

INTERNATIONAL STANDARD



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



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INTERNATIONAL STANDARD



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

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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**

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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- withdrawn,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 combinations ~~(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 $\tan \delta$ 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 $\frac{dU}{dt}$ 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 $\frac{(dU)}{(dt)_R}$

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:

- ~~rated~~ nominal capacitance (in clear or code in accordance with IEC 60062);
- rated AC and/or pulse voltage (AC voltage may be indicated by the symbol $\sim$ (IEC 60417-5032-2002-10)) and the corresponding frequency if different from 50 Hz;
- tolerance on ~~rated~~ nominal capacitance;

- d) rated DC voltage (DC voltage may be indicated by the symbol $\overline{\text{---}}$ 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: $-55\text{ }^{\circ}\text{C}$, $-40\text{ }^{\circ}\text{C}$, $-25\text{ }^{\circ}\text{C}$ and $-10\text{ }^{\circ}\text{C}$;
- upper category temperature: $+70\text{ }^{\circ}\text{C}$, $+85\text{ }^{\circ}\text{C}$, $+100\text{ }^{\circ}\text{C}$, $+105\text{ }^{\circ}\text{C}$, $+110\text{ }^{\circ}\text{C}$ and $+125\text{ }^{\circ}\text{C}$;
- 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 ($\times 10^n$, where n is an integer).

2.2.2 **Tolerances on ~~rated~~ nominal capacitance**

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

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	$\pm 20\%$
E 12	$\pm 10\%$
E 24	$\pm 5\%$
E 48	$\pm 2\%$
E 96	$\pm 1\%$

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 ~~→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.

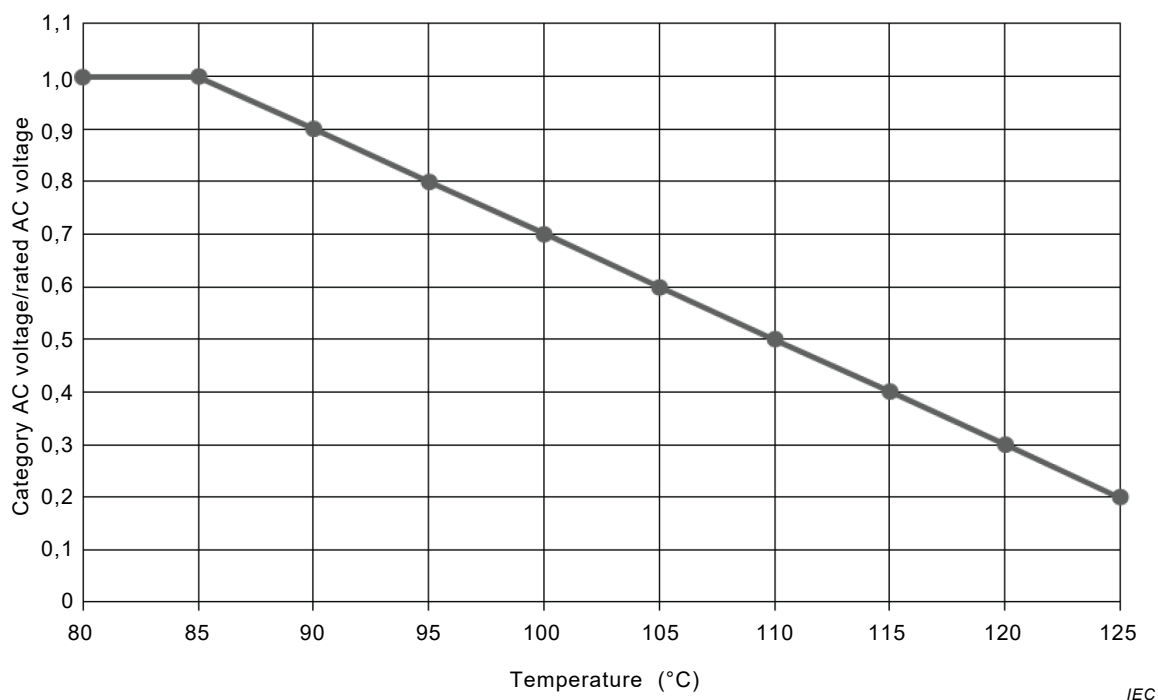


Figure 1 – Category AC voltage/rated AC voltage versus upper category temperature

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 $\tan \delta$. 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 ^e	For four or less values to be tested ^e			For six values to be tested ^e			
					n	4-n	c	c total	6-n	c	c total
0		Visual examination Marking Dimensions Capacitance Tangent of loss angle Voltage-proof Insulation resistance Inductance ^c Sealing ^e —— Spare specimens	4.1 1.6 4.1 4.2.2 4.2.3 4.2.1 4.2.4 4.2.5	29 (+5) ^e (+5) ^e 2	116 (+20) ^e (+20) ^e 8	2 ^b 2		174 (+30) ^e (+30) ^e 12	3 ^b 2		
1A		Robustness of terminations Resistance to soldering heat Component solvent resistance	4.3 4.4 4.14	3	12	1	4	18	1	6	
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		54	3		
2		Damp heat, steady state	4.11	5	20	1		30	2 ^b		
3		Endurance test at 50 Hz/60 HZ —— alternating voltage Endurance test with sinusoidal —— current or voltage ^e Pulse endurance test ^e	4.12.1 4.12.2 4.12.3	10 5 5	40 20 20	3 ^b 1 ^b 1 ^b		60 30 30	4 ^b 2 ^b 2 ^b		
4		Temperature characteristics ^c 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 (<i>n</i>) and permissible number of non-conforming items (<i>c</i>)					
			Per value ^b	For four or less values to be tested ^b		For six values to be tested ^b	<i>c</i>	
			<i>n</i>	4 <i>n</i>		6 <i>n</i>		
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	(5) ^d	(20) ^d		(30) ^d			
Insulation resistance	4.2.4							
Inductance ^d	4.2.5							
Sealing ^d	4.16							
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						
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 (e)	Performance requirements ^a
Group 0 4.1 — Visual examination 4.1 — Dimensions (detail) 4.2.2 — Capacitance 4.2.3 — Tangent of loss angle (tan δ) 4.2.1 — Voltage proof 4.2.4 — Insulation resistance 4.2.5 — Inductance (if applicable) — Sealing (if applicable)	ND	Frequency: 1 kHz See detail specification for the method See detail specification for the method See detail specification for the method	See Table 3 ↓	As in 4.1 Legible marking and as specified in the detail specification See detail specification Within specified tolerance As in 4.2.3.2 No breakdown or flashover As in 4.2.4.2 Inductance: $\leq \dots$ mH (see detail specification) No seepage of impregnant or harmful deformation of the case
Group 1A 4.3.1 — Initial measurements 4.3 — Robustness of terminations 4.4 — Resistance to soldering heat 4.14 — Component solvent resistance (if applicable) 4.4.2 — Final measurements	D	Capacitance Tangent of loss angle: For $C_R > 1 \mu\text{F}$: at 1 kHz — $C_R \leq 1 \mu\text{F}$: at 10 kHz Visual examination No pre-drying See detail specification for the method (1A or 1B) Solvent: ... Solvent temperature: ... Method 2 Recovery: ... Visual examination Capacitance Tangent of loss angle	See Table 3 ↓	No visible damage See detail specification No visible damage Legible marking $\Delta C/C$ for Grade 1.1: $\leq 1\%$ — Grade 1.2: $\leq 2\%$ — Grade 2: $\leq 3\%$ of value measured in 4.3.1 Increase of tan δ for $C \leq 1 \mu\text{F}$: — for Grade 1.1: $\leq 0,001$ — Grade 1.2: $\leq 0,002$ — Grade 2: $\leq 0,004$ for $C > 1 \mu\text{F}$: 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 $C_R > 1 \mu\text{F}$: at 1 kHz — $C_R \leq 1 \mu\text{F}$: 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 $\Delta C/C$ for Grade 1.1: $\leq 1\%$ — Grade 1.2: $\leq 2\%$ — Grade 2: $\leq 3\%$ of value measured in 4.6.1
		Capacitance		
		Tangent of loss angle		Increase of $\tan \delta$: for $C \leq 1 \mu\text{F}$: — for Grade 1.1: $\leq 0,001$ — Grade 1.2: $\leq 0,002$ — Grade 2: $\leq 0,004$ for $C > 1 \mu\text{F}$: see detail — specification, compared — to values measured in 4.6.1
		Insulation resistance		$\geq 50\%$ of values in 4.2.4.2

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

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conformances (<i>c</i>)	Performance requirements ^a
Group 2 (continued)		Tangent of loss angle	See Table 3 ↓	Increase of $\tan \delta$: for $C \leq 1 \mu\text{F}$: —— for Grade 1: $\leq 0,001$ —— Grade 2: $\leq 0,002$ for $C > 1 \mu\text{F}$: see detail —— specification, compared to —— values measured in 4.11.1 ≥ 50 % of values in 4.2.4.2
		Insulation resistance	↓	≥ 50 % of values in 4.2.4.2
Group 3A	D	Duration: Grade 1: 2 000 h Grade 2: 1 000 h	See Table 3 ↓	
4.12.1 — Endurance test at 50/60 Hz alternating voltage (if applicable)				
4.12.1.1 Initial measurements		Capacitance Tangent of loss angle For $C_R > 1 \mu\text{F}$: at 1 kHz —— $C_R \leq 1 \mu\text{F}$: at 10 kHz		
4.12.1.3 Final measurements		Visual examination Capacitance Tangent of loss angle		No visible damage Legible marking $\Delta C/C$ for Grade 1: ≤ 5 % —— Grade 2: ≤ 10 % of value measured in 4.12.1.1 Increase of $\tan \delta$: for $C \leq 1 \mu\text{F}$: —— for Grade 1: $\leq 0,0015$ —— Grade 2: $\leq 0,003$ for $C > 1 \mu\text{F}$: 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	Duration: Grade 1: 2 000 h Grade 2: 1 000 h Frequency: Hz	See Table 3 ↓	
4.12.2 — Endurance test with sinusoidal current or voltage (if applicable)				
4.12.2.1 Initial measurements		Capacitance Tangent of loss angle For $C_R > 1 \mu\text{F}$: at 1 kHz —— $C_R \leq 1 \mu\text{F}$: at 10 kHz		
4.12.2.3 Final measurements		Visual examination Capacitance		No visible damage Legible marking $\Delta C/C$ 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 (<i>n</i>) and number of permissible non-conformances (<i>c</i>)	Performance requirements ^a
Group 3B^c <i>(continued)</i>		Tangent of loss angle	See Table 3 ↓	Increase of $\tan \delta$: for $C \leq 1 \mu\text{F}$: — for Grade 1: $\leq 0,0015$ — Grade 2: $\leq 0,003$ for $C > 1 \mu\text{F}$: see detail — specification, compared to — values measured in — 4.12.2.1
		Insulation resistance		$\geq 50\%$ of values in 4.2.4.2
Group 3C^c 4.12.3 ~~Pulse endurance test (if applicable)~~	D	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)	See Table 3 ↓	
4.12.3.1 Initial measurements		Capacitance Tangent of loss angle: For $C_R > 1 \mu\text{F}$: at 1 kHz — $C_R \leq 1 \mu\text{F}$: at 10 kHz		
4.12.3.3 Final measurements		Visual examination Capacitance Tangent of loss angle Insulation resistance		No visible damage Legible marking $\Delta C/C$ for Grade 1: $\leq 5\%$ — Grade 2: $\leq 10\%$ of value measured in 4.12.3.1 Increase of $\tan \delta$: for $C \leq 1 \mu\text{F}$: — for Grade 1: $\leq 0,0015$ — Grade 2: $\leq 0,003$ for $C > 1 \mu\text{F}$: see detail — specification, compared to — values measured in — 4.12.3.1 $\geq 50\%$ of values in 4.2.4.2
Group 4 4.2.6 ~~Characteristics depending on temperature (if applicable)~~ 4.13 ~~Charge and discharge (not applicable when pulse endurance test is required)~~	D	Capacitance Insulation resistance	See Table 3 ↓	As in 4.2.6 As in 4.2.6

Subclause number and test ^a	D or ND ^b	Conditions of test ^a	Number of specimens (<i>n</i>) and number of permissible non-conformances (<i>c</i>)	Performance requirements ^a
Group 4 (continued)				
4.13.1 Initial measurements		Capacitance Tangent of loss angle: for $C_R > 1 \mu\text{F}$: at 1 kHz — $C_R \leq 1 \mu\text{F}$: at 10 kHz Duration of charge: . . . s Duration of discharge: . . . s	See Table 3 ↓	
4.13.3 Final measurements		Capacitance Tangent of loss angle Insulation resistance		$\Delta C/C$ for Grade 1.1: $\leq 1\%$ — Grade 1.2: $\leq 3\%$ — Grade 2: $\leq 5\%$ of value measured in 4.13.1 Increase of $\tan \delta$: for $C \leq 1 \mu\text{F}$: — for Grade 1: $\leq 0,003$ — Grade 2: $\leq 0,005$ for $C > 1 \mu\text{F}$: see detail — specification, compared to — values measured in 4.13.1 $\geq 50\%$ 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 (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
Group 0 4.1 Visual examination 4.1 Dimensions (detail) 4.2.2 Capacitance 4.2.3 Tangent of loss angle ($\tan \delta$) 4.2.1 Voltage proof, either 4.2.1.2 DC test, or AC test See detail specification for the test 4.2.4 Insulation resistance 4.2.5 Inductance ^d 4.16 Sealing ^d	ND	See 4.1.2 See 4.1.2 See 4.2.2.2 See 4.2.3.2 and 4.2.3.4 See 4.2.1.2.2 See 4.2.1.3.2 See 4.2.4.2 See 4.2.5 See detail specification for the method	See Table 3	Legible marking and as specified in the detail specification See detail specification Within specified tolerance See 4.2.3.3 and 4.2.3.5 See 4.2.1.4 See 4.2.1.4 See 4.2.4.3 See detail specification No seepage of impregnant or harmful deformation of the case
Group 1A 4.3 Robustness of terminations 4.3.2 Initial inspections Capacitance Tangent of loss angle 4.3.3 Final inspections Visual examination Capacitance Tangent of loss angle 4.4 Resistance to soldering heat 4.14 Component solvent resistance ^d 4.4.5 Final inspections and measurements Visual examination Capacitance	D	See IEC 60384-1:2016, 4.13 See 4.2.2.2 See 4.2.3.2 and 4.2.3.4 See 4.1.2 See 4.2.2.2 See 4.2.3.2 and 4.2.3.4 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 See IEC 60384-1:2016, 4.31 See 4.4.5 See 4.2.2.2	See Table 3	Within specified tolerance ≤ initial limit no visible damage See detail specification See detail specification See detail specification No visible damage $ \Delta C/C $ 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 (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
Group 1A (continued) Tangent of loss angle	D	See 4.2.3.2 and 4.2.3.4	See Table 3	Increase of $\tan \delta$ for $C_N \leq 1 \mu\text{F}$: 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 $C_N > 1 \mu\text{F}$: see detail specification ^c
Group 1B 4.5 Solderability 4.5.3 Final inspections Visual examination 4.15 Solvent resistance of the marking ^d 4.6 Rapid change of temperature 4.6.2 Initial inspections Capacitance Tangent of loss angle Visual inspection 4.6.4 Final inspections Visual examination Capacitance Tangent of loss angle 4.7 Vibration 4.7.4 Final inspections Visual examination 4.8 Bump (or shock, see 4.9) ^d 4.9 Shock (or bump, see 4.8) ^d	D	See 4.5.2. See detail specification for the method See IEC 60384-1:2016, 4.32.1 See 4.6.3 between T_A and T_B T_A = Lower category temperature T_B = Upper category temperature See 4.2.2.2 See 4.2.3.2 and 4.2.3.4 See 4.1.2 See 4.2.2.2 See 4.2.3.2 and 4.2.3.4 See 4.7.3 See detail specification for the frequency range See 4.1.2 See 4.8.3 See 4.9.3 See detail specification for mounting method and severities	See Table 3	See 4.5.3 Legible marking Within specified tolerance $\leq$ initial limit No visible damage See detail specification See detail specification No visible damage

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

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 (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	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		$ \Delta C/C $ for Grade 1.1: $\leq 1\%$ Grade 1.2: $\leq 3\%$ Grade 2: $\leq 5\%$ of value applied in 4.10.2
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of $\tan \delta$: for $C_N \leq 1 \mu\text{F}$: for Grade 1.1: $\leq 0,0015$ Grade 1.2: $\leq 0,003$ Grade 2: $\leq 0,005$ for $C_N > 1 \mu\text{F}$: see detail specification ^c
Insulation resistance		See 4.2.4.3		$\geq 50\%$ of values in 4.2.4.3
Group 2				
4.11 Damp heat, steady state	D	See 4.11.3	See Table 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		$\leq$ 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 $ \Delta C/C $ for Grade 1.1: $\leq 1\%$ Grade 1.2: $\leq 3\%$ Grade 2: $\leq 5\%$ 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 (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
Group 2 (Continued)				
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		b) Test with rated voltage Minimum requirements according to Annex A $\Delta C/C$ for Grade 1.1: $\leq 2\%$ Grade 1.2: $\leq 6\%$ Grade 2: $\leq 10\%$ of value measured in 4.11.2 See detail specification for more stringent requirements Increase of $\tan \delta$: a) Test without voltage: for $C_N \leq 1 \mu\text{F}$: for Grade 1: $\leq 0,001$ Grade 2: $\leq 0,002$ for $C_N > 1 \mu\text{F}$: see detail specification compared to values measured in 4.11.2^c b) Test with rated voltage: Minimum requirements according to Annex A: for $C_N \leq 1 \mu\text{F}$: for Grade 1: $\leq 0,002$ Grade 2: $\leq 0,004$ for $C_N > 1 \mu\text{F}$: 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		$\geq 50\%$ 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 (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	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		$ \Delta C/C $ 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 $\tan \delta$: for $C_N \leq 1 \mu\text{F}$: for Grade 1: ≤ 0,002 Grade 2: ≤ 0,004 for $C_N > 1 \mu\text{F}$: 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		$ \Delta C/C $ 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 (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	Performance requirements ^a
Group 3B (Continued)				
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of $\tan \delta$: for $C_N \leq 1 \mu\text{F}$: for Grade 1: $\leq 0,0015$ Grade 2: $\leq 0,003$ for $C_N > 1 \mu\text{F}$: see detail specification, compared to values measured in 4.12.3.2 ^c
Insulation resistance		See 4.2.4.3		$\geq 50 \%$ 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		$\leq$ 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		$ \Delta C/C $ for Grade 1: $\leq 5 \%$ Grade 2: $\leq 10 \%$ of value measured in 4.12.4.2
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of $\tan \delta$: for $C_N \leq 1 \mu\text{F}$: for Grade 1: $\leq 0,0015$ Grade 2: $\leq 0,003$ for $C_N > 1 \mu\text{F}$: see detail specification, compared to values measured in 4.12.4.2 ^c
Insulation resistance		See 4.2.4.3		$\geq 50 \%$ 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 (<i>n</i>) and number of permissible non-conforming items (<i>c</i>)	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 $C_N > 1 \mu\text{F}$: See 4.2.3.2 For $C_N \leq 1 \mu\text{F}$: See 4.2.3.4		$\leq$ 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		$ \Delta C/C $ for Grade 1.1: $\leq 1 \%$ Grade 1.2: $\leq 3 \%$ Grade 2: $\leq 5 \%$ of value measured in 4.13.2
Tangent of loss angle		See 4.2.3.2 and 4.2.3.4		Increase of $\tan \delta$: for $C_N \leq 1 \mu\text{F}$: for Grade 1: $\leq 0,003$ Grade 2: $\leq 0,005$ for $C_N > 1 \mu\text{F}$: see detail specification, compared to values measured in 4.13.2 ^e
Insulation resistance		See 4.2.4.3		$\geq 50 \%$ 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

^a IL = inspection level;
^a AQL = acceptable quality level;
^a n = sample size;
^a 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
^a n = sample size
^a 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	4							6	5	0
C1B				6	18	4							6	5	0
C1				6	27	2							6	10	0
C2				6	15	4							6	10	0
C3A				3	20	4							6	5	0
C3B				3	–5	4							6	5	0
C3C				3	–5	4							6	5	0
C4				3	–9	4							6	10	0
C5				12	–6	4							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): $1,4 U_{R\sim} + 2\,000\text{ V d.c.}$~~

Table 7 – Test voltages, DC

Measuring point	Test voltage, DC
1a)	$2,5 U_{R\sim}$
1b), 1c) ^a	$1,4 U_{R\sim} + 2\,000\text{ V DC}$
^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): $1,5 U_{R\sim}$ with $U_{R\sim} \leq 250$ V~~

~~$1,4 U_{R\sim}$ with $U_{R\sim} > 250$ V~~

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

~~NOTE 1 — $U_{R\sim}$ 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)	$1,5 U_{R\sim}$ for $U_{R\sim} \leq 250$ 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 ~~rated~~ nominal capacitance values >10 μ F, 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 ($\tan \delta$)

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

4.2.3.3 Requirement for measurements at 1 kHz

$\tan \delta$ 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	$C_R \leq 1 \mu\text{F}$	$\leq 10 \times 10^{-4}$	$\leq 20 \times 10^{-4}$
NOTE – For $C_R > 1 \mu\text{F}$, values of $\tan \delta$ 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 $C_N > 1 \mu\text{F}$, values of $\tan \delta$ shall be specified in the detail specification.

4.2.3.4 Measuring conditions for measurements at 10 kHz

For capacitors with $C_R C_N \leq 1 \mu\text{F}$, $\tan \delta$ shall be measured as follows.

- frequency: 10 kHz;
- voltage: $\leq 1 \text{ V (RMS)}$;
- 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	$\leq 20 \times 10^{-4}$	$\leq 40 \times 10^{-4}$

For $C_N > 1 \mu\text{F}$, 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 $\geq 0,01$ 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 <i>RC</i> product (<i>R</i> = insulation resistance between the terminations) (<i>C</i> = ~~rated~~ nominal capacitance)				Minimum insulation resistance between the terminations		Minimum insulation resistance between terminations and case
s				GΩ		GΩ
Measuring points in accordance with Table 3 of IEC 60384-1:						
1 a)				1 a)		1 b), 1 c)
~~Rated~~ Nominal capacitance: 						

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 factors 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) ~~and 1d)~~
		~~C_R~~ $C_N > 0,33 \mu F$ $R_i \times \frac{C_N}{C_s}$	~~C_R~~ $C_N \leq 0,33 \mu F$ 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 ~~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: $5 \text{ s} \pm 0,5 \text{ s}$ or $10 \text{ s} \pm 1 \text{ s}$, unless otherwise specified in the detail specification.

If method 1 is applied, immersion and withdrawal speed shall be $25 \text{ mm/s} \pm 2,5 \text{ mm/s}$

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: $235 \text{ }^{\circ}\text{C} \pm 3 \text{ }^{\circ}\text{C}$ for $(2 \pm 0,2) \text{ s}$;
- Sn96,5Ag3Cu,5 solder: $245 \text{ }^{\circ}\text{C} \pm 3 \text{ }^{\circ}\text{C}$ for $(3 \pm 0,3) \text{ s}$;
- Sn99,3Cu,7 solder: $250 \text{ }^{\circ}\text{C} \pm 3 \text{ }^{\circ}\text{C}$ for $(3 \pm 0,3) \text{ s}$.

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.