

INCH-POUND

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SUPERSEDING
MIL-C-49467
5 April 1990

PERFORMANCE SPECIFICATION

CAPACITOR, FIXED, CERAMIC, MULTILAYER, HIGH VOLTAGE
(GENERAL PURPOSE), ESTABLISHED RELIABILITY,
GENERAL SPECIFICATION FOR

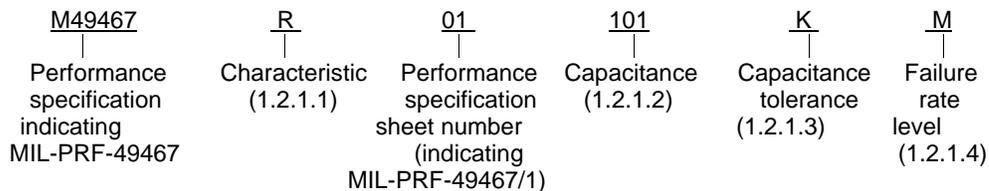
This specification is approved for use by all Departments
and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the general requirements for established reliability (ER), general purpose, ceramic multilayer high voltage capacitors for use in applications where appreciable variations in capacitance with respect to temperature, voltage, frequency, and life can be tolerated (BR and BZ characteristics) (see 6.1), or in critical frequency determining applications, timing circuits, and other applications where absolute stability is required (BP characteristic). Capacitors covered by this specification have failure rate levels (FRL) ranging from 1.0 to 0.001 percent per 1,000 hours. These FRL are established at a 60 percent confidence level and maintained at a 10 percent producer's risk and are based on life tests performed at maximum rated voltage at maximum rated temperature.

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

1.2.1 Part or Identifying Number (PIN). Capacitors specified herein (see 3.1) should be identified by a PIN which should consist of the basic number of the performance specification and a coded number. The coded number should provide information concerning the characteristic, specification sheet number, capacitance, capacitance tolerance, and FRL. The PIN should be in the following form with the coded number derived as indicated:



1.2.1.1 Characteristic. The characteristic refers to the voltage-temperature limits of the capacitor. The first letter (B) (not shown) identifies the rated temperature range of -55°C to +125°C. The second letter indicates the voltage temperature limits as shown in table I.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: US Army Communication-Electronics, ATTN: AMSEL-LC-LEO-E-EP, Fort Monmouth, NJ 07703-5023, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of the document, or by letter.

AMSC N/A
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FSC 5910

TABLE I. Characteristic.

Symbol	Capacitance change with reference to +25°C		
	Steps A through D of table IX	Rated voltage	Steps E through G of table IX
P	0 ± 30 PPM	100 percent	0 ± 30 PPM
R	± 15 percent	100 percent	+15, -40 percent
Z	± 15 percent	60 percent	+15, -45 percent

1.2.1.2 Capacitance. The nominal capacitance value, expressed in picofarads (pF) is identified by a three digit number; the first two digits represent significant figures and the last digit specifies the number of zeros to follow.

1.2.1.3 Capacitance tolerance. The capacitance tolerance is identified by a single letter in accordance with table II.

TABLE II. Capacitance tolerance.

Symbol	Capacitance tolerance
J	± 5 percent
K	± 10 percent
M	± 10 percent

1.2.1.4 FRL. The FRL should be as specified in table III.

TABLE III. FRL (established at a 60 percent confidence level).

Symbol	FRL (percent per 1,000 hours)
M	1.0
P	0.1
R	0.01
S	0.001

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of the documents cited in sections 3 and 4 of this specification, whether or not they are listed.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation (see 6.2).

SPECIFICATIONS

DEPARTMENT OF DEFENSE

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

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-202	-	Electronic and Electrical Component Parts, Test Methods for.
MIL-STD-690	-	Failure Rate Sampling Plans and Procedures.
MIL-STD-790	-	Standard Practice for Established Reliability and High Reliability Qualified Products List (QPL) Systems for Electrical, Electronic, and Fiber Optic Parts Specifications.
MIL-STD-810	-	Environmental Test Methods and Engineering Guidelines.
MIL-STD-1276	-	Leads for Electronic Component Parts.

(Unless otherwise indicated, copies of the above specifications, standard, and handbooks are available from the Defense Printing Service Detachment Office, Building 4D, Customer Service, 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of 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).

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI/J-STD-004	-	Requirements for Soldering Fluxes.
ANSI/J-STD-006	-	Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications.

(Application for copies should be addressed to the American National Standards Institute (ANSI), 11 West 42nd Street, New York, NY 10036-0350.)

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

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

(Application for copies should be addressed to the Electronic Industries Association, 2500 Wilson Boulevard, Arlington, VA 22201-3834.)

(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.)

2.4 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated specifications, specification sheets, or MS standards), the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

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

3.2 Qualification. Capacitors furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list (QPL) before contract award. In addition, the manufacturer shall obtain certification from the qualifying activity that the QPL system requirements of 3.3 and 4.2 have been met and are being maintained. Authorized distributors who are approved to MIL-STD-790 distributor requirements by the QPL manufacturer are listed in the QPL.

3.3 Qualified Products List (QPL) system. The manufacturer shall establish and maintain a QPL system for parts covered by this specification. Requirements for this system are specified in MIL-STD-690 and MIL-STD-790. In addition, the manufacturer shall establish a Statistical Process Control (SPC) and Part Per Million (PPM) system which meets the requirements of 3.3.1 and 3.3.2, respectively.

3.3.1 SPC system. As part of the overall MIL-STD-790 QPL system, the manufacturer shall establish an SPC system which meets the requirements of EIA-557. Typical manufacturing processes for application of SPC include raw material mixing and blending, stacking and electrode printing, laminating and dicing, and chip firing.

3.3.2 PPM system. As part of the overall MIL-STD-790 QPL system, the manufacturer shall establish a PPM system for assessing the average outgoing quality of lots in accordance with EIA-554-1. Data exclusion, in accordance with EIA-554-1, may be used with approval of the qualifying activity. The PPM system shall identify the PPM rate at the end of each month and shall be based on a six month moving average.

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 Insulating and impregnating compounds. Insulating and impregnating compounds, including resins, varnishes, waxes, and the like, shall be suitable for each particular application. Compounds shall preserve the electrical characteristics of the insulation to which they are applied.

3.4.2 Solder and soldering flux. Solder and soldering flux shall be in accordance with ANSI/J-STD-006 and ANSI/J-STD-004, respectively.

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

3.5.1 Terminals.

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

3.5.1.1.1 Qualifying activity approval. Approval of the solder dip process will be based on one of the following options:

- a. When the original lead finish qualified was hot solder dip lead finish 52 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 hot solder dip lead finish 52 of MIL-STD-1276 as prescribed in 3.5.1.1.1a., approval for the process to be used for solder dip shall be based on the following procedure:
 - (1) Thirty samples of any capacitance value for each style and lead finish shall be subjected to the manufacturer's solder dip process. The capacitors shall then be subjected to all group A, subgroup 1 post-electrical tests and subgroup 2 radiographic inspection, with no defects allowed.
 - (2) Ten of the thirty 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, with no defects allowed.

3.5.1.1.2 Solder dip/reflowing options. The manufacturer (or his authorized category C distributor) may solder dip/reflow as follows:

- a. As a corrective action if the lot fails the group A solderability test.
- b. After the group A inspection has been completed and, following the solder dip/reflowing process, the dielectric withstanding voltage, insulation resistance (at 25°C), dissipation factor, and capacitance measurements shall be performed on 100 percent of the lot. The percent defective allowable (PDA) shall be the same as that allowed for subgroup 1 of the group A inspection.

3.5.1.2 Tin plated finishes. Tin plating is prohibited as a final finish or as an undercoat. Tin-lead (Sn-Pb) finishes are acceptable provided that the minimum lead content is 3 percent (see 6.5).

3.6 Thermal shock and voltage conditioning. When tested as specified in 4.8.2, capacitors shall withstand the extremes of high and low temperature without visible damage and meet the following requirements:

- a. Dielectric withstanding voltage (at +25°C): As specified in 3.9. Shall be performed after the thermal shock test only.
- b. Insulation resistance (at +25°C): Shall not be less than the value shown on figure 1.
- c. Insulation resistance (at elevated ambient temperature): Shall not be less than the value shown on figure 1.
- d. Dissipation factor (at +25°C): Shall not exceed the value as specified.
- e. Capacitance (at +25°C): Shall be within the tolerance as specified.

3.7 Capacitance. When measured as specified in 4.8.3, the capacitance shall be within the specified tolerance.

3.8 Dissipation factor. When determined as specified in 4.8.4, the dissipation factor shall not exceed the percent as specified.

3.9 Dielectric withstanding voltage. Capacitors shall withstand direct current (dc) potential as specified in 4.8.5 without damage or breakdown.

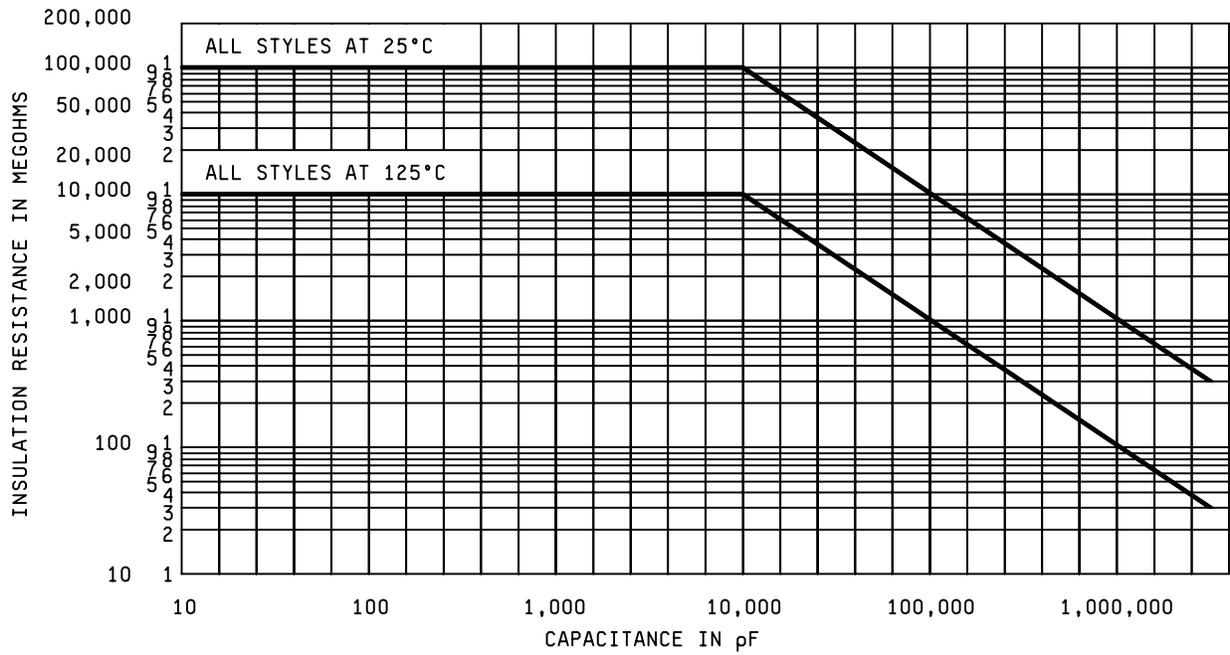


FIGURE 1. Insulation resistance versus capacitance.

3.10 Partial discharge (corona). When measured as specified in 4.8.6, the corona inception voltage (CIV) at the 100 picocoulombs (pC) level shall not be less than 0.42 times (dc rated V) rms volts.

3.11 Resistance to soldering heat. When tested as specified in 4.8.7, capacitors shall meet the following requirements:

- a. Insulation resistance at +25°C: Not less than the initial +25°C requirement.
- b. Capacitance: Shall not change more than -1.0 percent to +6.0 percent of initial measured value (BR and BZ characteristics) or -1.0 percent to +2.0 percent or 0.5 pF, whichever is greater, of initial measured value (BP characteristic).
- c. Dissipation factor: Shall not exceed the initial limits.

3.12 Insulation resistance. When measured as specified in 4.8.8, the insulation resistance shall be not less than the value specified on figure 1.

3.13 Solderability. When capacitors are tested as specified in 4.8.9, the dipped surface of the leads shall be at least 95 percent covered with a new, smooth, solder coating. The remaining 5 percent may contain only small pinholes or rough spots; these shall not be concentrated in one area. Bare base metal where the solder dip failed to cover the original coating is an indication of poor solderability, and pinholes or rough spots shall be determined by actual measurement of these areas, as compared to the total area.

3.14 Voltage-temperature limits. The capacitance change over the range of temperatures as specified in 4.8.10 shall not exceed the limits as specified in table I. The capacitance value obtained in step C of table IX shall be considered as the reference point.

3.15 Vibration, high frequency. When capacitors are tested as specified in 4.8.11, there shall be no intermittent contact of 0.5 millisecond (ms) or greater duration, open-circuiting or short-circuiting, or evidence of mechanical damage.

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

- a. Visual examination: No mechanical damage. Marking shall remain legible.
- b. Dielectric withstanding voltage: As specified in 3.9.
- c. Insulation resistance: Not less than the value specified.
- d. Capacitance: Change not to exceed ± 10 percent of initial measured value (BR and BZ characteristics) or ± 0.5 percent or 5 pF, whichever is greater, of initial measured value (BP characteristic).
- e. Dissipation factor: Shall not exceed initial limits.

3.17 Shock, specified pulse. When tested as specified in 4.8.13, there shall be no momentary or intermittent contact of 0.5 ms or greater duration, open-circuiting or short-circuiting, or other evidence of breakdown, arcing, and mechanical damage.

3.18 Terminal strength. When capacitors are tested as specified in 4.8.14, there shall be no loosening or rupturing of the terminals.

3.19 Moisture resistance. When tested as specified in 4.8.15, capacitors shall meet the following requirements:

- a. Visual examination: No mechanical damage. Marking shall remain legible.
- b. Dielectric withstanding voltage: As specified in 3.9.
- c. Insulation resistance: Not less than 10 percent of the initial +25°C requirement.
- d. Capacitance: Change not to exceed ± 10 percent of initial measured value (BR and BZ characteristics) or ± 0.5 percent or 5 pF, whichever is greater, of initial measured value (BP characteristic).

3.20 Fungus. The manufacturer shall certify that all materials are fungus resistant or shall perform the test as specified in 4.8.16. When capacitors are tested as specified in 4.8.16, examination shall not disclose evidence of fungus growth on the external surface.

3.21 Resistance to solvents. When capacitors are tested as specified in 4.8.17, there shall be no evidence of mechanical damage and the marking shall remain legible.

- a. INK: Capacitors marked with ink (INK) or laser etched and back filled with ink shall be examined in the qualification and group B inspections.
- b. OLM: Capacitors over-coated and then laser marked (OLM) shall be examined in the qualification and group B inspections.
- c. NLM: Capacitors not over-coated prior to laser marking (NLM) and etched directly into the bodies shall be examined in the qualification and group B inspections.

3.22 Life (at elevated ambient temperature). When tested as specified in 4.8.18, capacitors shall meet the following requirements:

- a. Insulation resistance (at elevated ambient temperature): Shall not be less than the value as specified (see figure 1).
- b. Visual examination: No mechanical damage. Marking shall remain legible.
- c. Insulation resistance (at +25°C): Shall not be less than the value as specified (see figure 1).
- d. Capacitance: Shall not change more than ± 3.0 percent or 0.5 pF, whichever is greater, of the initial reading (BP characteristic) or ± 20 percent of the initial reading (BR and BZ characteristics).
- e. Dissipation factor: Shall not exceed .2 percent (BP characteristic) or 3.0 percent (BR and BZ characteristics).

3.23 Low temperature storage. When tested as specified in 4.8.19, capacitors shall withstand the low temperature as specified without evidence of mechanical damage.

3.24 Radiographic inspection. When capacitors are tested as specified in 4.8.20, radiographic examination shall not disclose evidence of improperly made connections, substandard soldering or structural weakness, or attached solder particles or slivers.

3.25 Marking. Capacitors shall be marked as specified herein. Paper labels shall not be used. Other markings which in any way interfere with, obscure, or confuse those specified herein, are prohibited. Each capacitor shall be legibly marked with smear-resistant ink that will withstand the environmental conditions as specified herein. At the option of the manufacturer, capacitors may be laser marked. The marking shall remain legible after all tests.

3.25.1 Marking legibility (laser marking only). When tested as specified in 4.8.1.1, the marking shall remain legible.

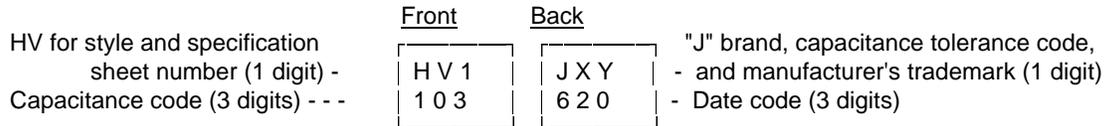
3.25.2 JAN and J marking. The United States Government has adopted, and is exercising legitimate control over the certification marks "JAN" and "J", respectively, to indicate that items so marked or identified are manufactured to, and meet all the requirements of specifications. Accordingly, items acquired to and meeting all of the criteria specified herein and in applicable specification, shall bear the certification mark "JAN" except that items too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" or "J" shall be placed immediately before the part number except that if such location would place a hardship on the manufacturer in connection with such marking, the "JAN" or "J" may be located on the first line above or below the part number. Items furnished under contracts or orders which either permit or require deviation from the conditions or requirements specified herein and in applicable specifications shall not bear "JAN" or "J". In the event an item fails to meet the requirements of this specification and the applicable specification sheets or associated specifications, the manufacturer shall remove completely the military part number and the "JAN" or the "J" from the sample tested and also from all items represented by the sample. The "JAN" or "J" certification mark shall not be used on products acquired to contractor drawings or specifications. The United States Government has obtained Certificate of Registration Number 504,860 for the certification mark "JAN" and Registration Number 1,586,261 for the certification mark "J".

3.25.3 Full marking. Unless otherwise specified (see 3.1), capacitors shall be marked with the "JAN" or "J" marking, PIN, date code and lot number, manufacturer's name (not trademark) or commercial and Government entity (CAGE), voltage, capacitance, and capacitance tolerance. There shall be no space between the symbols which comprise the PIN. The date code and lot number shall consist of the year, week, and lot code. For example: The third week of 1996 would be 9603. At the option of the manufacturer, the marking may be placed on one side of the capacitor, in the same order as shown in the example. Additional marking is permitted, following the required marking or on the opposite side, as long as it conforms to 3.25.

EXAMPLE:



3.25.4 Marking of smaller capacitors. Case codes A, B, and C (see 3.1) may, at the option of the manufacturer, be marked in accordance with the following example:



3.25.5 Substitution of FRL. A manufacturer may supply to all higher FRL than to which they are qualified. Items of an exponential FRL as shown in table IV 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 order (see 6.2), the lot date codes on the parts are unchanged, and the workmanship criteria is met.

TABLE IV. FRL substitutability.

Parts qualified to FRL	Are substitutable for FRL
S	M, P, and R
R	M and P
P	M

3.25.6 Substitution of capacitance tolerance and voltage. Parts qualified and marked to tighter capacitance tolerance or higher rated voltage are, with procuring agency approval, substitutable for parts marked to looser capacitance tolerance or lower rated voltage, provided all other values, such as case size, characteristic, and leads are the same. The substitutable parts shall not be remarked unless specified in the contract or order (see 6.2), the lot date codes on the parts are unchanged, and the workmanship criteria is met.

3.26 Recycling and waste prevention. Recovered materials or environmentally preferable materials shall be used wherever possible without jeopardizing the intended use of this item.

3.27 Workmanship. Capacitors shall be processed in such a manner as to be uniform in quality when using 2x minimum to 4x maximum magnification. External leads shall not exhibit cuts, nicks, or scrapes exceeding 10 percent of the diameter of the leads. Within .050 inch (1.27 mm) of the body of the component, 10 percent of the surface area of the leads may exhibit bare base metal. These capacitors are not expected to be solderable within .050 inch (1.27 mm) of the case.

4. VERIFICATION

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

- a. Qualification inspection (see 4.4).
- b. Verification of qualification (see 4.5).
- c. Conformance inspection (see 4.6).
- d. Periodic group B inspection (see 4.7).

4.2 Reliability and quality.

4.2.1 QPL system. The manufacturer shall establish and maintain a QPL system in accordance with 3.3. Evidence of such compliance is a prerequisite for qualification and retention of qualification.

4.3 Inspection conditions and methods.

4.3.1 Inspection conditions. Unless otherwise specified herein, all inspections shall be made in accordance with the "GENERAL REQUIREMENTS" of MIL-STD-202 except relative humidity shall not exceed 75 percent. Accuracy of all test voltage measurements shall be within ± 2.0 percent of the specified voltage.

4.3.2 Methods.

4.3.2.1 Reference measurements. When requirements are based on comparative measurements made before and after conditioning, the reference measurement shall be considered the last measurement made at $+25^{\circ}\text{C} \pm 3^{\circ}\text{C}$ prior to 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 specified test voltage.

4.4 Qualification inspection. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3), on sample units produced with equipment and procedures normally used in production.

4.4.1 Sample size. The number of capacitors to be submitted for qualification inspection shall be as specified in table V and in appendix A. Each capacitor style shall be qualified separately.

4.4.1.1 Sample selection. Samples shall be selected in accordance with 4.6.1.1.1 and shall be representative of the highest capacitance value.

4.4.2 Test routine. Sample units shall be subjected to the qualification inspection as specified in table V, in the order shown. All sample units shall be subjected to the inspection of groups I and II. The sample shall then be divided as specified in table V for groups III through VII inclusive, and subjected to the tests for their particular group. Samples which have been selected to be submitted to the life test shall be subjected to rated conditions. The decision as to whether or not the product is to be included on the QPL shall be made at the conclusion of the 2000-hour life test. Each unit shall be continued for a total of 10,000 hours.

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

4.4.4 FRL and quality level verification.

4.4.4.1 Failure rate (FR) qualification. Failure rate qualification shall be in accordance with the general and detailed requirements of MIL-STD-690 with the following details:

- a. Procedure I: Qualification at the initial FRL. Level "M" (1.0 percent/1,000 hours) of FRSP-60 shall apply. Sample units which have been subjected to the qualification inspection as specified in group VII, table V shall be continued on test as specified in 4.8.18.
- b. Procedure II: Extension of qualification to lower FRL. To extend qualification to the 0.01 percent/1,000 hours "R", and 0.001 percent/1,000 hours "S" FRL, data from two or more styles of similar construction may be combined.
- c. Procedure II: Maintenance of FRL qualification. Maintenance period B of FRSP-10 shall apply. Regardless of the number of production lots produced during this period, the specified number of unit hours shall be accumulated to maintain qualification.

4.4.4.2 Quality level verification. The manufacturer is responsible for establishing a quality system to assess the PPM defect level of lots that are subjected to the group A inspections. All capacitor styles may be combined for PPM calculations. The PPM defect level shall be based on a 6-month moving average.

MIL-PRF-49467A

TABLE V. Qualification inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of defectives permitted ^{1/}
<u>Group I</u>				
Thermal shock and voltage conditioning	3.6	4.8.2	All units	Not applicable
Partial discharge (corona)	3.10	4.8.6	All units	Not applicable
Radiographic inspection ^{2/}	3.24	4.8.20	All units	Not applicable
<u>Group II ^{3/}</u>				
Visual and mechanical examination:		4.8.1	4/ 157	1
Material, interface requirements, and workmanship	3.4, 3.4.1, 3.5, 3.27			
Physical dimensions and marking	3.1 and 3.25 through 3.25.4 inclusive			
Capacitance	3.7	4.8.3		
Dissipation factor	3.8	4.8.4		
Dielectric withstanding voltage	3.9	4.8.5		
Insulation resistance	3.12	4.8.8		
<u>Group III</u>				
Low temperature storage	3.23	4.8.19	6	1
Solderability	3.13	4.8.9		
Marking legibility (laser marking only)	3.25.1	4.8.1.1		
<u>Group IV</u>				
Voltage-temperature limits	3.14	4.8.10	18	1
Vibration, high frequency	3.15	4.8.11		
Immersion	3.16	4.8.12		
<u>Group V</u>				
Shock, specified pulse	3.17	4.8.13	18	1
Terminal strength	3.18	4.8.14		
Resistance to soldering heat	3.11	4.8.7		
Moisture resistance	3.19	4.8.15		
<u>Group VI</u>				
Fungus ^{5/}	3.20	4.8.16	6 } 12	1
Resistance to solvents	3.21	4.8.17		
<u>Group VII</u>				
Life (at elevated ambient temperature)	3.22	4.8.18	102	1
Partial discharge ^{6/}	3.10	4.8.6		

See footnotes at end of table.

TABLE V. Qualification inspection - Continued.

- 1/ A sample unit having one or more defects will be charged as a single defective.
- 2/ Molded and encapsulated case types only, see 3.1.
- 3/ Nondestructive examinations and tests.
- 4/ One additional sample unit is included in each sample of 157 sample units to permit substitution for the permitted defective in group II.
- 5/ Certification of fungus resistance may be substituted for testing. Only 151 samples are needed if certification is given for fungus (see 3.20).
- 6/ Partial discharge shall be performed after 2,000 hours of the life (at elevated ambient temperature) test for initial qualification. Partial discharge shall also be performed after 10,000 hours of the life (at elevated ambient temperature) test and the data shall be reported for informational purposes only.

4.5 Verification of qualification. Every 6 months, the manufacturer shall provide verification of qualification to the qualifying activity. Continuation of qualification shall be based on meeting the following requirements:

- a. MIL-STD-790 program.
- b. The capacitor design has not been modified.
- c. Lot rejection for group A inspection does not exceed 10 percent or one lot, whichever is greater.
- d. Periodic group B inspection.
- e. FRL.
- f. PPM assessment. All capacitor styles may be combined for PPM calculations.

4.6 Conformance inspection.

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of group A inspection.

4.6.1.1 Inspection and production lot.

4.6.1.1.1 Inspection lot. An inspection lot shall consist of all capacitors of one style and voltage-temperature limit, from the same production line or lines, produced under essentially the same conditions and offered for inspection during a single work week. Each inspection lot shall be kept separate from every other inspection lot. The sample from the inspection lot shall be representative of the highest capacitance values in the inspection lot. All sample units belonging to a lot shall be identified by means of a code symbol (either letters or numbers, at the option of the manufacturer).

4.6.1.1.2 Production lot. A production lot shall consist of all capacitors of the same style, voltage rating, nominal capacitance value, and voltage-temperature characteristic. The manufacture of all parts in the production lot shall have been started, processed, assembled, and tested as a group. Lot identity shall be maintained throughout the manufacturing cycle.

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

4.6.1.2.1 Subgroup 1 tests. 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 this subgroup shall be removed from the lot. If, during the 100 percent inspection, screening requires that more than 10 percent of the capacitors be discarded, the entire lot shall be rejected.

4.6.1.2.2 Subgroup 2.

4.6.1.2.2.1 Sampling plan. Subgroup 2 shall be performed on a production lot basis. Samples subjected to subgroup 2 shall be selected in accordance with table VII, based on the size of the inspection lot. In the event of one or more failures the lot shall be rejected.

4.6.1.2.2.2 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 screened and any defects found shall be removed from the lot. A new sample of parts shall then be randomly selected in accordance with table VII. If one or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification.

TABLE VI. Group A inspection.

Inspection	Requirement paragraph	Test method paragraph	Sampling procedure
<u>Subgroup 1</u>			
Thermal shock	3.6	4.8.2.1	100% inspection
Voltage conditioning	3.6	4.8.2.2	100% inspection
Partial discharge (when specified, see 3.1)	3.10	4.8.6	100% inspection
<u>Subgroup 2</u>			
Radiographic inspection <u>1/</u>	3.24	4.8.20	See table VII
<u>Subgroup 3</u>			
Mechanical examination <u>2/</u> Interface requirements (dimensions only)	3.5		See table VII
<u>Subgroup 4</u>			
Visual examination <u>2/</u> Material	3.4 and 3.4.1	4.8.1	} 13 samples 0 failure
Marking <u>3/</u>	3.25		
Workmanship	3.27		
<u>Subgroup 5</u>			
Solderability <u>4/</u>	3.13	4.8.9	13 samples 0 failure

1/ Molded and encapsulated case types only, see 3.1. Not applicable to conformal coated parts.

2/ The manufacturer may request the deletion of the visual and mechanical examination provided an in-line or process control system to assure the visual and mechanical requirements are met can be validated and approved by the qualifying activity. Deletion of these examinations does not relieve the manufacturer from meeting these requirements in case of dispute. If the design, material, construction, or processing of the part is changed or if there are any quality problems, the qualifying activity may require resumption of these examinations.

3/ Marking defects are based on visual examination only.

4/ Defective units from subgroups 1 and 2 tests may be used. Parts subjected to this test shall not be delivered. The manufacturer may request the deletion of the subgroup 5 solderability test, provided an in-line or process control system for assessing and assuring the solderability of leads can be validated and approved by the qualifying activity. Deletion of the test does not relieve the manufacturer from meeting this test requirement in case of dispute. If the design, material, construction, or processing of the part is changed or if there are any quality problems, the qualifying activity may require resumption of the test.

4.6.1.2.3 Subgroup 3 tests.

4.6.1.2.3.1 Sampling plans. Subgroup 3 tests shall be performed on an inspection lot basis. Samples subjected to subgroup 3 shall be selected in accordance with table VII based on the size of the inspection lot. In the event of one or more failures the lot shall be rejected..

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

TABLE VII. Sampling plans for subgroups 2 and 3 (group A inspection).

Lot size	Sample size
1- 13	100%
14- 150	13
151- 280	20
281- 500	29
501- 1,200	34
1201- 3,200	42
3201- 10,000	50
10,001- 35,000	60
35,001-150,000	74
50,001-500,000	90
500,001-Up	102

4.6.1.2.4 Subgroup 4. Subgroup 4 shall be performed on an inspection lot basis. The sampling procedure shall be as specified in table VI.

4.6.1.2.4.1 Rejected lots. The rejected lot shall be segregated from new lots and those lots that have passed inspection. Lots rejected because of failures in subgroup 4 may be offered for acceptance only if the manufacturer inspects all units in the lot for those quality characteristics found defective in the sample and, after removing all defective units found, reinspects the lot using the sampling procedure specified in table VI. If one or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification. Resubmitted lots shall be kept separate from new lots, and shall be identified as resubmitted lots.

4.6.1.2.5 Subgroup 5. Subgroup 5 shall be performed on an inspection lot basis. The sampling procedure shall be as specified in table VI.

4.6.1.2.5.1 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. The individual production lot, or lots, from which the defect originated shall be individually subjected to the solderability test as required in 4.6.1.2.5. Production lots that pass the solderability test are available for shipment. Production lots that fail the solderability test may be reworked only if they are subjected to the solder dip procedure in 4.6.1.2.5.1b.
- b. The manufacturer shall submit the failed lot to a 100 percent reprocessing of the termination finish in accordance with 3.5.1.1.2. Thirteen additional samples shall then be selected and subjected to the solderability test with no defects allowed. If the lot fails this solderability test, the lot shall be considered rejected and shall not be furnished against the requirements of this specification.

4.6.1.2.6 PPM calculations. The manufacturer shall establish a PPM system in accordance with 3.3.2 for assessing and calculating average outgoing quality of capacitors. A PPM rate combining capacitance, DF, IR (25°C), and DWV shall be assessed for lots that have passed the group A inspection. The manufacturer's PPM system shall also address rectification procedures for lots failing PPM assessment. Data from the rectification process shall not be used to calculate PPM.

4.7 Periodic group B inspection. Periodic group B inspection shall consist of the tests specified in table VIII in the order shown, and shall be performed on sample units selected from lots that have passed group A inspection. Capacitor styles manufactured during each 2-month or 6-month period, as applicable, shall be represented, as far as practical, in at least the approximate ratio of production. Except where the results of this inspection show noncompliance with the applicable requirements (see 4.7.3), delivery of products which have passed group A inspection shall not be delayed pending the results of this periodic inspection.

4.7.1 Sampling plan.

4.7.1.1 Subgroups 1 through 3. Twenty-eight sample units shall be taken from production every 6 months and subjected to the applicable tests for their particular subgroup. Permitted failures shall be as specified in table VIII.

4.7.1.2 Subgroup 4. A minimum of 10 sample units of the highest capacitance value per style produced shall be selected from each inspection lot produced during a 2-month period. The actual number of samples selected shall be such that the number of unit hours generated meet the maintenance period requirements of MIL-STD-690 for the qualified FRL. Permitted failures shall be as specified in MIL-STD-690. The accumulated data shall be used for maintenance and extension of failure rate qualification.

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

4.7.3 Noncompliance. If a sample unit fails to pass group B 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 were manufactured under essentially the same conditions, with 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 Government, has been taken. After the corrective action has been taken, group B 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. Group A inspection may be reinstated; however, final acceptance shall be withheld until the group B inspection has shown that corrective action was successful.

4.8 Methods of examination and test.

4.8.1 Visual and mechanical examination. Capacitors shall be examined to verify that the materials, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.4, 3.4.1, 3.5, 3.25, and 3.27).

4.8.1.1 Marking legibility (laser marking only, see 3.25.1). Capacitors shall be coated with .005 inch (0.13 mm) minimum of silicone resin (SR) insulating compound. After curing, coated capacitors shall be examined for legibility under normal production room lighting by an inspector with normal or corrected 20/20 vision.

4.8.2 Thermal shock and voltage conditioning (see 3.6). Capacitors shall be subjected to the tests of 4.8.2.1 and 4.8.2.2, as applicable (see tables V and VI).

TABLE VIII. Periodic group B inspection.

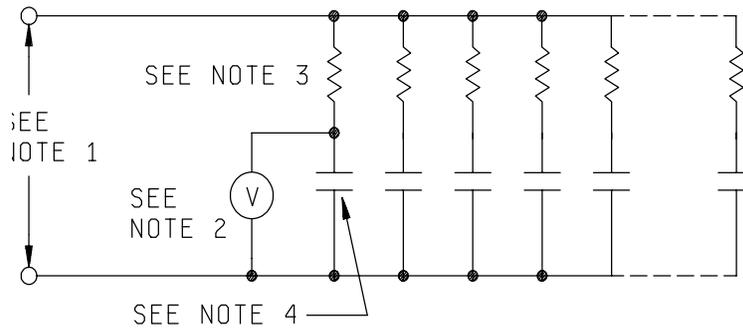
Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of defectives permitted ^{1/}
<u>Every 6 months</u>				
<u>Subgroup 1</u>				
Terminal strength	3.18	4.8.14] 18]] 1]
Resistance to soldering heat	3.11	4.8.7		
Moisture resistance	3.19	4.8.15		
<u>Subgroup 2</u>				
Voltage-temperature limits ^{3/}	3.14	4.8.10] 6]] 1]
Low temperature storage	3.23	4.8.19		
Marking legibility (laser marking only)	3.25.1	4.8.1.1		
<u>Subgroup 3</u>				
Resistance to solvents	3.21	4.8.17	^{4/} 4	0
<u>Every 2 months</u>				
<u>Subgroup 4</u>				
Life (at elevated ambient temperature)	3.22	4.8.18] 10 minimum per style]] See 4.7.1.2]
Partial discharge (when specified, see 3.1) ^{5/}	3.10	4.8.6		

- ^{1/} A sample unit having one or more defects shall be charged as a single defective.
- ^{2/} Samples shall be representative of the highest capacitance value of each style manufactured during the sampling period.
- ^{3/} Samples shall be selected from a minimum of two lots per sampling period when more than one lot of dielectric is used.
- ^{4/} When more than one marking type is used (see 3.21), an additional four samples shall be added for each additional marking type.
- ^{5/} Partial discharge shall be performed on completion of the 10,000 hour life (at elevated ambient temperature) test. The data shall be reported for informational purposes only.

4.8.2.1 Thermal shock. Capacitors shall be tested in accordance with method 107 of MIL-STD-202. The following detail and exception shall apply:

- a. Test condition: A, except that in step 3, sample units shall be tested at +125°C.
- b. Measurement after cycling: Dielectric withstanding voltage as specified in 4.8.5.

4.8.2.2 Voltage conditioning. Voltage conditioning shall be started immediately after completion of the thermal shock test. The voltage conditioning shall consist of applying rated voltage to the units at +125°C +4°C, -0°C for 96 hours minimum. Voltage shall be applied and shall reach maximum value within 30 seconds. To assure that at least 95 percent of the applied test voltage is maintained for the duration of the test period, the circuit on figure 2 shall be used.



NOTES:

1. The power supply shall be capable of providing a minimum of twice the rated voltage of the capacitors at five times the current requirement of the circuit.
2. There shall be a voltage monitor that will trigger an alarm and shut off the test if the applied voltage drops or increases by more than 5 percent. The resistance of the voltage monitor shall be a minimum of 10 times the equivalent resistance of the capacitors.
3. The current limiting device shall be a resistor. For 1,000 V dc tests the resistor shall be 10 megohms maximum. For tests above 1,000 V dc, the resistor shall be 100 megohms maximum.
4. There is no minimum number of capacitors in the capacitor bank.

FIGURE 2. Voltage conditioning circuit.

After completion of the test period, with the capacitors maintained at the +125°C test temperature, the insulation resistance shall be measured in accordance with 4.8.8. The units shall then be allowed to stabilize at room temperature (+25°C). After stabilization at room temperature, the insulation resistance shall be measured as specified in 4.8.8. After measurement of insulation resistance at +25°C, the capacitance and dissipation factor shall be measured as specified in 4.8.3 and 4.8.4, respectively.

4.8.3 Capacitance (see 3.7). Capacitors shall be tested in accordance with method 305 of MIL-STD-202. The following detail and exception shall apply:

- a. Test frequency: 1 megahertz \pm 100 kHz when the nominal capacitance is 100 pF or less, and 1 kHz \pm 100 Hz when the nominal capacitance is greater than 100 pF.
- b. Voltage: A root-mean-square potential of 1.0 \pm 0.2 volts, when no polarizing voltage is applied.

4.8.4 Dissipation factor (see 3.8). The dissipation factor shall be measured with a capacitance bridge or other suitable method at the frequency and voltage as specified in 4.8.3a and 4.8.3b. The inherent accuracy of the measurement shall be \pm 2 percent of the reading plus 0.1 percent dissipation factor (absolute) unless otherwise specified. Suitable measurement techniques shall be used to minimize errors due to the connections between the measuring apparatus and the capacitor.

4.8.5 Dielectric withstanding voltage (see 3.9).

4.8.5.1 Dielectric. Capacitors shall be tested in accordance with method 301 of MIL-STD-202. The following details shall apply:

- a. Magnitude and nature of test voltage: 150 percent of dc rated voltage shall be applied for 1,250 volts or less, and 120 percent of dc rated voltage shall be applied for 1,251 volts and higher. It is recommended that the capacitors be immersed in an inert medium to prevent arcing or high leakage currents.
- b. Duration of application of test voltage: 1 second minimum. The test voltage shall be raised from 0 to the specified value within 1 minute, maximum.
- c. Points of application of test voltage: Between the capacitor-element terminals.
- d. Limiting value of surge current: 10 mA maximum.
- e. Examination after test: Capacitors shall be examined for evidence of damage and breakdown.

4.8.5.2 Body insulation (qualification, group II only). Capacitors shall be tested at 1,000 V dc. Points of application of test voltage: Capacitors shall be wrapped with a conductive tape or foil so that the tape or foil shall not be less than .100 inch (2.54 mm) and more than .150 inch (3.81 mm) away from the lead wires. The dc potential shall be applied between the two leads connected together and the tape or foil for a period of 5 seconds ± 1 second. The test circuit shall be so arranged that the surge current does not exceed 30 mA.

4.8.6 Partial discharge (corona) (when specified, see 3.1)(see 3.10). Capacitors shall be tested in accordance with appendix B.

4.8.7 Resistance to soldering heat (see 3.11). Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details and exceptions shall apply:

- a. Special preparation of the specimen: The parts shall be adequately preheated or heat sinks shall be used on each lead during the test. Both leads shall be dipped in flux and then dipped into solder, both for 5 seconds ± 0.5 second. The bath shall be maintained at $+260^{\circ}\text{C} \pm 5^{\circ}\text{C}$. The parts shall be immersed to within .075 inch ± 0.025 inch (1.90 inch ± 0.64 mm) of the body.
- b. Test condition: C.
- c. Measurements after test: After completion of the cleaning process and following a minimum 3-hour cooling period, the capacitance, dissipation factor, dielectric withstanding voltage, and insulation resistance shall be measured as specified in 4.8.3, 4.8.4, 4.8.5, and 4.8.8, respectively.
- d. Examination after test: Capacitors shall be examined for evidence of mechanical damage.

4.8.8 Insulation resistance (see 3.12). Capacitors shall be tested in accordance with method 302 of MIL-STD-202. The following details shall apply:

- a. Test potential: 500 V dc.
- b. Special conditions: If a failure occurs at a relative humidity of 50 percent or higher, the insulation resistance may be measured again at a relative humidity of less than 50 percent.
- c. Points of measurement: Between the capacitor element terminals.
- d. Surge current: Limited to 30 mA.

4.8.9 Solderability (see 3.13). Capacitors shall be tested in accordance with method 208 of MIL-STD-202. Number of terminations to be tested: Two.

4.8.10 Voltage-temperature limits (see 3.14).

4.8.10.1 For qualification inspection. The temperature of each capacitor shall be varied as specified in table IX. Capacitance measurements shall be made at the frequency and voltage specified in 4.8.3a and 4.8.3b. The voltage specified in table IX shall be maintained on the capacitor during steps E through G. Capacitance measurements shall be made at each step specified in table IX and at a sufficient number of intermediate temperatures between steps B and G to establish a true characteristic curve. Capacitors shall be kept at each temperature until temperature equilibrium is attained.

4.8.10.2 For quality conformance inspection. Capacitance measurements shall be made as specified in 4.8.10.1 with the following exceptions:

- a. Measurements shall be made only for steps C, D, E, and G of table IX.
- b. Temperature characteristic BZ shall be measured at 60 percent of rated voltage.

TABLE IX. Voltage-temperature limit cycle.

Step	Voltage, dc	Temperature
A	None	$^{\circ}\text{C} \pm 2^{\circ}\text{C}$ +25
B	None	-55
C <u>1/</u>	None	+25
D	None	+125
E	See 3.1	+125
F	See 3.1	+25
G	See 3.1	-55

1/ Reference point.

4.8.11 Vibration, high frequency (see 3.15). Capacitors shall be tested in accordance with method 204 of MIL-STD-202. The following details and exception shall apply:

- a. Mounting: Capacitors shall be rigidly mounted on a mounting fixture by the body. Leads shall be secured to rigidly supported terminals, so spaced that the length of each lead from the capacitor is approximately .375 inch (9.52 mm) when measured from the edge of the supporting terminal. Leads shall be within 15 degrees of being parallel. When securing leads, care shall be taken to avoid pinching the leads. The mounting fixture shall be so constructed as to preclude any resonances within the test range. An examination of the mounting fixture shall be made on a vibrator. If any resonant frequencies are observed, adequate steps must be taken to damp the structure.
- b. Electrical-load conditions: During the test, a minimum test voltage of 200 V dc shall be applied between the terminals of the capacitor element under test.
- c. Test condition: D (20 g's).
- d. Duration and direction of motion: Equal amounts of time in each of three mutually perpendicular planes (total of 8 hours).
- e. Measurements during vibration: During the last cycle in each direction, an electrical measurement shall be made to determine intermittent contacts of 0.5 ms or greater duration, or open-circuiting or short-circuiting.
- f. Examination after vibration: Capacitors shall be visually examined for evidence of mechanical damage.

4.8.12 Immersion (see 3.16). Capacitors shall be tested in accordance with method 104 of MIL-STD-202. The following details shall apply:

- a. Test condition: B.
- b. Examinations and measurements after final cycle: Capacitors shall be visually examined for evidence of mechanical damage and obliteration of marking; dielectric withstanding voltage, insulation resistance, capacitance, and dissipation factor shall then be measured as specified in 4.8.5, 4.8.8, 4.8.3, and 4.8.4, respectively.

4.8.13 Shock, specified pulse (see 3.17). Capacitors shall be tested in accordance with method 213 of MIL-STD-202. The following details shall apply:

- a. Mounting: Capacitors shall be rigidly mounted by the body.
- b. Test condition: I (100 g's).
- c. Measurements during shock: During the last shock in each direction, an electrical measurement shall be made to determine intermittent contacts of 0.5 ms or greater duration, or open-circuiting or short-circuiting.
- d. Examination after shock: Capacitors shall be visually examined for evidence of breakdown, arcing, and mechanical damage.

4.8.14 Terminal strength (see 3.18). Capacitors shall be tested in accordance with method 211 of MIL-STD-202. The following details and exceptions shall apply:

- a. Test condition: A.
- b. Applied force: 5 pounds (2.3 kg).
- c. Examination after test: Capacitors shall be visually examined for evidence of loosening or rupturing of the terminals.

4.8.15 Moisture resistance (see 3.19). Capacitors shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

- a. Initial measurements: Not applicable.
- b. Number of cycles: Twenty continuous cycles.
- c. Step 7b: Not applicable.
- d. Loading: During the first 10 cycles only, a dc potential of 100 volts shall be applied across the capacitor terminals. Once each day, a check shall be performed to determine whether a capacitor has shorted.
- e. Examinations and final measurement: On completion of step 6 of the final cycle, capacitors shall be conditioned at $+25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and a relative humidity of 50 percent ± 5 percent for a period of 18 hours minimum, 24 hours maximum, and shall be visually examined for evidence of mechanical damage and obliteration of marking; capacitance, dielectric withstanding voltage, and insulation resistance shall then be measured as specified in 4.8.3, 4.8.5, and 4.8.8, respectively.

4.8.16 Fungus (see 3.20). Capacitors shall be tested in accordance with method 508 of MIL-STD-810.

4.8.17 Resistance to solvents (see 3.21). Capacitors shall be tested in accordance with method 215 of MIL-STD-202. The following details shall apply:

- a. The marked portion of the capacitor body shall be brushed.
- b. Capacitors shall be visually examined for evidence of mechanical damage and obliteration of marking.

4.8.18 Life (at elevated ambient temperature) (see 3.22). Capacitors shall be tested in accordance with method 108 of MIL-STD-202. The following details and exceptions shall apply:

- a. Distance of temperature measurements from specimens in inches: Not applicable.
- b. Test temperature and tolerance: +125°C, +4°C, -0°C.
- c. Operating conditions: Capacitors shall be subjected to the rated voltage, ±5 percent. The test voltage shall be raised from zero to the rated value, ±5 percent, within 1 minute maximum. Test circuitry shall be the same as that required for voltage conditioning (see 4.8.2.2).
- d. Test condition: 2,000 hours elapsed time for qualification inspection with all samples continued to 10,000 hours; 10,000 hours for FRL inspection of group B.
- e. Measurements during and after exposure: Insulation resistance shall be measured during exposure by the method specified in 4.8.2.2. Measurements shall be taken at: 0 hours; 250 hours +48 hours, -0 hours; 1,000 hours +48 hours, -0 hours; 2,000 hours +96 hours, -0 hours; and every 2,000 hours +96 hours, -0 hours thereafter until the required 10,000 hours have elapsed.

After exposure, the insulation resistance, capacitance, and dissipation factor shall be measured as specified in 4.8.8, 4.8.3, and 4.8.4, respectively.

4.8.19 Low temperature storage (see 3.23). Capacitors shall be subjected to exposure at -65°C +0°C, -3°C for a period of 8 hours, minimum.

4.8.20 Radiographic inspection (see 3.24). Capacitors shall be tested in accordance with method 209 of MIL-STD-202. The following details and exception shall apply:

- a. Radiographic quality: The radiograph shall render a clear, sharp image of the penetrameter.
- b. Image-quality indicator: A radiograph of the penetrameter shall be included on each radiograph film. The penetrameter may be made from a sample capacitor, of the same style as the capacitor being radiographed, with an AWG number 48 copper wire mounted across the capacitor body or it may be fabricated in accordance with or be equivalent to the example on figure 3.
- c. Positions of specimen: Unless otherwise specified (see 6.2), one view shall be taken of each capacitor perpendicular to the plane of the lead surface (see figure 4).

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 3.24.

e. Additional required examination:

- (1) There shall be a minimum of 80 percent solder fillet between capacitor element and each lead.
- (2) There shall be a minimum of .005 inch (0.13 mm) encapsulating material encasing the capacitor element (see figure 5).
- (3) There shall be a minimum of .005 inch (0.13 mm) between edge of case and tip of solder spike.
- (4) Extraneous particles or voids in encapsulating material shall not be greater than .005 inch (0.13 mm) in any dimension.

NOTE: Test results (covering the number of capacitors tested with number and kinds of failure noted) and radiograph shall be retained for a minimum period of 2 years. On request of user, this data shall be supplied with each shipment.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When actual packaging of materiel is to be performed by DoD personnel, these personnel need to contact the responsible packaging activity to ascertain requisite packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Department or Defense Agency, or within the Military Department's System Command. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

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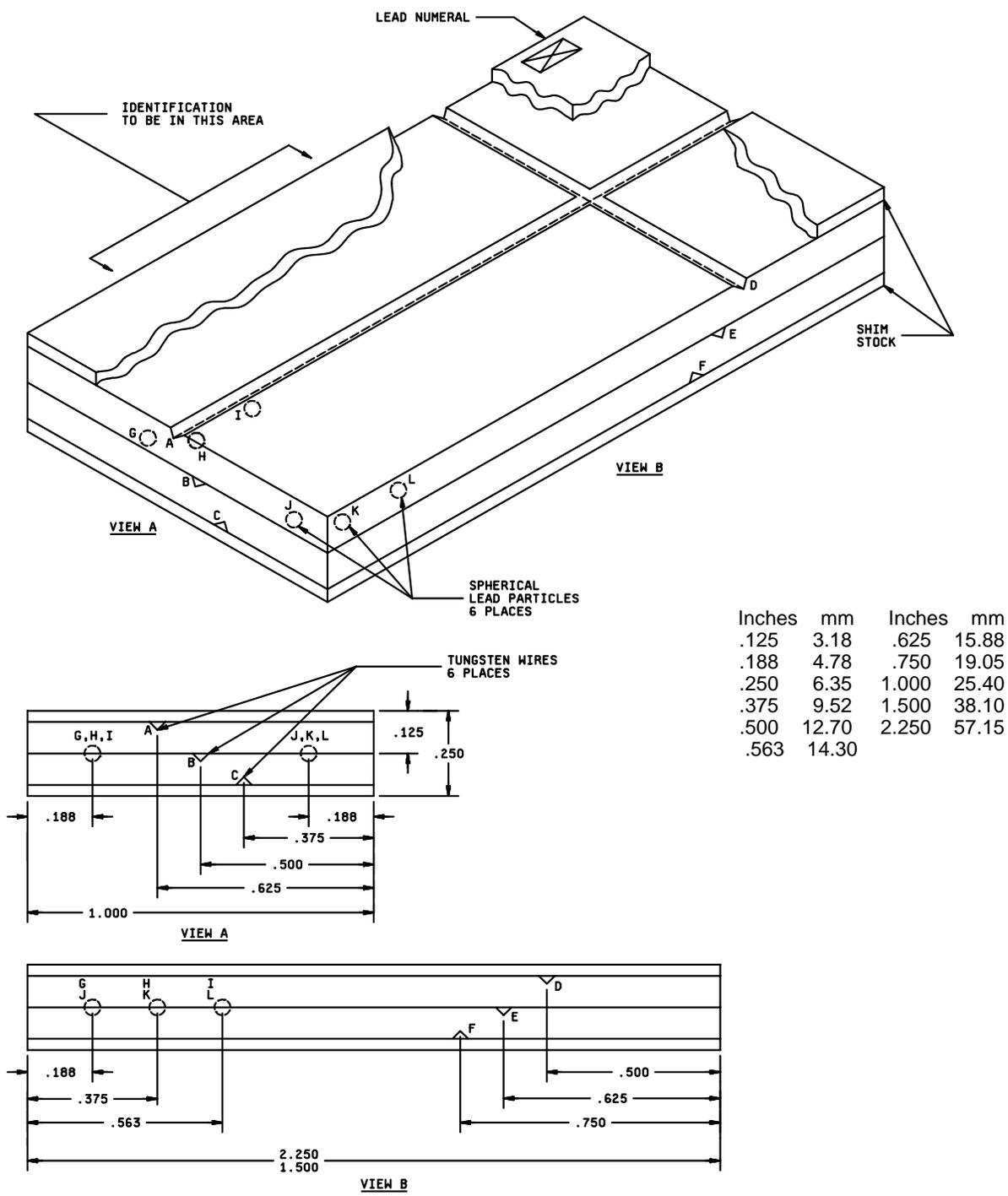


FIGURE 3. Image quality indicator (optional).

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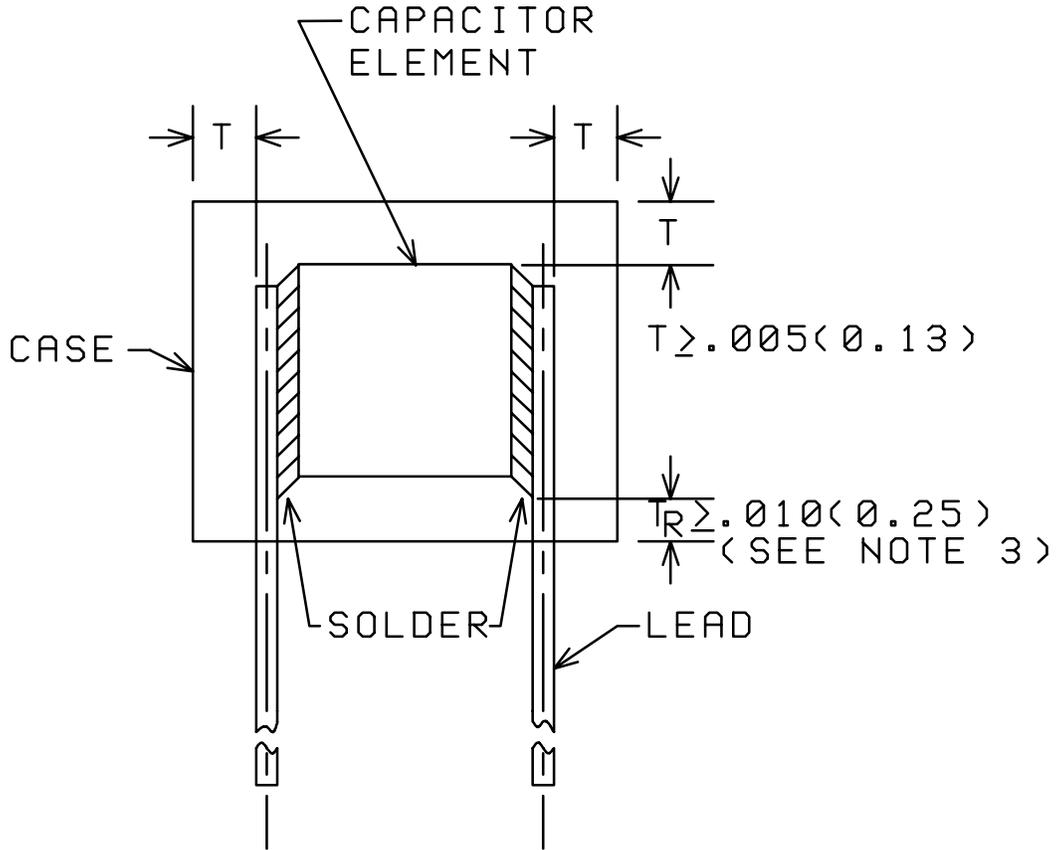
Table of image quality indicators

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)	.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)	.002 (0.05)
.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)	.005 (0.13)
.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)	.007 (0.18)
.003 (0.08)	.002 (0.05)	.001 (0.03)	.001 (0.03)	.002 (0.05)	.003 (0.08)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.010 (0.25)
.003 (0.08)	.002 (0.05)	.001 (0.03)	.001 (0.03)	.002 (0.05)	.003 (0.08)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.015 (0.38)
.005 (0.13)	.003 (0.08)	.002 (0.05)	.002 (0.05)	.003 (0.08)	.005 (0.13)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.025 (0.64)
.005 (0.13)	.003 (0.08)	.002 (0.05)	.002 (0.05)	.003 (0.08)	.005 (0.13)	.015 (0.38)	.010 (0.25)	.008 (0.20)	.006 (0.15)	.004 (0.10)	.002 (0.05)	.035 (0.89)

NOTES:

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

FIGURE 3. Image quality indicator (optional) - Continued.



NOTES:

1. Dimensions are in inches.
2. Metric equivalents are in parentheses and are given for information only.
3. T_R is measured to the point at which the lead diameters are increased above their nominal dimension by the solder meniscus.

FIGURE 4. Radiographic inspection criteria.

6. NOTES

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

6.1 Intended use. These capacitors are primarily designed for use where a small physical size with comparatively large electrical capacitance and high insulation resistance is required. General purpose (BR and BZ characteristics) ceramic capacitors are not intended for frequency-determining or precision circuits but are suitable for use as by-pass, filter, and noncritical coupling elements in high-frequency circuits. All of these applications are of the type where dissipation factor is not critical, and moderate changes due to temperature, voltage, and frequency variations do not effect the proper functioning of the circuit. BP characteristic ceramic capacitors are for use in critical frequency determining applications, timing circuits, and other applications where absolute stability is required.

6.1.1 Case insulation. It is not intended that the case insulation be subjected to sustained voltage in excess of 500 volts. Supplementary insulation should be provided where the case may come in contact with higher voltage or a ground.

6.2 Acquisition requirements. Acquisition documents must specify the following:

- a. Title, number, and date of this specification.
- b. Issue of DoDISS to be cited in the solicitation and if required, the specific issue of individual documents referenced (see 2.2.1).
- c. Required number of views and planes for radiographic inspection, if other than that specified (see 4.8.20c).
- d. If remarking of parts is required to indicate FRL, capacitance tolerance, or voltage (see 3.25.5 and 3.25.6).
- e. Packaging requirements.

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in the Qualified Products List, whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the QPL list is the US Army Communications-Electronics Command and Fort Monmouth, ATTN: AMSEL-LC-LEO-E-EP, Fort Monmouth, NJ 07703-5023; however, information pertaining to qualification of products may be obtained from the Defense Supply Center Columbus (DSCC-VQ), 3990 East Broad Street, Columbus, OH 43216-5000. Application for qualification tests shall be made in accordance with SD-6, "Provisions Governing Qualification", copies of which may be obtained on application to the Defense Printing Service Detachment Office, Building 4D, Customer Service, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

6.4 Application caution. Additional encapsulation is necessary in applications where the possibility of a voltage breakdown between leads of the capacitor, or the capacitor to another potential, could occur.

6.4.1 Soldering installation or removal. Heat sinks on each lead or adequate preheating is required when these capacitors are installed in or removed from circuits by soldering iron.

6.5 Tin plated finishes. Tin plating is prohibited (see 3.5.1.2) because it may result in tin whisker growth. Tin whisker growth could adversely affect the operation of electronic equipment systems. For additional information, see ASTM B545, "Standard Specification for Electrodeposited Coatings of Tin".

6.6 Subject term (key word) listing.

Statistical process control (SPC)

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

APPENDIX A

PROCEDURE FOR QUALIFICATION INSPECTION

A.1 SCOPE

A.1.1 This appendix details the procedure for submission of samples, with related data, for qualification inspection of capacitors covered by this specification. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance. The procedure for extending qualification of the required sample to other capacitors covered by this specification is also outlined herein.

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

A.3 SUBMISSION

A.3.1 Sample.

A.3.1.1 Single-style submission. A sample of the size required in the qualification inspection table, of the highest capacitance value in each voltage rating in each operating temperature range and voltage-temperature limit in each style for which qualification is sought shall be submitted. After qualification has been granted, no changes shall be made in materials or interface requirements without the prior notification of the qualifying activity.

A.3.2 Test data. When examinations and tests are to be performed at a Government laboratory, prior to submission, all sample units shall be subjected to all of the examinations and tests indicated as nondestructive in table V. Each submission shall be accompanied by the test data obtained from these examinations and tests. The performance of the destructive tests by the contractor on a duplicate set of sample units is encouraged, although not required. All test data shall be submitted in duplicate.

A.4 EXTENT OF QUALIFICATION

A.4.1 Single-style submission. Capacitance-range qualification will be restricted to values equal to and less than the capacitance value submitted. Capacitance-tolerance qualification will be restricted to tolerances equal to and wider than the tolerance submitted. DC rated voltage qualification will be restricted to that submitted. Operating temperature range and voltage-temperature limit qualification will be restricted to that submitted. Qualification shall be performed only on units specifically designed to this specification. Approval shall not be allowed by similarity to low voltage units. The BZ characteristic parts shall qualify the BR characteristic parts if the partial discharge and voltage-temperature limits tests are performed on the highest capacitance BR characteristic parts in each voltage rating.

A.4.2 Extension of qualification to other specification sheets. Extension of qualification from some specification sheets to other specification sheets is permitted as specified in table X. This provision for extension of qualification is restricted to parts with the same temperature characteristic from which qualification is extended.

TABLE X. Extension of qualification to specification sheets.

Qualification to specification sheets	Will qualify
/5 and /3	/4
/3 and /7	/1 and /2
/3, /5, and /7	/1, /2, and /4

APPENDIX B

AC PARTIAL DISCHARGE (CORONA) TEST

B.1 SCOPE

B.1.1 Scope. This appendix details the detection and measurement of partial discharge (corona) under ac applied voltage as required in 3.10 and 4.8.6. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

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

B.3 REQUIREMENTS AND DEFINITIONS

B.3.1 Supply voltage. The supply voltage for ac partial discharge tests shall be variable ac voltage at a frequency of 60 Hz ± 5 percent and shall be measured in ac volts rms with a tolerance of ± 5 percent of the ac test voltage.

B.3.2 Sensitivity. The partial discharge detection system's sensitivity depends on the capacitance of the test specimen. The test specimen shall be connected during system calibration and the sensitivity requirements shall be:

- a. For capacitances of less than or equal to 0.005 μF , system sensitivity shall be able to detect 5 pC or less;
- b. For capacitances above 0.005 μF to and including 0.1 μF , system sensitivity shall be able to detect 15 pC or less;
- c. For capacitances above 0.1 μF to and including 0.47 μF , the sensitivity shall be 50 pC or less.

B.3.3 Corona inception voltage (CIV). CIV at a given pC level shall be defined as the voltage at which continuous partial discharges can be recorded at that pC level. This is above the minimum sensitivity, as the applied voltage is increased at a constant rate.

B.4 TEST CONDITIONS AND PROCEDURE

B.4.1 Connection. The capacitor under test shall be connected between the high voltage terminal and ground of the detection system with insulated, corona-free cables. The capacitor, its leads, and bare metal connecting clips shall be immersed in FC-40 or FC-43 dielectric fluid (fluorinert) or equivalent.

B.4.2 System calibration. The system shall then be calibrated in accordance with the requirements of B.3.2.

B.4.3 Application of voltage. The applied voltage shall then be increased at a constant rate of approximately 0.2 kV rms/second. The maximum test voltage shall not be more than 42 percent of dc rated voltage.

B.4.4 Measurement. The maximum voltage specified in B.4.3 shall be maintained from 1 seconds to 5 seconds. If the maximum corona pulse exceeds 100 pC amplitude in this time period, the component shall be considered to be a failure. The voltage shall then be decreased to 0 volts.

MIL-PRF-49467A

Custodians:

Army - CR
Navy - EC
Air Force - 85
NASA - NA

Review activities:

Army - AT, AV, ME, MI
Navy - MC
Air Force - 19, 99
DLA - CC

Preparing activity:
Army - CR

Agent:
DLA - CC

(Project 5910-1867)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

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

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

I RECOMMEND A CHANGE:

1. DOCUMENT NUMBER
MIL-PRF-49467A

2. DOCUMENT DATE (YYMMDD)
970519

3. DOCUMENT TITLE CAPACITOR, FIXED, CERAMIC, MULTILAYER, HIGH VOLTAGE (GENERAL PURPOSE), ESTABLISHED RELIABILITY

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)

b. ORGANIZATION

c. ADDRESS (Include Zip Code)

d. TELEPHONE (Include Area Code)
(1) Commercial
(2) AUTOVON
(if applicable)

7. DATE SUBMITTED
(YYMMDD)

8. PREPARING ACTIVITY

a. NAME

COMMUNICATIONS ELECTRONICS COMMAND

b. TELEPHONE (Include Area Code)

(1) Commercial (2) AUTOVON
(908) 427-3148 987-3148

c. ADDRESS (Include Zip Code)

ATTN: AMSEL-LC-LEO-E-EP
FORT MONMOUTH, NJ 07703-5000

IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:

DEFENSE QUALITY AND STANDARDIZATION OFFICE
5203 Leesburg Pike, Suite 1403, Falls Church, VA 22401-3466
Telephone (703) 756-2340 AUTOVON 289-2340