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MILITARY SPECIFICATION

CAPACITORS, FIXED, ELECTROLYTIC (SOLID ELECTROLYTE), TANTALUM,
ESTABLISHED RELIABILITY, GENERAL SPECIFICATION FOR

FAILURE RATE LEVELS "M", "P," AND "R" ARE
INACTIVE FOR NEW DESIGN AFTER 2 FEBRUARY 1984.

FAILURE RATE LEVEL "S" IS INACTIVE
FOR NEW DESIGN AFTER 15 AUGUST 1984.

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, insulated, tantalum, electrolytic (solid electrolyte), fixed capacitors, hermetically sealed ^{1/} in metal cases (see 6.1). Rated voltages range from 6 to 100 volts dc with surge voltages of 8 to 130 volts dc, respectively (see 4.7.19). These capacitors are designed for full rated voltage operation between -55°C and +85°C, derated linearly between +85°C and +125°C to the value shown in table I. A part per million (PPM) quality system is used for documenting and reporting the average outgoing quality of capacitors supplied to this specification. Statistical Process Control (SPC) techniques are required in the manufacturing process to minimize variation in production of capacitors supplied to the requirements of this specification. These capacitors have reliability ratings established on the basis of life tests performed at specified voltage at +85°C for Failure Rate Levels (FRL's) ranging from:

- a. 1.0 percent per 1,000 hours 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 (Exponential distribution).
- b. 0.1 percent per 1,000 hours to 0.001 percent per 1,000 hours at a 90-percent confidence level (Weibull distribution).

^{1/} For the purpose of this specification, a hermetically-sealed capacitor is one in which the capacitance element is contained within a sealed enclosure of ceramic, glass or metal, or combination thereof, where sealing is accomplished by material fusion, welding, brazing, or soldering.

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-ES, 1507 Wilmington Pike, Dayton, OH 45444-5274, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document, or by letter.

AMSC N/A

DISTRIBUTION STATEMENT A. Approved for public release; distribution is unlimited.

FSC 5910

TABLE I. Voltage.

Rated voltage (at +85°C)	Derated voltage (at +125°C)
<u>Volts, dc</u> 6	<u>Volts, dc</u> 4
10	7
15	10
20	13
35	23
50	33
75	50
100	67

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

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).

SPECIFICATIONS

MILITARY

- MIL-F-14256 - Flux, Soldering, Liquid (Rosin Base).
- MIL-I-23053 - Insulation Sleeving, Electrical, Heat Shrinkable, General Specification for.
- MIL-C-39028 - Capacitors, Packaging of.
- MIL-C-55365 - Capacitor, Fixed, Electrolytic (Tantalum), Chip, Established Reliability, General specification for.

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

STANDARDS

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.

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Navy Publishing and Printing Service Office, Building 4D, NPM-DODSSP, 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 (EIA), 2001 Pennsylvania Avenue, N.W., Washington, DC 20006.)

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

2.3 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or IIS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

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

3.2 Qualification. Capacitors furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list (QPL) at the time of award of contract (see 4.4 and 6.3). In addition, the manufacturer shall obtain certification from the qualifying activity that the reliability assurance requirements of 4.1.2 have been met and are being maintained. Authorized distributors which are approved to MIL-STD-790 distributor requirements by the QPL manufacturers are listed in the QPL.

3.3 Reliability and quality.

3.3.1 Reliability. 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 4.1.2, 4.4.4, and 4.5. The reliability rating is identified by the following FR level symbols:

<u>Symbol</u>	<u>Exponential FR Level</u> <u>(%/1,000 hrs)</u>		<u>Symbol</u>	<u>Weibul FR level</u> <u>(%/1,000 hrs)</u>
M	1.0		B	0.1
P	0.1		C	0.01
R	0.01		D	0.001
S	0.001			

3.3.2 Quality.

3.3.2.1 Statistical process control. The contractor shall implement and use statistical process control techniques in the manufacturing process for parts covered by this specification. The SPC program shall be developed and maintained in accordance with 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 statistical process control shall be 12 months from the date of this specification. Processes for application of SPC techniques should include but are not limited to the following:

- a. Pressing.
- b. Sintering.
- c. Electro-chemical processing.
- d. Assembly/encapsulation.
- e. Packaging.

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 the group A inspection shall be established and maintained in accordance with 4.6.1.2.2 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 manufacturer shall notify the qualifying activity when the 100 PPM defect level is reached or exceeded for PPM-2. The manufacturer 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 the removal of the affected product from the QPL.

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

3.4.1 Sleeving. The sleeving shall be of a nonfungus nutrient material in accordance with MIL-I-23053 (cardboard shall not be used). In addition, the material used shall not soften, creep, or shrink to a point where any part of the cylindrical case is left uncovered at any test temperature specified herein. Insulating tape or heat-shrinkable insulating tape shall not be used.

3.5 Design and construction. Capacitors shall be of the design, construction, and physical dimensions specified (see 3.1). Nonpolarized capacitors shall be constructed from two style CSR13 polarized units which have passed group A inspection.

3.5.1 Case. Each capacitor shall be enclosed in a hermetically-sealed metal case which will protect the capacitor element from moisture and mechanical damage under all test conditions specified herein. Nonpolarized capacitors, consisting of two hermetically-sealed capacitors joined together, need not be hermetically sealed within the joining sleeve.

3.5.2 Terminal leads. Terminal leads shall conform to MIL-STD-1276; the lead type, length, and diameter shall be as specified (see 3.1). Terminal leads shall be permanently secured internally and externally.

3.5.2.1 Solder dip (retinning). Only the capacitor manufacturer may solder dip/retin the lead of the capacitors 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 shall be based on one of the following options:

- a. When the original lead finish qualified was hot solder dip lead finish 52 in accordance with MIL-STD-1276 (NOTE: The 200 microinch maximum thickness is not applicable). The manufacturer shall use the same solder dip process for reflowing as was used in the original manufacture of the capacitor.
- b. When the lead originally qualified was not 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 procedure:
 - (1) 30 samples of any capacitance value for each style and lead finish shall be subjected to the manufacturer's solder dip process. The capacitors shall be subjected to all group A, subgroup 1 post-electrical tests, with no defects allowed. (NOTE: If radiographic inspection and hermetic seal testing are required in group A, these tests shall also be performed, with no defects allowed.)
 - (2) 10 of the 30 samples shall then be subjected to the solderability test, with no defects allowed.
 - (3) The remaining 20 samples shall be subjected to the resistance to soldering heat test, followed by the moisture resistance test (or seal test if the capacitor is hermetically sealed), with no defects allowed.

3.5.2.1.2 Solder dip/reflowing options. The capacitor manufacturer may solder dip/reflow after the 100 percent group A screening tests or as a corrective action. After solder dip/reflowing, the following inspection and tests shall be performed on 100 percent of the lot:

Seal: Shall conform to the requirements of 3.8 (polarized capacitors only, see 3.1).
 Radiographic inspection: Shall conform to the requirements of 3.9 (polarized capacitors only, see 3.1) (all FR levels apply).
 DC leakage: Shall not exceed the requirement specified in 3.10.
 Capacitance: Shall be within the tolerance specified (see 3.1).
 Dissipation factor: Shall not exceed the requirement specified in 3.12.
 Equivalent series resistance (style CSR21 only): Shall not exceed the requirement specified in 3.13.

NOTE: The capacitor manufacturer may solder dip/reflow before the 100 percent electrical measurements of the group A, subgroup 1 tests.

Failed parts shall not be delivered on the contract or purchase order.

3.6 Thermal shock. When tested as specified in 4.7.2, capacitors shall withstand the extremes of high and low temperatures without visible damage.

3.7 Voltage aging (exponential only). When tested as specified in 4.7.3, capacitors shall meet the following requirements:

DC leakage: Shall not exceed the requirement specified in 3.10.
 Capacitance: Shall be within the tolerance specified (see 3.1).
 Dissipation factor: Shall not exceed the requirement specified in 3.12.
 Equivalent series resistance (style CSR21 only): Shall not exceed the requirement specified in 3.13.

3.8 Seal (polarized capacitors only, see 3.1). When capacitors are tested as specified in 4.7.4, there shall be no evidence of leakage.

3.9 Radiographic inspection (polarized capacitors only, see 3.1) (not applicable to exponential distribution FR Level "M"). When capacitors are tested as specified in 4.7.5, radiographic inspection shall disclose no evidence of improperly made connections, misalignment of slugs and seals or eyelets, substandard soldering or structural weakness, or solder particles or solder balls that exceed .010 (0.25 mm) in their largest dimension (see 4.7.5d).

3.10 DC Leakage. When measured as specified in 4.7.6, the dc leakage shall not exceed the applicable value specified (see 3.1).

3.11 Capacitance. When measured as specified in 4.7.7, the capacitance shall be within tolerance of the nominal value specified (see 3.1).

3.12 Dissipation factor. When measured as specified in 4.7.8, the dissipation factor shall not exceed the value specified (see 3.1).

3.13 Equivalent series resistance (ESR) (style CSR21 only). When measured as specified in 4.7.9, the ESR shall not exceed the value specified (see 3.1)

3.14 Shock (specified pulse) (see 3.1). When capacitors are tested as specified in 4.7.10, there shall be no intermittent contacts of 0.5 ms or greater duration, or arcing or other indication of breakdown, nor shall there be any open- or short-circuiting or evidence of mechanical damage.

3.15 Vibration, high frequency (polarized capacitors only, see 3.1). When capacitors are tested as specified in 4.7.11, there shall be no intermittent contacts of 0.5 ms or greater duration, or arcing or other indication of breakdown, nor shall there be any open- or short-circuiting or evidence of mechanical damage.

3.16 Salt spray (corrosion). When capacitors are tested as specified in 4.7.12, there shall be no harmful corrosion, and at least 90 percent of any exposed metal surface of the capacitor shall be protected by the finish. There shall be no unwrapping of, or mechanical damage to, the sleeving. Marking shall remain legible.

NOTE: Harmful corrosion shall be construed as being any type of corrosion which in any way interferes with the mechanical or electrical performance of the capacitor.

3.17 Thermal shock and immersion (polarized capacitors only, see 3.1). When tested as specified in 4.7.13, capacitors shall meet the following requirements:

DC leakage: Shall not exceed the requirement specified in 3.10.

Capacitance: Shall change not more than ± 3 percent from the value obtained when measured as specified in 4.7.7.

Dissipation factor: Shall not exceed the requirement specified in 3.12.

ESR (style CSR21 only): Shall not exceed the requirement specified in 3.13.

Visual examination: There shall be no evidence of harmful corrosion (as defined in 3.16), mechanical damage, or obliteration of marking.

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

3.19 Terminal strength (polarized capacitors only, see 3.1). When capacitors are tested as specified in 4.7.15, there shall be no loosening of the terminals nor permanent damage to the terminals, terminal weld, or terminal solder, as applicable.

3.20 Moisture resistance (polarized capacitors only, see 3.1). When tested as specified in 4.7.16, capacitors shall meet the following requirements:

DC leakage: Shall not exceed the requirement specified in 3.10.

Capacitance: Shall change not more than ± 2 percent from the value obtained when measured as specified in 4.7.7.

Dissipation factor: Shall not exceed the requirement specified in 3.12.

ESR (style CSR21 only): Shall not exceed the requirement specified in 3.13.

Visual examination: There shall be no evidence of harmful corrosion (as defined in 3.16), mechanical damage, or obliteration of marking.

3.21 Sleeving (polarized capacitors only, see 3.1). When capacitors are tested as specified in 4.7.17, the sleeving shall withstand the specified potential without breakdown; the insulation resistance shall be 1,000 megohms, minimum.

3.22 Stability at low and high temperatures (polarized capacitors only, see 3.1). When tested as specified in 4.7.18, capacitors shall meet the following requirements:

Step 1 (+25°C):

DC leakage: Shall not exceed the requirement specified in 3.10.

Capacitance: Shall be within tolerance of the nominal value specified (see 3.1).

Dissipation factor: Shall not exceed the requirement specified in 3.12.

Step 2 (-55°C):

Capacitance: Shall change not more than the applicable value specified (see 3.1) from the step 1 measured value.

Dissipation factor: Shall not exceed the applicable value specified (see 3.1).

Step 3 (+25°C):

DC Leakage: Shall not exceed the applicable value specified (see 3.1).

Capacitance: Shall change not more than ± 2 percent from the step 1 measured value.

Dissipation factor: Shall not exceed the applicable value specified (see 3.1).

Step 4 (+85°C):

DC Leakage: Shall not exceed the applicable value specified (see 3.1).

Capacitance: Shall change not more than the applicable value specified (see 3.1) from the step 1 measured value.

Dissipation factor: Shall not exceed the applicable value specified (see 3.1).

Step 5 (+125°C):

DC Leakage: Shall not exceed the applicable value specified (see 3.1).

Capacitance: Shall change not more than ± 2 percent from the step 1 measured value.

Dissipation factor: Shall not exceed the applicable value specified (see 3.1).

Step 6 (+25°C):

DC Leakage: Shall not exceed the applicable value specified (see 3.1).

Capacitance: Shall change not more than ± 2 percent from the step 1 measured value.

Dissipation factor: Shall not exceed the applicable value specified (see 3.1).

3.23 Surge voltage (polarized capacitors only, exponential only, see 3.1). When tested as specified in 4.7.19, capacitors shall meet the following requirements:

DC Leakage: Shall not exceed the requirement specified in 3.10.

Capacitance: Shall change not more than ± 2 percent from the value obtained when measured as specified in 4.7.7.

Dissipation factor: Shall not exceed the requirement specified in 3.12.

3.24 Life (polarized capacitors only, see 3.1). When capacitors are tested as specified in 4.7.20, there shall be no mechanical damage, intermittent shorts, or permanent shorts or opens.

3.24.1 Qualification inspection. When tested as specified in 4.7.20.1, capacitors shall meet the following requirements:

At +25°C:

DC Leakage: Shall not exceed the applicable value specified (see 3.1).

Capacitance: Shall change not more than the applicable value specified (see 3.1) from the value obtained when measured as specified in 4.7.7.

Dissipation factor: Shall not exceed the applicable value specified (see 3.1).

At +85°C:

DC Leakage: Shall not exceed the applicable value specified (see 3.1).

At +125°C:

DC Leakage: Shall not exceed the applicable value specified (see 3.1).

3.24.2 Quality conformance inspection.

3.24.2.1 Group A inspection. When tested as specified in 4.7.3 or 4.7.25, exponential or Weibull as applicable, capacitors shall meet the requirements specified in 3.7 or 3.29. Weibull failure rate level requirements of 4.7.25 and 3.29 shall be accepted in lieu of group B inspection data.

3.24.2.2 Group B inspection (exponential only). When tested as specified in 4.7.20.2.1, capacitors shall meet the requirements specified in 3.24.1.

3.24.2.3 Group C Life or extended Life (see 4.6.1.3.2). When tested as specified in 4.7.20.2.2, capacitors shall meet the following requirements:

At +25°C:

DC Leakage: Shall not exceed the applicable value specified (see 3.1).

Capacitance: Shall change not more than ± 10 percent from the value obtained when measured as specified in 4.7.7.

Dissipation factor: Shall not exceed the applicable value specified (see 3.1).

At +85°C:

DC Leakage: Shall not exceed the applicable value specified (see 3.1).

At +125°C:

DC Leakage: Shall not exceed the applicable value specified (see 3.1).

3.25 Fungus (polarized capacitors only, see 3.1). The manufacturer shall certify that all external materials are fungus resistant or shall perform the test specified in 4.7.21. When tested as specified in 4.7.21, examination shall disclose no evidence of fungus growth on the external surface.

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

3.27 Resistance to soldering heat (polarized capacitors only, see 3.1). When tested as specified in 4.7.23, capacitors shall meet the following requirements:

DC Leakage: Shall not exceed the requirement specified in 3.10.

Capacitance: Shall change not more than ± 2 percent from the value obtained when measured as specified in 4.7.7.

Dissipation factor: Shall not exceed the requirement specified in 3.12.

Visual examination: There shall be no evidence of external damage.

3.28 Ripple current (style CSR21 only). When capacitors are tested as specified in 4.7.24, there shall be no mechanical damage, intermittent shorts, or permanent shorts or opens, and the capacitors shall meet the following requirements:

DC Leakage: Shall not exceed the applicable value specified in 3.10.

Capacitance: Shall change not more than ± 2.0 percent from the value obtained when measured as specified in 4.7.7.

Dissipation factor: Shall not exceed the applicable value specified in 3.12.

ESR: Shall not exceed the applicable value specified in 3.13.

3.29 Weibull FR level grading (in lieu of 3.7). When tested as specified in 4.7.25, capacitors shall exhibit decreasing failure rate with respect to time as evidenced by a value of beta (β) which is less than 0.9; and the instantaneous failure rate in the last interval shall be no more than the failure rate specified. After grading, capacitors shall meet the following requirements:

DC leakage: Shall not exceed the requirement specified in 3.10.
 Capacitance: Shall be within the tolerance specified (see 3.1).
 Dissipation factor: Shall not exceed the requirement specified in 3.12.
 ESR (style CSR21 only): Shall not exceed the requirement specified (see 3.1).

Capacitors tested as specified in 4.7.25 shall be exempt from group A Percent Defective Allowable (PDA) provisions (see 4.6.1.2); exempt from 3.24.2.2 group B inspection (see 4.6.1.3); and exempt from 3.24.2.3 extended life (see 4.6.1.3.2).

3.30 Surge current (styles CSR21 and CSR33 only). When tested as specified in 4.7.26, the capacitors shall meet the following requirements:

DC leakage: Shall not exceed the applicable value specified in 3.10.
 Capacitance: Shall be within the tolerance specified (see 3.1).
 Dissipation factor: Shall not exceed the requirement specified in 3.12.

3.31 Marking.

3.31.1 Capacitor marking. Capacitors shall be marked in accordance with method I of MIL-STD-1285 and shall include the specified information, in the sequence shown, for the applicable case size (see 3.1), as shown in the following examples:

Example (case sizes A, A1, and B1):

39003 - Military specification number
 02 - TM - Specification sheet number and trademark.
 2054J - Nonsignificant dash number and "J" for JAN.
 +424 A 2/ - Polarity, date code (first digit indicates year and the next two digits indicate the week), and lot symbol(s).

Example (case size B):

M39003 - Military specification number.
 01 - Specification sheet number.
 6007J - Nonsignificant dash number and "J" for JAN.
 12345 - CAGE code.
 +424 A 3/ - Polarity, date code (first digit indicates year and the next two digits indicate the week), and lot symbol(s).

2/ Polarity symbol shall be near the positive terminal and may be placed on either end of the fourth line of type depending on the marking orientation with respect to the polarity.

3/ Polarity symbol shall be near the positive terminal and may be placed on either end of the fifth line of type depending on the marking orientation with respect to the polarity.

Example (case sizes C and D):

M39003	-	Military specification number.
01 - 6300J	-	Specification sheet number, nonsignificant dash number, and "J" for JAN.
+12 μ F 4/	-	Positive terminal identifier and capacitance value.
10% 75 V	-	Capacitance tolerance and voltage rating.
12345	-	CAGE code.
9424 AB	-	Date code, lot code.

Example (case sizes W, X, Y, and Z):

M39003	-	Military specification number.
04 - 3168J	-	Specification sheet number, nonsignificant dash number, and "J" for JAN.
.0023 μ F	-	Capacitance value.
10% 100VNP	-	Capacitance tolerance and voltage rating, nonpolarized.
9424 AB 12345	-	Date code, lot code, CAGE code.

NOTE: There shall be no marking on the capacitor sleeving

3.31.2 Package marking. For Government shipment, all packages shall be marked with the capacitance value, capacitance tolerance, dc rated voltage, contract number of part (not the package), National Stock Number (NSN), CAGE code, and the date of packaging.

Additional marking may appear at the option of the manufacturer, provided that it does not interfere with the required marking.

3.31.3 "JAN" and "J" marking. The United States Government has adopted, and is exercising legitimate control over, the certification marks "JAN" and "J" to indicate electrical equipment, namely, resistors, capacitors, electron tubes and the like, acquired by, or manufactured for use by, or for, the Government in accordance with standard Government specifications. Accordingly, capacitors acquired to, and meeting all of, the criteria specified herein and in applicable specification sheets (see 3.1) 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 or orders which either permit or require deviation from the conditions or requirements specified herein and in applicable specification sheets (see 3.1) shall not bear "JAN" or "J". In the event a capacitor sample fails to meet the requirements of this specification and the applicable specification sheet (see 3.1), 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".

3.31.4 Substitution of failure rate levels. A manufacturer may substitute, with procuring agency approval, failure rate levels in accordance with table II. Qualified manufacturers may mark exponential failure rate dash numbers on parts that have been Weibull graded to levels B, C, or D. Items having a Weibull failure rate level (FRL) may be substituted, with procuring agency approval, for items of an exponential FRL as shown in table II. Parts qualified and marked to lower FRL's, with procuring agency approval, are substitutable for higher FRL's, and shall not be remarked unless specified in the contract or purchase order (see 6.2). In the event the failure rate levels are remarked, the date lot codes on the parts shall not be changed and the workmanship criteria shall be met.

4/ Polarity symbol shall be near the positive terminal and may be placed on either end of the third line of type depending on the marking orientation with respect to the polarity.

TABLE II. Failure rate level substitutability.

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

3.31.5 Substitution 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, such as case size and terminations 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 tolerances or rated voltages are remarked, the lot date codes 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 when using 2X minimum to 4X maximum magnification. They shall be free from cold soldering, harmful corrosion (see 3.16), pits, cracks, dents, rough edges, and other defects that will affect life, serviceability, or function. Solder on the surface of the case shall be smooth and unbroken and shall have no pinholes greater than .010 (0.25 mm) or buildup of solder exceeding the maximum diameter of the unsleeved case.

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 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 assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspection 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. 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). 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.

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

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

4.3 Inspection conditions and methods.

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

4.3.2 Methods.

4.3.2.1 AC measurements. AC measurements shall be made at the frequency specified. The magnitude of the ac voltage shall be equal to or less than 1.0 volt root mean squared (rms). For all ac measurements of polarized capacitors, the maximum dc bias voltage shall be equal to or less than 2.2 volts.

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

4.3.3 Power supply. The power supply used for life testing shall have a regulation of ±2 percent or less of the rated voltage. The power source employed for dc leakage current measurements shall be stabilized to at least ±100 ppm. During measurements there must be no voltage fluctuations of sufficient amplitude to produce a variation in the current measurement as read with any dc leakage current tester used to test capacitors.

4.4 Qualification inspection (polarized capacitors only, see 3.1 and 30.3). 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. Qualification approved will be based on the successful completion of the tests specified in table III, and will not be withheld pending completion of the extended life test of 4.4.4.1.1a.

4.4.1 Sample size. The number of capacitors to be subjected to qualification inspection shall be as specified in the appendices to this specification. Each capacitor style shall be qualified separately.

4.4.2 Inspection routine. The sample shall be subjected to the inspections specified in table III, in the order shown. All sample units shall be subjected to the inspection of group I. Two sample units shall be subjected to the visual and mechanical examination (internal) and 163 sample units (175 sample units for CSR21) shall be subjected to the remaining inspections of group II. The 163 units successfully completing group II inspection shall then be divided as specified in table III for groups III through VII (175 units for CSR21, successfully completing group II inspections shall then be divided as specified in table III for groups III through VIII), and subjected to the inspections for their particular group; for combined-voltage group submissions, each type shall be equally represented in each group.

TABLE III. Qualification inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of failures allowed <u>1/</u>
<u>Group I</u> <u>2/</u>				
Thermal shock	3.6	4.7.2	All units	Not Applicable
Voltage aging	3.7	4.7.3		
Surge current (Styles CSR21 and CSR33 only)	3.30	4.7.26		
Seal	3.8	4.7.4		
Radiographic inspection (not applicable to FRL "H")	3.9	4.7.5		
<u>Group II</u>				
Visual and mechanical inspection (internal)	3.1, 3.4, and 3.5	4.7.1	2	0
Visual and mechanical inspection (external) <u>2/</u> <u>3/</u>	3.1, 3.4, 3.5, 3.31, and 3.32	4.7.1	<u>4/</u>	
DC leakage <u>2/</u>	3.10	4.7.6		
Capacitance <u>2/</u>	3.11	4.7.7		
Dissipation factor <u>2/</u>	3.12	4.7.8		
ESR <u>2/</u> (style CSR21 only)	3.13	4.7.9		
<u>Group III</u>				
Shock (specified pulse)	3.14	4.7.10	<u>12</u>	
Vibration, high frequency	3.15	4.7.11		
Salt spray (corrosion)	3.16	4.7.12		
Thermal shock and immersion	3.17	4.7.13		
<u>Group IV</u>				
Solderability	3.18	4.7.14	<u>12</u>	1 <u>5/</u>
Terminal strength	3.19	4.7.15		
Fungus	3.25	4.7.21		
Resistance to solvents	3.26	4.7.22		
Resistance to soldering heat	3.27	4.7.23		
Moisture resistance	3.20	4.7.16		
Sleeving	3.21	4.7.17		
<u>Group V</u>				
Stability at low and high temperatures	3.22	4.7.18	<u>12</u>	
Surge voltage	3.23	4.7.19		
<u>Group VI</u> <u>6/</u>				
Life (at +125°C)	3.24.1	4.7.20.1	24	.

See footnotes at end of table.

TABLE III. Qualification inspection - Continued.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of failures allowed ^{1/}
<u>Group VII</u> ^{6/} Life (at +85°C)	3.24.1	4.7.20.1	102	1
<u>Group VIII</u> Ripple current (style CSR21 only)	3.28	4.7.24	12	1

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

^{2/} Nondestructive tests.

^{3/} Marking defects are based on visual examination only and shall be charged only for illegible, incomplete, or incorrect marking.

^{4/} The sample size for CSR21 shall be 175 units, and the sample size for all other styles shall be 163. One additional sample unit is included in each sample size to permit substitution for the failure allowed in groups II through VI.

^{5/} This failure shall not be for the shock (specified pulse) or the vibration, high frequency test.

^{6/} For qualification of design changes only, qualified manufacturers may submit Weibull data in lieu of groups VI and VII test data.

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

4.4.4 Failure rate level and quality level verification.

4.4.4.1 Failure rate level qualification.

4.4.4.1.1 Exponential. Exponential 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. FR level "M" of FRSP-60, Failure Rate Sampling Procedure (FRSP), shall apply. Sample units shall be subjected to the qualification inspection specified in group VII, table III (see 4.4.2). The entire life tests sample shall be continued on test to 10,000 hours as specified in 4.7.20.2.2 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", 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 4.5f).

TABLE V. Voltage groups.

Style	Voltage group	Case size	Voltage range
CSR09, CSR13, or CSR91	1	A and B; A1 and B1; W and X	<u>Volts</u> 6 through 35
	2	C and D; Y and Z	6 through 50
	3	A and B; A1 and B1; W and X	50 through 100
	4	C and D; Y and Z	75 and 100
CSR23 or CSR33	5	A and B	6 through 20
	6	C and D	6 through 20
	7	A and B	35 and 50
	8	C and D	35 and 50
CSR21	9	C and D	6 through 20
	10	C and D	35 and 50

4.6.1.2 Group A inspection. Group A inspection shall consist of the inspections specified in table VI or VII, and shall be made on the same set of sample units, in the order shown.

4.6.1.2.1 Subgroup 1 tests.

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

4.6.1.2.1.2 Weibull. Subgroup 1 tests shall be performed on an inspection/production lot basis (see 4.6.1.1.3) on 100 percent of the product supplied under this specification. Requirements for the infant mortality period and Weibull failure rate level grading shall be in accordance with 4.7.25.

4.6.1.2.1.3 Manufacturer's production inspection. If the manufacturer performs tests equal to or more stringent than those specified in subgroup 1 of table VI and VII, subgroup 1 of group A inspection may be waived and the data resulting from the manufacturer's production tests may be used instead as the final step of this production process. Authority to waive the subgroup 1 inspection shall be granted by the qualifying activity only. The following criteria shall be complied with:

- a. Tests conducted by the manufacturer during production shall be clearly identical to or more stringent than that specified for subgroup 1. 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 are 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 the production tests.
- f. Once approved, the manufacturer shall not change the test procedures or criteria without prior notification and concurrence of the qualifying activity.

TABLE VI. Group A inspection (exponential distribution).

Inspection	Requirement paragraph	Test method paragraph	Sampling procedure
<u>Subgroup 1</u>			
Thermal shock	3.6	4.7.2	} 100% inspection <u>3/</u>
Voltage aging	3.7	4.7.3	
Surge current (styles CSR21 and CSR33 only) <u>1/</u>	3.30	4.7.26	
Seal <u>2/</u>	3.8	4.7.4	
Radiographic inspection <u>2/</u>	3.9	4.7.5	
<u>Subgroup 2 (PPM)</u>			
DC Leakage (PPM-2)	3.10	4.7.6	} See table VIII
Capacitance (PPM-2)	3.11	4.7.7	
Dissipation factor (PPM-2)	3.12	4.7.8	
Equivalent series resistance (ESR)(style CSR21 only)(PPM-2)	3.13	4.7.9	
Mechanical examination (PPM-3)	3.5	4.7.1	
<u>Subgroup 3</u>			
Visual examination			} 13 samples 0 failures
Materials	3.4	4.7.1	
Physical dimensions	3.1		
Marking	3.31		
Workmanship	3.32		
<u>Subgroup 4 2/</u>			
Stability at low and high temperatures	3.22	4.7.18	13 samples 0 failures
<u>Subgroup 5 2/</u>			
Surge voltage	3.23	4.7.19	13 samples 0 failures
<u>Subgroup 6</u>			
Solderability	3.18	4.7.14	13 samples 0 failures

1/ 5 percent PDA applicable to failure rate levels P, R, and S only.

2/ Not applicable to style CSR91.

3/ 5 percent PDA not applicable to radiographic inspection.

TABLE VII. Group A inspection (Weibull distribution).

Inspection	Requirement paragraph	Test method paragraph	Sampling procedure
<u>Subgroup 1</u>			
Thermal shock	3.6	4.7.2	} 100% inspection 2/
Surge current (styles CSR21 and CSR33 only)	3.30	4.7.26	
Life (accelerated failure rate)	3.29	4.7.25	
Seal 1/	3.8	4.7.4	
Radiographic inspection 1/ 3/	3.9	4.7.5	
<u>Subgroup 2 (PPM)</u>			
DC Leakage (PPM-2)	3.10	4.7.6	} See table VIII
Capacitance (PPM-2)	3.11	4.7.7	
Dissipation factor (PPM-2)	3.12	4.7.8	
Equivalent series resistance (ESR) (Style CSR21 only) (PPM-2)	3.13	4.7.9	
Mechanical examination (PPM-3)	3.5	4.7.1	
<u>Subgroup 3</u>			
Visual examination			} 13 samples 0 failures
Materials	3.4	4.7.1	
Physical dimensions	3.1		
Marking	3.31		
Workmanship	3.32		
<u>Subgroup 4 1/</u>			
Stability at low and high temperatures	3.22	4.7.18	13 samples 0 failures
<u>Subgroup 5</u>			
Solderability	3.18	4.7.14	13 samples 0 failures

1/ Not applicable to style CSR91.

2/ Exempt from PDA; rejects shall not be delivered on the contract or purchase order.

3/ Not applicable to Weibull graded units marked with exponential M-level FR dash numbers.

TABLE VIII. Sampling plans for PPM categories.

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

4.6.1.2.2 Subgroup 2 tests (PPM categories).

4.6.1.2.2.1 Sampling plans. Subgroup 2 tests shall be performed on an inspection lot basis. Samples subjected to subgroup 2 shall be selected in accordance with table VIII based on the size of the inspection lot. In the event of one 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 tests.

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

4.6.1.2.2.3 PPM calculations. PPM calculations shall be based on the results of the first sample check as prescribed in 4.6.1.2.2.1. Calculations and data inclusion shall be in accordance with EIA-554. (Note: PPM calculations shall not use data on the second sample submission.)

4.6.1.2.3 Subgroups 3 and 4 tests. Subgroups 3 and 4 shall be performed on an inspection lot basis. Sampling inspection shall be in accordance with table VI or table VII.

4.6.1.2.3.1 Rejected lots. The rejected lot from either subgroup shall be segregated from new lots and those lots which have passed inspection. If a lot is rejected, another 13 samples shall be inspected. If the second sample lot has one or more failures, the entire production lot shall be rejected and shall not be delivered on the contract or purchase order.

4.6.1.2.4 Subgroup 5 test (exponential only). Subgroup 5 test shall be performed with 13 units from the subgroup 3 or 4 tests, with no failures allowed.

4.6.1.2.4.1 Rejected lots. The rejected lot shall be segregated from new lots and those lots which have passed inspection. If a lot is rejected, another 13 samples shall be inspected. If the second lot has one or more failures, the entire production lot shall be rejected and shall not be delivered on the contract or purchase order.

4.6.1.2.4.2 Disposition of sample units. Sample units which have been subjected to subgroup 5 shall not be delivered on the contract or purchase order.

4.6.1.2.5 Subgroup 6 (exponential only) or subgroup 5 (Weibull only) (solderability).

4.6.1.2.5.1 Sampling plan. Thirteen samples shall be selected randomly from each inspection lot, as defined in 4.6.1.1.1, and subjected to the 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.

4.6.1.2.5.2 Rejected lots. If there are 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 4.6.1.2.5.1. Production lots that pass the solderability test are available for shipment. Production lots failing the solderability test may be reworked only if submitted to the solder dip procedure in (b).
- b. The manufacturer shall submit the failed lot to a 100 percent solder dip using an approved solder dip process in accordance with 3.5.2.1.2. Following the solder dip the electrical measurements required in Group A subgroup 1 tests shall be repeated on 100 percent of the lot. The Percent Defective Allowable (PDA) for the electrical measurements shall be as for the Subgroup 1 tests. (NOTE: If radiographic inspection and hermetic seal are required in the group A, subgroup 1 tests, these tests shall be repeated.) Thirteen additional samples shall then be selected and subjected to the solderability test with zero defects allowed. If the lot fails this solderability test, the lot shall be considered rejected and shall not be furnished against the requirements of this specification.

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

4.6.1.3 Group B inspection (polarized units only) (exponential only). Group B inspection shall consist of the test specified in table IX, and shall be made on sample units which have been subjected to and have passed the group A (subgroups 1, 2, and 3) inspections.

TABLE IX. Group B inspection.

Inspection	Requirement paragraph	Test method paragraph
Life (at +85°C)	3.24.2.2	4.7.20.2.1

4.6.1.3.1 Sampling plan. A sample shall be selected at random from each inspection lot that has passed group A (subgroups 1, 2, and 3) inspections. The sample chosen shall be representative of each voltage group with the highest capacitance value in each case size represented in the lot (see 4.6.1.1.1). Sampling for quality conformance life test shall be as specified herein. The detailed quality conformance procedures of MIL-STD-690, with the following details and exceptions, shall apply:

- a. Lot sampling: 110 samples.
- b. Duration of lot conformance FR test: 240 hours.
- c. Failure criteria: As specified in 3.24; one failure per lot.
- d. Permissible combination of voltage rating and case size: As specified in 4.6.1.1.1.
- e. Disposition of samples and inspection lot: Sample units which have been subjected to group B inspection may be delivered on the contract or purchase order provided they are 100-percent inspected to verify that they meet all of the requirements listed in table VI, subgroup 3, and that the dissipation factor, capacitance, dc leakage, and ESR (when applicable) are within the initial limits as specified (see 3.1). The inspection lot may be shipped on completion of lot conformance FR test.

Even though the lot has been rejected, those units in the lot which were predesignated for extended life testing shall remain or be placed on test for the full length of time.

4.6.1.3.2 Extended Life. In addition, a minimum of 10 units shall be selected at random from each inspection lot and subjected to the extended life test specified in 4.7.20.2.2. The manufacturer may increase this sample size if desired in order to develop the necessary number of units hours of data for maintenance or extension of qualification. The sample size may vary over the minimum from lot to lot at the manufacturer's option. The units selected for the extended life test may be from those subjected to group B inspection or from other units in the lot. In any case, the units to be subjected to the extended life test shall be predesignated before any life tests are initiated. The extended life test may be initiated periodically with units accumulated from each lot, or may be initiated on a lot-by-lot basis. The units selected for extended life test from each lot shall be representative of the capacitance values, case sizes, and voltages included in the lot to the maximum extent possible. In any case, over the production period covered by the maintenance of qualification requirements, the data shall be representative of the case sizes, voltages, and range of values produced.

4.6.1.3.3 Failure in group B inspection. If an inspection lot is rejected as a result of failure to pass group B inspection, the lot shall not be resubmitted. Even though the lot has been rejected, those units which were predesignated for extended life testing shall remain or be placed on test for the full length of time.

4.6.2 Periodic inspection. Periodic inspection shall consist of group C inspection. Except where the results of these inspections show noncompliance with the applicable requirements (see 4.6.2.1.3), delivery of products which have passed groups A and B inspections shall not be delayed pending the results of these periodic inspections.

4.6.2.1 Group C inspection. Group C inspection shall consist of the tests specified in table X, in the order shown. Group C inspection shall be made on sample units selected from inspection lots which have passed the group A inspection for nonpolarized units, and Weibull distribution inspection/production lots; and groups A and B inspections for polarized units (exponential distribution inspection lots).

4.6.2.1.1 Sampling plan.

4.6.2.1.1.1 Polarized units. There shall be 48 sample units of each style (60 sample units for CSR21) taken from production every 2 months and subdivided as specified for subgroups 1, 2, 3, and 5 of table X and subjected to the tests specified in those subgroups, in the order shown. The maximum and minimum case sizes manufactured during those months shall be represented in at least the approximate ratio of production, except for subgroup 1. The sample for subgroup 1 shall be composed of a minimum of three pieces of any one case size, and all case sizes shall receive subgroup 1 testing at least once during the six-month reporting period. Allowable failures shall be as specified in table X.

TABLE X. Group C inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of samples	Number of failures allowed
<u>Subgroup 1</u>				
Shock (specified pulse)	3.14	4.7.10	} 12	} 1
Vibration, high frequency	3.15	4.7.11		
Salt spray (corrosion)	3.16	4.7.12		
Thermal shock and immersion	3.17	4.7.13		
<u>Subgroup 2</u>				
Terminal strength	3.19	4.7.15	} 12	} 1 <u>1/</u>
Resistance to solvents	3.26	4.7.22		
Resistance to soldering heat	3.27	4.7.23		
Moisture resistance	3.20	4.7.16		
Sleeving	3.21	4.7.17		
<u>Subgroup 3</u>				
Life (at +125°C)	3.24.2.3	4.7.20.2.2	24	
<u>Subgroup 4 <u>2/</u></u>				
Salt spray (corrosion)	3.16	4.7.12	6	} 0
Resistance to solvents	3.26	4.7.22	6	
<u>Subgroup 5</u>				
Ripple current (CSR21 only)	3.28	4.7.24	12	1

1/ This failure shall not be for the shock (specified pulse) or the vibration, high frequency test.

2/ Nonpolarized capacitors only, see 3.1.

4.6.2.1.1.2 Nonpolarized units. There shall be 12 sample units of style CSR91 taken from production every 2 months that style CSR91 is produced, subdivided as specified in subgroup 4 of table X, and subjected to the tests specified in that subgroup, in the order shown. The maximum and minimum case sizes manufactured during that 2-month period shall be represented in the sample in at least the approximate ratio of production. No failures are allowed.

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

4.6.2.1.3 Noncompliance. If a sample fails to pass group C inspection, the manufacturer shall notify the qualifying activity and cognizant inspection activity of such failure and take corrective action on the materials or processes, or both as warranted, and on all units of product which can be corrected and which are manufactured under essentially the same materials and processes, 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 inspections, 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.

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

4.7 Method of inspection.

4.7.1 Visual and mechanical inspection. Capacitors shall be examined from a distance of 6 inches in normal room lighting and without the aid of magnification to verify that the materials, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.4, 3.5, 3.31, and 3.32). If closer examination is required, the capacitors shall be examined at no greater than 4X magnification.

4.7.2 Thermal shock (see 3.6). Capacitors shall be tested in accordance with method 107 of MIL-STD-202. The following shall apply:

- a. Special mounting: Not applicable.
- b. Test condition letter: B.
- c. Measurements before and after cycling: Not applicable.

4.7.3 Voltage aging (exponential only) (see 3.7). Capacitors shall be placed in a suitable test chamber maintained at +85°C and shall be subjected to the applications of a minimum of rated dc voltage for a minimum of 40 hours, except nonpolarized capacitors (see 3.1) shall be tested for 20 hours, minimum, in each direction. The aging circuit shall have a total resistance, exclusive of the capacitor, but including fuse wiring and internal impedance of the power supply, of not more than 3 ohms under any operating condition. Capacitors shall be removed from the chamber, stabilized at room ambient conditions (see 4.3.1), and the dc leakage, capacitance, dissipation factor, and ESR (CSR21 only) shall then be measured as specified in 4.7.6, 4.7.7, 4.7.8, and 4.7.9, respectively.

4.7.4 Seal (polarized capacitors only, see 3.1) (see 3.8). Capacitors shall be tested in accordance with method 112 of MIL-STD-202. The following detail and exception shall apply:

- a. Test condition letter: A, D, or equivalent.
- b. Examination after test: Not applicable.

This test may be accomplished prior to the addition of the sleeve.

4.7.5 Radiographic inspection (polarized capacitors only, see 3.1) (not applicable for FR level "M") (see 3.9). Capacitors shall be tested in accordance with method 209 of MIL-STD-202. The following details shall apply:

- a. Radiographic quality: Sufficient definition to determine that specimens are free from defects specified in 3.9 and render a clear sharp image of the penetrator.
- b. Image-quality indicator: An image of the penetrator shall be included on each radiograph. The penetrator may be made from a sample capacitor, of the same style as the capacitor being radiographed, with an AWG number 48 copper, gold, or tungsten wire mounted across the capacitor body, or it may be fabricated in accordance with, or be equivalent to, the example in figure 1.
- c. Positions of specimen: One plane at 90° rotation perpendicular to the longitudinal axis. If failures exceed 10 percent, X-ray shall be performed in two planes for all subsequent lots. The manufacturer may return to one-plane testing when three sequential lots meet the 10 percent failure rate.
- d. Evaluation of images:
 - (1) Special kind of viewing equipment: Magnifying glass.
 - (2) Magnification: 10X.
 - (3) Defects to be sought in specimen: As specified in 3.9. Examples of acceptable parts, and minor and major defects are shown in figures 2 through 4, respectively.

4.7.6 DC Leakage (see 3.10). DC leakage shall be measured using the dc rated voltage ± 2 percent at the applicable test temperature (see 3.1), after a maximum electrification period of 5 minutes. A 1,000-ohm resistor shall be placed in series with the capacitor to limit the charging current. A steady source of power, such as a regulated power supply, shall be used. Measurement accuracy shall be within ± 2 percent or 0.02 microampere, whichever is greater (see 4.3.3). For nonpolarized capacitors, measurements shall be made in both directions.

4.7.7 Capacitance (see 3.11). Capacitors shall be tested in accordance with method 305 of MIL-STD-202. The following details shall apply:

- a. Test frequency: 1,000 ± 100 Hz for CSR21 only and 120 ± 5 Hz for all other styles.
- b. Limit of accuracy: Measurement accuracy shall be within ± 2.0 percent of the reading for ± 10 and ± 20 percent capacitance tolerance items and ± 0.5 percent of the reading for ± 5 percent capacitance tolerance items.
- c. Magnitude of polarizing voltage: Unless otherwise specified (see 3.1), maximum dc bias shall be 2.2 volts for all ac measurements. The magnitude of the ac voltage shall be limited to 1.0 volt rms.

4.7.8 Dissipation factor (see 3.12). The dissipation factor shall be measured at the frequency specified in 4.7.7a, by means of a polarized capacitance bridge. The inherent accuracy of the measurement shall be $\pm (2$ percent actual value $+ 0.001)$.

4.7.9 Equivalent series resistance (ESR) (style CSR21 only) (see 3.13). The ESR at the applicable temperature shall be measured directly or determined from measurements obtained from a bridge. The following details shall apply:

- a. Test temperature and tolerance: $+25^{\circ}\text{C} \pm 5^{\circ}\text{C}$.
- b. Test frequency: 100 kHz ± 5 kHz.
- c. Limit of accuracy: Measurement accuracy shall be within ± 5.0 percent of the reading.
- d. Magnitude of polarizing voltage: Unless otherwise specified (see 3.1), the maximum dc bias shall be 2.2 volts for all ac measurements. The magnitude of the ac voltage shall be limited to 0.5 volt rms maximum.

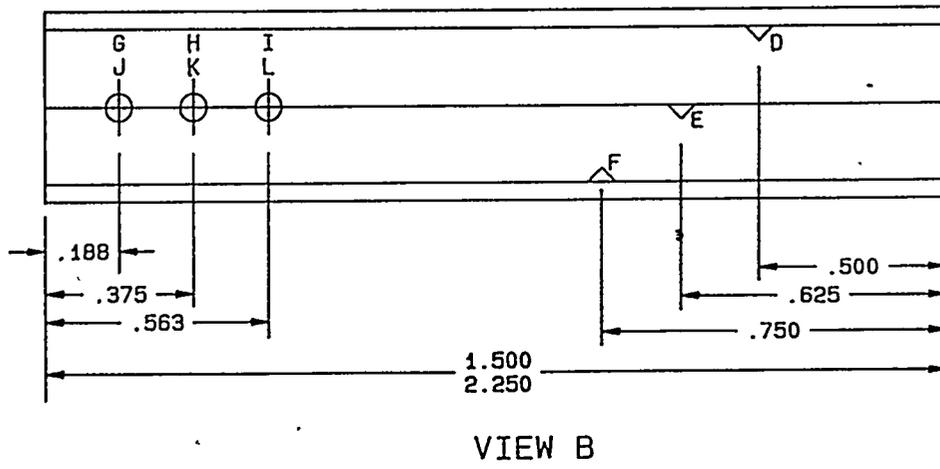
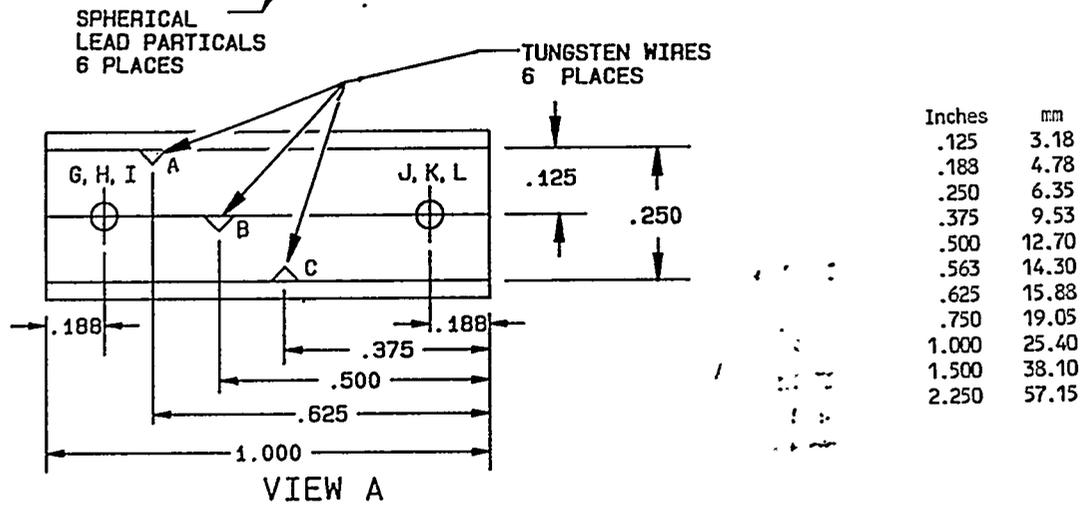
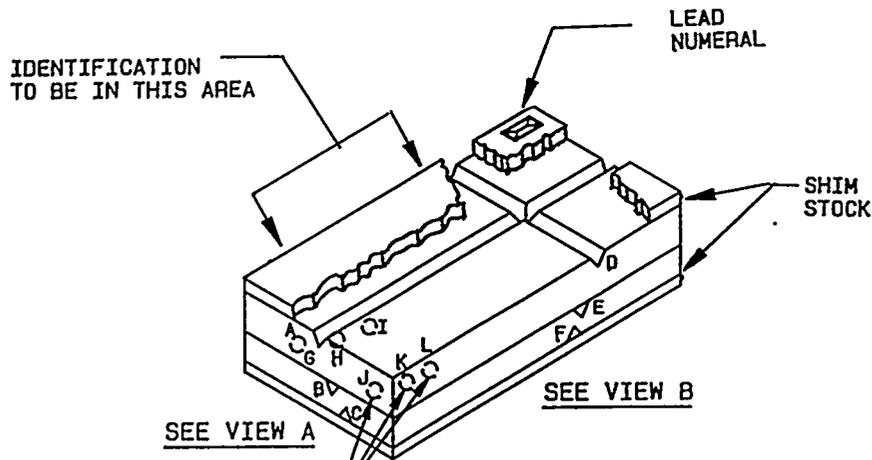


FIGURE 1. Image quality indicator (optional).

Table of image quality indicators

Tungsten wire diameters						Lead particle diameters						Steel shim stock
A	B	C	D	E	F	G	H	I	J	K	L	
.002 (0.05)	.001 (0.03)	.0005 (0.013)	.0005 (0.013)	.001 (0.03)	.002 (0.05)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	None
"	"	"	"	"	"	"	"	"	"	"	"	.002 (0.05)
"	"	"	"	"	"	"	"	"	"	"	"	.005 (0.13)
"	"	"	"	"	"	"	"	"	"	"	"	.007 (0.18)
.003 (0.08)	.002 (0.05)	.001 (0.03)	.001 (0.03)	.002 (0.05)	.003 (0.08)	"	"	"	"	"	"	.010 (0.25)
.003 (0.08)	.002 (0.05)	.001 (0.03)	.001 (0.03)	.002 (0.05)	.003 (0.08)	"	"	"	"	"	"	.015 (0.38)
.005 (0.13)	.003 (0.08)	.002 (0.05)	.002 (0.05)	.003 (0.08)	.005 (0.13)	"	"	"	"	"	"	.025 (0.64)
.005 (0.13)	.003 (0.08)	.002 (0.05)	.002 (0.05)	.003 (0.08)	.005 (0.13)	"	"	"	"	"	"	.035 (0.89)

NOTES:

1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. Metric equivalents are in parentheses.
4. Wires to be tungsten, shim stock to be carbon steel, particles to be lead. Center section to be .125 (3.18 mm) layers of clear acrylic plastic, bonded with clear plastic cement of low X-ray density. Fasteners may be used within .250 (6.35 mm) or less from each corner, but shall not interfere with end use of the penetrameter. Bottom surface shall be flush.
5. All dimensions shown are ± 0.005 (0.13 mm), except wires and shim stock, which shall be within standard mil tolerances, and lead particles which shall be ± 0.0002 (0.005 mm). Groove details are not critical except that wire must be embedded flush or below surface of plastic and centered at location shown. Particle-hole sizes are not critical, but should not exceed .031 (0.79 mm) in diameter and depth, and must be centered as shown within ± 0.005 (0.13 mm).
6. Additional layers of shim stock may be used as necessary.
7. Identification marking shall be permanent and legible. Location and size of character is not critical but shall not interfere with or obscure the radiographic image details.

FIGURE 1. Image quality indicator (optional) - Continued.

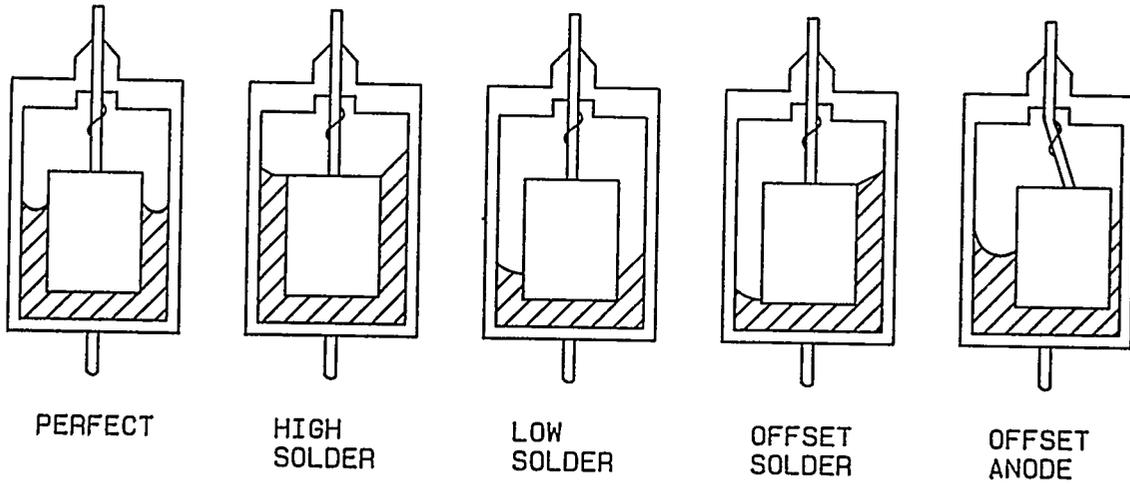
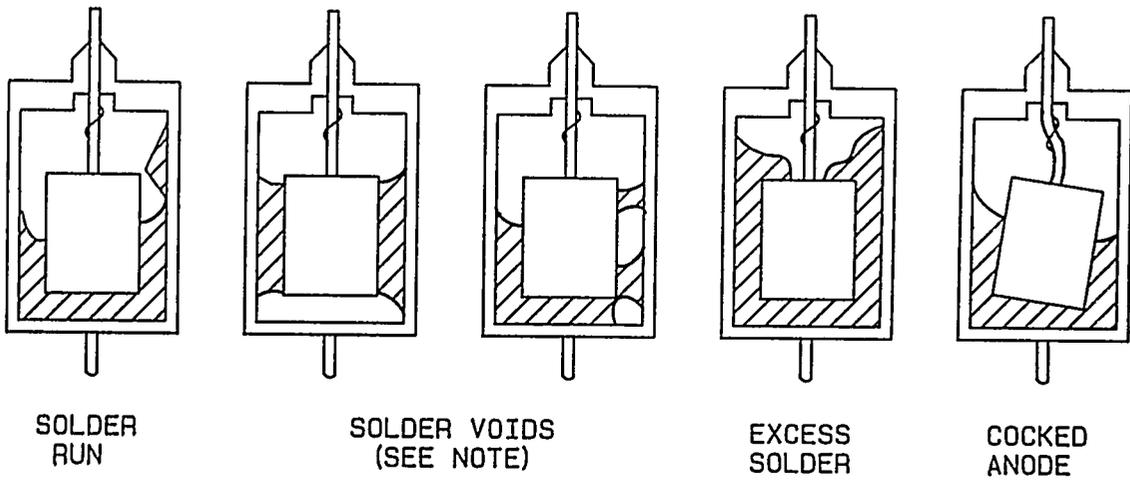
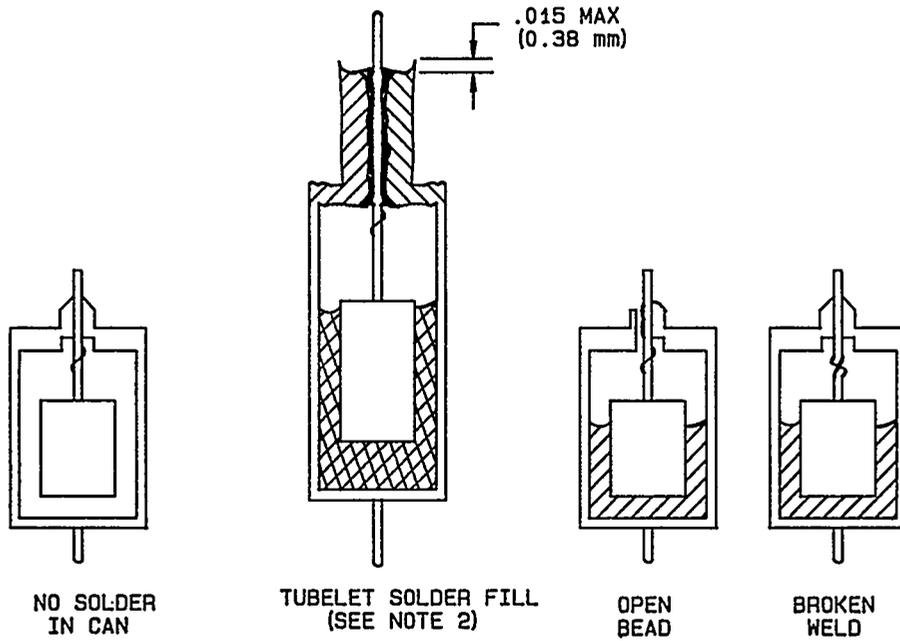
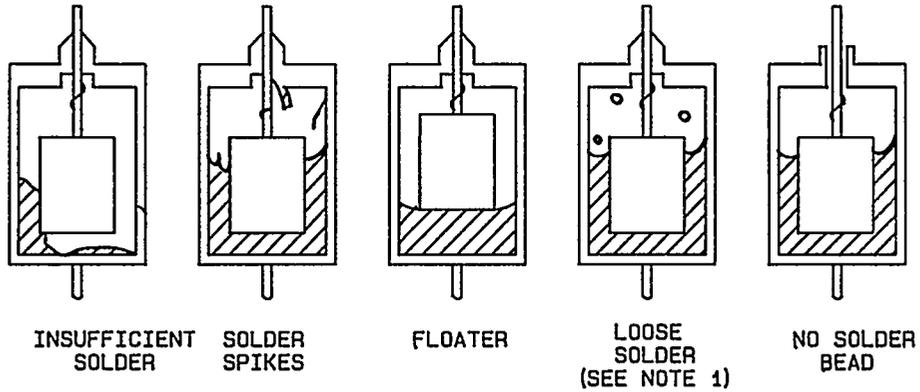


FIGURE 2. Acceptable parts.



NOTE: Voids in the anchor solder are permitted as long as each side is supported by at least 40 percent coverage of the anode length.

FIGURE 3. Minor defects - acceptable.



NOTES:

1. Solder balls or particles are rejectable if they are .01 (0.3 mm) or larger in the largest dimension.
2. Minimum solder fill shall not be less than one lead diameter, exclusive of voids. The top of the fill may extend above the tubelet but cannot be greater than .015 (0.38 mm) below the top of the tubelet, and the wicking angle to the lead wire and tubelet shall be positive. Solder shall not extend below the tubelet inside the component.

4.7.10 Shock (specified pulse) (polarized capacitors only, see 3.1) (see 3.14). 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 mount fixture by the body. (Potting compounds may be used to secure the capacitor body as long as the compound does not support the leads.) Leads shall be secured to rigidly supported terminals, so spaced that the length of each lead from the capacitor is approximately .375 (9.52 mm) when measured from the edge of the supporting terminal. Leads shall be within 30° of being parallel. When securing leads, care shall be taken to avoid pinching the leads.
- b. **Test condition letter:** I (100 g peak).
- c. **Measurements and electrical loading during shock:** During the test, observations shall be made to determine intermittent contact or arcing, or open- or short-circuiting. Detecting equipment shall be sufficiently sensitive to detect any interruption with a duration of 0.5 ms or greater. The dc rated voltage shall be applied to the capacitors during the test.
- d. **Examinations after test:** Capacitors shall be visually examined for evidence of arcing, breakdown, and mechanical damage.

4.7.11 Vibration, high frequency (polarized capacitors only, see 3.1) (see 3.15). Capacitors shall be tested in accordance with method 204 of MIL-STD-202. The following details and exceptions shall apply:

- a. **Mounting of specimens:** Capacitors shall be securely mounted as specified in 4.7.10a.
- b. **Electrical load conditions:** During the test, the specified dc rated voltage (see 3.1) shall be applied to the capacitors.
- c. **Test condition letter:** D (20 g).
- d. **Duration and direction of motion:** Four hours in each of two mutually perpendicular directions (total of 8 hours), one parallel and the other perpendicular to the cylindrical axis.
- e. **Measurements during vibration:** Electrical measurement shall be made to determine intermittent operation, or open- or short-circuiting for the duration of the last cycle. Detecting equipment shall be sufficiently sensitive to detect any interruption with a duration of 0.5 ms or greater.
- f. **Measurements after vibration:** Not applicable.
- g. **Examination after test:** Capacitors shall be visually examined for evidence of mechanical damage.

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

- a. **Application salt solution:** 5 percent.
- b. **Test condition letter:** B (48 hours).
- c. **Measurements after exposure:** Not applicable.
- d. **Examinations after test:** Capacitors shall be visually examined for evidence of corrosion or other defects that will affect life or serviceability.

4.7.13 Thermal shock and immersion (polarized capacitors only, see 3.1) (see 3.17).

4.7.13.1 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: 15 minutes at the inspection conditions specified in 4.3.1.
- b. Test condition letter: B.
- c. Measurements before and after cycling: Not applicable.

4.7.13.2 Immersion. Following temperature cycling, capacitors shall be tested in accordance with method 104 of MIL-STD-202. The following details and exceptions shall apply:

- a. Test condition letter: B.
- b. Measurements after final cycle: Within 30 minutes after removal from the final immersion bath, the dc leakage, capacitance, and dissipation factor shall be measured as specified in 4.7.6, 4.7.7, and 4.7.8, respectively.
- c. Examination after test: Capacitors shall be visually examined for evidence of corrosion, mechanical damage, and obliteration of marking.

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

Number of terminations of each part to be tested: Two, as follows:

1. Negative leads: 0.125 ± 0.025 (3.18 ± 0.64 mm) from end of case.
2. Positive leads: 0.125 ± 0.025 (3.18 ± 0.64 mm) from the point of "clean lead" emerging from the seal eyelet.

4.7.15 Terminal strength (polarized capacitors only, see 3.1) (see 3.19).

4.7.15.1 Pull. Capacitors shall be tested in accordance with method 211 of MIL-STD-202. The following details shall apply:

- a. Test condition letter: A.
- b. Method of holding: The body of the capacitor shall be secured.
- c. Applied force: Three pounds.

4.7.15.2 Twist. Capacitors shall be tested in accordance with method 211 of MIL-STD-202. The following detail and exception shall apply:

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

Capacitors shall be visually examined for loosening of terminals and permanent damage to the terminals, terminal welds, or terminal solder, as applicable.

4.7.16 Moisture resistance (polarized capacitors only, see 3.1) (see 3.20). Capacitors shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

- a. Special mounting: Not applicable.
- b. Initial measurements: DC leakage, capacitance, and dissipation factor shall be measured as specified in 4.7.6, 4.7.7, and 4.7.8, respectively.
- c. Polarization and loading voltages: Not applicable.
- d. Exception: Step 7b not required.
- e. Final measurements: After the final cycle and within 2 to 6 hours after removal of the capacitors from the humidity chamber, the dc leakage, capacitance, and dissipation factor shall be measured as specified in 4.7.6, 4.7.7, and 4.7.8, respectively, at the inspection conditions specified in 4.3.1.
- f. Examinations after test: Capacitors shall be examined for evidence of corrosion, mechanical damage, and obliteration of marking.

4.7.17 Sleeving (polarized capacitors only, see 3.1) (see 3.21).

4.7.17.1 Dielectric strength. The capacitors shall be placed in a fixture which will provide intimate contact with a minimum of 80 percent of the sleeving covering the rounded portion of the case. A dc potential of 2,000 volts shall then be applied, with a maximum leakage of 20 μ A allowed between the capacitor case and the fixture. The voltage shall be applied uniformly at the rate of 500 volts per second. Electrification time shall be 1 minute \pm 5 seconds.

4.7.17.2 Insulation resistance. The capacitors shall be placed in a V-block and the insulation resistance between the case and V-block shall be measured with a polarizing voltage of 500 \pm 50 volts dc for 1 minute +0, -15 seconds. The measurement shall be repeated five times, rotating the unit in the block each time.

4.7.18 Stability at low and high temperatures (polarized capacitors only, see 3.1) (see 3.22). Capacitors shall be measured for dc leakage, capacitance, and dissipation factor as specified in 4.7.6, 4.7.7, and 4.7.8, respectively, at each of the temperatures specified in table XI, except that dc leakage measurements at -55°C (step 2) are not required. After the measurements of capacitance and dissipation factor have been made at the -55°C temperature (step 2), rated voltage shall be applied through a 33-ohm load for a minimum of 5 minutes. The capacitors shall be brought to thermal stability at each test temperature. Thermal stability will have been reached when no further change in capacitance is observed between two successive measurements taken at 15-minute intervals.

TABLE XI. Temperatures for stability test.

Step	Test temperature
1	+25°C (\pm 2°C)
2	-55°C (+0, -3°C)
3	+25°C (\pm 2°C)
4	+85°C (+4, -0°C)
5	+125°C (+4, -0°C)
6	+25°C (\pm 2°C)

4.7.19 Surge voltage (polarized capacitors only, see 3.1) (see 3.23). Capacitors shall be subjected to 1,000 cycles of the applicable surge voltage as follows:

DC rated voltage at +85°C (volts)	DC surge voltage at +85°C (volts)
6	8
10	13
15	20
20	26
35	46
50	65
75	98
100	130

The ambient temperature during cycling shall be +85°C. Each cycle shall consist of a 30-second surge voltage application followed by a 30-second discharge period. Voltage application shall be made through a 33-ohm resistor. The tolerance of the resistor shall be ±5 percent. Each surge voltage cycle shall be performed in such a manner that the capacitor is shorted terminal-to-terminal through a copper bar, or an equivalent low resistance at the end of the 30-second application. An alternate method of shorting the capacitors is discharge through the same resistance that is utilized for charging. After the final cycle, the capacitors shall be stabilized at the inspection conditions specified in 4.3.1, and the dc leakage, capacitance, and dissipation factor shall be measured as specified in 4.7.6, 4.7.7, and 4.7.8, respectively.

4.7.20 Life (polarized capacitors only, see 3.1) (see 3.24).

4.7.20.1 For qualification inspection (see 3.24.1). Capacitors shall be tested in accordance with method 108 of MIL-STD-202. The following details and exception shall apply:

- a. Distance of temperature measurements from specimens, in inches: Not applicable.
- b. Method of mounting: Capacitors shall be mounted by their leads.
- c. Test temperature and tolerance: Capacitors being subjected to the test of group VI of table III shall be tested at +125°C +4, -0°C. Capacitors being subjected to the test of group VII of table III shall be tested at +85°C +4, -0°C.
- d. Operating conditions: A minimum of rated dc voltage (see 3.1) or derated voltage at +125°C, as applicable (see table I), 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. The impedance of the voltage source, as seen from the terminals of each capacitor, shall not exceed 3 ohms (1 ohm for style CSR33). Storage batteries or an electronic power supply capable of supplying at least 1 ampere when a capacitor is shorted shall be used.
- e. Test condition letter: F (2,000 hours).
- f. Measurements during exposure: DC leakage at the applicable high test temperature shall be made at the following intervals: 0; 240 +48, -0 hours; 1,000 +48, -0 hours; and 2,000 +72, -0 hours.
- g. Measurements after exposure: Capacitors shall be returned to the inspection conditions specified in 4.3.1, and shall be visually examined for evidence of mechanical damage; dc leakage, capacitance, dissipation factor, and ESR (when applicable, see 3.1) shall then be measured as specified in 4.7.6, 4.7.7, 4.7.8, and 4.7.9, respectively (see 3.24.1). In addition, capacitors shall be subjected to the dielectric strength test as specified in 4.7.17.1 following these measurements.

4.7.20.2 For quality conformance inspection.

TABLE XII. Nominal acceleration factors.

Grading stress V_a/V_r 1/	Acceleration factor
1.0000	1.0000
1.1000	6.5355
1.2000	42.7128
1.3000	279.1496
1.4000	1,824.3823
1.5000	11,923.2626
1.5276	20,000.0000

1/ V_a = accelerated voltage.
 V_r = rated voltage.

4.7.26 Surge current (styles CSR21 and CSR33 only) (see 3.30). Capacitors shall be subjected to 3 consecutive cycles under the following conditions:

- a. Temperature: $+25^{\circ}\text{C} \pm 5^{\circ}\text{C}$.
- b. Rated voltage ± 2 percent shall be applied for 4 ± 1 seconds. The power source shall have an energy storage bank of 50,000 μF (minimum) across the output terminals.
- c. The capacitors shall then be discharged for 4 ± 1 seconds to a voltage below 1 percent of the rated voltage.
- d. The total dc resistance (excluding the capacitor) including the wiring, fixturing, and output impedance of the regulated power supply to each test position during the charging cycle shall be 1 ± 0.2 ohm.

5. PACKAGING

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

6. NOTE

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. Capacitors covered by this specification are intended mainly for use in filter, bypass, coupling, blocking, and other low-voltage applications (such as transistor circuits) where stability, size, weight, and shelf life are important factors. The dc leakage and dissipation factor of the suggested unit should be taken into consideration when designing transistor, timing, phase-shifting, and vacuum tube grid circuits.

6.1.1 Parallel operation. Operation of capacitors in parallel increases the risk of dc surge current failures in low-impedance circuits. The user is cautioned that the energy stored in a parallel capacitor circuit may discharge through other capacitors in the circuit.

6.1.2 Life degradation. The life of these capacitors is primarily dependent on voltage and temperature. These capacitors should not be used above the derated voltage at maximum rated temperature, $+125^{\circ}\text{C}$. The FR level at $+125^{\circ}\text{C}$ is not established in this specification; however, proof tests at $+125^{\circ}\text{C}$ are required (see 4.7.20).

6.1.3 Application of packaging.

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

6.2 Acquisition requirements. Acquisition documents should specify the following:

- a. Title, number, and date of this specification.
- b. Title, number, and date of the applicable specification sheet, and the complete Part or Identifying Number (PIN) (see 3.1).
- c. Issue of DODISS to be cited in the solicitation and, if required, the specific issue of individual documents referenced (see 2.1).
- d. If gold-plated leads are desired (see MIL-C-39003/2).
- e. Lead length, if different from that specified. Lead length may be specified to a minimum of 1 inch long for use in tape and reel automatic insertion equipment.

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 purchase orders for products covered by this specification. The activity responsible for the Qualified Products List is the Space and Naval Warfare Systems Command, Washington, DC; however, information pertaining to qualification of products may be obtained from the Defense Electronics Supply Center (DESC-E), 1507 Wilmington Pike, Dayton, OH 45444-5274. Application for qualification tests shall be made in accordance with SD-6, "Provisions Governing Qualification", which may be obtained by applying to the Naval Publishing and Printing Service Office, Building 40, NPM-DODSSP, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

6.4 Standard capacitor types. Equipment designers should refer to MIL-STD-198, "Capacitors, Selection and Use of", 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 Soldering heat. Caution should be exercised when subjecting these units to soldering heat. Preheat and soldering exposure times and temperatures should be held to a minimum.

6.6 Weibull FR Level determination. Weibull FR level determination is based on lot-by-lot 100 percent quality conformance accelerated failure rate life testing.

For example:

2500	Capacitors have a voltage rating (V_r) of 50 V dc.
X40	hours Weibull life test at 65 V dc voltage applied (V_a);
X279.1496	acceleration factor for $V_a/V_r = 1.3000$.
<hr/>	
27,914,960	Accelerated part hours.

Weibull FRL's are determined from actual lot performance data. Exponential FRL determination starts with several production lots which may be included in the same inspection lot. For example, 4 production lots of 2,500 capacitors having a voltage rating of 50 V dc are offered for inspection in the same inspection lot.

10,000	Capacitors with a voltage rating (V_r) of 50 V dc;
X40	hours voltage conditioning at 50 V dc minimum.
<hr/>	
400,000	Part hours, however, exponential lot voltage conditioning performance data are not used to determine FRL's.
110	Samples are drawn from the inspection lot of 10,000 capacitors;
X240	hours group B life test at 50 V dc applied;
<hr/>	
26,400	Parts hours, however, data accumulated and used to determine FRL's.

10	Samples selected on completing each group B inspection;
<u>X9760</u>	hours continuation life testing to 10,000 hours.
97,600	Rated condition part hours for FRL maintenance.
10	Samples selected on completing each group B inspection;
<u>X9760</u>	hours continuation life testing to 10,000 hours.
97,600	Rated condition part hours for FRL maintenance.

Exponential FRL's are based on the aggregate averages of a few samples drawn from many lots maintained in accordance with MIL-STD-690.

Time ordered distribution of failures for solid tantalum capacitors is described by the Weibull equation:

Equation 1

$$F(x) = 1 - \exp \left[- \frac{x^\beta}{\alpha} \right]$$

Where: $F(x)$ = Cumulative fraction failed (p) at time x
 x = Actual test time
 β = Weibull "shape parameter" (beta)
 α = Weibull "scale parameter"

This relationship may be plotted on graph paper which is constructed with $\ln x$ as abscissae and $\ln \ln 1/(1-p)$ as ordinates. Auxiliary scales allow plotting x and p directly. A straight line is obtained. The slope of this line is β , and the y-intercept is $-\ln \alpha$. Figure 5 illustrates a typical Weibull plot.

At any time x , values for β and p can be obtained and the lot failure rate $Z(x)$ may be calculated from equation 3. A second plot of failure rate versus time may be drafted as indicated on figure 6. The slope of this line is $\beta-1$. Acceptable capacitor lots always exhibit decreasing failure rate with respect to time as evidenced by a value of β which is less than unity.

6.6.1 Acceleration factors. In order to provide the equivalent of several thousand hours of testing within a practical time frame, voltage acceleration is employed. It has been determined that the application of voltage in excess of rated voltage produces a higher failure rate than that observed when the devices are operated at the nominal voltage rating. On the Weibull plot, a straight line, parallel to the line representing rated voltage, is obtained. The increased number of failures indicated by the line representing the higher voltage results from increased dielectric stress. The slopes (β) of both lines are essentially the same, but the time (x) required to produce any specified p is reduced as voltage is increased. As a result, acceleration factors may be specified which define the relationship between operation at rated voltage and operation at higher-than-rated voltages. For example, a lot of capacitors having a voltage rating of 50 V dc might be tested at 65 V dc. In this case, the ratio of applied voltage to rated voltage is 1.30, resulting in an acceleration factor (A) of 279. In practical terms, operation of these capacitors for 1 hour at 65 V dc is equivalent to operation at 50 V dc for 279 hours. This relationship may be mathematically represented as:

$$\text{Equation 2} \quad Z(t) = Z(Ax) = \frac{\beta}{\alpha} x^{\beta-1} \cdot \frac{1}{A}$$

In conjunction with equation 1, this function may be restated as:

$$\text{Equation 3} \quad Z(t) = F = \frac{-\beta \ln(1-p)}{x} \cdot \frac{10^5}{A}$$

The 10^5 factor allows for expression of $Z(t)$ in terms of percent per 1,000 hours when x denotes hours. Table XII illustrates a range of acceleration factors normally used for Weibull FR determination.

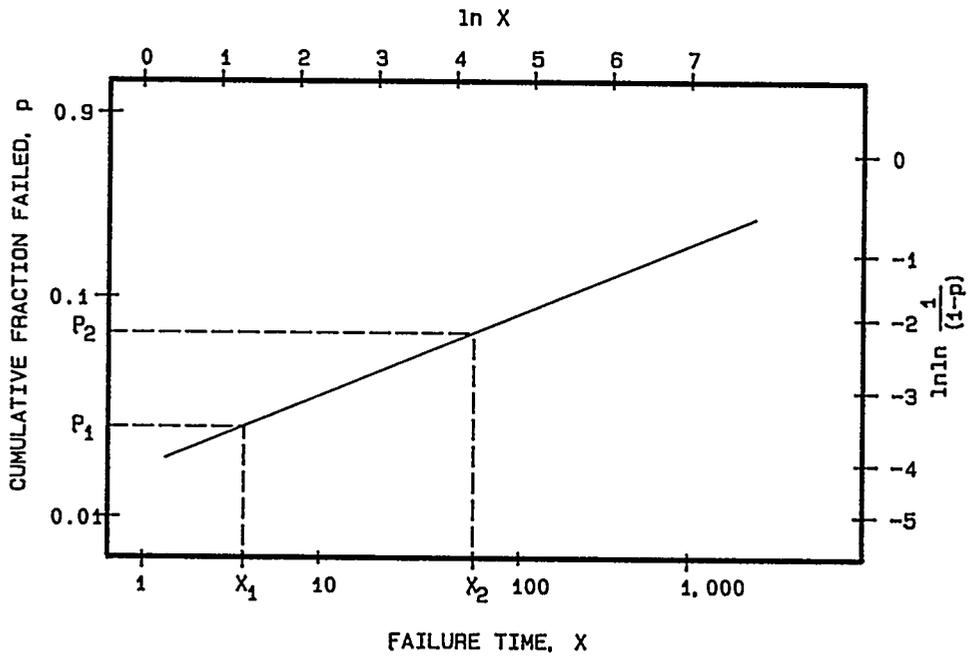


FIGURE 5. Typical Weibull plot.

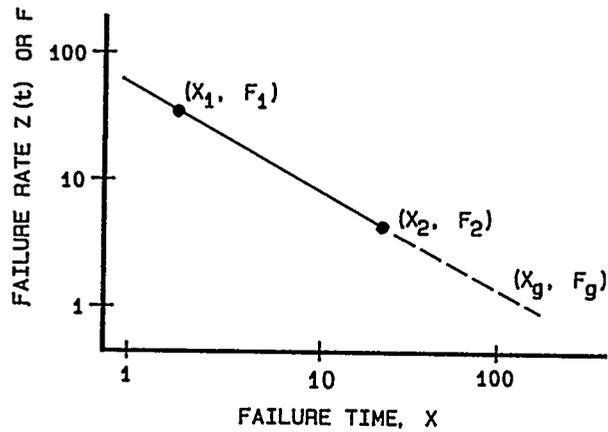


FIGURE 6. Failure rate versus time.

- d. 100 capacitors tested at a grading stress level of 1.4000 (1824.3823 acceleration factor) for 41 hours resulted in 3 failures at x_1 ; no additional failures at x_2 .

$$100 (1824.3823 \times 41) = 7,479,967.430$$

$$c = 3$$

FR = B level (MIL-STD-690, FRSP-90)

or assume one additional failure at x_2

$$\begin{aligned} x_1 &= 2 \text{ hours} \\ x_2 &= 41 \text{ hours} \\ p_1 &= .03 \\ p_2 &= .04 \\ A &= 1824.3823 \end{aligned}$$

$$\begin{aligned} \beta &= \frac{\ln \ln \frac{1}{1-p_2} - \ln \ln \frac{1}{1-p_1}}{\ln x_2 - \ln x_1} \\ &= \frac{\ln \ln \frac{1}{1-.04} - \ln \ln \frac{1}{1-.03}}{\ln 41 - \ln 2} \\ &= \frac{\ln \ln 1.041666 - \ln \ln 1.030928}{3.713572 - 0.693147} \\ &= \frac{-3.1985499 - (-3.4913617)}{3.02042425} \\ &= \frac{0.2928118}{3.02042425} = 0.096944 \\ \text{FRL} &= \frac{-\beta \ln(1-p_2)10^5}{x_2 A} = \frac{-0.096944 \ln (.96)10^5}{41(1824.3823)} \\ &= \frac{-0.096944(-0.040822)10^5}{74799.67} = 0.00000053 \times 10^5 \\ &= \frac{0.0053\%}{1,000 \text{ hours}} \end{aligned}$$

To compute hours needed to verify 0.001% per 1,000 hours FRL:

$$\ln x_g = \frac{\ln F_g - \ln F_2}{\beta-1} + \ln x_2$$

x_2 = hours at point 2

x_g = hours to test (goal)

F_2 = observed FRL at x_2

F_g = Failure rate level (goal)

$$\begin{aligned} \ln x_g &= \frac{\ln (0.001) - \ln (0.0053)}{-0.903056} + \ln 41 \\ &= \frac{-6.9077553 - (-5.2400485)}{-0.903056} + 3.713572 \\ &= \frac{-1.6677068}{-0.903056} + 3.713572 \\ &= 1.8467369 + 3.713572 \\ &= 5.5603089 \end{aligned}$$

$$x_g = 259.90 \text{ hours}$$

6.6.3 Weibull grading method. After determining the lot failure rate in accordance with 4.7.25, the balance of the lot (when applicable) should be tested to the same voltage acceleration conditions as the monitored test samples. These units shall then be subjected to the 100-percent electrical test shown in table VII.

6.7 Subject term (key work) listing.

Hermetically sealed
Nonpolarized
Polarized

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

MIL-C-39003H
APPENDIX A

PROCEDURES FOR QUALIFICATION INSPECTION
(EXPONENTIAL DISTRIBUTION)

10. SCOPE

10.1 This appendix details the procedures for submission of samples, with related data, for qualification inspection of capacitors covered by this specification. The procedures for extending qualification of the required sample to other capacitors covered by this specification is also outlined herein. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

20. SUBMISSION

20.1 Sample. For qualification to "M" FR Level in accordance with table III.

20.1.1 Single type submission. A sample consisting of 163 sample units (175 sample units for style CSR21) of each case size, dc rated voltage, and capacitance tolerance for which qualification is sought shall be submitted.

20.1.2 Combined-voltage group submission. A maximum of two voltage groups shall be represented (see table V). Except for styles CSR09 and CSR21, a sample consisting of 82 sample units of the highest capacitance value in the size B case of the lowest voltage and 82 sample units of the highest capacitance value in the size B case of the highest voltage; and a sample of 82 units of the highest capacitance value in the lowest voltage and 82 sample units of the highest capacitance value in the highest voltage in each qualification group (see table XIII) for which qualification is sought shall be submitted. For style CSR09 (see 3.1), the sample shall consist of 82 units of the highest capacitance value in the lowest voltage and 82 sample units of the highest capacitance value in the highest voltage in each qualification group. For style CSR21, the combined-voltage group submission shall be the same as for style CSR09, except that the number of sample units to be submitted shall be 88 in each qualification group.

20.2 Test data. When tests are to be performed at a Government laboratory, prior to submission, all sample units shall be subjected to all of the group I tests in table III. Each submission shall be accompanied by the test data obtained from these tests. The performance of the destructive 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 capacitors 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 range qualification will be restricted to values equal to or less than the capacitance value submitted. Voltage range approval will be restricted to the voltages equal to or less than that submitted in the same voltage group (see table V). Case size approval will be restricted to that submitted, except that approval of case size B or B1 may be a basis for approval of case size A or A1, respectively, and approval of case size D may be a basis for approval of case size C. Qualification of 20-percent capacitance tolerance will be restricted to 20-percent tolerance; qualification of 10-percent tolerance will be the basis for granting qualification for the 20-, 10-, and 5-percent capacitance tolerance.

30.2 Combined-voltage group submission. Qualification of the types submitted will be a basis for qualification of all intermediate voltages in the qualification group (see table XIV). Capacitance range, case size, and capacitance tolerance qualification shall be as specified in 30.1. Examples of combined-voltage group submissions are listed in table XIII.

30.3 Nonpolarized coverage for polarized submission. Qualification of polarized style CSR13 will be the basis for approval of nonpolarized style CSR91. Qualification will be restricted to the approval granted under 30.1 and 30.2, and will be granted only to manufacturers qualified to style CSR13 capacitors.

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APPENDIX A

TABLE XIV. Examples of qualification group. 1/

Style	Qualification group	Case size	DC rated voltage
CSR13 (see MIL-C-39003/1)	I	A and B	6, 10, 15, and 20
	II	C and D	6, 10, 15, and 20
	III	A and B	35 and 50
	IV	C and D	35 and 50
	V	A and B	75 and 100
	VI	C and D C	75 100
CSR09 (see MIL-C-39003/2)	I	A1 and B1	6, 10, 15, and 20
	III	A1 and B1	35 and 50
	V	A1 and B1	75
CSR23 (see MIL-C-39003/3)	I	A and B	6, 10, 15, and 20
	II	C and D	6, 10, 15, and 20
	III	A and B	35 and 50
	IV	C and D	35 and 50
CSR21 (see MIL-C-39003/9)	II	C and D	6, 10, 15, and 20
	IV	C and D	35 and 50
CSR33 (see MIL-C-39003/6)	I	A and B	6, 10, 15, and 20
	II	C and D	6, 10, 15, and 20
	III	A and B	35 and 50
	IV	C and D	35 and 50

1/ This table is set up as a guide. For other combinations, refer to the text of the appendix.

40. QUALIFICATION APPROVAL FOR LOWER FR LEVELS

40.1 Extension of qualification to lower FR levels shall be in accordance with 4.4.4.1.1 of this specification.

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APPENDIX B

PROCEDURES FOR QUALIFICATION INSPECTION
(WEIBULL DISTRIBUTION)

10. SCOPE

10.1 Weibull FR Level qualification. Weibull failure rate qualification will be extended only to manufacturers who have achieved the "P" level failure rate for any capacitor style covered by this specification in accordance with 4.4.4.1.1, or by MIL-C-55365. To extend qualification to include Weibull failure rate level, the manufacturer shall certify and demonstrate the capability of Weibull FR level grading (see 4.7.25) to the qualifying activity. Full range qualification shall be in accordance with table XV. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

TABLE XV. Matrix for Weibull qualification testing by rated voltage (dc), capacitance (μ F), and case size. 1/

Style	6 V	10 V	15 V	20 V	35 V	50 V	75 V	100 V	Case size
CSR13 2/	6.8	4.7	3.3	2.2	N/A	1.0	.68 3/	.56 3/	A
	56	39	22	15	6.8	3.9 3/ 4.7	2.7 3/ 3.9	2.7 4/	B
	180	120	68	47 3/	22	18.0	10	6.8 3/	C
	330	220	150	100	47 3/	22	15 3/	N/A	D
CSR09	2.7	2.2	1.5	1.0	.47 3/	.27	.18 3/	N/A	A1
	18	15	8.2	6.8	2.7	1.8 3/	1.2 3/	N/A	B1
CSR33 5/	12	8.2	5.6	3.9	1.8	1.5 3/	N/A	N/A	A
	100	82	39 3/	27	10	6.8 3/	N/A	N/A	B
	470	270	180	68 3/ 120	47	27 4/	N/A	N/A	C
	1,000	560	330	180	68	39 3/	N/A	N/A	D
CSR21	180	120	68	47 3/	22	18 3/	N/A	N/A	C
	330	220	150	100 3/	47	22 3/	N/A	N/A	D

1/ All capacitance tolerance shall be ± 10 percent.

2/ Qualification to style CSR13 will qualify style CSR91.

3/ The voltage and capacitance levels shown for this case size must be tested to obtain full range qualification at the B, C, or D failure rate levels.

4/ An exception is made for the C or D failure rate levels of the CSR13 B case 100 V or CSR33 C case 50 V; a 2.2 μ F CSR13 and a 22 μ F CSR33 shall be tested, respectively.

5/ Qualification to style CSR33 will qualify style CSR23.

CONCLUDING MATERIAL

Custodians:

Army - ER
Navy - EC
Air Force - 85

Review activities:

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

User activities:

Navy - AS, MC, OS
Air Force - 19

Preparing activity:

Navy - EC

Agent:

DLA - ES

(Project 5910-1689)

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I RECOMMEND A CHANGE:

1. DOCUMENT NUMBER

MIL-C-39003H

2. DOCUMENT DATE (YYMMDD)

20 March 1992

3. DOCUMENT TITLE *Capacitors, Fixed, Electrolytic (solid electrolyte), Tantalum, 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)

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7. DATE SUBMITTED (YYMMDD)

(1) Commercial
(2) AUTOVON (if applicable)

8. PREPARING ACTIVITY

a. NAME

b. TELEPHONE (Include Area Code)

(2) AUTOVON

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