

INCH-POUND
MIL-PRF-19978L
20 July 2016
SUPERSEDING
MIL-PRF-19978K
26 March 2009

PERFORMANCE SPECIFICATION

CAPACITOR, FIXED, PLASTIC (OR PAPER-PLASTIC) DIELECTRIC (HERMETICALLY SEALED IN METAL, CERAMIC, OR GLASS CASES), ESTABLISHED AND NON-ESTABLISHED RELIABILITY, GENERAL SPECIFICATION FOR

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

1. SCOPE

1.1 Scope. This specification covers the general requirements for established reliability (ER) and non-established reliability (non-ER), direct current (dc), plastic or paper-plastic dielectric, fixed capacitors, hermetically sealed in metal or ceramic or glass cases. Capacitors meeting the established reliability requirements specified herein have failure rate levels (FRL) ranging from 1.0 percent to 0.001 percent per 1,000 hours (see 1.2.1.9). These FRLs are established at a 90-percent confidence level and maintained at a 10-percent producer's risk and are based on life tests performed at maximum rated voltage and maximum rated temperature. An acceleration factor of 5:1 has been used to relate the life test data obtained at 140 percent of rated dc voltage at the applicable high test temperature to the rated voltage at the applicable high test temperature. This specification also covers removable mounting retainers for use with applicable capacitors (see 3.1). A parts per million (ppm) quality system is used for documenting and reporting the average outgoing quality of ER capacitors supplied to this specification. Statistical process control (SPC) techniques are required in the manufacturing process to minimize variation in production of ER capacitors supplied to the requirements of this specification.

1.2 Classification.

1.2.1 Part or Identifying Number (PIN). The PIN is in the following form and as specified (see 3.1).

ER

CQR09	A	1	M	C	152	K	1	M
ER	Terminal	Circuit	Charac-	Voltage	Capacitance	Capacitance	Vibration	Product
Style	(1.2.1.2)	(1.2.1.3)	teristic	(1.2.1.5)	(1.2.1.6)	tolerance	grade	level
(1.2.1.1)			(1.2.1.4)			(1.2.1.7)	(1.2.1.8)	designator
								(1.2.1.9)

NON-ER

CQR09	A	1	M	C	152	K	1
Style	Terminal	Circuit	Charac-	Voltage	Capacitance	Capacitance	Vibration
(1.2.1.1)	(1.2.1.2)	(1.2.1.3)	teristic	(1.2.1.5)	(1.2.1.6)	tolerance	grade
			(1.2.1.4)			(1.2.1.7)	(1.2.1.8)

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 emailed to capacitorfilter@dlamail.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>.



MIL-PRF-19978L

1.2.1.1 Style. The style is identified by either the three-letter symbol "CQR" or the two-letter symbol "CQ" followed by a two-digit number. The letters identify plastic (or paper-plastic) dielectric, fixed capacitor, hermetically sealed in metal, ceramic, or glass cases. The symbol "CQR" identifies ER capacitors; the symbol "CQ" identifies capacitors for which no specific reliability requirements are specified non-ER. The first digit following the letter symbols identifies the general shape of the case, and the second digit identifies specific details other than case size. Each style designation may include a family of case sizes.

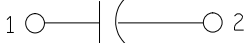
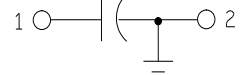
1.2.1.2 Terminal. The terminal is identified by a single letter in accordance with table I.

TABLE I. Terminal.

Symbol	Type of terminal
A	Axial wire lead
B	Solder lug (nonremovable)
C	Threaded stud and nuts
D and H	Pillar insulator for use at altitudes up to 7,500 feet (22.8 inches of mercury)
E	Pillar insulator for use at altitudes up to 50,000 feet (3.4 inches of mercury)

1.2.1.3 Circuit. The circuit diagram and the number of terminals are identified by a single digit in accordance with table II.

TABLE II. Circuit diagram and number of terminals.

Symbol	Circuit diagram	Number of terminals
1		2
3		2

1.2.1.4 Characteristic. The characteristic is identified by a single letter in accordance with table III.

TABLE III. Characteristic.

Characteristic	Values of characteristics							
	E	F and G	K <u>2/</u>	M	P	Q <u>4/</u>	T	V
High ambient test temperature, degrees Celsius $\pm 3^{\circ}\text{C}$ <u>1/</u>	+85	+85	+125	+85	+65	+125	+170	+125
Low ambient test temperature, degrees Celsius $+0^{\circ}\text{C}$, -5°C	-65	-55	-65	-65	-65	-55	-65	-55
Life-test dc voltage, percent of the dc voltage rating (see 4.7.20):								
Watt-second group (see 6.5.3):								
I (0.5 watt-second and less)	140	140	140	140	140	150	140	150
II (0.5+ to 5 watt-seconds)	140	130	140 <u>3/</u>	---	---	---	---	---
III (5+ to 50 watt-seconds)	140	110	140	---	---	---	---	---
IV (greater than 50 watt-seconds)	140	90	140	---	---	---	---	---
Flashpoint of impregnant of filling compound, degrees Celsius	+142	+135	+142	+142	+142	+142	+217	+142

1/ For characteristic K, voltage derating may be necessary at the high ambient test temperature (see 3.1).

2/ For tubular units of characteristic K rated at 1,000 volts dc, life test voltage is 1,200 volts.

3/ For tubular units of characteristic K in watt-seconds group II, use 130 percent of the dc voltage at $+40^{\circ}\text{C}$ for the life-test dc voltage.

4/ Characteristic Q capacitors are no longer available (see 6.1.6).

MIL-PRF-19978L

1.2.1.5 Voltage. The dc voltage rating for continuous operation at the high ambient test temperature specified in [table III](#) (except for characteristic K which is for +85°C operation), is identified by a single letter in accordance with [table IV](#).

TABLE IV. DC voltage rating.

Symbol	DC voltage rating ^{1/} (Volts)	Symbol	DC voltage rating ^{1/} (Volts)
Z	30	K	2,500
A	50	L	3,000
B	100	M	4,000
C	200	N	5,000
D	300	P	6,000
E	400	R	7,500
F	600	S	10,000
G	1,000	T	12,500
H	1,500	U	15,000
J	2,000		

^{1/} For characteristic K, voltage derating may be necessary at the high ambient test temperature (see [3.1](#)).

1.2.1.6 Capacitance. The nominal capacitance value expressed in picofarads (pF) is identified by a three-digit number; the first two digits represent significant figures and the last digit specifies the number of zeros to follow.

1.2.1.7 Capacitance tolerance. The capacitance tolerance in percent is identified by a single letter in accordance with [table V](#).

TABLE V. Capacitance tolerance.

Symbol	Capacitance tolerance percent (±)
F	1
G	2
J	5
K	10

1.2.1.8 Vibration grade. The vibration grade is identified by a single digit in accordance with [table VI](#).

TABLE VI. Vibration grade.

Symbol	Frequency range (Hz)	Acceleration (G)
1	10 to 55 inclusive	- - -
3	10 to 2,000 inclusive	15

1.2.1.9 Product level designator. The product level designation in percent per 1,000 hours is identified by a single letter in accordance with [table VII](#), and is based on rated voltage at the high test temperature, as applicable.

TABLE VII. Product level designator.

Symbol	Product level (percent per 1,000 hours)
M	1.0
P	0.1
R	0.01
S	0.001

MIL-PRF-19978L

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.

FEDERAL STANDARDS

[FED-STD-H28](#) - Screw Thread Standards for Federal Services.

DEPARTMENT OF DEFENSE SPECIFICATIONS

[MIL-PRF-83421/6](#) - Capacitors, Fixed, Metallized Plastic Film Dielectric, DC and AC, Hermetically Sealed In Metal Cases, Established Reliability.

(See Supplement 1 for list of associated specification sheets.)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-202	-	Test Method Standard Electronic and Electrical Component Parts
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-202-112	-	Method 112, Seal
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-202-209	-	Method 209, Radiographic Inspection
MIL-STD-202-210	-	Method 210, Resistance to Soldering Heat
MIL-STD-202-211	-	Method 211, Terminal Strength
MIL-STD-202-213	-	Method 213, Shock (Specified Pulse)
MIL-STD-202-215	-	Method 215, Resistance to Solvents
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-690	-	Failure Rate Sampling Plans and Procedures
MIL-STD-790	-	Established Reliability and High Reliability Qualified Products List (QPL) Systems for Electrical, Electronic, and Fiber Optic Parts Specifications
MIL-STD-810	-	Environmental Engineering Considerations and Laboratory Tests
MIL-STD-1285	-	Marking of Electrical and Electronic Parts.

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

MIL-PRF-19978L

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 D92	-	Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
--	--------------------------	---	---

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

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO)

	ISO/IEC 17025	-	General Requirements for the Competence of Testing and Calibration laboratories
--	-------------------------------	---	---

	ISO 10012	-	Measurement Management Systems - Requirements for Measurement Processes and Measuring Equipment
--	---------------------------	---	---

	(Copies of these documents are available online at http://www.iso.org .)		
--	---	--	--

SAE INTERNATIONAL (SAE)

	SAE EIA-554-1	-	Assessment of Average Outgoing Quality Levels in Parts Per Million (ppm)
--	-------------------------------	---	--

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

SOLID STATE TECHNOLOGY ASSOCIATION (JEDEC)

	JESD557	-	Statistical Process Control Systems
--	-------------------------	---	-------------------------------------

	(Copies of this document are available online at http://www.jedec.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 specification 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.

MIL-PRF-19978L

3. REQUIREMENTS

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

3.2 Qualification. Capacitors furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list (QPL) before contract award. In addition, the manufacturer shall obtain certification from the qualifying activity that the QPL system requirements of 3.3 and 4.2 have been met and are being maintained for the ER styles.

3.3 Qualified Products List (QPL) system. The manufacturer shall establish and maintain a QPL system for parts covered by this specification. Requirements for this system are specified in MIL-STD-690 and MIL-STD-790. In addition, the manufacturer shall establish a SPC and PPM system which meets the requirements of 3.3.1 and 3.3.2, respectively.

3.3.1 SPC system. As part of the overall MIL-STD-790 QPL system, the manufacturer shall establish a SPC system which meets the requirements of JESD557. Typical manufacturing processes for application of a SPC include pre-assembly, assembly, encapsulation, and packaging.

3.3.2 PPM system. As part of the overall MIL-STD-790 QPL system, the manufacturer shall establish a PPM system for assessing the average outgoing quality of lots in accordance with SAE EIA-554-1. Data exclusion, in accordance with SAE EIA-554-1, may be used with approval of the qualifying activity. The PPM system shall identify the PPM rate at the end of each month and shall be based on a six month moving average.

3.4 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 guarantee of the acceptance of the finished product.

3.4.1 Impregnant and filling compounds. Compounds used in the impregnation and filling of capacitors shall be chemically inactive with respect to the capacitor element and the case (see 3.5.1). The compound, either in the state of original application or as a result of having aged, shall have no adverse effect on the performance of the capacitor. For liquid-filled capacitors, the same material shall be used for impregnating as is used for filling (see 6.3).

3.5 Interface and physical dimension requirements. Capacitors and retainers shall meet the interface and physical dimensions specified (see 3.1).

3.5.1 Case. Each capacitor shall be enclosed in a hermetically-sealed case (see 3.1) which will protect the capacitor element from moisture, impregnant, or filling compound leakage, and mechanical damage under all test conditions specified herein.

3.5.2 Sleeving (when applicable, see 3.1). The sleeving material shall not soften, creep, or shrink to a point where any part of the cylindrical portion of the case is left uncovered at any test temperature specified herein. The sleeving shall not obscure the part marking.

3.5.3 Terminals.

3.5.3.1 Case as terminal. When the case is used as a terminal, any protective coating applied to the mounting surfaces shall be such as to provide a direct conducting path for an electric current from the case to the surface on which it is mounted.

3.5.3.2 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 solder coated.

3.5.3.3 Screw terminals. Screw terminals shall be supplied with one nut, one flat washer, and one lockwasher.

MIL-PRF-19978L

3.5.3.4 Wire leads and pins. Leads and pins shall be solder coated.

3.5.3.5 Pure tin. The use of pure tin, as an underplate or 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 6.7). Lead-free, tin alloy high temperature solders may be used where high temperature solder is necessary with approval by the qualifying activity. The tin content of lead-free high temperature solders shall not exceed 97 percent by mass.

3.5.4 Threaded parts. All threaded parts shall be as specified (see 3.1) and in accordance with FED-STD-H28.

3.5.4.1 Engagement of threaded parts. All threaded parts shall engage by at least three full threads.

3.5.4.2 Locking of screw-thread assemblies. All screw-thread assemblies shall be rendered resistant to loosening under vibration. Lockwashers shall be provided under all nuts.

3.6 Burn-in (ERs only, when applicable, see 3.1). When capacitors are tested as specified in 4.7.2, there shall be no evidence of damage, arcing, or breakdown.

3.7 Radiographic inspection (ERs only, when applicable, see 3.1). When capacitors are tested as specified in 4.7.3, x-ray examination shall disclose no evidence of improperly made connections, misalignments of seals or eyelets, substandard soldering or structural weakness, or solder particles or slivers attached to one end.

3.8 Thermal shock. When tested as specified in 4.7.4, capacitors and retainers shall withstand the extremes of high and low temperatures without visible damage.

3.9 Seal. When capacitors are tested as specified in 4.7.5, there shall be no continuous visible stream of bubbles or other evidence of leakage.

3.10 Dielectric Withstanding Voltage (DWV).

3.10.1 Capacitors. When capacitors are tested as specified in 4.7.6.1, there shall be no momentary or intermittent arcing or other indication of breakdown, nor shall there be any visible evidence of damage.

3.10.2 Sleeving (when applicable, see 3.1). When capacitors are tested as specified in 4.7.6.2, the insulating sleeve shall withstand the specified potential without breakdown.

3.11 Barometric pressure (reduced) (when applicable, see 3.1), qualification only. When capacitors are tested as specified in 4.7.7, there shall be no momentary or intermittent arcing or other indication of breakdown, nor shall there be any visible evidence of damage.

3.12 Insulation resistance (IR).

3.12.1 Sleeving (when applicable, see 3.1). When measured as specified in 4.7.8, the insulation resistance shall be not less than 1,000 megohms.

3.12.2 Terminal to terminal. When measured as specified in 4.7.8, the insulation resistance shall be not less than the applicable values specified (see 3.1).

3.12.3 Terminal to case. Unless otherwise specified (see 3.1), when measured as specified in 4.7.8, the insulation resistance between any terminal and case, when the case is not a terminal, shall exceed 50,000 megohms.

3.13 Capacitance. When measured as specified in 4.7.9, the capacitance shall be within the tolerance specified (see 3.1).

3.14 Dissipation factor. When measured as specified in 4.7.10, the dissipation factor shall not exceed the applicable value specified (see 3.1).

MIL-PRF-19978L

3.15 Vibration. When capacitors are tested as specified in 4.7.11, there shall be no intermittent contacts of 0.5 milliseconds (ms) or greater duration or momentary arcing, or other indication of breakdown, nor shall there be any open-or-short circuiting or evidence of mechanical damage. In addition, retainers, as tested to 4.7.11, shall exhibit no evidence of mechanical damage.

3.16 Salt spray (corrosion) (metal surfaces only, see 3.1). When capacitors or retainers are tested as specified in 4.7.12, there shall be no evidence of harmful corrosion and at least 90 percent of any exposed metal surfaces of the capacitor or retainer shall be protected by the finish. Harmful corrosion shall be construed as any type of corrosion which in any way interferes with the mechanical or electrical performance of the capacitor or retainer, as applicable. For capacitors or retainers with painted surfaces, not more than 10 percent of the surfaces shall be affected by flaking, peeling, or blistering of paint. There shall be no evidence of unwrapping of or mechanical damage to the insulating sleeves when applicable. In addition, corrosion of the terminal hardware or mounting surface shall not exceed 10 percent of the surface area. Marking shall remain legible.

3.17 Immersion. When tested as specified in 4.7.13, capacitors or retainers, as applicable, shall meet the following requirements:

a. Capacitors:

(1) Dielectric withstanding voltage:

(a) Insulating sleeves (when applicable, see 3.1): Not less than 4,000 V dc.

(b) Terminal to terminal: As specified in 3.10.1.

(c) Terminal to case: As specified in 3.10.1.

(2) Insulation resistance at +25°C:

(a) Insulating sleeves (when applicable, see 3.1): Not less than 1,000 megohms.

(b) Terminal to terminal: Unless otherwise specified, not less than 60 percent of the value specified in 3.12.2.

(c) Terminal to case: Unless otherwise specified, not less than 50 percent of the value specified in 3.12.3.

(3) Capacitance: Shall change not more than ± 1.0 percent from the value obtained when measured as specified in 4.7.9.

(4) Dissipation factor: Shall not exceed 120 percent of the initial value specified (see 3.1).

b. Capacitors and retainers: Visual examination: There shall be no harmful or extensive corrosion of the capacitors or retainers. The marking shall remain legible. There shall be no unwrapping of, or mechanical damage to, the insulating sleeves, when applicable.

3.18 Solderability (wire leads only, see 3.1). When capacitors are tested as specified in 4.7.14, the dipped portion of the terminals shall conform to the solid-wire termination criteria of method 208 of MIL-STD-202.

3.19 Shock (specified pulse). When capacitors are tested as specified in 4.7.15, there shall be no intermittent contacts of 0.5 ms or greater duration, or arcing or other indications of breakdown, nor shall there be any open or short circuiting or evidence of mechanical damage.

3.20 Terminal strength. When capacitors are tested as specified in 4.7.16, there shall be no mechanical damage to the capacitor or terminals.

3.21 Dielectric absorption (when specified, see 3.1). When measured as specified in 4.7.17, the dielectric absorption shall not exceed the value specified (see 3.1).

MIL-PRF-19978L

3.22 Stability at low end high temperatures. When capacitors are tested as specified in 4.7.18, there shall be no indication of breakdown or arcing, nor shall there be any open or short circuiting or any visible evidence of mechanical damage. The capacitance changes at the specified temperatures shall not exceed the applicable limits specified (see 3.1) from value at +25°C.

3.23 Temperature coefficient (characteristic P only) (see 3.1). When measured as specified in 4.7.19, the temperature coefficient shall not exceed -120 ppm per degree Celsius (ppm/°C) ± 50 ppm/°C.

3.24 Life. When tested as specified in 4.7.20, capacitors shall meet the following requirements.

- a. Insulation resistance at +25°C: Unless otherwise specified, not less than 60 percent of the value specified in 3.12.1.
- b. Capacitance: Shall change not more than the percent specified (see 3.1) of the initial value obtained when measured as specified in 4.7.9.
- c. Dissipation factor: Unless otherwise specified, shall not exceed the initial value specified (see 3.1).
- d. Visual examination: There shall be no leakage of impregnant or filling compound or deformation of the case either during or after the test.

3.25 Fungus. The manufacturer shall certify that all external materials are fungus resistant or shall perform the test specified in 4.7.21. When capacitors are tested as specified in 4.7.21, examination shall disclose no evidence of fungus growth on the external surface.

3.26 Resistance to solvents. When capacitors are tested as specified in 4.7.22, there shall be no evidence of mechanical damage and the marking shall remain legible.

3.27 Resistance to soldering heat (wire-lead capacitors only). When tested as specified in 4.7.23, capacitors shall meet the following requirements:

- a. Insulation resistance at +25°C: As specified in 3.12.
- b. Capacitance: Change not more than five percent from the Initial value obtained when measured as specified in 4.7.9.
- c. Dissipation factor: Shall not exceed initial limit.

3.28 Moisture resistance. When tested as specified in 4.7.24, capacitors or retainers as applicable, shall meet the following requirements.

a. Capacitors:

(1) Dielectric withstanding voltage:

- (a) Insulating sleeves (when applicable, see 3.1): Not less than 4,000 V dc.
- (b) Terminal to terminal: As specified in 3.10.1.
- (c) Terminals to case (circuit diagram 1 only): As specified in 3.10.1.

(2) Insulation resistance at +25°C:

- (a) Insulating sleeves (when applicable, see 3.1): Not less than 1,000 megohms.
- (b) Terminal to terminal: Not less than 60 percent of the value specified in 3.12.2.

MIL-PRF-19978L

- (c) Terminals to case (circuit diagram 1 only): Not less than 50 percent of the value specified in 3.12.3.
- (3) Capacitance: Shall change not more than ± 0.5 percent (± 2.0 percent for characteristic M) from the value obtained when measured as specified in 4.7.9.
- (4) Dissipation factor: Shall not exceed 120 percent of the initial values specified (see 3.1).
- b. Capacitors and retainers: Visual examination: There shall be no harmful or extensive corrosion of the capacitors or retainers. The marking shall remain legible. There shall be no unwrapping of, or mechanical damage to, the insulating sleeves when applicable.

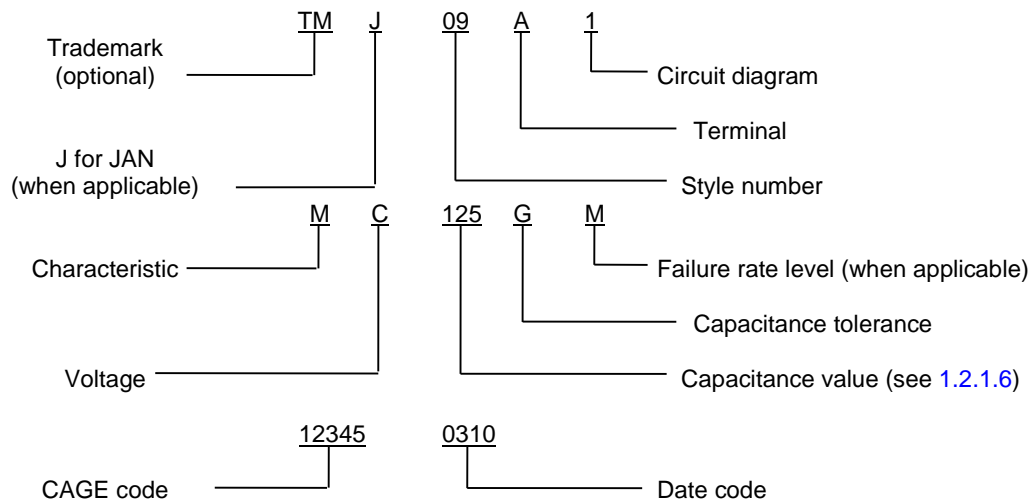
3.29 Flashpoint of impregnant or filling compound. Unless otherwise specified (see 3.1), when measured as specified in 4.7.25, the flashpoint of impregnant or filling compound shall be equal to or greater than $+142^{\circ}\text{C}$.

3.30 Marking.

3.30.1 Capacitors. Marking of capacitors shall conform to method I of MIL-STD-1285 and shall include the PIN, "JAN" brand (ER styles only), trademark (optional), commercial and Government entity (CAGE) code, date code, lot symbol, and when space permits, capacitance (in μF), capacitance tolerance, and rated voltage, and when applicable, failure rate level. Marking shall not be applied to the insulating sleeve. Unless otherwise specified (see 3.1), capacitors shall be marked as shown in the following example:

Example: CQR09A1MC152K1M - PIN.
 JAN TM 12345 - "JAN" brand (ER styles only), trademark (optional) and CAGE code.
 0150A.0011 μF - Date code, lot symbol, and capacitance.
 10% 1,000 V dc - Capacitance tolerance and rated voltage.

3.30.2 Partial marking. For tubular capacitors with case size of .15 by .406, .105 by .406, and .235 by .406, the following partial marking may be used.



3.30.3 Retainer. Retainers shall be marked with the PIN, trademark (optional), and CAGE code. Marking shall be on the outer surface of the retainers.

MIL-PRF-19978L

3.30.4 JAN and J marking (ER styles only). The United States Government has adopted and is exercising legitimate control over the certification marks "JAN" and "J", respectively, to indicate that items so marked or identified are manufactured to, and meet all the requirements of specifications. Accordingly, items acquired to, and meeting all of the criteria specified herein and in applicable specifications shall bear the certification mark "JAN" except that items too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" and "J" shall be placed immediately before the part number except that if such location would place a hardship on the manufacturer in connection with such marking, the "JAN" or "J" may be located on the first line above or below the part number. Items furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein or in applicable specifications shall not bear "JAN" or "J". In the event an item fails to meet the requirements of this specification and the applicable specification sheets, the manufacturer shall remove completely the military part number and the "JAN" or the "J" from the sample tested and also from all items represented by the sample. The "JAN" or "J" certification mark shall not be used on products acquired to contractor drawings or specifications. The United States Government has obtained Certificate of Registration Number 504,860 for the certification mark "JAN" and Registration Number 2,577,735 for the certification mark "J".

3.30.5 Substitution of FRLs. A manufacturer may supply to all higher FRL than to which they are qualified. Items of an exponential FRL as shown in [table VIII](#) and marked to lower FRL with acquiring agency approval, are substitutable for higher FRL, and shall not be remarked unless specified in the contract or purchase order (see [6.2](#)), the lot date codes on the parts are unchanged, and the workmanship criteria is met.

TABLE VIII. FRL substitutability.

Parts qualified to FRL	Substitutable for FRL
S	M, P, and R
R	M and P
P	M

3.30.6 Substitution of capacitance tolerance and voltage. Parts qualified and marked to tighter capacitance tolerance or higher rated voltage, with acquiring agency approval, are substitutable for parts marked to looser capacitance tolerance or lower rated voltage, provided all other values, such as case size, characteristic, and leads are the same. Unless specified in the contract or purchase order (see [6.2](#)), the substitutable parts shall not be remarked, the lot date code on the parts are unchanged, and the workmanship criteria are met.

3.30.7 Non-ER marking. An ER part may be marked and furnished as a non-ER part if produced on the same assembly line, and provided it is subject to and meets all the inspection requirements of the ER part.

3.31 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.

3.32 Workmanship. Capacitors and retainers 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.

MIL-PRF-19978L

4. VERIFICATION

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

- a. Qualification inspection (see [4.4](#)).
- b. Verification of qualification (ER styles: See [4.5](#); non-ER: See [4.5.1](#)).
- c. Conformance inspection (see [4.6](#)).

4.2 QPL system (applicable to ER parts only). The manufacturer shall establish and maintain a QPL system in accordance with [3.3](#). Evidence of such compliance is a prerequisite for qualification and retention of qualification.

4.3 Inspection conditions. Unless otherwise specified, all inspections shall be performed in accordance with the test conditions specified in the "GENERAL REQUIREMENTS" of [MIL-STD-202](#).

4.3.1 Test equipment and inspection facilities. The supplier shall establish and maintain a calibration system in accordance with [ISO/IEC 17025](#), [ISO 10012](#), or equivalent system.

4.3.2 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 maximum dc bias voltage shall be 2.2 volts for all ac measurements of capacitors.

4.3.3 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 ±5°C prior to conditioning. Unless reference measurements have been made within 30 days prior to the beginning of conditioning, they shall be repeated.

4.3.4 Power supply. The power supply used for life testing shall have a regulation of ±2 percent or less of the rated voltage. The power source employed for dc leakage current measurements shall be stabilized to at least 100 ppm. No voltage fluctuations shall occur during measurements that would produce a variation in the current measurement as read with any acceptable dc leakage current tester used to test capacitors.

4.4 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see [6.4](#)) on sample units produced with equipment and procedures normally used in production.

4.4.1 Sample size. The number of capacitors to be submitted for qualification inspection shall be as specified in [table IX](#) or [appendix A](#).

4.4.2 Inspection routine. Capacitors shall be subjected to the qualification inspection specified in [table IX](#) in the order shown. All sample units shall be divided as specified in [table IX](#) for groups I through VIII inclusive, and subjected to the inspection for their particular group; for combined voltage group submissions, each type shall be equally represented in each group.

4.4.3 Failures. Failures in excess of those allowed in [table IX](#) shall be cause for refusal to grant qualification approval.

4.4.4 FRL qualification (applicable to ER parts only). FRL qualification for capacitors shall be in accordance with the general and detailed requirements of [MIL-STD-690](#) and as follows.

- a. Procedure I: Qualification at the initial FRL. Level "M" (1.0 percent) of FRSP-90 shall apply. Sample units shall be subjected to the qualification inspection specified in group VI, [table IX](#) (see [4.4.2](#)). The entire life test sample shall be continued on test to 6,000 hours as specified in [4.7.20.3](#), upon completion of the 2,000 hour qualification.

MIL-PRF-19978L

- b. Procedure II: Extension of qualification to lower FRLs. To extend qualification to the "R" (0.01 percent) and "S" (0.001 percent) FRLs, data from two or more styles of similar construction (see 4.6.1.1.1) may be combined.
- c. Procedure III: Maintenance of FRL qualification. Maintenance period B of FRSP-10 shall apply. Regardless of the number of production lots produced during this period, the specified number of unit hours shall be accumulated to maintain qualification (see 4.6.1). Data from MIL-PRF-83421/6 (CRH31, CRH32, CRH33, CRH34, and CRH35), may be used to maintain FRL qualification of style CQR44.

4.4.5 Quality level verification (ER styles only). The manufacturer is responsible for establishing a quality system to assess the ppm defect level of lots that are subjected to subgroup 2 tests of the group A inspections. The ppm defect level shall be based on a 6-month moving average.

4.4.6 Qualification inspection of retainers. Qualification inspection for retainers is not required; however, retainers shall be capable of meeting the applicable requirements specified herein.

4.5 Verification of qualification (ER styles only). Every 12 months the manufacturer shall provide verification of qualification to the qualifying activity. Continuation of qualification shall be based on meeting the following requirements:

- a. MIL-STD-790 program.
- b. The capacitor design has not been modified.
- c. Lot rejection for group A inspection does not exceed 5 percent or one lot, whichever is greater.
- d. The requirements for group B inspection are met.
- e. Verification of FRLs.
- f. PPM assessment.

In the event that there is no production of a single style device during a maintenance period and the manufacturer is listed for more than one style on the QPL, the manufacturer shall certify that they retain the capabilities and facilities necessary to produce that product. However, the manufacturer shall still maintain the required number of unit hours in the maintenance period using those styles produced in order to remain qualified to the applicable failure rate levels. In the case where the lowest failure rate for an un-produced style is M, styles need not be manufactured for testing only but the manufacturer must certify that the capability and facilities needed to produce that style are still in place. In the event that units must be built for the purpose of maintaining the required hours, they shall also undergo all required testing prior to being placed on life test. If during three consecutive reporting periods there has been no production of a given style, the manufacturer may be required, at the discretion of the qualifying activity, to submit a newly-produced (not from stock) representative product of that style to testing.

4.5.1 Verification of qualification (non-ER styles only). Every 12 months, the manufacturer shall provide verification of qualification to the qualifying activity. Continuation of qualification shall be based on meeting the following requirements:

- a. Group A inspection (see 4.6.1.2).
- b. Periodic group B inspection (see 4.6.3).

In the event that there is no production of a single style device during a reporting period and the manufacturer is listed for more than one style on the QPL, the manufacturer shall certify that they retain the capabilities and facilities necessary to produce that product. If during three consecutive reporting periods there has been no production of a given style, the manufacturer may be required, at the discretion of the qualifying activity, to submit a representative product of that style to testing.

MIL-PRF-19978L

TABLE IX. Qualification inspection.

Inspection	Requirement paragraph	Method Paragraph	NON-ER		ER	
			Number of sample units to be inspected	Number of defectives allowed ^{1/}	Number of sample units to be inspected	Number of defectives allowed ^{1/}
<u>Group I</u> Visual and mechanical examination (internal): Material and workmanship	3.1, 3.4, and 3.32	4.7.1	2	0	2	0
<u>Group II</u> Visual and mechanical examination (external): Physical dimensions, marking, and workmanship ^{2/} Thermal shock ^{3/} Radiographic inspection (ER only, when applicable) ^{3/} Burn-in (ER only, when applicable) ^{3/} Seal Dielectric withstanding voltage ^{3/} Barometric pressure (reduced) (when applicable) ^{3/} Insulation resistance ^{3/} Capacitance ^{3/} Dissipation factor ^{3/}	3.1, 3.5, and 3.30 to 3.32 3.8 3.7 3.6 3.9 3.10 3.11 3.12 3.13 3.14	4.7.1 4.7.4 4.7.3 4.7.2 4.7.5 4.7.6 4.7.7 4.7.8 4.7.9 4.7.10	43	1	80	0
<u>Group III</u> Vibration Salt spray (corrosion) (metal case only) Immersion	3.15 3.16 3.17	4.7.11 4.7.12 4.7.13	6	1	12	1
<u>Group IV</u> Solderability (wire leads only)	3.18	4.7.14	6	1	6	1
<u>Group V</u> Shock (specified pulse) Terminal strength Moisture resistance	3.19 3.20 3.28	4.7.15 4.7.16 4.7.24	6	1	12	1
<u>Group VI</u> Dielectric absorption (when specified) Stability at low and high temperatures ^{3/} Temperature coefficient (characteristic P) Life	3.21 3.22 3.23 3.24	4.7.17 4.7.18 4.7.19 4.7.20	24	1	40	1
<u>Group VII</u> Fungus Resistance to solvents Resistance to soldering heat (wire lead only) Moisture resistance	3.25 3.26 3.27 3.28	4.7.21 4.7.22 4.7.23 4.7.24	N/A	N/A	5 5	10 1
<u>Group VIII</u> Flashpoint of impregnant or filling compound	3.29	4.7.25	2 ^{4/}	N/A	2 ^{4/}	N/A

^{1/} A sample unit having one or more defects will be considered as a single defective.

^{2/} Marking defects are based on visual examination only and will be charged only for illegible, incomplete, or incorrect marking.

^{3/} Nondestructive tests.

^{4/} Two samples shall be taken from the quarter-pound impregnant or filling compound submitted.

MIL-PRF-19978L

4.6 Conformance inspection.

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A inspection.

4.6.1.1 Inspection and production lot.

4.6.1.1.1 Inspection lot. An inspection lot shall consist of all capacitors in one or more styles, produced under essentially the same conditions, and offered for inspection during a single work month. The sample selected from the lot shall be representative of the styles in the lot. ER parts shall be kept separate from non-ER parts. The following styles are considered to be similar and may be combined for conformance and FRL maintenance:

<u>Group</u>	<u>Characteristic</u>	
1	K, M	CQR09, CQR12, CQR13, CQR19, CQR29, CQR32, CQR33, CQR39, CQR42, CQR43.
2	E, F, G, or K	CQ72.
3		All non-ER styles may be grouped by characteristic.

4.6.1.1.2 Production lot. A production lot shall consist of all capacitors of the same style, voltage rating, nominal capacitance value, and characteristic. The manufacture of all parts in the lot shall have been started, processed, assembled, and tested as a group. Lot identity shall be maintained throughout the manufacturing cycle.

4.6.1.2 Group A inspection. Group A inspection shall consist of the examination and tests specified in [table X](#) or [table XII](#).

4.6.1.2.1 ER styles.

4.6.1.2.1.1 Subgroup 1 tests. Subgroup 1 tests shall be performed on a production lot basis on 100 percent of the product supplied under this specification. Capacitors failing the tests of subgroup 1 shall be removed from the lot. If, during the 100 percent inspection, screening required that more than 5 percent of the capacitors be discarded, the entire production lot shall be rejected.

4.6.1.2.1.1.1 Manufacturer's production inspection. If the manufacturer performs tests similar to that specified in subgroup 1, [table X](#), as the final step of their production process, group A, subgroup 1 inspection may be waived and the data resulting from the manufacturer's production tests may be used instead. Authority to waive the subgroup 1 inspection shall be granted by the qualifying activity only. The following criteria must be complied with.

- Manufacturer's production tests are identical to, or more stringent than, that specified for subgroup 1.
- One hundred percent of the product is subjected to these tests.
- Failure criteria are identical to, or more stringent than, those specified herein.
- The lot rejection criteria are identical to, or more stringent than, that specified herein.
- Once approved, the manufacturer shall not change the test procedure or criteria without prior notification and concurrence by the qualifying activity.

MIL-PRF-19978L

TABLE X. Group A inspection (ER).

Inspection	Requirement paragraph	Test method paragraph	Sampling procedure
<u>Subgroup 1</u>			
Thermal shock	3.8	4.7.4	100% inspection
Radiographic inspection <u>1/</u>	3.7	4.7.3	
Burn in	3.6	4.7.2	
Seal	3.9	4.7.5	
Dielectric withstanding voltage	3.10	4.7.6	
Insulation resistance	3.12	4.7.8	
Capacitance	3.13	4.7.9	
Dissipation factor	3.14	4.7.10	
<u>Subgroup 2</u>			
Visual and mechanical examination (external):			See table XI
Physical dimensions	3.1, 3.5, and 3.30 to 3.32 inclusive	4.7.1	
Marking <u>2/</u>			
Workmanship			
<u>Subgroup 3</u> <u>3/</u>			
Solderability (wire lead styles only)	3.18	4.7.14	5 samples 0 failures

1/ Radiographic not applicable to FRL M.

2/ Marking defects are based on visual examination only.

3/ The manufacturer may request the deletion of the subgroup 3 solderability test, provided an in-line or process control system for assessing and assuring the solderability of leads can be validated and approved by the qualifying activity. Deletion of the test does not relieve the manufacturer from meeting this test requirement in case of dispute. If the design, material, construction, or processing of the part is changed or if there are any quality problems, the qualifying activity may require resumption of the test.

TABLE XI. Sampling plans for subgroup 2.

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

MIL-PRF-19978L

TABLE XII. Group A inspection (Non-ER).

Inspection	Requirement paragraph	Test method paragraph	Sampling procedure
<u>Subgroup 1</u>			
Thermal shock	3.8	4.7.4	See table XIII
Seal	3.9	4.7.5	
Dielectric withstanding voltage	3.10	4.7.6	
Insulation resistance	3.12	4.7.8	
Capacitance	3.13	4.7.9	
Dissipation factor	3.14	4.7.10	
<u>Subgroup 2</u>			
Visual and mechanical examination (external):			13 samples 0 failures
Physical dimensions	3.1, 3.5, and 3.30 to 3.32 inclusive	4.7.1	
Marking <u>1/</u>			
Workmanship			
<u>Subgroup 3</u> <u>2/</u>			
Solderability (wire lead styles only)	3.18	4.7.14	5 samples 0 failures

1/ Marking defects are based on visual examination only.

2/ The manufacturer may request the deletion of the subgroup 3 solderability test, provided an in-line or process control system for assessing and assuring the solderability of leads can be validated and approved by the qualifying activity. Deletion of the test does not relieve the manufacturer from meeting this test requirement in case of dispute. If the design, material, construction, or processing of the part is changed or there are any quality problems, the qualifying activity may require resumption of the test.

TABLE XIII. Sample size for subgroup 1.

Lot size	Sample size
1 - 125	100%
126 - 3,200	125
3,201 - 10,000	192
10,001 - 150,000	294
150,001 - 500,000	345
500,001 - Up	435

4.6.1.2.1.2 Subgroup 2 tests.

4.6.1.2.1.2.1 Sampling plans. Subgroup 2 shall be performed on an inspection lot basis. The sampling procedure shall be as specified in [table X](#).

4.6.1.2.1.2.2 Rejected lots. The rejected lot shall be segregated from new lots and those lots that have passed inspection. The rejected lot shall be 100 percent inspected for those quality characteristics found defective in the sample and any defectives found shall be removed from the lot. A new sample of parts shall then be randomly selected in accordance with [table X](#). If one or more defects are found in this second sample, the lot shall be rejected and shall not be supplied to this specification.

MIL-PRF-19978L

4.6.1.2.1.3 Subgroup 3 (solderability).

4.6.1.2.1.3.1 Inspection lot. An inspection lot for the purpose of this test shall consist of all capacitors manufactured with the same diameter lead wire and offered for inspection at one time. Each production lot shall be kept separate from every other lot. All samples belonging to a production lot shall be identified to that lot. Means of identification is at the option of the manufacturer.

4.6.1.2.1.3.2 Sampling plan. Five samples shall be selected randomly from each inspection lot. The manufacturer may use electrical rejects from the subgroup 1 screening tests for all or part of the samples to be used for solderability testing. If there are one or more failures, the lot shall be rejected.

4.6.1.2.1.3.3 Rejected lots. In the event of one or more defects, the inspection lot is rejected. The manufacturer may use one of the following options to rework the lot.

- a. Each production lot that was used to form the failed inspection lot shall be individually submitted to the solderability test as required in [4.6.1.2.1.3.2](#). Production lots that pass the solderability test are available for shipment. Production lots failing the solderability test can be reworked only if submitted to the solder dip procedure in [4.6.1.2.1.3.3b](#).
- b. The manufacturer submits the failed lot to a 100 percent solder dip using an approved solder dip process in accordance with [appendix A](#). Following the solder dip, the electrical measurements required in group A, subgroup 1 tests shall be repeated on 100 percent of the lot. The PDA for the electrical measurements shall be as for the subgroup 1 tests. (NOTE: If x-ray and hermetic seal are required in the group A, subgroup 1 tests, these tests shall be repeated.) Five additional samples shall then be selected and subjected to the solderability test with zero defects allowed. If the lot fails this solderability test, the lot may be reworked a second time and retested. If the lot fails this second rework, the lot shall be considered rejected and shall not be furnished against the requirements of this specification.

4.6.1.2.1.3.4 Disposition of sample. The solderability test is considered a destructive test and samples submitted to the solderability test shall not be supplied on the contract.

4.6.1.2.2 Non-ER styles.

4.6.1.2.2.1 Sampling plan. The inspection lot shall be submitted to the sampling plan for subgroup 1 and subgroup 2 as specified in [table XII](#).

4.6.1.2.2.2 Rejected lots. If an inspection lot for subgroup 1 or subgroup 2 is rejected, the contractor may rework the inspection lot to correct the defects, or screen out the defective units and resubmit for reinspection. If one or more defects are found during this reinspection, the lot shall be rejected and shall not be supplied to this specification. Reinspected lots shall be separated from new lots, and shall be clearly identified as reinspected lots.

4.6.1.2.2.3 Subgroup 3 (solderability). Five samples shall be selected randomly from each inspection lot. The manufacturer may use electrical rejects from the subgroup 1 screening tests for all or part of the samples to be used for solderability testing. If there are one or more failures, the lot shall be rejected.

4.6.1.2.2.3.1 Rejected lots. In the event of one or more defects, the inspection lot is rejected. The manufacturer may use one of the following options to rework the lot.

- a. Each production lot that was used to form the failed inspection lot shall be individually submitted to the solderability test as required in [4.6.1.2.2.3](#). Production lots that pass the solderability test are available for shipment. Production lots failing the solderability test can be reworked only if submitted to the solder dip procedure in [4.6.1.2.2.3.1b](#).

MIL-PRF-19978L

- b. The manufacturer submits the failed lot to a 100 percent solder dip using a approved solder dip process in accordance with [appendix A](#). Following the solder dip, the electrical measurements required in group A, subgroup 1 tests shall be repeated on 100 percent of the lot. The PDA for the electrical measurements shall be as for the subgroup 1 tests. Five additional samples shall then be selected and subjected to the solderability test with zero defects allowed. If the lot fails this solderability test, the lot may be reworked a second time and retested. If the lot fails this second rework, the lot shall be considered rejected and shall not be furnished against the requirements of this specification.

4.6.1.2.2.3.2 Disposition of sample. The solderability test is considered a destructive test and samples submitted to the solderability test shall not be supplied on the contract.

4.6.2 PPM calculations (non-ER and ER). The manufacturer shall establish and maintain a system for assessing and calculating average outgoing quality of capacitors. A PPM rate combining IR, capacitance, and DF shall be assessed for lots that have passed the group A inspection. The manufacturer's PPM system shall also address rectification procedures for lots failing PPM assessment. Data from the rectification process shall not be used to calculate PPM.

4.6.3 Periodic group B inspection. Periodic group B inspection shall consist of the tests specified in [table XIV](#) in the order shown, and shall be performed on sample units selected from lots that have passed group A inspection. Except where the results of this inspection show noncompliance with the applicable requirements (see [4.6.3.4](#)), delivery of products which have passed group A shall not be delayed pending the results of this periodic inspection.

4.6.3.1 Sampling plan.

4.6.3.1.1 For all non-ER styles and FRLs. Sample units shall be selected from the first lot and then from every two months production for subgroups 1, 2, 3, 4, and 5. The highest watt-second rating in each style, characteristic, and voltage manufactured during the specified periods shall be represented in at least the approximate ratio of production. A different sample shall be selected for each subgroup.

4.6.3.1.2 For FRLs M, P, R, and S. In addition to the tests specified in [4.6.3.1.1](#), a minimum ten sample units from each inspection lot (see [4.6.3.1.1](#)) shall be subjected to subgroup 3 of [table XIV](#). Allowable failures shall be as specified in [table IV](#) of [MIL-STD-690](#).

4.6.3.2 Failures. If the number of failures exceeds the number allowed in [table XIV](#), the sample shall be considered to have failed.

4.6.3.3 Disposition of sample units. Sample units which have been subjected to group B inspection shall not be delivered on the contract or order.

4.6.3.4 Noncompliance (applicable to both ER and non-ER parts). If a sample fails to pass group B inspection, the manufacturer shall notify the qualifying activity and cognizant inspection activity of such failure and take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials and processes, etcetera, and which are considered subject to the same failure. Acceptance of the product shall be discontinued until corrective action, acceptable to the Government, has been taken. After the corrective action has been taken, group B inspection shall be repeated on additional sample units (all inspections, or the inspection which the original sample failed, at the option of the Government). Group A inspection may be reinstituted; however, final acceptance shall be withheld until the group B reinspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure and corrective action taken shall be furnished to the qualifying activity and the contracting officer or purchaser.

MIL-PRF-19978L

TABLE XIV. Group B inspection

Inspection	Requirement paragraph	Method paragraph	Number of samples	Number of defectives allowed			
				Non-ER		ER	
<u>Subgroup 1</u> Shock (specified pulse) <u>1/ 2/</u> Vibration <u>2/</u> Salt spray (corrosion) (metal cases only) <u>3/</u> Immersion <u>3/</u>	3.19 3.15 3.16 3.17	4.7.15 4.7.11 4.7.12 4.7.13	12	1	1	1	1
<u>Subgroup 2</u> Terminal strength <u>3/</u> Moisture resistance <u>3/</u> Dielectric withstanding voltage (sleeving only) <u>3/</u>	3.20 3.28 3.10.2	4.7.16 4.7.24 4.7.6.2	12	1		1	
<u>Subgroup 3</u> Life	3.24	4.7.20.2	12 (Non-ER) 10 per inspection lot minimum (ER)	1		see 4.6.3.1	
<u>Subgroup 4</u> Insulation resistance (at high ambient Test temperature) Dielectric absorption (when specified) Stability at low and high temperatures Temperature coefficient (characteristic P only)	3.12 3.21 3.22 3.23	4.7.8 4.7.17 4.7.18 4.7.19	12	1		1	
<u>Subgroup 5</u> Resistance to solvents <u>3/</u> Resistance to soldering heat (wire-lead styles only) <u>3/</u>	3.26 3.27	4.7.22 4.7.23	6	N/A		1	

1/ Not applicable to ceramic or glass-cased units

2/ The time period for shock and vibration tests is a minimum of once every 24 months.

3/ If the manufacturer can demonstrate that this test has been performed five consecutive times with zero failures, this test, with the approval of the qualifying activity, can be deleted. The manufacturer, however, shall perform this test every three years after the deletion as part of long term design verification. If the design, material, construction, or processing of the part is changed, or if there are any quality problems, the qualifying activity may require resumption of the specified testing. Deletion of testing does not relieve the manufacturer from meeting the test requirements in case of dispute.

4.7 Methods of examination and test.

4.7.1 Visual and mechanical examination. Capacitors and retainers 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, 3.4 to 3.5.3 inclusive, 3.30 to 3.30.7 inclusive, and 3.32).

4.7.2 Burn-in (see 3.6) (ERs only, when applicable, see 3.1). Capacitors shall be subjected to 140 percent, minimum, of the dc rated voltage at the high ambient test temperature for 48 hours +8 hours, -0 hours. During this test, capacitors shall be adequately protected against temporary voltage surges of 10 percent or more of the test voltage. After the test, capacitors shall show no evidence of damage, arcing, or breakdown.

MIL-PRF-19978L

4.7.3 Radiographic inspection (see 3.7) (ERs only, when applicable, see 3.1). Capacitors shall be tested in accordance with [method 209 of MIL-STD-202](#). The following details shall apply:

- a. Radiographic quality: Sufficient definition to determine that specimens are free from defects specified in [3.7](#).
- b. Image-quality indicator: A sample part of the same type as the part being radiographed that contains either an actual or simulated defect which is at least 10 percent smaller than the smallest defect to be detected.
- c. Positions of specimen: Two views perpendicular to the terminal axis. After first view, specimen shall be rotated 90 degrees for the second view.
- d. Evaluation of images.
 - (1) Special kind of viewing equipment: Magnifying glass.
 - (2) Magnification: 10X.
 - (3) Defects to be sought in specimen: As specified in [3.7](#).

4.7.4 Thermal shock (see 3.8). Capacitors and retainers shall be tested in accordance with [method 107 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Test condition letter: Unless otherwise specified, B, except that during step 3, capacitors shall be conditioned at the high ambient test temperature (see [3.1](#)).
- b. Measurements before and after cycling: Not applicable.

4.7.5 Seal (see 3.9). Capacitors shall be tested in accordance with [method 112 of MIL-STD-202](#). The following details shall apply:

- a. Test condition letter: As specified, see [3.1](#).
- b. Examination after test: Capacitors shall be visually examined for evidence of leakage.

4.7.5.1 Seal - alternative test (see 3.9). For capacitors with a liquid impregnant, the following seal test may be substituted: Capacitors shall be placed on a clean sheet of absorbent paper and exposed to the applicable high ambient test temperature for a minimum of 1 hour. The capacitor shall then be visually examined for evidence of leakage of impregnant or filling compounds or bubbles from the seal. Capacitors to be subjected to the salt spray (corrosion), and immersion tests may be excluded from the seal test until after the salt spray (corrosion), and immersion tests are completed.

4.7.6 Dielectric withstanding voltage (see 3.10).

4.7.6.1 Capacitors (see 3.10.1). Capacitors shall be tested in accordance with [method 301 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Magnitude of test voltage: As specified in [table XV](#).
- b. Nature of potential: DC.
- c. Duration of application of test voltage: As specified in [table XV](#).
- d. Points of application of test voltage: As specified in [table XV](#).
- e. Examinations after test: Capacitors shall be visually examined for evidence of breakdown, arcing, or other visible damage.

MIL-PRF-19978L

4.7.6.2 Sleeving (See 3.10.2) (when applicable, see 3.1). With the capacitor horizontally mounted, a single loop of No. 20 AWG wire shall be secured around the insulating sleeve of the capacitor so that it extends downward from the capacitor 3 inches (76.2 mm) minimum, and the two ends of the wire twisted in about three cross turns. A 1-pound minimum weight shall then be suspended from the looped wire. After exposure in this position for a minimum of 24 hours, at the maximum rated temperature $\pm 3^{\circ}\text{C}$, a dc voltage of 4,000 volts minimum, shall be applied between the case and the looped wire. The rate of voltage application shall be 500 volts per second and the duration of application of test voltage shall be 15 seconds, minimum.

TABLE XV. Dielectric-withstanding-voltage test details.

Circuit-diagram symbol	Circuit diagram	Test points	Test connections	Magnitude of test voltage (percent rated dc voltage)	Duration of application of voltage (minutes)
1		Terminal to terminal Terminal to case <u>3/</u>	1 to 2 1 and 2 to case	200 <u>1/</u> 200	1 <u>2/</u> 1
3		Terminal to terminal	1 to 2 or 1 to case	200 <u>1/</u>	1 <u>2/</u>

1/ 175 percent rated dc voltage after immersion, and moisture resistance tests.

2/ For the 100-percent inspection specified in 4.6.1.2, the capacitors shall be subjected, at the option of the manufacturer, to the application of 250 percent of rated dc voltage for not less than 5 seconds, or 200 percent for not less than 15 seconds.

3/ For quality conformance inspection, application of potential may be made between each terminal individually and the case.

4.7.7 Barometric pressure (reduced) (see 3.11) (when applicable, see 3.1), qualification only. Capacitors shall be tested in accordance with method 105 of MIL-STD-202. The following details and exceptions shall apply:

- Method of mounting: By normal mounting means.
- Test condition: Unless otherwise specified (see 3.1), capacitors shall be subjected to a pressure of 0.82 inch of mercury (80,000 feet).
- Test during subjection to reduced pressure: Unless otherwise specified (see 3.1), a potential equal to that specified in table XVI, as applicable, shall be applied for at least 1 minute between test points specified (see 3.1). A suitable means shall be used to detect momentary or permanent breakdown. Capacitors shall then be visually examined for evidence of damage (see 6.5.5).

TABLE XVI. Barometric-pressure test potentials.

Case diameter (Inch (mm))	DC voltage (max) (Volts) <u>1/</u>
.175 (4.45)	200
.195 (4.95)	200
.235 (5.97)	300
.312 (7.92)	430
.400 (10.16)	500
.562 (14.27) and up	640

1/ The dc voltage shall be limited to 200 percent of the dc voltage rating at maximum rated temperature.

MIL-PRF-19978L

4.7.8 Insulation resistance (see [3.12](#)). Capacitors shall be tested in accordance with [method 302 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Test potential:
 - (1) Insulating sleeves: When applicable (see [3.1](#)). Test condition B.
 - (2) Terminal to terminal and terminal to case: A potential equal to the rated dc voltage (see [3.1](#)) or 500 V dc, whichever is less.
- b. Special conditions: The time constant of the measurement circuit with the capacitor connected shall not exceed 30 seconds.
- c. Points of measurement:
 - (1) Insulating sleeves: The test potential shall be applied between the case and a piece of metal foil placed around the insulating sleeve; the metal foil shall be of such dimension as to allow at least .125 inch ([3.18 mm](#)) surface exposure of the insulating sleeve on each end (see [3.12.1](#)).
 - (2) Terminal to terminal: Insulation resistance shall be measured between terminals at the maximum rated temperature, $\pm 3^{\circ}\text{C}$, and at $+25^{\circ}\text{C} \pm 3^{\circ}\text{C}$ (see [3.12.2](#)).
 - (3) Terminals to case: When the case is not a terminal, the measurement shall be made between each terminal and the case at $+25^{\circ}\text{C} \pm 3^{\circ}\text{C}$ (see [3.12.3](#)).
- d. Electrification time: 2 minutes.

4.7.9 Capacitance (See [3.13](#)). Capacitors shall be tested in accordance with [method 305 of MIL-STD-202](#). The following details shall apply:

- a. Test frequency: 1,000 Hertz (Hz) ± 100 Hz for capacitors whose nominal capacitance does not exceed 1 μF and whose dc voltage rating does not exceed 3,000 volts. For capacitors not within these limits, measurements shall be made at a frequency of 100 Hz ± 6 Hz or corrected thereto.
- b. Limit of accuracy: Shall be within ± 0.1 percent.

4.7.10 Dissipation factor (see [3.14](#)). The dissipation factor shall be measured with an ac voltage not greater than 20 percent of the dc voltage rating, at a frequency of 1,000 ± 100 Hz, for capacitors whose nominal capacitance does not exceed 1 μF and whose dc voltage rating does not exceed 3,000 volts. For capacitors not within these limits, measurements shall be made at a frequency of 100 Hz ± 6 Hz or corrected thereto. Measurement accuracy shall be one of the following:

- a. For dial reading: ± 2 percent of dial reading or .001, whichever is greater.
- b. For digital readout: ± 0.001 percent ± 2 percent of reading.

4.7.11 Vibration (see [3.1](#) and [3.15](#)).

4.7.11.1 Low frequency. Capacitors shall be tested in accordance with [method 201 of MIL-STD-202](#). 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, except that capacitors without mounting retainers in sizes 1.562 inch (39.67 mm) long or .670 inch (17.02 mm) in diameter or larger shall

MIL-PRF-19978L

be mounted by a supplemental means other than the wire leads. Wire-Lead capacitors shall be secured .5 inch \pm .125 inch (12.7 mm \pm 3.18 mm) from the case. The extraneous leads beyond the .5 inch (12.7 mm) securing point may be removed or supplemental support may be added.

- c. Duration of vibration: For tubular styles: 4 hours (2 hours in each of 2 mutually perpendicular planes). For rectangular styles: 6 hours (2 hours in each of 3 mutually perpendicular planes).
- d. Test and measurements during vibration: During the last 30 minutes of vibration in each direction, a signal of 1 kilohertz (kHz) \pm 0.2 kHz at a level of 1 volt \pm 0.5 volt shall be placed across the capacitor and measured with suitable ac detecting equipment to determine open-circuits or short-circuits, or intermittent contacts. The accuracy of the detecting equipment shall be sufficient to detect any interruption with a duration of 0.5 ms or greater.
- e. Examination after vibration: Capacitors shall be visually examined for evidence of mechanical damage.

4.7.11.2 High frequency. Capacitors and retainers shall be tested in accordance with [method 204 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Mounting of specimens: Capacitors shall be rigidly mounted by the body to a vibration test apparatus. Wire-lead capacitors shall be secured .5 inch \pm .125 inch (12.7 mm \pm 3.18 mm) from the case. The extraneous leads beyond the .5 inch (12.7 mm) securing point may be removed or supplemental support may be added.
- b. Electrical-load conditions: During the test, a potential of 125 percent of the dc rated voltage shall be applied between the terminals of the capacitor.
- c. Test condition letter: B, with exception as specified (see [3.1](#)).
- d. Measurements: During the last cycle in each direction, a signal of 1 kHz \pm 0.2 kHz at a level of 1 volt \pm .05 volt shall be placed across the capacitor and measured with a suitable ac recording device (a permanent record is not necessary for this test) to determine open- or short-circuits, or intermittent contacts. The accuracy of the detecting equipment shall be sufficient to detect any interruption with a duration of 0.5 ms or greater.
- e. Measurements and examination after vibration: After the test, with capacitors still mounted on the vibration jig, the insulating sleeve shall be tested for dielectric withstanding voltage, as specified in [4.7.6](#), with a potential of 2,000 V dc between the case and bracket. Capacitors and retainers shall be visually examined for evidence of mechanical damage.

4.7.12 Salt spray (corrosion) (see [3.16](#)). Capacitors and retainers shall be tested in accordance with [method 101 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Applicable salt solution: The salt solution concentration shall be 5 percent.
- b. Test condition letter: B (48 hours).
- c. Examination after exposure: Capacitors and retainers shall be visually examined for evidence of harmful corrosion, unwrapping of, or mechanical damage to insulating sleeves (when applicable), and obliteration of marking.

4.7.13 Immersion (see [3.17](#)). Capacitors and retainers shall be tested in accordance with [method 104 of MIL-STD-202](#). The following details shall apply:

- a. Test condition letter B.
- b. Measurements after final cycle: For capacitors with insulating sleeves, dielectric withstanding voltage, and insulation resistance at +25°C shall be measured as specified in [4.7.6](#) and [4.7.8](#), respectively. The test potential shall be applied between the case and a piece of metal foil placed around the insulating sleeve; the

MIL-PRF-19978L

metal foil shall be of such dimension as to allow at least .125 inch (3.18 mm) surface exposure of the insulating sleeve on each end. In addition, dielectric withstanding voltage and insulation resistance at +25°C of all capacitors shall be measured as specified in 4.7.6 and 4.7.8, respectively. Capacitors and retainers shall then be examined for harmful or extensive corrosion and obliteration of marking.

- c. Examination after immersion: Capacitors shall be inspected for evidence of extensive corrosion and unwrapping of, or mechanical damage to the insulating sleeves, when applicable.

4.7.14 Solderability (wire leads only, see 3.1) (see 3.18). Capacitors shall be tested in accordance with [method 208 of MIL-STD-202](#). The following details shall apply:

- a. Number of terminations to be tested: Both leads of the capacitor shall be subjected to the solderability test.
- b. Depth of immersion in flux and solder: The leads shall be immersed to within .125 inch (3.18 mm) of the capacitor body.

4.7.15 Shock (specified pulse) (see 3.19). Capacitors and retainers shall be tested in accordance with [method 213 of MIL-STD-202](#). The following details shall apply:

- a. Mounting: The body of the capacitor shall be securely fastened by mounting retainers. The leads shall be soldered to rigidly supported terminals so spaced that the length of each lead from the capacitor shall be .5 inch \pm .125 inch (12.7 mm \pm 3.18 mm) from the edge of the supporting terminal.
- b. Test condition letter: I (100 g's).
- c. Electrical loading during shock: During the test, a potential of 125 percent of the dc voltage rating shall be applied between the terminals of the capacitor.
- d. Measurements during shock: During the test, observations shall be made to determine intermittent contact or arcing or open-circuiting 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 evidence of breakdown, arcing, fractures, or any other visible mechanical damage. Retainers shall be visually examined for mechanical damage.

4.7.16 Terminal strength (see 3.20). Capacitors shall be tested in accordance with [method 211 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Test condition letter: As specified (see 3.1).
- b. Examination after test: The capacitors and terminals shall be examined for mechanical damage.

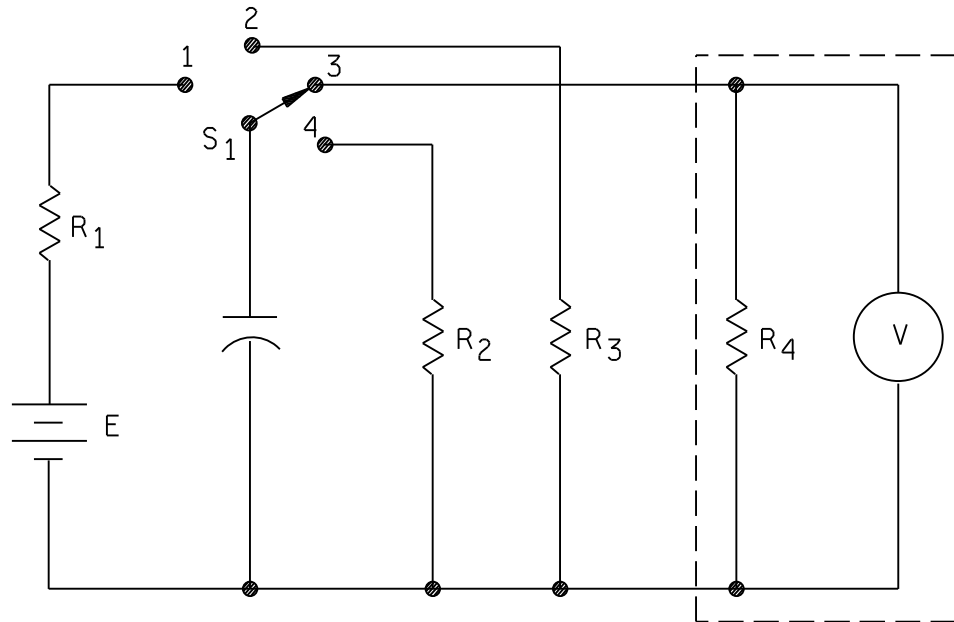
4.7.17 Dielectric absorption (see 3.21), (when specified, see 3.1). The capacitor shall be charged at the dc voltage rating for 1 hour \pm 1 minute. The initial surge current shall not exceed 50 milliamperes. At the end of this period, the capacitor shall be disconnected from the power source and discharged through a 5 ohm \pm 5 percent resistor for 10 seconds \pm 1 second. The discharge resistor shall be disconnected from the capacitor at the end of the 10 second discharge period, and the voltage remaining on the capacitor (recovery voltage) shall be measured with an electrometer or other suitable device having an input resistance of 10,000 megohms or greater. Recovery voltage shall be read at the maximum voltage within a 15 minute period. The dielectric absorption shall be computed from the following formula.

$$d = \frac{V_1 \times 100}{V_2}$$

Where: d = Percent dielectric absorption.
 V_1 = Maximum recovery voltage.
 V_2 = Charging voltage.

For an alternate production test method see [figure 1](#).

MIL-PRF-19978L



- E = dc rated dc voltage or 100 volts dc, whichever is less (± 2 percent).
 R_1 and R_2 = 1,000 ohms ± 20 percent. (This is not critical.)
 R_3 = 5 ohms ± 1 percent.
 R_4 = 10,000 megohms, minimum.

Suggest use of $\pm 1230A$ GR electrometer or equivalent set to 10,000 megohms range input resistance.

NOTES:

1. Charge for 5 minutes ± 10 seconds with switch in position 1.
2. Switch in position 2 for 5 seconds ± 0.5 second.
3. Switch in position 3 for 1 minute.
4. After 1 minute read recovery voltage and compute as a percentage of charge voltage.
5. Switch to position 4, discharge and remove.

FIGURE 1. Typical production dielectric absorption test method.

4.7.18 Stability at low and high temperatures (see 3.22). Capacitors shall be placed in a chamber maintained at $65^\circ\text{C} \pm 0^\circ\text{C}$, -5°C or $-55^\circ\text{C} \pm 0^\circ\text{C}$, -5°C (as applicable, see 3.1), and a potential equal to the dc rated voltage shall be applied at this condition for 48 hours ± 4 hours. The air within the conditioning chamber shall be circulated. Before capacitors are moved from the conditioning chamber, capacitance shall be measured at the applicable low temperature (see 3.1) as specified in 4.7.9. Capacitance shall then be measured at the following temperature as specified in 4.7.9. (The measurement at each temperature shall be recorded when two successive readings taken at 5-minute intervals indicate no change in capacitance.)

$+25^\circ\text{C} \pm 5^\circ\text{C}$
 High ambient test temperature (see 3.1)
 $+25^\circ\text{C} \pm 5^\circ\text{C}$

After the test, capacitors shall be visually examined for evidence of breakdown, arcing, open-circuiting and short-circuiting, and other visible mechanical damage.

MIL-PRF-19978L

4.7.19 Temperature coefficient (see 3.23) (characteristic P only, see 3.1). Capacitance measurements shall be made after the capacitors have been stabilized at each of the following temperatures: -65°C, +25°C, and the high ambient test temperature (see 3.1). Stability shall be indicated when no change exists in two capacitance measurements made at 5-minute intervals. Temperature coefficient shall be computed from the following formula:

$$T_C = \frac{(C_2 - C_1) 10^6}{(T_2 - T_1) C_1}$$

Where:

- T_C = temperature coefficient in ppm/°C.
- C_1 = capacitance at +25°C in pF.
- C_2 = capacitance at test temperature in pF.
- T_1 = +25°C.
- T_2 = test temperature in degrees C.

TABLE XVII. Life test in hours

NON-ER capacitors			
Characteristic	Qualification	Group B	
All characteristics except M M	240 +48, -0 <u>1</u> / 2,000 +72, -0	240 +48, -0 <u>1</u> / 2,000 +72, -0	
ER capacitors			
Style	Qualification	Group B	Extended life
CQR39, 42, and 43	240 +48, -0	240 +48, -0	---
FRLs M, P, R, S, for all styles except CQR39, 42, and 43	2,000 +72, -0	2,000 +72, -0	4,000 +72, -0

1/ Test time for characteristic K tubular capacitors with voltage rating of 1,000 volts shall be 500 ± 12 hours.

4.7.20 Life (see 3.24).

4.7.20.1 Life test (qualification inspection). Capacitors shall be tested in accordance with [method 108 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Distance of temperature measurements from specimens, inches: Not applicable.
- b. Test temperature and tolerance: At the applicable high-test temperature, +4°C, -0°C (see 3.1).
- c. Operating conditions: Capacitors shall be subjected to 140 percent of the rated dc voltage. The surge current shall be limited to between 5 milliamperes and 1 ampere. When necessary, a suitable current-limiting resistor shall be used.
- d. Test duration: See [table XVII](#).
- e. Measurements during and after exposure: At the conclusion of the test, the capacitors shall be returned to the inspection conditions specified in 4.3 and shall be visually examined for evidence of mechanical damage and obliteration of marking; insulation resistance at +25°C, capacitance, and dissipation factor shall be measured as specified in 4.7.8, 4.7.9, and 4.7.10, respectively.

4.7.20.2 Life test (group B inspection) (see 3.24). Except as specified in the following, capacitors shall be tested as specified in 4.7.20.1.

- a. Test duration: See [table XVII](#).
- b. Measurements during and after exposure: Measurements, as specified in 4.7.20.1e, shall be taken at the following intervals of exposure: During the first hour; 240 hours +48 hours, -0 hours; and where applicable, 1,000 hours +48 hours, -0 hours; and 2,000 hours +72 hours, -0 hours.

MIL-PRF-19978L

4.7.20.3 Extended life (see 3.24). Sample units that have been subjected to 2,000 hours of life test as specified in 4.7.20.1 and 4.7.20.2, shall remain on test for an additional 4,000 hours +72 hours. -0 hours. After completion of the 6,000-hour life test time capacitors shall be measured as specified in 4.7.20.1e.

4.7.21 Fungus (see 3.25). Capacitors shall be tested in accordance with method 508 of MIL-STD-810. Pretest and post-test measurements are not required.

4.7.22 Resistance to solvents (see 3.26) Capacitors shall be tested in accordance with method 215 of MIL-STD-202. The following details shall apply:

- a. Portion of specimen to be brushed: That portion on which marking is present.
- b. Number of specimens to be tested: As specified in applicable inspection tables.
- c. Permissible extent of damage: As specified in 3.26.

4.7.23 Resistance to soldering heat (see 3.27) (applicable to wire-lead capacitors only). Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details shall apply:

- a. Test condition letter: C
- b. Cooling time prior to measurement after test: 10 minutes \pm 1 minute.
- c. Measurements after test: Insulation resistance, capacitance, and dissipation factor shall be measured at +25°C \pm 3°C as specified in 4.7.8, 4.7.9, and 4.7.10, respectively.

4.7.24 Moisture resistance (see 3.28). Capacitors and retainers shall be tested in accordance with method 107 of MIL-STD-202, test condition A, except that no measurement shall be made before and after cycling. Capacitors shall then be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

- a. Initial measurements: Not applicable.
- b. Polarization voltage: During steps 1 through 6, inclusive, a dc potential of 100 volts shall be applied across the terminals of 50 percent of the capacitors. No potential shall be applied to the remaining 50 percent of the capacitors.
- c. Loading voltage: Not applicable.
- d. Final measurements: After the final cycle, the capacitors shall be conditioned at +25°C \pm 5°C and a relative humidity of 50 percent \pm 5 percent for a period of at least 22 hours but not more. Dielectric withstanding voltage and insulation resistance at +25°C shall be measured on insulating sleeves as specified in 4.7.6 and 4.7.8, respectively. The test potential shall be applied between the case and a piece of metal foil placed around the insulating sleeve. The metal foil shall be of such dimension as to allow at least .125 inch (3.18 mm) surface exposure of the insulating sleeve on each end. In addition, dielectric withstanding voltage, insulation resistance, capacitance, and dissipation factor at +25°C, of all capacitors shall be measured as specified in 4.7.6, 4.7.8, 4.7.9, and 4.7.10, respectively.

After the test, capacitors and retainers shall be visually examined for evidence of harmful corrosion and obliteration of marking; capacitors shall be examined for unwrapping of or mechanical damage to insulated sleeves, when applicable.

4.7.25 Flashpoint of impregnant or filling compound (see 3.29). The flashpoint of impregnant or filling compound shall be measured as specified in ASTM D92, except that the fire point and precision do not apply. "Impregnant or filling compound" shall be substituted for the word "oil" throughout the test method.

MIL-PRF-19978L

5. PACKAGING.

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of material is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. 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. Capacitors covered by this specification are intended for use in electronic equipment. Capacitors covered by this specification are unique due to the fact that these devices must be able to operate satisfactorily in military systems under the following demanding conditions: 15 G's of high and low frequency vibration, 100 G's of shock (specified pulse), operate in extreme temperatures (-65°C to +170°C), and operate in moist environments. These capacitors also offer high reliability that is verified under a qualification system. Commercial components are not designed to withstand these military environmental conditions.

6.1.1 Polystyrene dielectric capacitors (characteristic P). Capacitors of polystyrene dielectric, because of their low dielectric absorption and radiofrequency losses, are intended primarily for use in calculators, computers, integrators, time-base oscillators, laboratory standards, and other pulse applications. The outstanding characteristics of these capacitors are low temperature coefficient and stability.

6.1.2 Polyethylene terephthalate dielectric capacitors (characteristic M). Capacitors of polyethylene terephthalate dielectric are intended for use in high temperature applications similar to those served by hermetically sealed paper capacitors, but where higher insulation resistance at the upper temperature limits is required.

6.1.3 Paper and polyethylene terephthalate dielectric capacitors (characteristics E, F, G, and K). Capacitors of paper and polyethylene terephthalate dielectric are intended for applications where small case sizes and high temperature operation are required.

6.1.4 Polytetrafluoroethylene dielectric capacitors (characteristic T). Capacitors of polytetrafluoroethylene dielectric are intended for high temperature applications where high insulation resistance, small capacitance change, and low dielectric absorption are required. These capacitors exhibit excellent insulation resistance values at high temperatures.

6.1.5 Polycarbonate dielectric capacitors (characteristic Q) (obsolete). Capacitors of polycarbonate dielectric are especially suitable for use in tuned circuits and precision timing due to their capacitance stability and minimum capacitance change with temperature. Characteristic Q capacitors are no longer available in this specification due to a lack of source (see 6.1.6).

6.1.6 Polyphenylene sulfide foil dielectric capacitors (characteristic V). Capacitors of polyphenylene sulfide foil dielectric are intended as alternatives for polycarbonate dielectric capacitors (obsolete characteristic Q) (see 6.1.5).

6.2 Acquisition data. Acquisition documents should specify the following:

- a. Title, number, and date of this specification.
- b. Title, number, and date of the applicable specification sheet and the complete PIN (see 1.2.1 and 3.1).
- c. Whether removable mounting retainers are to be supplied with capacitors (see 3.1).
- d. If remarking of parts is required to indicate FRL (see 3.30.5).

MIL-PRF-19978L

e. Packaging requirements (see 5.1).

6.3 Definitions.

6.3.1 Liquid-impregnated capacitor. A liquid-impregnated capacitor is a capacitor in which a liquid impregnant is dominantly contained within the capacitor element, but does not occupy substantially all of the case volume not required by the capacitor element and its connection.

6.3.2 Liquid-filled capacitor. A liquid-filled capacitor is a capacitor in which a liquid impregnant occupies substantially all of the case volume not required by the capacitor element and its connections. Space may be allowed for the expansion of the liquid with temperature variations.

6.3.3 Nonmagnetic case capacitor. A nonmagnetic case capacitor is a capacitor in which no part of the case or retainer is made of magnetizable material; however, the end seal may be made of a material having a ferrous metal content in order to affect a glass-to-metal seal.

6.3.4 Hermetic seal. For the purpose of this specification, a hermetically sealed capacitor is one in which the capacitive element is contained within a sealed enclosure of ceramic, glass or metal, or combinations thereof, where sealing is accomplished by material fusion, welding, brazing, or soldering. The capacitor must be capable of passing the seal test specified in 4.7.5 or of meeting a leak-rate requirement of not more than 1.76×10^6 cubic centimeters (cm^3) per second, when determined by any other method having sensitivity equal to or better than the stated limit. When capacitors are tested as specified in 4.7.5, there must be no continuous visible stream of bubbles.

6.4 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in the Qualified Products List (QPL) whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from DLA Land and Maritime, ATTN: VQP, PO Box 3990, Columbus, OH 43218-3990, or by email to vqp.chief@dla.mil. An online listing of products qualified to this specification may be found in the Qualified Products Database (QPD) at <https://assist.dla.mil>.

6.5 Application information.

6.5.1 Mounting. Capacitors covered by this specification should be mounted by a retainer or clasp or should be potted when vibration or shock are likely to be encountered in service.

6.5.2 Voltage derating with temperature (for characteristic M). Characteristic M tubular capacitors may be used in applications up to $+125^\circ\text{C}$ with voltage derating as indicated in figure 2. However, insulation resistance requirements at $+125^\circ\text{C}$ cannot be expected to exceed 100 megohm-microfarads; greater capacitance change may be encountered, and life expectancy of the unit will be reduced.

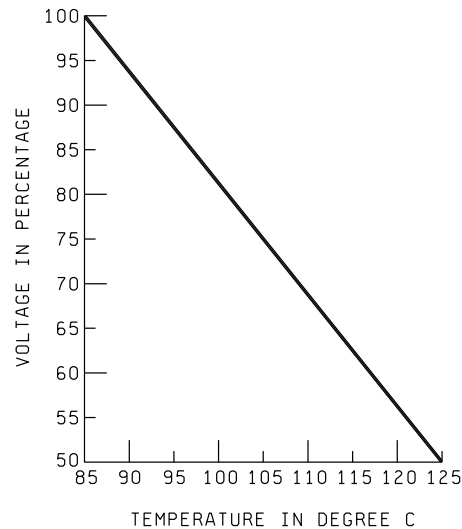
6.5.3 Energy content (in watt-seconds). The energy content of a fully charged dc capacitor is determined by the following formula:

$$W = \frac{CE^2}{2}$$

Where: W = energy content in watt-seconds.
C = nominal capacitance in farads.
E = dc voltage rating in volts.

6.5.4 AC component. The rating given is the steady-state dc voltage, or the sum of the dc voltage and the peak ac voltage, provided that the peak ac voltage does not exceed 20 percent of the rating at 60 Hz, 15 percent at 120 Hz, or 1 percent at 10,000 Hz. Where heavy transient or pulse currents are encountered, the requirements of this specification are not sufficient to guarantee satisfactory performance, and due allowance must therefore be made in the selection of a capacitor.

MIL-PRF-19978L

FIGURE 2. Intended operating temperature.6.5.5 Barometric pressure (reduced) (see 4.7.7).

6.5.5.1 Ceramic-cased or glass-cased tubular capacitors. The dc voltage that may be applied to ceramic-cased or glass-cased tubular capacitors at altitudes from 50,000 to 100,000 feet may be obtained from figure 3.

6.5.5.2 Metal-cased tubular capacitors. The dc voltage that may be applied to metal-cased tubular capacitors at altitudes other than 80,000 feet may be obtained from figure 4, except that the dc voltage rating must not be exceeded.

6.5.6 Representation of minimum insulation resistance. A graphical representation of minimum insulation resistance, as specified in the applicable specification sheet, is shown in figure 5.

6.5.7 Life at temperatures and voltages below and above rated. The failure rates used in this specification are referred to operation at rated voltage at the maximum rated temperature. The sampling plans and failure-rate determinations throughout the specification assume an acceleration factor of 5 for the life test conducted at the maximum rated temperature and 140 percent of rated voltage. Lower failure rates than those for which the manufacturer has obtained qualification may be achieved by operating the capacitors at lower voltage, or at lower temperatures, or both. Factors by which failure rates are to be multiplied under conditions other than maximum conditions are shown on figure 6 (characteristic K only).

MIL-PRF-19978L

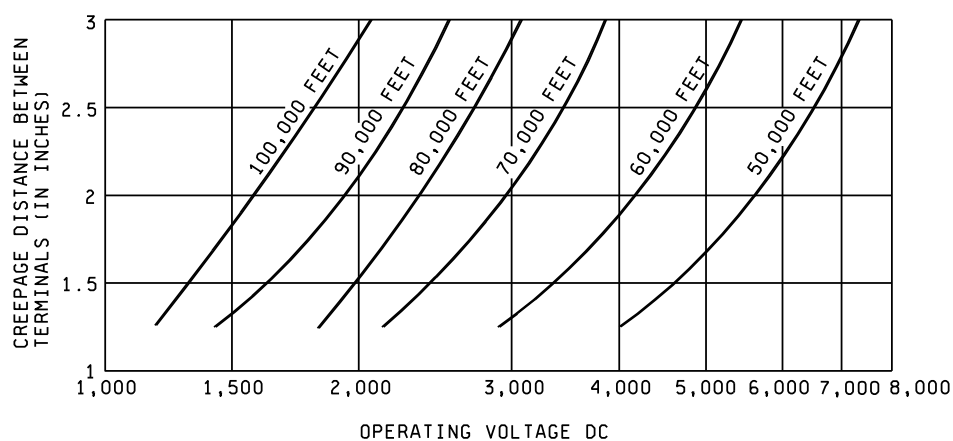


FIGURE 3. Permissible operating voltage at altitudes from 50,000 to 100,000 feet.

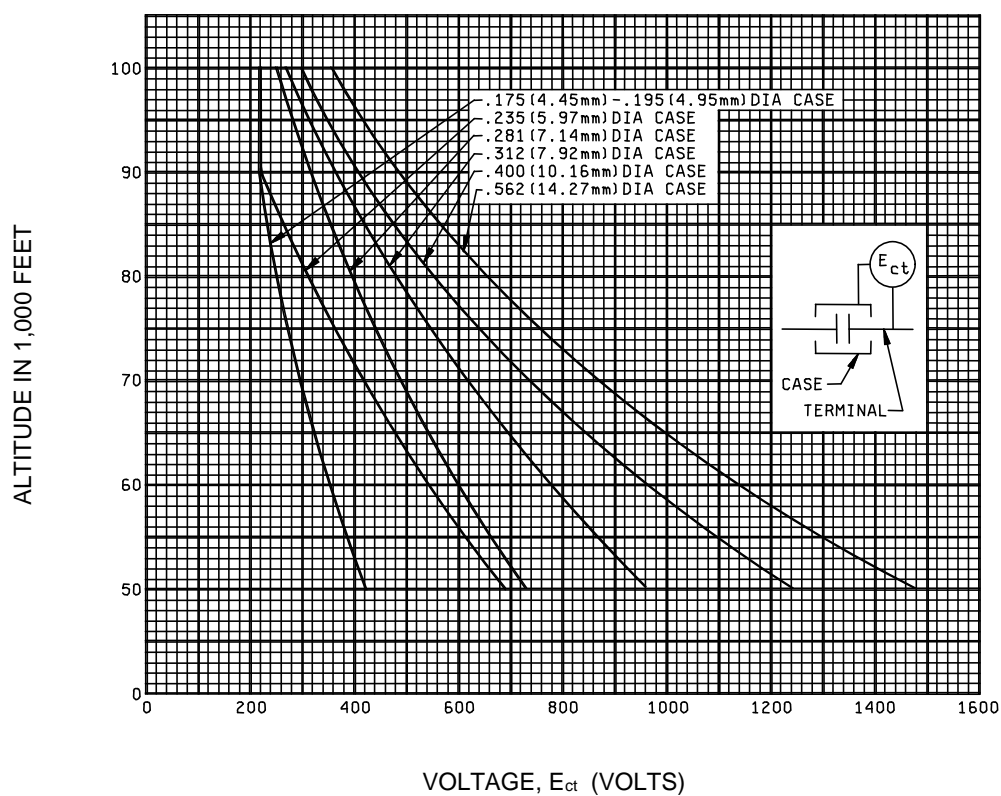


FIGURE 4. Permissible operating voltage at altitudes other than 80,000 feet (metal-cased tubular).

MIL-PRF-19978L

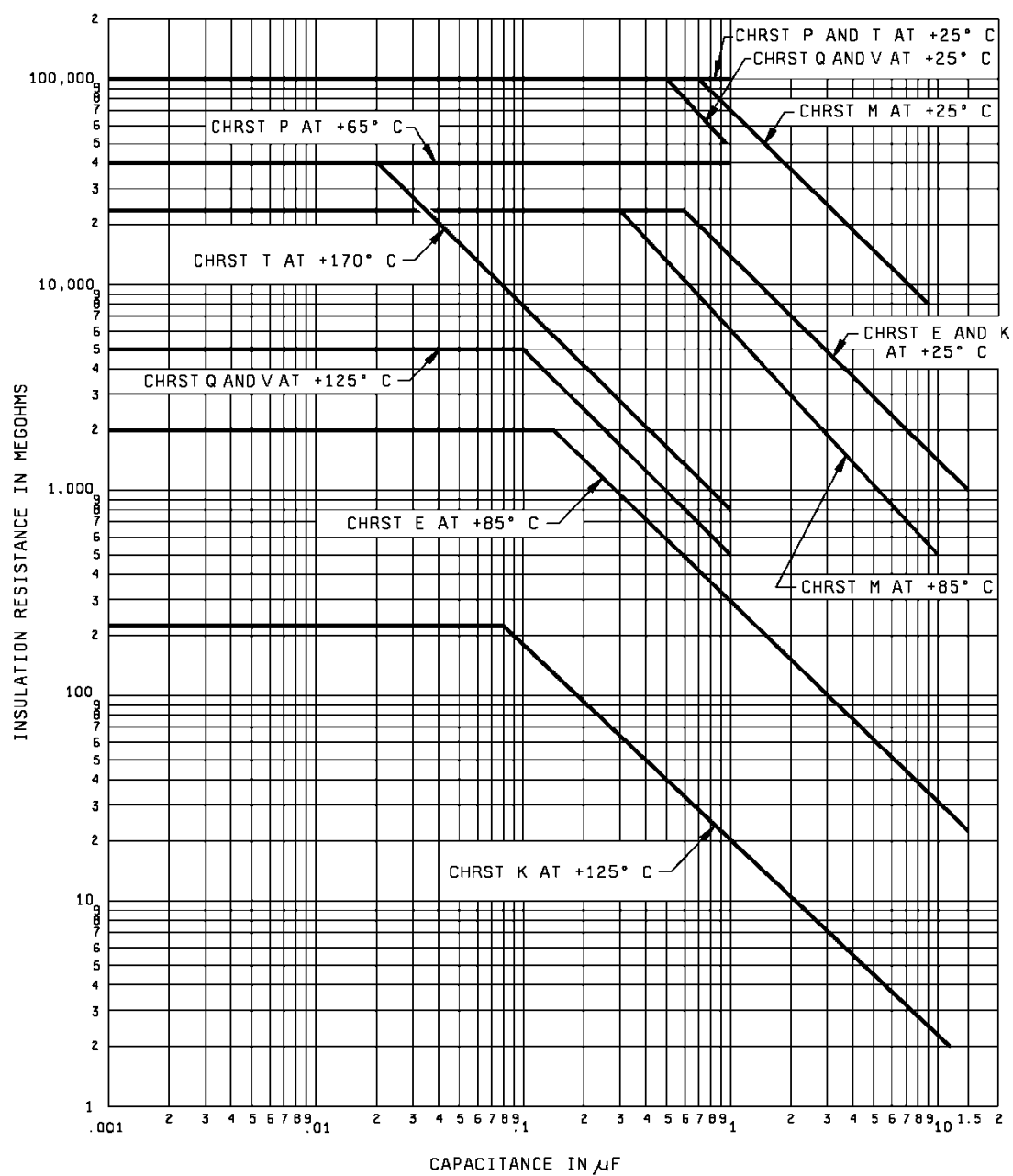
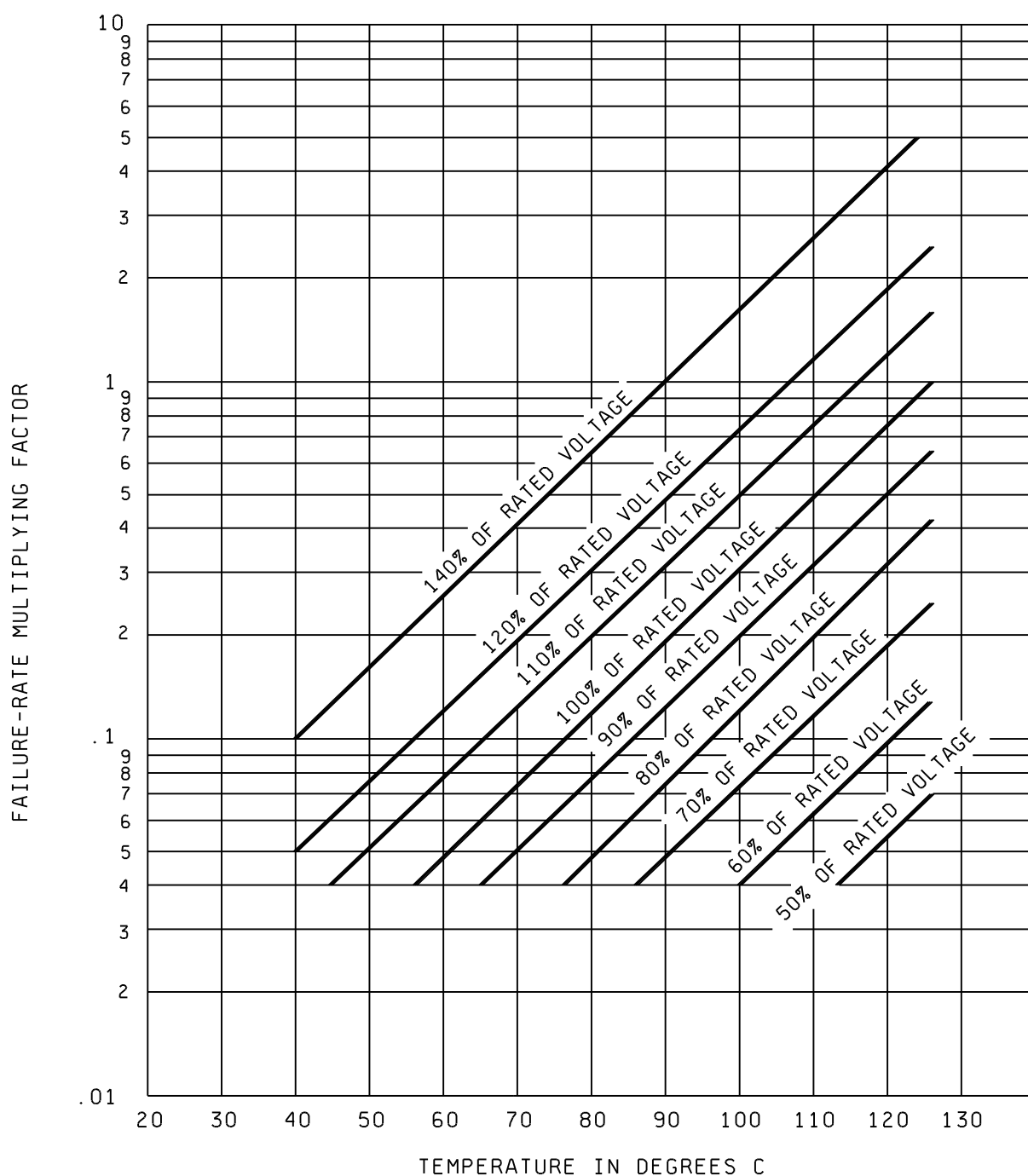


FIGURE 5. Graphical representation of minimum insulation resistance by dielectric as specified in the applicable specification sheet.

MIL-PRF-19978L



NOTES: Curves for 100 percent of rated voltage and higher are based on the 5th power rule and curves for 90 percent of rated voltage and below are based on the 4th power rule.

FIGURE 6. Life at temperature and voltages relative to percent rating (characteristic K only).

MIL-PRF-19978L

6.6 Failure rate L. Failure rate L has been canceled from this specification.

6.7 Tin whisker growth (see [3.5.3.5](#)). The use of alloys with tin content greater than 97 percent, by mass, may exhibit tin whisker growth problems after manufacture. Tin whiskers may occur anytime from a day to years after manufacture 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).

6.8 PIN. This specification requires a PIN that describes codification and classification and appropriate references to associated documents (see [1.2](#) and [3.1](#)).

6.9 Subject term (key word) listing.

Part Per Million (ppm)
Statistical process control (SPC)

6.10 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.

MIL-PRF-19978L

APPENDIX A

PROCEDURE FOR QUALIFICATION INSPECTION

A.1 SCOPE

A.1.1 Scope. This appendix details the procedure for submission of samples for qualification inspection of capacitors covered by this specification. The procedure for extending qualification of the required sample to other capacitors covered by this specification is also outlined herein. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

A.2 APPLICABLE DOCUMENTS

A.2.1 General. The documents listed in this section are specified in sections A.3 and A.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 A.3 and A.4 of this specification, whether or not they are listed.

A.2.2 Government documents.

A.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.

DEPARTMENT OF DEFENSE STANDARDS

[MIL-STD-1276](#) - Leads for Electronic Component Part

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

A.2.3 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 specification 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.

A.3 SUBMISSION

A.3.1 Single-type capacitor submission. The following details apply:

- a. Sample size: As specified in table IX.
- b. Sampling criteria: Sample units of the same style, terminal, circuit, characteristic, rated voltage, capacitance, capacitance tolerance, and vibration grade will be submitted.
- c. Extent of qualification:
 - (1) Circuit diagram 1 will qualify circuit diagram 3 in the same capacitor design.
 - (2) Qualification in one characteristic does not constitute qualification in any other characteristic.
 - (3) Any capacitance tolerance may represent all other authorized capacitance tolerances.
 - (4) Vibration grade 3 will qualify vibration grade 1 provided that the designs of the capacitors are the same.
 - (5) Qualification of insulated styles will be the basis for qualification of uninsulated styles of the same design.

MIL-PRF-19978L

APPENDIX A

- (6) Styles CQ09, CQ13, CQR09, CQR13, CQR19, CQR29, CQR33, CQR39, and CQR43 require individual voltage and characteristic qualification. Style CQ09 will qualify styles CQ08, and CQ12; CQR09 will qualify style CQR12; CQR29 will qualify CQR32, and CQR39 will qualify CQR42, provided the type submitted has the same impregnant or filling compound. The highest capacitance value submitted in each voltage rating will confer qualification of all units of the same style and lesser capacitance with the same voltage rating.

Style CQ20 qualification is limited to the watt-second rating qualified and lesser values in the same voltage rating.

Qualification of ER styles will qualify applicable non-ER styles of the same characteristic, voltage rating, and case size.

Qualification of style CQ72 is restricted to those capacitance values and voltage ratings equal to and less than the ratings represented within the same watt-second group of the submission. Except type CQ72D1ES105K3 will qualify units in the same watt-second group (characteristic E) with 12,500 volt ratings provided that type CQ72D1ET105K3 qualification is complete; otherwise, type CQ72D1ET504K3 will qualify lesser watt-second ratings of 12,500 volt units in characteristic E. Type CQ72D1KT254K3 will qualify type CQ72D1KS504K3 rated at 25 watt-seconds. Terminal style E4 will represent E3.

Qualification approval granted for one of the lower failure rate levels will include qualification approval for all of the higher failure rate levels as indicated in table A-I.

TABLE A-I. FRL qualification data.

Failure rate level	Will qualify failure rate level
S	S, R, P, M
R	R, P, M
P	P, M
M	M

A.3.2 Combined type submission. Qualification of the types submitted will be a basis for qualification of the style represented, based on the same provisions stated in A.3.1 with the following exceptions: Voltage ratings are grouped in table A-II for the styles shown; samples are divided equally between the two voltage ratings of each group. Voltage ratings not listed in the table are qualified separately. Styles are grouped as shown in [table A-III](#).

TABLE A-II. Voltage rating groups.

Styles CQ09, CQ13, CQR09, CQR13, CQR19, CQR29, CQR33, CQR39, CQR43	Style CQ20
Voltage rating 600 and 400 200 and 100 50 and 30	Voltage rating 15000 and 12500 10000 and 7500 5000 and 3000 2000 and 1000

NOTE: In view of the relatively few sample units of each type represented, a combined-type submission will be treated similarly to a single-type submission, and the failure of one type will disqualify the entire submission.

MIL-PRF-19978L

APPENDIX A

TABLE A-III. Examples of combined-type submissions. 1/

Styles	Types to be submitted	Number of sample units to be submitted	DC voltage rating	Watt-second rating
CQ08, CQ09, CQ12, and CQ13	CQ09A1KC105J3	23	200	.0200
	CQ13A1KC105J3	23	200	.0200
	CQ09A1KE474J3	23	400	.0376
	CQ13A1KF474J3	23	600	.0846
	CQ09A1KG474J3	23	1,000	.235
	CQ13A1KG474J3	23	1,000	.235
	CQ09A1MZ106J3	23	30	.0045
	CQ13A1MA125J3	23	50	.0015
	CQ09A1MB685J3	23	100	.0340
	CQ13A1MC105J3	23	200	.0200
	CQ09A1ME105J3	23	400	.0800
	CQ13A1MF684J3	23	600	.1224
	CQ09A1MG224J3	23	1,000	.110
	CQ13A1MG224J3	23	1,000	.110
	CQ09A1PA105J3	23	50	.00125
	CQ13A1PA105J3	23	50	.00125
	CQ09A1PC474J3	23	200	.0094
	CQ13A1PC474J3	23	200	.0094
	CQ09A1PE154J3	23	400	.0120
	CQ13A1PF224J3	23	600	.0396
	CQ09A1TC104J3	23	200	.0020
	CQ13A1TC104J3	23	200	.0020
	CQ09A1TE334J3	23	400	.0264
	CQ13A1TF154J3	23	600	.0275
CQ20	CQ20A1KG105K1	23	1,000	.500
	CQ20C1KJ684K1	23	2,000	1.36
	CQ20A1KL334K1	23	3,000	1.485
	CQ20C1KN154K1	23	5,000	2.375
	CQ20-1KR683K1	23	7,500	1.862
	CQ20-1KS393K1	23	10,000	1.950
	CQ20-1KT223K1	23	12,500	1.714
CQ72	CQ20-1KU153K1	23	15,000	1.688
	CQ72B1EG105K3	23	1,000	.5
	CQ72E1KG105K3	23	1,000	.5
	CQ72E1EN104K3	23	5,000	1.25
	CQ72D1ES104K3	23	10,000	5.0
	CQ72D1KS104K3	23	10,000	5.0
	CQ72D1ES105K3	23	10,000	50.0
	CQ72D1KT254K3	23	12,500	19.531
	CQ72D1ET105K3	23	12,500	78.125

See footnote at end of table.

MIL-PRF-19978L

APPENDIX A

TABLE A-III. Examples of combined-type submissions - Continued. 1/

Styles	Types to be submitted	Number of sample units to be submitted	DC voltage rating	Watt-second rating
CQR09, CQR12, and CQR13	CQR09A1KC105J3M	41	200	.020
	CQR13A1KC105J3M	41	200	.020
	CQR09A1KE474J3M	41	400	.0376
	CQR13A1KF474J3M	41	600	.0846
	CQR09A1KG474J3M	41	1,000	.235
	CQR13A1KG474J3M	41	1,000	.235
CQR19	CQR19A1KD105J3M	41	300	.045
	CQR19A1KE105J3M	41	400	.080
	CQR19A1KF474J3M	82	600	.0846
CQR29, CQR32, and CQR33	CQR29A1MZ106J3M	41	30	.0045
	CQR33A1MA125J3M	41	50	.0015
	CQR29A1MB685J3M	41	100	.0340
	CQR33A1MC105J3M	41	200	.0200
	CQR29A1ME105J3M	41	400	.0800
	CQR33A1MF684J3M	41	600	.1224
	CQR29A1MG224J3M	41	1,000	.1100
	CQR33A1MG224J3M	41	1,000	.1100
CQR39, CQR42, and CQR43	CQR39A1KB105K3M	41	100	.0050
	CQR43A1KC105K3M	41	200	.0200
	CQR39A1KE474K3M	41	400	.0376
	CQR43A1KF474K3M	41	600	.0846
	CQR39A1KG474K3M	41	1,000	.2350
	CQR42A1KG474K3M	41	1,000	.2350
CQ05 and CQ10	CQ05A1KE105K3	23	400	.08
	CQ10A1KE105K3	23	400	.08
	CQ05A1KG474K3	23	1,000	.235
	CQ10A1KG474K3	23	1,000	.235
CQ11	CQ11A1KE474K3	23	400	.04
	CQ11A1KF684K3	23	600	.122
CQR44	CQR44A1VA105J3M	82	50	.00125
	CQR44A1VB105J3M	41	100	.005
	CQR44A1VC684J3M	41	200	.0136
	CQR44A1VE474J3M	41	400	.0376
	CQR44A1VF224J3M	41	600	.0432

1/ This table is set up as a guide; for other combinations, reference is made to the text.

A.3.3 Impregnant of filling compound. A minimum of .25 pound of each impregnant or filling compound used in the sample units for which qualification is sought shall be submitted.

A.4 SOLDER DIP (RETNING) LEADS

A.4.1 Solder dip (retinning) leads. The manufacturer (or authorized category C distributor) may solder dip/retin the leads of product supplied to this specification provided the solder dip process or an equivalent process has been approved by the qualifying activity.

MIL-PRF-19978L

APPENDIX A

A.4.2 Qualifying activity approval. Approval of the solder dip process will be based on one of the following options.

- a. When the original lead finish qualified was hot solder dip lead finish 52 of [MIL-STD-1276](#), the manufacturer shall use the same solder dip process for retinning as is used in the original manufacture of the product. (NOTE: The 200 microinch maximum thickness requirement is not applicable.)
- b. When the lead originally qualified was not hot solder dip lead finish 52 of [MIL-STD-1276](#) as prescribed in A.4.2a, approval for the process to be used for solder dip shall be based on the following test procedure:
 - (1) Thirty samples of any capacitance value for each style and lead finish are subjected to the manufacturer's solder dip process. Following the solder process, the capacitors shall be subjected to the electrical tests of group A inspection. No defects are allowed.
 - (2) Ten of the 30 samples shall then be subjected to the solderability tests. No defects are allowed.
 - (3) The remaining 20 samples shall be subjected to the resistance to soldering heat test followed by the moisture resistance test. No defects are allowed.

A.4.3 Solder dip/retinning options. The manufacturer (or authorized category C distributor) may solder dip/retin as follows:

- a. As a corrective action if the lot fails the group A solderability test.
- b. After the group A inspection has been completed and, following the solder dip/retinning process, the capacitance, DF, and IR (at +25°C) measurements shall be performed on 100 percent of the lot. The percent defective allowable (PDA) for the electrical measurements shall be as for the subgroup 1 tests. (NOTE: If x-ray and hermetic seal are required in the group A, subgroup 1 tests, these tests shall be repeated.) Following these tests, the manufacturer shall submit the lot to the group A solderability test as specified in 4.7.14.

MIL-PRF-19978L

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

Preparing activity:
DLA - CC

(Project 5910-2016-020)

Review activities:
Navy - MC
Air Force - 19, 71, 99

| 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 the ASSIST Online database at <https://assist.dla.mil/>.