

MIL-C-39018B
23 March 1978
SUPERSEDING
MIL-C-39018A
23 March 1972

MILITARY 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:

Symbol	FR level (%/1,000 hr)
M - - - - -	1.0
P - - - - -	0.1
R - - - - -	0.01
S - - - - -	0.001

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

2. APPLICABLE DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

SPECIFICATIONS

MILITARY

- MIL-C-39028 - Capacitors, Packaging of.
- MIL-C-45662 - Calibration System Requirements.

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

STANDARDS

MILITARY

- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
- 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-1285 - Marking of Electrical and Electronic Parts.

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Naval Electronic Systems Command ATTN: ELEX 5043, Department of the Navy, Washington DC 20360 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FSC 5910

2.2 Other publications. The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

NATIONAL BUREAU OF STANDARDS

Handbook H28 - Screw-Thread Standards for Federal Services.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, DC 20402).

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 qualified for listing on the applicable qualified products list at the time set for opening of bids (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 (ER styles only). Reliability of 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 4.1.1, 4.4.4, and 4.4.6.

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 guaranty 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 and construction. 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 from 40 to 70 percent. Threaded portions of screw-thread terminals shall be in accordance with Handbook H28 as specified (see 3.1).

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.

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 the terminals or permanent damage to the terminals, 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 be not 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) (not applicable to styles CUB1 and CUR81). 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 injury. 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 (when applicable) - - - - -	Shall be as specified in 3.15.
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 after the test.

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, and CUR19). 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 (style CUR91 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 (when specified, see 3.1). 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 ± 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 polarized styles). 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 - - - - -	± 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 styles only); part number (see 3.1); capacitance in (μ F); capacitance tolerance; dc rated voltage; date code; and source code. The dc rated voltage for polarized capacitors shall be designated "VDC" and for 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 a plus (+) symbol on the first and last lines of the marking 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 electrical equipment, namely, resistors, capacitors, electron tubes and the like, procured by, or manufactured for use by, or for the Government in accordance with standard Government specifications. Accordingly, capacitors procured to, and meeting all of, the criteria specified herein and in applicable specification sheets shall bear the certification mark "JAN", except that capacitors too small to bear the certification mark "JAN" shall bear the letter "J". Capacitors furnished under contracts which either permit or require deviation from the conditions or requirements specified herein and in applicable specification sheets shall not bear "JAN" or "J". In the event a capacitor sample fails to meet the requirements of this specification and the applicable specification sheets, the manufacturer shall remove the "JAN" or "J" from the sample tested and also from all capacitors represented by the sample. The United States Government has obtained Certificate of Registration No. 504.860 for the certification mark "JAN".

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

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, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract, 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 assure supplies and services conform to prescribed requirements.

4.1.1 Reliability assurance program (ER styles only). A reliability assurance program shall be established and maintained in accordance with MIL-STD-790; "Program implementation" exceptions are as follows:

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

Evidence of such compliance shall be verified by the qualifying activity of this specification as a prerequisite for qualification and continued qualification.

4.1.2 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-C-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 styles only)(see 4.4.6).
- 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 I and appendix A to this specification.

4.4.2 Test routine. The sample shall be subjected to the qualification inspection specified in table I, in the order shown. Two 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 I for groups II to XII inclusive, 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 I shall be cause for refusal to grant qualification approval.

4.4.4 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-60 shall apply. Sample units shall be subjected to the qualification inspection specified in group III, table I. The entire life test sample shall be continued on test to 10,000 hours as specified in 4.6.11.1.1 upon 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", data shall be limited to each voltage group within a style; for FR levels "R" and "S", 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 4.4.6f.).

Qualification approval will be based on the successful completion of the test specified in table I, and will not be withheld pending completion of the extended life test of 4.4.4a.

4.4.5 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 test 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 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.

4.4.6 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 4.4.4c.

When group C requirements were not met and the manufacturer has taken corrective action satisfactory to the Government, group C retesting shall be instituted. A summary of the retesting shall be forwarded to the qualifying activity within 30 days after completion of the retest.

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 inspection.

4.5.1.1 Inspection lot. An inspection lot shall consist of all capacitors covered by the same specification sheet, in the same voltage group (see 20.1.2 of appendix A), produced under essentially the same conditions, and offered for inspection at one time. A production period will be a maximum of 2 weeks.

TABLE I. Qualification inspection.

Inspection	Requirement paragraph	Test Method paragraph	Number of sample units to be inspected		Number of failures allowed <u>1/</u>	
			Non-ER	ER	Non-ER	ER
<u>Group I</u>						
Visual & mechanical inspection (internal examination) - - - - -	3.1,3.4,3.4.2, 3.5 to 3.5.2 incl, 3.32 & 3.32.1	4.6.2 & 4.6.2.1	2	2	0	0
Visual & mechanical inspection (external examination) <u>2/</u> - - - - -	3.1,3.4,3.4.1, 3.5 to 3.5.2 incl, 3.31 to 3.32.1 incl	4.6.2	} <u>3/ 4/</u>	} <u>4/</u>	} 1	} 0
Burn-in (ER styles only) <u>2/</u> - - - - -	3.6	4.6.3				
DC leakage <u>2/</u> - - - - -	3.7	4.6.4				
Capacitance <u>2/</u> - - - - -	3.8	4.6.5				
ESR <u>2/</u> - - - - -	3.9	4.6.6				
<u>Group II</u>						
Low temperature exposure - - - - -	3.10	4.6.7	} 6	} 6	} 1	} 2
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				1
<u>Group III</u>						
Life (2,000 hours) - - - - -	3.14	4.6.11.1	} 22	} 46	} 0	} 0
Case insulation (insulated capacitors only)	3.15	4.6.12				
<u>Group IV</u>						
Shock (specified pulse) - - - - -	3.16	4.6.13	} 6	} 6	} 1	} 1
Vibration - - - - -	3.17	4.6.14				
Salt spray (corrosion) (not applicable to styles CU81 and CUR81) - - - - -	3.18	4.6.15				
Thermal shock and immersion - - - - -	3.19	4.6.16				
<u>Group V</u>						
Surge voltage - - - - -	3.20	4.6.17	} 6	} 6	} 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
Fungus <u>6/</u> - - - - -	3.23	4.6.20				
<u>Group VII</u>						
Barometric pressure (reduced) - - - - -	3.24	4.6.21	} 8	} 8	} 1	} 1
High temperature exposure - - - - -	3.25	4.6.22				
<u>Group VIII</u>						
Reverse voltage (styles CU12, CU13, CUR13, CU16, CU17, & CUR17 only) - - - - -	3.26	4.6.23	6	6	1	1
<u>Group IX</u>						
High temperature verification (styles CU12, CU13, CUR13, CU14, CU15, CU16, CU17, CUR17, & CUR19 only) - - - - -	3.27	4.6.24	24	24	1	1
<u>Group X</u>						
AC verification (style CUR91 only) - - - - -	3.28	4.6.25	NA	12	NA	1
<u>Group XI</u>						
Penetration of solvents (not applicable to styles CU71, CUR71, CU81, CUR81, & CUR91) - - - - -	3.29	4.6.26	6	6	1	1

TABLE I. Qualification inspection - Continued.

Inspection	Requirement paragraph	Test Method paragraph	Number of sample units to be inspected		Number of failures allowed 1/	
			Non-ER	ER	Non-ER	ER
Group XII Reverse voltage aging (not applicable to styles 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 | ER |
| 73 - Style CU71 | 132 - CUR13 |
| 73 - Style CU81 | 132 - CUR17 |
| 109 - Styles CU16 & CU17 | 126 - CUR19 |
| 93 - Styles CU14 & CU15 | 96 - CUR71 |
| 109 - Styles CU12 & CU13 | 96 - CUR81 |
| | 108 - CUR91 |

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

4.5.1.2 Group A inspection. Group A inspection shall consist of the inspections specified in table II, and shall be made on the same set of sample units in the order shown.

4.5.1.2.1 Sampling plan. Subgroup 1 tests shall be performed on each ER capacitor offered for acceptance. Such tests shall not be repeated for purposes of reinspection. Statistical sampling and inspection for subgroups 1 and 2 (for non-ER capacitors) and subgroup 2 (for ER capacitors) shall be in accordance with MIL-STD-105 for general inspection level II. Major and minor defects shall be as defined in MIL-STD-105. If during the 100 percent inspection of subgroup 1, screening requires that over 5 percent of the capacitors be discarded, the lot shall be rejected.

4.5.1.2.2 Manufacturer's production inspection (for ER styles only). If the manufacturer performs tests similar to those specified in subgroup 1, table II, 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:

- Tests 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.
- Manufacturer subjects 100 percent of the product supplied under this specification to his production tests.
- The parameters measured and the failure criteria shall be the same or more stringent than those specified herein.
- The lot rejection criteria is the same or more stringent than that specified herein.
- 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.

4.5.1.2.3 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. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

TABLE II. Group A inspection.

Inspection	Requirement paragraph	Test method paragraph	Non-ER		ER	
			AQL (percent defective)		AQL (percent defective)	
			Major	Minor	Major	Minor
<u>Subgroup 1</u>						
Burn-in (ER styles only) - - - - -	3.6	4.6.3	Not applicable		} 100% inspection	
DC leakage 1/ - - -	3.7	4.6.4	} .65	} 1.5		
Capacitance - - - -	3.8	4.6.5				
ESR - - - - -	3.9	4.6.6				
<u>Subgroup 2</u>						
DC leakage (High test Temperature) - - -	3.7	4.6.4	Not applicable		.65	1.5
<u>Subgroup 3</u>						
Visual and mechanical inspection: - - -	3.1,3.4, & 3.4.1	4.6.2	} 1.0	} 4.0	} 1.0	} 4.0
Design and construction - -	3.5	4.6.2				
Marking 2/ - - -	3.31	4.6.2				
Workmanship - - -	3.32	4.6.2				

1/ DC leakage for ER styles in subgroup 1 to be at room temperature only.

2/ Marking defects are based on visual examination only.

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

TABLE III. Group B inspection.

Inspection	Requirement paragraph	Test method paragraph
<u>Subgroup 1</u>		
Solderability (capacitors with wire-lead terminals) - - - - -	3.11	4.6.8
Terminal strength - - - - -	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 subgroups 1 and 2, the sampling plan shall be in accordance with MIL-STD-105 for special inspection level S-4; the AQL shall be 1.5 percent defective. 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 will be subjected to the test with no failures permitted. No failures by shorting will be allowed. Sample units shall not be shipped on contract or orders.

For styles CUI2, CUI3, and CUR13 - 10 sample units
 For styles CUI6, CUI7, 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. Resubmitted lots shall be inspected using tightened inspection. Such lots shall be separate from new lots, and shall be clearly identified as reinspected lots.

4.5.1.3.3 Disposition of sample units. Sample units subjected to subgroups 1 and 3 of group B inspection shall not be delivered on the contract. Sample units subjected to subgroup 2 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. 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 shall not be delayed pending the results of these periodic inspections.

4.5.2.1 Group C inspection. Group C inspection shall consist of the inspections specified in table IV, in the order shown.

4.5.2.1.1 Sampling plan. Every 2 months, the inspections shall consist of subgroups 1, 2, and 3. Every 6 months, the inspections shall consist of subgroups 4 through 9. Sampling shall be as follows:

- a. Every 2 months, 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, sample units to be subjected to the 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, including units of the largest capacitance value in each style (insulated or uninsulated), and voltage group that have passed the 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 12 months in order to assure that all styles in production have been drawn into the 6-month testing 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 inspection 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 $^{\circ}$ C prior to conditioning. Unless reference measurements have been made within 30 days prior to the beginning of conditioning, they shall be repeated.

TABLE IV. Group C inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of failures allowed ^{1/}	
				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) (not applicable to styles CU81 and CUR81) - - - - -	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 (wire lead terminal styles only) - - - - -	3.29	4.6.26	6	0 ^{2/}	0
<u>Subgroup 4</u>					
Moisture resistance - - - - -	3.22	4.6.19	12	1	1
<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	--
Life(10,000 hours) (ER only) - -	3.14	4.6.11.2.3	12	N/A	1 4/
<u>Subgroup 7</u>					
Reverse voltage (styles CU12, CU13, CUR13, CU16, CU17, and CUR17 only) - - - - -	3.26	4.6.23	6	1	1
<u>Subgroup 8</u>					
High temperature verification (styles CU12, CU13, CUR13, CU14, CU15, CU16, CU17, CUR17, CUR19 only) - - - - -	3.27	4.6.24	24	1	1
<u>Subgroup 9</u>					
AC verification (style CUR91 only) - - - - -	3.28	4.6.25	12 ^{3/}	N/A	1

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

2/ One failure per sample of 12 units at 85°C and one failure per sample of 12 units at 125°C is allowed.

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

4/ Number of allowable failures may vary depending on the failure rate level of the part being tested.

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 foils of tab to roll, shall be examined for corrosion.

4.6.3 Burn-in (ER styles only)(see 3.6). Capacitors shall be subjected to 100 percent of the dc rated voltage at the high ambient test temperature for 48_{-0}^{+5} hours. During this test, capacitors shall be adequately protected against temporary voltage surges of 10 percent or more of the test voltage.

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 $5 \pm 1/2$ minutes 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 $5 \pm 1/2$ minutes 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 ± 5 Hz.
- b. Limit of accuracy - Measurement accuracy shall be within ± 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 ± 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 $_{-5}^{+0}$ °C with no voltage applied. After exposure, the capacitors shall be returned to room ambient conditions and the dc leakage, capacitance, and ESR shall be measured as specified in 4.6.4, 4.6.5, and 4.6.6, respectively.

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

- a. The number of terminations of each part to be tested - Two,(four for CUR19).
- b. Depth of immersion in flux and solder - Leads shall be immersed to within 1/8 inch of the eyelet or seal, or 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 condition - A.
- b. Method of holding - The body of the capacitor shall be secured.
- 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 V 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 V. 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 ⁺⁰₋₃°C (or as specified, see 3.1) in accordance with 4.6.1.1. The application of voltage shall be such as to cause no readable change in impedance due to the change in temperature of the capacitor. Measurement accuracy shall be within ±5 percent.

4.6.11 Life (see 3.14).

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

- a. Distance of temperature measurements from specimens, in inches - Not applicable.
- b. Method of mounting - Capacitors shall be mounted by normal mounting means.
- c. Test temperature and tolerance - All capacitors shall be tested at 85 ⁺⁵₋₀° or 105 ⁺⁵₋₀°C as applicable. For capacitors covered by MIL-C-39018/1 and MIL-C-39018/2, a quantity of capacitors equal to the quantity tested at 85°C shall be tested at 125°C.
- d. Operating conditions - 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 capacitors covered by MIL-C-39018/2, 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 exceeding 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 $\begin{smallmatrix} +72 \\ -0 \end{smallmatrix}$ hours; measurements after completion of the 10,000 hour life test 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). Except as specified in the following, capacitors shall be tested as specified in 4.6.11.1.

- a. Test duration - 10,000 $\begin{smallmatrix} +96 \\ -0 \end{smallmatrix}$ hours.
- b. Measurements during exposure - Hot DC leakage shall be measured during the first hour of exposure and then at 240 $\begin{smallmatrix} +48 \\ -0 \end{smallmatrix}$, 1,000 $\begin{smallmatrix} +48 \\ -0 \end{smallmatrix}$, 2,000 $\begin{smallmatrix} +72 \\ -0 \end{smallmatrix}$, and every 2,000 $\begin{smallmatrix} +72 \\ -0 \end{smallmatrix}$ hours thereafter to 10,000 hours. DC leakage capacitance and ESR at 25° will be measured 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. Capacitors shall be tested in accordance with method 301 of MIL-STD-202. The following details and exceptions shall apply:

- a. Magnitude and nature of test voltage - 2,000 volts, dc.
- b. Duration of application of test voltage - 60 ±5 seconds.
- c. Points of application - Between a strip of metal foil 1/4 ±1/64 inch 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. 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 1/4 ±1/64 inch 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 3/8 inch 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 contact, arcing, 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 or 4.6.14.2, 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 - 1-1/2 hours.
- 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 be 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 (15G), 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 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)(not applicable to styles 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 affect 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 - $0^{\circ} +0^{\circ}$
 -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, 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). Non-polarized 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 5-1/2 minute discharge period. Voltage application shall be made through a resistor (of 1,000 \pm 100 ohms for capacitance values of less than 2,500 μ F and 100 \pm 10 ohms for capacitance values of 2,500 μ 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 (styles CU71, CUR71, CU81, CUR81, and CUR91 only). Capacitors shall be subjected to the application of a constant reverse current (dc) 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 Funous (see 3.23). Capacitors shall be tested in accordance with method 508 of MIL-STD-810. Pretest and post-test measurements are not required.

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

- a. Method of mounting - By normal mounting means.
- b. Maximum pressure - 0.82 inch of mercury (equivalent to 80,000 feet).
- 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. Test 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 ($+5^{\circ}$ to -0° 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 (styles CU12, CU13, CUR13, CU16, CU17, and CUR17 only)(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 $\begin{matrix} +5^\circ \\ -0^\circ \end{matrix}$ C (see 3.1).

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

4.6.24 High temperature verification (styles CU12, CU13, CUR13, CU14, CU15, CU16, CU17, CUR17, and CUR19)(see 3.27). Capacitors shall be tested at the applicable temperature and voltage

(see 3.1), for 2,000 $\begin{matrix} +72 \\ -0 \end{matrix}$ 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 (style CUR91 only)(see 3.28). Capacitors shall be exposed to the voltage and frequencies specified (see 3.1) at 105°C for 2,000 $\begin{matrix} +72 \\ -0 \end{matrix}$ 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 (when specified, see 3.1)(see 3.29). Capacitors shall be immersed in Dupont type TF solvent, or equivalent, at 25°C for 4 hours minimum, followed by exposure at 85°C or 125°C for 250 hours minimum with rated voltage applied. 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 (see 6.6).

4.6.27 Reverse voltage aging (all polarized styles)(see 3.30). Capacitors shall be subjected to 1.5 volts applied in the reverse polarity direction for 96 $\begin{matrix} +5 \\ -0 \end{matrix}$ 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 2500 μ F is 1000 ohms maximum and 100 ohms maximum for capacitors values of 2500 μ F and greater. DC leakage shall then be measured at rated voltage as specified in 4.6.4. Capacitors shall be examined for evidence of mechanical damage and for leakage of the electrolyte.

5. PACKAGING

5.1 Packaging shall be in accordance with MIL-C-39028. (see 6.1.1).

6. NOTES

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 excesses 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).

6.1.1 Application of packaging.

6.1.1.1 Shipments to Government activities. The packaging requirements of this specification are primarily intended for the preparation of capacitors for shipment to Government activities.

6.1.1.2 Shipments of ER capacitors to Government contractors and manufacturers' distributors. Federal Standard No. 356, Commercial Packaging of Supplies and Equipment, should be specified for the packaging of ER capacitors shipped to Government contractors and subcontractors and to category A and B distributors as defined in MIL-STD-790. The marking of the unit containers should not be required provided the intermediate containers are marked.

6.2 Ordering data. Procurement documents should specify the following:

- a. Title, number, and date of this specification.
- b. Title, number, and date of the applicable specification sheet, and the complete part number (see 3.1).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable Qualified Products List whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Naval Electronic Systems Command; however, 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" (see 6.3.1).

6.3.1 Copies of "Provisions Governing Qualification" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, Pennsylvania 19120.

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, methyl cellosolve, alconox and water, and naphtha. Chlorinated or fluorinated hydrocarbon solvents are prohibited.

6.6 Ripple voltage and ac ripple current. Ripple voltage and ac ripple current are calculated in accordance with appendix B and as specified (see 3.1).

6.7 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.

Custodians:

Army - EL
Navy - EC
Air Force - 11

Review activities:

Army - EL
Navy - SH
Air Force - 11, 17, 80, 99
DLA - ES

User activities:

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

Preparing activity:

Navy - EC

Agent:

DLA - ES

Project 5910-1185)

APPENDIX A
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 specified 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. SUBMISSION

20.1 Sample.

20.1.1 Single-type submission. A sample consisting of 61, 67, 73, 89, 112, 115, or 155 as applicable (see table I), 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.

20.1.2 Voltage-group submission. A sample group as specified (see table VII), of the highest capacitance value in the lowest voltage rating as applicable, samples of the highest capacitance value in the highest voltage rating 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 VII.

20.2 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 I. 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, although not required. All test data shall be submitted in duplicate.

20.3 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.

20.4 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.

30. EXTENT OF QUALIFICATION

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

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

TABLE VI. 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		

TABLE VII. 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	
M39018/01-1005M	66	Style CUR13. All capacitance values in all voltage rating of voltage group I.
M39018/01-1038M	66	
M39018/01-1045M	66	Style CUR13. All capacitance values in all voltage rating of voltage group II.
M39018/01-1074M	66	
M38018/01-1081M	66	Style CUR13. All capacitance values in all voltage rating in voltage group III.
M39018/01-1088M	66	
M39018/02-0404	26	Styles CU14 and CU15. All capacitance values in all voltage ratings of voltage group I.
M39018/02-0604	26	
M39018/02-0423	26	
M39018/02-0623	26	
M39018/02-0428	26	Styles CU14 and CU15. All capacitance values in all voltage ratings of voltage group II.
M39018/02-0628	26	
M39018/02-0446	26	
M39018/02-0646	26	
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	

TABLE VII. Examples of voltage group submission - Continued.

Types to be submitted	Quantity	When qualification is sought for
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	
M39018/03-1009M	66	Style CUR17. All capacitance values in all voltage ratings of voltage group I.
M39018/03-1099M	66	
M39018/03-1051M	66	Style CUR17. All capacitance values in all voltage ratings of voltage group II.
M39018/03-1083M	66	
M39018/03-1091M	66	Style CUR17. All capacitance values in all voltage ratings of voltage group III.
M39018/03-1098M	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 CU81. 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	
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	

APPENDIX B

PROCEDURE FOR CALCULATING RIPPLE VOLTAGE AND AC RIPPLE CURRENT

10. SCOPE

10.1 This appendix outlines the procedure for determining the maximum permissible ripple voltage and maximum ac ripple current, as applicable (see 3.1).

20. METHOD

20.1 Ripple currents. For capacitors covered by MIL-C-39018/1, the maximum permissible ripple currents can be determined from table VIII. For capacitors covered by MIL-C-39018/3, the maximum permissible ripple currents can be determined from table IX. The appropriate multiplier from table VII or IX should be used where operation at other frequencies or temperatures is desired. Operation of these capacitors outside the limits of 50 to 100,000 Hz is not recommended.

TABLE VIII. Multipliers for MIL-C-39018/1 capacitors.

With temperature	25°C	45°C	65°C	85°C	125°C
	1.4	1.4	1.2	1.0	0.3
With frequency	0-60 Volts 61-200 201-350	60 Hz	120 Hz	400 Hz	1 K thru 100 K Hz
		.85	1.0	1.1	1.15
		.83	1.0	1.15	1.2
		.80	1.0	1.3	1.4

TABLE IX. Multipliers for MIL-C-39018/3 capacitors.

With temperature	25°C	45°C	65°C	85°C	---
	1.4	1.4	1.2	1.0	---
With frequency	0-60 Volts 61-200 201-350	60 Hz	120 Hz	400 Hz	1 K thru 100 K Hz
		.85	1.0	1.1	1.15
		.83	1.0	1.15	1.2
		.80	1.0	1.30	1.4

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER		2. DOCUMENT TITLE	
3a. NAME OF SUBMITTING ORGANIZATION		4. TYPE OF ORGANIZATION (Mark one)	
b. ADDRESS (Street, City, State, ZIP Code)		<input type="checkbox"/> VENDOR	
		<input type="checkbox"/> USER	
		<input type="checkbox"/> MANUFACTURER	
		<input type="checkbox"/> OTHER (Specify): _____	
5. PROBLEM AREAS			
a. Paragraph Number and Wording:			
b. Recommended Wording:			
c. Reason/Rationale for Recommendation:			
6. REMARKS			
7a. NAME OF SUBMITTER (Last, First, MI) – Optional		b. WORK TELEPHONE NUMBER (Include Area Code) – Optional	
c. MAILING ADDRESS (Street, City, State, ZIP Code) – Optional		8. DATE OF SUBMISSION (YYMMDD)	