DRAFTING COMMITTEE ON ELECTROLYTIC CAPACITORS

C O N S T I T U T I O N

NAME	ORGANIZATION
Mr, C.K. Nanayakkara (Chairman)	Air Lanka Ltd
Mr. V.C. Balasubramanium	Ceylon Government Railway
Commander U.L.R. Perera	Sri Lanka Navy
Dr. Ranjith Perera	University of Moratuwa
Mr. K. Udayasiri	State Fertilizer Manufacturing Corporation
Mrs. J. Dewasurendra Mr. V.C. Sri Skandharajah	Bureau of Ceylon Standards

Draft Sri Lanka Standard

679

SPECIFICATION FOR ELECTROLYTIC CAPACITORS

FOREWORD

This Sri Lanka Standard was authorised for adoption and publication by the Council of the Bureau of Ceylon Standards on ..83.11.29.... after the draft, finalised by the Drafting Committee on Electrolytic Capacitos had been approved by the Electrical Engineering Divisional Committee.

All values in this standard have been given in metric units.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value observed or calculated expressing the result of a test or observation shall be rounded off in accordance with CS : 102. The number of figures to be retained in the rounded off values shall be the same as that of the specified value in this standard.

This standard lays down the test methods and requirements for judging the, electrical, mechanical and physical properties of aluminium electrolytic capacitors and tantalum electrolytic capacitors.

The assistance derived from the publication of the International Electro-technical Commission and, Indian Standard Institution in the preparation of this standard is gratefully acknowledged.

1. SCOPE

This standard prescribes electrical, mechanical and physical requirements, marking, ratings and test methods for electrolytic capacitors primarily intended for d.c. applications and of the following types.

a) Tahtalum solid electrolytic capacitos

1) Capacitors for long life applications

2) Capacitors for general-purpose applications

b) Aluminium solid or non solid electrolytic capacitors

1) Capacitors for long life applications

2) Capacitors for general-purpose applications

2 REFERENCES

CS - 102 Presentation of numerical values
CS - 103 Ceylon Standards for preferred numbers
SLS - 374 Standard atmosperic conditions for testing
SLS - 520 Marking Codes for resistors and capacotprs
SLS - 580 Part 1 Basic environmental testing procedures general
IEC - 63 - Preferred number series for resistors and capacitors
IEC - 68 - 2 -1 Basic environmental testing procedures cold test
IEC - 68 - 2 -2 Basic environmental testing procedures dry heat test
IEC - 68 - 2 -6 Vibration test

IEC - 68 - 2 -3 Damp heat steady state
IEC - 68 - 2 -14 Change of temperature

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IEC - 68 - 2 -17 Sealing test
IEC - 68 - 2 -29 Bump test
IEC - 68 - 2 -30 Damp heat (Cyclic)

3 DEFINITIONS

For the purpose of this standard following definitions shall apply.

3.1 capacitance : The capacitance of an electrolytic capacitor is the capacitance of an equivalent circuit having capacitance and resistance in series measured with alternating current of approximately sinusodial wave-form of the specified frequency.

3.2 category voltage (V_c): The voltage which may be applied to a capacitor in use at its upper category temperature. However for aluminium capacitors category voltage is same as the rated voltage.

3.3 long-life grade capacitors: Long life grade capacitors are capacitors intended for applications where a high degree of stability of characteristics over a long life is essential.

The materials are so chosen and, manufacture so carried out that improved performance is obtained with consequent increase in life.

3.4 general purpose grade capacitors: General purpose grade capacitors are capacitors intended for applications where the high performance level of long life grade capacitors is not required.

3.5 rated capacitance: The value of the capacitance indicated by the manufacturer and marked on the capacitors.

3.6 rated ripple current: The rated ripple current is the r.m.s value of the maximum allowable alternating current of a specified frequency at which the capacitor may be operated continuously at a specified temperature.

3.7 rated ripple voltage: The r.m.s. value of the maximum allowable alternating voltage of a specified frequency superimposed on the d.c. voltage at which the capacitor may be operated continuously at a specified temperature. The peak voltage resulting from this alternating voltage superimposed on the direct voltage shall not exceed the value of the rated direct voltage and the permissible reverse voltage.

3.8 rated temperature: The maximum ambient temperature at which the rated voltage is applicable continuously.

3.8.1. lower category temperature: The minimum ambient temperature for which a component has been designed to operate continuously.

3.8.2 upper category temperature: The maximum ambient temperature for which a compoenent has been designed to operate continuously.

NOTE - 3.6.1 and 3.6.2 are applicable only for tantalum capacitors.

3.9 rated voltage: The maximum direct voltage which may be applied continuously to the terminals or a capacitor at any temperature between the lower category temperature and the rated temperature.

3.10 reverse voltage: A voltage applied to the capacitor terminations in the reverse polarity direction.

3.11 tangent of loss angle (Tan S.): The power loss of the capacitor divided by the reactive power of the capacitor at a sinusodial voltage of specified frequency.

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3.12 type tests: Tests carried out to prove conformity with the requirements of the standard. These are intended to prove the general quality and design of a given type of capacitor.

4 RATINGS AND CHARACTERISTICS

4.1 Rated voltage: Preferred values of rated direct voltages taken from the R_5 and R_{10} series of C.S. 103 : 1971.

For voltage values ≤ 250V : 1V, 1.6V, 2.5V, 4V, 6.3V and their (R_5 series) decimal multiples.

For voltage values > 250V : 250V, 315V, 350V, 400V, 450V (250, 315 and 400V are in accordance with the R_{10} series. 350V and 450V are permitted in addition.)

4.2 Rated capacitance: Preferred values of rated capacitance shall be selected from the E_6 series of IEC publication 63.

4.2.1 Tolerance on rated capacitance: Preferred values of tolerances on rated capacitance are ± 10 per cent and ± 20 per cent.

4.3 Climatic category: The electrolytic capacitors covered by this standard are classified into climatic categories according to the several rules given in SLS 580 Part 1.

The preferred severities for the cold, dry heat and damp heat tests are within the following ranges for aluminium electrolytic capacitors.

Cold test - 10°C to - 55°C

Dry heat test + 70°C to + 125°C

Damp heat steady state test : 4 to 56 days

For tantalum electrolytic capacitors:-

	Type I	Type II
Lower category temperature	- 55°C	- 55°C
Upper category temperature	+ 85°C to + 125°C	+ 85°C to+125°C
Damp heat, steady state	21 to 56 days	-

5 MARKING

5.1 The information given in the marking shall be selected from the following list. The relative importance of each item is indicated by its position in the list.

a) Rated capacitance in microfarads

NOTE: When value and tolerances are coded, one of the methods specified in SLS 520 should be used.

b) Rated voltage: Direct voltage may be indicated by the symbols ⎓ or ⎓ or by letter d.c.

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c) Polarity of the terminations: For multisection capacitors, the rated capacitance and rated voltage of the sections connected to each termination shall be shown in an unambiguous way.

The termination of a capacitor section which is intended for direct connection to the rectifier (so called reservoir section) shall be marked with the number 1 or with the colour red.

d) Tolerance on rated capacitance (see note of 5.1 a)

e) Type or grade of the capacitor. Long life grade capacitors should be marked with 'LL'

f) Rated ripple current

g) Climatic category

h) Year and month of manufacture

j) Manufacturer's type designation

k) Reference to this standard or the national specification appropriate to the capacitor.

5.2 The capacitors shall be at least clearly marked with items a), b) c), d) and e) of 5.1 and with as many of the remaining items as is practicable, in case of aluminium capacitors, and with as many as practicable in the order of priority in case of tantalum capacitors.

5.3 The marking shall be legible and not smeared or removed by rubbing with the finger.

5.4 The package containing the capacitors shall be clearly marked with all the applicable information listed in 5.1.

5.5 Any additional marking shall be so applied that no misunderstanding can arise.

6 REQUIREMENTS

6.1 Electrical requirements

6.1.1 leakage current: The leakage current measured as described in 7.4.1 shall be as follows:

a) Aluminium capacitors

1) For non-solid electrolytic capacitors, the leakage current shall not exceed the values given in Table 1.

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TABLE 1 - Limits of leakage currents

CV product in µc...	Leakage current in µA	
	Long life grade capacitor	General purpose grade capacitors
≤1000	0.01 CV or 1 µA (whichever is the greater)	0.05 CV or 5 µA (whichever is the greater)
>1000	0.006 CV + 4 µA	0.03 CV + 20 µA

C = rated capacitance in microfarads.
V = rated voltage in volts.

2) For solid electrolyte capacitors the leakage currents should be as follows:-

For long life grade capacitors : ≤ 0.1 CV
For general purpose grade capacitors : ≤ 0.15CV

b) For tantalum capacitors: The leakage current in microamperes shall not exceed 0.02 CV or 1 µA which ever is greater.

6.1.2 Capacitance: The capacitance, when meausred in the manner described in 7.4.2, shall comply with the rated value of capacitance within the appropriate tolerance.

6.1.3 Tangent of loss angle: The tangent of loss angle when measured as in 7.4.3, shall not exceed the following values.

6.1.3.1 For aluminium electrolytic capacitors

a) For capacitors with CV products ≤ 100,000 µC, the values given in Table 2 shall not be exceeded.

TABLE 2 - Limits of the tangent of loss angle

Rated Voltage	Tangent of loss angle (Tan δ)	
	Solid electrolyte capacitors	Non-solid electrolyte capacitors
$V_R \leq 4V$	To be agreed upon between customer and manufacturers	
$4V < V_R \leq 10V$	0.18	0.5
$10V < V_R \leq 25$	0.16	0.35
$25 < V_R \leq 63V$	0.12	0.25
$63 < V_R$	-	0.20

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b) For capacitors with CV products > 100,000 μC, the maximum tangent of loss angle shall be agreed upon between customer and manufacturer.

6.1.3.2 For tantalum electrolytic capacitors: The tangent of loss angle at 27 ± 2°C shall not exceed the following:

$V_R \leq 10V$: 0.06

$V_R < 10V$: 0.08

6.1.4 Impedance : The impedance shall meet the requirements given in the detail specification, when measured as in 7.4.4.

6.1.5 Insulation resistance of the insulating sleeve: (If applicable) The insulation resistance measured as described in 7.4.5, shall be not less than 1000MΩ for category 1 of tantalum capacitors and long life purpose grade aluminium capacitors, and 100MΩ for category 2 & 3 of tahtalum and general purpose grade of aluminium capacitors.

6.1.6 Voltage proof of the external insulation (if applicable)
There shall be no sign of breakdown or flashover during the test period when tested as in 7.4.6.

6.1.7 Ability of capacitors to withstand electrical surges:
Capacitors shall meet the requirements given in Table 3 when tested as in 7.4.7.

TABLE 3 - Requirements to check the ability of capacitors to withstand electrical surges

Measurement	Measuring conditions	Requirement
Visual inspection (for non-solid electrolyte capacitors)	-	No leakage of electrolyte or other visible damage.
Leakage current	7.4.1	Limits given in 6.1.1
Capacitance	7.4.2	The difference between the capacitors measured initially and finally in 7.4.7 shall not exceed: a) for aluminium capacitors 1) solid electrolyte capacitors Long-life grade applications: 5% General-purpose grade applications: 10% 2) non-solid electrolyte capacitors: 15% b) For tantalum capacitors: The difference between the capacitances measured finally and in 7.4.7 1.2 at 27°C shall not exceed 10%.
Tangent of loss angle	7.4.3	6.1.3

6.1.8. Endurance : Capaciters shall meet the requirements given in Tables 4,5 and 6 as applicable, when tested as described in 7.4.8.

TABLE 4 - Requirements to check the endurance of aluminium solid electrolyte capacitors

Inspection or measurement	Measuring conditions	Requirement
Visual inspection	-	No visual damage The marking shall be legible.
Leakage current	7.4.1	6.1.1
Capacitance	7.4.2	The difference between the capacitances measured in 7.4.8 finally and the limites given in 6.4.2 shall not exceed 10%
Tangent of loss angle	7.4.3	$\leq$ 1.2 times the limit shown in 6.1.3.
Impedance	7.4.4.	$\leq$ 1.2 times the limit shown in 6.1.4.
Insulation resistance (if applicable)	7.4.5.	6.1.5
Voltage proof (if applicable)	7.4.6.	6.1.6

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TABLE 5 - Requirements to check the endurance of aluminium non-solid electrolyte capacitors

Inspection or measurement	Measuring conditions	Requirement
Visual inspection	-	No leakage of electrolyte or other visible damage The marking shall be legible.
Leakage current	7.4.1	6.1.1
Capacitance	7.4.2	The difference between the capacitances measured initially and finally in 7.4.8 shall not exceed the following values: Long life grade: $V_R \leq 6.3$: ± 15 to -30; $6.3 < V_R \leq 160$: ± 15; $V_R > 160$: ± 10 General purpose grade: $V_R \leq 6.3$: ± 25 to -40; $6.3 < V_R \leq 160$: ± 30; $V_R > 160$: ± 15
Tangent of loss angle	7.4.3	Long-life grade: the tangent of loss an angle shall not exceed 1.3 times the limit shown in 6.1.3. General-purpose grade: the tangent of loss angle shall not exceed 1.5 times the limit showin in 6.1.3 or 0.4 (whichever is the greater)
Impedance	7.4.4	Long-life grade: ≤ times the limit in 6.1.4. General-purpose grade: ≤ 3 times the linit im 6.1.4
Insulations resistance (if applicable)	7.4.5	6.1.5
Voltage proof (if applicable)	7.4.6	6.1.6

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TABLE 6 - Requirements to check the endurance of tantalum capacitors

Inspection or measurement	Measuring conditions	Requirement
Visual inspection	-	There shall be no visible damage The marking shall be legible.
Leakage current	7.4.1	The leakage current shall not exceed twice the limit showin in 6.1.1.
Capacitance	7.4.2	The difference between the capacitances measured finally and limits given in 6.1.2 shall not exceed 10%.
Tangent of loss	7.4.3	The tangent of loss angle shall not exceed 1.5 times the limit showin in 6.1.3

6.1.9 Ability of capacitors to withstand reverse voltages:

Capacitors shall beet following requirements when tested as in 7.4.9.

TABLE 7 - Requirements to check ability to withstand reverse voltage

Measurement	Measuring conditions	Requirement
Leakage current	7.4.1	Limits given in 6.1.1
Capacitance	7.4.2	For solid electrolyte capacitors the difference between the capacitances measured initially and finally in 7.4.9 shall not exceed 10%. For non-solid electrolyte capacitors, see detail specification.
Tangent of loss angle	7.4.3	7.4.3

6.1.10 Charge and discharge : Capacitors shall meet the requirements given in Table 8, when tested as in 7.4.10.

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TABLE 8 - Requirements to check charging and discharging of Capacitors

Inspection or measurement	Measuring conditions	Requirement
Visual inspection	-	No leakage of electrolyte (for non-solid electrolyte capacitors) or other visible damage.
Capacitance	7.4.2	The difference between the capacitances measured in 7.4.10.1 and in 7.4.10.3 shall not exceed 10% for non-solid electrolyte capacitors and 5% for solid electrolyte capacitors.

6.2 Physical and mechanical requirements

6.2.1 Robustness of terminations

6.2.1.1 Tensile strength of terminations: Each termination shall withstand the test without fracture of the seals or terminal supports, or their deterioration, when tested as in 7.5.1.1.

6.2.1.2 Bending of terminations

a) Wire terminations: Each termination shall withstand two consecutive bands without visible damage to the capacitor, when tested as in 7.5.1.2a).

b) Tag terminations: Each tag termination shall withstand one bend when tested as in 7.5.1.2b without visible damage to the capacitor.

6.2.1.3 Torsion test: Each termination shall withstand two successive rotations without visible damage to the capacitor when tested as in 7.5.1.3.

6.2.2 Soldering

6.2.2.1 Solderability of terminations: Good tinning as evidenced by free flowing of the solder with wetting of the terminations when tested as in 7.5.2.1.

6.2.2.2 Resistance to soldering heat: When tested as in 7.5.2.2 capacitors shall meet the requirements given in table 9.

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TABLE 9 - Resistance to soldering heat

Inspection or measurement	measuring condition	Requirement
Visual examination	7.3	No visual damage. The marking shall be legible
Capacitance	7.4.2	The percentage difference between the capacitances measured after the test in 7.5.3 and 6.1.2 limits in shall not exceed 5 per cent.

6.2.3 Ability to withstand rapid change of temperature

Capacitors shall meet the requirements given in Table 10, when tested as in 7.5.3.

TABLE 10 - Requirements to withstand rapid change of temperature

Measurement	Measuring conditions	Requirements
Visual inspection		No leakage of electrolyte or other visible damage.
Leakage current	7.4.1	Limit of 6.1.1
Capacitance (for tantalum only)	7.4.2	The difference between the capacitances measured in 7.5.3 and the limits given in 6.1.2 shall not exceed the following: type I 5% type II 10%
Tangent of loss angle	7.4.3	Limits in 6.1.3
Impedance (if required)	7.4.4	Limit in 6.1.4

6.2.4 Ability to withstand vibration severities

Capacitors shall meet the requirements given in Table 11, when tested as described in 7.5.4.

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TABLE 11 - Requirements to withstand vibration severities

Inspection or measurement	Measuring conditions	Requirements
Visual inspection	-	No leakage of electrolyte (for non-solid electrolyte capacitors) or, other visible damage. The marking shall be legible.
Capacitance (for aluminium only)	7.4.2	Unless otherwise specified in the detail specification, the difference between the capacitances measured in 7.5.4 and after the test in 7.5.2.2 shall not exceed 5%.

6.2.5 Suitability of capacitors for applications where they are subjected to bumps (not required for tantalum capacitors)

Capacitors shall meet the requirements given in Table 12, when tested as in 7.5.5.

TABLE 12 - Requirements to check ability of capacitors to withstand bumps

Inspection or measurement	Measuring conditions	Requirements
Visual inspection	-	No leakage of electrolyte or other visible damage.
Capacitance	7.4.2	Unless otherwise specified in the detail specification, the difference between the capacitances measured in 7.5.5. and limits given in 6.1.2 shall not exceed 5%.

6.2.6 Climatic sequence

6.2.6.1 Aluminium capacitors

There shall be no break down, flash-over or harmful deformation of the case, when tested as in 7.5.6.

6.2.6.2 Tantalum capacitors

Capacitors shall meet the requirements given in the Table 13.

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TABLE 13 - Requirements to determine the suitability of tantalum capacitors to environmental changes

Inspection	Measuring conditions	Requirement
Visual inspection	-	There shall be no visible damage.
Leakage current	7.4.1	The leakage current shall not exceed the limits in 6.1.1.
Capacitance	7.4.2	The difference between the capacitances measured in 7.5.6 and 7.5.3 shall not exceed 10%.
Tangent of loss angle	7.4.3	The tangent of loss angle shall not exceed 1.2 times the limits in 6.1.3.

6.2.7. Effectiveness of seals of capacitors (if required by the detail specification)

Capacitors shall meet the requirements given in Table 14 when tested as in 7.5.7.

TABLE 14 - Requirements to check the effectiveness of seals

Inspection or measurement	Measuring conditions	Requirement
Visual inspection	-	No leakage of electrolyte (for non-solid electrolyte capacitors) or other visible damage. The marking shall be legible.
Leakage current	7.4.1	6.1.1.
Capacitance	7.4.2	The difference between the capacitances measured in 7.5.7 and 7.5.6 and 7.5.2.2 as applicable shall not exceed, a) solid electrolyte capacitors longplife grade applications 5% b) General-purpose grade applications and non-solid electrolyte capacitors: 10%
Tangent of loss angle	7.4.3	1.2 times the limit shown in 6.1.3.

6.2.8 Suitability of capacitors for use and storage under conditions of high relative humidity

Capacitors shall meet the requirements given in Table 15 when subjected to the test in 7.5.8.

TABLE 15 - Requirements to check preformance or storage of capacitors under conditions of high relative humidity

Inspection or measurement	Measureing conditions	Requirement
Visual inspection	-	No leakage of electrolyte (for non-solid electrolyte capacitors) or other visible damage. The marking shall be ligible.
Leakage current	7.4.1	6.1.1.
Capacitance	7.4.2	For aluminium capacitors: The difference between the capacitances measured initially and finally in 7.5.8 shall not exceed the following: a) solid electrolyte capacitors long-life grade applications: 5%. -general-purpose grade applications: 10% b) non-solid electrolyte capacitors-long life grade applications: 10% -general-purpose grade applications: 20% For tantalum capacitors: Difference between the capacitances measured in 7.5.8 and limits given in 6.1.2 shall not exceed 10%.
Tangent of loss angle	7.4.3	1.2 times the limit shown in 6.1.3.
Insulation resistance (if applicable)	7.4.5	6.1.5.
Voltage proof of the insulation	7.4.6	no break down or flashover.

6.2.9 Adhesion(only for tantalum capacitors, if applicable)

Capacitors shall be subjected to the test given in 7.5.9. There shall be no visible damage.

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6.2.10 Ability of the pressure relief device to avoid danger if applicable

The pressure relief device shall open in such a way as to avoid any danger of explosion on fire when tested as described in 7.5.10.

6.2.11 Characteristics at high and low temperature

Following requirements shall meet when tested as in 7.5.11.

TABLE 16 (a) - Requirements to determine the characteristics at high and low temperature for solid aluminium capacitors

Step	temperature	Measurement	Measuring conditions	Requirement
1	27°C	Capacitance*	7.4.2	(for use as reference value)
		Impedance * *	7.4.3	
		Tan δ *	7.4.4	
2	Low temperature	Capacitance *	7.4.2	$\Delta C/C$ 20% of value measured in Step 1
		Impedance	7.4.3	Ratio with respect to value in step 1: $\leq$ 2 times
		Tan (δ) *	7.4.4	$\leq$ 2 times the limit shown in 6.1.4
3	High temperature	Leakage current	7.4.1	At 125°C (with V_C) $\leq$ 8 times the limit shown in 6.1.1.
				At 85°C (with V_R) $\leq$ 10 times the limit shown in 6.1.1.
		Capacitance (*)	7.4.2	$\Delta C/C$ 20% of value measured in step 1
		Tan (δ)*	7.4.4.	$\leq$ the limit shown in sub-clause 6.1.4.

* If applicable
** Measured at the same frequency used in step 2.

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TABLE 16 (b) - Requirements to determine the characteristics at high and low temperature for aluminium non-solid electrolyte capacitors

Step	Temperature	Measurement	Measuring conditions	Requirement
1	27°C	Capacitance *		-
		Tan *		-
		Impedance **		-
2	Low temperature	Impedance		The ratio of the impedances measured at low temperature and at step I shall not exceed the following values:
				Rated voltage (V) / Ratio of impedance: $V_R \leq 6.3$: 7; $6.3 < V_R \leq 16$: 5; $16 < V_R \leq 160$: 4; $160 < V_R$: 7
3	High temperature	Leakage current	+125°C	≤ 10 times the limit shown in 6.1.1
			+ 85°C	≤ 5 times the limit shown in 6.1.1
			+ 70°C	≤ 3 times the limit shown in 6.1.1
		Capacitance *	.....	Detail specification
		Tan δ *	.....	Detail specification

* If applicable

** Measured at the same frequency as used in Step 2.

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TABLE 16 (c) - Requirements to determine the characteristics at high and low temperature for tantalum capacitors

Temperature	Capacitance	Leakage current	Upper limit of tangent of loss angle	
	Methods of measurement			
(°C)	7.4.2	7.4.1	7.4.3	
	$\Delta C/C$ in per cent *	(μA)	$V_R \geq 10V$	$V_R < 10V$ (absolute value)
27° ± 2	(Initial measurement)	$\leq$0.02 CV or 1 μA **	0.06	0.08
-55 $^{+0}_{-3}$	-12	No measurement	0.12	0.15
27 ± 2	±5	$\leq$0.02 CV or 1 μA **	0.06	0.08
85 $^{+3}_{\pm 0}$	+10	$\leq$0.02 CV or 1 μA **	0.12	0.15
125 $^{+3}_{-0}$	+ 15	$\leq$0.25 CV or 2 μA **	0.15	0.15
27 ± 2	±5	$\leq$0.02 CV or 1 μA **	0.06	0.08

* $\Delta C/C$ = change of capacitance with respect to the initially measured value.

** Whichever is greater.

6.2.12 Suitability of capacitors for use and storage at high temperature

Capacitors shall meet the requirements given in the Table 17 when tested as in 7.5.12.

TABLE 17 - Requirements to check suitability of capacitors for use and storage at high temperature.

Inspection or measurement	Measuring conditions	Requirement
Visual inspection	-	No leakage of electrolyte (for non-solid eletrolyte capacitors) or other visible damage.
Leakage current	7.4.1	For solid electrolyte capacitors, see 6.1.1. For non-solid electrolyte capacitors, the leakage current shall not exceed 2 times the limit shown in 6.1.1.
Capacitance	7.4.2	The difference between the capacitances measured in 7.5.12 and in 6.1.2 shall not exceed 5% for solid electrolyte capacitors and 10% for non-solid electrolyte capacitors.
Tangent of loss	7.4.3	For solid electrolyte capacitors, see 6.1.3.7 or non-solid electrolyte capacitors, the tangent of loss angle shall not exceed 1.2 times the limit shown in 6.1.3.

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6.2.13 Suitability of capacitors for use and storage at low temperature

Capacitors shall meet the requirements given in the Table 18 when tested as described in 7.5.13.

TABLE 18 - Requirements to check suitability of capacitors for use and storage at low temperature.

Inspection or measurement	Measureing conditions	Requirement
Visual	-	No leakage of electrolyte (for non-solid electrolyte capacitors) or other visible damage. The marking shall be legible.
Leakage current	7.4.1	Limits in 6.1.1
Capacitances	7.4.2	The difference between the capacitances measured in 7.5.13 and limits in 6.1.2 shall not exceed 10%.
Tangent of loss angle	7.4.3	Limits in 6.1.3

7 TESTS

7.1 Classification of tests

7.1.1 Type tests

The capacitors shall be subjected to the tests according to the schedule given in Appendix A

7.1.2 Acceptance tests

7.1.2.1 Number of tests

Each capacitor selected as in Table 23 shall be examined for the requirements given in 9.2.
For aluminium capacitors,

a) Visual examination; 7.3
b) Voltage proof; 7.4.6.
c) Capacitance; 7.4.2
d) Leakage current; 7.4.1
e) Tangent of loss angle; and 7.4.3
f) Impedance 7.4.4.

For tantalum capacitors,

a) Visual examination; 7.3
b) Capacitance; 7.4.2

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c) Leakage current ; (7.4.1)
d) Tangent of the loss angle ; and (7.4.3)
e) Sealing (7.5.7)

7.1.2.2 Two samples of size as given in Table 24 shall be drawn and tested for the following requirements.

Sample 1 - Endurance; (7.4.8)
Sample 2 - Robustness of termination, solderability, bump, climatic sequence.

7.1.3 Routine tests

The following shall comprise the routine test for tantalum capacitors.

a) Visual examination; (7.3)
b) Capacitance, and (7.4.2)
c) Leakage test (7.4.1)

For tantalum capacitors,

a) Visual examination; (7.3)
b) Voltage proof; (7.4.6)
c) Capacitance; and (7.4.2)
d) Leakage current (7.4.1)

7.2 Test sequence

Each specimen of the test sample shall be subjected to the following tests in order shown herein.

a) Visual examination
b) Electrical tests
    1) Leakage current
    2) Capacitance
    3) Tangent of loss angle
    4) Impedance

7.3 Visual examination

The capacitor shall be examined for compliance with any dimensional requirements agreed upon between purchaser and manufacturer.

The marking shall be examined and shall comply with the requirement of section 5.

7.4 Electrical tests

Pre-conditioning: (for non-solid electrolyte capacitors only) Before starting the test programme, all capacitors shall be preconditioned by the application of the rated voltage from a direct voltage source having low internal resistance such as a regulated power supply. The voltage shall be applied to the capacitor through a series resistor, the value of which shall be approximately 100Ω for rated voltages up to and including 100V, and approximately 1000Ω for rated voltages above 100V. The voltage shall be maintained for one hour after its value across the capacitor has become equal to the rated voltage, with a tolerance of ± 3 percent.

Cont'd...20

After this preconditioning the capacitors shall be discharged through a resistance of approximately 1Ω per applied volt. The tests in 7.4 shall then be made after the capacitors have been stored for a period of 12h to 48h during which no voltage shall be applied. No further preconditioning described above shall be applied during the test programme.

7.4.1 Method of measurement of leakage current

Before this measurement is made, the capacitors shall be fully discharged.

The rated voltage shall be applied across the capacitor and its protective resistor in series. Unless otherwise stated in the detail specification the protective resistor shall be approximately 100Ω for rated voltages < 100V, and approximately 1000Ω for rated voltages > 1000V.

The leakage current shall be measured, unless otherwise prescribed in the detail specification, using the direct voltage (V_r or V_c) appropriate to the test temperature, after a maximum electrification period of 5 minutes. A steady source of power such as a regulated power supply shall be used.

7.4.2 Method of measurement of capacitance

The measuring voltage shall be a.c. having a frequency of 100Hz or 120Hz and shall have a maximum 0.5V r.m.s or such lower voltage as is required in order not to exceed the rated ripple current. During the measurement a d.c. voltage of 80 per cent of the rated voltage shall be applied to the aluminium capacitors, and direct polarizing voltage for tantalum capacitors is in between 2.1V to 2.5V.

7.4.3 Tangent of the loss angle

The tangent of the loss angle shall be measured under the conditions specified in 7.4.2 above.

7.4.4 Impedance

7.4.4.1 Measuring conditions

The tests shall be carried out at 27 ± 2°C standard test temperature laid down in SLS 374. The voltage used for the measurement shall be as small as practicable and shall be applied for a time short enough to avoid undue heating of the capacitor. To demostrate that the voltage is sufficiently small, it shall be applied to one of the capacitors in each sample for 1 minute during which time there shall be no readable change in the impedance of the capacitor.

For tantalum capacitors measuring voltage - ≤ 100 mV a.c. ....r.m.s
Frequency of the measuring voltage - 100 kHz.

7.4.4.2 Method of measurement

A suitable method is given in Appendix B
The error of the measurement for tantalum capacitors shall not exceed 5 percent of the requirement or 0.1Ω whichever is greater, and the error of the measurement for aluminium capacitors shall not exceed 5 percent of the requirement or 0.02Ω whichever is the greater.

7.4.5 Insulation resistance of the insulating sleeve: (if applicable)

Before this measurement is made, the capacitors shall be fully discharged.

7.4.5.1 Measuring conditions:

A metal foil shall be wrapped clc
length of the body of the capacito
5 mm from each end provided a mini
maintained between the metal foil
The ends of the foil shall not be
capacitor. If the 1 mm space cann
the foil shall be reduced, if neces

7.4.5.2 Method of measurement

A direct voltage of 500 + 50V shall
the metal foil and the termination c
body for a minimum of 1 minute or for
obtain a stable reading. At the end of this period
resistance shall be measured.

This could be applied for aluminium electrolyte ca
and climatic category 1 of tantalum electrolyte capac

For climatic category 2 and 3 of tantalum a direct vo
of 100 + 10V shall be applied between the metal foil and
termination.

7.4.6 Voltage proof of the external insulation (if

In case of aluminium capacitor metal foil sha
around the full length of the capacitor, protr
5 mm from each end, provided a distance of not
can be maintained between the metal foil and t
The ends of the foil shall not be folded over t
capacitor. If the 1mm distance cannot be maint
protrusion of the foil shall be reduced as may b
to establish the 1 mm distance.

A direct voltage of gradually increasing at a rate
to a maximum of 1000V shall be applied between the
and the termination connected to the capacitor body

The test prescribed below, is a d.c. test, if a.c.
it shall be prescribed in the detail specification.

A suitable test circuit is shown below:

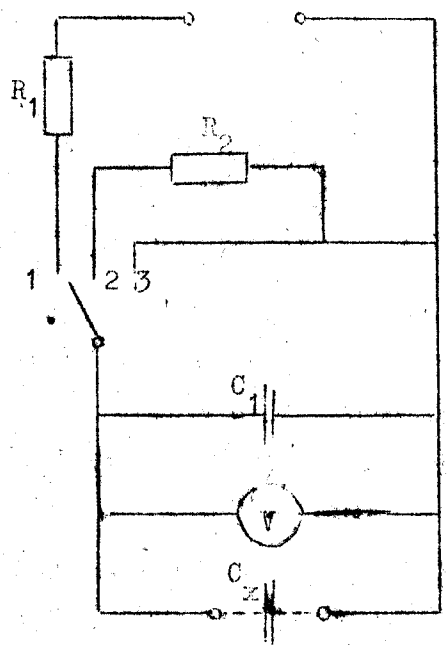

FIGURE 1 - Voltage proof test

cont'd

ltmeter shall be not less than 10,000-/V.

shall be chosen so that, in conjunc
nd the capacitance of the part u
current do not exceed the specified
st voltage. The capacitance of C_1 shall be
capacitance of the part under test.

nnected to R_2. The two terminals at the top
oe connected to a variable d.c. supply of
ch shall be adjusted to the required test
or to be tested (C_x) shall be connected as
d in the diagram.

witch shall then be connected to R_1 so that the capacitors
nd C_x are charged.

e switch shall remain in this position for 1m ± 5s after the
st voltage has been reached. The capacitor shall be discharged
onnecting the switch to R_2. As soon as the voltage reading
allen to zero the capacitors shall be short-circuited and
all b disconnected.

ase of the capacitor is non-metallic or where the
as a metallic case with an insulating sleeve, the
shall be applied in one of the two following ways;

oils shall be closely wrapped around the body of the
r to within a distance from the terminations equal
oximately 1mm/kV test voltage. The test voltage shall
lied between the terminations connected together and
oil.

apacitor shall be mounted in its normal manner on a metal
e, which extends at least 15mm beyond the mounting
of the capacitor in all directions; the test voltage
be applied between the terminations connected together
he metal plate.

te shall be made at successive points of application as
ied in Table 19.

ail specification shall prescribe;

The duration of the test;

The maximum charging and discharging currents; and

Where applicable the maximum value of time constant $R_1 (C_1 + C_x)$

Cont'd....23

TABLE 19 - Test points for voltage proof test

Test	1) Single section capacitors	2) Multiple section capacitors having a common termination for all sections	3) Multiple section capacitors having no common termination
A between terminations	1a) Between terminations	2a) Between each of the terminations and the common termination.	3a) Between terminations of each section.
B Internal insulation	1b) Between terminations connected together and the case (except where the case is one termination) (metal cased types only)	2b) Between all terminations connected together and the case (except where the case is one of the terminations) (metal cased types only)	3b) Between all terminations connected together and the case (metal cased types only)
		2c) Between the non-common termination of each section and all the other terminations connected together	3c) Between the terminations of separate sections, the two terminations of each section being connected together
C External insulation	1c) Between terminations connected together and the metal plate of foil (insulated types not employing metal cases)	2d) Between all terminations connected together and the metal plate or foil. (insulated types not employing cases)	3d) Between all terminations connected together and the metal plate of foil (insulated types not employing metal cases)
	1d) Between case and the metal plate of foil insulated metal cased types only)	2e) Between case and the metal plate or foil (insulated metal cased types only)	3e) Between case and the metal plate or foil (insulated metal cased types only)

7.4.7 Surge test

The capacitors shall be subjected to a test under standard atmospheric conditions laid down in SLS 374 for testing as specified below.

NOTE - Attention is drawn to the fact that the surge test and the charge/discharge test are also similar but have different applied voltages and different time constants.

Cont'd.....24

Suitable test circuits are shown below.

NOTE - Thyristor circuit has the advantage of high repitition rates and is free from problems associated with contaminated contacts and contact bounce.

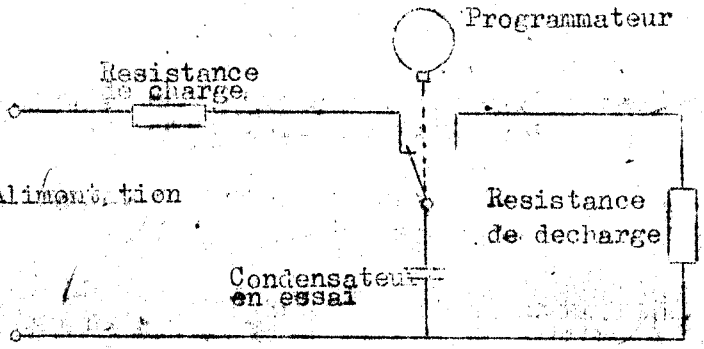

FIGURE 2 - Relay circuit

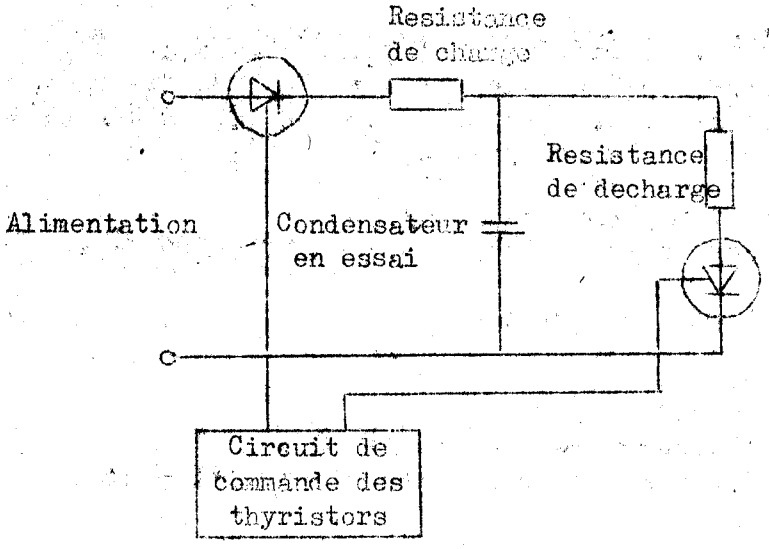

FIGURE 3 - Thyristor circuit

The voltage waveform across the capacitor under test shall be approximately as follows:

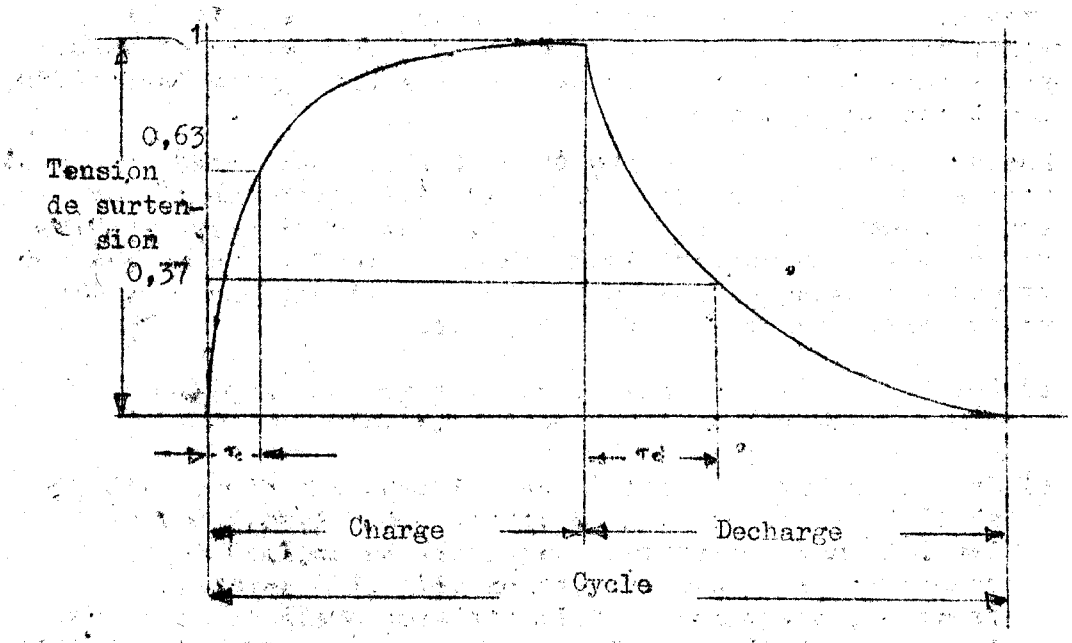

FIGURE 4 - Waveform for charging and discharging

Cont'd...25

7.4.7.1 Test procedure for aluminium capacitors

The capacitors shall be subjected to 1000 cycles each consisting of a charge as described below, followed by a discharge period of 5 min 30s. The test temperature shall be upper category temperature for long-life grade capacitors and room temperature for general-purpose grade capacitors.

Charge

a) Applied voltage: 1.15 times the rated or category voltage for rated voltages $\leq$ 315 V;

1.10 times the rated or category voltage for rated voltages $>$ 315V

b) Internal resistance of the voltage source: as required for RC = 0.1 ±0.05s.

Duration: 30s.

7.4.7.2 Test procedure for tantalum electrolytic capacitors

The capacitors shall be subjected to 1000 cycles at upper category temperature, each cycle consisting of a charge a) immediately followed by a discharge b).

a) Applied voltage: 1.15 times category voltage
Internal resistance of the voltage source: 1000±10% Ω

Duration of the surge period: 30s.

b) Applied voltage: 0V
Discharge resistor: 1,000 ± 10% Ω
Duration of the discharge period: 5 min 30s.

Capacitors shall be visually examined and electrically checked after the test.

7.4.8 Endurance test

An intial measurement of capacitors shall be made as described in 7.4.2 before the test. The capacitor shall be placed in a test chamber in such a manner as to be at least 25mm from any other capacitor withing the chamber. It shall then be brought to the rated temperature range and held in this condition for a period of 1,000 hours, for general purpose grade capacitors, and 2,000h. for long-life grade capacitors, and tantalum capacitors.

During this period the capacitor shall be subjected to a test voltage of approximately sine wave form with one of the frequencies given here, (50Hz, 60Hz, 100Hz or 120Hz) superimposed on a d.c. voltage such that the peak voltage does not exceed the value of the rated direct voltage, and that the rated ripple current is not exceeded.

a) For non-solid electrolyte capacitors, the impedance of the voltage source shall be 3Ω maximum.

b) For non-solid electrolyte capacitors, the direct voltage shall be supplied by a regulated power supply having a low internal resistance, and shall be applied to each capacitor or capacitor section through a separate resistor, the value of this resistor shall be so chosen that a short circuit of one of the capacitors or capacitor sections will have no influence on the rest of the sample, but the resistance value shall not exceed 1000Ω.

Means shall be taken to ensure that the capacitor is not affected by direct radiation and that the circulation of the air in the chamber is adequate to prevent the temperature from departing by more than ± 3°C from the specified temperature in any point where the capacitor may be placed.

There shall be no permanent short-circuit or open-circuit of the capacitor during this test period.

At the completion of the test period the capacitor shall be allowed to cool under standard atmospheric conditions for testing for a time as indicated below to allow the whole of the capacitor to reach the ambient temperature.

a) For tantalum capacitors between 1h and 2h.

b) For aluminium capacitors 16h.

The capacitors shall then be visually examined and electrically checked.

7.4.9 Reverse voltage : (if required by the detail specification)

An initial measurement of capacitance shall be made as described in 7.4.2 before the test.

7.4.9.1 Conditioning:

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

a) Test temperature: upper category temperature,

Applied voltage: i) For solid electrolyte capacitors, a direct voltage 0.15 times the category voltage shall be applied in the reverse polarity direction.

ii) For non-solid electrolyte capacitors, the value shall be given in the detail specification.

Duration : 125h.

b) Test temperature: upper category temperature,

Applied voltage : direct voltage equal to the maximum category voltage in the forward polarity direction.

Duration: 125h.

7.4.9.2 Recovery

The capacitors shall remain under the standard atmospheric conditions for testing for 1h to 2h.

Capacitance, leakage current and tangent of loss angle shall be measured, and recorded.

7.4.10 Charge and discharge test : (if required)

Test shall be carried out at the standard atmospheric temperature. Suitable test circuit is shown in Figure 2 and 3.

7.4.10.1 Initial measurements

Capacitance shall be measured as in 7.4.2.

Cont'd....27

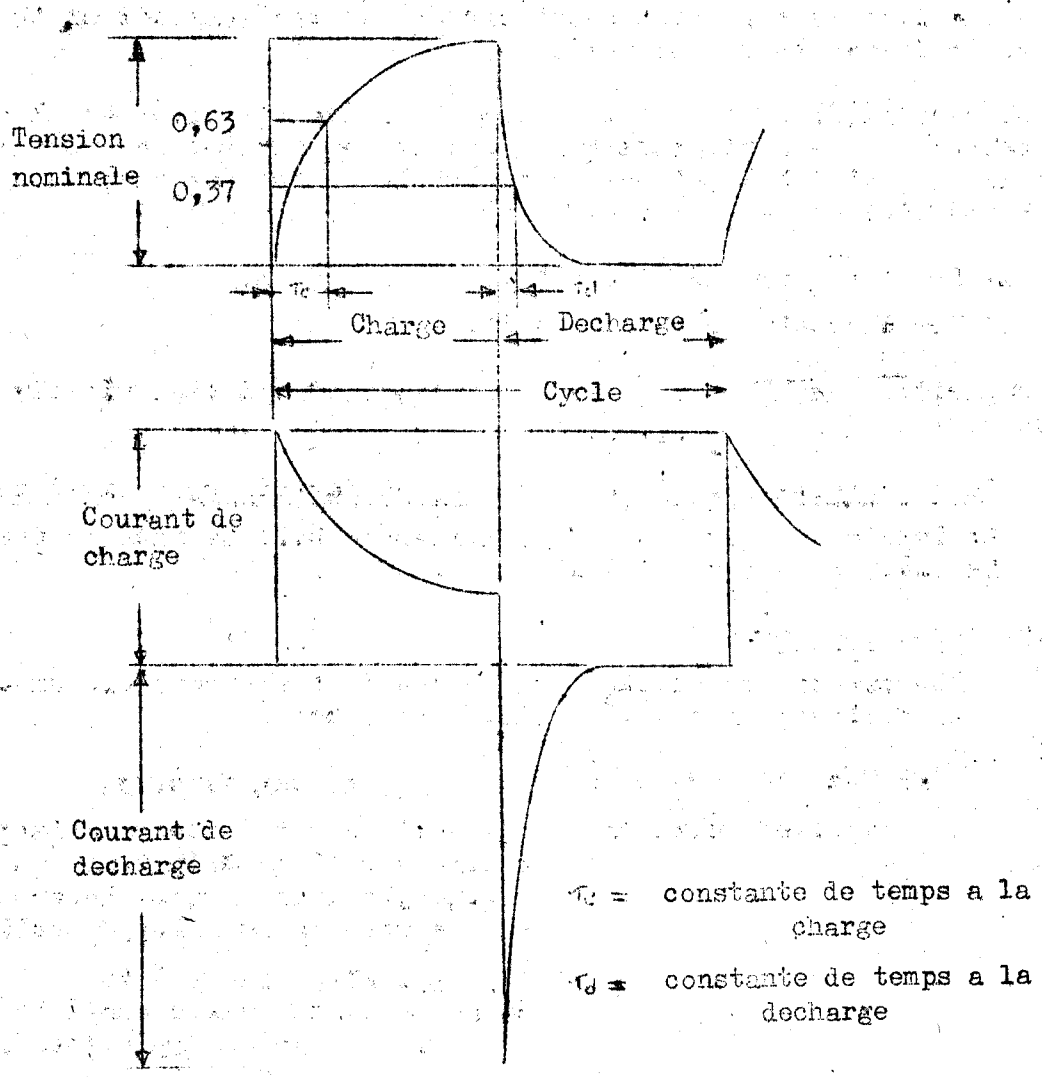

FIGURE 5 - The voltage end current wave form

Tension nominale
0,63
0,37

7.4.10.2 The capacitors shall be subjected to the number of cycles as given herein, each cycle consisting of a charge according to a) by a discharge according to b).

In cases where an increase of the cycling period is required leaving the charging time unchanged in order not to exceed the maximum permissible heat generated in the capacitor, this shall be stated in the detail specification. The voltage and current waveforms across and through the capacitor under test are approximately shown in Fig. 5.

a) Charge
Applied voltage: rated direct voltage
Internal resistance of the voltage source plus external series resistor;

as required for RC = 0.1 s.

Duration: 0.5 s.

b) Discharge
No voltage applied.
Discharge resistor; as required for RC = 0.1 s.
Duration: 0.5 s.
Number of cycles:

For capacitors with rated voltage $V_R \leq 160V$: 10^6

For capacitors with rated voltage $V_R > 160V$ under consideration.

7.4.10.3 Capacitors shall then be visually inspected and measured.

7.5 Physical and Mechanical tests

7.5.1 Robustness of terminations

7.5.1.1 Tensile test

The object of the tensile test is to determine the ability of terminations to withstand the direct axial pulls likely to be applied during normal assembly operations.

The body of the component shall be clamped and the terminations loaded in turn in their normal position relative to the body in the direction of the axes of the terminations for a period of 10 seconds.

The loading weight shall be as follows:

For terminations other than wire terminations: 20N
For wire terminations as given in the Table 20.

TABLE 20 - Diameters of the wire terminations and corresponding forces

Nominal area (mm^2)	Corresponding dia. (mm)	Force (N)
$A \leq 0.05$	$d \leq 0.25$	1
$.05 < A \leq 0.07$	$.25 < d \leq .3$	2.5
$.07 < A \leq 0.2$	$.3 < d \leq .5$	5
$.2 < A \leq .5$	$.5 < d \leq .8$	10
$.5 < A \leq 1.2$	$.8 < d \leq 1.25$	20
$1.2 < A$	$1.25 < d$	40

Cont'd....29

7.5.1.2 Bending test for terminations:

The purpose of this test is to determine the ability of the terminations to withstand the bending likely to be applied during normal assembly operations.

a) Method of test on wire terminations: The component shall have a load equal to half of that specified for the tensile test, freely suspended from each of its terminations and even in the direction of the termination the body of the component being held such that the wire is in its normal position relative to the component.

The body of the component shall then be inclined, reasonably slowly, so as to bend the wire through 90 and returned to normal, the entire action taking place in one vertical plane. Bending through an angle of 90 and back shall be defined as one bend.

When the terminations are so designed that they are weaker in one plane than in others, they shall be tested in the weakest direction, or several tests, each on a seperate sample shall be made.

Consecutive bends shall be in opposite directions.

Care shall be taken to ensure that the bend occurs at a point 6mm from the point of emergence of wire or strip from the capacitor and around a radius of 0.75 mm. Suitable arrangements to ensure this requirement are shown in Fig 6.

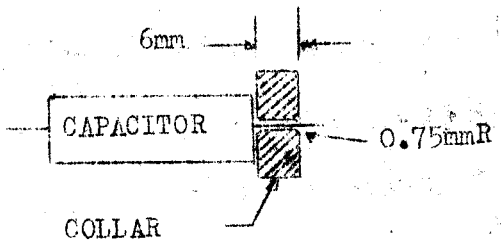

FIGURE 6 - Arrangement for bend test

b) Method of test on tag terminations:

Wire shall be soldered to each tag so as to permit loading in the direction of the termination. The component shall be held with the tag in its normal position relative to the component and a load equal to half of that specified for the tensile test freely suspended from each tag in turn.

Cont'd....30

The body of the component shall then be inclined gradually, so as to bend the wire through 45 degrees in the opposite direction, and finally back through 45 degrees to normal. This operation shall be defined as one bend.

7.5.1.3 Torsion test : (for axial termination only)

The purpose of the test is to determine the ability of wire termination to withstand the twisting likely to be applied during inspection or serving after the components have been soldered into an assembly.

Each termination shall be bend through 90° at a point of 6mm from the point of emergence of the termination. The radius of curvature of the bend shall be approximately 0.75 mm (Fig. 7A)

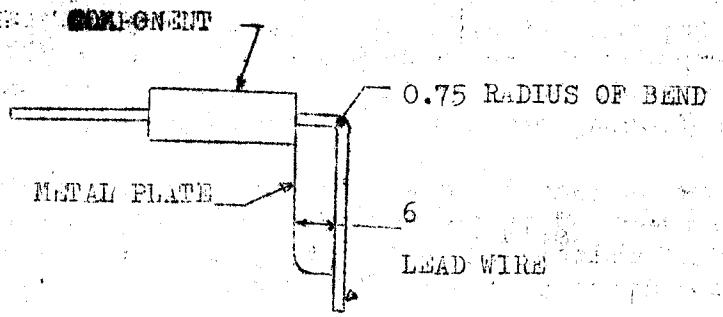

FIGURE 7A - Method of Bending Wire Leads for the Torsion test

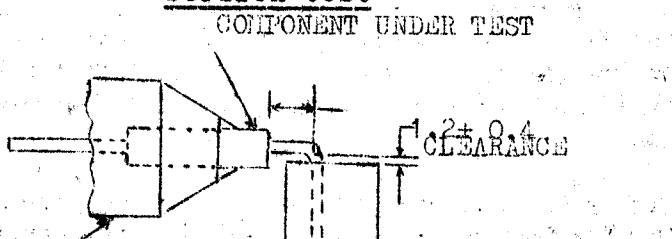

FIGURE 7B - Method of Twisting Wire Leads for the Torsion test (All dimension in millimeters)

FIGURE 7 - Torsion test on components with axial leads

The free end of the termination shall be clamped at a point 1.2 ±0.4mm from the bend (see Fig. 7B). The body of the component or the clamping device shall then be rotated through 180° and back about the original axis of the termination at a rate of one rotation per five seconds. Successive rotations shall be in alternate senses.

7.5.2 Soldering

7.5.2.1 Solderability of terminations

This test is to determine the ability of component terminations to wet easily, and to check that the component itself will not be damaged by assembly soldering.

Cont'd....31

Method

(Solder Bath test)

The solder bath shall have a volume sufficient to ensure that the temperature of the solder remains uniform when introducing the termination of the component. The exposed area of the surface of the solder shall be reduced as far as possible by the use of a sheet of asbestos in order that the component shall not be heated by direct radiation from the bath.

It shall be fitted with means of maintaining the temperature of the solder at any of the following temperatures.

Components for printed wiring applications: 230°C
Components for normal applications: 270°C.

The surface of the bath shall be kept clean and bright, and immediately prior to a test, a piece of 60/40 tin-lead alloy (approximately of 12mm length and 1.6 mm diameter) with a non activated rosin core, shall be dropped into the middle of the bath. No other fluxing shall be used for this test.

As soon as the added solder has melted, the component termination shall be immersed in the direction of its longitudinal axis into the bath of molten solder at the test temperature. The duration of immersion shall be 2 minutes $\pm$ 5 seconds.

Wire termination shall be immersed upto 6 mm from the point where the termination emerges from the body. Soldering tags shall be immersed up to a point 3mm beyond the place intended for the connection of wires or for half their length if this would result in a smaller depth of immersion. The terminations shall be examined for good tining as evidenced by free flowing of the solder, and wetting of the terminations.

Components intended for use or printed wiring boards shall be mounted on a heat insulating board of a specified thickness (2mm $^{+0}_{-5}$) so that the components are pressed against the board with the wire terminations protruding through holes in the board. The underside of the board shall then be placed parallel to the solder bath. For axial lead components, the components shall be mounted on the board vertically with one end of the component pressed against the hole through which the associated wire terminations protrudes. The termination from the opposite end shall be bent over and parallel to the side of the component and shall protrude through another hole on the board. The board shall then be placed directly in a solder bath having the temperature as indicated above.

7.5.2.2 Resistance to soldering heat

The object of the test is to determine the ability of a component to withstand damage during assembly soldering processes.

Method

The terminations shall be immersed as described in 7.5.2.1 but at 350°C for a period of 3 $^{+1}_{-0}$ seconds and withdrawn. The terminations of components mounted on printed wiring boards shall be immersed at 230°C for 8 seconds or 270°C for 2 seconds.

Termination shall be immersed up to 2 $\pm$0.5 mm from the emergence of the body using a heat shield or, the terminations shall be immersed up to 6 $^{+0}_{-0.5}$ mm from the body and no heat shield shall be used.

Cont'd...32

7.5.3 Rigid change of temperature

The capacitors shall be subjected to the test of IEC 68-2-1 for 5 cycles. The duration of the exposure at each temperature limit shall be 30 minutes for tantalum capacitors, and 30 min. or 3h. for aluminium electrolyte capacitors, as specified in the relevant specifications.

Recovery time:

Aluminium capacitor :- 16h
Tantalum capacitor :- between 1h and 2h

7.5.4 Vibration

To determine the ability of capacitors to withstand specified severities of vibration.
The test shall be carried out in accordance with test F_c Procedure B_4, IEC Publication 68-2-6 with the following details.

a) Mounting
The mounting method shall be as prescribed in the detail specification. 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 + 1mm.

b) Conditioning

The secerity shall be one of the following as specified in the detail specification:

TABLE 21 - Vibration severities

Frequency (Hz)	Amplitude or acceleration (whicever is the lower acceleration)	Duration (hours)
10 - 500	0.75mm or 10g	3 x 2
10 - 55	0.75mm or 10g	3 x 2
10 - 55	0.35mm or 5g	3 x 0.5
10 - 2000	0.75mm or 10g	3 x 2

c) Final measurements

Capacitance shall be measured and recorded after the test.

7.5.5 Bump test (not required for tantalum capacitors)

To determine the suitability of capacitors for applications where they are subjected to prolonged bumping and/or to asses their structural integrity.

This test shall be carried out as prescribed in IEC publication 68-2-29 with the following details.

The number of specimens shall be not less than six.

a) Mounting

The method of mounting shall be as prescribed in the detail specification.

Cont'd...33

b) Conditioning: Degree of severity:

1000 bumps for general-purpose grade capacitors
4000 bumps for long-life grade capacitors
Acceleration 40g.
Duration of pulse 6 ms.

c) Final measurements
Capacitance shall be measured after the test.

7.5.6 Climatic sequence

Tests shall be carried out as described in 7.5.6.3 with the following details,

7.5.6.1 For aluminium capacitors

a) Low air pressure
The initial measurements are required.

Conditioning:
Air pressure 85 X 10^2 Pa
Ambiant temperature range 15° -35°C
Duration 5 min.

During the last minute of conditioning, the rated direct voltatage shall be applied.

7.5.6.2 For tantalum capacitors

i) Dry heat: No final measurements at high temperature are required.
ii) Damp heat, accelerated. 1 cycle.
iii) Cold.
No final measurements at low temperature are required.
iv) Low air pressure.
Not applicable
v) Damp heat, accelerated remaining cycles.
Five cycle for categories -/-/56
One cycle or categories -/-/21
vi) Recovery: Duration between 1h and 2h.

7.5.6.3 Method

7.5.6.3.1 Initial measurements
The measurements prescribed in the detail specification shall be made.

7.5.6.3.2 Dry heat
The capacitors shall be subjected to test B_d of IEC 68-2-2 (1974) using this appropriate degree of severity of upper category temperature for 16h.

While still at the specified high temperature and at the end of the period of high temperature, the measurements prescribed in thedetail specification shall be made.

7.5.6.3.3 Damp heat, accelerated, first cycle
The capacitors, other than those of categories -/-/04 and -/-/A shall be subjected to Test D_b of IEC 68-2-30 for one cycle of 24h.

After recovery the capacitors shall be subjected immediately to the cold test.

Cont'd...34

7.5.6.3.4 Cold

The capacitors shall be subjected to test A_a of IEC 68-2-1 using the appropriate degree of severity.

While still at the specified low temperature and at the end of the period of low temperature, the measurements prescribed in the detail specification.shall be made.

7.5.6.3.5 Low air pressure

The capacitor shall be subjected to test M of IEC 68-2-13 using the appropriate degree of severity prescribed in the detail specification.

The detail specification shall prescribe:

i) duration of test;

ii) temperature;

iii) degree of severity.

While still at the specified low pressure a direct voltage shall be applied as prescribed in the detail specification.

The value of the test voltage will depend on the construction of the capacitor, and shall be agreed upon between the customer and the manufacturer.

After this test the capacitor shall satisfy the requirements of the detail specification.

7.5.6.3.6 Damp heat, accelerated, remaining cycles

The capacitors shall be subjected to test D_b of IEC 68-2-30 the following number of cycles of 24.

TABLE 22 - Categories and Corresponding No. of Cycles for damp accelerated test

Categories	Number of cycles
-/-/56	5
-/-/21	1
-/-/10	none
-/-/04	none
-/-/A4	none

7.5.6.3.7 Final measurements

i) After recovery the capacitors shall be visually examined.

ii) The measurements prescribed in the detail specification shall then be made.

Cont'd.....35

7.5.7 Sealing

To determine the effectiveness of seals of capacitors not completely filled with impregnant.

At the end of the climatic sequence, sealing test Q_c given in IEC publication 68-2-17, shall be applied as follows:

a) Conditioning
Method 1 or 2 of gas leakage test shall be used or any other suitable method agreed upon between customer and manufacturer.

b) Recovery
The capacitor shall be removed from the liquid, shaken to remove excess liquid, and then remain under standard atmospheric conditions for recovery for minimum 1h and maximum 2h.

7.5.8 Damp heat, steady state

The purpose of the test is to determine the suitability of capacitors for use and storage under conditions of high relative humidity.

The capacitors shall be subjected to test C of IEC publication 68-2-3 (1969) using the degree of severity corresponding to the climatic category of the capacitor.

The voltage-proof test of 7.4.6 shall be carried out at test point A only using the rated voltage within 15 min. after removal from the test chamber.

7.5.8.1 Final inspection and measurements

The capacitors shall be inspected and measured after the test.

7.5.9 Adhesion test (only for tantalum capacitors if applicable)

Unless otherwise specified in the detail specification, the capacitors shall be mounted as given below:

A force of 5 N shall be applied to the line joining the terminations and in a plane parallel to the substrate.

7.5.9.1 Mounting

Capacitors shall be mounted on a suitable substrate, the method of mounting will depend on the capacitor construction.

The substrate material shall not affect the result of any test or measurement.

The substrate shall have surface metallized land areas of proper spacing to permit mounting of capacitors and shall provide electrical connection to capacitors.

A typical substrate is shown in Fig

Cont'd....36

A typical test substrate is shown in Fig. 8.

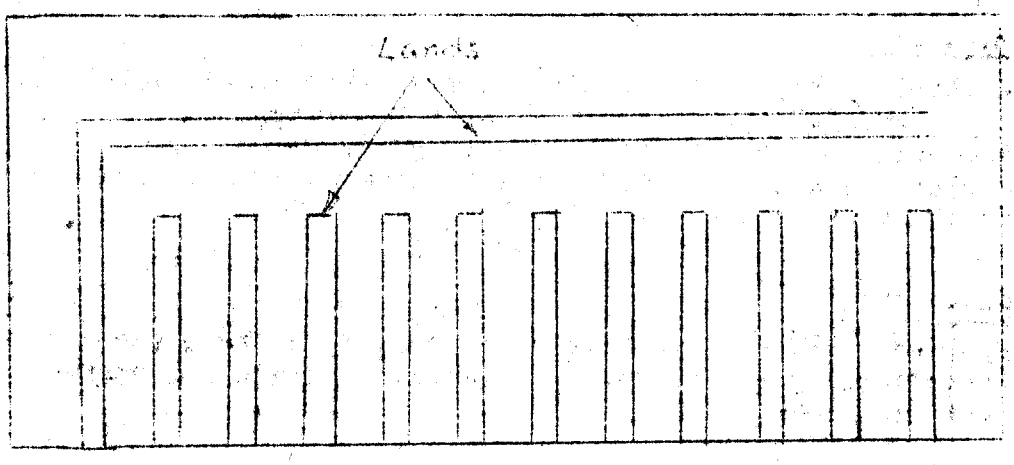

FIGURE 8 - Mounting

If another method of mounting is used, the method shall be clearly described in the detail specification.

When the capacitors have metallized termination areas suitable for reflow soldering, the following mounting procedure applies;

a) The solder used in preform or pasteform shall be silver (2 per cent minimum) eutectic tin/lead solder together with a non-active flux.

b) The chip capacitor shall then be placed across the metallized land areas of the test substrate so as to make contact between chip and substrate land areas.

c) The substrate shall then be placed in or on a suitable heat transfer unit (molten solder, hot plate, tunnel, oven, etc.) The temperature of the unit shall be maintained between 230 °C and 260 °C until the solder bend but for not longer than 10s.

NOTES-

1 - Flux shall be removed by a suitable solvent treatment. All subsequent handling must be such as to avoid contamination. Care shall be taken to maintain cleanliness in test chambers and during post-test measurements.

2 - The above mounting procedure also comprises a resistance to soldering heat test. The measurements of electrical parameters are therefore repeated after the mounting process.

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7.5.10 Pressure relief: (only for tantalum capacitor if it is applicable)

Unless otherwise specified in the detail specification or agreed upon between customer and manufacturer, one of the following three tests shall be applied in order to test the pressure relief device of the capacitor.

7.5.10.1 a.c. test

Applied voltage: alternating voltage with r,m,s, value not exceeding 0.7 times the rated direct voltage.
Frequency of the applied voltage: 50 Hz or 60 Hz.
Series resistor: R = 0.5 times the impedance of the capacitor at the test frequency.

7.5.10.2 d.c. test

Applied voltage: direct voltage applied in the reverse direction, of an amplitude necessary to produce a current of 1A to 10A.

7.5.10.3 Pneumatic test

Applied pnuematic pressure: gas pressure introduced from outside shall be increased at a rate of 2×10^4 Pa/s continuously.

7.5.11 Characteristics at high and low temperatures

7.5.11.1 For aluminium capacitors

The capacitors shall be subjected in turn to the procedures of the dry test B_a of IEC publication 68-2-2 for 16h using the degree of severity of the upper category temperature, and cold test A_a of IEC publication 68-2-1 for 2h using the degree of severity of the lower temperature.

The capacitors shall be measured at 27°C, low category temperature and upper category temperature.

7.5.11.2 For tantalum capacitors

The capacitance, the tangent of loss angle and the leakage current shall be measured at 27°C, low category temperature and upper category temperature.

7.5.12 Storage at high temperature

To determine the suitability of capacitors for use and storage under conditions of high temperature.

Test B_a of IEC publication 68-2-2 shall be carried out with the following details.

Conditioning upper category temperature.
Duration 96 + 4h.

7.5.12.1 Recovery

Temperature - standard atmospheric conditions for testing
Duration - not less than 16h.

7.5.12.2 Final measurements

Capacitors shall be visually examined. Capacitance, leakage current and tangent of loss angle shall be measured and recorded.

7.5.13 Storage at low temperature

To determine the suitability of capacitors to use and store under conditions of low temperature.
Test A_a of IEC publication 68-2-1 shall be carried out with the following details.

The capacitors shall be stored at - 40° for either a period of 4h after thermal stability has been reached, or for 16h, whichever is the shorter period.

After recovery for 16h, the capacitors shall be visually examined and electrically measured.

8 SAMPLING

8.1 Number of samples for type tests

To obtain type approval, the manufacturer or supplier shall furnish to testing authority 36 specimens for each type.

8.1.1 Selection of samples

The samples shall be selected at random from regular production lot. The samples shall be representative of the range of values of the type under consideration. Samples shall comprise quantities as equal as possible of the largest and the smallest case size specimen with the lowest and the highest rated voltages. When there are more than four case sizes, and intermediate case size shall also be chosen for testing. For each case size, the samples with the highest voltage as well as those with maximum voltage at its highest capacitance shall be chosen.

NOTE - A capacitor subjected to type tests shall not be used in equipment nor be returned to bulk supply.

8.1.2 Information regarding samples

All relevant information regarding components shall be furnished with the samples. Any subsequent changes in the design, construction, material used or manufacturing process of approved components shall be brought to the notice of the testing authority, who may, at their discretion, call for fresh samples embodying these changes. All information given to the testing authority by the manufacturer or supplier in connection with type approval shall be treated as confidential and shall not be divulged without the consent of the party concerned.

8.2 Sampling for acceptance tests

8.2.1 Lot

All capacitors of the same type, category, grade and routine, manufactured by same factory under the same conditions of manufacture shall constitute a lot.

8.2.2 Scale of sampling

8.2.2.1 The number of samples to be selected from a lot shall be in accordance with Tables 23 and 24.

TABLE 23 - Sample Sizes and Criteria for Acceptance

Lot size	Sample size	Acceptance number
Up to 25	5	0
26 to 50	8	0
51 to 90	13	0
91 to150	20	1
151 to280	32	1
281 to500	50	2
501 and above	80	3

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TABLE 24 - Criteria for acceptance of a lot

Lot size	Sample size	Acceptance number
Up to 150	3	0
151 to 500	5	0
501 and above	8	1

8.2.2.2 The samples shall be selected at random. In order to ensure randomness of selection, random number table as given in SLS 42[illegible] shall be used.

9. CRITERIAN FOR CONFORMITY

9.1 Type tests

The components shall be considered to satisfy the type tests if each sample tested passes the test or tests to which it is subjected. In such a case, type approval shall be given by the testing authority along with a detailed test report specifying the validity period for the approval.

NOTES - a) The period of validity will normally be three years.

b) The storage (normal) test is a prolonged one extending over months and, therefore, it may not be practicable to wait for the result of this test in case of a provisional type approval may be given on satisfactory completion of other tests subject to confirmation after results of the storage test.

9.1.1 Rejection and re-testing

In case of failure in any one test, the requirements of type approval may be considered as not having been satisfied and fresh samples not exceeding the original number may be called for to undergo repeat tests as required by the relevant component specification. In such cases, a detailed report on the tests carried out shall be furnished. Fresh samples may be submitted after incorporating in the components, any modifications considered necessary. The specific test or tests to be carried out on the fresh samples shall be decided by the testing authority who may wish to carry out all the related tests whether or not the earlier samples passed these tests [illegible]arily/ satisfactorily. If, in the repeat tests no single failure occurs, the type shall be considered to be eligible for approval.

9.1.2 Maintenance of type approval

At the end of the validity period mentioned in 9.1 or earlier, if necessary, the testing authority may call for fresh samples for type testing for the purpose of maintenance of the type approval.

9.2 Criteria for conformity to acceptance tests

The lot shall be declared as conforming to the requirements of this specification, if the following conditions are satisfied.

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9.2.1 The number of capacitors not conforming to the requirements when tested as in 7.1.2.1 is less than or equal to the corresponding capacitance number given in Table 23.

9.2.2 The number of capacitors not conforming to the any one or more requirements when tested as in 7.1.2.2 for each sample is less than or equal to the corresponding acceptance number given in Table 24.

APPENDIX A

MEASUREMENT OF IMPEDANCE OF FIXED CAPACITORS

A.1 IMPEDANCE

A.1.1 The basic method of measurement of impedance of a capacitor is to pass a known current through it and to measure the voltage across it. At frequencies of 100 kHz or less, this is relatively simple, but at higher frequencies, care is necessary by the use of coaxial cables and screening to avoid spurious coupling.

A.1.1.1 The basic circuit diagram is shown in Fig. 9.

A.1.1.2 The impedance of the capacitor be given by:

$$Z_c = R_c + j\left(wL_c - \frac{1}{wC}\right)$$

$$= R \pm jX_c$$

Where

Z_c = impedance of the capacitor at the frequency of measurement;

R_c = effective series resistance of the capacitor;

w = $2\pi f$, f being the frequency of measurement;

L_c = inductance of the capacitor; and

C = capacitance of the capacitor at the frequency of measurement.

Using the notation of Fig. 9;

$$I_{in} = \frac{V_{in}}{R_s + Z_c}$$

$$V_{out} = I_{in} Z_c = \frac{V_{in} Z_c}{R_s + Z_c}$$

$$Z = \frac{V_{out} R_s}{V_{in} - V_{out}}$$

This equation can be used to determine the impedance at any frequen

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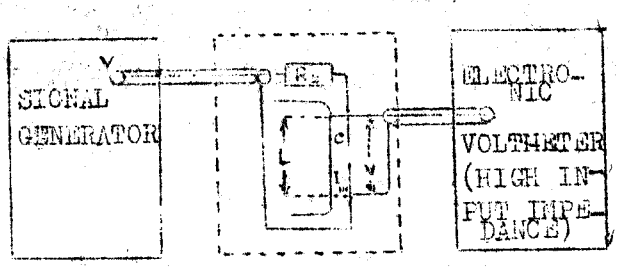

C = capacitor under test

R = non-inductive resistor approximately equal to the output impedance of the signal generator (normally 50 or 75)

L = specified length (terminal wire and body) at which measurement is made.

V_{in} = voltage output of the signal generator with the measuring circuit connected.

I_{in} = voltage in the measuring circuit.

V_{out} = voltage measured across the capacitor as indicated by the electronic voltmeter.

RE 4 - Method of Determination of Impedance, Resonant Frequency or Inductance of Capacitors

APPENDIX B

Schedule for type tests

.1 For aluminium capacitors

The capacitors shall be subjected to the tests according to Table 23 and in the order given.

After the completion of the tests in Group I, the sample shall be divided into six parts which shall be tested as laid down under Group II in Table 25.

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TABLE 25 - Schedule of type tests for aluminium capacitors

Group	Sample part	Test	Sub-clause of this std.
I	All items	Visual examination and check of dimensions	7.3
		Leakage current	7.4.1
		Capacitance	7.4.2
		Tangent of the loss angle	7.4.3
		Impedance (if required by the detail specification)	7.4.4
II	First part First half	(Robustness of terminations	7.5.1
		(Resistance to soldering heat	7.5.3
		(Solderability of terminations	7.5.2.1
		(Rapid change of temperature	7.5.3
	Second half	(Vibration	7.5.4
		(Bump	7.5.5
	All items	Climatic sequence	7.5.6
	Second part	Damp heat, steady state	7.5.8
	Third part	Endurance	7.4.8
	Fourth part First half	Surge	7.4.7
	Second half	Reverse voltage(if applicable)	7.4.9
		Pressure relief (if applicable)	7.5.10
	Fifth part First half	Storage at upper category temperature	7.5.12
	Second half	Storage at lower temperature (for non-solid electrolyte capacitors only)	7.5.13
	Sixth part	Characteristics at high and low temperature	7.5.11
		Charge and discharge(if applicable)	7.4.10

NOTE - An interval of not more than three days is permitted between any of the tests in the climatic sequence except that the cold test shall be immediately after the recovery period for the first cycle of the accelerated damp-heat test.

B 1.2 For tantalum capacitors

The capacitors shall be subjected to the tests in accordance with Table 26 below and in the order given.

After the completion of the tests in Group I., four specimens shall be taken for the solderability test (Group I). The remainder of the sample is then mounted and measured as required for Group IIA and is then divided into four parts which are tested in accordance with Group IIB.

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