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PERFORMANCE SPECIFICATION

CAPACITOR, FIXED, ELECTROLYTIC (DC, ALUMINUM, DRY ELECTROLYTE, POLARIZED), GENERAL SPECIFICATION FOR

This specification is approved for use by all Departments and Agencies of the Department of Defense.

INACTIVE FOR NEW DESIGN AFTER 7 OCTOBER 1998

1. SCOPE

1.1 Scope. This specification covers the general requirements for polarized, dry-electrolyte, aluminum, direct current (dc), fixed capacitors for use in filter and bypass circuits where large excesses of capacitance over the nominal capacitance can be tolerated.

1.2 Classification.

1.2.1 Part or Identifying Number (PIN). The PIN will be in the following form, and as specified (see 3.1):

CE10	C	5R6	F
Style (see 1.2.1.1)	Characteristic (see 1.2.1.2)	Capacitance (see 1.2.1.3)	Voltage (see 1.2.1.4)

1.2.1.1 Style. The style is identified by the two-letter symbol “CE” followed by a two-digit number. The letters identify polarized, dry-electrolyte, aluminum, dc, fixed capacitors. The number identifies the shape and dimension of the capacitor.

1.2.1.2 Characteristic. The characteristic is identified by a single letter in accordance with table I.

TABLE I. Characteristic.

Symbol	Operating temperature range
C - - - - - - - - - -	-40° to +85°C

Comments, suggestions, or questions on this document should be addressed to: DLA Land and Maritime, ATTN: VAT, Post Office Box 3990, Columbus, OH 43218-3990 or e-mailed to capacitorfilter@dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil/ .

1.2.1.3 Capacitance. The nominal capacitance value expressed in microfarads (μF) is identified by a three-digit number. When the nominal capacitance is 10 μF or greater, the first two digits represent significant figures and the last digit specifies the number of zeros to follow (Examples: 10 μF = 100; 150 μF = 151; 1,500 μF = 152). When the nominal capacitance value is less than 10 μF (Examples: whole number such as 9; a mixed number such as 4.7; or a fractional number such as 0.1 or 0.56), the letter "R" will be used to indicate the decimal point and will be placed where appropriate in the three digit number. When the letter "R" is used, the succeeding digit or digits become significant (Examples: 2 μF = 2R0; 4.7μF = 4R7; 0.1 μF = 0R1: 0.56 μF = R56).

1.2.1.4 Voltages. The dc rated voltage, dc surge voltage, and capacitance tolerance are identified by a single letter in accordance with table II.

TABLE II. DC working voltage, dc surge voltage, and capacitance tolerance.

Symbol	DC rated voltage	DC surge voltage	Capacitance tolerance	Symbol	DC rated voltage	DC surge voltage	Capacitance tolerance
	volts	volts	percent		volts	volts	percent
C	5	7	-10, +75	K	200	250	-10, +50
D	10	15	-10, +75	M	250	300	-10, +50
E	15	20	-10, +75	N	300	350	-10, +50
F	25	40	-10, +75	P	350	400	-10, +50
G	50	75	-10, +75	Q	400	450	-10, +50
H	100	150	-10, +75	R	450	500	-10, +50
J	150	200	-10, +75				

1.2.2 Family. Capacitors covered by this specification are classified by families according to their means of mounting, as specified in table III (see 3.1).

TABLE III. Families.

Family	Means of mounting	Styles
1	Axial wire-lead capacitors mounted by a tangential bracket or wrap-around bands.	CE10, CE11, CE12, and CE13
2	Universal-mounting capacitors mounted by a mounting ring.	CE31, CE33, CE34, and CE36
3	Stud-mounting capacitors mounted by a nut screwed on the threaded portion at the terminal end of the capacitor.	CE41, CE42, CE44, and CE45
4	Plug-in capacitors mounted by plugging the terminals into a standard, medium octal socket with a .687 ± .007-inch (17.45 mm ± 0.18 mm)-diameter pin circle and secured by suitable clamps.	CE51, CE52, CE53, CE56, CE57, and CE58
5	Bathtub capacitors mounted by mounting lugs.	CE63 and CE64
6	Tapped-terminal capacitors (screw insert for bus-bar connection), mounted by a wraparound, footed-type bracket.	CE70 and CE71

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract (see 6.2).

FEDERAL STANDARDS

FED-STD-H28	-	Screw-Thread Standards for Federal Services

DEPARTMENT OF DEFENSE SPECIFICATIONS

(See supplement 1 for list of applicable specification sheets.)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-202-101	-	Method 101, Salt Atmosphere (Corrosion)
MIL-STD-202-104	-	Method 104, Immersion
MIL-STD-202-105	-	Method 105, Barometric Pressure (Reduced)
MIL-STD-202-106	-	Method 106, Moisture Resistance
MIL-STD-202-107	-	Method 107, Thermal Shock
MIL-STD-202-108	-	Method 108, Life (at Elevated Ambient Temperature)
MIL-STD-202-201	-	Method 201, Vibration
MIL-STD-202-204	-	Method 204, Vibration, High Frequency
MIL-STD-202-208	-	Method 208, Solderability
MIL-STD-202-211	-	Method 211, Terminal Strength
MIL-STD-202-213	-	Method 213, Shock (Specified Pulse)
MIL-STD-202-301	-	Method 301, Dielectric Withstanding Voltage
MIL-STD-202-302	-	Method 302, Insulation Resistance
MIL-STD-202-305	-	Method 305, Capacitance
MIL-STD-1285	-	Marking of Electrical and Electronic Parts

(Copies of these documents are available online at https://quicksearch.dla.mil.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL (ASTM)

ASTM E1282	-	Standard Guide for Specifying the Chemical Compositions and Selecting Sampling Practices and Quantitative Analysis Methods for Metals, Ores, and Related Materials

(Copies of this document are available online at http://www.astm.org.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein (except for related associated specifications, specification sheets, or MS sheets), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual part requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between any requirements of this specification and the specification sheet, the latter shall govern (see 6.2).

3.2 First article. When specified (see 6.2), a sample shall be subjected to first article inspection in accordance with 4.3.

3.3 Material. The material shall be as specified herein. However, when a definite material is not specified, a material shall be used which will enable the capacitors to meet the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.

3.3.1 Aluminum foil. Foil used in the construction of the anode shall have a minimum aluminum content of 99.95 percent, determined by the difference between 100 percent and the sum of all other metallic elements present in the amounts of 0.001 percent or more, each expressed to the third decimal. If analysis of the aluminum foil is required, it shall be made in accordance with ASTM E1282.

3.3.2 Internal examination. There shall be no visible evidence of corrosion when capacitors are examined as specified in 4.5.1.1.

3.4 Design and construction. Capacitors shall be of the design, construction, and physical dimensions specified (see 3.1).

3.4.1 Case. Each capacitor shall be in a metallic case and shall be effectively sealed against the entry of contaminants, and leakage or evaporation of the electrolyte. The element shall be secured so that there will be no injurious movement in the case.

3.4.1.1 Case insulation (when applicable). Case insulation shall not soften or creep at the high operating temperature. The use of cardboard sleeves for insulating purposes shall not be permitted.

3.4.2 Terminals. The terminals shall be permanently secured internally or externally, as applicable. All external joints shall be soldered or welded. Axial wire or tab-type terminals shall be coated in such a manner as to insure their ability to meet the requirements of the solderability test (see 3.5 and 3.23.1).

3.4.2.1 Solder lugs and solder-lug terminals. Solder lugs and solder-lug terminals may be of any shape, provided dimensional limits are met, and shall be coated with solder having a tin content of 40 to 70 percent. Solder lugs on styles CE31 through CE45 may be secured by spinning.

3.4.3 Threaded parts. All threaded parts shall be in accordance with FED-STD-H28 (see 3.1). All threaded parts shall engage by at least three full threads.

3.4.4 Pure tin. The use of pure tin, as an undercoat for final finish, is prohibited both internally and externally. Tin content of capacitor components and solder shall not exceed 97 percent, by mass. Tin shall be alloyed with a minimum of 3 percent lead, by mass (see 6.17).

3.5 Solderability (not applicable to plug-in capacitors and styles CE70 and CE71). When tested as specified in 4.5.2, the dipped surface of the leads shall be at least 95-percent covered with a new, smooth, solder coating. The remaining 5-percent of the lead surface shall show only small pinholes or rough spots; these shall not be concentrated in one area. Bare base metal and areas where the solder dip failed to cover the original coating are indication of poor solderability, and shall be cause for failure. In case of dispute, the percent of coverage with pinholes or rough spots shall be determined by actual measurement of these areas, as compared to the total area.

3.6 DC leakage. When measured as specified in 4.5.3, the dc leakage shall not exceed the value specified (see 3.1).

3.7 Capacitance. When measured as specified in 4.5.4, the capacitance value shall be within the tolerance specified (see table II).

3.8 Dissipation factor. When measured as specified in 4.5.5, the dissipation factor shall not exceed the value specified (see 3.1).

3.9 Terminal strength (not applicable to plug-in capacitors). When capacitors are tested as specified in 4.5.6, there shall be no loosening of the terminals nor permanent damage to the terminals, terminal weld, or terminal solder. Threaded or tapped-stud terminals shall exhibit no perceptible movement relative to the case, under the applied torque.

3.10 Shock (specified pulse). When capacitors are tested as specified in 4.5.7, there shall be no intermittent contacts of 0.5 milliseconds (ms) or greater, nor shall there be any arcing, open- or short-circuiting, or mechanical damage.

3.11 Vibration. When capacitors are tested as specified in 4.5.8, there shall be no intermittent contacts of 0.5 ms or greater, nor shall there be any open- or short-circuiting, mechanical damage, or leakage of the electrolyte.

3.12 Salt atmosphere (corrosion). When capacitors are tested as specified in 4.5.9, there shall be no corrosion or other defects that will affect life or serviceability. There shall be no unwrapping of or mechanical damage to insulating sleeves. Marking shall remain legible after the test.

3.13 Thermal shock and immersion. When tested as specified in 4.5.10, capacitors shall meet the following requirements:

a. Dielectric withstanding voltage (see 4.5.11.2) insulating sleeves only: Shall withstand a potential of not less than 4,000 volts dc.

b. DC leakage: Shall not exceed 150 percent of the initial requirement (see 3.6), when measured as specified in 4.5.3.

c. Capacitance: Change not more than 5 percent from the initial value obtained when measured as specified in 4.5.4.

d. Dissipation factor: As specified in 3.8.

e. Visual examination: There shall be no harmful or extensive corrosion and at least 90 percent of any exposed metallic surface of the capacitor shall be protected by the finish. There shall be no more than 10 percent corrosion of the terminal hardware or mounting surface. There shall be no unwrapping of or mechanical damage to insulating sleeves. There shall be no leakage of the electrolyte or deformation of the case, and marking shall remain legible after the test.

3.14 Moisture resistance. When tested as specified in 4.5.11, capacitors shall meet the following requirements:

a. Dielectric withstanding voltage (see 4.5.11.2) insulating sleeves only: Shall withstand a potential of not less than 4,000 volts dc.

b. Insulation resistance (insulating sleeves): Shall be not less than 100 megohms.

c. DC leakage: Shall not exceed 150 percent of the initial requirement (see 3.6) when measured as specified in 4.5.3.

d. Capacitance: Change not more than 5 percent from the initial value obtained when measured as specified in 4.5.4.

e. Dissipation factor: As specified in 3.8.

f. Visual examination: There shall be no harmful or extensive corrosion and at least 90 percent of any exposed metallic surface of the capacitor shall be protected by the finish. There shall be no more than 10 percent corrosion of the terminal hardware or mounting surface. There shall be no leakage of the electrolyte or deformation of the case, and marking shall remain legible after the test. Insulating sleeves shall not exhibit evidence of burning, charring, or arcing.

3.15 Impedance. When determined as specified in 4.5.12, the impedance shall not exceed the value specified (see 3.1).

3.16 Stability at low and high temperatures. When tested as specified in 4.5.13, capacitors shall meet the following requirements:

a. Step 1

(1) DC leakage: As specified in 3.6.

(2) Capacitance: As specified in 3.7.

(3) Dissipation factor: As specified in 3.8.

b. Step 2: Impedance: As specified in 3.15.

c. Step 3

(1) DC leakage: As specified in 3.6.

(2) Capacitance: Change not more than 5 percent from the initial +25°C value (step 1).

(3) Dissipation factor: As specified in 3.8.

d. Step 4

(1) DC leakage: Shall not exceed 10 times the initial +25°C value (step 1) or shall meet the initial +25°C requirement, whichever is greater.

(2) Capacitance: Shall not increase more than 20 percent from the initial +25°C value (step 1).

(3) Dissipation factor: As specified in 3.8.

e. Step 5

(1) DC leakage: As specified in 3.6.

(2) Capacitance: Shall not increase more than 20 percent from the initial +25°C value (step 1).

(3) Dissipation factor: As specified in 3.8.

3.17 Surge voltage. When capacitors are tested as specified in 4.5.14, there shall be no breakdown or other permanent injury. Terminals and seals shall remain intact. There shall be no evidence of leakage of the electrolyte when the capacitor is held with its terminals downward during the test. The capacitors shall meet the following requirements:

a. DC leakage: As specified in 3.6.

b. Capacitance: Change not more than 6 percent from the initial value obtained when measured as specified in 4.5.4, unless otherwise specified (see 3.1).

c. Dissipation factor: As specified in 3.8.

d. Visual examination: There shall be no mechanical damage, leakage of the electrolyte, or deformation of the case.

3.18 Vent (applicable only to styles CE70 and CE71). When capacitors are tested as specified in 4.5.15, the vent shall operate, and there shall be no explosive expelling of the contents. Disruption shall occur only at the vent; the case or end seal shall not otherwise rupture (see 3.1 and 3.4.1).

3.19 Life. When tested as specified in 4.5.16, capacitors shall meet the following requirements:

a. DC leakage: As specified in 3.6.

b. Capacitance: Shall be within the following percentages of the initial value obtained when measured as specified in 4.5.4.

(1) -20 percent, +15 percent for capacitors with dc rated voltage of 100 volts or less.

(2) ± 15 percent for capacitors with dc rated voltage above 100 volts.

c. Dissipation factor Shall not exceed 150 percent of the initial measured value or shall meet the initial requirement, whichever is greater (see 3.8).

d. Visual examination: There shall be no mechanical damage, leakage of the electrolyte, or deformation of the case.

e. Internal examination: As specified in 3.3.2.

3.20 Barometric pressure (reduced). When capacitors are tested as specified in 4.5.17, there shall be no flashover, breakdown, deformation of the case, or leakage of the electrolyte.

3.21 Shelf life. When tested as specified in 4.5.18, capacitors shall meet the following requirements:

a. Build factor: Shall not exceed 4.0 when determined as specified in 4.5.18.1.

b. Shelf factor: Shall not exceed 3.0 when determined as specified in 4.5.18.1.

c. DC leakage: Shall not exceed 150 percent of the initial requirement (see 3.6) when measured as specified in 4.5.3.

d. Capacitance: Change not more than 6 percent from the initial value obtained when measured as specified in 4.5.4.

e. Dissipation factor: Shall not exceed 175 percent of the initial requirement (see 3.8).

f. Visual examination: There shall be no leakage of the electrolyte or deformation of the case.

g. Internal examination: As specified in 3.3.2.

3.22 Marking. Capacitors shall be marked with the PIN, manufacturer's name or code symbol, capacitance in μF, dc rated voltage, positive terminals (see 3.22.1) and date of manufacture. The date and source coding shall be in accordance with MIL-STD-1285.

3.22.1 Polarity. Polarity shall be indicated by a plus (+) symbol near the positive terminal except for styles CE10, CE11, CE12, and CE13 which shall have the polarity indicated by a series of plus (+) symbols completely surrounding the perimeter of positive end of the tubular case.

3.23 Workmanship. Capacitors shall be processed in such a manner as to be uniform in quality and shall be free from pits, corrosion, cracks, rough edges, and other defects that will affect life, serviceability, or appearance.

3.23.1 Soldering. All excess flux and solder shall be removed. Electrical connections shall be mechanically secure before soldering, when possible, and electrically continuous after soldering.

3.24 Recycled, recovered, environmentally preferable, or biobased materials. Recycled, recovered, environmentally preferable, or biobased materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

4. VERIFICATION

4.1 Classification of inspection. The inspection requirements specified herein are classified as follows:

a. First article inspection (see 4.3).

b. Conformance inspection (see 4.4).

4.2 Inspection conditions and methods.

4.2.1 Conditions. Unless otherwise specified herein, all inspection shall be made at or referred to +25°C ± 3°C, and at room ambient relative humidity and pressure. Unless otherwise specified, when tests are made at other than +25°C, the tolerance shall be ± 3°C. At temperatures higher than +35°C, adequate circulation of air shall be provided to maintain the required temperature within the specified tolerance.

4.2.2 Methods.

4.2.2.1 AC measurements. Alternating-current (ac) measurements shall be made at the frequency specified. The magnitude of the ac voltage shall be limited to 1.0 volt root mean square (rms). The dc polarizing voltage, if applied, shall be greater than the peak ac voltage; the sum of the peak ac and polarizing voltage shall not exceed the dc rated voltage (see 3.1).

4.2.2.2 Reference measurements. When requirements are based on comparative measurements made before and after conditioning, the reference measurement shall be considered the last measurement made at +25°C prior to the conditioning. The reference measurements shall have been made within 30 days prior to the beginning of conditioning.

4.3 First article inspection. First article inspection shall be performed at a laboratory acceptable to the Government (see 6.3).

4.3.1 Sample. The number of sample units comprising a sample of capacitors to be submitted for first article inspection shall be as specified in table IV. The sample shall be taken from a production run and shall be produced with equipment and procedures normally used in production.

4.3.2 Inspection routine. Sample units shall be subjected to the first article inspection specified in table IV, in the order shown. Two sample units shall be subjected to the visual and mechanical examination (internal). The remaining sample units shall be subjected to the subsequent inspection of group I. The sample units shall then be divided as specified in table IV for groups II to VI, inclusive. The sample units shall then be subjected to the inspection for their particular group.

4.3.3 Failures. Failures in excess of those allowed in table IV shall be cause for refusal to grant first article approval.

TABLE IV. First article inspection.

Examination or test	Requirement paragraph	Method paragraph	Number of sample units to be inspected	Number of defectives allowed 1/	
Group I Visual and mechanical examination (internal): Material, design, construction, and workmanship	3.1, 3.3 to 3.4.3 incl, 3.23, and 3.23.1	4.5.1 and 4.5.1.1	2	0	
Solderability (not applicable to plug-in capacitors and styles CE70 and CE71)	3.5	4.5.2	6	0	
Visual and mechanical examination (external): 2/ Physical dimensions, marking, 3/ and workmanship	3.1, 3.4 to 3.4.3 incl, and 3.22 to 3.23.1 incl	4.5.1	43 4/ 31 4/	1	2
DC leakage 2/ Capacitance 2/ Dissipation factor 2/ Terminal strength (not applicable to plug-in capacitors) 2/	3.6 3.7 3.8 3.9	4.5.3 4.5.4 4.5.5 4.5.6			
Group II Shock (specified pulse) Vibration Salt atmosphere (corrosion) Thermal shock and immersion	3.10 3.11 3.12 3.13	4.5.7 4.5.8 to 4.5.8.2 incl 4.5.9 4.5.10 to 4.5.10.2 incl	6	1	
Group III Moisture resistance	3.14	4.5.11	6	1	
Group IV Stability at low and high temperatures 2/ Surge voltage Vent (applicable only to styles CE70 and CE71)	3.16 3.17 3.18	4.5.13 4.5.14 4.5.15	6	1	
Group V Life	3.19	4.5.16	18 5/	1	
Group VI Barometric pressure (reduced) Shelf life	3.20 3.21	4.5.17 4.5.18 and 4.5.18.1	6	1	

1/ A sample unit having one or more defects shall be considered as a single defective.
2/ Nondestructive tests.
3/ Marking shall be considered as a defect only if it becomes illegible as a result of any of the inspections.
4/ One additional sample unit is included in each sample of 43 (or 31, as applicable) sample units to permit substitution for the allowable defect in group I.
5/ Six sample units to be inspected for styles CE63 and CE64 capacitors.

4.4 Conformance inspection.

4.4.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A Inspection.

4.4.1.2 Group A inspection. Group A inspection shall consist of the examination and tests specified in table V, and shall be made on the same set of sample units, in the order shown.

TABLE V. Group A inspection.

Inspection	Requirement paragraph	Test Method paragraph	Sampling procedure
Subgroup 1			
DC leakage	3.6	4.5.3	See table VI
Capacitance	3.7	4.5.4	
Dissipation factor	3.8	4.5.5	
Subgroup 2			
Visual and mechanical examination:			
Material	3.3 and 3.3.1	4.5.1	5 samples 0 failures
Physical dimentions	3.4		
Design and construction (other than physical dimentions	3.4.1 to 3.4.3		
Subgroup 3			
Marking 1/	3.22 and 3.22.1	4.5.1	5 samples 0 failures
Workmanship	3.23		

1/ Marking defects are based on visual examination only and shall be charged only for illegible, incomplete, or incorrect marking. Any subsequent electrical defects shall not be used as a basis for determining marking defects.

TABLE VI. Sampling plans for Group A inspection.

Lot size	Sample size
1 - 13	100%
14 - 150	13
151 - 280	20
281 - 500	29
501 - 1,200	34
1,201 - 3,200	42
3,201 - 10,000	50
10,001 - 35,000	60
35,001 - 150,000	74
150,001 - 500,000	90
500,001 - Up	102

4.4.1.2.2 Rejected lots. If an inspection lot is rejected, the supplier may withdraw the lot, rework it to correct the defects, or screen out the defective units, as applicable, and re-inspect. Such lots shall be separate from new lots, and shall be clearly identified as re-inspected lots.

4.5 Methods of examination and test.

4.5.1 Visual and mechanical examination. Capacitors shall be examined to verify that the materials, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.3 to 3.4.3 inclusive, and 3.22 to 3.23.1 inclusive).

4.5.1.1 Internal examination. Capacitors shall be opened and the foils and separator shall be unrolled for a visual examination of the internal construction. The entire interior, including foils, tabs, and contact area of tab to foil, shall be examined for corrosion (see 3.3.2).

4.5.2 Solderability (see 3.5) (not applicable to plug-in capacitors and styles CE70 and CE71). Capacitors shall be tested in accordance with MIL-STD-202-208. The following details shall apply:

a. Number of terminations of each part to be tested: 2.

b. Depth of immersion in flux and solder: Leads shall be immersed to within .125 inch (3.18 mm) of the capacitor body, or to within .125 inch (3.18 mm) of the soldered or welded joint, as applicable (see 3.1).

4.5.3 DC leakage (see 3.6). DC leakage shall be measured using the dc rated voltage (see 3.1), applied across the terminals of the capacitor for a period of 5 minutes with a suitable current-limiting resistor (see 6.10), and dc milliammeter or microammeter connected in series. The buildup of voltage shall occur within 60 seconds. The dc leakage shall be measured at the end of the 5-minute period. Measurement accuracy shall be within ± 5 percent.

4.5.4 Capacitance (see 3.7). Capacitance shall be measured in accordance with MIL-STD-202-305. The following details shall apply:

a. Test frequency: 120 ± 5 Hertz (Hz).

b. Limit of accuracy: Within ± 2 percent.

c. Magnitude of polarizing voltage: The application and magnitude of a dc polarizing voltage is optional (see 4.2.2), if no substantial difference is noted between capacitance measurements with and without polarizing voltage applied. The reading with a polarizing voltage applied shall govern in case of conflict.

4.5.5 Dissipation factor (see 3.8). Dissipation factor shall be determined by a capacitance bridge at a frequency of 120 ± 5 Hz. Measurement accuracy shall be within ± 2 percent. The application and magnitude of a dc polarizing voltage is optional (see 4.2.2), if no substantial difference is noted between dissipation factor measurements with and without polarizing voltage applied. The reading with a polarizing voltage applied shall govern in case of conflict. Equivalent series resistance may be measured and converted to dissipation factor.

4.5.6 Terminal strength (see 3.9). Terminals shall be tested in accordance with MIL-STD-202-211. The following details and exceptions shall apply:

a. Test condition A, applicable to all except plug-in terminals:

(1) Applied force: As specified in table VII.

(2) Direction and duration of applied force, other than axial-wire leads: The pull may be applied in any direction, including the weakest, at the point where the terminal is normally connected in an actual circuit. The pull shall be increased gradually to the specified magnitude and held at that value for at least 10 seconds.

(3) Direction and duration of applied force, axial-wire leads: The contact shall be made .625 inch (15.88 mm) from the insulator (case) and the pull shall be applied axially. The pull shall be increased gradually to the specified magnitude and held at that value for at least 30 seconds.

b. Test condition B, applicable to solder lugs: Number of bending operations: Three.

c. Test condition D, applicable to axial-wire leads.

d. Test condition E, applicable to solder-lug and screw-insert terminals: Applied force: As specified in table VII.

e. Examination after test: Terminals shall be examined for loosening or permanent damage, and the terminal weld or solder joint shall be examined for perceptible movement relative to the case (see 3.9).

TABLE VII. Terminal strength.

Type of terminal	Pull Pounds	Torque Pound-inches
Axial-wire lead	5	---
Solder lug	5	1
Screw-insert	10	10

4.5.7 Shock, (specified pulse) (see 3.10). Capacitors shall be tested in accordance with MIL-STD-202-213. The following details and exceptions shall apply:

a. Special mounting means: Rigidly mounted by the body; axial-wire-lead capacitors shall be fastened to rigidly supported terminals.

b. Test condition: I, except for styles CE70 and CE71, test condition H shall apply.

c. Measurements during and after shock: During the test, an electrical measurement shall be made to determine intermittent contacts or arcing or open-or short-circuiting. Detecting equipment shall be sufficiently sensitive to detect an interruption with a duration of 0.5 ms or greater.

d. Examination after test: Capacitors shall be visually examined for mechanical damage.

4.5.8 Vibration (see 3.11).

4.5.8.1 Low frequency (applicable only to styles CE63, CE64, CE70, and CE71). Capacitors shall be tested in accordance with MIL-STD-202-201. The following details and exceptions shall apply:

a. Tests and measurements prior to vibration: Not applicable.

b. Method of mounting: Securely fastened by normal mounting means (see table III and 3.1).

c. Duration of vibration: 1.5 hours.

d. Direction of motion: 45 minutes in each of two mutually perpendicular directions, an electrical measurement shall be made to determine intermittent contacts or open- or short-circuiting. Detecting equipment shall be sufficiently sensitive to detect any interruption with a duration of 0.5 ms or greater.

e. Examinations after test: Capacitors shall be visually examined for mechanical damage and leakage of the electrolyte.

4.5.8.2 High frequency (applicable to all styles except CE63, CE64, CE70, and CE71). Capacitors shall be tested in accordance with of MIL-STD-202-204. The following details and exceptions shall apply:

a. Mounting of specimens: Body of the capacitor shall be rigidly mounted to the vibration-test apparatus.

b. Test condition: B, except that the peak acceleration shall be 10 gravity units.

c. Duration and direction of motion: 4 hours in each of two mutually perpendicular directions (total of 8 hours), one parallel and the other perpendicular to the cylindrical axis.

d. Measurements: During the last 30 minutes in each direction, an electrical measurement shall be made to determine intermittent contacts or open- or short-circuiting. Detecting equipment shall be sufficiently sensitive to detect any interruption with a duration of 0.5 ms or greater.

e. Examinations after test: Capacitors shall be visually examined for mechanical damage and leakage of the electrolyte.

4.5.9 Salt atmosphere (corrosion) (see 3.12). Capacitors shall be tested in accordance with MIL-STD-202-101, test condition B. After this test, capacitors shall be visually examined for corrosion and other defects that will affect life or serviceability, for unwrapping of and mechanical damage to insulation sleeves, and obliteration of marking.

4.5.10 Thermal shock and immersion (see 3.13).

4.5.10.1 Thermal shock. Capacitors shall be tested in accordance with MIL-STD-202-107. The following details and exceptions shall apply:

a. Conditioning prior to first cycle: 15 minutes at room ambient temperature.

b. Test condition: A, except that in step 1, capacitors shall be tested at -40°C.

c. Measurements before and after cycling: Not applicable.

4.5.10.2 Immersion. Following temperature cycling, capacitors shall be tested in accordance with MIL-STD-202-104. The following details and exceptions shall apply:

a. Test condition: C, except that the duration of each immersion shall be 15 minutes. Change from one solution to the other shall be made in not more than 3 seconds.

b. Time after final cycle allowed for measurements: Measurements shall be made within 30 minutes to 4 hours after capacitors are removed from the immersion tank.

c. Measurements after final cycle: DC leakage, capacitance, and dissipation factor shall be measured at room ambient temperature and as specified in 4.5.3, 4.5.4, and 4.5.5, respectively.

d. Examinations after test: Capacitors shall be visually examined for corrosion, unwrapping of and mechanical damage to insulating sleeves, leakage of the electrolyte, deformation of the case, and obliteration of marking.

4.5.11 Moisture resistance (see 3.14). Capacitors shall be tested in accordance with MIL-STD-202-106. The following details and exceptions shall apply:

a. Mounting: Except during examination and measurements, rigidly mounted by normal mounting means (see 3.1).

b. Conditioning prior to first cycle: Not applicable.

c. Initial measurements: Not applicable.

d. Polarization and load: During step 7 of the ninth cycle, the dc rated voltage (see 3.1), shall be applied to the capacitor for 30 minutes. If the subcycle is performed during the ninth cycle, the voltage shall be applied after step 7b.

e. Final measurements:

(1) For capacitors with insulating sleeves: Within 10 minutes after removal from the controlled atmosphere, the insulation resistance shall be measured as specified in 4.5.11.1. Within 5 minutes after measurement of insulation resistance, capacitors shall be subjected to dielectric withstanding voltage as specified in 4.5.11.2.

(2) For all capacitors: After the final cycle and within 2 to 6 hours after removal of capacitors from the humidity chamber, dc leakage, capacitance, and dissipation factor shall be measured as specified in 4.5.3, 4.5.4, and 4.5.5, respectively.

f. Examinations after test: Capacitors shall be visually examined for corrosion, leakage of the electrolyte, deformation of the case, and obliteration of marking.

4.5.11.1 Insulation resistance (insulating sleeves). Capacitor insulating sleeves shall be tested in accordance with MIL-STD-202-302. The following details and exceptions shall apply:

a. Test condition: B, 500 ± 10 percent volts dc.

b. Points of measurement: Between a strip of metallic foil .5 ± .06 inch (12.7 mm ± 1.5 mm)-wide and the capacitor case. The foil shall be wrapped smoothly for approximately two complete turns around the capacitor sleeve and shall be held in place by at least two turns of AWG size 20 bare copper wire.

c. Electrification time: Not more than 1 minute.

4.5.11.2 Dielectric withstanding voltage (insulating sleeves). Capacitor insulating sleeves shall be tested in accordance with MIL-STD-202-301. The following details and exceptions shall apply:

a. Magnitude and nature of test voltage: 4,000 volts dc; the test potential shall be increased from 0 to 4,000 volts at a rate of not more than 500 volts per second.

b. Points of application: Between the strip of metallic foil and the capacitor case (see 4.5.11.1(b)).

c. Examination after test: The foil wrap shall be removed from insulating sleeves shall be examined for burning, charring, and arcing.

4.5.12 Impedance (see 3.15). Impedance shall be determined at -40° +0° -3°C at a frequency of 120 +10 –5 Hz. The capacitors shall be brought to thermal stability at the test temperature. Thermal stability will have been reached when no further change in impedance is observed between two successive measurements taken at 15-minute intervals. Measurement accuracy shall be within ± 5 percent (see 4.2.2).

4.5.13 Stability at low and high temperatures (see 3.16). The measurements specified in table VIII shall be made in the order shown. The capacitors shall be brought to thermal stability. Thermal stability will have been reached when no further change in capacitance is observed between two successive measurements taken at 15-minute intervals.

TABLE VIII. Temperatures and measurements for stability test at low and high temperatures.

Step	Temperature	Test	Method paragraph
1	+25° ± 3°C	DC leakage Capacitance Dissipation factor	4.5.3 4.5.4 4.5.5
2	-40° -3° +0°C	Impedance	4.5.12
3	+25° ± 3°C	DC leakage Capacitance Dissipation factor	4.5.3 4.5.4 4.5.5
4	+85° +3° -0°C	DC leakage 1/ Capacitance Dissipation factor	4.5.3 4.5.4 4.5.5
5	+25° ± 3°C	DC leakage Capacitance Dissipation factor	4.5.3 4.5.4 4.5.5

1/ DC leakage measurement not required for styles CE63 and CE64.

4.5.14 Surge voltage (see 3.17). Capacitors shall be subjected to 1,000 cycles of the dc surge voltage specified in table II. The ambient temperature during cycling shall be the applicable maximum temperature (see 3.1). Each cycle shall consist of a 30-second surge-voltage application followed by a 5.5 minute discharge period. Voltage application shall be made through a resistor in series with the capacitor and the voltage source. For capacitors whose nominal capacitance is below 2,500 uF, the resistor shall have a value of 1,000 ± 100 ohms. For capacitors whose nominal capacitance is 2,500 uF and above, the value of the resistor shall be determined from the following formula:

$$R = \frac{2.5 \times 10^6}{C}$$

Where:

R = resistance in ohms.
C = capacitance in uF.

Each surge-voltage cycle shall be performed in such a manner that the capacitor is discharged through the applicable resistor at the end of the 30-second application. After the test, dc leakage, capacitance, and dissipation factor shall be measured as specified in 4.5.3, 4.5.4, and 4.5.5, respectively. Capacitors shall then be visually examined for mechanical damage, leakage of the electrolyte, and deformation of the case.

4.5.15 Vent (applicable only to styles CE70 and CE71) (see 3.18). Capacitors shall be subjected to an ac test current in accordance with table IX. The vent shall operate within 5 minutes. If the capacitor opens or short-circuits and the vent has not operated, additional capacitors shall be selected and subjected to this test.

TABLE IX. Venting.

Nominal capacitance	Test current (rms)
uF	Amperes, inclusive
Up to 3,000 inclusive	10 to 100
3,001 to 20,000 inclusive	85 to 150
Over 20,000	100 to 175

4.5.16 Life (see 3.19). Capacitors shall be tested in accordance with MIL-STD-202-108. The following details and exceptions shall apply:

a. Distance of temperature measurements from specimens: Not applicable.

b. Method of mounting: Normal mounting means.

c. Test temperature and tolerance: +85° +3° -0°C.

d. Operating conditions: The dc rated voltage (see 3.1), shall be applied continuously to the capacitors through a current-limiting resistor.

e. Test condition: D (1,000 hours) ± 12 hours.

f. Measurements after exposure: Capacitors shall be returned to the inspection conditions specified in 4.2.1. DC leakage, capacitance, and dissipation factor shall then be measured as specified in 4.5.3, 4.5.4, and 4.5.5. Capacitors shall then be visually examined for mechanical damage, leakage of the electrolyte, and deformation of the case. Two capacitors shall then be subjected to the internal examination specified in 4.5.1.1 (see 3.3.2 and 3.19).

4.5.17 Barometric pressure (reduced) (see 3.20). Capacitors shall be tested in accordance with MIL-STD-202-105. The following details and exceptions shall apply:

a. Method of mounting: Except during examination and measurement, rigidly mounted by normal mounting means (see table III and 3.1).

b. Test condition and period of time at reduced pressure prior to application of potential: Capacitors shall be placed in an atmospheric pressure of .82 inch (20.8 mm) of mercury for a period of 5 minutes.

c. Test during subjection to reduced pressure: At the end of the 5-minute conditioning period, with the capacitors still at reduced pressure, the dc rated voltage (see 3.1), shall be applied for 1 minute between the terminals of each capacitor.

d. Examinations after subjection to reduced pressure: Capacitors shall be examined for flashover, breakdown, deformation of the case, and leakage of the case, and leakage of the electrolyte.

4.5.18 Shelf life (see 3.21). The build factor of the capacitors shall be determined and calculated as specified in 4.5.18.1. The capacitors shall then be stored for 100 ± 8 hours, in a forced-air oven at a temperature of +85° ± 3°C without any application of voltage. After the storage period, the capacitors shall be removed from the chamber and returned to and stabilized at room ambient conditions. The shelf factor shall then be determined as specified in 4.5.18.1. DC leakage, capacitance, and dissipation factor shall then be measured, in that order, as specified in 4.5.3, 4.5.4, and 4.5.5, respectively, except that the electrification time for dc leakage measurements before and after this test shall be 10 minutes. Capacitors shall then be examined for leakage of the electrolyte and deformation of the case. Two capacitors shall then be subjected to the internal examination specified in 4.5.1.1 (see 3.3.2).

4.5.18.1 Build and shelf factors. Capacitors shall be charged to the dc rated voltage (see 3.1), from a constant current source. The time to charge shall be recorded to the nearest 0.1 second. The charging current shall be such that the charge time will not be less than 5.0 seconds and not greater than 50.0 seconds. The build factor shall be computed as follows:

$$\text{Build factor} = \frac{\text{Actual charge time}}{\text{Theoretical charge time}} = \frac{A}{T} = \frac{AI}{CV} \times 10^3$$

Where:

A = actual charge time.
T = theoretical charge time.
I = charge current in milliamps.
C = measured capacitance in microfarads.
V = dc rated voltage (see 3.1).

$CV = g = IT$

$T = \frac{CV}{I}$

The shelf factor shall be computed as follows:

$$\text{Shelf factor} = \frac{\text{Actual charge time after storage}}{\text{Actual charge time before storage}}$$

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. Aluminum oxide electrolytic capacitors are intended for use in filter and bypass applications where large capacitance values are required in small cases and where excess of capacitance over the nominal value can be tolerated. For polarized capacitors, the applied ac peak voltage should never exceed the applied dc voltage; the sum of the applied ac peak and dc voltages should never exceed the dc rated voltage (see 3.1). They are military unique due to the fact that they must be able to operate satisfactorily in military systems under the following demanding conditions: +85°C operating temperature range, 100Gs of shock, 48 hours of salt spray corrosion, and 2000 hours of rated voltage testing. Commercial components are not designed to withstand these military environmental conditions.

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of the applicable specification sheet, and the complete PIN (see 1.2.1 and 3.1).

b. When first article is required (see 3.2 and 6.3).

c. Packaging requirements (see 5.1)

6.3 First article. When first article inspection is required, the contracting officer should provide specific guidance to offerors whether the item(s) should be a preproduction sample, a first article sample, a first production item, a sample selected from the first production items, or, a standard production item from the contractor's current inventory (see 3.2), and the number of items to be tested as specified in 4.3 The contracting officer should also include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results, and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract. Bidders should not submit alternate bids unless specifically requested to do so in the solicitation.

6.4 Reforming of dielectric film. Caution should be exercised in using capacitors which have had an idle shelf life of more than 4 years. Users should refer to MIL-HDBK-1131 “Storage Shelf Life and Reforming Procedures for Aluminum Electrolytic Fixed Capacitors” for inspection and reforming procedures.

6.4 Working temperature range. In the selection or use of these capacitors, careful consideration should be given to the overall temperature requirements of the basic equipment, since many equipments must operate over a greater temperature range than that covered by this specification. Capacitors should be operated within their normal temperature range for satisfactory service and maximum life.

6.5 High temperature. In planning the location of the capacitors with respect to other component parts, careful consideration should be given to the proximity of the capacitors to transformers, electron tubes, and high-current resistors because of the usual temperature rise involved in these components. Continued operation at temperatures above the normal rating will cause a permanent decrease in capacitance and an increase in series resistance.

6.6 Low temperature. The performance of these capacitors at subzero temperatures is mainly affected by an increase in series resistance and by a decrease in capacitance. These changes do not persist with the return of normal temperature conditions. At -40°C these capacitors retain approximately 50 percent of the initial capacitance.

6.7 Circuit diagram. For all styles except CE10 to CE13, inclusive, the electrolyte cannot be insulated completely from the case. The circuit diagram (see 3.1), for these styles shows an indeterminate resistance, which may change with time, between the negative terminal and ground (case). To insure proper circuit operation, the case should be considered as being directly connected to the terminal. In applications where the negative terminal is not at ground potential, the capacitor should be insulated from the chassis by means of an insulating sleeve.

6.8 Polarity. These capacitors should be used only in dc circuits with polarity properly observed. If ac components are present, the sum of the peak ac voltage plus the applied dc voltage must not exceed the dc rated voltage (see 3.1). The peak ac value should also be less than the applied dc voltage, in order that polarity may be maintained even on negative peaks. Capacitors which have been subjected to voltage reversal should be discarded.

6.9 Storage. It is to be noted that these capacitors deform and become unusable when stored at high temperatures; however, they may be subjected, without permanent damage, to conditions in transit where the temperatures range from -55° to +85°C, and where the altitude is up to 80,000 feet.

6.10 Current-limiting resistor. It is recommended that the current-limiting resistor referenced in 4.5.2 have a resistance in ohms equal to or less than the dc rated voltage (see 3.1).

6.11 Insulated capacitors. Sleeved capacitors are recommended for use in those applications where the case is to be connected at a potential above or below ground potential. The use of uninsulated capacitors in such applications could present a shock hazard to personnel or possibly cause an accidental short circuit.

6.12 Ripple current. To avoid overheating and shortened life, the maximum rms ripple current through the capacitor should not exceed the value determined. The formulas (see 3.1) for calculating the ripple current are based on operation at 120 Hz and +85°C. For other frequencies or temperatures the calculated value should be multiplied by the applicable factor from table X.

TABLE X. Ripple current multiplier.

Frequency	Multiplier				
	+85°C	+65°C	+55°C	+45°C	+40°C and below
60 Hz	0.8	1.2	1.6	2.2	3.0
120 Hz	1.0	1.5	2.0	2.8	3.0
Above 120 Hz	1.1	1.7	2.2	3.0	3.0

6.13 Standard capacitor types. Equipment designers should refer to MIL-HDBK-198 “Capacitors, Selection and Use of”, for standard capacitor types and selected values chosen from this specification. MIL-HDBK-198 provides a selection of standard capacitors for new equipment design.

6.14 Application data. Capacitor styles CE63 and CE64 are retained for replacement and maintenance purposes only. For new design, use styles CE11 or CE13.

6.15 Supersession. Minor changes made in this revision, in order to incorporate decade capacitance values, standardize case dimensions, and standards DF or impedance limits, will not require assignation of new stock numbers.

6.16 Part or Identifying Number (PIN). This specification requires a PIN that describes codification and/or classification and appropriate references to associated documents (see 1.2.1 and 3.1).

6.17 Tin whisker growth. The use of alloys with tin content greater than 97 percent by mass, may exhibit tin whisker growth problems after manufacturer. Tin whiskers may occur anytime from a day to years after manufacturer and can develop under typical operating conditions, on products that use such materials. Conformal coatings applied over top of a whisker-prone surface will not prevent the formation of tin whiskers. Alloys of 3 percent lead, by mass, have shown to inhibit the growth of tin whiskers. For additional information on this matter, refer to ASTM-B545 (Standard Specification for Electrodeposited Coatings of Tin).

6.18 Changes from previous issue: The margins of this specification are marked with vertical lines to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

6.19 Subject term (key word) listing.

Capacitance
Dissipation factor
Insulation resistance

Custodians:
Army - CR
Navy - EC
Air Force - 85
DLA - CC

Preparing activity:
DLA - CC

(Project 5910-2020-016)

Review activities:
Army - AR
Navy - AS, MC, OS
Air Force - 19

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using ASSIST Online database at https://assist.dla.mil .