

Interference Suppression Film Capacitor - Class X2

Radial MKT 310 V_{AC} - High Stability Grade



FEATURES

- 15 mm to 37.5 mm lead pitch
- Internal series construction
- AEC-Q200 qualified for C ≤ 470 nF
- Material categorization:
for definitions of compliance please see
www.vishay.com/doc?99912

AUTOMOTIVE
GRADE
Available



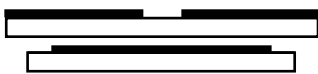
RoHS
COMPLIANT

APPLICATIONS

High stability grade for continuous across the line X2 applications.

See also application note: www.vishay.com/doc?28153

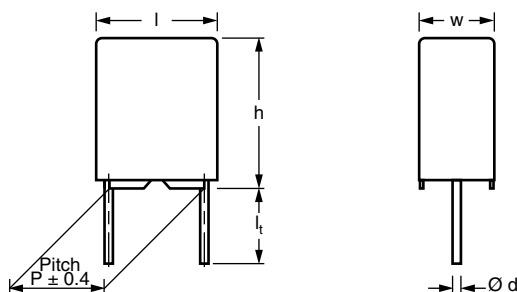
QUICK REFERENCE DATA

Capacitance range (E12 series)	0.01 µF to 2.2 µF (preferred values acc. to E6)
Capacitance tolerance	± 10 %, ± 20 % (± 5 % on request)
Rated AC voltage	310 V _{AC} ; 50 Hz to 60 Hz
Permissible DC voltage	800 V _{DC} at 85 °C 630 V _{DC} at 110 °C
Climatic testing class according to IEC 60068-1	40/110/56/C
Maximum application temperature	110 °C
Reference standards	IEC 60384-14 ed-4 and EN 60384-14 IEC 60065 pass. flamm. class C CSA-E384-14 UL 60384-14
Dielectric	Polyester film
Electrodes	Metallized
Construction	Series construction 
Encapsulation	Plastic case, epoxy resin sealed, flame retardant UL-class 94 V-0
Leads	Tinned wire
Marking	C-value; tolerance; rated voltage; sub-class; manufacturer's type; code for dielectric material; manufacturer location, year and week; manufacturer's logo or name; safety approvals

Note

- For more detailed data and test requirements, contact rfi@vishay.com

DIMENSIONS in millimeters



COMPOSITION OF CATALOG NUMBER


Example: F1772415**2215** means 0.15 µF, ± 20 %; standard pitch 22.5 mm; lead length 15 mm - 1 mm;
 F1772415**2265** means 0.15 µF, ± 20 %; reduced pitch 15.0 mm; lead length 15 mm - 1 mm

Notes

- For detailed tape specifications refer to packaging information www.vishay.com/doc?28139
- ⁽¹⁾ Taped on reel pitch ≥ 27.5 mm is not available
- ⁽²⁾ Same capacitance values ≥ 0.15 µF are available in two different pitch sizes and dimensions

SPECIFIC REFERENCE DATA	
DESCRIPTION	VALUE
Rated AC voltage (U _{RAC})	310 V
Permissible DC voltage (U _{RDC})	630 V
Tangent of loss angle	≤ 100 x 10 ⁻⁴ at 1 kHz
Rated voltage pulse slope at (dU/dt) _R 435 V _{DC}	100 V/µs
R between leads, for C ≤ 0.33 µF at 100 V; 1 min	> 15 000 MΩ
RC between leads, C > 0.33 µF at 100 V; 1 min	> 5000 s
R between leads and case; 100 V; 1 min	> 30 000 MΩ
Withstanding (DC) voltage (cut off current 10 mA) ⁽¹⁾ ; rise time ≤ 1000 V/s	
C ≤ 0.47 µF	2200 V; for 1 min
C > 0.47 µF	2150 V; for 1 min
Withstanding (AC) voltage between leads and case	2120 V; 1 min
Maximum application temperature	110 °C

Note

- See "Voltage Proof Test for Metalized Film Capacitors": www.vishay.com/doc?28169



ELECTRICAL DATA AND ORDERING INFORMATION

U_{RAC} (V)	CAP. (μ F)	PITCH (mm)	DIMENSIONS ⁽⁴⁾ w x h x l MAX. (mm)	MASS ⁽³⁾ (g)	SPQ (pieces) SHORT LEAD	ORDERING CODE BULK LEAD LENGTH 6 mm - 1 mm ⁽¹⁾⁽²⁾
310	$d_t = 0.60 \text{ mm} \pm 0.06 \text{ mm}; \text{C-TOL.} = \pm 10 \%$					
	0.010	15	5.0 x 11.0 x 17.5	1.4	750	F17723102000
	0.012	15	5.0 x 11.0 x 17.5	1.4	750	F17723122000
	0.015	15	5.0 x 11.0 x 17.5	1.4	750	F17723152000
	0.018	15	5.0 x 11.0 x 17.5	1.4	750	F17723182000
	0.022	15	5.0 x 11.0 x 17.5	1.4	750	F17723222000
	0.027	15	5.0 x 11.0 x 17.5	1.4	750	F17723272000
	0.033	15	5.0 x 11.0 x 17.5	1.4	750	F17723332000
	0.039	15	6.0 x 12.0 x 17.5	2.0	500	F17723392000
	0.047	15	6.0 x 12.0 x 17.5	2.0	500	F17723472000
	0.056	15	6.0 x 12.0 x 17.5	2.0	500	F17723562000
	$d_t = 0.80 \text{ mm} \pm 0.08 \text{ mm}; \text{C-TOL.} = \pm 10 \%$					
	0.068	15	7.0 x 13.5 x 17.5	2.4	450	F17723682000
	0.082	15	8.5 x 15.0 x 17.5	2.7	300	F17723822000
	0.10	15	8.5 x 15.0 x 17.5	2.7	325	F17724102000
	0.12	15	8.5 x 15.0 x 17.5	2.7	300	F17724122000
	0.15	15	8.5 x 15.0 x 17.5	2.7	300	F17724152160
	0.15	22.5	7.0 x 16.5 x 26.0	4.1	235	F17724152000
	0.18	22.5	7.0 x 16.5 x 26.0	4.1	235	F17724182000
	0.22	15	10.0 x 16.5 x 17.5	3.0	235	F17724222160
	0.22	22.5	8.5 x 16.5 x 26.5	4.6	200	F17724222000
	0.27	22.5	10.0 x 19.5 x 26.0	6.7	170	F17724272000
	0.33	15	13.5 x 22.5 x 18.0	5.5	185	F17724332160
	0.33	22.5	10.0 x 19.5 x 26.0	6.7	170	F17724332000
	0.39	27.5	11.0 x 21.0 x 31.0	9.1	125	F17724392000
	0.47	22.5	12.0 x 22.0 x 26.0	13.0	110	F17724472160
	0.47	27.5	11.0 x 21.0 x 31.0	9.1	125	F17724472000
	0.56	27.5	11.0 x 21.0 x 31.0	9.1	125	F17724562000
	0.68	22.5	15.5 x 26.5 x 26.5	13.5	110	F17724682160
	0.68	27.5	13.0 x 23.0 x 31.0	12.9	110	F17724682000
	0.82	27.5	13.0 x 23.0 x 31.0	12.9	110	F17724822000
	1.0	22.5	15.5 x 26.5 x 26.5	13.5	110	F17725102160
	1.0	27.5	15.0 x 25.0 x 31.5	15.0	100	F17725102000
	1.2	37.5	14.5 x 24.5 x 41.5	18.9	80	F17725122000
	1.5	27.5	18.0 x 28.0 x 31.0	19.0	85	F17725152160
	1.5	37.5	15.5 x 28.5 x 41.5	24.0	70	F17725152000
	1.8	37.5	15.5 x 28.5 x 41.5	24.0	70	F17725182000
	2.2	27.5	21.0 x 31.0 x 31.0	28.0	70	F17725222160
	2.2	37.5	18.0 x 32.5 x 41.5	31.6	60	F17725222000
	$d_t = 0.60 \text{ mm} \pm 0.06 \text{ mm}; \text{C-TOL.} = \pm 20 \%$					
	0.010	15	5.0 x 11.0 x 17.5	1.4	750	F17723102200
	0.015	15	5.0 x 11.0 x 17.5	1.4	750	F17723152200
	0.022	15	5.0 x 11.0 x 17.5	1.4	750	F17723222200
	0.033	15	5.0 x 11.0 x 17.5	1.4	750	F17723332200
	0.047	15	5.0 x 11.0 x 17.5	1.4	750	F17723472200
	0.068	15	6.0 x 12.0 x 17.5	2.0	600	F17723682200
	0.10	15	6.0 x 12.0 x 17.5	2.0	600	F17724102200

ELECTRICAL DATA AND ORDERING INFORMATION

U_{RAC} (V)	CAP. (μ F)	PITCH (mm)	DIMENSIONS ⁽⁴⁾ w x h x l MAX. (mm)	MASS ⁽³⁾ (g)	SPQ (pieces) SHORT LEAD	ORDERING CODE BULK LEAD LENGTH 6 mm - 1 mm ⁽¹⁾⁽²⁾
310	$d_t = 0.80 \text{ mm} \pm 0.08 \text{ mm}$; C-TOL. = $\pm 20 \%$					
	0.15	15	8.5 x 15.0 x 17.5	2.7	325	F17724152260
	0.15	22.5	6.0 x 15.5 x 26.0	3.3	260	F17724152200
	0.22	15	10.0 x 16.5 x 17.5	4.5	300	F17724222260
	0.22	22.5	7.0 x 16.5 x 26.0	4.1	235	F17724222200
	0.33	15	13.5 x 22.5 x 18.0	5.5	185	F17724332260
	0.33	22.5	8.5 x 18.0 x 26.0	5.3	190	F17724332200
	0.47	22.5	10.0 x 19.5 x 26.0	6.7	170	F17724472260
	0.47	27.5	9.0 x 19.0 x 31.5	6.8	160	F17724472200
	0.68	22.5	12.0 x 22.0 x 26.0	13.4	110	F17724682260
	0.68	27.5	11.0 x 21.0 x 31.0	12.9	125	F17724682200
	1.0	22.5	15.5 x 26.5 x 26.5	13.5	110	F17725102260
	1.0	27.5	15.0 x 25.0 x 31.5	15.0	100	F17725102200
	1.5	27.5	18.0 x 28.0 x 31.5	19.0	85	F17725152260
	1.5	37.5	14.5 x 24.5 x 41.5	18.9	80	F17725152200
	2.2	27.5	21.0 x 31.0 x 31.0	28.0	70	F17725222260
	2.2	37.5	15.5 x 28.5 x 41.5	24.0	70	F17725222200

Notes

- SPQ = Standard Packing Quantity
- For detailed tape specifications refer to packaging information: www.vishay.com/doc?28139
- (1) For further packaging see table "Composition of Catalog Number"
- (2) Further information about packaging quantities with different lead length and / or taped versions, see document "Packing Quantities" www.vishay.com/doc?27608
- (3) Weight for short lead product only
- (4) For tolerances see chapter "Space Requirements for Printed-Circuit Board Applications and Dimension Tolerances"

APPROVALS

SAFETY APPROVALS X2	VOLTAGE	VALUE	FILE NUMBERS	LINK
EN 60384-14 (ENEC) (= IEC 60384-14 ed-4)	310 V _{AC}	0.01 μ F to 2.2 μ F X2	40005079	www.vishay.com/doc?28196
UL 60384-14	310 V _{AC}	0.01 μ F to 2.2 μ F X2	E354331	www.vishay.com/doc?28191
CSA-E 384-14	310 V _{AC}	0.01 μ F to 2.2 μ F X2	E354331	
CB test-certificate	310 V _{AC}	0.01 μ F to 2.2 μ F X2	DE1-58410	www.vishay.com/doc?28226
The ENEC-approval together with the CB-certificate replace all national marks of the following countries (they have already signed the ENEC-agreement): Austria; Belgium; Czech. Republic; Denmark; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Luxembourg; Netherlands; Norway; Portugal; Slovenian; Spain; Sweden; Switzerland and United Kingdom.				
 				

MOUNTING

Normal Use

The capacitors are designed for mounting on printed-circuit boards. The capacitors packed in bandoliers are designed for mounting in printed-circuit boards by means of automatic insertion machines.

For detailed tape specifications refer to packaging information: www.vishay.com/doc?28139.

Specific Method of Mounting to Withstand Vibration and Shock

In order to withstand vibration and shock tests, it must be ensured that stand-off pips are in good contact with the printed-circuit board:

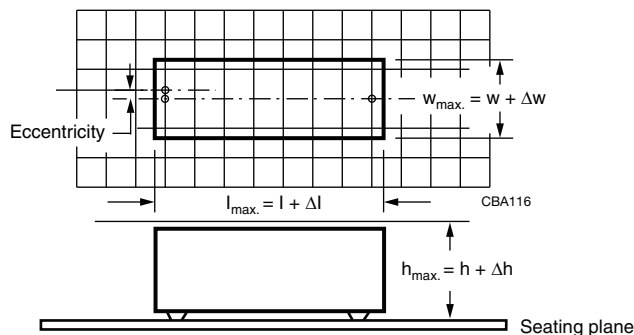
- For pitches ≤ 15 mm capacitors shall be mechanically fixed by the leads
- For larger pitches the capacitors shall be mounted in the same way and the body clamped

SPACE REQUIREMENTS FOR PRINTED-CIRCUIT BOARD APPLICATIONS AND DIMENSION TOLERANCES

For the maximum product dimensions and maximum space requirements for length ($l_{max.}$), width ($w_{max.}$) and height ($h_{max.}$) following tolerances must be taken in account in the envelopment of the components as shown in the drawings below.

- For products with pitch ≤ 15 mm, $\Delta w = \Delta l = 0.3$ mm, and $\Delta h = 0.1$ mm
- For products with $15 \text{ mm} < \text{pitch} \leq 27.5$ mm, $\Delta w = \Delta l = 0.5$ mm, and $\Delta h = 0.1$ mm
- For products with pitch = 37.5 mm, $\Delta w = \Delta l = 0.7$ mm, and $\Delta h = 0.5$ mm

Eccentricity defined as in drawing. The maximum eccentricity is smaller than or equal to the lead diameter of the product concerned.



For the minimum product dimensions for length ($l_{min.}$), width ($w_{min.}$) and height ($h_{min.}$) following tolerances of the components are valid:

$l_{min.} = l - \Delta l$, $w_{min.} = w - \Delta w$, and $h_{min.} = h - \Delta h$ following

- For products with pitch ≤ 10 mm, $\Delta l = 0.3$ mm, and $\Delta w = \Delta h = 0.3$ mm
- For products with pitch = 15 mm, $\Delta l = 0.5$ mm, and $\Delta w = \Delta h = 0.5$ mm
- For products with $15 \text{ mm} < \text{pitch} \leq 27.5$ mm, $\Delta l = 1.0$ mm and $\Delta w = \Delta h = 0.5$ mm
- For products with pitch = 37.5 mm, $\Delta l = 1.0$ mm and $\Delta w = \Delta h = 1.0$ mm

SOLDERING CONDITIONS

For general soldering conditions and wave soldering profile, we refer to the application note: "Soldering Guidelines for Film Capacitors": www.vishay.com/doc?28171

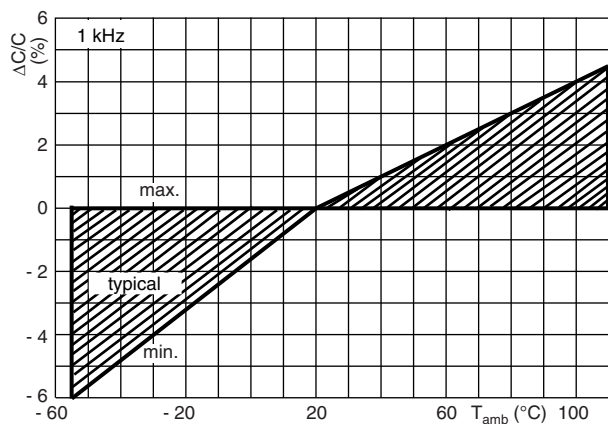
Storage Temperature

$T_{stg} = -25$ °C to $+35$ °C with RH maximum 75 % without condensation

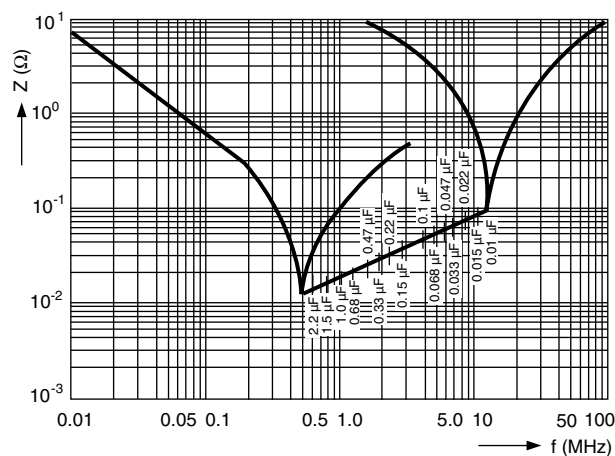
Ratings and Characteristics Reference Conditions

Unless otherwise specified, all electrical values apply to an ambient temperature of 23 °C ± 1 °C, an atmospheric pressure of 86 kPa to 106 kPa and a relative humidity of 50 % ± 2 %.

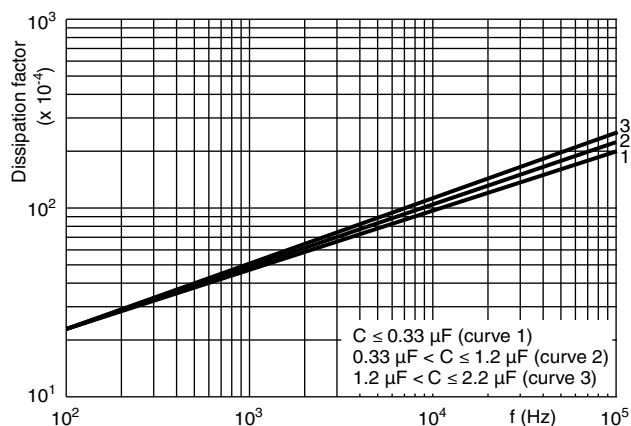
For reference testing, a conditioning period shall be applied over 96 h ± 4 h by heating the products in a circulating air oven at the rated temperature and a relative humidity not exceeding 20 %.

CHARACTERISTICS


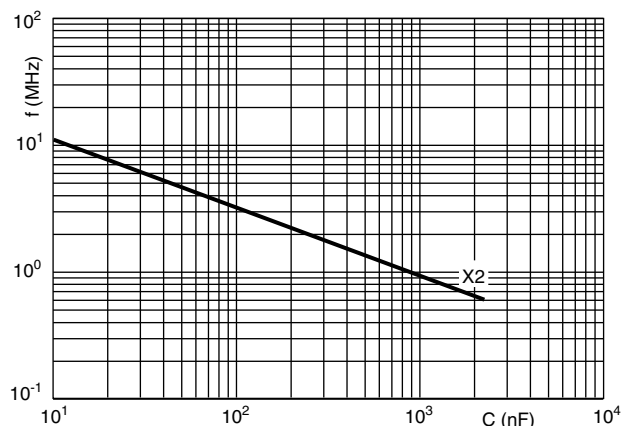
Capacitance as a function of ambient temperature
(typical curve)



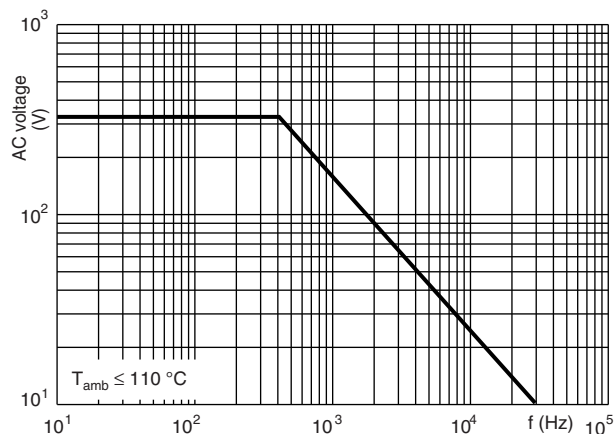
Impedance as a function of frequency
(typical curve)



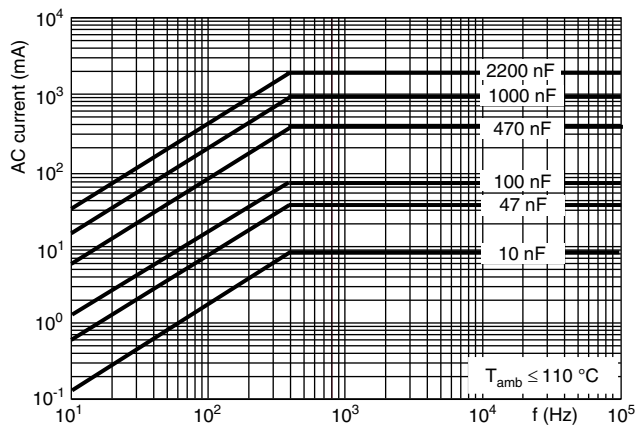
Tangent of loss angle as a function of frequency
(typical curve)



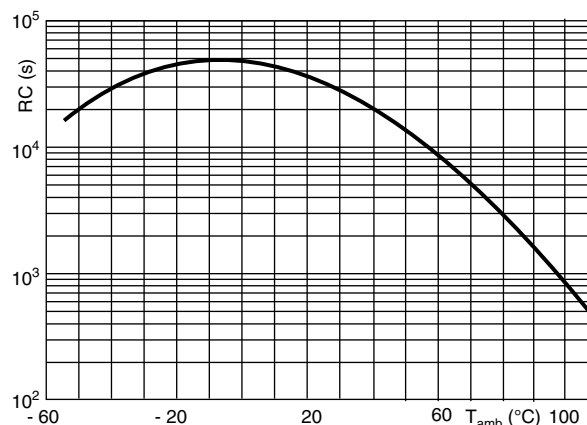
Resonant frequency as a function of capacitance
(typical curve)



Max. RMS voltage as a function of frequency



Max. RMS current as a function of frequency



Insulation resistance as a function of ambient temperature (typical curve)

APPLICATION NOTES AND LIMITING CONDITIONS

- For X2 electromagnetic interference suppression where a higher stability grade is needed for **continuous across the line applications** (50 Hz/60 Hz) with a maximum mains voltage of 310 V_{AC}.
- These capacitors are not intended for continuous pulse application. For these situations capacitors of the AC and pulse programs must be used.
- For series impedance applications we refer to application note: www.vishay.com/doc?28153
- The maximum ambient temperature must not exceed 110 °C.
- Rated voltage pulse slope:
if the pulse voltage is lower than the rated voltage, the values of the specific reference data can be multiplied by 435 V_{DC} and divided by the applied voltage.

INSPECTION REQUIREMENTS

General Notes

Sub-clause numbers of tests and performance requirements refer to the “Sectional Specification, Publication IEC 60384-14 ed 3 and Specific Reference Data”.

GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
SUB-GROUP C1A PART OF SAMPLE OF SUB-GROUP C1		
4.1 Dimensions (detail)		As specified in chapter “General Data” of this specification
Initial measurements	Capacitance Tangent of loss angle: for C ≤ 1 µF at 10 kHz for C > 1 µF at 1 kHz	
4.3 Robustness of terminations	Tensile: load 10 N; 10 s Bending: load 5 N; 4 x 90°	No visible damage
4.4 Resistance to soldering heat	No pre-drying Method: 1A Solder bath: 280 °C ± 5 °C Duration: 10 s	



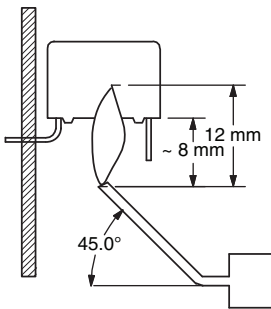
GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
SUB-GROUP C1A PART OF SAMPLE OF SUB-GROUP C1		
4.19 Component solvent resistance	Isopropylalcohol at room temperature Method: 2 Immersion time: 5 min ± 0.5 min Recovery time: min. 1 h, max. 2 h	
4.4.2 Final measurements	Visual examination Capacitance Tangent of loss angle Insulation resistance	No visible damage Legible marking $ \Delta C/C \leq 5\%$ of the value measured initially Increase of $\tan \delta$ ≤ 0.008 for: $C \leq 1 \mu F$ or ≤ 0.005 for: $C > 1 \mu F$ Compared to values measured initially As specified in section "Insulation Resistance" of this specification
SUB-GROUP C1B PART OF SAMPLE OF SUB-GROUP C1		
Initial measurements	Capacitance Tangent of loss angle: for $C \leq 1 \mu F$ at 10 kHz for $C > 1 \mu F$ at 1 kHz	
4.20 Solvent resistance of the marking	Isopropylalcohol at room temperature Method: 1 Rubbing material: cotton wool Immersion time: 5 min ± 0.5 min	No visible damage Legible marking
4.6 Rapid change of temperature	$\theta A = -40\text{ }^{\circ}\text{C}$ $\theta B = +110\text{ }^{\circ}\text{C}$ 5 cycles Duration $t = 30\text{ min}$	
4.6.1 Inspection	Visual examination	No visible damage
4.7 Vibration	Mounting: see section "Mounting" of this specification Procedure B4 Frequency range: 10 Hz to 55 Hz Amplitude: 0.75 mm or Acceleration 98 m/s^2 (whichever is less severe) Total duration 6 h	
4.7.2 Final inspection	Visual examination	No visible damage
4.9 Shock	Mounting: See section "Mounting" for more information Pulse shape: half sine Acceleration: 490 m/s^2 Duration of pulse: 11 ms	
4.9.2 Final measurements	Visual examination Capacitance Tangent of loss angle Insulation resistance	No visible damage $ \Delta C/C \leq 5\%$ of the value measured initially Increase of $\tan \delta$ ≤ 0.008 for: $C \leq 1 \mu F$ or ≤ 0.005 for: $C > 1 \mu F$ Compared to values measured initially As specified in section "Specific Reference" of this specification



GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
SUB-GROUP C1 COMBINED SAMPLE OF SPECIMENS OF SUB-GROUPS C1A AND C1B		
4.11 Climatic sequence	Capacitance	
4.11.1 Initial measurements	Measured in 4.4.2 and 4.9.2 Tangent of loss angle Measured initially in C1A and C1B	
4.11.2 Dry heat	Temperature: 110 °C Duration: 16 h	
4.11.3 Damp heat cyclic Test Db, first cycle		
4.11.4 Cold	Temperature: -40 °C Duration: 2 h	
4.11.5 Damp heat cyclic Test Db, remaining cycles		
4.11.6 Final measurements	Visual examination	No visible damage Legible marking
	Capacitance	$ \Delta C/C \leq 5\%$ of the value measured in 4.11.1
	Tangent of loss angle	Increase of $\tan \delta$ ≤ 0.008 for: $C \leq 1\ \mu\text{F}$ or ≤ 0.005 for: $C > 1\ \mu\text{F}$ Compared to values measured in 4.11.1
	Voltage proof 1350 V _{DC} 1 min between terminations	No permanent breakdown or flash-over
	Insulation resistance	$\geq 50\%$ of values specified in section "Insulation Resistance" of this specification
SUB-GROUP C2		
4.12 Damp heat steady state	56 days, 40 °C, 90 % to 95 % RH No load	
4.12.1 Initial measurements	Capacitance Tangent of loss angle: 1 kHz	
4.12.3 Final measurements	Visual examination	No visible damage Legible marking
	Capacitance	$ \Delta C/C \leq 5\%$ of the value measured in 4.12.1
	Tangent of loss angle	Increase of $\tan \delta$ ≤ 0.008 for: $C \leq 1\ \mu\text{F}$ or ≤ 0.005 for: $C > 1\ \mu\text{F}$ Compared to values measured in 4.12.1
	Voltage proof 1350 V _{DC} ; 1 min between terminations	No permanent breakdown or flash-over
	Insulation resistance	$\geq 50\%$ of values specified in section "Insulation Resistance" of this specification



GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
SUB-GROUP C3		
4.13.1 Initial measurements	Capacitance Tangent of loss angle: for $C \leq 1 \mu\text{F}$ at 10 kHz for $C > 1 \mu\text{F}$ at 1 kHz	
4.13 Impulse voltage	3 successive impulses, full wave, peak voltage: X2: 2.5 kV for $C \leq 1 \mu\text{F}$ X2: $2.5 \text{ kV}/\sqrt{C}$ for $C > 1 \mu\text{F}$ Max. 24 pulses	No self healing breakdowns or flash-over
4.14 Endurance	Duration: 1000 h $1.25 \times U_{\text{RAC}}$ at 110 °C Once in every hour the voltage is increased to 1000 V (RMS) for 0.1 s via resistor of $47 \Omega \pm 5 \%$	
4.14.7 Final measurements	Visual examination Capacitance Tangent of loss angle Voltage proof 1350 V _{DC} ; 1 min between terminations 2120 V _{AC} ; 1 min between terminations and case Insulation resistance	No visible damage Legible marking $ \Delta C/C \leq 5 \%$ compared to values measured in 4.13.1 Increase of $\tan \delta$ ≤ 0.008 for: $C \leq 1 \mu\text{F}$ or ≤ 0.005 for: $C > 1 \mu\text{F}$ Compared to values measured in 4.13.1 No permanent breakdown or flash-over $\geq 50 \%$ of values specified in section "Insulation Resistance" of this specification
SUB-GROUP C4		
4.15 Charge and discharge	10 000 cycles Charged to 435 V _{DC} Discharge resistance: $R = \frac{435 \text{ V}_{\text{DC}}}{1.5 \times C(dU/dt)}$	
4.15.1 Initial measurements	Capacitance Tangent of loss angle: for $C \leq 1 \mu\text{F}$ at 10 kHz for $C > 1 \mu\text{F}$ at 1 kHz	
4.13.3 Final measurements	Capacitance Tangent of loss angle Insulation resistance	$ \Delta C/C \leq 10 \%$ compared to values measured in 4.15.1 Increase of $\tan \delta$ ≤ 0.008 for: $C \leq 1 \mu\text{F}$ or ≤ 0.005 for: $C > 1 \mu\text{F}$ Compared to values measured in 4.15.1 $\geq 50 \%$ of values specified in section "Insulation Resistance" of this specification

GROUP C INSPECTION REQUIREMENTS		
SUB-CLAUSE NUMBER AND TEST	CONDITIONS	PERFORMANCE REQUIREMENTS
SUB-GROUP C5		
4.16 Radio frequency characteristic	Resonance frequency	≥ 0.9 times the value as specified in section "Resonant Frequency" of this specification.
SUB-GROUP C6		
4.17 Passive flammability Class C	Bore of gas jet: $\varnothing 0.5$ mm Fuel: butane Test duration for actual volume V in mm³: $V \leq 250$: 5 s $250 < V \leq 500$: 10 s $500 < V \leq 1750$: 20 s $V > 1750$: 30 s One flame application 	After removing test flame from capacitor, the capacitor must not continue to burn for more than 30 s. No burning particle must drop from the sample.
SUB-GROUP C7		
4.18 Active flammability	20 cycles of 2.5 kV discharges on the test capacitor connected to U_{RAC} .	The cheese cloth around the capacitors shall not burn with a flame. No electrical measurements are required.



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