

INCH-POUND

MIL-PRF-55514G
6 September 2013
SUPERSEDING
MIL-PRF-55514F
15 December 2005

PERFORMANCE SPECIFICATION

CAPACITORS, FIXED, PLASTIC (OR METALLIZED PLASTIC) DIELECTRIC, DC OR DC-AC, IN NONMETAL CASES, NON-ESTABLISHED AND ESTABLISHED RELIABILITY GENERAL SPECIFICATION FOR

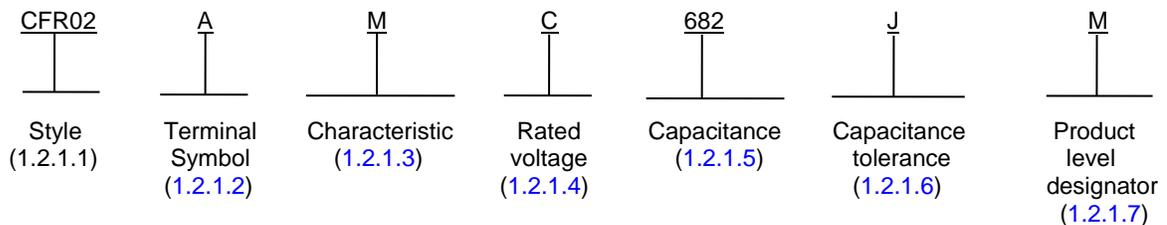
This specification is approved for use by all Departments
and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for established reliability (ER) and non-established reliability (non-ER), (product level C), plastic (or metallized plastic) dielectric, fixed capacitors, enclosed in nonmetal cases intended primarily, in view of the limited long term moisture resistant characteristics, for use in potted or encapsulated systems, in blocking, filter, and by-pass applications (see 6.4). ER capacitors covered by this specification have failure rate levels (M, P, R, and S) ranging from 1.0 percent to 0.001 percent per 1,000 hours. These failure rates (FR) are established at a 90-percent confidence level and maintained at a 10-percent producer's risk and based on life tests performed at +85°C or +105°C, whichever is applicable. An acceleration factor of 5:1 has been used to relate life test data obtained at 125 percent, or 140 percent of rated voltage at +85°C or +105°C, whichever is applicable, to rated voltage at +85°C or +105°C, whichever is applicable. The product levels are based on catastrophic failures and failures occurring outside the degradation limits.

1.2 Classification. Capacitors covered by this specification are classified by style (see 1.2.1.1 and 3.1).

1.2.1 Part or Identifying Number (PIN). The term Part or Identifying Number (PIN) is equivalent to the term (part number, identification number, and type designator) that was previously used in this specification. The PIN is in the following form and as specified (see 3.1).



1.2.1.1 Style. The style is identified by the three-letter symbol "CFR" followed by a two-digit number; the letters identify ER and non-ER, plastic dielectric fixed capacitors in nonmetal cases.

Comments, suggestions, or questions on this document should be addressed to: US Army Communications-Electronics Command, ATTN: RDER-PRQ-QE, Aberdeen Proving Ground, MD 21015 or e-mailed to usarmy.APG.cerdec.mbx.standardization-crx@mail.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.dla.mil>.

1.2.1.2 Terminal symbol. The terminal is identified by a single letter as shown in table I.

TABLE I. Terminal symbol.

Symbol	Terminal
A	Axial wire-lead
R	Radial wire-lead
L	Lugs

1.2.1.3 Characteristic. The characteristic is identified by a single letter as shown in table II.

TABLE II. Characteristic.

Characteristic	Construction		Operating temperature range
	Dielectric material	Electrode	
K	Polypropylene	Foil	-55°C to +105°C
L	Polypropylene	Metallized polypropylene	-55°C to +105°C
M	Polyethylene terephthalate	Foil	-55°C to + 85°C
N	Polyethylene terephthalate	Metallized polyethylene terephthalate	-55°C to + 85°C
Q	Polycarbonate	Foil	-55°C to +125°C <u>1/</u>
R	Polycarbonate	Metallized polycarbonate	-55°C to +125°C <u>1/</u>
U	Polyphenylene sulfide	Metallized polyphenylene sulfide	-55°C to +125°C <u>1/</u>
V	Polyphenylene sulfide	Foil	-55°C to +125°C <u>1/</u>

1/ For operation at +125°C, characteristics Q, R, U and V capacitors are voltage derated (see table III).

1.2.1.4 Rated voltage. The rated voltage is identified by a single symbol as shown in table III.

TABLE III. Voltage rating.

Symbol	DC voltage rating at +85°C <u>1/</u>	Characteristics Q and V DC voltage rating at +125°C	Characteristics R and U DC voltage rating at +125°C
A	50	33.3	25
B	100	66.7	50
C	200	133.3	100
D	300	200.0	150
E	400	266.7	200
F	600	400.0	300
G	75	50.0	37.5
H	150	100.0	75
J	25	16.7	12.5
K	250	166.7	125
L	800	533.3	400

1/ DC voltage rating for characteristics K and L at +105°C are the same as those at +85°C.

1.2.1.5 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.

NOTE: Tabulated capacitance values expressed in microfarads (μ F) are given for information only (see 3.1).

1.2.1.6 Capacitance tolerance. The capacitance tolerance is identified by a single letter as shown in table IV.

TABLE IV. Capacitance tolerance.

Symbol	Capacitance tolerance percent (\pm)
F	1
G	2
J	5
K	10
M	20

1.2.1.7 Product level designator. The product level designator is identified by a single letter as shown in table V.

TABLE V. Failure rate level (FRL) (established at a 90-percent confidence level).

Symbol	FRL
C	non-ER
M	1.0 $\frac{1}{1}$
P	0.1 $\frac{1}{1}$
R	0.01 $\frac{1}{1}$
S	0.001 $\frac{1}{1}$

$\frac{1}{1}$ FRL (percent per 1,000 hours).

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.

DEPARTMENT OF DEFENSE SPECIFICATIONS

(See [supplement 1](#) for list of associated specification sheets.)

DEPARTMENT OF DEFENSE STANDARDS

- [MIL-STD-202](#) - Test Methods for Electronics and Electrical Component Parts
- [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-1276](#) - Leads for Electronic Component Parts
- [MIL-STD-1285](#) - Marking of Electrical and Electronic Parts

(Copies of these documents are available online at <http://quicksearch.dla.mil/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

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.

TECHAMERICA

- EIA-554-1 - Assessment of Average Outgoing Quality Levels in Parts Per Million (PPM)
- EIA-557 - Statistical Process Control Systems

(Copies of these documents are available from <http://www.techamerica.org> or from TechAmerica, 601 Pennsylvania Ave. NW, North Building Ste. 600, Washington DC, 20004-2650.)

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.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the 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 (see 4.4 and 6.3). In addition, the manufacturer shall obtain certification from the qualifying activity that the reliability assurance requirements of 4.1 have been met and are being maintained. Authorized distributors which are approved to MIL-STD-790 distributor requirements by the QPL manufacturers are listed in the QPL.

3.3 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-790 and MIL-STD-690 (ER only). In addition the manufacturer shall also establish a SPC and PPM system that meets the requirements as detailed in 3.3.1 and 3.3.2 respectively. The following MIL-STD-790 exceptions are allowed:

- a. Under "Description of production processes and controls", the procedure for identification of each production lot shall include only "the manufacturer shall as a minimum be able to identify the time period during which the final production operation was performed on each item of product prior to final test. The date or lot code marked on each part shall be identified to a production lot."
- b. "Traceability" of materials shall not apply.

3.3.1 SPC system. As part of the overall MIL-STD-790 QPL system, the manufacturer shall establish an SPC system that meets the requirements of EIA-557.

3.3.2 PPM system. As part of the overall MIL-STD-790 QPL system, the manufacturer shall establish a ppm system of assessing the average outgoing quality of lots in accordance with EIA-554-1. Data exclusion, in accordance with 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 6-month moving average. Style reporting may include both ER and non-ER style combinations.

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

3.4.1 Insulating and sealing materials. Compounds and films used in the insulating and sealing of capacitors shall be chemically inactive with respect to the capacitor element. The material, either in state of original application or as a result of having aged, shall have no adverse effect on the performance of the capacitors.

3.4.2 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. Tin shall be alloyed with a minimum of 3 percent lead (see 6.8). Lead-free, tin alloy high temperature solders may be used where high temperature solder is necessary with the approval of the qualifying activity. The tin content of lead-free high temperature solders shall not exceed 97 percent, by mass.

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

3.5.1 Case. Each capacitor shall be enclosed in a nonmetal case which will protect the capacitor element from moisture, impregnant leakage, and mechanical damage under the test conditions specified herein. Cardboard shall not be used for insulating purposes.

3.5.2 Terminals. Terminals shall be of a solid conductor, of the length and diameter specified (see 3.1), and shall be suitably treated to facilitate soldering. When a coating containing tin is used, the tin content shall range between 40 percent and 70 percent.

3.5.2.1 Solder dip (retinning) leads. Only the manufacturer (or his authorized category B or category C distributor) may solder dip/retin the leads of product supplied to this specification provided the solder dip process has been approved by the qualifying activity.

3.5.2.2 Qualifying activity approval. Approval of the solder dip process shall 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 (NOTE: The 200 microinch maximum thickness is not applicable.), the manufacturer shall use the same solder dip process for retinning as is used in the original manufacture of the product.
- b. When the lead originally qualified was not hot solder dip lead finish 52 of MIL-STD-1276, as prescribed in 3.5.2.2a, 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 dip process, the capacitors are subject to the capacitance, dissipation factor, insulation resistance, dielectric withstanding voltage, and equivalent series resistance measurements (as applicable). No defects are allowed.
 - (2) Ten of the 30 samples are then subjected to the solderability test. No defects are allowed.
 - (3) The remaining 20 samples are subjected to the resistance to solder heat test. No defects are allowed. (NOTE: Solder dip of gold plated leads is not allowed.)

3.5.2.3 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, following the solder dip/retinning process, the capacitance, dissipation factor, insulation resistance, dielectric withstanding voltage, and equivalent series resistance measurements (as applicable) 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. Following these tests, the manufacturer shall submit the lot to the group A solderability test as specified in 4.8.16.

3.6 Resistance to solvents. When capacitors are tested as specified in 4.8.2, markings shall remain legible and shall not smear.

3.7 Preconditioning. When tested as specified in 4.8.3, capacitors shall withstand the test conditions specified without evidence of unwrapping of the capacitor case or sleeve or other damage to the case.

3.8 Burn-in (when specified, see 3.1). When tested as specified in 4.8.4, capacitors shall withstand the exposure to high temperature and overvoltages without visible damage.

3.9 Insulation resistance. Unless otherwise specified (see 3.1), when measured as specified in 4.8.5, the insulation resistance shall be not less than the applicable value specified in table VI, and as shown on figure 1. The value of insulation resistance varies with temperature, and a correction factor obtained in accordance with table VII shall be applied, when necessary, by multiplying the value measured by the correction factor.

3.10 Dielectric withstanding voltage. When capacitors are tested as specified in 4.8.6, there shall be no momentary or intermittent arcing or other indication of breakdown, nor shall there be any visible evidence of damage.

3.11 Barometric pressure (reduced) for qualification only. When capacitors are tested as specified in 4.8.7, there shall be no momentary or intermittent arcing or other indication of breakdown, nor shall there be any visible evidence of damage.

3.12 Capacitance. When measured as specified in 4.8.8, the capacitance shall be within the applicable tolerance specified (see 3.1).

3.13 Dissipation factor (all styles except CFR13, CFR14, CFR26, CFR27, and CFR29). When measured as specified in 4.8.9, the dissipation factor shall not exceed the applicable value specified in table VIII.

3.14 Equivalent series resistance (ESR) (applicable to styles CFR13, CFR14, CFR26, CFR27, and CFR29). When measured as specified in 4.8.10, the ESR (in ohms) shall not exceed the value specified (see 3.1).

3.15 Resistance to soldering heat. When tested as specified in 4.8.11, capacitors shall meet the following requirements:

- a. Capacitance: Shall change not more than ± 5 percent from the initial measured value.
- b. Dissipation factor (at +25°C): Shall be as specified in 3.13.

3.16 Moisture resistance. When tested as specified in 4.8.12, capacitors shall meet the following requirements:

- a. Dielectric withstanding voltage: Shall be as specified in 3.10.
- b. Insulation resistance (at +25°C): Shall be not less than 50 percent of the requirement specified in table VI.
- c. Dissipation factor: Shall not exceed the requirements specified in table VIII.
- d. Capacitance: Shall change not more than 5.0 percent from the initial measured value.

3.17 Vibration (high frequency). When capacitors are tested as specified in 4.8.13, there shall be no evidence of mechanical damage, momentary or intermittent contacts of 0.5 millisecond (ms) or greater duration, or other indication of breakdown, nor shall there be any open-circuiting or short-circuiting or visible mechanical damage.

3.18 Shock (specified pulse). When capacitors are tested as specified in 4.8.14, there shall be no momentary or intermittent contacts of 0.5 ms or greater duration, or other indication of breakdown, nor shall there be any evidence of fractures or other visible mechanical damage.

3.19 Terminal strength. When capacitors are tested as specified in 4.8.15, there shall be no mechanical damage to the capacitor or terminals.

3.20 Solderability. When capacitors are tested as specified in 4.8.16, the criteria for evaluation shall be as specified in method 208 of MIL-STD-202.

TABLE VI. Insulation resistance.

Corresponding letter on figure 1	Capacitance	Minimum insulation resistance (terminal to terminal)
J	<u>Characteristics K and L</u> 0 μ F to .5 μ F Greater than .5 μ F	At +25°C 400,000 megohms 200,000 megohm-microfarads <u>1/</u>
D	0 μ F to .5 μ F Greater than .5 μ F	At +85°C 20,000 megohms 10,000 megohms-microfarads <u>1/</u>
A	0 μ F to .5 μ F Greater than .5 μ F	At +105°C 2,000 megohms 1,000 megohm-microfarads <u>1/</u>
K	<u>Characteristics M</u> 0 μ F to .1 μ F Greater than .1 μ F	At +25°C 500,000 megohms 50,000 megohm-microfarads <u>1/</u>
F	0 μ F to .1 μ F Greater than .1 μ F	At +85°C 50,000 megohms 5,000 megohm-microfarads <u>1/</u>
I	<u>Characteristic N</u> 0 μ F to .25 μ F Greater than .25 μ F	At +25°C 200,000 megohms 50,000 megohm-microfarads <u>1/</u>
E	0 μ F to .1 μ F Greater than .1 μ F	At +85°C 35,000 megohms 3,500 megohm-microfarads <u>1/</u>
L	<u>Characteristic Q</u> 0 μ F to .2 μ F Greater than .2 μ F	At +25°C 500,000 megohms 100,000 megohm-microfarads <u>1/</u>
H	0 μ F to .1 μ F Greater than .1 μ F	At +85°C 100,000 megohms 10,000 megohms-microfarads <u>1/</u>
C	0 μ F to .1 μ F Greater than .1 μ F	At +125°C 10,000 megohms 1,000 megohm-microfarads <u>1/</u>
L	<u>Characteristic R</u> 0 μ F to .2 μ F Greater than .2 μ F	At +25°C 500,000 megohms 100,000 megohm-microfarads <u>1/</u>
G	0 μ F to .1 μ F Greater than .1 μ F	At +85°C 70,000 megohms 7,000 megohms-microfarads <u>1/</u>
B	0 μ F to .1 μ F Greater than .1 μ F	At +125°C 7,000 megohms 700 megohm-microfarads <u>1/</u>
M	<u>Characteristics U and V</u> 0 μ F to .2 μ F Greater than .2 μ F	At +25°C 100,000 megohms 20,000 megohm-microfarads <u>1/</u>
G	0 μ F to .1 μ F Greater than .1 μ F	At +85°C 70,000 megohms 7,000 megohms-microfarads <u>1/</u>
B	0 μ F to .1 μ F Greater than .1 μ F	At +125°C 7,000 megohms 700 megohm-microfarads <u>1/</u>

1/ Product obtained by multiplying the capacitance (in μ F) by the measured insulation resistance (in megohms).

TABLE VII. Insulation resistance correction factors.

Correction factor	Temperature, (°C)	Correction factor	Temperature, (°C)
2.00	15	.94	26
1.87	16	.87	27
1.74	17	.82	28
1.62	18	.76	29
1.52	19	.71	30
1.42	20	.67	31
1.33	21	.63	32
1.24	22	.59	33
1.16	23	.55	34
1.08	24	.51	35
1.00	25		

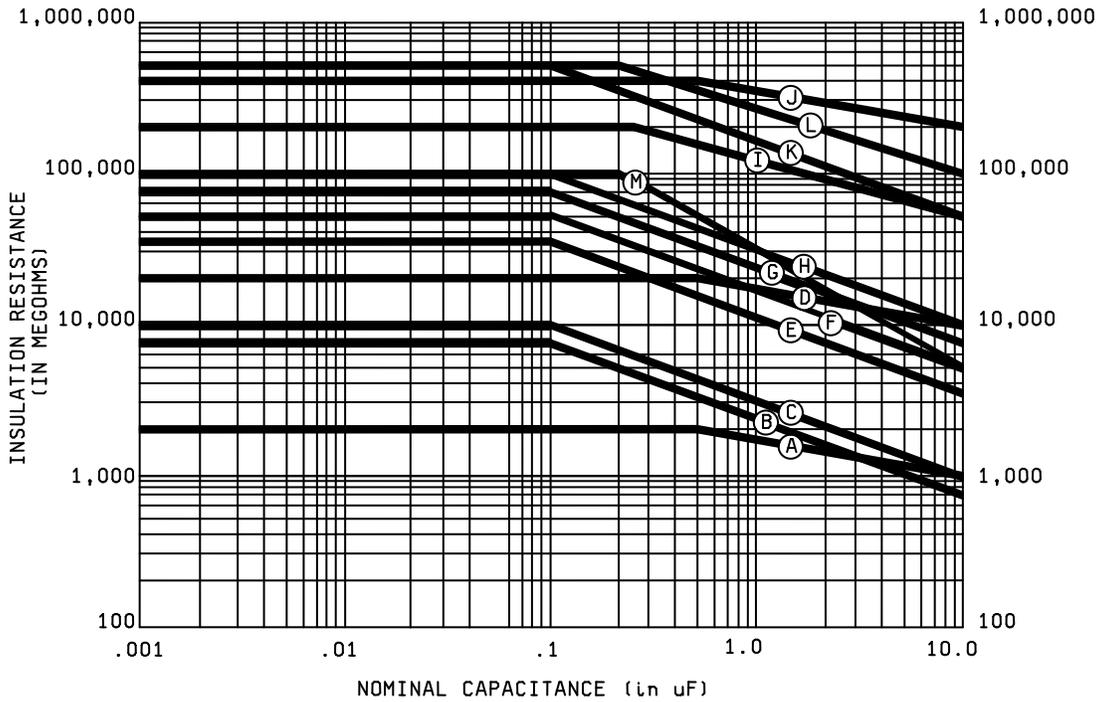


FIGURE 1. Graphical representation of minimum insulation resistance.

TABLE VIII. Dissipation factor.

Characteristic	Dissipation factor at (%)			
	+25°C	+85°C	+105°C	+125°C
K	0.1	0.1	0.1	
L	0.1	0.1	0.1	
M	0.75	0.85		
N	1.0	1.0		
Q	0.3	0.3		0.3
R	0.3	0.3		0.3
U	0.3	0.3		0.3
V	0.3	0.3		0.3

3.21 AC conditioning (when specified, see 3.1). When tested as specified in 4.8.17, capacitors shall withstand the ac voltage and current exposure without visible damage.

3.22 Low-temperature conditioning and capacitance change with temperature. When capacitors are tested as specified in 4.8.18, there shall be no indication of breakdown or arcing, nor shall there be any open-circuiting or short-circuiting or any visible evidence of mechanical damage. The capacitance shall change not more than the applicable values specified in table IX (the initial +25°C capacitance value (see 3.12) shall be used for determination of the capacitance change). In addition (for qualification testing only), the insulation resistance shall equal or exceed the minimum value specified in table VI for the high test temperature and the dissipation factor shall not exceed the applicable value for the high test temperature as specified in table VIII.

TABLE IX. Capacitance change with temperature.

Characteristic	Capacitance change (in percent) from +25°C value			
	-55°C	+85°C	+105°C	+125°C
K ^{1/}	0 to +2.0	0 to -1.5	0 to -2.5	
L	0 to +2.0	0 to -2.5	0 to -3.5	
M	0 to -10.0	0 to +10.0		
N	0 to -10.0	0 to +10.0		
Q	0 to -2.5	±1.0		+2.0 to -1.0
R	0 to -2.5	±1.0		+2.0 to -1.0
U	±2.5	±1.0		+2.0 to -1.0
V	±2.5	±1.0		+2.0 to -1.0

^{1/} For 800 volt units, the capacitance change shall be: 0 to +2.0 at -55°C, 0 to -2.5 at +85°C, and 0 to -3.5 at +105°C.

3.23 Thermal shock and immersion. When tested as specified in 4.8.19, capacitors shall meet the following requirements:

- a. Dielectric withstanding voltage: Shall be as specified in 3.10.
- b. Insulation resistance (at +25°C): Shall be not less than 50 percent of the value specified in table VI.
- c. Visual examination: Shall show no visible deterioration, permanent damage to terminals or case, or corrosion on terminals.

3.24 Life. When tested as specified in 4.8.20, capacitors shall meet the following requirements:

- a. Insulation resistance (at +25°C): Shall meet or exceed the initial requirement.
- b. Capacitance: Shall change not more than ±5 percent from the initial measured value (group I or subgroup 2).
- c. Dissipation factor (at +25°C): Shall not exceed the value specified (see 3.13).

3.25 Fungus. The manufacturer shall certify that all external materials are fungus resistant or shall perform the test specified in 4.8.21. When capacitors are tested as specified in 4.8.21, examination shall disclose no evidence of fungus growth on the external surface.

3.26 Marking. Capacitors shall be permanently and legibly marked with the PIN, "JAN" or "J" marking, date code, and manufacturer's name, trademark, or code symbol. In the event the manufacturer's name, trademark, or code symbol exceeds two characters, it may appear on the next line. Paper labels shall not be used. Other markings which in any way interfere with, obscure, or confuse those specified herein are prohibited. Markings shall remain legible after all tests.

3.26.1 PIN (see 1.2.1). There shall be no space between the symbols which comprise the PIN. When the size of the capacitor does not permit the PIN to be marked on one line, it may be divided into two or three lines as shown in the following examples:

Examples:	CFR02AM		CFR02
	C682JM	or	AMC
	J0045™		682JM
			J0045™

3.26.2 Date code. The date code shall be in accordance with MIL-STD-1285.

3.26.3 JAN and J marking. 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 to certification mark "JAN" shall bear the letter "J". The "JAN" or "J" shall be placed immediately before the part number except that if such location would place 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 the specification and the applicable specification sheets or associated specifications, 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 1,586,261 for the certification mark "J".

3.26.4 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable 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.

3.26.5 Substitutability of product levels. A manufacturer may supply to those product levels, as listed in table X, with FR higher than to which they are qualified. Parts with lower FR are substitutable, with the acquiring agency approval, for higher FR parts. The substitutable parts shall not be remarked unless specified in the contract or acquisition document (see 6.2). In the event that the parts are remarked, the lot date codes on the parts shall not be changed.

TABLE X. Product level substitutability.

Parts qualified to product level	Are substitutable for product level
S	C, M, P, and R,
R	C, M, and P
P	C and M
M	C
C	N/A

3.26.6 Supplying to looser capacitance tolerance and lower rated 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 acquisition document (see 6.2), the substitutable parts shall not be remarked.

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

4. VERIFICATION

4.1 QPL system. The manufacturer shall establish and maintain a QPL system as described in 3.3. Evidence of such compliance is prerequisite for qualification and retention of qualification.

4.2 Classification of inspections. The inspections specified herein are classified as follows:

- a. Qualification inspection (see 4.4).
- b. Verification of qualification (see 4.5).
- c. Conformance inspection (see 4.6).

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

4.3.1 Accuracy of voltage measurements. Accuracy of voltage measurements shall be within ± 2 percent of the specified voltage.

4.4 Qualification inspection (see 3.2). Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3) on sample units produced with equipment and procedures normally used in production. The decision as to whether or not the product is to be included on the QPL shall be made at the conclusion of the 2,000 hour life test.

4.4.1 Sample size. The number of sample units comprising a sample of capacitors to be submitted for qualification inspection shall be as specified in table XI, or in appendix A of this specification. The sample shall be taken from a production run and shall be produced with equipment and procedures normally used in production.

4.4.2 Test routine. The sample shall be subjected to the inspections specified in table XI, in the order shown. Except as specified below, all sample units shall be subjected to the inspections of group I (two sample units are to be subjected to the visual and mechanical examination, three sample units are to be subjected to the resistance to solvents examination, and the remaining sample units are to be subjected to the subsequent examinations of group I). The sample shall then be divided as specified in table XI for group II through group VI and subjected to the inspections for their particular group.

4.4.3 Failures. Failures in excess of those allowed in table XI shall be cause for refusal to grant qualification approval.

TABLE XI. Qualification inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected <u>1/</u>	Number of defects permitted <u>2/</u>	
<u>Group I</u> Visual and mechanical examination (internal): Material, design, construction, and workmanship	3.1, 3.4 to 3.5.2, 3.26 and 3.27	4.8.1	2	0	
Visual and mechanical examination (external) <u>3/</u> : Physical dimensions, marking and workmanship <u>4/</u>	3.1, 3.5, 3.5.1, 3.5.2, 3.26 and 3.27	4.8.1	120	0	
Resistance to solvents	3.6	4.8.2	3	0	
Preconditioning	3.7	4.8.3	117	1	
Burn-in (when specified, see 3.1)	3.8	4.8.4			
Insulation resistance (at +25°C)	3.9	4.8.5			
Dielectric withstanding voltage	3.10	4.8.6			
Barometric pressure (reduced)	3.11	4.8.7			
Capacitance	3.12	4.8.8			
Dissipation factor (at +25°C) <u>5/</u>	3.13	4.8.9			
Equivalent series resistance <u>6/</u>	3.14	4.8.10			
<u>Group II</u> Resistance to soldering heat	3.15	4.8.11	12	1	1
Moisture resistance	3.16	4.8.12			
Vibration, high frequency	3.17	4.8.13			
Shock (specified pulse)	3.18	4.8.14			
Terminal strength	3.19	4.8.15			
<u>Group III</u> Solderability	3.20	4.8.16	6	0	1
AC conditioning (when specified, see 3.1)	3.21	4.8.17			
<u>Group IV</u> Low temperature conditioning and capacitance change with temperature	3.22	4.8.18	12	1	
Thermal shock and immersion	3.23	4.8.19			
<u>Group V</u> Life (rated conditions)	3.24	4.8.20	50	1	
Life (accelerated conditions)	3.24	4.8.20	30		
<u>Group VI</u> Fungus <u>7/</u>	3.25	4.8.21	4	0	

1/ One additional sample unit is included in each sample size to permit substitution for the permitted defect in group I.

2/ A sample unit having one or more defects shall be considered as a single defect.

3/ Nondestructive examinations and tests.

4/ Marking defects are based on visual examination only and shall be charged only for illegible, incomplete, or incorrect marking.

5/ All styles except CFR13, CFR14, CFR26, CFR27, and CFR29.

6/ For styles CFR13, CFR14, CFR26, CFR27, and CFR29.

7/ Certification of fungus resistance may be substituted for testing.

4.4.4 FRL and quality level verification.

4.4.4.1 FR and lot conformance inspection (ER only). FR qualification and lot conformance FR inspection for ER parts shall be in accordance with the general and detailed requirements of [MIL-STD-690](#) and the following details:

- 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 V, [table XI](#) (see [4.4.2](#)).
- b. Procedure II: Extension of qualification to lower FRLs. To extend qualification to the P (0.1 percent) FRL, data from two or more voltages within style may be combined. To extend qualification to the "R" (0.01 percent) and "S" (0.001 percent) FRLs, data from two or more voltage ratings within a style 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.
- d. Procedure IV: Lot conformance FR inspection. Lot conformance FR procedures shall be in accordance with [4.7.1.2](#).

4.4.4.2 Quality level verification. The contractor is responsible for establishing a quality system to assess the ppm defect level of lots that are subjected to the group A inspections. The ppm defect level can be maintained for each specification sheet, or alternatively can combine all specification sheets. The ppm defect level shall be based on a 6-month moving average.

4.5 Verification of qualification. Every 6 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 10 percent or one lot, whichever is greater.
- d. The requirements for group B have been met.
- e. Verification of FRL's.
- f. PPM assessment. This information shall be submitted on a specification sheet basis.
- g. Continued qualification to non-ER (C level) shall be based upon continued maintenance of qualification for the ER part (FRL P).

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, a report shall be submitted certifying that the manufacturer still has 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 FRL. In the case where the lowest FR for an unproduced 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 Records. Maintenance of life test and FRL records shall be as specified in [MIL-STD-690](#).

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 from the same production line or lines, of the same style, rated voltage, dielectric material, and offered for inspection during a single work month. All sample units belonging to a lot shall be identified by means of a code symbol (either letters or numbers, at the option of the manufacturer).

4.6.1.1.2 Production lot. A production lot shall consist of capacitors of the same style, voltage rating, nominal capacitance value, and characteristic. 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. ER and non-ER lots shall be kept separate.

4.6.1.2 Group A inspection. Capacitors failing the tests of subgroup 1 shall be removed from the lot. If, during the 100 percent inspection, screening requires that more than 5 percent of the capacitors be discarded, the entire production lot shall be rejected.

4.6.1.2.1 Non-ER capacitors (C level). The manufacturer shall establish and maintain an inspection system to verify that capacitors meet the capacitance, dissipation factor, insulation resistance, dielectric withstanding voltage, equivalent series resistance (when applicable), visual/mechanical, and solderability requirements. In-line or process control may be a part of such system. The inspection system shall also include criteria for lot rejection and corrective actions. The inspection system shall be verified under the overall [MIL-STD-790](#) QPL system. NOTE: Since the Non-ER (C level) is the ER design without the mandatory conformance inspection and FRL assessment, the product is still expected to meet the environmental qualification type requirements such as moisture resistance and thermal shock.

4.6.1.2.2 ER capacitors. Group A inspection shall consist of the inspections specified in [table XII](#) and shall be made on the same set of sample units, in the order shown.

4.6.1.2.2.1 Subgroup 1 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 requires that more than 5 percent of the capacitors be discarded, the entire production lot shall be rejected. A failure is defined as capacitance value exceeding ± 20 percent of its nominal value, insulation resistance (IR) less than the specified limit, dissipation factor (DF) exceeding the specified limit, or an ESR value exceeding the specified limit, where applicable.

4.6.1.2.2.1.1 Manufacturer's production inspection. If the manufacturer performs tests equal to, or more stringent than, those specified in subgroup 1 as the final step of his manufacturing process, the subgroup 1 tests may be eliminated when approved by the qualifying activity. The following criteria shall be complied with:

- a. The manufacturer's production tests are identical to, or more stringent than, those specified for subgroup 1 tests.
- b. One hundred percent of the product shall be subjected to these tests.
- c. Failure criteria are identical to, or more stringent than, the subgroup 1 tests.
- d. The lot rejection criteria are identical to, or more stringent than, the subgroup 1 criteria.
- e. Once approved, future changes require approval from the qualifying activity.

TABLE XII. Group A inspection.

Inspection	Requirement paragraph	Test method paragraph	Sampling procedure
<u>Subgroup 1</u> Burn-in (when specified, see 3.1) Dielectric withstanding voltage Insulation resistance (at +25°C) Capacitance Dissipation factor (at +25°C) Equivalent series resistance (at +25°C) <u>1/</u>	3.8 3.10 3.9 3.12 3.13 3.14	4.8.4 4.8.6 4.8.5 4.8.8 4.8.9 4.8.10	100 percent inspection
<u>Subgroup 2</u> Mechanical examination external (dimensions only) <u>2/</u>	3.4	4.8.1	See table XIII
<u>Subgroup 3</u> Visual inspection: Marking <u>2/ 3/</u>	3.26	4.8.1	13 samples 0 failures
<u>Subgroup 4</u> Insulation resistance (at high operating temperature) Dissipation factor (at high operating temperature) Equivalent series resistance (at high operating temperature) <u>1/</u>	3.9 3.13 3.14	4.8.5 4.8.9 4.8.10	13 samples 0 failures
<u>Subgroup 5</u> <u>4/</u> Solderability	3.20	4.8.16	5 samples 0 failures

1/ For CFR13, CFR14, CFR26, CFR27 and CFR29 only.

2/ The manufacturer may request the deletion of the subgroup 2 mechanical examination external test and subgroup 3 visual inspection, provided an in-line or process control system for assessing and assuring the mechanical requirements and visual requirements are met, can be validated, and approved by the qualifying activity. Deletion of this examination and inspection does not relieve the manufacturer from meeting these requirements. 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.

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

4/ The manufacturer may request the deletion of the subgroup 5 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. 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

4.6.1.2.2.2 Subgroup 2.

4.6.1.2.2.2.1 Sampling plans. Subgroup 2 tests shall be performed on an inspection lot basis. Samples subjected to subgroup 2 shall be selected in accordance with [table XIII](#), based on the size of the inspection lot. In the event of one or more failures, the lot shall be rejected.

4.6.1.2.2.2.2 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, removed from the lot. A new sample of parts shall then be randomly selected in accordance with [table XIII](#). If one or more defects are found in this second sample, the lot shall be rejected and shall not be supplied to this specification.

4.6.1.2.2.3 Subgroup 3.

4.6.1.2.2.3.1 Sampling plan. Subgroup 3 tests shall be performed on inspected lot basis. The number of samples selected shall be in accordance with [table XII](#). In the event of one or more failures, the lot shall be rejected.

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

4.6.1.2.2.4 Subgroup 4.

4.6.1.2.2.4.1 Sampling plan. Subgroup 4 tests shall be performed on inspected lot basis. The number of samples selected shall be in accordance with [table XII](#).

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

4.6.1.2.2.5 Subgroup 5 tests (solderability), styles CFR26 and CFR27 not applicable.

4.6.1.2.2.5.1 Sampling plan. Five samples shall be selected randomly from each inspection lot and subjected to the solderability test. For solderability, all styles within a specification sheet may be combined. 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 defects, the lot shall be rejected.

4.6.1.2.2.5.2 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 4.6.1.2.2.5.1. 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 4.6.1.2.2.5.2b.
- b. The manufacturer submits the failed lot to a 100 percent solder dip using an approved solder dip process in accordance with [3.5.2.1](#). 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 shall be considered rejected and shall not be furnished against the requirements of this specification.

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

4.6.1.2.3 PPM calculations. The manufacturer shall establish a ppm system in accordance with 3.3.2 for assessing and calculating average outgoing quality of capacitors. A ppm rate combining capacitance, dissipation factor, insulation resistance (+25°C), dielectric withstanding voltage and equivalent series resistance 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.

4.7 Group B inspection (ER only). 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. Maximum and minimum case sizes shall be represented, as far as practical, in at least the approximate ratio of production.

TABLE XIV. Group B inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of failures allowed ^{1/}
<u>Subgroup 1 (every 3 months)</u> Low temperature conditioning and capacitance change with temperature ^{2/} Thermal shock and immersion ^{2/}	3.22 3.23	4.8.18 4.8.19	^{3/} 16	1
<u>Subgroup 1A (every month)</u> Life (at accelerated conditions)	3.24	4.8.20.2	10 minimum	
<u>Subgroup 1B (every 3 months) ^{4/}</u> Life at +125°C (proof test) characteristics Q, R, U and V	3.24	4.8.20.3.2	10	1
<u>Subgroup 1C (every 3 months)</u> AC conditioning (when specified, see 3.1)	3.21	4.8.17	(see 3.1)	5 percent
<u>Subgroup 2 (every 6 months)</u> Resistance to soldering heat ^{2/} Moisture resistance ^{2/} Vibration, high frequency ^{2/} Shock (specified pulse) ^{2/} Terminal strength ^{2/}	3.15 3.16 3.17 3.18 3.19	4.8.11 4.8.12 4.8.13 4.8.14 4.8.15	12	0
<u>Subgroup 2A (every 6 months)</u> Resistance to solvents	3.6	4.8.2	5	0

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

^{2/} 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.

^{3/} Six samples for characteristics K, L, M, and N.

^{4/} Proof test data may be used in FRL determination.

4.7.1 Sampling plan.

4.7.1.1 Subgroup 1 (all FRLs). Six (characteristics K, L, M and N) or sixteen (characteristics Q, R, U and V) sample units shall be taken from production every 3 months and subjected to the applicable tests. Allowable failures shall be as specified in table XIV.

4.7.1.2 Subgroup 1A (all FRLs). A minimum of 10 sample units shall be selected from each inspection lot produced during a 1-month period. Allowable failures shall be as specified in [MIL-STD-690](#). The accumulated data shall be used for maintenance and extension of FR qualification. The following may be combined: M, N, Q, and R dielectric styles; all styles within one specification sheet; styles CFR09 (/7) and CFR30 (/13).

4.7.1.3 Subgroup 1B (all FRLs). Ten sample units shall be selected from production every 3 months and subjected to the applicable test. Allowable failures shall be as specified in [table XIV](#).

4.7.1.4 Subgroup 2 and 2A (all FRLs). Seventeen sample units shall be taken from production every 6 months and subjected to the applicable tests for their particular subgroup. Styles, voltages and dielectric materials may be grouped. Allowable failures shall be as specified in [table XIV](#).

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

4.7.1.6 Noncompliance. If a sample fails to pass group B inspection, the manufacturer shall notify the qualifying activity and the 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, processes, etc., and which are considered subject to the same failure. Acceptance and shipment of the product shall be discontinued until corrective action, acceptable to the qualifying activity has been taken. After the corrective action has been taken, group B inspection shall be repeated on additional sample units (all inspection, or the inspection which the original sample failed, at the option of the qualifying activity). Group A inspection may be reinstated; however, final acceptance and shipment shall be withheld until the group B inspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure shall be furnished to the cognizant inspection activity and the qualifying activity.

4.8 Methods of examination and test.

4.8.1 Visual and mechanical examination. Capacitors shall be examined to verify that the materials, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see [3.1](#), [3.4](#), [3.5](#), [3.26](#), and [3.27](#)).

4.8.2 Resistance to solvents (see [3.6](#)). Capacitors shall be tested in accordance with [method 215 of MIL-STD-202](#). Brushing is not required.

4.8.3 Preconditioning (see [3.7](#)). Capacitors shall be exposed to a saturated steam atmosphere of 5 lb/in² (gauge pressure) for a period of 90 minutes. The terminals shall not be welded, soldered, or disfigured to perform the seal part of this test. Capacitors shall be examined for unwrapping of case material or other damage to the case.

4.8.4 Burn-in (when specified, see [3.1](#)) (see [3.8](#)). Capacitors shall be tested as follows:

- a. DC: 140 percent of dc rated voltage shall be applied for 48 hours, minimum at +125°C +4°C, -0°C.
- b. AC: 140 percent of rated root mean square voltage shall be applied for 16 hours, minimum at +125°C +4°C, -0°C and 400 Hz ±10 Hz.

4.8.5 Insulation resistance (see [3.9](#)). Capacitors shall be tested in accordance with [method 302 of MIL-STD-202](#). The following details shall apply:

- a. Test potential: Equal to rated voltage (or derated voltage if applicable), or 500 V dc, whichever is less (see [3.1](#)).
- b. Points of measurement: Terminal to terminal.
- c. Electrification time: Two minutes maximum; however, for capacitance values greater than 1 µF an additional 1 minute per µF is permitted.

4.8.6 Dielectric withstanding voltage (see 3.10). Capacitors shall be tested in accordance with method 301 of MIL-STD-202. The following details and exception shall apply:

- a. Magnitude and duration of test voltage: 200 percent of rated voltage for 10 seconds to 60 seconds.
- b. Nature of potential: DC.
- c. Points of application of test voltage: Between terminals.
- d. Limiting value of surge current: Shall not exceed 50 milliamperes (mA).
- e. Examination after test: Capacitors shall be examined for evidence of damage, arcing, or breakdown.

4.8.7 Barometric pressure (reduced) for qualification only (see 3.11). Capacitors shall be tested in accordance with method 105 of MIL-STD-202. The following details shall apply:

- a. Method of mounting: Normal mounting means.
- b. Test condition: D (100,000 feet).
- c. Test during subjection to reduced pressure: 150 percent of rated voltage (characteristics M, Q and V), or 140 percent of rated voltage (characteristics K, L, N, R and U) shall be applied between the terminals for not less than 1 minute.
- d. Examination after test: Capacitors shall be visually examined for evidence of damage.

4.8.8 Capacitance (see 3.12). Capacitance shall be measured in accordance with method 305 of MIL-STD-202. The following details shall apply:

- a. Test frequency: 1 kilohertz (kHz) \pm 100 hertz (Hz).
- b. Limit of accuracy: Within \pm 0.5 percent.

4.8.9 Dissipation factor (all styles except CFR13, CFR14, CFR26, CFR27, and CFR29) (see 3.13). The dissipation factor shall be measured at an ac voltage not greater than 20 percent of the rated voltage (or 10 volts, whichever is less (see 3.1)), at a frequency of 1 kHz \pm 100 Hz. Measurement accuracy shall be within \pm 2 percent.

4.8.10 ESR applicable to styles CFR13, CFR14, CFR26, CFR27, and CFR29 (see 3.14). ESR shall be determined by a suitable measuring device. Instrument measurement accuracy shall be within \pm 2 percent. AC measurements shall be made at a frequency of 100 kHz \pm 10 percent. ESR is to be measured within .250 inch (6.35 mm) to .500 inch (12.70 mm) of case.

4.8.11 Resistance to soldering heat (see 3.15). Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details shall apply:

- a. Test condition: C, except the time shall be 10 seconds \pm 1 second.
- b. Cooling time prior to measurement after test: 10 minutes \pm 1 minute.
- c. Measurement after test: Capacitance and dissipation factor at +25°C shall be measured as specified in 4.8.8 and 4.8.9 respectively.

4.8.12 Moisture resistance (see 3.16). Capacitors shall be tested in accordance with [method 106 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Mounting: Capacitors shall be mounted by their normal mounting means. Except during measurements, the terminals shall be secured .500 inch \pm .125 inch (12.70 mm \pm 3.17 mm) from point of egress to test jig.
- b. Initial measurements: Not applicable.
- c. Number of cycles: 20.
- d. Polarization voltage: During step 1 to step 6 inclusive, a dc potential of 100 volts or rated voltage, whichever is less (see 3.1), 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.
- e. Loading voltage: Not applicable.
- f. Final measurements: After the final cycle, capacitors shall be conditioned at +25°C \pm 5°C at a relative humidity of 50 percent \pm 5 percent for a period of at least 22 hours, but not more than 24 hours. Dielectric withstanding voltage, insulation resistance, dissipation factor, and capacitance shall be measured at +25°C as specified in 4.8.6, 4.8.5, 4.8.9, and 4.8.8 respectively.

4.8.13 Vibration, high frequency (see 3.17). Capacitors shall be tested in accordance with [method 204 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Mounting of specimens: Securely fastened so that the body is restrained from movement. The terminals shall be soldered to rigidly supported stud-terminals, so spaced that the length of each terminal from the capacitor body to the edge of the supporting stud-terminal is .500 inch (12.70 mm) \pm .125 inch (\pm 3.18 mm).
- b. Electrical-load conditions: During the test, rated voltage (see 3.1) shall be applied between the terminals of the capacitor.
- c. Test condition: D (20 G's).
- d. Direction and duration of motion: Unless otherwise specified (see 3.1), 4 hours in each of two mutually perpendicular directions (total 8 hours), one parallel and the other perpendicular to the cylindrical axis.
- e. Measurements during vibration: During the last cycle in each direction, an electrical measurement shall be made to detect intermittent contacts of 0.5 ms or greater duration or open-circuiting or short-circuiting.
- f. Examination after test: While still mounted on the vibration jig, capacitors shall be visually examined for evidence of mechanical damage.

4.8.14 Shock (specified pulse) (see 3.18). Capacitors shall be tested in accordance with [method 213 of MIL-STD-202](#). The following details and exception shall apply:

- a. Mounting: Rigidly mounted by the body.
- b. Test condition: I (100 G's pk).
- c. Electrical loading during shock: During the test, 125 percent of rated voltage (see 3.1) shall be applied between the terminals of the capacitor.
- d. Measurements during shock: During the test, a cathode-ray oscilloscope or other comparable means capable of detecting intermittent contacts of 0.5 ms duration or greater shall be used as an indicating device in determining any electrical failures.

- e. Examination after test: Capacitors shall be visually examined for evidence of breakdown, arcing, fractures, or any other visible mechanical damage.

4.8.15 Terminal strength (see 3.19). Capacitors shall be tested in accordance with [method 211 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Test condition: A (axial and radial), 5 pounds; C (radial only), 5 pounds; and D (axial only).
- b. Test condition: A (lugs), 10 pounds for 1 minute.

4.8.16 Solderability (see 3.20). Capacitors shall be tested in accordance with [method 208 of MIL-STD-202](#). The following details shall apply (see 3.5.2.3):

- a. The number of terminations of each capacitor to be tested: Two.
- b. Depth of immersion in flux and solder: Both terminals shall be immersed to within .125 inch (3.18 mm) of the capacitor body.
- c. No physical damage after test.

4.8.17 AC conditioning (when specified, see 3.1) (see 3.21). Capacitors shall be exposed to the voltages, currents, frequencies, and temperature specified (see 3.1) for 240 hours +48 hours, -0 hour.

4.8.18 Low-temperature conditioning and capacitance change with temperature (see 3.22).

4.8.18.1 Low-temperature conditioning. Capacitors shall be placed in a chamber maintained at $-55^{\circ}\text{C} \pm 3^{\circ}\text{C}$. Rated voltage (see 3.1), shall be applied at this condition for 48 hours ± 4 hours. The air within the conditioning chamber shall be circulated.

4.8.18.2 Capacitance change with temperature. Capacitance shall be measured as specified in 4.8.8, at the temperatures and in the order shown in [table XV](#).

TABLE XV. Capacitance measurement temperatures.

Step	Temperature
1	$-55^{\circ}\text{C} \pm 3^{\circ}\text{C}$
2	$+25^{\circ}\text{C} \pm 5^{\circ}\text{C}$
3	$+85^{\circ}\text{C} \pm 3^{\circ}\text{C}$ <u>1/</u>
4	$+105^{\circ}\text{C} \pm 3^{\circ}\text{C}$ <u>2/</u>
5	$+125^{\circ}\text{C} \pm 3^{\circ}\text{C}$ <u>3/ 4/</u>
6	$+25^{\circ}\text{C} \pm 5^{\circ}\text{C}$

1/ Only applicable to characteristics M and N.

2/ Only applicable to characteristics K and L.

3/ Not applicable to characteristics K, L, M, and N capacitors.

4/ When measuring insulation resistance at $+125^{\circ}\text{C}$, the applicable derated voltage shall be used (see 3.1).

NOTE: The capacitance measurement at each temperature shall be recorded when two successive readings, taken at 5-minute intervals, indicate no change in capacitance.

In addition (for qualification testing only), insulation resistance and dissipation factor shall be measured at high test temperature(s) (step 3 and step 4 of [table XIV](#)), as specified in 4.8.5 and 4.8.9 respectively. Capacitors shall then be visually examined for evidence of breakdown, arcing, and other visible mechanical damage.

4.8.19 Thermal shock and immersion (see [3.23](#))

4.8.19.1 Thermal shock. Capacitors shall be tested in accordance with [method 107 of MIL-STD-202](#). The following details shall apply:

- a. Test condition: A, except that during step 3, capacitors shall be conditioned at high operating temperature (see [3.1](#)).
- b. Measurements before and after cycling: Not applicable.

4.8.19.2 Immersion. Within 4 hours to 24 hours after completion of temperature cycling, capacitors shall be tested in accordance with [method 104 of MIL-STD-202](#). The following details shall apply:

- a. Test condition: B.
- b. Measurement after final cycle: Dielectric withstanding voltage and insulation resistance at +25°C shall be measured as specified in [4.8.6](#) and [4.8.5](#) respectively.

4.8.20 Life (see [3.24](#)).

4.8.20.1 2,000-hour (qualification inspection). Capacitors shall be tested in accordance with [method 108 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Method of mounting and distance between specimens: Rigidly mounted by the body with a distance of not less than 1-inch separation between units.
- b. Test temperature and tolerance: +85°C +4°C, -0°C for characteristics M, N, Q, and R;
+105°C +4°C, -0°C for characteristics K and L.
- c. Rated operating conditions: Characteristics M, N, Q, R, U and V capacitors shall be at the +85°C dc rated voltage; characteristics K and L capacitors shall be at the +105°C dc rated voltage.
- d. Accelerated operating conditions: Characteristics K, M, Q and V capacitors shall be subjected to 140 percent of dc rated voltage; characteristics L, N, R, and U capacitors shall be subjected to 125 percent of dc rated voltage.
- e. The surge current shall be limited to 1 ampere. When necessary, a suitable current-limiting resistor shall be inserted into the circuit. Means shall be provided to assure that the full required voltage is applied to the capacitor when current-limiting resistors are used. Radiation shall not be used as a means of heating the chamber.
- f. Test condition: F (2,000 hours +72 hours, -0 hour).
- g. Measurements after exposure: Capacitors shall be returned to the inspection conditions specified in [4.3](#), and shall be visually examined for deformation of body, obliteration of markings, and leakage of filling compound, when applicable. Insulation resistance (at +25°C), capacitance, and dissipation factor (at +25°C), shall then be measured as specified in [4.8.5](#), [4.8.8](#), and [4.8.9](#) respectively.

4.8.20.2 2,000-hour (group B inspection) (see 3.24). Except as specified in the following, capacitors shall be tested as specified in [4.8.20.1](#): Test duration: 2,000 hours +72 hours, -0 hour at accelerated conditions only.

4.8.20.3 Extended life (see [3.24](#)).

4.8.20.3.1 Following 2,000-hour qualification test. Capacitors tested under rated conditions shall be continued on test for an additional 8,000 hours +96 hours, -0 hour; measurements during and after exposure shall be accomplished after 2,000 hours +96 hours, -0 hour and every 2,000 hours +96 hours, -0 hour thereafter until a combined total of 10,000 hours +96 hours, -0 hour have elapsed.

4.8.20.3.2 +125°C proof test (characteristics Q, R, U and V). Except as specified in the following, capacitors shall be tested as specified in [4.8.20.1](#):

- a. Test temperature and tolerance: +125°C +4°C, -0°C.
- b. Operating conditions: Characteristics R and U capacitors shall be subjected to 125 percent of the derated voltage (see [table III](#)). Characteristic Q and V capacitors shall be subjected to 140 percent of the derated voltage (see [table III](#)).

4.8.21 Fungus (see 3.25). Capacitors shall be tested in accordance with method 508 of [MIL-STD-810](#).

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 materiel 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. These capacitors are intended to be used in potted or encapsulated systems, in blocking, filter, and by-pass applications (see [6.4](#)). 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: 20 Gs of high frequency vibration, 100 Gs of shock (specified pulse), and operate in extreme temperatures (-55°C and up to +125°C). These capacitors also offer high reliability that is verified under a qualification system. Commercial components are not designed to withstand these military environmental conditions.

6.2 Acquisition requirements. Acquisition documents must specify the following:

- a. Title, number, and date of this specification, the applicable specification sheet, and the complete PIN (see [3.1](#)).
- b. Packaging requirements (see [5.1](#)).
- c. Marking requirement for FRL (see [3.26.5](#)).
- d. Marking requirements for tolerance and rated voltage levels (see [3.26.6](#)).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products that are, at the time of award of contract, qualified for inclusion in Qualified Products List 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. The activity responsible for the Qualified Products List is the U.S. Army Communications-Electronics Command, ATTN: RDER-PRQ-QE, Aberdeen Proving Ground, MD 21015; however, information pertaining to qualification of products may be obtained from the DLA Land and Maritime, ATTN: VQP, PO Box 3990, Columbus, OH 43218-3990, or by e-mail 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>.

6.4 Application information. Capacitors acquired under provisions of this specification will experience failure at a rate depending almost exclusively upon the manner in which the capacitors are used. For military applications, in view of their limited long term moisture resistant characteristics, these capacitors should be used in potted or encapsulated circuit packaging systems. For Navy use, these units should only be used in potted or encapsulated circuit packaging systems. In any case, the acquiring activity should review the specific application. Where the capacitors are not incorporated in an encapsulated or potted circuit package, hermetically sealed foil capacitors of MIL-PRF-19978 or hermetically sealed metallized capacitors of MIL-PRF-39022 or MIL-PRF-83421 are recommended. In addition, the life of the capacitors specified herein is primarily dependent upon the operating temperature and applied voltage. They should not be used above rated voltage or temperature.

6.4.1 Mounting. Capacitors covered by this specification should be mounted by a bracket or clamp, or they should be potted when vibration or shock are likely to be encountered in service. When a bracket or clamp is used, care should be taken to assure that the capacitor body is not deformed.

6.5 Interchangeability. Capacitors specified as style CTM, characteristic V of MIL-C-27287/1 (USAF) are directly replaceable by style CFR02AM of MIL-PRF-55514/1 in the same +85°C voltage rating, capacitance value, tolerance, and in FRL-M.

NOTE: Even though style CTM units are voltage derated to +125°C, and style CFR02 units are rated only to +85°C, units are unilaterally interchangeable.

6.6 PIN. The PIN is structured as shown in 1.2.1.

6.7 Subject term (key word) listing.

Capacitance
Dielectric withstanding voltage
Dissipation factor
Insulation resistance

6.8 Tin whisker growth. The use of alloys with tin content greater than 97 percent may exhibit tin whisker growth problems after manufacture. Tin whiskers may occur anytime from a day to years after manufacturer, and can develop under typical operating conditions on products that use such materials. Conformal coatings applied over top of a whisker-prone surface will not prevent the formation of tin whiskers. Alloys of 3 percent lead have shown to inhibit the growth of tin whiskers (see 3.4.2).

6.9 Environmentally preferable material. Environmentally preferable materials should be used to the maximum extent possible to meet the requirements of this specification. As of the dating of this document, the U.S. Environmentally Protection Agency (EPA) is focusing efforts on reducing 31 priority chemicals. The list of chemicals and additional information is available on their website at <http://www.epa.gov/osw/hazard/wastemin/priority.htm>. Included in the list of 31 priority chemicals are cadmium, lead, and mercury. Use of the materials on the list should be minimized or eliminated unless needed to meet the requirements specified herein (see section 3).

6.10 Retinning. If retinning (hot solder dip) of the leads is required, see 3.5.2.1.

6.11 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.

APPENDIX A

QUALIFICATION-SUBMITTAL PLANS

A.1 SCOPE

A.1.1 Scope. This appendix details the qualification-submittal plans for capacitors to be subjected to the qualification inspection specified in this specification. These plans specify the sample size, sampling criteria, and limits of coverage for the type of qualification sought. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance only.

A.2 APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

A.3 SUBMISSION

A.3.1 Single PIN. The following details shall apply:

- a. Sample size: 122.
- b. Sampling criteria: Sample units of the same style, rated voltage, terminal, characteristic, capacitance, and capacitance tolerance.
- c. Limits of coverage: Qualification coverage will be limited to the PIN submitted.

A.3.2 Single-voltage. The following details apply:

- a. Sample size: 122.
- b. Sampling criteria: Sample units of the same style, same characteristic, highest capacitance, tightest tolerance, and same voltage rating. Styles with more than one characteristic available will require separate submission for each characteristic. When axial and radial terminals apply to the same sample group, capacitors shall be divided equally between the two terminals types.
- c. Limits of coverage: Qualification coverage will be extended to all lower capacitance values and broader tolerances in the style, characteristic, and voltage rating represented.

A.3.3 Combined voltage. The following details apply:

- a. Sample size and voltage: 122 (61 each of any two adjacent voltages).
- b. Sampling criteria: Sample units of the same style, characteristic, highest capacitance, and lowest tolerance. Styles with more than one characteristic available will require separate submission for each characteristic. When axial and radial terminals apply to the same sample group, capacitors shall be divided equally between the two terminals types.
- c. Limits of coverage: Qualification coverage will be extended to all lower capacitance values and broader tolerances in the style, characteristic, and both voltage ratings represented.

A.3.4 Complete style. For complete style, submission shall be in accordance with [table A-I](#).

A.3.5 Qualification of non-ER. Qualification of the C (non-ER) level is predicated upon meeting the qualification requirements for the ER FRL P.

MIL-PRF-55514G

APPENDIX A

TABLE A-I. Qualification samples.

Style	Type designation	Sample size
CFR02	CFR02AMB105GM	61
	CFR02AMC105GM	61
	CFR02AME105GM	61
	CFR02AMF104GM	61
	CFR02AVB105FM	61
	CFR02AVC105FM	61
CFR05	CFR05AUA506FM	61
	CFR05AUB206FM	61
	CFR05AUC106FM	61
	CFR05AUE505FM	61
CFR06	CFR06AUA506FM	61
	CFR06RUB206FM	61
	CFR06ANC106FM	61
	CFR06RNE335FM	61
CFR09	CFR09AUA186FM	61
	CFR09AUB106FM	61
	CFR09AUH505FM	61
	CFR09AUC395FM	61
CFR13	CFR13ALB306JM	61
	CFR13ALC206JM	61
	CFR13ALE106JM	122
CFR14	CFR14LLB306JM	61
	CFR14LLC206JM	61
	CFR14LLE106JM	122
CFR15	CFR15AKC105JM	61
	CFR15AKE105JM	61
	CFR15AKF105JM	61
	CFR15AKL564JM	61
CFR26 CFR27 1/	CFR2-LUA106JM	61
	CFR2-LUA506JM	61
	CFR2-LUG505JM	61
	CFR2-LUG506JM	61
	CFR2-LUB505JM	61
	CFR2-LUB506JM	61
CFR29	CFR29RUA106JM	61
	CFR29RUA506JM	61
	CFR29RUG305JM	61
	CFR29RUG506JM	61
	CFR29RUB305JM	61
	CFR29RUB506JM	61
CFR30	CFR30AUA186FM	61
	CFR30AUB106FM	61
	CFR30AUH505FM	61
	CFR30AUC395FM	61

1/ The complete type designation shall include a "6" or "7" for styles CFR26 or CFR27.

MIL-PRF-55514G

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

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

Preparing activity:
Army - CR

Agent:
DLA - CC

(Project 5910-2013-021)

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