

INCH-POUND

MIL-PRF-39018G  
 20 February 2009  
 SUPERSEDING  
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## PERFORMANCE SPECIFICATION

CAPACITORS, FIXED, ELECTROLYTIC (ALUMINUM OXIDE), ESTABLISHED RELIABILITY  
 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. SCOPE. This specification covers the general requirements for established reliability (ER) and non-ER, aluminum oxide, electrolytic, fixed capacitors (see 6.1). Capacitors meeting the ER requirements of this specification have reliability established on the basis of life tests performed at rated voltage at 85°C for failure rate (FR) levels ranging from 1.0 percent to 0.001 percent per 1,000 hours in accordance with MIL-STD-690. These FR levels are established at a 60-percent confidence level and are maintained at a 10 percent producer's risk. The level of reliability is identified by the following FR level symbols:

<u>Symbol</u>	<u>FR Level (percent/1,000 hr)</u>
M	1.0
P	0.1
R	0.01
S	0.001

1.2 Classification. Capacitors covered by this specification are classified by the style, as specified (see 3.1).

1.2.1 Part of Identification Number (PIN) The PIN should be in the following form and as specified (see 3.1).

M39018	/01	-	0001	M
Performance specification number	Specification sheet number	(see 1.2.1.1)	Non-significant dash number	failure rate level/high freq vibration option (see 1.2.1.2)

1.2.1.1 Dash. Use "-" for standard product or replace with "R" for random vibration option (CUR13 and CUR17 only).

1.2.1.2 Failure Rate Level or High Frequency Vibration. The failure rate level is identified by a single letter (M,P,R or S) as shown in scope (CUR styles only). An "H" will indicate high frequency option for CU17 capacitors only or this character should be left blank.

Comments, suggestions, or questions on this document should be addressed to: Defense Supply Center, Columbus, DSCC-VAT, Post Office Box 3990, Columbus, OH 43218-3990 or e-mailed to [capacitorfilter@dsc.dla.mil](mailto:capacitorfilter@dsc.dla.mil). Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <http://assist.daps.dla.mil/quicksearch> or <http://assist.daps.dla.mil>.

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## 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 listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation ([see 6.2](#)).

## DEPARTMENT OF DEFENSE SPECIFICATIONS

[MIL-DTL-39028](#) - Capacitors, Packaging of.

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

## FEDERAL STANDARDS

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

## DEPARTMENT OF DEFENSE STANDARDS

[MIL-STD-202](#) - Test Method Standard, Electronic and Electrical Component Parts.  
[MIL-STD-690](#) - Failure Rate Sampling Plans and Procedures.  
[MIL-STD-790](#) - Standard Practice for Established Reliability and High Reliability Qualified Products List (QPL) Systems for Electrical, Electronic and Fiber Optic Parts Specification.  
[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://assist.daps.dla.mil/quicksearch/> or <http://assist.daps.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.

## ELECTRONIC INDUSTRIES ALLIANCE (EIA)

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

(Application for copies can be found online at <http://www.eia.org/> or should be addressed to the Electronic Industries Alliance (EIA), 2500 Wilson Boulevard, Arlington VA 22201-3834.)

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2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated specifications, specification sheets, or MS standards), 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 sheets. In the event of any conflict between requirements of this specification and the specification sheet, the latter shall govern (see 6.2).

3.2 Qualification. Capacitors furnished under this specification shall be products that 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 4.4 have been met and are being maintained. Authorized distributors who are approved to MIL-STD-790 distributor requirements by the QPL manufacturer are listed in the QPL.

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-790. In addition, the manufacturer shall establish a Statistical Process Control (SPC) 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 an SPC system that meets the requirements of EIA-557. Typical manufacturing processes for application of SPC include: foil classification, rolling, impregnation, cover assembly, and encapsulation.

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 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 non-ER and 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 guarantee of the acceptance of the finished product.

3.4.1 Case insulation (insulated capacitors only). Case insulation shall not soften, creep, or shrink to a point where a part of the cylindrical case is left uncovered at the high operating temperature. Capacitor bodies shall not be free to turn within the sleeving (except for CU13, CUR13, CU15, CU17, CUR17, CU71, CUR71, CUR91 and CUR92 Insulated styles). The use of exterior cardboard sleeves for insulating purposes shall not be permitted.

3.4.2 Internal examination. When capacitors are examined as specified in 4.6.2.1, there shall be no visible evidence of corrosion.

\* 3.4.3 Pure tin. The use of pure tin, as an undercoat 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 6.8)

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

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

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3.5.2 Terminals. All terminals shall be permanently secured internally and externally, as applicable, so that normal handling of the terminals will not result in wear, damage, or excessive strain to the capacitor element, case, or case insulation. Wire-lead terminals shall be hot solder dipped or electroplated with solder having a tin content of at least 40 percent. Threaded portions of screw thread terminals shall be in accordance with [FED-STD-H28](#) as specified ([see 3.1](#)).

3.5.3 Terminal lead finish. The terminal lead finish shall be in accordance with code 52 of [MIL-STD-1276](#) (NOTE: The 200 microinch maximum dimension for code 52 is not applicable).

3.5.3.1 Solder dip (re-tinning). The manufacturer may solder dip/re-tin the leads of capacitors supplied to this specification provided the solder dip process ([see appendix A](#)) has been approved by the qualifying activity.

3.5.3.2 Tin plated finishes. Tin plating is prohibited as a final finish or as an undercoat. Tin-lead (Sn-Pb) finishes are acceptable provided that the minimum lead content is 3 percent ([see 6.6](#)).

3.6 Burn-in (ER styles only). When capacitors are tested as specified in [4.6.3](#), there shall be no evidence of damage, arcing, or breakdown. After burn-in, capacitors shall meet the following requirements:

DC leakage:	Shall not exceed the initial requirement specified ( <a href="#">see 3.1</a> ).
Capacitance:	Within the tolerance specified ( <a href="#">see 3.1</a> ).
ESR:	Shall not exceed the initial requirement specified ( <a href="#">see 3.1</a> ).

3.7 DC leakage. When measured as specified in [4.6.4](#), the dc leakage shall not exceed the applicable value specified ([see 3.1](#)). For nonpolarized style capacitors, the limits apply to measurements in both directions, except that after environmental tests involving one directional polarization greater than 30 minutes, the limits shall apply to the last polarized direction only.

3.8 Capacitance. When measured as specified in [4.6.5](#), the capacitance shall be within tolerance of the nominal value specified ([see 3.1](#)).

3.9 Equivalent series resistance (ESR). When measured as specified in [4.6.6](#), the ESR (in ohms) shall not exceed the value specified ([see 3.1](#)).

3.10 Low temperature exposure. When tested as specified in [4.6.7](#), capacitors shall meet the following requirements:

DC leakage:	Shall not exceed the initial requirement specified ( <a href="#">see 3.1</a> ).
Capacitance:	Within the tolerance specified ( <a href="#">see 3.1</a> ).
ESR:	Shall not exceed the initial requirement specified ( <a href="#">see 3.1</a> ).

3.11 Solderability (capacitors with wire-lead terminals only). When capacitors are tested as specified in [4.6.8](#), the dipped surface of the capacitor leads shall be at least 95-percent covered with a new continuous, solder coating. The remaining 5 percent of the lead surface shall show only small pinholes or voids. These shall not be concentrated in one area. Bare base metal and areas where the solder dip failed to cover the original coating are indications of poor solderability, and shall be cause for failure. In case of dispute, the percentage of area covered by pinholes or voids shall be determined by actual measurement of these areas, as compared to the total area.

3.12 Terminal strength. When capacitors are tested as specified in [4.6.9](#), there shall be no loosening of terminals or permanent damage to the terminal weld, or terminal solder, as applicable.

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3.13 Stability at reduced and high temperatures. When tested as specified in 4.6.10, capacitors shall meet the following requirements:

## Step 1:

DC leakage: Shall not exceed the initial requirement specified (see 3.1).  
 Capacitance: Within the tolerance specified (see 3.1).  
 ESR: Shall not exceed the initial requirement specified (see 3.1).

## Step 2:

Impedance: Shall not exceed the value specified (see 3.1).  
 Capacitance: Change not more than the value specified (see 3.1).

## Steps 3 through 5:

DC leakage: Shall not exceed the value specified (see 3.1).  
 Capacitance: Change not more than the value specified (see 3.1).  
 ESR: Shall not exceed the value specified (see 3.1).

3.14 Life. When tested as specified in 4.6.11, capacitors shall meet the following requirements:

DC leakage: Shall not exceed the value specified (see 3.1).  
 Capacitance: Change not more than the value specified (see 3.1).  
 ESR: Shall not exceed the value specified (see 3.1).  
 Visual examination: There shall be no leakage of electrolyte or evidence of mechanical damage, and the marking shall remain legible.

3.15 Case insulation (insulated capacitors only).

3.15.1 Dielectric withstanding voltage. When capacitors are tested as specified in 4.6.12.1, there shall be no breakdown of the insulation.

3.15.2 Insulation resistance. When capacitors are tested as specified in 4.6.12.2, there shall be no breakdown of the insulation, and the insulation resistance shall not be less than 100 megohms.

3.16 Shock (specified pulse). When capacitors are tested as specified in 4.6.13, there shall be no intermittent contacts of 0.5 millisecond (ms) or greater duration, arcing, or open- or short-circuiting, nor shall there be any evidence of mechanical damage or leakage of electrolyte.

3.17 Vibration. When capacitors are tested as specified in 4.6.14, there shall be no intermittent contacts of 0.5 ms or greater duration, or open- or short-circuiting, nor shall there be any evidence of mechanical damage or leakage of electrolyte.

3.18 Salt spray (corrosion). When capacitors are tested as specified in 4.6.15, there shall be no harmful corrosion and at least 90 percent of any exposed metal surface of the capacitor shall be unaffected. In addition, there shall be no more than 10-percent corrosion of the terminal surface. Harmful corrosion shall be construed as any type of corrosion which in any way interferes with mechanical or electrical performance. There shall be no unwrapping of or mechanical damage to the insulating sleeves (when applicable). The marking shall remain legible.

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3.19 Thermal shock and immersion. When tested as specified in 4.6.16, capacitors shall meet the following requirements:

DC leakage:	Shall not exceed the initial requirement specified (see 3.1).
Capacitance:	Change not more than the value specified (see 3.1).
ESR:	Shall not exceed the initial requirement specified (see 3.1).
Visual examination:	There shall be no harmful or extensive corrosion and at least 90 percent of any exposed metal surface of the capacitor shall be protected by the finish. There shall be no more than 10-percent corrosion of the terminal hardware or mounting surface. There shall be no leakage of electrolyte or mechanical damage, and marking shall remain legible after the test. When applicable, case insulation shall not exhibit evidence of burning, charring, or arcing, and shall meet the requirements of 3.15. In addition, there shall be no evidence of dye penetration when viewed under ultraviolet light.

3.20 Surge voltage. When capacitors are tested as specified in 4.6.17, there shall be no breakdown or other permanent damage. Terminals and seals shall remain intact. There shall be no leakage of the electrolyte when the capacitor is held with its end seal downward during the test. Capacitors shall meet the following requirements:

DC leakage:	Shall not exceed the initial requirement specified (see 3.1).
Capacitance:	Change not more than the value specified (see 3.1).
ESR:	Shall not exceed the initial requirement specified (see 3.1).

3.21 Vent (when specified, see 3.1). When capacitors are tested as specified in 4.6.18, the vent shall operate, and there shall be no explosive expelling of the contents. Disruption shall occur only at the vent; the case or end seal shall not otherwise rupture.

3.22 Moisture resistance. When tested as specified in 4.6.19, capacitors shall meet the following requirements:

DC leakage	Shall not exceed the initial requirement specified (see 3.1).
Capacitance	Change not more than the value specified (see 3.1).
ESR	Shall not exceed the initial requirement specified (see 3.1).
Case insulation	Shall be as specified in 3.15 (when applicable).
Visual examination	There shall be no harmful or extensive corrosion and at least 90 percent of any exposed metal surface of the capacitor shall be protected by the finish. There shall be no more than 10-percent corrosion of the terminal hardware or mounting surface. There shall be no unwrapping of or mechanical damage to case insulation (when applicable). There shall be no leakage of the electrolyte or deformation of the case, and marking shall remain legible.

3.23 Fungus. The manufacturer shall certify that all external materials are fungus resistant or shall perform the test specified in 4.6.20. When capacitors are tested as specified in 4.6.20, examination shall disclose no evidence of fungus growth on the external surface of the capacitor.

3.24 Barometric pressure (reduced). When capacitors are tested as specified in 4.6.21, there shall be no flashover, breakdown, and evidence of mechanical damage or leakage of the electrolyte. The marking shall remain legible.

3.25 High temperature exposure. When tested as specified in 4.6.22, capacitors shall meet the following requirements:

DC leakage	Shall not exceed the value specified (see 3.1).
Capacitance	Change not more than the value specified (see 3.1).
ESR	Shall not exceed the value specified (see 3.1).
Visual examination	There shall be no deformation of the case.

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3.26 Reverse voltage (when specified, see 3.1). When tested as specified in 4.6.23, capacitors shall meet the following requirements:

DC leakage	Shall not exceed the value specified (see 3.1).
Capacitance	Change not more than the value specified (see 3.1).
ESR	Shall not exceed the initial requirement specified (see 3.1).

3.27 High temperature verification (styles CU12, CU13, CUR13, CU14, CU15, CU16, CU17, CUR17, CUR19, CU01, CUR01, and CUR02, only). When capacitors are tested as specified in 4.6.24, there shall be no evidence of damage, arcing or breakdown, and the capacitors shall meet the following requirements:

DC leakage	Shall not exceed the value specified (see 3.1).
Capacitance	Change not more than the value specified (see 3.1).
ESR	Shall not exceed the initial requirement specified (see 3.1).

3.28 AC verification (styles CUR91 and CUR92 only). When tested as specified in 4.6.25, capacitors shall withstand the ac voltage exposure without visible damage, and shall meet the following requirements:

DC leakage:	Shall not exceed the value specified (see 3.1).
Capacitance:	Change not more than the value specified (see 3.1).
ESR:	Shall not exceed the initial requirement specified (see 3.1).

3.29 Reverse voltage aging (all styles except CU14 and CU15). When tested as specified in 4.6.26, capacitors shall meet the following requirements:

DC leakage:	Shall not exceed 300 percent of the initial requirement specified (see 3.1).
Capacitance:	Shall not exceed $\pm 10$ percent of initial measured value.
ESR:	Shall not exceed the initial requirement specified (see 3.1).

3.30 Marking. Capacitors shall be marked in accordance with method 1 of MIL-STD-1285. Marking shall include the "JAN" brand (ER style only); Part or Identifying Number (PIN) (see 3.1); capacitance in ( $\mu$ F); capacitance tolerance; dc rated voltage; date code; and CAGE code. The dc rated voltage for polarized capacitors shall be designated "VDC" and nonpolarized capacitors shall be designated "VNP". Both voltages and temperatures shall be shown on dual-rated units. Polarity on polarized capacitors with axial wire-lead terminals shall be indicated by a minimum of two plus (+) symbol at the positive end of the case. For capacitors with both terminals on the same end, the positive terminal shall be identified by a single plus (+) symbol adjacent to the terminal, or as specified (see 3.1). Each capacitor body shall be legibly marked with smear-resistant ink that will withstand the environmental conditions specified herein. The marking shall remain legible after all tests.

3.30.1 "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" or "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 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".

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3.30.2 Supplying to better failure rate levels (FRL's). A manufacturer may supply to all better failure rate levels than to which he is qualified. Items of an exponential FRL as shown in [table I](#) and marked to lower FRL's, with procuring agency approval, are substitutable for higher FRL's and shall not be remarked unless specified in the contract or purchase order ([see 6.2](#)). In the event the FRL is remarked, the lot date codes on the parts shall not be changed and the workmanship criteria shall be met.

TABLE I. Failure rate level substitutability.

Parts qualified to failure rate level	Are substitutable for failure rate level
S R P	M, P, and R M and P M

3.30.3 Substitutability of capacitance tolerance and rated voltage. Parts qualified and marked to tighter capacitance tolerance or higher rated voltage, with procuring agency approval, are substitutable for parts marked to looser capacitance tolerance or lower rated voltage, provided all other values are the same. The substitutable parts shall not be remarked unless specified in the contract or purchase order ([see 6.2](#)). In the event the capacitance tolerance or voltage rating is remarked, the lot date codes on the parts shall not be changed and the workmanship criteria shall be met.

3.30.4 Substitutability of vibration levels. Parts qualified and marked to high frequency vibration levels, with procuring agency approval, are substitutable for lower frequency vibration level parts, provided all other values are the same. The substitutable parts shall not be remarked unless specified in the contract or purchase order ([see 6.2](#)). In the event the vibration level is remarked, the lot date code on the parts shall not be changed and the workmanship criteria shall be met.

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

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

3.32 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.

#### 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 ([see 4.4.5](#) and [4.4.6](#)).
- c. Conformance inspection ([see 4.5](#)).
- d. Group C inspection ([see 4.5.2.1](#)).

4.2 QPL system. 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.



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4.2.1 SPC. An SPC program shall be maintained in accordance with [EIA-557](#). Evidence of such compliance shall be verified by the qualifying activity of this specification as prerequisite for qualification and continued 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](#), except relative humidity shall not exceed 75 percent. Unless otherwise specified ([see 3.1](#)), accuracy of all test voltage measurements shall be within  $\pm 2.0$  percent of specified voltage.

4.3.1 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  $25^{\circ}\text{C} \pm 3^{\circ}\text{C}$  prior to beginning of conditioning. Unless reference measurements have been made within 30 days prior to the beginning of conditioning, they shall be repeated.

4.3.2 Power supply. The power supply used for life testing shall have a regulation of  $\pm 2$  percent or less of the specified test voltage.

4.4 Qualification inspection. 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.

4.4.1 Sample size. The number of capacitors to be subjected to qualification inspection shall be as specified in the [appendix A](#) to this specification.

4.4.2 Inspection routine. Sample units shall be subjected to the qualification inspection specified in [table II](#), in the order shown. All sample units shall be subjected to the inspections of group II. The sample units shall then be divided into six remaining groups as specified in [table II](#), and subjected to the tests for their particular group.

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

4.4.4 Failure rate (FR) qualification. FR qualification 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/1,000 hours) of FRSP-60 shall apply. Sample units shall be subjected to the life test specified in group IV, [table II](#). The entire life test sample shall be continued on test to 10,000 hours as specified in [4.6.11.1.1](#) on completion of the 2,000-hour qualification test.
- b. Procedure II - Extension of qualification to lower FRLs. To extend qualification to the "P" (0.1 percent), FRL, data shall be limited to each voltage group within a style; for FR levels "R" (0.01 percent) and "S" (0.001 percent), data from two or more voltage groups within a style of similar construction 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 4.4.5f](#)).

Qualification approval will be based on the successful completion of the tests specified in [table II](#), and will not be withheld pending completion of the extended life test of [4.4.4a](#).

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TABLE II. Qualification inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected		Number of failures allowed <sup>1/</sup>	
			Non-ER	ER	Non-ER	ER
<u>Group I</u>						
Visual and mechanical Inspection (internal examination)- - -	3.1, 3.4, 3.4.2, 3.5 to 3.5.2 incl, 3.32 and 3.32.1	4.6.2 and 4.6.2.1	2	2	0	0
<u>Group II</u>						
Visual and mechanical inspection (external examination) <sup>2/</sup> - - - Burn-in (ER styles only) <sup>2/</sup> - - - - - - - - DC leakage <sup>2/</sup> - - - - - Capacitance <sup>2/</sup> - - - - - ESR <sup>2/</sup> - - - - - - - -	3.1, 3.4, 3.4.1, 3.5 to 3.5.2 incl, 3.31 and 3.32.1 3.6 3.7 3.8 3.9	4.6.2 4.6.3 4.6.4 4.6.5 4.6.6	<sup>3/</sup> <sup>4/</sup>	<sup>4/</sup>	1	0
<u>Group III</u>						
Low temperature exposure - - - - - Solderability (capacitors with wire-lead terminals only) - - - - - Terminal strength - - - Stability at reduced and high temperatures - - - -	3.10 3.11 3.12 3.13	4.6.7 4.6.8 4.6.9 4.6.10	6	6	1	2 1
<u>Group IV</u>						
Life (2,000 hours only) - - - - - Case insulation (insulated capacitors only) - - -	3.14 3.15	4.6.11.1 4.6.12	22	46	0	

See footnotes at end of table.

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TABLE II. Qualification inspection. - Continued.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected		Number of failures allowed <u>1/</u>	
			Non-ER	ER	Non-ER	ER
<u>Group V</u>						
Shock (specified pulse) -----	3.16	4.6.13				
Vibration -----	3.17	4.6.14				
Salt spray (corrosion)	3.18	4.6.15	6	6	1	1
Thermal shock and immersion -----	3.19	4.6.16				
<u>Group VI</u>						
Surge voltage -----	3.20	4.6.17	6	6	1	1
Vent (when specified, see 3.1) -----	3.21	4.6.18			1	1
<u>Group VII</u>						
Moisture resistance --	3.22	4.6.19	12	12	1	1
Fungus <u>5/</u> -----	3.23	4.6.20				
<u>Group VIII</u>						
Barometric pressure (reduced) -----	3.24	4.6.21	8	8	1	1
High temperature exposure -----	3.25	4.6.22				
<u>Group IX</u>						
Reverse voltage (styles CU12, CU13, CUR13, CU16, CU17, and CUR17 only) -----	3.26	4.6.23	6	6	1	1

See footnotes at end of table.

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TABLE II. Qualification inspection - Continued.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected		Number of failures allowed <sup>1/</sup>	
			Non-ER	ER	Non-ER	ER
<u>Group X</u> High temperature Verification (styles CU12, CU13, CUR13, CU14, CU15, CU16, CU17, CUR17, CUR19, CU01, CUR01, and CUR02, only) -----	3.27	4.6.24	24	24	1	1
<u>Group XI</u> AC verification (styles CUR91 and CUR92 only) -----	3.28	4.6.25	N/A	12	N/A	1
<u>Group XII</u> Reverse voltage aging (all styles except CU14 and CU15) -----	3.29	4.6.26	10	10	0	0

<sup>1/</sup> A sample unit having one or more defects shall be considered as a single failure.

<sup>2/</sup> Nondestructive test.

<sup>3/</sup> One additional sample unit is included in each sample size to permit substitution for the allowable failure in group I.

<sup>4/</sup> The number of sample units to be inspected are:

Non-ER

73 - Styles CU71 and CU81  
93 - Styles CU14 and CU15  
103 - Style CU01  
109 - Styles CU12, CU13,  
CU16, and CU17

ER

96 - Styles CUR71 and CUR81  
108 - Styles CUR91 and CUR92  
126 - Styles CUR01, CUR02, and  
CUR19  
132 - Styles CUR13 and CUR17

<sup>5/</sup> Certification of fungus resistance may be substituted for testing.

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4.4.5 Verification of qualification (ER styles only). Every 6 months, the manufacturer shall provide verification of qualification to the qualifying activity. Continuation 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 C 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 these 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.

4.4.6 Verification of qualification (non-ER styles only). 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. Group A inspection.
- b. Group B inspection.
- c. Periodic group C inspection.

Periodic group C testing from ER styles may be substituted for testing of non-ER styles as shown in the following table:

ER style	Non-ER styles
CUR13	CU12, CU13, CU14, CU15
CUR17	CU16, CU17
CUR71	CU71

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.

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4.5 Conformance inspection.

4.5.1 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A and B inspection.

4.5.1.1 Inspection lot and production lot.

4.5.1.1.1 Inspection lot. An inspection lot shall consist of all capacitors covered by the same specification sheet produced under essentially the same conditions, and offered for inspection at one time. A production period shall be a maximum of 2 weeks.

4.5.1.1.2 Production lot. A production lot shall consist of all capacitors of the same style, voltage rating, nominal capacitance value, capacitance tolerance, and case size. 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.

4.5.1.2 Group A inspection. Group A inspection shall consist of the inspections specified in [tables III \[ER\]](#) and [table V \[non ER\]](#), and shall be made on the same set of sample units in the order shown.

TABLE III. Group A inspection (ER).

Inspection	Requirement paragraph	Test method paragraph	Sampling procedure
<u>Subgroup 1</u> Burn-in -----	<a href="#">3.6</a>	<a href="#">4.6.3</a>	100% inspection
<u>Subgroup 2</u> DC leakage (high test temperature) -----	<a href="#">3.7</a>	<a href="#">4.6.4</a>	See <a href="#">table IV</a>
<u>Subgroup 3</u> Visual examination ----- Mechanical examination (dimensions only) ----- Marking <u>1/</u> ----- Workmanship -----	<a href="#">3.1, 3.4, and 3.4.1</a> <a href="#">3.5</a> <a href="#">3.31</a> <a href="#">3.32</a>	<a href="#">4.6.2</a> <a href="#">4.6.2</a> <a href="#">4.6.2</a> <a href="#">4.6.2</a>	See <a href="#">table IV</a>
<u>Subgroup 4</u> Solderability (capacitors with wire-lead terminals)-----	<a href="#">3.11</a>	<a href="#">4.6.8</a>	5 samples 0 failures

1/ Marking defects are based on visual examination only.

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TABLE IV. Sampling plans for Group A inspection.

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

TABLE V. Group A inspection (non-ER).

Inspection	Requirement paragraph	Test method paragraph	Sampling procedure
<u>Subgroup 1</u>			
DC leakage -----	3.7	4.6.4	See table IV
Capacitance -----	3.8	4.6.5	
ESR -----	3.9	4.6.6	
<u>Subgroup 2</u>			
Visual examination ----	3.1, 3.4, and 3.4.1	4.6.2	13 samples 0 failures
Mechanical examination (dimensions only) ---	3.5	4.6.2	
Marking <u>1</u> /-----	3.31	4.6.2	
Workmanship -----	3.32	4.6.2	
<u>Subgroup 3</u>			
Solderability (capacitors with wire-lead terminals)	3.11	4.6.8	5 samples 0 failures

1/ Marking defects are based on visual examination only.

4.5.1.2.1 ER styles.

4.5.1.2.1.1 Subgroup 1 test. The subgroup 1 test shall be performed on a production lot basis on 100 percent of the product supplied under this specification. Capacitors failing the test of subgroup 1 shall be removed from the lot. If, during the 100 percent inspection, screening requires that more than 5 percent (Percent Defective Allowed (PDA)) of the capacitors be discarded, the entire production lot shall be rejected.

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

- a. Test conducted by the manufacturer during production shall be clearly identical to or more stringent than that specified for subgroup I and shall be performed only on a fully sealed capacitor. Test conditions shall be equal to or more stringent than those specified for subgroup I.
- b. Manufacturer subjects 100 percent of the product supplied under this specification to his production tests.
- c. The parameters measured and the failure criteria shall be the same or more stringent than those specified herein.
- d. The lot rejection criteria is the same or more stringent than that specified herein.
- e. The manufacturer shall make available all information concerning the test procedures and instrumentation used in his production tests. The manufacturer shall also make available to the Government all records of all detail test data resulting from production tests.
- f. Once approved, the manufacturer shall not change the test procedures or criteria without prior notification and concurrence by the qualifying activity.

4.5.1.2.1.2 Subgroup 2 tests. Subgroup 2 tests shall be performed on an inspection lot basis. The sampling procedure shall be as specified in [table III](#). If one or more defects are found, the lot shall be rescreened and defects removed. A new sample shall then randomly be selected. If one or more defects are found in this second sample, the lot shall be rejected and shall not be supplied to this specification.

4.5.1.2.1.3 Subgroup 3 tests. Subgroup 3 tests shall be performed on an inspection lot basis. The sampling procedure shall be as specified in [table III](#).

4.5.1.2.1.4 Subgroup 4 (solderability).

4.5.1.2.1.4.1 Sampling plan. A minimum of 5 pieces shall be selected randomly from each inspection lot; however, each production lot shall be represented in the sample. If the inspection lot consists of more than 5 production lots, then a minimum of one sample shall be selected from each production lot. If there are one or more failures, the inspection lot shall be considered to have failed. Test samples may be selected from subgroup 1 electrical failures.

4.5.1.2.1.4.2 Rejected lots. In the event of one or more defects, the inspection lot shall be 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 [4.5.1.2.1.3](#). 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 [4.5.1.2.1.3.2b](#).
- b. The manufacturer shall submit the failed lot to a 100 percent solder dip using an approved solder dip process in accordance with the [appendix A](#). Following the solder dip, the electrical measurements required in group A, subgroup 1 test 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 no 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.

4.5.1.2.1.3.3 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.



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4.5.1.2.1.4 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, DC leakage, and ESR 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.

4.5.1.2.2 Non-ER styles.

4.5.1.2.2.1 Sampling plan. The sampling procedure for subgroups 1 and 2 shall be as specified in table V.

4.5.1.2.2.2 Rejected Lots. If an inspection lot for subgroup 1 or subgroup 2 is rejected, the contractor may rework it to correct the defects, or screen out the defective units, and resubmit for reinspection. Another sample size based on lot size shall be inspected. If the second sample lot has one or more failures, the entire production lot shall be rejected and shall not be delivered on the contract or purchase order.

4.5.1.2.2.3 Subgroup 3 (solderability).

4.5.1.2.2.3.1 Sampling plan. A minimum of 5 pieces shall be selected randomly from each inspection lot; however, each production lot shall be represented in the sample. If the inspection lot consists of more than 5 production lots, then a minimum of one sample shall be selected from each production lot. If there are one or more failures, the inspection lot shall be considered to have failed. Test samples may be selected from subgroup 1 electrical failures.

4.5.1.2.2.3.2 Rejected lots. In the event of one or more defects, the inspection lot shall be 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 4.5.1.2.2.3.1. 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 4.5.1.2.2.3.2b.
- b. The manufacturer shall submit 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 test 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 no 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.

4.5.1.2.2.3.3 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.

4.5.1.3 Group B inspection. Group B inspection shall consist of the inspections specified in table VI, in the order shown, and shall be made on sample units which have been subjected to and have passed the group A inspection.

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TABLE VI. Group B inspection.

Inspection	Requirement paragraph	Test method paragraph
<u>Subgroup 1</u>		
Terminal strength <u>1/</u>	3.12	4.6.9
Stability at reduced and high temperatures <u>2/</u>	3.13	4.6.10
<u>Subgroup 2</u>		
Life (250 hours) (non-ER only)	3.14	4.6.11.2.1
<u>Subgroup 3</u>		
Reverse voltage aging (all polarized styles)	3.29	4.6.26

- 1/ 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.
- 2/ If the manufacturer can demonstrate that this test has been performed five consecutive times with zero failures, the frequency of this test, with the approval of the qualifying activity, can be performed on an annual basis. If the design, material, construction or processing of the part is changed, or if there are any quality problems or failures, the qualifying activity may require resumption of the original test frequency.

4.5.1.3.1 Sampling plan. The sample size used for all styles shall be eight with no failures permitted for subgroups 1 or 2, and one failure permitted for subgroup 3. If one failure does occur in subgroups 1 or 2, or two failures occur in subgroup 3, a second group of sample units shall be subjected to the test with no failure permitted. No failures by shorting shall be allowed. Sample units shall not be shipped on contract or purchase orders.

4.5.1.3.2 Rejected lots. If an inspection lot is rejected, the contractor may rework it to correct the defects, or screen out the defective units, and resubmit for reinspection. Another sample lot, in accordance with 4.5.1.3.1, shall then be inspected. If this lot has one or more failures, the entire production lot shall be rejected and shall not be delivered on the contract or purchase order.

4.5.1.3.3 Disposition of sample units. Sample units subjected to subgroups 1 and 3 of group B inspection may be shipped on the contract provided all sample units are resubmitted to group A inspection and pass.

4.5.2 Periodic inspection. Periodic inspection shall consist of group C inspection. Except where the results of these inspections show noncompliance with the applicable requirements (see 4.5.2.1.3), delivery of products which have passed groups A and B inspections shall not be delayed pending the results of this inspection.

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4.5.2.1 Group C inspection. Group C inspection shall consist of the inspections specified in [table VII](#), in the order shown.

TABLE VII. Group C inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of failures allowed			
				Non-ER		ER	
<u>Subgroup 1</u>							
Vibration:	3.17	4.6.14	6	1	1	1	1
Low Freq Vib when specified (see 3.1)							
High Freq Vib when specified (see 3.1)							
Random Vib when specified (see 3.1)							
shock (specified pulse) 2/	3.16	4.6.13					
Salt spray (corrosion) 3/	3.18	4.6.15					
Thermal shock and immersion 3/	3.19	4.6.16					
<u>Subgroup 2</u>							
Surge voltage 2/	3.20	4.6.17	6	1		1	
Vent (when specified, see 3.1) 2/	3.21	4.6.18					
<u>Subgroup 3</u>							
Moisture resistance	3.22	4.6.19	12	1		1	
<u>Subgroup 4</u>							
Barometric pressure (reduced) 3/	3.24	4.6.21	6	1		1	
High temperature exposure	3.25	4.6.22					
<u>Subgroup 5</u>							
Life (1,750 hours) (non-ER only)	3.14	4.6.11.2.2	12	1		N/A	
Life (10,000 hours) (ER only)	3.14	4.6.11.2.3	12	N/A		4/	
<u>Subgroup 6</u>							
Reverse voltage (styles CU12, CU13, CUR13, CU16, CU17, and CUR17 only) 5/	3.26	4.6.23	6	1		1	

See footnotes at end of table.

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TABLE VII. Group C inspection - Continued.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of failures allowed	
				Non-ER	ER
<u>Subgroup 7</u> High temperature verification (styles CU12, CU13, CUR13, CU14, CU15, CU16, CU17, CUR17, CUR19, CU01, CUR01, and CUR02, only) <u>5/</u>	3.27	4.6.24	24	1	1
<u>Subgroup 8</u> AC verification (styles CUR91 and CUR92 only) <u>5/</u>	3.28	4.6.25	<u>6/</u> 12	N/A	1

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

2/ (Not applicable for styles CU14, CU15) If the manufacturer can demonstrate that this test has been performed five consecutive times with zero failures, the frequency of this test, with the approval of the qualifying activity, can be performed on a semiannual basis. If the design, material, construction or processing of the part is changed, or if there are any quality problems or failures, the qualifying activity may require resumption of the original test frequency.

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 3 years after the deletion as part of long-term 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/ Number of allowable failures may vary depending on the failure rate level of the part being tested.

5/ (Not applicable for CU14, and CU15 in subgroup 7). If the manufacturer can demonstrate that this test has been performed five consecutive times with zero failures, the frequency of this test, with the approval of the qualifying activity, can be performed on an annual basis. If the design, material, construction or processing of the part is changed, or if there are any quality problems or failures, the qualifying activity may require resumption of the original test frequency.

6/ Six units of each voltage group every 6 months.

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4.5.2.1.1 Sampling plan. Every 2 months (every year for styles CU14, CU15), the inspections shall consist of subgroups 1 and 2. Every 6 months (every 2 years for styles CU14, CU15), the inspections shall consist of subgroups 3 through 8. Sampling shall be as follows:

- a. Every 2 months (every year for styles CU14, CU15), sample units from production, including those with the largest capacitance voltage product per case size, shall be selected at random from each style in production that has passed group A inspection.
- b. Every 6 months (every 2 years for styles CU14, CU15), sample units to be subjected to tests of subgroups 3, 4, 6, 7, and 8 shall be selected at random from units that have passed the group A inspection. Sample units to be subjected to the test of subgroup 5 shall be randomly selected every 6 months (every 2 years for styles CU14, CU15), including units of the largest capacitance value in each style (insulated or uninsulated) and voltage group that have passed group A inspection and subgroup 2 of the group B inspection.
- c. When the samples are selected, the contractor shall review all selections made within the preceding time period in order to assure that all styles in production have been drawn into the test program.

4.5.2.1.2 Disposition of sample units. Sample units subjected to group C inspection shall not be delivered on the contract.

4.5.2.1.3 Noncompliance. If a sample fails to pass group C 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 C 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). Groups A and B inspections may be reinstated; however, final acceptance and shipment shall be withheld until the group C inspection 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.

#### 4.6 Methods of examination and test.

##### 4.6.1 Test criteria.

4.6.1.1 AC measurements. AC measurements shall be made at a frequency of 120  $\pm$ 5 Hertz (Hz). The magnitude of the ac voltage shall be limited to 1.0 volt root-mean-square. The maximum dc bias voltage shall be 2.2 volts for all ac measurements.

4.6.1.2 Reference measurements. When requirements are based on comparative measurements made before and after conditioning, the reference measurement shall be considered the last measurement made at 25°C  $\pm$ 5°C prior to conditioning. Unless reference measurements have been made within 30 days prior to the beginning of conditioning, they shall be repeated.

4.6.2 Visual and mechanical inspection. 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 to 3.5.2 inclusive, and 3.31 to 3.31.1 inclusive).

4.6.2.1 Internal examination (see 3.4.2). Capacitors shall be opened and the foils and separator shall be unrolled for a visual examination of the internal construction. The entire interior, including foils, tabs, and contact areas of tab to foil, shall be examined for corrosion.

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4.6.3 Burn-in (ER styles only) (see 3.6). Capacitors shall be subjected to a minimum of 100 percent of the dc rated voltage at the high ambient test temperature for 48 hours minimum but not to exceed 96 hours. During this test, capacitors shall be adequately protected against temporary voltage surges of 10 percent or more of the test voltage. After burn-in, the capacitors shall be returned to room ambient conditions and the dc leakage, capacitance, and ESR shall be measured as specified in 4.6.4, 4.6.5, and 4.6.6, respectively.

4.6.4 DC leakage (see 3.7).

4.6.4.1 For qualification inspection. DC leakage shall be measured with appropriate rated voltage (see 3.1) applied 5 minutes  $\pm$ 30 seconds after capacitors have reached the rated voltage across the terminals.

4.6.4.2 Conformance inspection. DC leakage shall be measured with the appropriate rated voltage (see 3.1) applied at room temperature and at the applicable maximum high temperature 5 minutes  $\pm$ 30 seconds after capacitors have reached the rated voltage across the terminals.

4.6.5 Capacitance (see 3.8). Capacitance shall be measured in accordance with [method 305 of MIL-STD-202](#). The following details shall apply:

- a. Test frequency - 120  $\pm$ 5 Hz.
- b. Limit of accuracy - Measurement accuracy shall be within  $\pm$ 2 percent of the reading.
- c. Magnitude of polarizing voltage - As specified in 4.6.1.1.

4.6.6 ESR (see 3.9). ESR shall be determined by a polarized capacitance bridge. Instrument measurement accuracy shall be within  $\pm$ 2 percent (see 4.6.1.1).

4.6.7 Low temperature exposure (see 3.10). Capacitors shall be exposed for 48 hours at the applicable low temperature +0°C, -5°C with no voltage applied. After exposure, the capacitors shall be returned to room ambient conditions and the dc leakage, capacitance, and ESR shall be measured as specified in 4.6.4, 4.6.5, and 4.6.6, respectively.

4.6.8 Solderability (capacitors with wire-lead terminals only) (see 3.11). Capacitors shall be tested in accordance with [method 208 of MIL-STD-202](#). The following details shall apply:

- a. The number of termination's of each part to be tested - Two (four for style CUR19).
- b. Depth of immersion in flux and solder - Leads shall be immersed to within .125 inch (3.18 mm) of the eyelet, seal, lead weld, or case.

4.6.9 Terminal strength (see 3.12). All capacitors shall be tested in accordance with 4.6.9.1 and, when specified (see 3.1), in accordance with 4.6.9.2 or 4.6.9.3.

4.6.9.1 Pull test. Capacitors shall be tested in accordance with [method 211 of MIL-STD-202](#). The following details shall apply:

- a. Test method - A.
- b. Method of holding - The body of the capacitor shall be secured, when applicable.
- c. Applied force - 3 pounds.

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4.6.9.2 Twist test. Capacitors shall be tested in accordance with [method 211 of MIL-STD-202](#). The following details shall apply:

- a. Test condition - D.
- b. Number of rotations - Three.

4.6.9.3 Torque test (threaded terminals only). Capacitors shall be tested in accordance with [method 211 of MIL-STD-202](#). The following details shall apply:

- a. Test condition - E.
- b. Torque - as specified ([see 3.1](#)).

After the test(s), capacitors shall be visually examined for loosening of terminals and permanent damage to the terminal or terminal solder, as applicable.

4.6.10 Stability at reduced and high temperatures ([see 3.13](#)). The measurements specified in [table VIII](#) shall be made in the order shown. The capacitors shall be brought to thermal stability before the measurements are made. Thermal stability will have been reached when no further change in capacitance is observed between two successive measurements taken at 15-minute intervals.

TABLE VIII. Temperature and measurement for stability tests at reduced and high temperatures.

Step	Temperature (°C)	Measurement	Requirement paragraph	Test method paragraph
1	25 ±5	DC leakage Capacitance ESR	<a href="#">3.7</a> <a href="#">3.8</a> <a href="#">3.9</a>	<a href="#">4.6.4</a> <a href="#">4.6.5</a> <a href="#">4.6.6</a>
2	-55 +0, -3 (or as specified, see 3.1)	Impedance Capacitance	<a href="#">3.13</a> <a href="#">3.8</a>	<a href="#">4.6.10.1</a> <a href="#">4.6.5</a>
3	25 ±5	DC leakage Capacitance ESR	<a href="#">3.7</a> <a href="#">3.8</a> <a href="#">3.9</a>	<a href="#">4.6.4</a> <a href="#">4.6.5</a> <a href="#">4.6.6</a>
4	Applicable maximum high temperature +3, -0 (as specified, see 3.1)	DC leakage Capacitance ESR	<a href="#">3.7</a> <a href="#">3.8</a> <a href="#">3.9</a>	<a href="#">4.6.4</a> <a href="#">4.6.5</a> <a href="#">4.6.6</a>
5	25 ±5	DC leakage Capacitance ESR	<a href="#">3.7</a> <a href="#">3.8</a> <a href="#">3.9</a>	<a href="#">4.6.4</a> <a href="#">4.6.5</a> <a href="#">4.6.6</a>

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4.6.10.1 Impedance (see 3.13). Impedance shall be measured at -55°C +0°C, -3°C (or as specified, see 3.1) in accordance with 4.6.1.1. The following current limits shall be used when measuring impedance:

<u>Max current level (mA)</u>	<u>Range of expected impedance (ohms)</u>
100	.001 to .1
10	.03 to 3
1	1.0 to 30
.1	10 to 300
.01	100 to 3,000

These values are sufficiently low to prevent a detectable change in impedance due to internal heating of the capacitor. Measurement accuracy shall be within ±5 percent.

4.6.11 Life (see 3.14).

4.6.11.1 For qualification inspection. Capacitors shall be tested in accordance with method 108 of MIL-STD-202, test condition F (2,000 hours). The following details shall apply :)

- a. Distance of temperature measurements from specimens, in inches - Not applicable.
- b. Method of mounting - Capacitors shall be mounted by normal mounting means.
- c. Test temperature and tolerance - All capacitors shall be tested at 85°C +5°C, -0°C or 105°C +5°C, -0°C, as applicable. For styles CU12, CU13, and CUR13, a quantity of capacitors equal to the quantity tested at 85°C shall be tested at 125°C.
- d. Operating conditions - A minimum of dc rated voltage (see 3.1) shall be applied gradually (not to exceed 5 minutes either by a slow build-up of the voltage or through a resistor which shall be shorted out within 5 periods. During the life test of styles CU14 and CU15, the applied voltage shall be reversed at regular intervals. A specific number of hours between intervals shall be chosen. The interval shall be between 95 and 125 hours, and, once established, shall remain the same throughout the test. The voltage shall be reversed gradually over a period not to exceed 5 minutes.
- e. Measurements after exposure - Capacitors shall be returned to room ambient conditions and dc leakage, capacitance, and ESR shall be measured as specified in 4.6.4, 4.6.5, and 4.6.6, respectively. Capacitors shall then be examined for evidence of mechanical damage, obliteration of marking, and leakage of electrolyte.

4.6.11.1.1 Following 2,000-hour qualification inspection (ER styles only). Sample units that have been subjected to 2,000 hours of life test as specified in 4.6.11.1 shall remain on test for an additional 8,000 +72, -0 hours; measurements after completion of the 10,000 hour life time shall be as specified in 4.6.11.1e.

4.6.11.2 Conformance inspection.

4.6.11.2.1 Performance check (non-ER). Capacitors shall be tested as specified in 4.6.11.1, except that test condition B (250 hours) is applicable.

4.6.11.2.2 Continuation test (non-ER). Capacitors that have been subjected to the 250-hour performance check test (see 4.6.11.2.1) shall be tested for an additional period of 1,750 hours in accordance with 4.6.11.1.



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4.6.11.2.3 10,000-hour group C test (ER). Capacitors shall be tested as specified in [4.6.11.1](#). The following details and exceptions shall apply:

- a. Test duration - 10,000 +96, -0 hours.
- b. Measurements during exposure - Hot dc leakage shall be measured during the first hour of exposure and then at 240 +48, -0; 1,000 +48, -0; 2,000 +72, -0; and every 2,000 +72, -0 hours thereafter to 10,000 hours. DC leakage, capacitance, and ESR at 25°C shall be measured as specified in [4.6.4](#), [4.6.5](#), and [4.6.6](#), respectively, at 0, 240, 2,000, and 10,000 hours.
- c. Measurements after exposure - In accordance with [4.6.11.1e](#).
- d. Test temperature - 85°C.

4.6.12 Case insulation (insulated capacitors only) ([see 3.15](#)).

4.6.12.1 Dielectric withstanding voltage ([see 3.15.1](#)). Capacitors shall be tested in accordance with [method 301 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Magnitude and nature of test voltage - 2,000 volts, dc.
- b. Duration of application of test voltage - 60 ±5 seconds.
- c. Points of application - Between a strip of metal foil .250 inch (6.35 mm) ± 016 inch (0.41 mm) wide (placed around the sleeve) and the capacitor case.
- d. Examination after test - Capacitors shall be visually examined for breakdown at the sleeve.

4.6.12.2 Insulation resistance ([see 3.15.2](#)). Insulation resistance shall be measured in accordance with [method 302 of MIL-STD-202](#). The following details shall apply:

- a. Test condition - A (100 volts).
- b. Points of measurement - Between a strip of metal foil .250 inch (6.35 mm) ±016 inch (0.41 mm) wide (placed around the sleeve) and the capacitor case.

4.6.13 Shock (specified pulse) ([see 3.16](#)). Capacitors shall be tested in accordance with [method 213 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Special mounting means - Capacitors shall be rigidly mounted on a mounting fixture by the body. Leads shall be secured to rigidly supported terminals, so spaced that the length of each lead from the capacitor is approximately .375 inch (9.52 mm) when measured from the edge of the supporting terminal. Leads shall be within 30 degrees of being parallel. When securing leads, care should be taken to avoid pinching the leads.
- b. Test condition - I, unless otherwise specified ([see 3.1](#)).
- c. Measurement and electrical loading during shock - DC rated voltage shall be applied to the capacitor during test. Observations shall also be made to determine intermittent contacts, arcing, or open- or short-circuiting. Detecting equipment shall be sufficiently sensitive to detect any interruption of 0.5 ms or greater duration.
- d. Examination after test - Capacitors shall be visually examined for evidence of arcing, breakdown, mechanical damage, and leakage of electrolyte.

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4.6.14 Vibration ([see 3.17](#)). Capacitors shall be tested as specified in [4.6.14.1](#), [4.6.14.2](#), or [4.6.14.3](#), as specified ([see 3.1](#)).

4.6.14.1 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.
- c. Duration of vibration - 1 hour 30 minutes.
- d. Direction of motion - 45 minutes in each of two mutually perpendicular directions, one parallel and the other perpendicular to the cylindrical axis.
- e. Measurements during vibration - During the last 3 minutes of vibration in each direction, an electrical measurement shall be made to determine intermittent contacts or open- or short-circuiting. Detecting equipment shall be sufficiently sensitive to detect any interruption of 0.5 ms or greater duration.
- f. Examination after test - Capacitors shall visually be examined for mechanical damage and leakage of electrolyte.

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

- a. Mounting - Body of the capacitor shall be rigidly mounted to the vibration test apparatus.
- b. Test condition - B (15 G), unless otherwise specified ([see 3.1](#)).
- c. Duration and direction of motion - 4 hours in each of two mutually perpendicular directions (total of 8 hours), one parallel and the other perpendicular to the cylindrical axis.
- d. Measurements - During the last 30 minutes of vibration in each direction, an electrical measurement shall be made to determine intermittent contacts or open- or short-circuiting. Detecting equipment shall be sufficiently sensitive to detect any interruption of 0.5 ms or greater duration.
- e. Examination after test - Capacitors shall be visually examined for mechanical damage and leakage of electrolyte.

4.6.14.3 Random vibration (styles CUR13, CUR17, CUR01, and CUR02, only) ([see 3.1](#)). Capacitors shall be tested in accordance with [method 214 of MIL-STD-202](#). The following details shall apply:

- a. Mounting - Body of the capacitor shall be rigidly supported.
- b. Test condition - E of table 214-2.
- c. Duration and direction of motion - 1 hour 30 minutes in each of three mutually perpendicular directions (total of 4 hours 30 minutes).
- d. Measurements - During the last 30 minutes of vibration in each direction, an electrical measurement shall be made to determine intermittent contacts or open- or short-circuiting. Detecting equipment shall be sufficiently sensitive to detect any interruption of 0.5 ms or greater duration.
- e. Examination after test - Capacitors shall be visually examined for mechanical damage and leakage of electrolyte.

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4.6.15 Salt spray (corrosion) (see 3.18). Capacitors shall be tested in accordance with [method 101 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Test condition letter B (48) hours.
- b. Measurements after exposure: Not applicable.

After this test, capacitors shall be visually examined for evidence of harmful corrosion and other defects that will effect life or serviceability, for unwrapping of and mechanical damage to case insulation (when applicable), and obliteration of marking.

4.6.16 Thermal shock and immersion (see 3.19).

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

- a. Conditioning prior to first cycle - For a period of 15 minutes at room ambient temperature.
- b. Test condition - A, except that in step 3, sample units shall be tested at the applicable maximum high temperature ([see 3.1](#)).
- c. Measurements before and after cycling - Not applicable.

4.6.16.2 Immersion cycling. Following thermal shock, capacitors shall be tested in accordance with [method 104 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Test condition - B, with the addition of a noncorrosive dye, rhodamine B (tetraethylrhodamine or equivalent), added to both baths.
- b. Temperature of cold bath - 0°C +0°C, -5°C.
- c. Duration of each immersion - 30 minutes. Change from one solution to the other shall be made in not more than 3 seconds.
- d. Measurements after cycling - Between 30 minutes and 4 hours after removal from the immersion bath, dc leakage, capacitance, and ESR shall be measured at room ambient conditions as specified in [4.6.4](#), [4.6.5](#), and [4.6.6](#), respectively. When applicable ([see 3.1](#)), case insulation shall be tested as specified in [4.6.12](#).
- e. Examination after test - Capacitors shall be visually examined for evidence of corrosion ([see 3.18](#)), mechanical damage, and obliteration of marking. Capacitors shall also be examined for leakage of electrolyte, and shall then be opened and examined for evidence of penetration of dye. Internal materials that do not pick up visual amounts of the dye shall be observed under ultraviolet light.

4.6.17 Surge voltage (see 3.20). Capacitors shall be subjected to 1,000 cycles of the dc surge voltage specified ([see 3.1](#)). Nonpolarized styles shall be subjected to 1,000 cycles in each direction. The ambient temperature during cycling shall be the applicable maximum high temperature ([see 3.1](#)). Each cycle shall consist of a 30-second surge voltage application, followed by a 5 minute 30 second discharge period. Voltage application shall be made through a resistor (1,000 ±100 ohms for capacitance values of less than 2,500 µF and 100 ±10 ohms for capacitance values of 2,500 µF and greater) in series with the capacitor and the voltage source. Each surge voltage cycle shall be performed in such a manner that the capacitor is discharged through the resistor at the end of the 30-second application. The test shall be terminated on the discharge portion of the cycle. After the last voltage application cycle, capacitors shall be stabilized at the inspection conditions specified in [4.6.1](#), and the dc leakage, capacitance, and ESR shall be measured as specified in [4.6.4](#), [4.6.5](#), and [4.6.6](#), respectively. After the test, capacitors shall be visually examined for evidence of mechanical damage or leakage of electrolyte.

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4.6.18 Vent (when specified, see 3.1) (see 3.21). Capacitors shall be subjected to the application of a constant reverse dc current of  $10 \pm 0.5$  amperes for  $30 \pm 1$  minutes. The vent shall operate within the time period of current application. If the capacitor opens or short-circuits and the vent has not operated, additional capacitors shall be selected and subjected to this test.

4.6.19 Moisture resistance (see 3.22). Capacitors shall be tested in accordance with [method 106 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Mounting - Rigidly mounted by normal mounting means ([see 3.1](#)), except during measurements.
- b. Initial measurements and conditioning - Not applicable.
- c. Polarization voltage - Not applicable.
- d. Loading voltage - Not applicable.
- e. Final measurements - After the final cycle and within 2 to 6 hours after removal of capacitors from the humidity chamber, dc leakage, capacitance, and ESR shall be measured at room ambient conditions as specified in [4.6.4](#), [4.6.5](#), and [4.6.6](#), respectively. When applicable, case insulation shall be tested as specified in [4.6.12](#).
- f. Examinations after test - Capacitors shall be visually examined for corrosion, mechanical damage, and obliteration of marking. Capacitors shall also be examined for leakage of electrolyte.

4.6.20 Fungus (see 3.23). Capacitors shall be tested in accordance with [method 508 of MIL-STD-810](#). Pretest and post-test measurements are not required.

4.6.21 Barometric pressure (reduced) (see 3.24). Capacitors shall be tested in accordance with [method 105 of MIL-STD-202](#). The following details and exceptions shall apply:

- a. Method of mounting - By normal mounting means.
- b. Maximum pressure - .82 inch (20.8 mm) of mercury (equivalent to 80,000 feet or 24,384 m).
- c. Test during subjection to reduced pressure - At the end of the conditioning period, with the capacitors still at reduced pressure, the dc rated voltage ([see 3.1](#)) shall be applied for 1 minute  $\pm 5$  seconds.
- d. Exposure time prior to measurements - 5 minutes.
- e. Examination after subjection to reduced pressure - Capacitors shall be visually examined for evidence of mechanical damage, obliteration of marking, leakage of electrolyte, and indications of flashover and breakdown.

4.6.22 High temperature exposure (see 3.25). Unless otherwise specified ([see 3.1](#)), capacitors shall be stored for  $500 \pm 8$  hours in a forced-air oven at the applicable maximum high temperature ( $+5^{\circ}\text{C}$ ,  $-0^{\circ}\text{C}$ ) ([see 3.1](#)) without any application of voltage. After the storage period, the capacitors shall be removed from the oven, and returned to and stabilized at room ambient conditions. DC leakage, capacitance, and ESR shall then be measured as specified in [4.6.4](#), [4.6.5](#), and [4.6.6](#), respectively. Capacitors shall be examined for evidence of mechanical damage, and for leakage of electrolyte. Two capacitors shall then be subjected to the internal examination specified in [4.6.2.1 \(see 3.4.2\)](#).

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4.6.23 Reverse voltage (when specified, see 3.1) (see 3.26). Unless otherwise specified (see 3.1), capacitors shall be subjected to the specified dc test voltage (see 3.1) applied in the reverse polarity direction for 125 ±5 hours, and to the dc rated voltage applied in the forward polarity direction, for an additional period of 125 ±5 hours. The ambient temperature during the tests shall be the applicable maximum high temperature (+5°C, -0°C) (see 3.1).

After the last 125-hour period, the capacitors shall be returned to room ambient conditions and the dc leakage, capacitance, and ESR shall be measured as specified in 4.6.4, 4.6.5, and 4.6.6, respectively.

4.6.24 High temperature verification (styles CU12, CU13, CUR13, CU14, CU15, CU16, CU17, CUR17, CUR19, CU01, CUR01, and CUR02 only) (see 3.27). Capacitors shall be tested at the applicable temperature and voltage (see 3.1) for 2,000 +72, -0 hours. Capacitors shall be returned to room ambient conditions and dc leakage, capacitance, and ESR shall be measured as specified in 4.6.4, 4.6.5, and 4.6.6, respectively.

4.6.25 AC verification (styles CUR91 and CUR92 only) (see 3.28). Capacitors shall be exposed to the voltage and frequencies specified (see 3.1) at 105°C +5°C, -0°C for 2,000 +72, -0 hours. Capacitors shall be returned to room ambient conditions and dc leakage, capacitance, and ESR shall be measured as specified in 4.6.4, 4.6.5, and 4.6.6, respectively.

4.6.26 Reverse voltage aging (all styles except CU14 and CU15) (see 3.29). Capacitors shall be subjected to 1.5 volts applied in the reverse polarity direction for 96 +5, -0 hours at maximum rated temperature with 10 ohms maximum impedance. Capacitors shall be returned to 25°C and surge voltage shall be applied in a forward direction for a period of 2 hours minimum to 24 hours maximum. Impedance for capacitance values of less than 2,500 µF is 1,000 ohms maximum and 100 ohms maximum for capacitance values of 2,500 µF and greater. DC leakage shall then be measured at rated voltage as specified in 4.6.4. Capacitors shall be visually examined for evidence of mechanical damage and leakage of electrolyte.

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## 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. Aluminum oxide electrolytic capacitors are intended for use in filter and bypass applications where large capacitance values are required in small cases and where excess of capacitance over the nominal value can be tolerated. For polarized capacitors, the applied ac peak voltage should never exceed the applied dc voltage; the sum of the applied ac peak and dc voltages should never exceed the dc rated voltage (see 3.1). They are military unique due to the fact that they must be able to operate satisfactorily in military systems under the following demanding conditions: +85°C or +125°C operating temperature range, 100Gs of shock, 48 hours of salt spray corrosion, and 2000 hours of rated voltage testing. Commercial components are not designed to withstand these military environmental conditions.

6.2 Acquisition requirements. Acquisition documents must specify the following:

- a. Title, number and date of the specification.
- b. Title, number, and date of the applicable specification sheet, and the complete PIN (see 3.1).
- c. If retinning (hot-solder dip) of the leads is required (see 3.5.3.1).
- d. Packaging requirements (see 5.1).

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. Information pertaining to qualification of products may be obtained from the Defense Supply Center, Columbus, ATTN: DSCC-VQP, PO Box 3990, Columbus, OH 43218-3990, or by e-mail to [vqp.chief@dla.mil](mailto:vqp.chief@dla.mil).

6.3.1 Copies of SD-6, "Provisions Governing Qualification".

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

6.4 Standard capacitor types. Equipment designers should refer to MIL-HDBK-198 for standard capacitor types and selected values chosen from this specification. MIL-HDBK-198 provides a selection of handbook capacitors for new equipment design.

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6.5 Subject term (key word) listing.

Capacitance  
Dissipation factor  
Insulation resistance

6.6 Tin plated finishes. Tin plating is prohibited ([see 3.5.3.2](#)) since it may result in tin whisker growth. Tin whisker growth could adversely affect the operation of electronic equipment systems. For additional information, [see ASTM B545](#), (Standard Specification for Electrodeposited Coating of Tin).

6.7 Cleaning solvents. Recommended solvents include all those free of halogen or halogen groups, such as toluene, methanol, methyl cellosolve, alconox and water, and naphtha. Chlorinated or fluorinated hydrocarbon solvents are prohibited for capacitors without an epoxy or polymer end seal.

\* 6.8 Tin whisker growth. 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 of this matter, refer to ASTM-B545 (Standard Specification for Electrodeposited Coatings of Tin).

\* 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. Environmental Protection Agency (EPA) is focusing efforts on reducing 31 priority chemicals. The list of chemicals is available on their website <http://www.epa.gov/osw/hazard/wastemin/priority.htm>. Included in the EPA list of 31 priority chemicals are cadmium, lead, and mercury. Use of these materials on the list should be minimized or eliminated unless needed to meet the requirements specified herein ([see Section 3](#)).

6.10 Shelf life. This specification covers items where shelf life is a consideration. Specific shelf life requirements should be specified in the contract or purchase order. The shelf life codes are contained in the Federal Logistics Information System Total Item Record. Additive information for shelf life management may be obtained from [DoD 4120.27M](#), Shelf life Management Manual, or the designated shelf life Points of Contact (POC). The POC should be contacted in the following order: (1) the Inventory Control Points (ICPs), and (2) the DoD Service and Agency administrators for the DoD Shelf life Program. Appropriate POCs for the DoD Shelf Life Program can be contacted through the DoD Shelf Life Management website: <http://www.shelflife.hq.dla.mil>

6.11 Changes from previous issues. The margins of this specification are marked with asterisks to indicate where changes from 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.

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## APPENDIX A

## PROCEDURE FOR QUALIFICATION INSPECTION

## A.1. SCOPE

A.1.1 Scope. This appendix details the qualification-submittal plans for capacitors to be subjected to the qualification inspection 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.

A.1.2 Qualification categories. Qualification shall be categorized as follows:

Category A - Qualification shall be in accordance with the requirements of this specification.

## A.2. APPLICABLE DOCUMENTS

**MIL-STD-1276** - Leads for Electronic component Parts.

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

## A.3. SUBMISSION

A.3.1 Sample.

A.3.1.1 Single-type submission. A sample consisting of 73, 93, 96, 103, 108, 109, 126 or 132, as applicable (see footnote to [table II](#)), sample units of each style in the highest capacitance value in the voltage rating for which qualification is sought shall be submitted. The capacitance tolerance shall be the same for all submitted samples.

A.3.1.2 Voltage-group submission. A sample group, as specified (see [table A-I](#)), of the highest capacitance value in the lowest and highest voltage ratings, as applicable, for which qualification within each voltage group is sought shall be submitted. Separate submissions shall be made for each voltage group. Styles covered by different specification sheets shall not be combined. Examples of voltage-group submission are listed in [table A-II](#).

TABLE A-I. Voltage groups.

For qualification and maintenance of qualification for subgroup 3 of group B		For maintenance of qualification for the remainder of the specification	
Group number	Voltage rating (at 85°C or 105°C)	Group number	Voltage rating (at 85°C or 105°C)
I	5-50	I	5-100
II	75-250	II	150-350
III	300-350		



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TABLE A-II. Examples of voltage-group submission.

Types to be submitted	Quantity	When qualification is sought for
M39018/01-0406	27	Styles CU12 and CU13. All capacitance values in all voltage ratings of voltage group I.
M39018/01-0606	28	
M39018/01-0438	27	
M39018/01-0638	28	
M39018/01-0445	27	Styles CU12 and CU13. All capacitance values in all voltage ratings of voltage group II.
M39018/01-0645	28	
M39018/01-0474	27	
M39018/01-0674	28	
M39018/01-0481	27	Styles CU12 and CU13. All capacitance values in all voltage ratings of voltage group III.
M39018/01-0681	28	
m39018/01-0488	27	
M29018/01-0688	28	
M39018/01-1006M	66	Style CUR13. All capacitance values in all voltage ratings of voltage group I.
M39018/01-1038M 1/	66	
M39018/01-1045M	66	Style CUR13. All capacitance values in all voltage ratings of voltage group II.
M39018/01-1074M 1/	66	
M39018/01-1081M	66	Style CUR13. All capacitance values in all voltage ratings of voltage group III.
M39018/01-1088M 1/	66	
M39018/02-0404	23	Styles CU14 and CU15. All capacitance values in all voltage ratings of voltage group I.
M39018/02-0604	24	
M39018/02-0423	23	
M39018/02-0623	24	
M39018/02-0428	23	Styles CU14 and CU15. All capacitance values in all voltage ratings of voltage group II.
M39018/02-0628	24	
M39018/02-0446	23	
M39018/02-0646	24	
M39018/03-0409	27	Styles CU16 and CU17. All capacitance values in all voltage ratings of voltage group I.
M39018/03-0609	28	
M39018/03-0442	27	
M39018/03-0699	28	
M39018/03-0451	27	Styles CU16 and CU17. All capacitance values in all voltage ratings of voltage group II.
M39018/03-0651	28	
M39018/03-0483	27	
M39018/03-0683	28	
M39018/03-0491	27	Styles CU16 and CU17. All capacitance values in all voltage ratings of voltage group III.
M39018/03-0691	28	
M39018/03-0498	27	
M39018/03-0698	28	

See footnote at end of table.

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TABLE A-II. Examples of voltage-group submission - Continued.

Types to submitted	Quantity	When qualification is sought for
M39018/03-1009M	66	Style CUR17. All capacitance values in all voltage ratings of voltage group I.
M39018/03-1099M <u>1/</u>	66	
M39018/03-1051M	66	Style CUR17. All capacitance values in all voltage ratings of voltage group II.
M39018/03-1083M <u>1/</u>	66	
M39018/03-1091M	66	Style CUR17. All capacitance values in all voltage ratings of voltage group III.
M39018/03-1098M <u>1/</u>	66	
M39018/03-1209M	66	Style CUR17 (high frequency vibration). All capacitance values in all voltage ratings of voltage group I.
M39018/03-1299M <u>1/</u>	66	
M39018/03-1251M	66	Style CUR17 (high frequency vibration). All capacitance values in all voltage ratings of voltage group II.
M39018/03-1283M <u>1/</u>	66	
M39018/03-1291M	66	Style CUR17 (high frequency vibration). All capacitance values in all voltage ratings of voltage group III.
M39018/03-1298M <u>1/</u>	66	
M39018/04-0010	37	Style CU71. All capacitance values in all voltage ratings of voltage group I.
M39018/04-1168	37	
M39018/04-1188	37	Style CU71. All capacitance values in all voltage ratings of voltage group II.
M39018/04-0086	37	
M39018/04-1303	37	Style CU71. All capacitance values in all voltage ratings of voltage group III.
M39018/04-0105	37	
M39018/04-2025M	48	Style CUR71. All capacitance values in all voltage ratings of voltage group I.
M39018/04-2170M	48	
M39018/04-2190M	48	Style CUR71. All capacitance values in all voltage ratings of voltage group II.
M39018/04-2237M	48	
M39018/04-2249M	48	Style CUR71. All capacitance values in all voltage ratings of voltage group III.
M39018/04-2259M	48	
M39018/06-0020M	54	Style CUR91. All capacitance values in all voltage ratings of voltage group I.
M39018/06-0157M	54	
M39018/06-0177M	54	Style CUR91. All capacitance values in all voltage ratings of voltage group II.
M39018/06-0213M	54	

See footnote at end of table.

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TABLE A-II. Examples of voltage-group submission - Continued.

Types to be submitted	Quantity	When qualification is sought for
M39018/07-0012M	63	Style CUR19. All capacitance values in all voltage ratings of voltage group I.
M39018/07-0095M	63	
M39018/07-0104M	63	Style CUR19. All capacitance values in all voltage ratings of voltage group II.
M39018/07-0128M	63	
M39018/07-0212M	63	Style CUR19 (high frequency vibration). All capacitance values in all voltage ratings of voltage group I.
M39018/07-0295M	63	
M39018/07-0304M	63	Style CUR19 (high frequency vibration). All capacitance values in all voltage ratings of voltage group II.
M39018/07-0328M	63	
M39018/08-0001	52	Style CU01. All capacitance values in all voltage ratings of voltage group I.
M39018/08-0012	52	
M39018/08-0013	52	Style CU01. All capacitance values in all voltage ratings of voltage group II.
M39018/08-0018	52	
M39018/08-0102M	63	Style CUR01. All capacitance values in all voltage ratings of voltage group I.
M39018/08-0113M <u>1/</u>	63	
M39018/08-0114M	63	Style CUR01. All capacitance values in all voltage ratings of voltage group II.
M39018/08-0119M <u>1/</u>	63	
M39018/09-0018M	63	Style CUR02. All capacitance values in all voltage ratings of voltage group I.
M39018/09-0086M <u>1/</u>	63	
M39018/09-0104M	63	Style CUR02. All capacitance values in all voltage ratings of voltage group II.
M39018/09-0176M <u>1/</u>	63	
M39018/10-0001M	27	Style CUR92. All capacitance values in all voltage ratings of voltage group I, terminal style A.
M39018/10-0011M	27	
M39018/10-0141M	27	
M39018/10-0151M	27	
M39018/10-0012M	27	Style CUR92. All capacitance values in all voltage ratings of voltage group I, terminal style B.
M39018/10-0020M	27	
M39018/10-0152M	27	
M39018/10-0160M	27	
M39018/10-0161M	27	Style CUR92. All capacitance values in all voltage ratings of voltage group II, terminal style A.
M39018/10-0171M	27	
M39018/10-0201M	27	
M39018/10-0211M	27	
M39018/10-0172M	27	Style CUR92. All capacitance values in all voltage ratings of voltage group II, terminal style B.
M39018/10-0180M	27	
M39018/10-0212M	27	
M39018/10-0220M	27	

1/ For parts with optional random vibration, the letter "R" shall be used in place of the dash (i.e., M39018/09R0001M).

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## APPENDIX A

## A.4. EXTENT OF QUALIFICATION

A.4.1 Single-type submission. Capacitance qualification shall be restricted to values equal to and less than the capacitance value in the style and dc rated voltage submitted. Capacitance tolerance qualification shall be restricted to the capacitance tolerances equal to or wider than the tolerances submitted.

A.4.2 Voltage-group submission. Qualification of types submitted shall be a basis for qualification of all intermediate voltages of the voltage group submitted. Capacitance qualification for each voltage submitted shall be restricted to the capacitance value equal to and less than the capacitance value submitted. For intermediate voltages in the same voltage group, capacitance qualification shall be restricted to capacitance values equal to and less than the higher capacitance values submitted. Capacitance tolerance qualification shall be restricted to the tolerances equal to and wider than those submitted. Qualification of an insulated style shall be the basis for qualification of the uninsulated style from the same specification sheet.

A.4.3 Qualification for styles with optional random vibration. Qualification for styles with optional random vibration shall be granted for the same styles that have been qualified without random vibration under the following conditions:

- a. For parts with random vibration having the same design and construction as those without random vibration, a sample of 6 units shall be subjected to the random vibration test, with one failure allowed.
- b. Parts with random vibration not having the same design and construction, as those without random vibration shall be subjected to the entire qualification inspection in accordance with [table II](#). The number of samples for each style shall be the same as those listed in [table A-I](#).

A.5.1 Solder dip (retinning leads) (capacitors with wire-lead terminals). The manufacturer (or his authorized category B or C distributor) may solder dip/retin the leads of product supplied to this specification, provided the solder dip process (50.2) or an equivalent process has been approved by the qualifying activity.

A.5.2 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](#) (Note: The 200 microinch maximum thickness requirement 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 50.2a, approval for the process to be use for solder dip shall be base 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. The capacitors shall then be subjected to all group A subgroup 1 post electrical tests with no defects allowed.
  - (2) Ten of the 30 samples shall then be subjected to the solderability test. No defects are allowed.

A.5.3 Solder dip/retinning options. The manufacturer (or his authorized category B or 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 100 percent A inspection has been completed. Following the solder dip/retinning process, the electrical measurements required in group A, subgroup 1 screening tests shall be repeated on 100 percent of the lot. The percent defective allowable (PDA) (5%) shall be the same as that allowed for subgroup 1 of the group A inspection.

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Custodians:

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

Preparing activity:  
DLA - CC

Review activities:

Army - MI  
Navy - AS, MC, OS, SH  
Air Force - 19

(Project 5910-2009-019)

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 <http://assist.daps.dla.mil>.