 Final inspections				
Visual examination		See 4.12.2.3		No visible damage Legible marking
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1: ≤ 5 % Grade 2: ≤ 10 % of value measured in 4.12.2.1
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \leq 1$ µF: for Grade 1: ≤ 0,002 Grade 2: ≤ 0,004 for $C_N > 1$ µF: see detail specification, compared to values measured in 4.12.2.1[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3
Group 3B[c]	D		See Table 3	
4.12.3 Endurance test with sinusoidal current or voltage (if required)				
4.12.3.2 Initial inspections and measurements		See 4.12.3.2		
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		≤ initial limit
4.12.3.3 Test conditions		See 4.12.3.3 Test frequency shall be given in the detail specification		
4.12.3.4 Final inspections and measurements		See 4.12.3.4		
Visual examination		See 4.12.3.4		No visible damage Legible marking
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1: ≤ 5 % Grade 2: ≤ 10 % of value measured in 4.12.3.2

Table 4 *(7 of 8)*

Subclause number, test and inspection items[a]	D or ND[b]	Conditions of test and measurements[a]	Number of specimens (n) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 3B *(Continued)*				
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \le 1$ µF: for Grade 1: ≤ 0,0015 Grade 2: ≤ 0,003 for $C_N > 1$ µF: see detail specification, compared to values measured in 4.12.3.2[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3
Group 3C[c]	D		See Table 3	
4.12.4 Pulse endurance test (if required)				
4.12.4.2 Initial inspections and measurements		See 4.12.4.2		
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		≤ initial limit
4.12.4.3 Test conditions		See 4.12.4.3 The pulse repetition rate and the applied peak voltage shall be given in the detail specification		
4.12.4.4 Final inspections and measurements		See 4.12.4.4		
Visual examination		See 4.12.4.4		No visible damage Legible marking
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1: ≤ 5 % Grade 2: ≤ 10 % of value measured in 4.12.4.2
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \le 1$ µF: for Grade 1: ≤ 0,0015 Grade 2: ≤ 0,003 for $C_N > 1$ µF: see detail specification, compared to values measured in 4.12.4.2[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3

Table 4 *(8 of 8)*

Subclause number, test and inspection items[a]	D or ND[b]	Conditions of test and measurements[a]	Number of specimens (n) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 4	D		See Table 3	
4.2.6 Characteristics depending on temperature [d]		See 4.2.6.2		
4.2.6.2 Measuring conditions		See 4.2.6.2		
4.2.6.3 Requirements				
Capacitance		See 4.2.2.2		See Table 13 and Table 14
Insulation resistance		See 4.2.4.3		See Table 11
4.13 Charge and discharge (not applicable when pulse endurance test is required)		See 4.13.2		
4.13.2 Initial inspections and measurements				
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		For $C_N > 1$ µF: See 4.2.3.2 For $C_N \le 1$ µF: See 4.2.3.4		≤ initial limit
4.13.3 Test conditions		See 4.13.4		
4.13.4 Recovery		See 4.13.4		
4.13.5 Final inspections				
Capacitance		See 4.2.2.2		$\lvert \Delta C/C \rvert$ for Grade 1.1: ≤ 1 % Grade 1.2: ≤ 3 % Grade 2: ≤ 5 % of value measured in 4.13.2
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \le 1$ µF: for Grade 1: ≤ 0,003 Grade 2: ≤ 0,005 for $C_N > 1$ µF: see detail specification, compared to values measured in 4.13.2[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3

[a] Subclause numbers of test and performance requirements refer to Clause 4.

[b] In this table: D = destructive; ND = non-destructive.

[c] C_N = nominal capacitance in microfarads.

[d] If required.

[e] For use as reference value.

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.

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

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

b) 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.

c) if there are ~~less~~ fewer 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~~ a certification body (CB).

3.5.1.2 Group C inspection

These tests shall be carried out on a periodic basis.

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

3.5.2 Test schedule

The schedule for the lot-by-lot and periodic tests for quality conformance inspection is given in ~~Table 4 of~~ the blank detail specification ~~IEC 60384-17-1~~.

3.5.3 Delayed delivery

When, in accordance with the procedures of IEC 60384-1:2016, ~~3.10~~ Q.1.7, re-inspection has to be made, solderability and capacitance shall be checked as specified in Group A and Group B inspection.

3.5.4 Assessment levels

~~The assessment level(s) given in the blank detail specification shall preferably be selected from the following Tables 5 and 6:~~

The assessment level EZ is stated in Table 5 and Table 6.

Table 5 – Lot-by-lot inspection

~~Inspection subgroup~~[b]	~~D~~[a]		~~E~~		~~F~~[a]		~~G~~[a]		~~EZ~~		
	~~*IL*~~	~~*AQL*~~ ~~%~~	~~*IL*~~	~~*AQL*~~ ~~%~~	~~*IL*~~	~~*AQL*~~ ~~%~~	~~*IL*~~	~~*AQL*~~ ~~%~~	~~*IL*~~	~~*n*~~	~~*c*~~
~~A0~~									~~100 %~~[c]		
~~A1~~			~~S-3~~	~~2,5~~						[d]	~~0~~
~~A2~~			~~S-3~~	~~1,0~~						[d]	~~0~~
~~B1~~			~~S-3~~	~~2,5~~						[d]	~~0~~

~~*IL* = inspection level;~~
~~*AQL* = acceptable quality level;~~
~~*n* = sample size;~~
~~*c* = permissible number of non-conforming items.~~

~~[a, b] See Table 6.~~

~~[c] 100 % testing shall be followed by re-inspection by sampling in order to monitor outgoing quality level by non-conforming items per million (10^{-6}). The sampling level shall be established by the manufacturer. For the calculation of 10^{-6} values any parametric failure shall be counted as non-conforming item. In case one or more non-conforming items occur in a sample, this lot shall be rejected.~~

~~[d] Number to be tested: Sample size as directly allotted to the code letter for *IL* in Table 2a of IEC 60410 .~~

Inspection subgroup[b]	**EZ**		
	IL[a]	n[a]	c[a]
A0	100 %[c]		
A1	S-4	[d]	0
A2	S-3	[d]	0
B1	S-3	[d]	0

[a] IL = inspection level
n = sample size
c = permissible number of non-conforming items

[b] The content of the inspection subgroup is described in Clause 2 of the blank detail specification.

[c] The inspection shall be performed after removal of non-conforming items by 100 % testing during the manufacturing process. The sampling level shall be established by the manufacturer, preferably in accordance with IEC 61193-2:2007, Annex A.

Whether the lot was accepted or not, all samples for sampling inspection shall be inspected in order to monitor outgoing quality level by non-conforming items per million ($\times 10^{-6}$).

In case one or more non-conforming items occur in a sample, this lot shall be rejected but all non-conforming items shall be counted for the calculation of quality level values.

Outgoing quality level by non-conforming items per million ($\times 10^{-6}$) values shall be calculated by accumulating inspection data in accordance with the method given in IEC 61193-2:2007, 6.2.

[d] Number to be tested: sample size shall be determined in accordance with IEC 61193-2:2007, 4.3.2.

Table 6 – Periodic ~~inspection~~ tests

~~Inspection subgroup~~[b]	~~D~~[a]			~~E~~			~~F~~[a]			~~G~~[a]			~~EZ~~		
	~~p~~	~~n~~	~~c~~	~~p~~	~~n~~	~~c~~	~~p~~	~~n~~	~~c~~	~~p~~	~~n~~	~~c~~	~~p~~	~~n~~	~~c~~
~~C1A~~				~~6~~	~~9~~	~~1~~							~~6~~	~~5~~	~~0~~
~~C1B~~				~~6~~	~~18~~	~~1~~							~~6~~	~~5~~	~~0~~
~~C1~~				~~6~~	~~27~~	~~2~~							~~6~~	~~10~~	~~0~~
~~C2~~				~~6~~	~~15~~	~~1~~							~~6~~	~~10~~	~~0~~
~~C3A~~				~~3~~	~~20~~	~~1~~							~~6~~	~~5~~	~~0~~
~~C3B~~				~~3~~	~~5~~	~~1~~							~~6~~	~~5~~	~~0~~
~~C3C~~				~~3~~	~~5~~	~~1~~							~~6~~	~~5~~	~~0~~
~~C4~~				~~3~~	~~9~~	~~1~~							~~6~~	~~10~~	~~0~~
~~C5~~				~~12~~	~~6~~	~~1~~							~~6~~	~~10~~	~~0~~

~~p = periodicity in months;~~
~~n = sample size;~~
~~c = permissible number of non-conforming items.~~

~~[a] The assessment levels D, F and G are under consideration.~~

~~[b] The content of the inspection subgroups is described in Clause 2 of the relevant blank detail specification.~~

Inspection subgroup[b]	**EZ**		
	p[a]	n[a]	c[a]
C1A	6	5	0
C1B	6	5	0
C1	6	10	0
C2	6	10	0
C3A	6	5	0
C3B	6	5	0
C3C	6	5	0
C4	6	10	0
C5	6	10	0

[a] p = periodicity in months
n = sample size
c = permissible number of non-conforming items

[b] The content of the inspection subgroup is described in Clause 2 of the blank detail specification.

4 Test and measurement procedures

NOTE This clause supplements the information given in IEC 60384-1:2016, Clause 4.

4.1 Visual examination and check of dimensions

4.1.1 General

See IEC 60384-1:2016, 4.4, with the details in 4.1.2 and 4.1.3.

4.1.2 Visual examination and check of dimensions

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.

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

The capacitors shall be examined to verify that the materials, design, construction and physical dimensions are appropriate.

4.1.3 Requirements

See Table 4.

The workmanship shall be in accordance with the applicable requirements given in the detail specification.

4.2 Electrical tests

4.2.1 Voltage proof for AC capacitors

4.2.1.1 General

The detail specification shall state which voltage proof test, DC or AC, is to be applied.

4.2.1.2 DC voltage proof test

4.2.1.2.1 General

Test circuit, see IEC 60384-1:2016, 4.6, with the following details.

The product of R_1 and the nominal capacitance of the capacitor under test (C_X) shall be smaller than or equal to 1 s and greater than 0,01 s.

R_1 includes the internal resistance of the power supply.

R_2 shall limit the discharge current to a value equal to or less than 1 A.

4.2.1.2.2 Test conditions

The voltages given in Table 7 shall be applied between the given measuring points (from IEC 60384-1:2016, Table 3) for a period of 1 min for qualification approval testing, and between measuring point 1a) for a period of minimum 1 s for the lot-by-lot quality conformance testing.

~~– point 1a): 2,5 $U_{R\sim}$~~

~~– point 1b) – 1c) – 1d) (insulated styles only): 1,4 $U_{R\sim}$ + 2 000 V d.c.~~

Table 7 – Test voltages, DC

Measuring point	Test voltage, DC
1a)	2,5 $U_{R\sim}$
1b), 1c) [a]	1,4 $U_{R\sim}$ + 2 000 V DC

[a] Insulated styles only

~~NOTE~~ If the capacitor has also a rated DC voltage, it ~~must~~ shall be tested with the DC voltage proof test of the DC specification (IEC 60384-16) but if the value mentioned here in Table 7 is higher, this value ~~must~~ shall be used.

4.2.1.3 AC voltage proof test (50 Hz or 60 Hz)

4.2.1.3.1 General

Test circuit as in IEC 60384-1:2016, 4.6, but the capacitor C_1 and resistor R_2 shall be omitted.

The product of R_1 and the nominal capacitance of the capacitor under test (C_X) shall be smaller than or equal to 1 s and greater than 0,01 s.

R_1 includes the internal resistance of the power supply.

4.2.1.3.2 Test conditions

The voltages given in Table 8 shall be applied between the given measuring points (from IEC 60384-1:2016, Table 3) for a period of 1 min for qualification approval testing, and between measuring point 1a) for a period of at least 1 s for the lot-by-lot quality conformance testing.

~~The r.m.s. value of the test voltage is:~~

~~– point 1a): 1,5 $U_{\mathrm{R}\sim}$ with $U_{\mathrm{R}\sim}$ ≤250 V~~
~~1,4 $U_{\mathrm{R}\sim}$ with $U_{\mathrm{R}\sim}$ >250 V~~

~~– point 1b) – 1c) – 1d) (insulated styles only): 1,4 $U_{\mathrm{R}\sim}$ + 2 000 V d.c.~~

~~NOTE 1 $U_{\mathrm{R}\sim}$ and other a.c. values are r.m.s. values.~~

~~NOTE 2 The test voltage must be applied during:~~

- ~~One minute for qualification approval tests and periodic tests.~~
- ~~A minimum of 1 s for lot-by-lot tests.~~

Table 8 – Test voltages, AC

Measuring point	Test voltage, AC (RMS)
1a)	1,5 $U_{\mathrm{R}\sim}$ for $U_{\mathrm{R}\sim}$ ≤ 250 V 1,4 $U_{\mathrm{R}\sim}$ for $U_{\mathrm{R}\sim}$ > 250 V
1b), 1c) [a]	1,4 $U_{\mathrm{R}\sim}$ + 1 500 V AC

[a] Insulated styles only

4.2.1.4 Requirement

This is valid for both DC and AC tests.

There shall be no breakdown or flashover during the test.

NOTE The occurrence of self-healing breakdowns during the application of the test voltages is allowed.

4.2.2 Capacitance

4.2.2.1 General

See IEC 60384-1:2016, 4.7, with the details in 4.2.2.2 and 4.2.2.3.

4.2.2.2 Measuring conditions

The capacitance shall be measured at, or corrected to, a frequency of 1 kHz. For ~~rated~~ nominal capacitance values >10 µF, 50 Hz to 120 Hz may be used, but 1 kHz shall be the reference frequency.

The applied peak voltage at 1 kHz shall not exceed 3 % of the rated voltage, and the applied peak voltage at 50 Hz to 120 Hz shall not exceed 20 % of the rated voltage with a maximum of 100 V (70 V RMS).

4.2.2.3 Requirements

The capacitance shall be within the specified tolerance.

4.2.2.4 Presentation of the allowed capacitance change in tests

The allowed capacitance change in tests in Table 4 shall be presented using either performance grade or performance and stability grade combination designations in accordance with Table 1, depending on the test.

4.2.3 Tangent of loss angle (tan δ)

4.2.3.1 General

See IEC 60384-1:2016, 4.8, with the details from 4.2.3.2 to 4.2.3.5.

4.2.3.2 Measuring conditions for measurements at 1 kHz

~~Tan δ shall be measured~~ The test conditions are as follows:

- frequency: 1 kHz;
- peak voltage: ≤ 3 % of the rated voltage;
- inaccuracy: ≤ 5×10^{-4} (absolute value).

4.2.3.3 Requirement for measurements at 1 kHz

Tan δ shall not exceed the applicable values shown in Table 9.

Table 9 – Tangent of loss angle limits, 1 kHz

~~Measurement frequency~~	~~Rated capacitance~~	~~Tangent of loss angle~~	
		~~Performance Grade 1~~	~~Performance Grade 2~~
~~1 000 Hz~~	~~$C_R \leq 1$ µF~~	~~$\leq 10 \times 10^{-4}$~~	~~$\leq 20 \times 10^{-4}$~~
~~NOTE For $C_R > 1$µF, values of tan δ must be specified in the detail specification.~~			

Nominal capacitance µF	Tan δ (absolute value)	
	Grade 1 capacitors	Grade 2 capacitors
≤ 1	$\leq 10 \times 10^{-4}$	$\leq 20 \times 10^{-4}$

For $C_N > 1$ µF, values of tan δ shall be specified in the detail specification.

4.2.3.4 Measuring conditions for measurements at 10 kHz

For capacitors with ~~C_R~~$C_N \leq 1$ µF, tan δ shall be measured as follows.

- frequency: 10 kHz;
- voltage: ≤ 1 V (RMS);
- inaccuracy: ≤ 5×10^{-4} (absolute value).

4.2.3.5 Requirement for measurements at 10 kHz

Tan δ shall not exceed the applicable values shown in Table 10.

Table 10 – Tangent of loss angle limits, 10 kHz

Nominal capacitance μF	Tan δ (absolute value)	
	Grade 1 capacitors	Grade 2 capacitors
≤1	$\leq 20 \times 10^{-4}$	$\leq 40 \times 10^{-4}$

For C_N > 1 μF, values of tan δ shall be specified in the detail specification.

4.2.3.6 Presentation of the allowed tan δ change in tests

The allowed tan δ change in tests in Table 4 shall be presented using either performance grade or performance and stability grade combination designations in accordance with Table 1, depending on the test.

4.2.4 Insulation resistance

4.2.4.1 General

See IEC 60384-1:2016, 4.5, with the details 4.2.4.2 and 4.2.4.3.

4.2.4.2 Measuring conditions

Prior to the test, capacitors shall be carefully cleaned to remove any contamination. Care shall be taken to maintain cleanliness in the test chambers and during post-test measurements.

Before the measurement, the capacitors shall be fully discharged. The product of the resistance of the discharge circuit and the ~~rated~~ nominal capacitance of the capacitor under test shall be ≥ 0,01 s or any other value prescribed in the detail specification.

The measuring voltage shall be in accordance with IEC 60384-1:2016, 4.5.2. The measuring points shall be in accordance with IEC 60384-1:2016, Table 3.

The voltage shall be applied immediately at the correct value through the internal resistance of the voltage source. The product of the internal resistance and the ~~rated~~ nominal capacitance of the capacitor shall be smaller than 1 s or any other value prescribed in the detail specification.

4.2.4.3 Requirements

The insulation resistance shall meet the requirements shown in Table 11.

Table 11 – Insulation resistance requirements

Minimum RC product (R = insulation resistance between the terminations) (C = ~~rated~~ nominal capacitance) s				Minimum insulation resistance between the terminations GΩ		Minimum insulation resistance between terminations and case GΩ
Measuring points in accordance with Table 3 of IEC 60384-1:						
1 a)				1 a)		1 b), 1 c)
~~Rated~~ Nominal capacitance:						
> 0,33 µF				≤ 0,33 µF		
Rated voltage:						
> 100 V		≤ 100 V		All voltages		
Grade:						
1	2	1	2	1	2	
30 000	7 500	15 000	3 750	100	25	100

When the test is carried out at a temperature other than 20 °C, the result shall, when necessary, be corrected to 20 °C by multiplying the result of the measurement by the appropriate correction factor. In case of doubt, measurement at 20 °C is decisive. The correction factors given in Table 12 can be considered as an average for metallized polypropylene film capacitors.

Table 12 – Insulation resistance correction factor~~s~~ dependent on test temperature

Temperature °C	Correction factor
15	0,75
20	1,00
23	1,25
27	1,5
30	1,75
35	2

4.2.5 Inductance (if required)

See IEC 60384-1:2016, 4.11, with the following details.

The maximum inductance value shall be stated in the detail specification.

An approximative value can be provided from measurement of resonance frequency and from capacitance value measured in 4.2.2.

4.2.6 Characteristics depending on temperature (if required in the detail specification)

4.2.6.1 General

See IEC 60384-1:2016, 4.24.1, with the details in 4.2.6.2 and 4.2.6.3.

4.2.6.2 Measuring conditions

The capacitance measurements shall be carried out at the temperatures given in items b), d) and f) of IEC 60384-1:2016, 4.24.1.2. The measurement of insulation resistance is also carried out at the temperature as given in item f). The measuring points of insulation resistance are 1a), 1b) and 1c) from IEC60384-1:2016, Table 3.

4.2.6.3 Requirements

The requirements in lower and upper category temperature are given in Table 13 and Table 14 respectively.

Table 13 – Characteristics at lower category temperature

Test temperature as given in item b)	Temperature characteristic of capacitance
−10 °C and −25 °C	$0 \le \frac{\Delta C}{C} \le + 2,25\ \%$
−40 °C	$0 \le \frac{\Delta C}{C} \le + 3\ \%$
−55 °C	$0 \le \frac{\Delta C}{C} \le + 3,75\ \%$

Table 14 – Characteristics at upper category temperature

Test temperature as given in item f)	Temperature characteristic of capacitance	Insulation resistance (measuring point 1 a)		Insulation resistance (measuring point 1b) and 1c)~~ and 1d)~~)
		~~C_R~~ C_N > 0,33 µF $R_i \times$ ~~C_R~~ C_N s	~~$C_R >$~~ $C_N \le$ 0,33 µF R_i GΩ	GΩ
70 °C	$-2,5\ \% \le \frac{\Delta C}{C} \le 0$	1 500	5	5
85 °C	$-3,25\ \% \le \frac{\Delta C}{C} \le 0$	1 200	4	4
100 °C	$-4\ \% \le \frac{\Delta C}{C} \le 0$	750	2,5	2,5
105 °C and 110 °C	$-4,5\ \% \le \frac{\Delta C}{C} \le -1$	600	2,2	2.2
125 °C	$-6\ \% \le \frac{\Delta C}{C} \le -2$	500	2,0	2,0

4.3 Robustness of terminations

4.3.1 General

See IEC 60384-1:2016, 4.13, with the details in 4.3.2 and 4.3.3.

4.3.2 Initial ~~measurements~~ inspections

The capacitance shall be measured in accordance with 4.2.2.2.

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4 as appropriate.

4.3.3 Final inspections and requirements

No visible damage.

4.4 Resistance to soldering heat

4.4.1 General

See IEC 60384-1:2016, 4.14 with the details from 4.4.2 to 4.4.5.

4.4.2 Initial inspections

In accordance with 4.3.2.

4.4.3 Test Conditions

No pre-drying.

- Method 1 (solder bath) or 2 (soldering iron) of IEC 60384-1:2016, 4.14, unless otherwise specified in the detail specification.
- Duration: 5 s ± 0,5 s or 10 s ± 1 s, unless otherwise specified in the detail specification.

If method 1 is applied, immersion and withdrawal speed shall be 25 mm/s ± 2,5 mm/s

4.4.4 Recovery

The recovery period shall be 1 h to 2 h.

4.4.5 Final inspections, measurements and requirements

The capacitors shall be visually examined and measured and shall meet the following requirements~~ given in Table 4~~:

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 in accordance with 4.2.3.2 and shall meet the requirements given in Table 4.

4.5 Solderability

4.5.1 General

See IEC 60384-1:2016, 4.15, with the details in 4.5.2 and 4.5.3.

4.5.2 Test conditions

No ageing.

Temperature of the solder bath and process time for preferred solders:

– SnPb solder:	235 °C ± 3 °C for (2 ± 0,2) s;
– Sn96,5Ag3Cu,5 solder:	245 °C ± 3 °C for (3 ± 0,3) s;
– Sn99,3Cu,7 solder:	250 °C ± 3 °C for (3 ± 0,3) s.

The requirements for the globule test method shall be prescribed in the detail specification. When neither the solder bath nor the solder globule method is appropriate the soldering iron test shall be used with soldering iron Size A.

~~4.5.2 The performance requirements are given in Table 4.~~

4.5.3 Final inspections and requirements

The capacitor shall be visually examined under normal lighting and approximately 10× magnification.

The areas to be soldered 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 dewetted areas. These imperfections shall not be concentrated in one area.

In the solder globule method, the detail specification shall define the flow time of the solder in seconds.

4.6 Rapid change of temperature

4.6.1 General

See IEC 60384-1:2016, 4.16, with the details from 4.6.2 to 4.6.4.

~~4.6.1 Initial measurement~~

~~Initial measurements shall be made as prescribed by 4.3.1.~~

~~4.6.2 Number of cycles: 5~~

~~Duration of exposure at the temperature limits: 30 min, unless otherwise prescribed in the detail specification for larger capacitors. When prescribed in the detail specification, capacitors shall be measured after recovery; they shall meet the requirements of the detail specification.~~

4.6.2 Initial inspections

The capacitance shall be measured in accordance with 4.2.2.2.

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4 as appropriate.

4.6.3 Test conditions

Test conditions are as follows:

- capacitors shall be tested for 5 cycles;
- duration of exposure at the temperature limits: 30 min, unless otherwise prescribed in the detail specification for larger capacitors.

4.6.4 Final inspections and requirements

The capacitors shall be visually examined and there shall be no visual damage.

When prescribed in the detail specification, capacitors shall be measured after recovery; they shall meet the requirements of the detail specification.

4.7 Vibration

4.7.1 General

See IEC 60384-1:2016, 4.17, with the details from 4.7.2 to 4.7.4.

4.7.2 Initial inspections

Not required

4.7.3 Test conditions

The following degree of severity of test Fc applies.

~~0,75 mm displacement or 100 m/s^2, whichever is the lower amplitude, over one of the following frequency ranges: 10 Hz to 55 Hz, 10 Hz to 500 Hz, 10 Hz to 2 000 Hz. The total duration shall be 6 h.~~

- frequency range is one of the following: 10 Hz to 55 Hz, 10 Hz to 500 Hz or 10 Hz to 2 000 Hz;
- amplitude or acceleration (whichever is the lower acceleration): 0,75 mm or 100 m/s^2;
- total duration: 6 h (2 h in each X, Y and Z -axis direction).

The detail specification shall specify the frequency range and shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.7.4 Final inspections~~, measurements~~ and requirements

~~See Table 4.~~ The capacitors shall be visually examined and there shall be no visual damage.

4.8 Bump (repetitive shock)

4.8.1 General

The detail specification shall state whether the bump or the shock test applies.

See IEC 60384-1:2016, 4.18, with the details from 4.8.2 to 4.8.4.

4.8.2 Initial measurements

Not required.

4.8.3 Test conditions

The detail specification shall state which of the following severities applies.

Total number of bumps: 1 000 or 4 000

Acceleration:	400 m/s^2	or	100 m/s^2
Pulse duration:	6 ms		16 ms

The detail specification shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.8.4 Final inspections, measurements and requirements

The capacitors shall be visually ~~examined and measured~~ inspected and shall meet the requirements given in Table 4.

4.9 Shock

4.9.1 General

The detail specification shall state whether the shock or the bump test applies.

See IEC 60384-1:2016, 4.19, with the details from 4.9.2 to 4.9.4.

4.9.2 Initial measurements

Not required.

4.9.3 Test conditions

The detail specification shall state which of the following preferred severities applies:

Pulse-shape: half-sine

Table 15 – Preferred severities in shock test

Peak acceleration m/s^2	Corresponding duration of the pulse ms
300	18
500	11
1 000	6

The detail specification shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.9.4 Final inspection, measurements and requirements

The capacitors shall be visually ~~examined and measured~~ inspected and shall meet the requirements given in Table 4.

4.10 Climatic sequence

4.10.1 General

See IEC 60384-1:2016, 4.21, with the details from 4.10.2 to 4.10.9.

4.10.2 Initial measurements

Not required, see 4.3.2, 4.4.4, 4.8.4 or 4.9.4 as applicable.

4.10.3 Dry heat

See IEC 60384-1:2016, 4.21.3.

4.10.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:2016, 4.21.4.

4.10.5 Cold

See IEC 60384-1:2016, 4.21.5.

4.10.6 Low air pressure (if required)

4.10.6.1 General

See IEC 60384-1:2016, 4.21.6, with the details in 4.10.6.2 and 4.10.6.3.

4.10.6.2 Test conditions

The test, if required in the detail specification, shall be made at a temperature of 15 °C to 35 °C and a pressure of 8 kPa. The duration of the test shall be 1 h.

While still at the specified low pressure and during the last 5 min of the 1-h period, the rated voltage shall be applied.

The sample part of capacitors submitted to this test shall be subdivided into two or three parts as necessary and each part submitted to one of the tests laid down in Table 3 of IEC 60384-1:2016. The test voltage shall be applied to terminations, case, etc., as given in 4.2.1.

4.10.6.3 Final inspections, measurements and requirements

The capacitors shall be visually ~~examined~~ inspected and shall meet the requirements given in Table 4.

4.10.7 Damp heat, cyclic, Test Db, remaining cycles

4.10.7.1 General

See IEC 60384-1:2016, 4.21.7, with the details in 4.10.7.2.

4.10.7.2 Test conditions

Within 15 min after removal from the damp heat test, the rated voltage shall be applied for 1 min at ~~test~~ measuring point ~~A~~ 1a) using the test circuit conditions as given in 4.2.1.

4.10.8 Recovery

The recovery period shall be 1 h to 2 h, unless otherwise specified in the detail specification.

4.10.9 Final inspections, measurements and requirements

After recovery, the capacitors shall be visually ~~examined~~ inspected and measured and ~~shall~~ meet the requirements given in Table 4.

4.11 Damp heat, steady state

4.11.1 General

See IEC 60384-1:2016, 4.22, with the details from 4.11.2 to 4.11.6.

4.11.2 Initial ~~measurements~~ inspections

The capacitance shall be measured according to 4.2.2.2. The tangent of loss angle shall be measured according to 4.2.3.2 or 4.2.3.4.

~~4.11.2 Within 15 min after removal from the damp heat test, the voltage proof test according to 4.2.1 shall be carried out, but with the rated voltage applied.~~

4.11.3 Test conditions

Test conditions are as follows:

- temperature: 40 °C ± 2 °C;
- relative humidity: (93 ± 3) %;
- applied voltage:
  a) No voltage shall be applied;

     within 15 min after removal from the test chamber, the voltage proof test of 4.2.1 shall be carried out at test point 1a) only, using the rated voltage ;

  b) If the detail specification so requires, there shall be another test group for testing with rated voltage. The detail specification shall define the inspection and measurement requirements;

  Both test groups are equal in size.
- duration: 4 d, 10 d, 21 d or 56 d.

4.11.4 Recovery

The recovery period shall be 1 h to 2 h.

4.11.5 Final inspections, measurements and requirements

After recovery, the capacitors shall be visually ~~examined~~ inspected and measured and shall meet the requirements given in Table 4. The requirements for testing without voltage and with voltage should be separately defined.

4.11.6 Humidity robustness grades

Annex A describes the classification of various humidity robustness grades and the associated test conditions. If the detail specification describes a humidity robustness grade, it should be selected from this Annex A.

4.12 Endurance

4.12.1 General

See IEC 60384-1:2016, 4.23, with the details from 4.12.2 to 4.12.4.

4.12.2 Endurance test at 50 Hz/60 Hz alternating voltage ~~(if applicable)~~

4.12.2.1 Initial ~~measurements~~ inspections

~~Initial measurements shall be made as prescribed by 4.3.1.~~

The capacitance shall be measured in accordance with 4.2.2.2.

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4.

4.12.2.2 Test conditions

In addition to IEC 60384-1:2016, 4.23, the following details apply, unless otherwise specified in the detail specification:

– duration of test:	1 000 h ± 24 h (Grade 2) or 2 000 h ±24 h (Grade 1);
– value of the applied voltage:	1,25 times the rated AC voltage (frequency: 50/60 Hz sinusoidal);
– temperature of the chamber:	AC rated temperature;
– source impedance:	lower than 0,1 times the impedance of the group of capacitors under test.

NOTE This test is not applicable for capacitors with rated AC voltages less than 200 V (RMS).

4.12.2.3 Final ~~examination~~ inspections, measurements and requirements

The capacitors shall be visually inspected and measured and shall meet the requirements given in Table 4.

4.12.3 Endurance test with sinusoidal current or voltage (if ~~applicable~~ required)

4.12.3.1 General

NOTE The object of the test is to produce an average overheating of the capacitor by carrying out an endurance test with a sinusoidal wave.

4.12.3.2 Initial ~~measurements~~ inspections

~~Initial measurements shall be made as prescribed by 4.3.1.~~

The capacitance shall be measured in accordance with 4.2.2.2.

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4.

4.12.3.3 Test conditions

– duration of test:	1 000 h ± 24 h (Grade 2) or 2 000 h ±24 h (Grade 1);
– RMS current or voltage:	1,1 % $^{+10}_{0}$ % times the rated AC current or voltage (RMS) with reference to the ~~rated~~ nominal capacitance;
– frequency:	to be given in the detail specification;
– test temperature:	standard atmospheric conditions for testing.

~~*Reference document*~~

~~See IEC 60384-1, 2.2.35 to 2.2.38 and 4.23.~~

NOTE ~~1~~ The RMS value of the current ~~must~~ shall also be applicable to the lowest limit of the capacitance tolerance. The RMS value of the voltage ~~must~~ shall also be applicable to the highest limit of the capacitance tolerance.

~~NOTE 2~~ If the capacitor is guaranteed in current, the test ~~must~~ shall be understood without any correction on the applied current. If the capacitor is guaranteed in voltage, the test ~~must~~ shall be understood without any correction on the applied voltage.

~~NOTE 3~~ For qualification approval, capacitors within 2 % from the lowest tolerance limit shall be selected for current testing. For qualification approval, capacitors within 2 % from the highest tolerance limit ~~must~~ shall be selected for voltage testing. No special selection shall be made for periodic tests.

4.12.3.4 Final inspections, measurements and requirements

The capacitors shall be inspected and measured and shall meet the requirements given in Table 4.

4.12.4 Pulse endurance test (if ~~applicable~~ required)

4.12.4.1 General

~~NOTE~~ The object of the test is to verify that the capacitor can withstand an endurance test of periodic pulses without significant temperature rise.

4.12.4.2 Initial ~~measurements~~ inspections

~~Initial measurements shall be made according to 4.3.1.~~

The capacitance shall be measured in accordance with 4.2.2.2.

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4.

4.12.4.3 Test conditions

- duration of test: 1 000 h ± 24 h (Grade 2) or 2 000 h ±24 h (Grade 1);
- temperature: standard atmospheric conditions for testing;
- pulse repetition rate: according to the detail specification;

  ~~NOTE A frequency of 1 Hz may be used for~~ $\frac{dU}{dt}$ ~~ratings greater than 500 V/µs if 50/60 Hz gives a significant temperature rise (>10 °C).~~

  A frequency of 1 Hz may be used for ratings greater than 500 V/µs if 50 Hz/60 Hz gives a significant temperature rise (> 10 °C).

- applied peak voltage: equal to the rated peak voltage (to be given in the detail specification);

  discharge time constant:
  a) 1,5 times the rated value, when expressed by peak current per unit of capacitance (A/µF) or by the maximum $\frac{dU}{dt}$ (V/µs);
  b) 0,67 times the rated value, when expressed by discharge time constant(s);

NOTE $\frac{I_p}{C} = \frac{dU}{dt} = \frac{U}{R_d \cdot C_N}$ with $R_d \cdot C_N$ = discharge time constant.

- charge time constant: 10 times the discharge time constant;
- duration of the charge period: > 5 times the charge time constant;
- duration of the discharge period: > 5 times the discharge time constant;
- maximum peak reverse voltage: 10 % of the applied peak voltage.

4.12.4.4 Final ~~examination~~ inspections, measurements and requirements

The capacitors shall be visually inspected and measured and shall meet the requirements given in Table 4.

4.13 Charge and discharge

4.13.1 General

See IEC 60384-1:2016, 4.27, with the details from 4.13.2 to 4.12.5.

~~NOTE The charge and discharge test is not applicable when the pulse endurance test is prescribed.~~

4.13.2 Initial ~~measurements~~ inspections

~~Initial measurements shall be made as according to 4.3.1.~~

The capacitance shall be measured in accordance with 4.2.2.2.

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4.

4.13.3 Test conditions

The capacitors shall be subjected to 10 000 cycles of charge and discharge at a rate of approximately one cycle per second. Each cycle shall consist of charging and discharging the capacitor. Each capacitor shall be individually charged with the rated voltage through a resistor with a value

$$\cancel{\frac{220 \times 10^{-6}}{C_R}\ \Omega,} \qquad (220 \times 10^{-6})/C_N \quad (\Omega)$$

where ~~C_R~~ C_N is the ~~rated~~ nominal capacitance in farads, or the value required to limit the charge current to 1 A (or to the higher current value given in the detail specification), whichever resistance value is the greater.

Each capacitor shall be individually discharged through a resistor with a value of

$$\cancel{\frac{10 \times 10^{-6}}{C_R}\ \Omega} \qquad (10 \times 10^{-6})/C_N \quad (\Omega)$$

with a minimum of 20 Ω, or a lower value when prescribed in the detail specification, calculated as follows from the value of $\frac{dU}{dt}$ prescribed in the detail specification:

$$R = \frac{U}{C \cdot \frac{dU}{dt}}$$

4.13.4 Recovery

The recovery shall be 1 h to 2 h.

4.13.5 Final inspections, measurements and requirements

After recovery, the capacitors shall be measured and shall meet the requirements given in Table 4.

4.14 Component solvent resistance (if required)

See IEC 60384-1:2016, 4.31.

4.15 Solvent resistance of marking (if required)

See IEC 60384-1:2016, 4.32.

4.16 Sealing (if required)

See IEC 60384-1:2016, 4.20.

Annex A
(normative)

Humidity robustness grades

A.1 General

In addition to the description of preferred climatic categories in 2.1 and the damp heat, steady-state test in 4.11, this Annex A describes specific humidity robustness grades for applications, where high stability under high-humidity operating conditions is required.

A.2 Humidity robustness grades

Standard

See 2.1.2 and 4.11.3, a).

In this grade, humidity robustness under operating conditions with applied voltage is not defined.

Grade (I) robustness under humidity

An additional sample shall be tested with rated AC voltage applied. See 2.1 and 4.11.3, b).

> **Test condition**: damp heat, steady state; 40 °C / 93 % RH, duration 21 days, rated AC voltage applied.

Grade (II) robustness under high humidity

An additional sample shall be tested with rated AC voltage applied. See 2.1 and 4.11.3, b).

> **Test condition**: damp heat, steady state; 40 °C / 93 % RH, duration 56 days, rated AC voltage applied.

Grade (III) high robustness under high humidity

An additional sample shall be tested with rated AC voltage applied. See 2.1 and 4.11.3, b).

> **Test condition**: damp heat, steady state; 60 °C / 93 % RH, duration 56 days, rated AC voltage applied.

NOTE 1 In Grade (III), the test temperature has been increased to 60 °C from the standard condition to keep the test time in acceptable limits.

NOTE 2 For fixed metallized polypropylene capacitors the 85 °C / 85 % RH test is not applicable, because it can generate failure mechanisms, which do not exist in most applications. If the 85 °C / 85 % RH test is required for specific applications, additional design measures are necessary.

The requirements for the tests have to be given in the detail specification, but the minimum requirements given in the Table A.1 shall be fulfilled.

Table A.1 – Minimum requirements

Measurement	Measuring method	Requirements
Capacitance	4.2.2	Grade 1.1 $\lvert \Delta C/C \rvert \leq 2\%$

		Grade 1.2 $\lvert \Delta C/C \rvert$ ≤ 6% Grade 2 $\lvert \Delta C/C \rvert$ ≤ 10%
Tangent of loss angle	4.2.3	Grade 1 ≤ 0,002 Grade 2 ≤ 0,004
Insulation resistance	4.2.4	> 50% of the applicable limits in 4.2.4.3, Table 11

A.3 Indication of humidity robustness grades

In addition to the climatic category, information on the humidity robustness grade shall be indicated in the information provided by the manufacturer. Marking on the capacitor is not required.

Bibliography

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

~~IEC 60065, *Audio, video and similar electronic apparatus – Safety requirements*~~

IEC 60068 (all parts), *Environmental testing*[1]

IEC 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60417, *Graphical symbols for use on equipment* (available at http://www.graphical-symbols.info/equipment)

~~IECQ 001005, *Register of Firms, Products and Services approved under the IECQ System, including ISO 9000 – updated 30, June 2000*~~

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[1] For the tests in the IEC 60068 series of standards, the editions referenced in the applicable test clauses of the generic specification are used.

IEC 60384-17

Edition 3.0 2019-03

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Fixed capacitors for use in electronic equipment – Part 17: Sectional specification – Fixed metallized polypropylene film dielectric AC and pulse capacitors

Condensateurs fixes utilisés dans les équipements électroniques – Partie 17: Spécification intermédiaire – Condensateurs fixes pour tension alternative et pour impulsions à diélectrique en film de polypropylène métallisé

IEC 60384-17:2019-03(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 17: Sectional specification – Fixed metallized polypropylene film dielectric AC and pulse capacitors

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.

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International Standard IEC 60384-17 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 2005. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) all parts of the document have been revised based on the ISO/IEC Directives, Part 2:2016 (seventh edition) and harmonization between other similar kinds of documents;

b) tables and Clause 4 have been revised so as to prevent duplications and contradictions;

c) new damp heat steady-state robustness classes with test conditions have been added in text, in Clause 4 and in Annex A.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
40/2654/FDIS	40/2664/RVD

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

This document 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 document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

The contents of the corrigendum of December 2020 have been included in this copy.

FIXED CAPACITORS FOR USE IN ELECTRONIC EQUIPMENT –

Part 17: Sectional specification – Fixed metallized polypropylene film dielectric AC and pulse capacitors

1 General

1.1 Scope

This part of IEC 60384 applies to fixed capacitors with metallized electrodes and polypropylene dielectric for use in electronic equipment.

NOTE Capacitors that have mixed film and metallized electrodes are also within the scope of this standard.

These capacitors may have "self-healing" properties depending on conditions of use.

Capacitors covered by this specification are mainly intended for use with alternating voltage and/or for pulse applications. The maximum reactive power applicable is 10 000 var and the maximum peak voltage is 3 000 V.

Capacitors for reactive power exceeding 500 var, and to which a maximum peak voltage of 2 500 V at 50 Hz can be applied, are not covered by this document, except when they are the highest part of a range of reactive power mainly situated below 500 var at 50 Hz.

This document is not intended to cover capacitance values higher than 20 µF.

Two performance grades of capacitors are covered, Grade 1 for long-life application and Grade 2 for general application.

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

Capacitors for electrical shock hazard protection (covered by IEC 60065 of IEC technical committee 61) and fluorescent lamp and motor capacitors (covered by IEC 60252-1 and IEC 60252-2 of IEC technical committee 33), and capacitors for use in tubular fluorescent and other discharge lamp circuits (covered by IEC 61048 and IEC 61049 of IEC technical committee 34) are also excluded.

1.2 Object

The object of this document is to prescribe preferred ratings and characteristics and to select from IEC 60384-1:2016, 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 shall be of equal or higher performance level. Lower performance levels are not permitted.

1.3 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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*

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60384-1:2016, *Fixed capacitors for use in electronic equipment – Part 1: Generic specification*

IEC 60384-16, *Fixed capacitors for use in electronic equipment – Part 16: Sectional specification: Fixed metallized polypropylene film dielectric d.c. capacitors*

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

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

1.4 Information to be given in a detail specification

1.4.1 General

Detail specifications shall be derived from the 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 information given in 1.4.2 may, for convenience, be presented in tabular form.

The information in 1.4.2 to 1.4.4 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.

1.4.2 Outline drawing and dimensions

There shall be 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 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.

The numerical values of the body shall be given as follows:

- general case: width, length and height;
- for cylindrical body: diameter and length.

The numerical values of the terminals shall be given as follows:

- width or diameter, length and spacing.

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 capacitor. When the capacitor is not designed for use on printed boards, this shall be clearly stated in the detail specification.

1.4.3 Mounting

The detail specification shall specify the method of mounting to be applied for normal use and for the application of the vibration and the bump or shock tests. The capacitors shall be mounted by their normal means. The design of the capacitor may be such that special mounting fixtures are required in its use. In this case, the detail specification shall describe the mounting fixtures and they shall be used in the application of the vibration and bump or shock tests.

1.4.4 Ratings and characteristics

1.4.4.1 General

The ratings and characteristics shall be in accordance with the clauses of this specification, including the items as specified in 1.4.4.2 to 1.4.4.5.

1.4.4.2 Nominal capacitance range

See 2.2.1.

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

1.4.4.3 Sinusoidal current (if applicable)

The detail specification shall state the derating curve of the sinusoidal current versus temperature with reference to 70 °C, and the derating curve of the sinusoidal current versus frequency and of the sinusoidal current versus capacitance.

1.4.4.4 Particular characteristics

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

1.4.4.5 Soldering

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

1.4.5 Marking

The detail specification shall specify the content of the marking on the capacitor and on the packaging. When there are deviations from 1.6, these shall be given in the detail specification.

1.5 Terms and definitions

1.5.1 General

For the purposes of this document, the applicable terms and definitions of IEC 60384-1:2016, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

1.5.2 Performance and stability grades

The performance grade describes the capacitor's ability to function in the intended applications. The stability grade describes capacitance drift in tests.

1.5.2.1
performance grade 1 capacitors
<long-life> capacitors for long-life applications with stringent requirements for the electrical parameters

1.5.2.2
performance grade 2 capacitors
<general purpose> capacitors for general application where the stringent requirements for grade 1 capacitors are not necessary

1.5.2.3
stability grade
capacitance drift after climatic and mechanical tests and after endurance tests

Note 1 to entry: The performance grade and the stability grade shall be noted in the detail specification.

1.5.2.4
performance grade and stability grade combination
designation for combined performance grade and stability grade

Note 1 to entry: Table 1 shows the preferred combination designations.

Table 1 – Preferred designations of performance grade and stability grade combinations

Performance grades	Stability grades	Combination designations
1	1	1.1
	2	1.2
2	–	2

The three combinations concern capacitance stability and tan δ values. Distinction in performance of the three combinations is shown in Table 4.

1.5.3 Rated voltages

1.5.3.1 General

The sum of the DC voltage and the peak AC voltage or the peak pulse voltage applied to the capacitor shall not exceed the rated voltage. The value of the peak AC voltage allowed at different frequencies is under consideration.

1.5.3.2
rated DC voltage
maximum DC voltage that may be applied continuously to a capacitor at the rated temperature

1.5.3.3
rated AC voltage
maximum RMS alternating voltage that may be applied continuously to a capacitor at the rated temperature and at a given frequency

1.5.3.4
rated pulse voltage
peak value of the pulse voltage that may be applied continuously to a capacitor at the rated temperature and at a given frequency

1.5.3.5
rated voltage pulse slope

maximum admissible value of the voltage slope $\frac{\mathrm{d}U}{\mathrm{d}t}$ of a pulse at the rated temperature at such a repetition frequency that no significant increase of temperature occurs

Note 1 to entry: The formula for rated voltage pulse slope is $\frac{(\mathrm{d}U)}{(\mathrm{d}t)_\mathrm{R}}$

1.6 Marking

1.6.1 General

See IEC 60384-1:2016, 2.4, with the details given in 1.6.2 to 1.6.5.

1.6.2 Information for marking

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) nominal capacitance (in clear or code in accordance with IEC 60062);
b) rated AC and/or pulse voltage (AC voltage may be indicated by the symbol ∼ (IEC 60417-5032-2002-10)) and the corresponding frequency if different from 50 Hz;
c) tolerance on nominal capacitance;
d) rated DC voltage (DC voltage may be indicated by the symbol ⎓ or — (IEC 60417-5031-2002-10)) (if applicable);
e) rated voltage pulse slope (if applicable);
f) rated current and corresponding frequency (if applicable);
g) year and month (or year and week) of manufacture;
h) manufacturer's name and/or trade mark;
i) climatic category;
j) manufacturer's type designation;
k) reference to the detail specification.

1.6.3 Marking on capacitors

The capacitor shall be clearly marked with a), b) and c) of 1.6.2 with as many as possible of the remaining items as is considered necessary. Any duplication of information in the marking on the capacitor should be avoided.

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

1.6.4 Marking on packaging

The packaging containing capacitor(s) should be clearly marked with all the information listed in 1.6.2 as applicable.

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

2.1.1 General

The values given in detail specifications shall preferably be selected from 2.2.1 to 2.2.8.

2.1.2 Preferred climatic categories

The capacitors covered by this specification are classified into climatic categories in accordance with the general rules given in IEC 60068-1:2013, Annex A.

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 and −10 °C;
- upper category temperature: +70°C, +85 °C, +100 °C, +105 °C, +110 °C and +125 °C;
- duration of the damp heat, steady-state test: 4 d, 10 d, 21 d and 56 d.

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

If specified in the detail specification, the humidity robustness grade according to Annex A should be given in connection with the climatic category.

2.2 Preferred values of ratings

2.2.1 Nominal capacitance (C_N)

Preferred values of nominal capacitance are values chosen from the E series of IEC 60063, which are given in Table 2, and their decimal multiples (× 10^n, where n is an integer).

2.2.2 Tolerance on nominal capacitance

The preferred tolerances on the nominal capacitance are ±20 %; ±10 %; ±5 %; ±2 %; ±1 %.

2.2.3 Nominal capacitance with associated tolerance values

For preferred combinations of capacitance series and tolerances, see Table 2.

Table 2 – Preferred combinations of capacitance series and tolerance

Preferred combinations	
Series	**Tolerances**
E 6	±20 %
E 12	±10 %
E 24	±5 %
E 48	±2 %
E 96	±1 %

2.2.4 Rated AC voltage (U_{RAC} or $U_{R\sim}$)

The frequency for the rated AC voltage shall be 50 Hz/60 Hz unless the detail specification prescribes a higher frequency.

The preferred values of rated AC voltage (RMS value) shall be chosen from the R10 or R20 series given in ISO 3.

The detail specification shall give the derating curve of the admissible RMS voltage versus temperature (higher than rated temperature) and, if applicable, versus frequency.

2.2.5 Category AC voltage (U_{CAC} or $U_{C\sim}$)

The category AC voltage is equal to the rated AC voltage U_{RAC} for upper category temperatures up to 85 °C. For an upper category temperature 100 °C, the category AC voltage is 0,7 U_{RAC}. For upper category temperatures > 100 °C, the category AC voltage will be calculated following the slope from U_{RAC} at 85 °C to 0,7 U_{RAC} at 100 °C for each temperature (for example 105 °C, 110 °C or 125 °C).

Figure 1 gives the category AC voltage ratio to rated AC voltage as a function of upper category temperature.

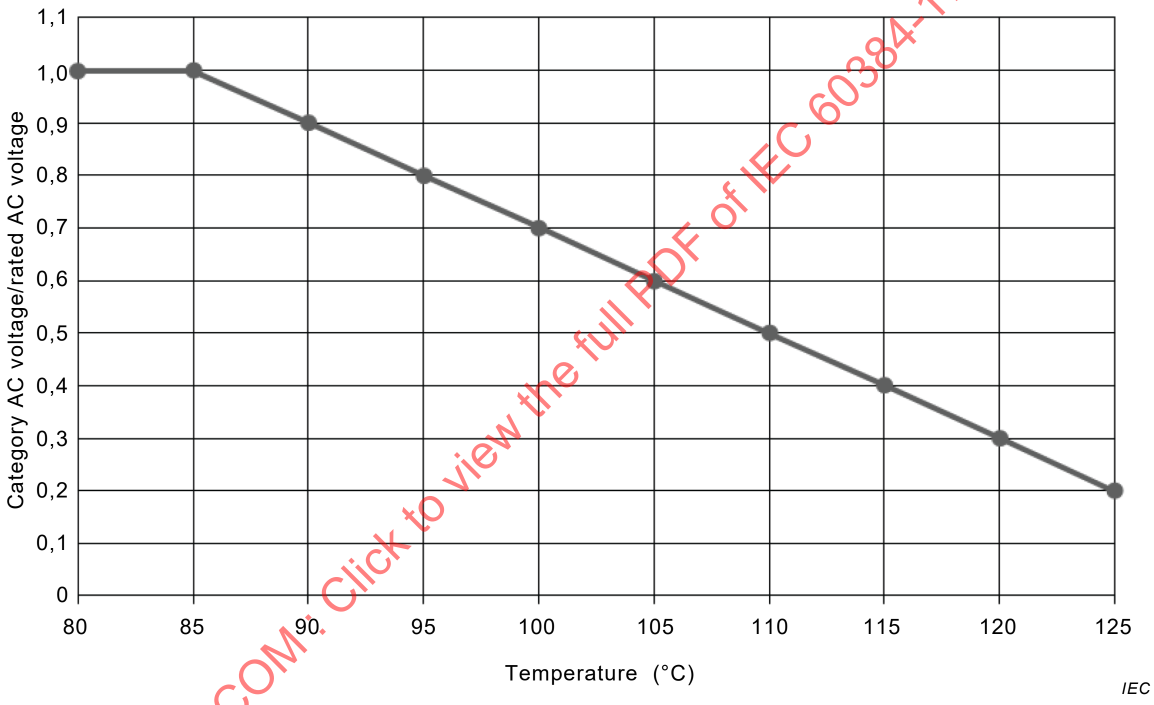

Figure 1 – Category AC voltage/rated AC voltage versus upper category temperature

2.2.6 Rated temperature

The standard value for rated temperature is 85 °C. Except for an upper category temperature of 70 °C, the rated temperature is 70 °C.

NOTE For DC rated voltage, the rated temperature is 15 °C higher than for AC rated voltage.

2.2.7 Rated AC current (if required)

The detail specification shall state:

- the frequency;
- the RMS value of the rated AC current applicable at the specified frequency (value chosen from R10 or R20 series);
- the derating curve of the admissible AC current versus ambient temperature.

2.2.8 Rated pulse voltage (if required)

The detail specification shall state:

- voltage pulse slope
- duration of the pulse
- repetition frequency of the pulses

3 Quality assessment procedures

3.1 Primary stage of manufacture

The primary stage of manufacture is the winding of the capacitor element or the equivalent operation.

3.2 Structurally similar components

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

3.3 Certified test records of released lots

The information required in IEC 60384-1:2016, Q.1.5 shall be made available when prescribed in the detail specification and when requested by a purchaser. After the endurance test, the required parameters are the capacitance and tan δ. The insulation resistance is only required by attribute.

3.4 Qualification approval procedures

3.4.1 General

The procedures for qualification approval testing are given in IEC 60384-1:2016, Q.2.

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

3.4.2 Qualification approval on the basis of the fixed sample size procedure

3.4.2.1 Sampling

The fixed sample size procedure is described in IEC 60384-1:2016, Q.2.4. The sample shall be representative of the range of capacitors for which approval is sought. The sample may be the whole or part of the range given in the detail specification.

The sample shall consist of four specimens having the maximum and minimum rated voltages, and, for these voltages, the maximum and minimum capacitances. When there are more than four rated voltages, an intermediate voltage shall also be tested. Thus, for the approval of a range, testing is required of either four or six values (capacitance/voltage combinations). When the range consists of fewer 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 that 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 3 gives the number of samples to be tested for each group with the permissible number of non-conforming items for qualification approval tests.

3.4.2.2 Tests

The complete series of tests specified in Table 3 and Table 4 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.

Specimens found to be non-conforming in the tests of Group 0 shall not be used for the other groups.

Approval is granted when the number of non-conforming items is zero.

Table 3 and Table 4 together form the fixed sample size test schedule for the qualification approval on the basis of the fixed sample size procedure.

Table 3 gives the number of the samples and permissible non-conforming items for each test and test group.

Table 4 gives a summary of the test conditions and performance requirements, and choices of the test conditions and performance requirements in the detail specification.

The test conditions and performance requirements for the qualification approval on the basis of the fixed sample size procedure should be identical to those for quality conformance inspections given in the detail specification.

Table 3 – Test and sampling plan for qualification approval, assessment level EZ

Group No.	Test	Subclause	Number of specimens (*n*) and permissible number of non-conforming items (*c*)			
			Per value[b]	For four or less values to be tested[b]	For six values to be tested[b]	*c*
			n	4 *n*	6 *n*	
0	Visual examination	4.1				0
	Marking	1.6				
	Dimensions	4.1				
	Capacitance	4.2.2	29	116	174	
	Tangent of loss angle	4.2.3				
	Voltage proof	4.2.1				
	Insulation resistance	4.2.4				
	Inductance [d]	4.2.5	(+5)[d]	(+20)[d]	(+30)[d]	
	Sealing [d]	4.16	(+5)[d]	(+20)[d]	(+30)[d]	
	Spare specimens		2	8	12	
1A	Robustness of terminations	4.3	3	12	18	
	Resistance to soldering heat	4.4				
	Component solvent resistance [d]	4.14				
1B	Solderability	4.5	6	24	36	
	Solvent resistance of the marking	4.15				
	Rapid change of temperature	4.6				
	Vibration	4.7				
	Bump or shock [a]	4.8 or 4.9				
1	Climatic sequence	4.10	9	36	54	
2	Damp heat, steady state without voltage	4.11	5	20	30	
	Damp heat, steady state with voltage [d]		(+5)[d]	(+20)[d]	(+30)[d]	
3A	Endurance test at 50 Hz/60 HZ alternating voltage	4.12.1	10	40	60	
3B[e]	Endurance test with sinusoidal current or voltage [d]	4.12.2	(+5)[d]	(+20)[d]	(+30)[d]	
3C[e]	Pulse endurance test [d]	4.12.3	(+5)[d]	(+20)[d]	(+30)[d]	
4	Characteristics depending on temperature [d]	4.2.6	(+5)[d]	(+20)[d]	(+30)[d]	
	Charge and discharge [c]	4.13	5[c]	20[c]	30[c]	

[a] As required in the detail specification.

[b] Capacitance-voltage combinations, see 3.4.2.

[c] Not required when pulse endurance test is required.

[d] If required in the detail specification.

Table 4 – Test schedule for qualification approval *(1 of 8)*

Subclause number, test and inspection items[a]	D or ND[b]	Conditions of test and measurements[a]	Number of specimens (n) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 0	ND		See Table 3	
4.1 Visual examination		See 4.1.2		Legible marking and as specified in the detail specification
4.1 Dimensions (detail)		See 4.1.2		See detail specification
4.2.2 Capacitance		See 4.2.2.2		Within specified tolerance
4.2.3 Tangent of loss angle (tan δ)		See 4.2.3.2 and 4.2.3.4		See 4.2.3.3 and 4.2.3.5
4.2.1 Voltage proof, either				
4.2.1.2 DC test, or		See 4.2.1.2.2		See 4.2.1.4
AC test		See 4.2.1.3.2		See 4.2.1.4
See detail specification for the test				
4.2.4 Insulation resistance		See 4.2.4.2		See 4.2.4.3
4.2.5 Inductance [d]		See 4.2.5		See detail specification
4.16 Sealing [d]		See detail specification for the method		No seepage of impregnant or harmful deformation of the case
Group 1A	D		See Table 3	
4.3 Robustness of terminations		See IEC 60384-1:2016, 4.13		
4.3.2 Initial inspections				
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		≤ initial limit
4.3.3 Final inspections				
Visual examination		See 4.1.2		no visible damage
Capacitance		See 4.2.2.2		See detail specification
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		See detail specification
4.4 Resistance to soldering heat		See IEC 60384-1:2016, 4.14 See 4.4.3 and detail specification for the method (1 or 2), and the duration of the test		
4.14 Component solvent resistance [d]		See IEC 60384-1:2016, 4.31		See detail specification
4.4.5 Final inspections and measurements				
Visual examination		See 4.4.5		No visible damage
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1.1: ≤ 1 % Grade 1.2: ≤ 2 % Grade 2: ≤ 3 % of value measured in 4.3.2

Table 4 *(2 of 8)*

Subclause number, test and inspection items[a]	**D or ND**[b]	**Conditions of test and measurements**[a]	**Number of specimens (n) and number of permissible non-conforming items (c)**	**Performance requirements**[a]
Group 1A *(continued)*	D		See Table 3	
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ for $C_{\mathrm{N}} \leq 1\ \mu\mathrm{F}$: for Grade 1.1: $\leq$ 0,001 Grade 1.2: $\leq$ 0,002 Grade 2: $\leq$ 0,004 of values measured in 4.3.2 for $C_{\mathrm{N}} > 1\ \mu\mathrm{F}$: see detail specification[c]
Group 1B	D		See Table 3	
4.5 Solderability		See 4.5.2. See detail specification for the method		
4.5.3 Final inspections				
Visual examination				See 4.5.3
4.15 Solvent resistance of the marking [d]		See IEC 60384-1:2016, 4.32.1		Legible marking
4.6 Rapid change of temperature		See 4.6.3 between T_{A} and T_{B} T_{A} = Lower category temperature T_{B} = Upper category temperature		
4.6.2 Initial inspections				
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		$\leq$ initial limit
Visual inspection				
4.6.4 Final inspections				
Visual examination		See 4.1.2		No visible damage
Capacitance		See 4.2.2.2		See detail specification
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		See detail specification
4.7 Vibration		See 4.7.3 See detail specification for the frequency range		
4.7.4 Final inspections				
Visual examination		See 4.1.2		No visible damage
4.8 Bump (or shock, see 4.9) [d]		See 4.8.3		
4.9 Shock (or bump, see 4.8)[d]		See 4.9.3 See detail specification for mounting method and severities		

Table 4 *(3 of 8)*

Subclause number, test and inspection items[a]	D or ND[b]	Conditions of test and measurements[a]	Number of specimens (n) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 1B *(continued)*.				
4.8.5 or 4.9.5 Final inspections and measurements				
Visual examination		See 4.1.2		No visible damage
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1.1: ≤ 1 % Grade 1.2: ≤ 2 % Grade 2: ≤ 3 % of value measured in 4.6.2
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \le 1$ µF: for Grade 1.1: ≤ 0,001 Grade 1.2: ≤ 0,002 Grade 2: ≤ 0,004 for $C_N > 1$ µF: see detail specification, compared to values measured in 4.6.2[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3
Group 1	D		See Table 3	
4.10 Climatic sequence				
4.10.2 Initial inspections				
Visual examination		See 4.1.2		No visible damage
Capacitance [e]		See 4.2.2.2		See detail specification
Tangent of loss angle [e]		See 4.2.3.2 and 4.2.3.4		See detail specification
Insulation resistance [e]		See 4.2.4.3		See detail specification
4.10.3 Dry heat		See IEC 60384-1:2016, 4.21.3		
4.10.4 Damp heat, cyclic, Test Db, first cycle		See IEC 60384-1:2016, 4.21.4		
4.10.5 Cold		See IEC 60384-1:2016, 4.21.5		
4.10.6 Low air pressure [d]		See 4.10.6.2		
4.10.6.3 Final inspections				
Visual examination		See 4.1.2		No permanent breakdown, flashover or harmful deformation of the case
4.10.7 Damp heat, cyclic, Test Db, remaining cycles		See 4.10.7.2		
4.10.7.3 Recovery [d]		See 4.10.7.3		
4.10.7.4 Final inspections				

Table 4 *(4 of 8)*

Subclause number, test and inspection items[a]	**D or ND**[b]	**Conditions of test and measurements**[a]	**Number of specimens (n) and number of permissible non-conforming items (c)**	**Performance requirements**[a]
Group 1 *(Continued)*				
4.10.7.4 Final inspections				
Visual examination		See 4.1.2		No visible damage Legible marking
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1.1: ≤ 1 % Grade 1.2: ≤ 3 % Grade 2: ≤ 5 % of value applied in 4.10.2
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \le 1$ µF: for Grade 1.1: ≤ 0,0015 Grade 1.2: ≤ 0,003 Grade 2: ≤ 0,005 for $C_N > 1$ µF: see detail specification[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3
Group 2	D		See Table 3	
4.11 Damp heat, steady state		See 4.11.3		
4.11.2 Initial inspections		See 4.11.2		
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		≤ initial limit
4.11.3 Test conditions		a) Without voltage b) If the detail specification so specifies, two sets of samples of equal size shall be prepared, one set to be tested without voltage and one set with rated voltage applied		
4.11.4 Recovery [d]		See 4.11.4		
4.11.5 Final inspections				
Visual examination		See 4.1.2		No visible damage Legible marking
Capacitance		See 4.2.2.2		a) Test without voltage $\lvert\Delta C/C\rvert$ for Grade 1.1: ≤ 1 % Grade 1.2: ≤ 3 % Grade 2: ≤ 5 % of value measured in 4.11.2

Table 4 *(5 of 8)*

Subclause number, test and inspection items[a]	**D or ND**[b]	**Conditions of test and measurements**[a]	**Number of specimens (n) and number of permissible non-conforming items (c)**	**Performance requirements**[a]
Group 2 *(Continued)*				b) Test with rated voltage Minimum requirements according to Annex A $\lvert\Delta C/C\rvert$ for Grade 1.1: ≤ 2 % Grade 1.2: ≤ 6 % Grade 2: ≤ 10 % of value measured in 4.11.2 See detail specification for more stringent requirements
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: a) Test without voltage: for $C_N \leq 1$ µF: for Grade 1: ≤0,001 Grade 2: ≤0,002 for $C_N > 1$ µF: see detail specification compared to values measured in 4.11.2[c] b) Test with rated voltage: Minimum requirements according to Annex A: for $C_N \leq 1$ µF: for Grade 1: ≤ 0,002 Grade 2: ≤ 0,004 for $C_N > 1$ µF: see detail specification compared to values measured in 4.11.2[c] See detail specification for more stringent requirements
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3 for both a) and b)

Table 4 *(6 of 8)*

Subclause number, test and inspection items[a]	D or ND[b]	Conditions of test and measurements[a]	Number of specimens (n) and number of permissible non-conforming items (c)	Performance requirements[a]
Group 3A	D		See Table 3	
4.12.2 Endurance test at 50/60 Hz alternating voltage				
4.12.2.1 Initial inspections and measurements		See 4.12.2.1		
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		≤ initial limit
4.12.5 Final inspections				
Visual examination		See 4.12.2.3		No visible damage Legible marking
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1: ≤ 5 % Grade 2: ≤ 10 % of value measured in 4.12.2.1
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \leq 1$ µF: for Grade 1: ≤ 0,002 Grade 2: ≤ 0,004 for $C_N > 1$ µF: see detail specification, compared to values measured in 4.12.2.1[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3
Group 3B[c]	D		See Table 3	
4.12.3 Endurance test with sinusoidal current or voltage (if required)				
4.12.3.2 Initial inspections and measurements		See 4.12.3.2		
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		≤ initial limit
4.12.3.3 Test conditions		See 4.12.3.3 Test frequency shall be given in the detail specification		
4.12.3.4 Final inspections and measurements		See 4.12.3.4		
Visual examination		See 4.12.3.4		No visible damage Legible marking
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1: ≤ 5 % Grade 2: ≤ 10 % of value measured in 4.12.3.2

Table 4 *(7 of 8)*

Subclause number, test and inspection items[a]	**D or ND**[b]	**Conditions of test and measurements**[a]	**Number of specimens (n) and number of permissible non-conforming items (c)**	**Performance requirements**[a]
Group 3B *(Continued)*				
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \leq 1$ µF: for Grade 1: ≤ 0,0015 Grade 2: ≤ 0,003 for $C_N > 1$ µF: see detail specification, compared to values measured in 4.12.3.2[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3
Group 3C[c]	D		See Table 3	
4.12.4 Pulse endurance test (if required)				
4.12.4.2 Initial inspections and measurements		See 4.12.4.2		
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		≤ initial limit
4.12.4.3 Test conditions		See 4.12.4.3 The pulse repetition rate and the applied peak voltage shall be given in the detail specification		
4.12.4.4 Final inspections and measurements		See 4.12.4.4		
Visual examination		See 4.12.4.4		No visible damage Legible marking
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1: ≤ 5 % Grade 2: ≤ 10 % of value measured in 4.12.4.2
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \leq 1$ µF: for Grade 1: ≤ 0,0015 Grade 2: ≤ 0,003 for $C_N > 1$ µF: see detail specification, compared to values measured in 4.12.4.2[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3

Table 4 *(8 of 8)*

Subclause number, test and inspection items[a]	**D or ND**[b]	**Conditions of test and measurements**[a]	**Number of specimens (n) and number of permissible non-conforming items (c)**	**Performance requirements**[a]
Group 4	D		See Table 3	
4.2.6 Characteristics depending on temperature [d]		See 4.2.6.2		
4.2.6.2 Measuring conditions		See 4.2.6.2		
4.2.6.3 Requirements				
Capacitance		See 4.2.2.2		See Table 13 and Table 14
Insulation resistance		See 4.2.4.3		See Table 11
4.13 Charge and discharge (not applicable when pulse endurance test is required)		See 4.13.2		
4.13.2 Initial inspections and measurements				
Capacitance		See 4.2.2.2		Within specified tolerance
Tangent of loss angle		For $C_N > 1$ µF: See 4.2.3.2 For $C_N \leq 1$ µF: See 4.2.3.4		≤ initial limit
4.13.3 Test conditions		See 4.13.4		
4.13.4 Recovery		See 4.13.4		
4.13.5 Final inspections				
Capacitance		See 4.2.2.2		$\lvert\Delta C/C\rvert$ for Grade 1.1: ≤ 1 % Grade 1.2: ≤ 3 % Grade 2: ≤ 5 % of value measured in 4.13.2
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of tan δ: for $C_N \leq 1$ µF: for Grade 1: ≤ 0,003 Grade 2: ≤ 0,005 for $C_N > 1$ µF: see detail specification, compared to values measured in 4.13.2[c]
Insulation resistance		See 4.2.4.3		≥ 50 % of values in 4.2.4.3

[a] Subclause numbers of test and performance requirements refer to Clause 4.

[b] In this table: D = destructive; ND = non-destructive.

[c] C_N = nominal capacitance in microfarads.

[d] If required.

[e] For use as reference value.

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.

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

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

b) 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.

c) if there are fewer than five of any one value in the sample, the basis for the drawing of samples shall be agreed between the manufacturer and a certification body (CB).

3.5.1.2 Group C inspection

These tests shall be carried out on a periodic basis.

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

3.5.2 Test schedule

The schedule for the lot-by-lot and periodic tests for quality conformance inspection is given in the blank detail specification.

3.5.3 Delayed delivery

When, in accordance with the procedures of IEC 60384-1:2016, Q.1.7, re-inspection has to be made, solderability and capacitance shall be checked as specified in Group A and Group B inspection.

3.5.4 Assessment levels

The assessment level EZ is stated in Table 5 and Table 6.

Table 5 – Lot-by-lot inspection

Inspection subgroup[b]	EZ		
	IL[a]	n[a]	c[a]
A0	100 %[c]		
A1	S-4	[d]	0
A2	S-3	[d]	0
B1	S-3	[d]	0

[a] IL = inspection level

n = sample size

c = permissible number of non-conforming items

[b] The content of the inspection subgroup is described in Clause 2 of the blank detail specification.

[c] The inspection shall be performed after removal of non-conforming items by 100 % testing during the manufacturing process. The sampling level shall be established by the manufacturer, preferably in accordance with IEC 61193-2:2007, Annex A.

Whether the lot was accepted or not, all samples for sampling inspection shall be inspected in order to monitor outgoing quality level by non-conforming items per million ($\times 10^{-6}$).

In case one or more non-conforming items occur in a sample, this lot shall be rejected but all non-conforming items shall be counted for the calculation of quality level values.

Outgoing quality level by non-conforming items per million ($\times 10^{-6}$) values shall be calculated by accumulating inspection data in accordance with the method given in IEC 61193-2:2007, 6.2.

[d] Number to be tested: sample size shall be determined in accordance with IEC 61193-2:2007, 4.3.2.

Table 6 – Periodic tests

Inspection subgroup[b]	EZ		
	p[a]	n[a]	c[a]
C1A	6	5	0
C1B	6	5	0
C1	6	10	0
C2	6	10	0
C3A	6	5	0
C3B	6	5	0
C3C	6	5	0
C4	6	10	0
C5	6	10	0

[a] p = periodicity in months

n = sample size

c = permissible number of non-conforming items

[b] The content of the inspection subgroup is described in Clause 2 of the blank detail specification.

4 Test and measurement procedures

NOTE This clause supplements the information given in IEC 60384-1:2016, Clause 4.

4.1 Visual examination and check of dimensions

4.1.1 General

See IEC 60384-1:2016, 4.4, with the details in 4.1.2 and 4.1.3.

4.1.2 Visual examination and check of dimensions

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.

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

The capacitors shall be examined to verify that the materials, design, construction and physical dimensions are appropriate.

4.1.3 Requirements

See Table 4.

The workmanship shall be in accordance with the applicable requirements given in the detail specification.

4.2 Electrical tests

4.2.1 Voltage proof for AC capacitors

4.2.1.1 General

The detail specification shall state which voltage proof test, DC or AC, is to be applied.

4.2.1.2 DC voltage proof test

4.2.1.2.1 General

Test circuit, see IEC 60384-1:2016, 4.6, with the following details.

The product of R_1 and the nominal capacitance of the capacitor under test (C_X) shall be smaller than or equal to 1 s and greater than 0,01 s.

R_1 includes the internal resistance of the power supply.

R_2 shall limit the discharge current to a value equal to or less than 1 A.

4.2.1.2.2 Test conditions

The voltages given in Table 7 shall be applied between the given measuring points (from IEC 60384-1:2016, Table 3) for a period of 1 min for qualification approval testing, and between measuring point 1a) for a period of minimum 1 s for the lot-by-lot quality conformance testing.

Table 7 – Test voltages, DC

Measuring point	Test voltage, DC
1a)	2,5 $U_{R\sim}$
1b), 1c) [a]	1,4 $U_{R\sim}$ + 2 000 V DC
[a] Insulated styles only	

If the capacitor has also a rated DC voltage, it shall be tested with the DC voltage proof test of the DC specification (IEC 60384-16), but if the value mentioned here in Table 7 is higher, this value shall be used.

4.2.1.3 AC voltage proof test (50 Hz or 60 Hz)

4.2.1.3.1 General

Test circuit as in IEC 60384-1:2016, 4.6, but the capacitor C_1 and resistor R_2 shall be omitted.

The product of R_1 and the nominal capacitance of the capacitor under test (C_X) shall be smaller than or equal to 1 s and greater than 0,01 s.

R_1 includes the internal resistance of the power supply.

4.2.1.3.2 Test conditions

The voltages given in Table 8 shall be applied between the given measuring points (from IEC 60384-1:2016, Table 3) for a period of 1 min for qualification approval testing, and between measuring point 1a) for a period of at least 1 s for the lot-by-lot quality conformance testing.

Table 8 – Test voltages, AC

Measuring point	Test voltage, AC (RMS)
1a)	1,5 $U_{R\sim}$ for $U_{R\sim} \le 250$ V 1,4 $U_{R\sim}$ for $U_{R\sim} > 250$ V
1b), 1c) [a]	1,4 $U_{R\sim}$ + 1 500 V AC

[a] Insulated styles only

4.2.1.4 Requirement

This is valid for both DC and AC tests.

There shall be no breakdown or flashover during the test.

NOTE The occurrence of self-healing breakdowns during the application of the test voltages is allowed.

4.2.2 Capacitance

4.2.2.1 General

See IEC 60384-1:2016, 4.7, with the details in 4.2.2.2 and 4.2.2.3.

4.2.2.2 Measuring conditions

The capacitance shall be measured at, or corrected to, a frequency of 1 kHz. For nominal capacitance values >10 µF, 50 Hz to 120 Hz may be used, but 1 kHz shall be the reference frequency.

The applied peak voltage at 1 kHz shall not exceed 3 % of the rated voltage, and the applied peak voltage at 50 Hz to 120 Hz shall not exceed 20 % of the rated voltage with a maximum of 100 V (70 V RMS).

4.2.2.3 Requirements

The capacitance shall be within the specified tolerance.

4.2.2.4 Presentation of the allowed capacitance change in tests

The allowed capacitance change in tests in Table 4 shall be presented using either performance grade or performance and stability grade combination designations in accordance with Table 1, depending on the test.

4.2.3 Tangent of loss angle (tan *δ*)

4.2.3.1 General

See IEC 60384-1:2016, 4.8, with the details from 4.2.3.2 to 4.2.3.5.

4.2.3.2 Measuring conditions for measurements at 1 kHz

The test conditions are as follows:

- frequency: 1 kHz;
- peak voltage: ≤ 3 % of the rated voltage;
- inaccuracy: $\leq 5 \times 10^{-4}$ (absolute value).

4.2.3.3 Requirement for measurements at 1 kHz

Tan *δ* shall not exceed the applicable values shown in Table 9.

Table 9 – Tangent of loss angle limits, 1 kHz

Nominal capacitance µF	Tan δ (absolute value)	
	Grade 1 capacitors	**Grade 2 capacitors**
≤ 1	$\leq 10 \times 10^{-4}$	$\leq 20 \times 10^{-4}$

For C_N > 1 µF, values of tan *δ* shall be specified in the detail specification.

4.2.3.4 Measuring conditions for measurements at 10 kHz

For capacitors with $C_N \leq 1$ µF, tan *δ* shall be measured as follows.

- frequency: 10 kHz;
- voltage: ≤ 1 V (RMS);
- inaccuracy: $\leq 5 \times 10^{-4}$ (absolute value).

4.2.3.5 Requirement for measurements at 10 kHz

Tan *δ* shall not exceed the applicable values shown in Table 10.

Table 10 – Tangent of loss angle limits, 10 kHz

Nominal capacitance µF	Tan δ (absolute value)	
	Grade 1 capacitors	Grade 2 capacitors
≤1	≤ 20 × 10^{-4}	≤ 40 × 10^{-4}

For C_N > 1 µF, values of tan δ shall be specified in the detail specification.

4.2.3.6 Presentation of the allowed tan δ change in tests

The allowed tan δ change in tests in Table 4 shall be presented using either performance grade or performance and stability grade combination designations in accordance with Table 1, depending on the test.

4.2.4 Insulation resistance

4.2.4.1 General

See IEC 60384-1:2016, 4.5, with the details 4.2.4.2 and 4.2.4.3.

4.2.4.2 Measuring conditions

Prior to the test, capacitors shall be carefully cleaned to remove any contamination. Care shall be taken to maintain cleanliness in the test chambers and during post-test measurements.

Before the measurement, the capacitors shall be fully discharged. The product of the resistance of the discharge circuit and the nominal capacitance of the capacitor under test shall be ≥ 0,01 s or any other value prescribed in the detail specification.

The measuring voltage shall be in accordance with IEC 60384-1:2016, 4.5.2. The measuring points shall be in accordance with IEC 60384-1:2016, Table 3.

The voltage shall be applied immediately at the correct value through the internal resistance of the voltage source. The product of the internal resistance and the nominal capacitance of the capacitor shall be smaller than 1 s or any other value prescribed in the detail specification.

4.2.4.3 Requirements

The insulation resistance shall meet the requirements shown in Table 11.

Table 11 – Insulation resistance requirements

Minimum RC product (R = insulation resistance between the terminations) (C = nominal capacitance) s				Minimum insulation resistance between the terminations GΩ		Minimum insulation resistance between terminations and case GΩ
Measuring points in accordance with Table 3 of IEC 60384-1:						
1 a)				1 a)		1 b), 1 c)
Nominal capacitance:						
> 0,33 µF				≤ 0,33 µF		
Rated voltage:						
> 100 V		≤ 100 V		All voltages		
Grade:						
1	2	1	2	1	2	
30 000	7 500	15 000	3 750	100	25	100

When the test is carried out at a temperature other than 20 °C, the result shall, when necessary, be corrected to 20 °C by multiplying the result of the measurement by the appropriate correction factor. In case of doubt, measurement at 20 °C is decisive. The correction factors given in Table 12 can be considered as an average for metallized polypropylene film capacitors.

Table 12 – Insulation resistance correction factor dependent on test temperature

Temperature °C	Correction factor
15	0,75
20	1,00
23	1,25
27	1,5
30	1,75
35	2

4.2.5 Inductance (if required)

See IEC 60384-1:2016, 4.11, with the following details.

The maximum inductance value shall be stated in the detail specification.

An approximative value can be provided from measurement of resonance frequency and from capacitance value measured in 4.2.2.

4.2.6 Characteristics depending on temperature (if required in the detail specification)

4.2.6.1 General

See IEC 60384-1:2016, 4.24.1, with the details in 4.2.6.2 and 4.2.6.3.

4.2.6.2 Measuring conditions

The capacitance measurements shall be carried out at the temperatures given in items b), d) and f) of IEC 60384-1:2016, 4.24.1.2. The measurement of insulation resistance is also carried out at the temperature as given in item f). The measuring points of insulation resistance are 1a), 1b) and 1c) from IEC60384-1:2016, Table 3.

4.2.6.3 Requirements

The requirements in lower and upper category temperature are given in Table 13 and Table 14 respectively.

Table 13 – Characteristics at lower category temperature

Test temperature as given in item b)	Temperature characteristic of capacitance
−10 °C and −25 °C	$0 \leq \frac{\Delta C}{C} \leq +2{,}25\ \%$
−40 °C	$0 \leq \frac{\Delta C}{C} \leq +3\ \%$
−55 °C	$0 \leq \frac{\Delta C}{C} \leq +3{,}75\ \%$

Table 14 – Characteristics at upper category temperature

Test temperature as given in item f)	Temperature characteristic of capacitance	Insulation resistance (measuring point 1 a)		Insulation resistance (measuring point 1b) and 1c)) GΩ
		C_N > 0,33 µF $R_i \times C_N$ s	C_N ≤ 0,33 µF R_i GΩ	
70 °C	$-2{,}5\ \% \leq \frac{\Delta C}{C} \leq 0$	1 500	5	5
85 °C	$-3{,}25\ \% \leq \frac{\Delta C}{C} \leq 0$	1 200	4	4
100 °C	$-4\ \% \leq \frac{\Delta C}{C} \leq 0$	750	2,5	2,5
105 °C and 110 °C	$-4{,}5\ \% \leq \frac{\Delta C}{C} \leq -1$	600	2,2	2.2
125 °C	$-6\ \% \leq \frac{\Delta C}{C} \leq -2$	500	2,0	2,0

4.3 Robustness of terminations

4.3.1 General

See IEC 60384-1:2016, 4.13, with the details in 4.3.2 and 4.3.3.

4.3.2 Initial inspections

The capacitance shall be measured in accordance with 4.2.2.2.

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4 as appropriate.

4.3.3 Final inspections and requirements

No visible damage.

4.4 Resistance to soldering heat

4.4.1 General

See IEC 60384-1:2016, 4.14, with the details from 4.4.2 to 4.4.5.

4.4.2 Initial inspections

In accordance with 4.3.2.

4.4.3 Test conditions

No pre-drying.

– Method 1 (solder bath) or 2 (soldering iron) of IEC 60384-1:2016, 4.14, unless otherwise specified in the detail specification.

– Duration: 5 s ± 0,5 s or 10 s ± 1 s, unless otherwise specified in the detail specification.

If method 1 is applied, immersion and withdrawal speed shall be 25 mm/s ± 2,5 mm/s

4.4.4 Recovery

The recovery period shall be 1 h to 2 h.

4.4.5 Final inspections, 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 in accordance with 4.2.3.2 and shall meet the requirements given in Table 4.

4.5 Solderability

4.5.1 General

See IEC 60384-1:2016, 4.15, with the details in 4.5.2 and 4.5.3.

4.5.2 Test conditions

No ageing.

Temperature of the solder bath and process time for preferred solders:

– SnPb solder:	235 °C ± 3 °C for (2 ± 0,2) s;
– Sn96,5Ag3Cu,5 solder:	245 °C ± 3 °C for (3 ± 0,3) s;
– Sn99,3Cu,7 solder:	250 °C ± 3 °C for (3 ± 0,3) s.

The requirements for the globule test method shall be prescribed in the detail specification. When neither the solder bath nor the solder globule method is appropriate, the soldering iron test shall be used with soldering iron Size A.

4.5.3 Final inspections and requirements

The capacitor shall be visually examined under normal lighting and approximately 10× magnification.

The areas to be soldered 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 dewetted areas. These imperfections shall not be concentrated in one area.

In the solder globule method, the detail specification shall define the flow time of the solder in seconds.

4.6 Rapid change of temperature

4.6.1 General

See IEC 60384-1:2016, 4.16, with the details from 4.6.2 to 4.6.4.

4.6.2 Initial inspections

The capacitance shall be measured in accordance with 4.2.2.2.

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4 as appropriate.

4.6.3 Test conditions

Test conditions are as follows:

- capacitors shall be tested for 5 cycles;
- duration of exposure at the temperature limits: 30 min, unless otherwise prescribed in the detail specification for larger capacitors.

4.6.4 Final inspections and requirements

The capacitors shall be visually examined and there shall be no visual damage.

When prescribed in the detail specification, capacitors shall be measured after recovery; they shall meet the requirements of the detail specification.

4.7 Vibration

4.7.1 General

See IEC 60384-1:2016, 4.17, with the details from 4.7.2 to 4.7.4.

4.7.2 Initial inspections

Not required

4.7.3 Test conditions

The following degree of severity of test Fc applies.

- frequency range is one of the following: 10 Hz to 55 Hz, 10 Hz to 500 Hz or 10 Hz to 2 000 Hz;
- amplitude or acceleration (whichever is the lower acceleration): 0,75 mm or 100 m/s^2;
- total duration: 6 h (2 h in each X, Y and Z -axis direction).

The detail specification shall specify the frequency range and shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.7.4 Final inspections and requirements

The capacitors shall be visually examined and there shall be no visual damage.

4.8 Bump (repetitive shock)

4.8.1 General

The detail specification shall state whether the bump or the shock test applies.

See IEC 60384-1:2016, 4.18, with the details from 4.8.2 to 4.8.4.

4.8.2 Initial measurements

Not required.

4.8.3 Test conditions

The detail specification shall state which of the following severities applies.

Total number of bumps: 1 000 or 4 000

Acceleration:	400 m/s^2	or	100 m/s^2
Pulse duration:	6 ms		16 ms

The detail specification shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.8.4 Final inspections, measurements and requirements

The capacitors shall be visually inspected and shall meet the requirements given in Table 4.

4.9 Shock

4.9.1 General

The detail specification shall state whether the shock or the bump test applies.

See IEC 60384-1:2016, 4.19, with the details from 4.9.2 to 4.9.4

4.9.2 Initial measurements

Not required.

4.9.3 Test conditions

The detail specification shall state which of the following preferred severities applies.

Pulse-shape: half-sine

Table 15 – Preferred severities in shock test

Peak acceleration m/s^2	**Corresponding duration of the pulse** ms
300	18
500	11
1 000	6

The detail specification shall also prescribe the mounting method to be used. For capacitors with axial leads and intended to be mounted by the leads only, the distance between the body and the mounting point shall be 6 mm ± 1 mm.

4.9.4 Final inspection, measurements and requirements

The capacitors shall be visually inspected and shall meet the requirements given in Table 4.

4.10 Climatic sequence

4.10.1 General

See IEC 60384-1:2016, 4.21, with the details from 4.10.2 to 4.10.9.

4.10.2 Initial measurements

Not required, see 4.3.2, 4.4.4, 4.8.4 or 4.9.4 as applicable.

4.10.3 Dry heat

See IEC 60384-1:2016, 4.21.3.

4.10.4 Damp heat, cyclic, Test Db, first cycle

See IEC 60384-1:2016, 4.21.4.

4.10.5 Cold

See IEC 60384-1:2016, 4.21.5.

4.10.6 Low air pressure (if required)

4.10.6.1 General

See IEC 60384-1:2016, 4.21.6, with the details in 4.10.6.2 and 4.10.6.3.

4.10.6.2 Test conditions

The test, if required in the detail specification, shall be made at a temperature of 15 °C to 35 °C and a pressure of 8 kPa. The duration of the test shall be 1 h.

While still at the specified low pressure and during the last 5 min of the 1-h period, the rated voltage shall be applied

The sample part of capacitors submitted to this test shall be subdivided into two or three parts as necessary and each part submitted to one of the tests laid down in Table 3 of IEC 60384-1:2016. The test voltage shall be applied to terminations, case, etc., as given in 4.2.1.

4.10.6.3 Final inspections, measurements and requirements

The capacitors shall be visually inspected and shall meet the requirements given in Table 4.

4.10.7 Damp heat, cyclic, Test Db, remaining cycles

4.10.7.1 General

See IEC 60384-1:2016, 4.21.7, with the details in 4.10.7.2.

4.10.7.2 Test conditions

Within 15 min after removal from the damp heat test, the rated voltage shall be applied for 1 min at measuring point 1a) using the test circuit conditions as given in 4.2.1.

4.10.8 Recovery

The recovery period shall be 1 h to 2 h, unless otherwise specified in the detail specification.

4.10.9 Final inspections, measurements and requirements

After recovery, the capacitors shall be visually inspected and measured and meet the requirements given in Table 4.

4.11 Damp heat, steady state

4.11.1 General

See IEC 60384-1:2016, 4.22, with the details from 4.11.2 to 4.11.6.

4.11.2 Initial inspections

The capacitance shall be measured according to 4.2.2.2.

The tangent of loss angle shall be measured according to 4.2.3.2 or 4.2.3.4.

4.11.3 Test conditions

Test conditions are as follows:

- temperature: 40 °C ± 2 °C;
- relative humidity: (93 ± 3) %;
- applied voltage:
  a) No voltage shall be applied;

  within 15 min after removal from the test chamber, the voltage proof test of 4.2.1 shall be carried out at test point 1a) only, using the rated voltage ;

  b) If the detail specification so requires, there shall be another test group for testing with rated voltage. The detail specification shall define the inspection and measurement requirements;

  Both test groups are equal in size.
- duration: 4 d, 10 d, 21 d or 56 d.

4.11.4 Recovery

The recovery period shall be 1 h to 2 h.

4.11.5 Final inspections, measurements and requirements

After recovery, the capacitors shall be visually inspected and measured and shall meet the requirements given in Table 4. The requirements for testing without voltage and with voltage should be separately defined.

4.11.6 Humidity robustness grades

Annex A describes the classification of various humidity robustness grades and the associated test conditions. If the detail specification describes a humidity robustness grade, it should be selected from this Annex A.

4.12 Endurance

4.12.1 General

See IEC 60384-1:2016, 4.23, with the details from 4.12.2 to 4.12.4.

4.12.2 Endurance test at 50 Hz/60 Hz alternating voltage

4.12.2.1 Initial inspections

The capacitance shall be measured in accordance with 4.2.2.2.

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4.

4.12.2.2 Test conditions

In addition to IEC 60384-1:2016, 4.23, the following details apply, unless otherwise specified in the detail specification:

– duration of test:	1 000 h ± 24 h (Grade 2) or 2 000 h ±24 h (Grade 1);
– value of the applied voltage:	1,25 times the rated AC voltage (frequency: 50/60 Hz sinusoidal);
– temperature of the chamber:	AC rated temperature;
– source impedance:	lower than 0,1 times the impedance of the group of capacitors under test.

This test is not applicable for capacitors with rated AC voltages less than 200 V (RMS).

4.12.2.3 Final inspections, measurements and requirements

The capacitors shall be visually inspected and measured and shall meet the requirements given in Table 4.

4.12.3 Endurance test with sinusoidal current or voltage (if required)

4.12.3.1 General

The object of the test is to produce an average overheating of the capacitor by carrying out an endurance test with a sinusoidal wave.

4.12.3.2 Initial inspections

The capacitance shall be measured in accordance with 4.2.2.2

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4.

4.12.3.3 Test conditions

- duration of test: 1 000 h ± 24 h (Grade 2) or 2 000 h ±24 h (Grade 1);
- RMS current or voltage: $1{,}1\ {}^{+10}_{\ 0}$ % times the rated AC current or voltage (RMS) with reference to the nominal capacitance;
- frequency: to be given in the detail specification;
- test temperature: standard atmospheric conditions for testing.

The RMS value of the current shall also be applicable to the lowest limit of the capacitance tolerance. The RMS value of the voltage shall also be applicable to the highest limit of the capacitance tolerance.

If the capacitor is guaranteed in current, the test shall be understood without any correction on the applied current. If the capacitor is guaranteed in voltage, the test shall be understood without any correction on the applied voltage.

For qualification approval, capacitors within 2 % from the lowest tolerance limit shall be selected for current testing. For qualification approval, capacitors within 2 % from the highest tolerance limit shall be selected for voltage testing. No special selection shall be made for periodic tests.

4.12.3.4 Final inspections, measurements and requirements

The capacitors shall be inspected and measured and shall meet the requirements given in Table 4.

4.12.4 Pulse endurance test (if required)

4.12.4.1 General

The object of the test is to verify that the capacitor can withstand an endurance test of periodic pulses without significant temperature rise.

4.12.4.2 Initial inspections

The capacitance shall be measured in accordance with 4.2.2.2.

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4.

4.12.4.3 Test conditions

- duration of test: 1 000 h ± 24 h (Grade 2) or 2 000 h ±24 h (Grade 1);
- temperature: standard atmospheric conditions for testing;
- pulse repetition rate: according to the detail specification;

  A frequency of 1 Hz may be used for ratings greater than 500 V/µs if 50 Hz/60 Hz gives a significant temperature rise (> 10 °C).
- applied peak voltage: equal to the rated peak voltage (to be given in the detail specification);

  discharge time constant:
  a) 1,5 times the rated value, when expressed by peak current per unit of capacitance (A/µF) or by the maximum $\frac{\mathrm{d}U}{\mathrm{d}t}$ (V/µs);
  b) 0,67 times the rated value, when expressed by discharge time constant(s);

NOTE $\frac{I_p}{C} = \frac{dU}{dt} = \frac{U}{R_d \cdot C_N}$ with $R_d \cdot C_N$ = discharge time constant.

– charge time constant:	10 times the discharge time constant;
– duration of the charge period:	> 5 times the charge time constant;
– duration of the discharge period:	> 5 times the discharge time constant;
– maximum peak reverse voltage:	10 % of the applied peak voltage.

4.12.4.4 Final inspections, measurements and requirements

The capacitors shall be visually inspected and measured and shall meet the requirements given in Table 4.

4.13 Charge and discharge

4.13.1 General

See IEC 60384-1:2016, 4.27, with the details from 4.13.2 to 4.12.5.

4.13.2 Initial inspections

The capacitance shall be measured in accordance with 4.2.2.2.

The tangent of loss angle shall be measured in accordance with 4.2.3.2 or 4.2.3.4.

4.13.3 Test conditions

The capacitors shall be subjected to 10 000 cycles of charge and discharge at a rate of approximately one cycle per second. Each cycle shall consist of charging and discharging the capacitor. Each capacitor shall be individually charged with the rated voltage through a resistor with a value

$$(220 \times 10^{-6})/C_N \quad (\Omega)$$

where C_N is the nominal capacitance in farads, or the value required to limit the charge current to 1 A (or to the higher current value given in the detail specification), whichever resistance value is the greater.

Each capacitor shall be individually discharged through a resistor with a value of

$$(10 \times 10^{-6})/C_N \quad (\Omega)$$

with a minimum of 20 Ω, or a lower value when prescribed in the detail specification, calculated as follows from the value of $\frac{dU}{dt}$ prescribed in the detail specification:

$$R = \frac{U}{C \cdot \frac{dU}{dt}}$$

4.13.4 Recovery

The recovery shall be 1 h to 2 h.

4.13.5 Final inspections, measurements and requirements

After recovery, the capacitors shall be measured and shall meet the requirements given in Table 4.

4.14 Component solvent resistance (if required)

See IEC 60384-1:2016, 4.31.

4.15 Solvent resistance of marking (if required)

See IEC 60384-1:2016, 4.32.

4.16 Sealing (if required)

See IEC 60384-1:2016, 4.20.

Annex A
(normative)

Humidity robustness grades

A.1 General

In addition to the description of preferred climatic categories in 2.1 and the damp heat, steady-state test in 4.11, this Annex A describes specific humidity robustness grades for applications, where high stability under high-humidity operating conditions is required.

A.2 Humidity robustness grades

Standard

See 2.1.2 and 4.11.3, a).

In this grade, humidity robustness under operating conditions with applied voltage is not defined.

Grade (I) robustness under humidity

An additional sample shall be tested with rated AC voltage applied. See 2.1 and 4.11.3, b).

> **Test condition**: damp heat, steady state; 40 °C / 93 % RH, duration 21 days, rated AC voltage applied.

Grade (II) robustness under high humidity

An additional sample shall be tested with rated AC voltage applied. See 2.1 and 4.11.3, b).

> **Test condition**: damp heat, steady state; 40 °C / 93 % RH, duration 56 days, rated AC voltage applied.

Grade (III) high robustness under high humidity

An additional sample shall be tested with rated AC voltage applied. See 2.1 and 4.11.3, b).

> **Test condition**: damp heat, steady state; 60 °C / 93 % RH, duration 56 days, rated AC voltage applied.

NOTE 1 In Grade (III), the test temperature has been increased to 60 °C from the standard condition to keep the test time in acceptable limits.

NOTE 2 For fixed metallized polypropylene capacitors the 85 °C / 85 % RH test is not applicable, because it can generate failure mechanisms, which do not exist in most applications. If the 85 °C / 85 % RH test is required for specific applications, additional design measures are necessary.

The requirements for the tests have to be given in the detail specification, but the minimum requirements given in the Table A.1 shall be fulfilled.

Table A.1 – Minimum requirements

Measurement	Measuring method	Requirements
Capacitance	4.2.2	Grade 1.1 $\lvert \Delta C/C \rvert \leq 2\%$ Grade 1.2 $\lvert \Delta C/C \rvert \leq 6\%$ Grade 2 $\lvert \Delta C/C \rvert \leq 10\%$
Tangent of loss angle	4.2.3	Grade 1 ≤ 0,002 Grade 2 ≤ 0,004
Insulation resistance	4.2.4	> 50% of the applicable limits in 4.2.4.3, Table 11

A.3 Indication of humidity robustness grades

In addition to the climatic category, information on the humidity robustness grade shall be indicated in the information provided by the manufacturer. Marking on the capacitor is not required.

Bibliography

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

IEC 60068 (all parts), *Environmental testing*[1]

IEC 60384-14, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*

IEC 60417, *Graphical symbols for use on equipment* (available at http://www.graphical-symbols.info/equipment)

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[1] For the tests in the IEC 60068 series of standards, the editions referenced in the applicable test clauses of the generic specification are used.

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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CONDENSATEURS FIXES UTILISÉS DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –

Partie 17: Spécification intermédiaire – Condensateurs fixes pour tension alternative et pour impulsions à diélectrique en film de polypropylène métallisé

AVANT-PROPOS

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La Norme internationale IEC 60384-17 a été établie par le comité d'études 40 de l'IEC: Condensateurs et résistances pour équipements électroniques.

Cette troisième édition annule et remplace la deuxième édition parue en 2005. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) toutes les parties du document ont été révisées sur la base des Directives ISO/IEC, Partie 2:2016 (septième édition) et harmonisées avec les autres types de documents similaires;

b) les tableaux et l'Article 4 ont été révisés afin d'éliminer les doublons et les contradictions;

c) de nouvelles classes de résistance à la chaleur humide continue (avec les conditions d'essai associées) ont été ajoutées à l'Article 4 et à l'Annexe A.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
40/2654/FDIS	40/2664/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60384, publiées sous le titre général *Condensateurs fixes utilisés dans les équipements électroniques*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives au document recherché. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

Le contenu du corrigendum de décembre 2020 a été pris en considération dans cet exemplaire.

CONDENSATEURS FIXES UTILISÉS DANS LES ÉQUIPEMENTS ÉLECTRONIQUES –

Partie 17: Spécification intermédiaire – Condensateurs fixes pour tension alternative et pour impulsions à diélectrique en film de polypropylène métallisé

1 Généralités

1.1 Domaine d'application

La présente partie de l'IEC 60384 s'applique aux condensateurs fixes à électrodes métallisées et à diélectrique en polypropylène destinés aux équipements électroniques.

NOTE Les condensateurs équipés à la fois d'électrodes métallisées et d'électrodes en film sont également couverts par la présente norme.

Ces condensateurs peuvent avoir des propriétés "d'autorégénération" en fonction des conditions d'utilisation.

Les condensateurs couverts par la présente spécification sont principalement destinés à être utilisés dans des applications à impulsions et/ou à tension alternative. La puissance réactive maximale est 10 000 var et la tension de crête maximale est 3 000 V.

Les condensateurs destinés à être utilisés à des puissances réactives supérieures à 500 var et où une tension de crête maximale de 2 500 V à 50 Hz peut être appliquée ne sont pas couverts par le présent document, sauf s'ils sont dans la partie haute d'une plage de puissances réactives situées principalement sous 500 var à 50 Hz.

Le présent document n'est pas destiné à couvrir des valeurs de capacité supérieures à 20 µF.

Deux classes de performance sont couvertes, la classe 1 pour les applications de longue durée de vie et la classe 2 pour les applications d'usage courant.

Les condensateurs d'antiparasitage ne sont pas inclus, mais sont couverts par l'IEC 60384-14.

Les condensateurs de protection contre les dangers de chocs électriques (couverts par l'IEC 60065 du comité d'études 61 de l'IEC) ainsi que les condensateurs pour moteurs et pour lampes fluorescentes (couverts par l'IEC 60252-1 et l'IEC 60252-2 du comité d'études 33 de l'IEC) et les condensateurs destinés à être utilisés dans les circuits de lampes tubulaires à fluorescence et autres lampes à décharge (couverts par l'IEC 61048 et l'IEC 61049 du comité d'études 34 de l'IEC) sont également exclus.

1.2 Objet

Le présent document a pour objet de prescrire les valeurs assignées et caractéristiques préférentielles, de choisir les procédures d'assurance de la qualité, les essais et les méthodes de mesure pertinents dans l'IEC 60384-1:2016, et de spécifier les exigences de performance générales pour ce type de condensateur. Les sévérités et les exigences d'essai prescrites dans les spécifications particulières se rapportant à cette spécification intermédiaire doivent présenter un niveau de performance supérieur ou égal. Des niveaux de performance inférieurs ne sont pas admis.

1.3 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60062, *Codes de marquage des résistances et des condensateurs*

IEC 60068-1:2013, *Essais d'environnement – Partie 1: Généralités et lignes directrices*

IEC 60384-1:2016, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 1: Spécification générique*

IEC 60384-16, *Fixed capacitors for use in electronic equipment – Part 16: Sectional specification: Fixed metallized polypropylene film dielectric d.c. capacitors* (disponible en anglais seulement)

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

ISO 3, *Nombres normaux – Séries de nombres normaux*

1.4 Informations à spécifier dans une spécification particulière

1.4.1 Généralités

Les spécifications particulières doivent provenir de la spécification particulière-cadre.

Les spécifications particulières ne doivent pas spécifier d'exigences inférieures à celles de la spécification générique, intermédiaire ou particulière-cadre. Si des exigences plus strictes sont incluses, elles doivent figurer au 1.9 de la spécification particulière et être indiquées dans les programmes d'essais, par exemple, par un astérisque.

Les informations données au 1.4.2 peuvent, pour des raisons pratiques, être présentées sous forme de tableau.

Les informations contenues du 1.4.2 au 1.4.4 doivent être fournies dans chaque spécification particulière, et les valeurs citées doivent être choisies de préférence parmi celles données dans l'article applicable de la présente spécification intermédiaire.

1.4.2 Dessin d'encombrement et dimensions

Une illustration du condensateur doit être fournie afin d'identifier facilement le condensateur et le comparer à d'autres. Les dimensions et les tolérances associées, qui affectent l'interchangeabilité et le montage, doivent être indiquées dans la spécification particulière. Toutes les dimensions doivent être de préférence indiquées en millimètres. Lorsque, toutefois, les dimensions originales sont données en pouces, les dimensions métriques converties en millimètres doivent être ajoutées.

Les valeurs numériques du corps doivent être données comme suit:

- cas général: largeur, longueur et hauteur;
- pour les corps cylindriques: diamètre et longueur.

Les valeurs numériques des bornes doivent être données comme suit:

- largeur ou diamètre, longueur et espacement.

Si nécessaire, lorsqu'un certain nombre d'éléments (dimensions et plages de capacités/tensions) est couvert par une spécification particulière, les dimensions et les tolérances associées doivent être indiquées dans un tableau sous le dessin.

Lorsque la configuration est différente de celle décrite ci-dessus, la spécification particulière doit indiquer les informations sur les dimensions et décrire le condensateur de manière adéquate. Lorsque le condensateur n'est pas destiné à être utilisé sur des cartes imprimées, cette information doit être clairement indiquée dans la spécification particulière.

1.4.3 Montage

La spécification particulière doit spécifier la méthode de montage à utiliser pour une utilisation normale, et lors des essais de vibrations et de secousses ou de chocs. Les condensateurs doivent être montés normalement. La conception du condensateur peut être telle que des supports de montage spéciaux soient nécessaires à son utilisation. Dans ce cas, la spécification particulière doit décrire les supports de montage. Ces supports de montage doivent être utilisés lors des essais de vibrations et de secousses ou de chocs.

1.4.4 Valeurs assignées et caractéristiques

1.4.4.1 Généralités

Les valeurs assignées et caractéristiques doivent être conformes aux articles de la présente spécification, ainsi qu'aux 1.4.4.2 à 1.4.4.5.

1.4.4.2 Plage de capacités nominales

Voir 2.2.1.

Lorsque des produits approuvés conformément à la spécification particulière comportent différentes plages de capacités nominales, il convient d'ajouter la déclaration suivante: "La plage de capacités nominales disponible dans chaque plage de tensions est présentée dans le registre des agréments, disponible par exemple sur le site web du système de certification en ligne de l'IECQ, www.iecq.org."

1.4.4.3 Courant sinusoïdal (le cas échéant)

La spécification particulière doit indiquer la courbe de réduction du courant sinusoïdal en fonction de la température par rapport à la température de référence de 70 °C, ainsi que la courbe de réduction du courant sinusoïdal en fonction de la fréquence et du courant sinusoïdal en fonction de la capacité.

1.4.4.4 Caractéristiques particulières

D'autres caractéristiques peuvent être indiquées, si elles sont jugées nécessaires, pour préciser des informations relatives à la conception et aux applications du composant.

1.4.4.5 Brasage

La spécification particulière doit spécifier les méthodes d'essai, les sévérités et les exigences applicables aux essais de brasabilité et aux essais de résistance à la chaleur de brasage.

1.4.5 Marquage

La spécification particulière doit spécifier le contenu du marquage sur le condensateur et sur l'emballage. En cas d'écarts par rapport aux indications du 1.6, ces écarts doivent être précisés dans la spécification particulière.

1.5 Termes et définitions

1.5.1 Généralités

Pour les besoins du présent document, les termes et définitions donnés dans l'IEC 60384-1:2016 ainsi que les suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

1.5.2 Classes de performance et de stabilité

La classe de performance décrit la capacité du condensateur à fonctionner dans les applications prévues. La classe de stabilité décrit la dérive de capacité lors des essais.

1.5.2.1

condensateurs de classe 1
<longue durée> condensateurs pour applications longue durée, où les paramètres électriques sont soumis à des exigences rigoureuses

1.5.2.2

condensateurs de classe 2
<usage courant> condensateurs pour application courante, où les exigences rigoureuses des condensateurs de classe 1 ne sont pas nécessaires

1.5.2.3

classe de stabilité
dérive de capacité après des essais climatiques et mécaniques et après des essais d'endurance

Note 1 à l'article: La classe de performance et la classe de stabilité doivent être indiquées dans la spécification particulière.

1.5.2.4

combinaisons de classe de performance et de classe de stabilité
désignation pour la classe de performance et la classe de stabilité combinées

Note 1 à l'article: Les désignations de combinaisons préférentielles sont présentées au Tableau 1.

Tableau 1 –Désignations préférentielles des combinaisons de classe de performance et de classe de stabilité

Classes de performance	Classes de stabilité	Désignation de la combinaison
1	1	1.1
	2	1.2
2	–	2

Les trois combinaisons concernent les valeurs de tan δ et de la stabilité de capacité. Les différences de performances pour ces trois combinaisons sont décrites dans le Tableau 4.

1.5.3 Tensions assignées

1.5.3.1 Généralités

La somme de la tension continue et de la valeur de crête de la tension alternative, ou de la valeur de crête de la tension en impulsions appliquée au condensateur ne doit pas dépasser la tension assignée. La valeur de crête de la tension alternative admissible à différentes fréquences est à l'étude.

1.5.3.2
tension continue assignée

tension continue maximale pouvant être appliquée en permanence à un condensateur utilisé à la température assignée

1.5.3.3
tension alternative assignée

tension alternative efficace maximale pouvant être appliquée en permanence à un condensateur utilisé à la température assignée et à une fréquence donnée

1.5.3.4
tension assignée en impulsions

valeur de crête de la tension d'impulsion pouvant être appliquée en permanence à un condensateur utilisé à la température assignée et à une fréquence donnée

1.5.3.5
pente de la tension assignée d'une impulsion

valeur maximale admissible de la pente de la tension $\frac{\mathrm{d}U}{\mathrm{d}t}$ d'une impulsion, à la température assignée et à une fréquence de répétition n'entraînant pas d'augmentation importante de la température

Note 1 à l'article: La formule de calcul pour la pente de la tension assignée d'une impulsion est $\frac{(\mathrm{d}U)}{(\mathrm{d}t)_\mathrm{R}}$

1.6 Marquage

1.6.1 Généralités

Se référer à l'IEC 60384-1:2016, 2.4, avec les informations fournies du 1.6.2 au 1.6.5.

1.6.2 Informations pour le marquage

Les informations indiquées dans le marquage sont normalement choisies à partir de la liste ci-dessous. L'importance relative de chaque élément est indiquée par sa position dans la liste:

a) capacité nominale (en clair ou en code conformément à l'IEC 60062);
b) tension d'impulsion et/ou alternative assignée (la tension alternative peut être indiquée par le symbole ∼ (IEC 60417-5032-2002-10)) et fréquence correspondante si elle est différente de 50 Hz;
c) tolérance sur la capacité nominale;
d) tension continue assignée (la tension continue peut être indiquée par le symbole ⎓ ou —— (IEC 60417-5031-2002-10)) (le cas échéant);
e) pente de la tension assignée d'une impulsion (s'il y a lieu);
f) courant assigné et fréquence correspondante (le cas échéant);
g) année et mois (ou année et semaine) de fabrication;
h) nom du fabricant et/ou marque commerciale;
i) catégorie climatique;
j) désignation du modèle par le fabricant;
k) référence à la spécification particulière.

1.6.3 Marquage des condensateurs

Le condensateur doit comporter lisiblement les informations indiquées aux a), b) et c) du 1.6.2 et toutes autres informations jugées nécessaires. Il convient d'éviter les redondances sur le marquage du condensateur.

Tout marquage doit être lisible, sans s'étaler ni s'effacer facilement par le frottement d'un doigt.

1.6.4 Marquage sur l'emballage

Il convient que l'emballage contenant le(s) condensateur(s) soit clairement identifié avec toutes les informations répertoriées au 1.6.2 selon le cas.

1.6.5 Marquage complémentaire

Tout marquage complémentaire doit être appliqué de façon qu'aucune confusion ne puisse subvenir.

2 Valeurs assignées et caractéristiques préférentielles

2.1 Caractéristiques préférentielles

2.1.1 Généralités

Si possible, les valeurs données dans les spécifications particulières doivent être choisies parmi celles données du 2.2.1 au 2.2.8.

2.1.2 Catégories climatiques préférentielles

Les condensateurs couverts par la présente spécification sont classés en catégories climatiques selon les règles générales données dans l'IEC 60068-1:2013, Annexe A.

Les températures de catégorie inférieure et supérieure et la durée de l'essai continu de chaleur humide doivent être choisies dans la liste suivante:

- température de catégorie inférieure: −55 °C, −40 °C, −25 °C et −10 °C;
- température de catégorie supérieure: +70 °C, +85 °C, +100 °C, +105 °C, +110 °C et +125 °C;
- durée de l'essai continu de chaleur humide: 4 j, 10 j, 21 j et 56 j.

Les sévérités pour les essais de froid et de chaleur sèche sont respectivement les températures de catégorie inférieure et supérieure.

Si cela est indiqué dans la spécification particulière, il convient d'indiquer la classe de résistance à l'humidité visée en Annexe A correspondant à la catégorie climatique.

2.2 Valeurs assignées préférentielles

2.2.1 Capacité nominale (C_N)

Les valeurs préférentielles de capacité nominale sont des valeurs choisies dans la série E de l'IEC 60063, indiquées dans le Tableau 2, et leurs multiples décimaux (× 10^n, où n est un nombre entier).

2.2.2 Tolérance sur la capacité nominale

Les tolérances préférentielles sur la capacité nominale sont ± 20 %; ± 10 %; ± 5 %; ± 2 %; ± 1 %.

2.2.3 Capacité nominale avec les valeurs de tolérances associées

Les combinaisons préférentielles de séries et de tolérances de capacité sont indiquées dans le Tableau 2.

Tableau 2 – Combinaisons préférentielles de séries et de tolérances de capacité

Combinaisons préférentielles	
Séries	**Tolérances**
E 6	± 20 %
E 12	± 10 %
E 24	± 5 %
E 48	± 2 %
E 96	± 1 %

2.2.4 Tension alternative assignée (U_{RAC} ou $U_{\text{R}\sim}$)

La fréquence de la tension alternative assignée doit être 50 Hz/60 Hz sauf si la spécification particulière prescrit une fréquence plus élevée.

Les valeurs préférentielles d'une tension alternative assignée (valeur efficace) doivent être choisies dans la série R10 ou R20 donnée dans l'ISO 3.

La spécification particulière doit donner la courbe de réduction de la tension efficace admissible en fonction de la température (supérieure à la température assignée) et, s'il y a lieu, en fonction de la fréquence.

2.2.5 Tension alternative de la catégorie (U_{CAC} ou $U_{\text{C}\sim}$)

La tension alternative de la catégorie est égale à la tension alternative assignée U_{RAC} pour les températures de catégorie supérieure jusqu'à 85 °C. Pour une température de catégorie supérieure de 100 °C, la tension alternative de la catégorie est égale à 0,7 U_{RAC}. Pour une température de catégorie supérieure > 100 °C, la tension alternative de la catégorie sera calculée suivant la pente de U_{RAC} à 85 °C jusqu'à 0,7 U_{RAC} à 100 °C pour chaque température (par exemple 105 °C, 110 °C ou 125 °C).

Le rapport de la tension alternative de la catégorie à la tension alternative assignée en fonction de la température de catégorie supérieure est présenté à la Figure 1.

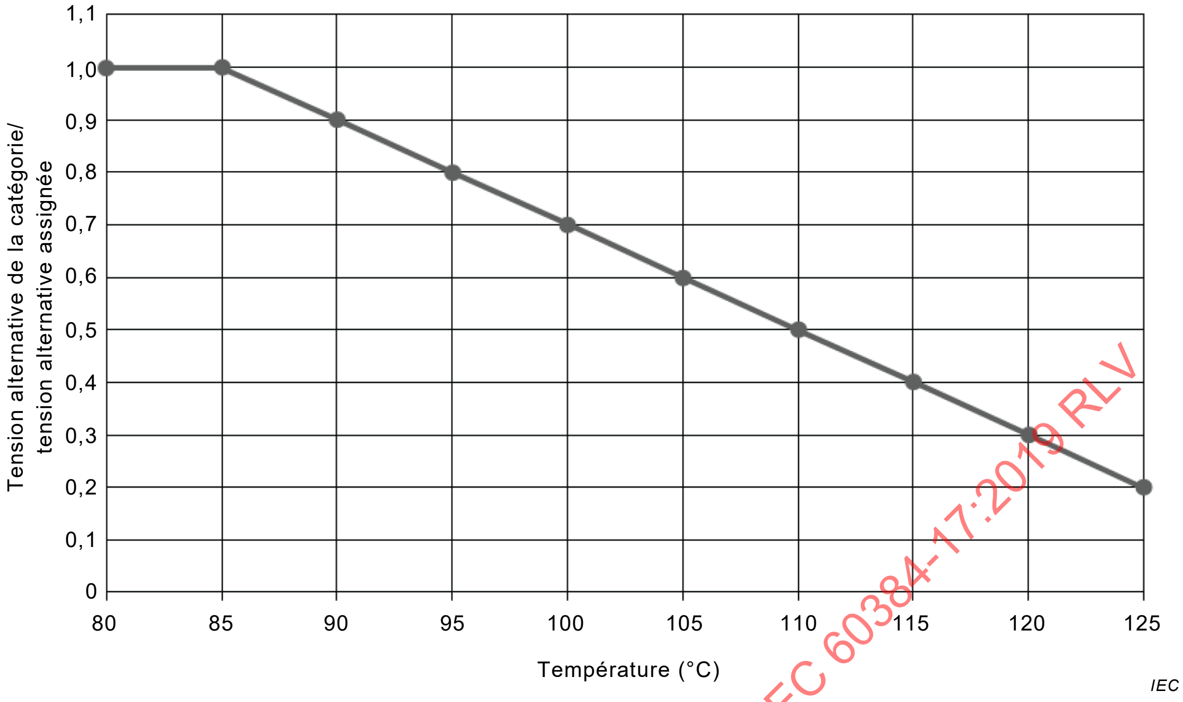

Figure 1 – Tension alternative de la catégorie/tension alternative assignée versus température de catégorie supérieure

2.2.6 Température assignée

La valeur normalisée pour la température assignée est 85 °C. Sauf pour une température de catégorie supérieure de 70 °C, la température assignée est 70 °C.

NOTE Pour la tension continue assignée, la température assignée est supérieure de 15 °C à celle de la tension alternative assignée.

2.2.7 Courant alternatif assigné (si nécessaire)

La spécification particulière doit indiquer:

- la fréquence;
- la valeur efficace du courant alternatif assigné applicable à la fréquence spécifiée (valeur choisie dans la série R10 ou R20);
- la courbe de réduction du courant alternatif admissible en fonction de la température ambiante.

2.2.8 Tension assignée en impulsions (si nécessaire)

La spécification particulière doit indiquer:

- la pente de la tension d'une impulsion;
- la durée de l'impulsion;
- la fréquence de répétition des impulsions.

3 Procédures d'assurance de la qualité

3.1 Étape initiale de fabrication

L'étape initiale de fabrication est l'enroulement de l'élément capacitif ou l'opération équivalente.

3.2 Composants de structure semblable

Les condensateurs supposés avoir une structure semblable sont des condensateurs produits à partir de matériaux et processus analogues, bien que les dimensions des boîtiers et leurs valeurs de capacité et de tension puissent être différentes.

3.3 Rapports certifiés d'essais des lots acceptés

Les informations exigées par l'IEC 60384-1:2016, Q.1.5 doivent être mises à disposition, lorsqu'elles sont prescrites dans la spécification particulière et qu'elles sont demandées par un client. Après l'essai d'endurance, les paramètres exigés sont la capacité et la tan δ. La résistance d'isolement est exigée uniquement par attribut.

3.4 Procédures d'homologation

3.4.1 Généralités

Les procédures d'essai d'homologation sont décrites dans l'IEC 60384-1:2016, Q.2.

Le programme à utiliser pour les essais d'homologation basés sur des essais lot par lot et des essais périodiques est présenté au 3.5. La procédure utilisant un programme avec une taille d'échantillons fixe est présentée au 3.4.2.

3.4.2 Homologation basée sur la procédure avec une taille d'échantillons fixe

3.4.2.1 Échantillonnage

La procédure avec une taille d'échantillons fixe est décrite dans l'IEC 60384-1:2016, Q.2.4. L'échantillon doit être représentatif de la gamme de condensateurs à homologuer. L'échantillon peut couvrir tout ou partie de la gamme indiquée dans la spécification particulière.

L'échantillon doit être constitué de quatre spécimens possédant les tensions assignées minimales et maximales et, pour ces tensions, les capacités minimales et maximales. En présence de plus de quatre tensions assignées, une tension intermédiaire doit également faire l'objet d'essais. De ce fait, pour l'homologation d'une plage, il est nécessaire de soumettre à l'essai quatre ou six valeurs (combinaisons capacité/tension). Lorsque la plage de valeurs est composée de moins de quatre valeurs, le nombre de spécimens soumis à l'essai doit être celui exigé pour quatre valeurs.

Des spécimens de rechange sont admis selon les modalités suivantes:

Deux (pour six valeurs) ou trois (pour quatre valeurs) spécimens par valeur peuvent être utilisés pour remplacer les spécimens non conformes en raison d'incidents non attribuables au fabricant.

Les nombres donnés dans le Groupe 0 prennent pour hypothèse que tous les groupes sont applicables. Si ce n'est pas le cas, ces chiffres peuvent être réduits en conséquence.

Lorsque des groupes supplémentaires sont ajoutés au programme d'essais d'homologation, le nombre exigé de spécimens pour le Groupe 0 doit être augmenté du nombre exigé pour les groupes supplémentaires.

Le Tableau 3 donne le nombre d'échantillons à soumettre à l'essai pour chaque groupe, ainsi que le nombre admissible d'éléments non conformes pour les essais d'homologation.

3.4.2.2 Essais

Les séries complètes d'essais spécifiés dans le Tableau 3 et le Tableau 4 sont nécessaires à l'homologation des condensateurs couverts par une spécification particulière. Les essais de chaque groupe doivent être effectués dans l'ordre indiqué.

La totalité de l'échantillon doit être soumise aux essais du Groupe 0, puis divisée pour les autres groupes.

Les spécimens déclarés non conformes lors des essais du Groupe 0 ne doivent pas être utilisés pour les autres groupes.

L'homologation est accordée lorsque le nombre d'éléments non conformes est égal à zéro.

Le Tableau 3 et le Tableau 4 forment ensemble le programme d'essai avec une taille d'échantillons fixe pour l'homologation sur la base de la procédure avec une taille d'échantillons fixe.

Le Tableau 3 donne le nombre d'échantillons et le nombre admissible d'éléments non conformes pour chaque essai et groupe d'essai.

Le Tableau 4 résume les conditions d'essai et les exigences de performance, ainsi que les choix des conditions d'essai et des exigences de performance donnés dans la spécification particulière.

Il convient que les conditions d'essai et les exigences de performance pour l'homologation sur la base de la procédure avec une taille d'échantillons fixe soient identiques à celles des contrôles de conformité de la qualité indiqués dans la spécification particulière.

Tableau 3 – Plan d'essai et d'échantillonnage pour homologation, niveau d'évaluation EZ

Groupe n°	Essai	Paragraphe	Nombre de spécimens (*n*) et nombre admissible d'éléments non conformes (*c*)			
			Par valeur [b]	Pour quatre valeurs ou moins à soumettre à l'essai [b]	Pour six valeurs à soumettre à l'essai [b]	*c*
			n	4 *n*	6 *n*	
0	Examen visuel	4.1				0
	Marquage	1.6				
	Dimensions	4.1				
	Capacité	4.2.2	29	116	174	
	Tangente de l'angle de pertes	4.2.3				
	Tenue en tension	4.2.1				
	Résistance d'isolement	4.2.4				
	Inductance [d]	4.2.5	(+5)[d]	(+20)[d]	(+30)[d]	
	Étanchéité [d]	4.16	(+5)[d]	(+20)[d]	(+30)[d]	
	Spécimens de rechange		2	8	12	
1A	Robustesse des sorties	4.3	3	12	18	
	Résistance à la chaleur de brasage	4.4				
	Résistance du composant au solvant [d]	4.14				
1B	Brasabilité	4.5	6	24	36	
	Résistance du marquage au solvant	4.15				
	Variations rapides de température	4.6				
	Vibrations	4.7				
	Secousses ou chocs [a]	4.8 ou 4.9				
1	Séquence climatique	4.10	9	36	54	
2	Essai continu de chaleur humide sans tension	4.11	5	20	30	
	Essai continu de chaleur humide avec tension [d]		(+5)[d]	(+20)[d]	(+30)[d]	
3A	Essai d'endurance avec une tension alternative à 50 Hz/60 Hz	4.12.1	10	40	60	
3B[e]	Essai d'endurance avec un courant ou une tension sinusoïdale [d]	4.12.2	(+5)[d]	(+20)[d]	(+30)[d]	
3C[e]	Essai d'endurance avec impulsions [d]	4.12.3	(+5)[d]	(+20)[d]	(+30)[d]	
4	Caractéristiques dépendant de la température [d]	4.2.6	(+5)[d]	(+20)[d]	(+30)[d]	
	Charge et décharge [c]	4.13	5[c]	20 [c]	30 [c]	

[a] Comme exigé dans la spécification particulière.

[b] Pour les combinaisons capacité/tension, voir 3.4.2.

[c] Non exigé lorsqu'un essai d'endurance avec impulsions est exigé.

[d] Si exigé dans la spécification particulière.