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**INCH-POUND**  
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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

1.1 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 (%/1,000 hr)</u>
M	1.0
P	0.1
R	0.01
S	0.001

A part per million (PPM) quality system is used for documenting and reporting the average outgoing quality of ER capacitors supplied to this specification. Statistical process control (SPC) techniques are required in the manufacturing process to minimize variation in production of ER capacitors supplied to the requirements of this specification.

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

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Defense Electronics Supply Center, ATTN: DESC-ELDM, 1507 Wilmington Pike, Dayton, OH 45444-5765, or by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A

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FSC 5910

## 2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 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).

## SPECIFICATION

## MILITARY

MIL-C-39028 - Capacitors, Packaging of.

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

## STANDARDS

## FEDERAL

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

## MILITARY

MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.  
 MIL-STD-690 - Failure Rate Sampling Plans and Procedures.  
 MIL-STD-790 - Reliability Assurance Program for Electronic Parts Specifications.  
 MIL-STD-810 - Environmental Test Methods.  
 MIL-STD-1276 - Leads for Electronic Component Parts.  
 MIL-STD-1285 - Marking of Electrical and Electronic Parts.  
 MIL-STD-45662 - Calibration Systems Requirements.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

## ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

EIA-554 - Assessment of Outgoing Nonconforming Levels in Parts Per Million (PPM).  
 EIA-557 - Statistical Process Control Systems.

(Application for copies should be addressed to the Electronic Industries Association, Engineering Department, 2001 Pennsylvania Avenue NW, Washington, DC 20006.)

(Non-Government standards and other publications are normally available from the organizations which prepare or distribute the documents. These documents may also be available in or through libraries or other informational services.)

### 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 which are authorized by the qualifying activity for listing on the applicable qualified products list at the time of award of contract (see 4.4 and 6.3). Unless procured from the manufacturer or his authorized distributor listed or approved for listing on the qualified products list, parts furnished under this specification shall not be considered as having met the requirements of this specification.

### 3.3 Reliability and quality (ER styles only).

3.3.1 Reliability. Reliability of ER capacitors furnished under this specification shall be established and maintained in accordance with the procedures and requirements specified in MIL-STD-790 and MIL-STD-690 with details specified in 4.1.2, 4.4.4.1, and 4.4.7.

#### 3.3.2 Quality.

3.3.2.1 Statistical process control (SPC). The manufacturer shall implement and use SPC techniques in the manufacturing process for ER parts covered by this specification. The SPC program shall be developed and maintained in accordance with all the requirements of EIA-557. The SPC program shall be documented and maintained as part of the overall reliability assurance program as specified in MIL-STD-790. The implementation date for SPC shall be 12 months from the date of this specification. Processes for application of SPC techniques should include but are not limited to:

- a. Foil classification.
- b. Rolling.
- c. Impregnation.
- d. Cover assembly.
- e. Encapsulation.

3.3.2.2 Quality levels. The quality of lots that have been subjected to and have passed the subgroup 1 100 percent screening inspections of group A inspection shall be established and maintained in accordance with 4.5.1.2.1.2.3 and EIA-554, method B. Individual PPM defect levels (i.e., PPM-2 and PPM-3) and an overall PPM defect level (i.e., PPM-5) shall be established, based on the tests prescribed in the subgroup 2 tests of the group A inspections. The defect level for PPM-2 shall be less than 100 PPM. Data shall not be excluded from the appropriate PPM calculation unless specifically authorized by the qualifying activity. Guidance for exclusion of data is specified in EIA-554.

**3.3.2.3 Noncompliance.** The contractor shall notify the qualifying activity when the 100 PPM level is reached or exceeded for PPM-2. The contractor shall provide sufficient information to the qualifying activity documenting the causes of the problem and what corrective action is being taken. Failure to correct this problem shall be the basis for removal of the affected product from the QPL.

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

**3.4.1 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. 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.

**3.5 Design, construction, and physical dimensions.** Capacitors shall be of the design, construction, 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.

**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-N28 as specified (see 3.1).

**3.5.2.1 Solder dip (retinning leads) (capacitors with wire-lead terminals).** Only 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 has been approved by the qualifying activity.

**3.5.2.1.1 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 3.5.2.1.1a, approval for the process to be used for solder dip shall be based on the following test procedure:
  - (1) Thirty samples of any capacitance value for each style and lead finish are subjected to the manufacturer's solder dip process. Following the solder process, the capacitors shall be subjected to the electrical tests of group A inspection, with no defects allowed.
  - (2) Ten of the 30 samples shall then be subjected to the solderability test as specified in 4.6.8. No defects are allowed.

**3.5.2.1.2 Solder dip/reteming options.** The manufacturer (or his authorized category B or C distributor) may solder dip/retin as follows:

- a. After the group A screening tests. Following the solder dip/reteming process, the electrical measurements required in group A, subgroup 1 screening tests shall be repeated on 100 percent of the lot. (Note: The manufacturer may solder dip/retin prior to the electrical measurements of the group A, subgroup 1 tests. This would eliminate the need for an additional set of electrical measurements.). The Percent Defective Allowable (PDA) for the electrical measurements shall be the same as for the subgroup 1 tests.
- b. As a corrective action if the lot fails the group A solderability test.
- c. After the group A inspection has been completed. Following the solder dip/reteming process, the electrical measurements required in group A, subgroup 1 screening tests shall be repeated on 100 percent of the lot. The PDA for the electrical measurements shall be as for the subgroup 1 tests. Following these tests, the manufacturer shall submit the lot to the group A solderability test as specified in 4.6.8.

**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 (see 3.1).
Capacitance	- - - - -	Within the tolerance specified (see 3.1).
ESR	- - - - -	Shall not exceed the initial requirement specified (see 3.1).

**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 (see 3.1).
Capacitance	- - - - -	Within the tolerance specified (see 3.1).
ESR	- - - - -	Shall not exceed the initial requirement specified (see 3.1).

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

3.12 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.

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) (all styles except CUB1 and CURB1).** 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.

**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, 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.

**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, CU02, CU03, and CU04 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 Penetration of solvents (not applicable to styles CU71, CUR71, CU81, CUR81, CUR91, and CUR92). When tested as specified in 4.6.26, capacitors shall meet the following requirements:

- DC leakage - - - - - Shall not exceed the initial requirement specified (see 3.1).
- Capacitance - - - - - Change not more than  $\pm 10$  percent of the initial measured value (see 3.1).
- ESR - - - - - Shall not exceed 115 percent of the initial requirement (see 3.1).

3.30 Reverse voltage aging (all styles except CU14 and CU15). When tested as specified in 4.6.27, 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).

3.31 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 source 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.

**3.31.1 "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 military 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 PIN 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 PIN. 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 detail specifications, the manufacturer shall remove 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".

**3.31.2 Supplying to higher failure rate levels (FRL's).** A manufacturer may supply to all higher 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), the lot date codes on the parts are unchanged, and the workmanship criteria is met.

TABLE I. Failure rate level substitutability.

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

**3.31.3 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.

**3.31.4 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.

**3.32 Workmanship.** Capacitors shall be processed in such a manner as to be uniform in quality and shall be free from cold soldering, corrosion (see 3.18), pits, cracks, dents, rough edges, and other defects that will affect life, serviceability, or appearance. Solder on the surface of the case shall be smooth and unbroken and shall have no pinholes or girdle.

**3.32.1 Soldering.** Flux for soldering shall be rosin, rosin and alcohol, or rosin and turpentine. No acid or acid salts shall be used in preparation for or during soldering. All excess flux and solder shall be removed. Electrical connections shall be mechanically secure before soldering, when possible, and electrically continuous after soldering.

#### 4. QUALITY ASSURANCE PROVISIONS

**4.1 Responsibility for inspection.** Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements (examinations and tests) as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to ensure supplies and services conform to prescribed requirements.

**4.1.1 Responsibility for compliance.** All items must meet all requirements of sections 3 and 5. The inspections set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of ensuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection, as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements; however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

**4.1.2 Reliability assurance program (ER styles only).** A reliability assurance program shall be established and maintained in accordance with MIL-STD-790. Evidence of such compliance shall be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification.

**4.1.3 Statistical process control (SPC) (ER styles only).** An SPC program shall be established and maintained in accordance with EIA-557. Evidence of such compliance shall be verified by the qualifying activity as a prerequisite for qualification and retention of qualification.

**4.1.4 Test equipment and inspection facilities.** Test and measuring equipment and inspection facilities of sufficient accuracy, quality, and quantity to permit performance of the required inspection shall be established and maintained by the contractor. The establishment and maintenance of a calibration system to control the accuracy of the measuring and test equipment shall be in accordance with MIL-STD-45662.

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

- a. Qualification inspection (see 4.4).
- b. Verification of qualification (ER only) (see 4.4.7).
- c. Quality conformance inspection (see 4.5).

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

4.4 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 table II and in the appendix to this specification.

4.4.2 Test routine. The sample shall be subjected to the qualification inspection specified in table II, in the order shown. The sample units shall be subjected to visual and mechanical inspection (internal examination). The remaining sample units shall be subjected to the subsequent inspections of group I. The sample shall then be divided as specified in table II for groups II through XII and subjected to the inspections for their particular group. For voltage-group submission, each style and capacitance value shall be equally represented in each 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 level and quality level verification.

4.4.4.1 FR qualification (ER styles only). 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 FR level. Level "M" (1.0%/1,000 hours) of FRSP-80 shall apply. Sample units shall be subjected to the qualification inspection specified in group III, 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 FR levels. To extend qualification to FR level "P" (0.1 percent), 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 FR level 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 4.4.7f).

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 4.4.4.1d.

4.4.5 Quality level verification (ER styles only). The manufacturer is responsible for establishing a quality system to verify the PPM defect level of lots that are subjected to subgroup 2 tests of the group A inspections. The PPM defect level shall be based on a 6-month moving average. The manufacturer shall verify and report individual PPM categories (i.e., PPM-2 and PPM-3) and an overall PPM defect level (i.e., PPM-5).

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
Visual and mechanical inspection (external examination) <sup>2/</sup> - -	3.1, 3.4, 3.4.1, 3.5 to 3.5.2 incl, 3.31 and 3.32.1	4.6.2	} <sup>3/</sup>	} <sup>4/</sup>	} <sup>4/</sup>	} <sup>1</sup>
Burn-in (ER styles only) <sup>2/</sup> - - - - -	3.6	4.6.3				
DC leakage <sup>2/</sup> - - - - -	3.7	4.6.4				
Capacitance <sup>2/</sup> - - - - -	3.8	4.6.5				
ESR <sup>2/</sup> - - - - -	3.9	4.6.6				
<u>Group II</u>						
Low temperature exposure - - - - -	3.10	4.6.7	} <sup>6</sup>	} <sup>6</sup>	} <sup>2</sup>	} <sup>1</sup>
Solderability (capacitors with wire-lead terminals only) - - - - -	3.11	4.6.8				
Terminal strength - -	3.12	4.6.9				
Stability at reduced and high temperatures - - -	3.13	4.6.10				
<u>Group III</u>						
Life (2,000 hours only) - - - - -	3.14	4.6.11.1	} <sup>22</sup>	} <sup>46</sup>	} <sup>0</sup>	} <sup>0</sup>
Case insulation (insulated capacitors only) - -	3.15	4.6.12				
<u>Group IV</u>						
Shock (specified pulse) - - - - -	3.16	4.6.13	} <sup>6</sup>	} <sup>6</sup>	} <sup>1</sup>	} <sup>1</sup>
Vibration - - - - -	3.17	4.6.14				
Salt spray (corrosion) (all styles except CUB1 and CURB1) - -	3.18	4.6.15				
Thermal shock and immersion - - - - -	3.19	4.6.16				

See footnotes at end of table.

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 V</u>							
Surge voltage - - - -	3.20	4.6.17	6	6	1	1	1
Vent (when specified, see 3.1) - - - - -	3.21	4.6.18					
<u>Group VI</u>							
Moisture resistance -	3.22	4.6.19	12	12	1	1	1
Fungus <u>5/</u> - - - - -	3.23	4.6.20					
<u>Group VII</u>							
Barometric pressure (reduced) - - - - -	3.24	4.6.21	8	8	1	1	1
High temperature exposure - - - - -	3.25	4.6.22					
<u>Group VIII</u>							
Reverse voltage (styles CU12, CU13, CUR13, CU16, CU17, and CUR17 only) - -	3.26	4.6.23	6	6	1	1	1
<u>Group IX</u>							
High temperature verification (styles CU12, CU13, CUR13, CU14, CU15, CU16, CU17, CUR17, CUR19, CU01, CU01, CU02, CU03, and CU04 only) - - - - -	3.27	4.6.24	24	24	1	1	1
<u>Group X</u>							
AC verification (styles CUR91 and CUR92 only) - - - -	3.28	4.6.25	N/A	12	N/A	1	1
<u>Group XI</u>							
Penetration of solvents (not applicable to styles CU71, CUR71, CU81, CUR81, CUR91, and CUR92) - - - - -	3.29	4.6.26	6	6	1	1	1

See footnotes at end of table.

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 XII</u> Reverse voltage aging (all styles except CU14 and CU15) - - - - -	3.30	4.6.27	10	10	0	0

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

2/ Nondestructive test.

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

4/ 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 CU01, CU02, CU03,  
CU04, and CUR19  
132 - Styles CUR13 and CUR17

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

**4.4.6 Retention of qualification (non-ER styles only).** To retain qualification, the contractor shall forward a report at 6-month intervals to the qualifying activity. The qualifying activity shall establish the initial reporting date. The report shall consist of:

- a. A summary of the results of the tests performed for inspection of product for delivery, groups A and B, indicating as a minimum the number of lots that have passed and the number that have failed. The results of tests of all reworked lots shall be identified and accounted for.
- b. A summary of the results of the tests performed for periodic inspection, group C, including the number and mode of failures. The summary shall include results of all periodic inspection tests performed and completed during the 6-month period. If the summary of the test results indicates nonconformance with specification requirements, and corrective action acceptable to the qualifying activity has not been taken, action may be taken to remove the failing product from the qualified products list.

Failure to submit the report within 30 days after the end of each 6-month period may result in loss of qualification for the product. In addition to the periodic submission of inspection data, the contractor shall immediately notify the qualifying activity at any time during the 6-month period that the inspection data indicates failure of the qualified product to meet the requirements of this specification.

In the event that no production occurred during the reporting period, a report shall be submitted certifying that the company still has the capabilities and facilities necessary to produce the item. If there has been no production during three consecutive reporting periods the manufacturer may be required, at the discretion of the qualifying activity, to submit a representative product of each style to testing in accordance with the qualification inspection requirements.

**4.4.7 Verification of qualification (ER styles only).** Every 6 months the manufacturer shall compile a summary of the results of quality conformance inspections and extended FR test data, in the form of a verification of qualification report, and forward it to the qualifying activity within 30 days after the end of the reporting period as the basis of continued qualification approval. In addition, the manufacturer shall immediately notify the qualifying activity whenever the FR data indicates that the manufacturer has failed to maintain the qualified FR level, or the group C inspection data indicates failure of the qualified product to meet the requirements of this specification. Continuation shall be based on evidence that over the 6-month period the following has been met:

- a. Verification by the qualifying activity that the manufacturer meets the requirements of MIL-STD-790.
- b. The manufacturer has not modified the design of the item.
- c. The specification requirements for the item have not been amended so far as to affect the character of the item.
- d. Lot rejection for group A inspection does not exceed 5 percent or one lot, whichever is greater.
- e. The requirements for group C inspection are met.

- f. The records of all FR tests combined substantiate that the "M" or "P" FR level has been maintained or that the manufacturer continues to meet the "R" or "S" FR level for which qualified, although the total component hours of testing may not, as yet, meet the requirements of 4.4.4.1c.
- g. The manufacturer shall provide documentation to the qualifying activity pertaining to PPM calculations, including numbers of part types tested, individual PPM defect categories (i.e., PPM-2 and PPM-3), and the overall PPM defect rate (PPM-5). All ER capacitor styles may be combined for PPM calculations.

If group C requirements were not met and the manufacturer has taken corrective action satisfactory to the Government, the forwarding of the verification of qualification report may be delayed up to 30 days after completion of retesting of the periodic quality conformance tests. In this case, the qualifying activity shall be notified of this condition within the time that the original verification of qualification report was due. All reports shall be certified by a responsible company official. The qualifying activity shall be contacted for the report format.

If group C testing requires a comparison of "post-test" readings with initial readings (delta measurements), the verification of qualification summary shall include the maximum and minimum delta changes for each inspection lot. For life testing, delta C readings shall be reported at each interval in which readings are taken.

Failure to submit the report within 30 days after the end of each 6-month period may result in loss of qualification for the product. In addition to the periodic submission of inspection data, the supplier shall immediately notify the qualifying activity at any time during the 6-month period that the inspection data indicates failure of the qualified product to meet the requirements of the specification.

In the event that no production occurred during the reporting period, a report shall be submitted certifying that the company still has the capabilities and facilities necessary to produce the item. If during three consecutive reporting periods there has been no production, the manufacturer may be required, at the discretion of the qualifying activity, to submit a representative product of each style to testing in accordance with the qualification inspection requirements.

#### 4.5 Quality conformance inspection.

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

##### 4.5.1.1 Inspection and production lot.

4.5.1.1.1 Inspection lot. An inspection lot shall consist of all capacitors covered by the same specification sheet, in the same voltage group (see 30.1.2 of the appendix), 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 and V, 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 - - - - -	3.6	4.6.3	100% inspection
<u>Subgroup 2 (PPM)</u> DC leakage (PPM-2) - - -	3.7	4.6.4	} See table IV
Capacitance (PPM-2) - - -	3.8	4.6.5	
ESR (PPM-2) - - - - -	3.9	4.6.6	
DC leakage (high test temperature) (PPM-2) - - - - -	3.7	4.6.4	
Mechanical examination design and construction (PPM-3)-	3.5	4.6.2	
<u>Subgroup 3</u> Visual examination- - -	3.1, 3.4, and 3.4.1	4.6.2	} 13 samples 0 failures
Marking 1/ - - - - -	3.31	4.6.2	
Workmanship - - - - -	3.32	4.6.2	
<u>Subgroup 4</u> Solderability (capacitors with wire-lead terminals)-	3.11	4.6.8	13 samples 0 failures

1/ Marking defects are based on visual examination only.

TABLE IV. Sampling plans for PPM categories.

Lot size	Sample size
1- 125	100 percent
126- 3,200	125
3,201- 10,000	200
10,001- 35,000	315
35,001-150,000	500
150,001-500,000	800
500,001-up	1250

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	} 125 samples 0 failures
Capacitance - - - - -	3.8	4.6.5	
ESR - - - - -	3.9	4.6.6	
<u>Subgroup 2</u>			
Visual and mechanical inspection - - - - -	3.1, 3.4, and 3.4.1	4.6.2	} 13 samples 0 failures
Design and construction - - - - -	3.5	4.6.2	
Marking 1/ - - - - -	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	13 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 of the capacitors be discarded, the entire production lot shall be rejected.

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

- a. Test conducted by the manufacturer during production shall be clearly identical to or more stringent than that specified for subgroup 1 and shall be performed only on a fully sealed capacitor. Test conditions shall be equal to or more stringent than those specified for subgroup 1.
- 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. This data shall be provided as part of the evaluation required for MIL-STD-790. The manufacturer shall also make available to the Government all records of all detail test data resulting from production tests.

4.5.1.2.1.2 Subgroups 2 tests (PPM categories).

4.5.1.2.1.2.1 Sampling plans. Subgroup 2 tests shall be performed on an inspection lot basis. Samples subjected to subgroup 2 shall be selected in accordance with table IV, based on the size of the production lot. In the event of 1 or more failures, the lot shall be rejected. Equipment and operators used to perform the subgroup 2 tests shall not be the same as those used in the subgroup 1 100 percent test.

4.5.1.2.1.2.2 Rejected lots. The rejected lot shall be segregated from new lots and those lots that have passed inspection. The rejected lot shall be 100 percent inspected for those quality characteristics found defectives in the sample and any defectives found shall be removed from the lot. A new sample of parts shall then be randomly selected in accordance with table IV. If 1 or more defects are found in this second sample, the lot shall be rejected and shall not be supplied to this specification.

4.5.1.2.1.2.3 PPM calculations. PPM calculations shall be based on the results of the first sample check as prescribed in 4.5.1.2.1.2.1. Calculations and data exclusion shall be in accordance with EIA-554. (Note: PPM calculations shall not use data on the second sample submission).

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.

4.5.1.2.1.3.1 Rejected lots. The rejected lot shall be segregated from new lots and those lots that have passed inspection. Lots rejected because of failures in subgroup 3 may be offered for acceptance only if the manufacturer inspects all units in the lot for those quality characteristics found defective in the sample and, after removing all defective units found, reinspects the lot using the sampling procedure specified in table III. If 1 or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification. Resubmitted lots shall be kept separate from new lots, and shall be identified as resubmitted lots.

4.5.1.2.1.4 Subgroup 4 (solderability).

4.5.1.2.1.4.1 Sampling plan. Thirteen samples shall be selected randomly from every inspection lot and subjected to the subgroup 4 solderability test. The manufacturer may use electrical rejects from the subgroup 1 screening tests for all or part of the samples to be used for solderability testing. If there are one or more defects, the lot shall be considered to have failed.

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 4.5.1.2.1.4.1. 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 4.5.1.2.1.4.2b.
- b. The manufacturer shall submit the failed lot to a 100 percent solder dip using an approved solder dip process in accordance with 3.5.2.1. Following the solder dip, the electrical measurements required in the 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. Thirteen 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.

4.5.1.2.1.4.3 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.

4.5.1.2.2 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 2 is rejected, the contractor may rework it to correct the defects, or screen out the defective units, and resubmit for reinspection. Another 125 or 13 samples, as applicable, shall then 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. Thirteen samples shall be selected randomly from every inspection lot and subjected to the subgroup 3 solderability test. The manufacturer may use electrical rejects from the subgroup 1 screening tests for all or part of the samples to be used for solderability testing. If there are one or more defects, the lot shall be considered to have failed.

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 3.5.2.1. Following the solder dip, the electrical measurements required in the group A, subgroup 1 test shall be repeated on another 125 samples, with no defects allowed. Thirteen 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.

TABLE VI. Group B inspections.

Inspection	Requirement paragraph	Test method paragraph
<u>Subgroup 1</u>		
Terminal strength (not applicable to style CU81) - - - - -	3.12	4.6.9
Stability at reduced and high temperatures - - - -	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) - -	3.30	4.6.27

4.5.1.3.1 Sampling plan. For ER styles in subgroup 1, and for non-ER styles in subgroups 1 and 2, the sample size shall be 8, with no failures permitted. For subgroup 3, the sample units, as applicable, see below, will be subjected to the test with one failure permitted. If one failure does occur, 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.

For styles CU12, CU13, and CUR13 - 10 sample units  
 For styles CU16, CU17, CUR17, and CUR19 - 6 sample units  
 All other polarized styles - 3 sample units

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.

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 <u>1/</u>	
				Non-ER	ER
<u>Subgroup 1</u>					
Shock (specified pulse)	3.16	4.6.13	6	1	1
Vibration - - - - -	3.17	4.6.14			
Salt spray (corrosion) (all styles except CUB1 and CURB1) - - -	3.18	4.6.15			
Thermal shock and immersion - - - - -	3.19	4.6.16			
<u>Subgroup 2</u>					
Surge voltage - - - -	3.20	4.6.17	6	1	1
Vent (when specified, see 3.1) - - - - -	3.21	4.6.18			
<u>Subgroup 3</u>					
Penetration of solvents (not applicable to styles CU71, CUR71, CUB1, CURB1, CUR91, and CUR92) - - - - -	3.29	4.6.26	6	1	1
<u>Subgroup 4</u>					
Moisture resistance - -	3.22	4.6.19	12	1	1
Terminal strength (style CUB1 only) - -	3.12	4.6.9	12	1	N/A

See footnote at end of table.

TABLE VII. Group C 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
<u>Subgroup 5</u>					
Barometric pressure (reduced) - - - - -	3.24	4.6.21	6	1	1
High temperature exposure - - - - -	3.25	4.6.22			
<u>Subgroup 6</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	<u>2/</u>
<u>Subgroup 7</u>					
Reverse voltage (styles CUI2, CUI3, CUR13, CUI6, CUI7, and CUR17 only) - - - - -	3.26	4.6.23	6	1	1
<u>Subgroup 8</u>					
High temperature verification (styles CUI2, CUI3, CUR13, CUI4, CUI5, CUI6, CUI7, CUR17, CUR19, CUO1, CURD1, CUO2, CUO3, and CURD4 only) - - - - -	3.27	4.6.24	24	1	1
<u>Subgroup 9</u>					
AC verification (styles CUR91 and CUR92 only)	3.28	4.6.25	<u>3/</u> 12	N/A	1

- 1/ A sample unit having one or more defects shall be considered as a single failure.
- 2/ Number of allowable failures may vary depending on the failure rate level of the part being tested.
- 3/ Six units of each voltage group every 6 months.

**4.5.2.1.1 Sampling plan.** Every 2 months (every year for styles CU14, CU15, and CUB1), the inspections shall consist of subgroups 1 through 3. Every 6 months (every 2 years for styles CU14, CU15, and CUB1), the inspections shall consist of subgroups 4 through 9. Sampling shall be as follows:

- a. Every 2 months (every year for styles CU14, CU15, and CUB1), 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, and CUB1), sample units to be subjected to tests of subgroups 4, 5, 7, 8, and 9 shall be selected at random from units that have passed the group A inspection. Sample units to be subjected to the test of subgroup 6 shall be randomly selected every 6 months (every 2 years for styles CU14, CU15, and CUB1), 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 shall be furnished to the cognizant inspection activity and the qualifying activity.

**4.5.3 Packaging inspection.** The sampling and inspection of the preservation-packaging, packing, and container marking shall be in accordance with the requirements of MIL-C-39028.

#### **4.6 Methods of inspection.**

##### **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  $\pm$  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 incl, and 3.31 to 3.32.1 incl).

**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.

**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 For quality 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  $+0$ ,  $-5^{\circ}\text{C}$  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 205 of MIL-STD-202. The following details shall apply:

- a. The number of terminations 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.

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	3.7 3.8 3.9	4.6.4 4.6.5 4.6.6
2	-55 +0, -3 (or as specified, see 3.1)	Impedance Capacitance	3.13 3.8	4.6.10.1 4.6.5
3	25 ±5	DC leakage Capacitance ESR	3.7 3.8 3.9	4.6.4 4.6.5 4.6.6
4	Applicable maximum high temperature +3, -0 (as specified, see 3.1)	DC leakage Capacitance ESR	3.7 3.8 3.9	4.6.4 4.6.5 4.6.6
5	25 ±5	DC leakage Capacitance ESR	3.7 3.8 3.9	4.6.4 4.6.5 4.6.6

4.6.10.1 Impedance (see 3.13). Impedance shall be measured at  $-55^{\circ}\text{C} \pm 0^{\circ}\text{C}$ ,  $-3^{\circ}\text{C}$  (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 3000

These values are sufficiently low to prevent a detectable change in impedance due to internal heating of the capacitor. Measurement accuracy shall be within  $\pm 5$  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  $85^{\circ}\text{C} \pm 5^{\circ}\text{C}$ ,  $-0^{\circ}\text{C}$  or  $105^{\circ}\text{C} \pm 5^{\circ}\text{C}$ ,  $-0^{\circ}\text{C}$ , as applicable. For styles CUI2, CUI3, and CUR13, a quantity of capacitors equal to the quantity tested at  $85^{\circ}\text{C}$  shall be tested at  $125^{\circ}\text{C}$ .
- 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 minutes). Voltage shall be applied continuously except for measurement periods. During the life test of styles CUI4 and CUI5, 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  $\pm 72$ ,  $-0$  hours; measurements after completion of the 10,000 hour life time shall be as specified in 4.6.11.1e.

**4.6.11.2 For quality 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 which 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.

**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 expectations shall apply:

- a. Test duration - 10,000  $\pm$ 96, -0 hours.
- b. Measurements during exposure - Hot dc leakage shall be measured during the first hour of exposure and then at 240  $\pm$ 48, -0; 1,000  $\pm$ 48, -0; 2,000  $\pm$ 72, -0; and every 2,000  $\pm$ 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  $\pm$ 5 seconds.
- c. Points of application - Between a strip of metal foil .250 inch (6.35 mm)  $\pm$ .015625 inch (0.39688 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)  $\pm$ .015625 inch (0.39688 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 - 1, 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.

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 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, CURO1, CURO2, and CURD4 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.

4.6.15 Salt spray (corrosion) (all styles except CU81 and CUR81) (see 3.18). Capacitors shall be tested in accordance with method 101, test condition B (48 hours) of MIL-STD-202. After this test, capacitors shall be visually examined for evidence of 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  $\pm$ 100 ohms for capacitance values of less than 2,500  $\mu$ F and 100  $\pm$ 10 ohms for capacitance values of 2,500  $\mu$ F 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.

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 5DB 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).

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  $\pm$  5 hours, and to the dc rated voltage applied in the forward polarity direction, for an additional period of 125  $\pm$  5 hours. The ambient temperature during the tests shall be the applicable maximum high temperature ( $+5^{\circ}\text{C}$ ,  $-0^{\circ}\text{C}$ ) (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 CUI2, CUI3, CUR13, CUI4, CUI5, CUI6, CUI7, CUR17, CUR19, CU01, CUR01, CUR02, CUR03, and CUR04 only) (see 3.27). Capacitors shall be tested at the applicable temperature and voltage (see 3.1) for 2,000  $\pm$  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  $105^{\circ}\text{C}$   $\pm$   $5^{\circ}\text{C}$ ,  $-0^{\circ}\text{C}$  for 2,000  $\pm$  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 Penetration of solvents (not applicable to styles CU71, CUR71, CUB1, CURB1, CUR91, and CUR92) (see 3.29). Capacitors shall be immersed in Dupont type 1F solvent, or equivalent, at 25°C ±5°C, -0°C for 4 hours minimum, followed by exposure at 85°C ±5°C, -0°C, or 125°C ±5°C, -0°C, as applicable, for 250 hours minimum with rated voltage applied (see 6.5). Following exposure, 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 and leakage of electrolyte.

4.6.27 Reverse voltage aging (all styles except CU14 and CU15) (see 3.30). 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.

## 5. PACKAGING

5.1 The requirements for packaging shall be in accordance with MIL-C-39028.

## 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).

6.2 Acquisition requirements. Acquisition documents must specify the following:

- a. Title, number, and date of the specification.
- b. Issue of DDDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1).
- c. Title, number, and date of the applicable specification sheet, and the complete PIN (see 3.1).
- d. If reflowing (hot-solder dip) of the leads is required (see 3.5.2.1).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in the Qualified Products List, whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and they 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 purchase orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Space and Naval Warfare Systems Command and information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-E), Dayton, Ohio 45444. Application for qualification tests shall be made in accordance with "Provisions Governing Qualification", copies of which may be obtained on application to Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

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

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

6.6 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue, due to the extensiveness of the changes.

6.7 Subject term (key word) listing.

Epoxy  
Polymer

## APPENDIX

## PROCEDURE FOR QUALIFICATION INSPECTION

## 10. SCOPE

10.1 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.

10.2 Qualification categories. Qualification shall be categorized as follows:

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

## 20. APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

## 30. SUBMISSION

30.1 Sample.

30.1.1 Single-type submission. A sample consisting of 73, 93, 96, 103, 108, 109, 126 or 132, as applicable (see 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.

30.1.2 Voltage-group submission. A sample group, as specified (see table IX), 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 X.

TABLE IX. 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		

## APPENDIX

TABLE X. 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	
M39018/01-0688	28	
M39018/01-1006M	66	Style CUR13. All capacitance values in all voltage ratings of voltage group I.
M39018/01-1038M	66	
M39018/01-1045M	66	Style CUR13. All capacitance values in all voltage ratings of voltage group II.
M39018/01-1074M	66	
M39018/01-1081M	66	Style CUR13. All capacitance values in all voltage ratings of voltage group III.
M39018/01-1088M	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.

## APPENDIX

TABLE X. Examples of voltage-group submission - Continued.

Types to be 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	66	
M39018/03-1051M	1/	Style CUR17. All capacitance values in all voltage ratings of voltage group II.
M39018/03-1083M		
M39018/03-1091M	66	Style CUR17. All capacitance values in all voltage ratings of voltage group III.
M39018/03-1098M	66	
M39018/03-1209M	66	Style CUR17 (high frequency vibration). All capacitance values in all voltage ratings of voltage group I.
M39018/03-1299M	66	
M39018/03-1251M	66	Style CUR17 (high frequency vibration). All capacitance values in all voltage ratings of voltage group II.
M39018/03-1283M	66	
M39018/03-1291M	66	Style CUR17 (high frequency vibration). All capacitance values in all voltage ratings of voltage group III.
M39018/03-1298M	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	
M39018/05-0004	37	Style CUB1. All capacitance values in all voltage ratings of voltage group I.
M39018/05-0036	37	
M39018/05-1004M	48	Style CUR81. All capacitance values in all voltage ratings of voltage group I.
M39018/05-1036M	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.

## APPENDIX

TABLE X. 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 CU01. All capacitance values in all voltage ratings of voltage group I.
M39018/08-0113M	63	
M39018/08-0114M	63	Style CU01. All capacitance values in all voltage ratings of voltage group II.
M39018/08-0119M	63	
M39018/09-0018M	63	Style CU02. All capacitance values in all voltage ratings of voltage group I.
M39018/09-0086M	63	
M39018/09-0104M	63	Style CU02. All capacitance values in all voltage ratings of voltage group II.
M39018/09-0176M	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	

See footnote at end of table.

## APPENDIX

TABLE X. Examples of voltage-group submission - Continued.

Types to be submitted	Quantity	When qualification is sought for
M39018/11-0018M M39018/11-0143M	63 63	Style CUR03. All capacitance values in all voltage ratings of voltage group I.
M39018/11-0161M M39018/11-0197M	63 63	Style CUR03. All capacitance values in all voltage ratings of voltage group II.
M39018/11-0218M M39018/11-0343M	63 63	Style CUR04. All capacitance values in all voltage ratings of voltage group I.
M39018/11-0361M M39018/11-0397M	63 63	Style CUR04. All capacitance values in all voltage ratings of voltage group II.

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

**30.2 Test data.** When inspections are to be performed at a Government laboratory prior to submission, all sample units shall be subjected to all of the nondestructive tests in table II. Each submission shall be accompanied by the test data obtained from these examinations and tests. The performance of the destructive examinations and tests by the manufacturer on a duplicate set of sample units is encouraged, but not required. All test data shall be submitted in duplicate.

**30.3 Certification of material.** When submitting samples for qualification, the manufacturer shall submit certification, in duplicate, that the materials used in his components are in accordance with the applicable specification requirements.

**30.4 Description of items.** The manufacturer shall submit a detailed description of the capacitors being submitted for inspection including information on the type of welds or solder buttons, the type of electrodes, the type of seals (inner or outer, as applicable), the case and lead materials, the case insulating material (when applicable), and the case finish.

#### 40. EXTENT OF QUALIFICATION

**40.1 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.

## APPENDIX

**40.2 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.

**40.3 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 11. The number of samples for each style shall be the same as those listed in table X.

## CONCLUDING MATERIAL

## Custodians:

Army - ER  
Navy - EC  
Air Force - 85

## Review activities:

Army - MI  
Navy - SH  
Air Force - 17, 99  
DLA - ES

## User activities:

Navy - AS, CG, MC, OS  
Air Force - 19

Preparing activity:  
Navy - EC

Agent:  
DLA - ES

(Project 5910-1688)



# STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

## INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
2. The submitter of this form must complete blocks 4, 5, 6, and 7.
3. The preparing activity must provide a reply within 30 days from receipt of the form.

**NOTE:** This form may not be used to request copies of documents, nor to request waivers, or clarification of requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

<b>1. RECOMMEND A CHANGE:</b>	1. DOCUMENT NUMBER MIL-C-39018C	2. DOCUMENT DATE (YYMMDD) 910107
3. DOCUMENT TITLE Capacitors, Fixed, Electrolytic (Aluminum Oxide), Established Reliability and Non-Established Reliability, General Specification for		
4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)		
5. REASON FOR RECOMMENDATION		
6. SUBMITTER		
a. NAME (Last, First, Middle Initial)		b. ORGANIZATION
c. ADDRESS (Include Zip Code)		d. TELEPHONE (Include Area Code)
		(1) Commercial
		(2) AUTOVON
		(If applicable)
7. DATE SUBMITTED		
8. PREPARING ACTIVITY		
a. NAME		b. TELEPHONE (Include Area Code)
Edward H. Back		(1) Commercial
		(2) AUTOVON
		(513) 296-6003
		986-6003
c. ADDRESS (Include Zip Code)		IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-7360 AUTOVON 786-7360
DEFENSE ELECTRONICS SUPPLY CENTER ATTN DESC-ECT		

