INCH-POUND
MIL-PRF-87164A
24 May 1999
SUPERSEDING
MIL-C-87164 (USAF)
22 November 1982

PERFORMANCE SPECIFICATION

CAPACITORS, FIXED, MICA DIELECTRIC, HIGH 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 high reliability, mica dielectric, fixed capacitors for space, missile, and other high reliability applications. Capacitors covered by this specification may be used in critical applications where the utmost in stability and dependability is required and where variations in capacitance with respect to temperature, voltage, frequency, and life cannot be tolerated (see 6.1). An acceleration factor of 25:1 has been used to relate life test data obtained at 150 percent of rated voltage at rated temperature to rated voltage at rated temperature.

1.2 Classification.

1.2.1 Part or Identifying Number (PIN). The capacitors specified herein (see 3.1) are identified by a PIN which consists of the basic number of the specification sheet followed by a series of coded characters. Each specification sheet covers a different capacitor style. The coded number provides information concerning the capacitor's characteristic, working voltage, capacitance value, and capacitance tolerance. The PIN is in the following format::

M87164	A	01	C	D	1R0	D
Performance specification number	Modification (see 1.2.1.1)	Slash sheet number	Characteristic (see 1.2.1.2)	Voltage (see 1.2.1.3)	Capacitance value (see 1.2.1.4)	Capacitance tolerance (see 1.2.1.5)

1.2.1.1 Modification. The modification letter is used to indicate the latest characteristic of the part in the specification sheet. This letter is changed under direction of the preparing activity.

1.2.1.2 Characteristic. The characteristic is identified by a single letter which indicates the relative stability of the capacitor with temperature change, in accordance with table I.

TABLE I. Characteristic.

Symbol	Temperature coefficient (Parts/million/°C (ppm/°C))	Capacitance drift
C	-200 to +200	±(0.5 percent +0.1 pF)
E	-20 to +100	±(0.1 percent +0.1 pF)
F	0 to +70	±(0.05 percent +0.1 pF)

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Defense Supply Center, Columbus, ATTN: DSCC/VAM, 3990 East Broad Street, Columbus, OH 43213-1199, by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC N/A FSC 5910

1.2.1.3 Voltage. The rated voltage for continuous operation at +125°C is identified by a single letter as shown in table II.

TABLE II. Rated voltage.

Symbol	Rated voltage (Volts, dc)
A	100
C	300
D	500

1.2.1.4 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. When the nominal value is less than 10 pF, the letter "R" shall be used to indicate the decimal point and the succeeding digit shall represent a significant figure. For example, 1R0 indicates 1.0 pF.

1.2.1.5 Capacitance tolerance. The capacitance tolerance is identified by a single letter in accordance with table III.

TABLE III. Capacitance tolerance.

Symbol	Capacitance tolerance
D	±0.5 pF
F	±1 percent
G	±2 percent
J	±5 percent

2. APPLICABLE DOCUMENTS

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

2.2 Government documents.

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

SPECIFICATIONS

DEPARTMENT OF DEFENSE

MIL-PRF-39001/5	-	Capacitors, Fixed, Mica Dielectric, Established Reliability; Styles CMR03, CMR04, CMR05, CMR06, CMR07, and CMR08.
MIL-PRF-87164/1	-	Capacitors, Fixed MICA Dielectric, High Reliability, Style CMS04.
MIL-PRF-87164/2	-	Capacitors, Fixed MICA Dielectric, High Reliability, Style CMS05.
MIL-PRF-87164/3	-	Capacitors, Fixed MICA Dielectric, High Reliability, Style CMS06.
MIL-PRF-87164/4	-	Capacitors, Fixed MICA Dielectric, High Reliability, Style CMS07.
MIL-PRF-87164/5	-	Capacitors, Fixed MICA Dielectric, High Reliability, Style CMS03.

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-202	-	Test Methods Standard Electronics and Electrical Component Parts.
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-1285	-	Marking of Electrical and Electronic Parts.

(Unless otherwise indicated, copies of the above specifications, standards, and handbooks are available from the Defense Automated Printing Service, Building 4D (DPM-DODSSP), 700 Robbins Avenue, Philadelphia, PA 19111-5094.)

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. The capacitors furnished under this specification shall be products which are qualified for listing on the applicable QPL at the time set for opening of bids. Distributors shall not be used (see 4.4 and 6.3).

3.3 QPL system. The manufacturer shall establish and maintain a QPL system for parts covered by this specification. Requirements for this system are specified in MIL-STD-790 and herein. As part of the MIL-STD-790 QPL system, the manufacturer shall establish and document a system which would include the following:

a. Traceability of materials
b. Capacitor design requirements
c. Silver to mica attachment
d. Assembly
e. Termination and connections
f. Encapsulation
g. Curing
h. Solder formulation
i. Visual inspection criteria.

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

3.4.1 Terminal leads. Lead shall be solderable and meet the solderability requirements of 3.12.

3.5 Interface and physical dimensions. The capacitors shall be of the interface and physical dimensions specified (see 3.1).

3.5.1 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 three percent (see 6.4).

3.5.2 Connections. All electrodes (foils, clips, and leads) used as terminations for the silvered mica conductor must be mechanically and electrically bonded together. Foils (and solder if used) must have a minimum melting point of 260°C. Solder, if used, for bonding the lead wires to the clips shall have a minimum melting point of 182°C and will be of the same alloy as the tin-lead coating on the lead wire.

3.6 Dielectric withstanding voltage. The capacitors shall withstand the direct current (dc) potential specified in 4.7.2 without damage, arcing, or breakdown.

3.7 Barometric pressure. The capacitors shall withstand the dc potential specified in 4.7.3 without damage, arcing, or breakdown.

3.8 Insulation resistance.

3.8.1 At room ambient temperature. When measured as specified in 4.7.4.1, the insulation resistance shall be not less than the applicable value specified on figure 1.

3.8.2 At high ambient temperature. When measured as specified in 4.7.4.2, the insulation resistance shall be not less than the applicable value specified on figure 1.

3.9 Capacitance. When measured as specified in 4.7.5, the capacitance shall be within the tolerance designated by the PIN (see 3.1).

3.10 Dissipation factor. When measured as specified in 4.7.6, the dissipation factor shall not exceed the applicable value shown on figure 2.

3.11 High voltage stabilization. When the capacitors are tested as specified in 4.7.7, there shall be no evidence of damage, arcing, or breakdown; and the insulation resistance shall be not less than the applicable value specified on figure 1.

3.12 Solderability. When the capacitors are tested as specified in 4.7.8, the dipped surface of the lead shall be at least 95 percent covered with continuous new solder coating. The remaining 5 percent of the lead surface shall show only small pinholes or voids. These shall not be concentrated in one area. No individual view of the dipped surface shall show less than 95 percent coverage. Bare base metal and areas where the solder dip failed to cover the original coating are indications of poor solderability, and shall be cause for failure. In case of dispute, the percent of coverage with pinholes or voids shall be determined by actual measurement of these areas, as compared to the total area.

3.13 Vibration, high frequency. When the capacitors are tested as specified in 4.7.9, there shall be no intermittent contacts of 0.5 milliseconds (ms) or greater duration, or momentary arcing, or other indication of breakdown, nor shall there be any open-circuiting or short-circuiting or evidence of mechanical damage.

3.14 Temperature coefficient and capacitance drift. When measured as specified in 4.7.10, the temperature coefficient and capacitance drift shall be within the limits specified in table I for the characteristic listed (see 3.1).

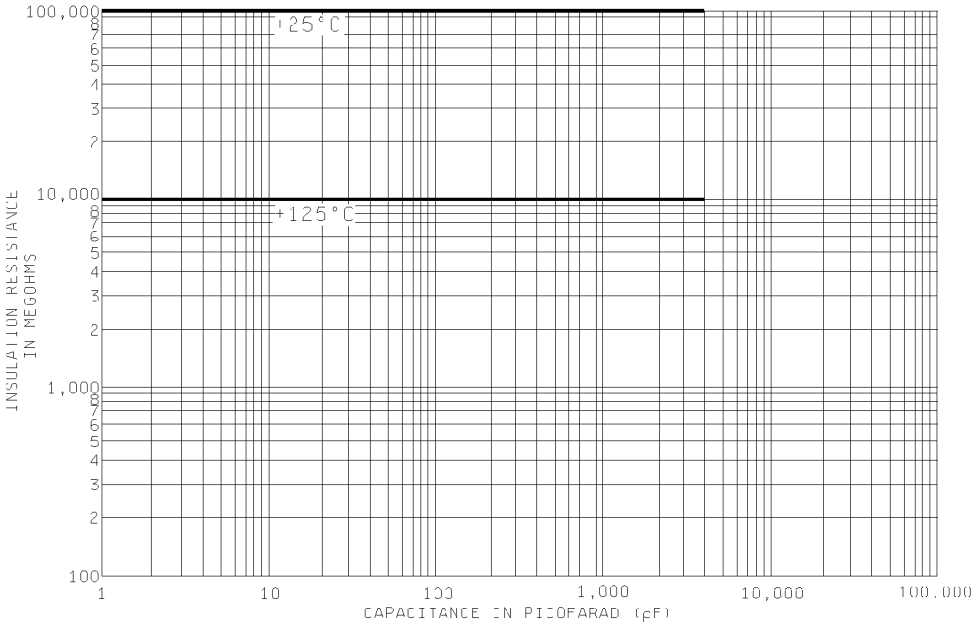

FIGURE 1. Insulation resistance versus capacitance at test temperatures.

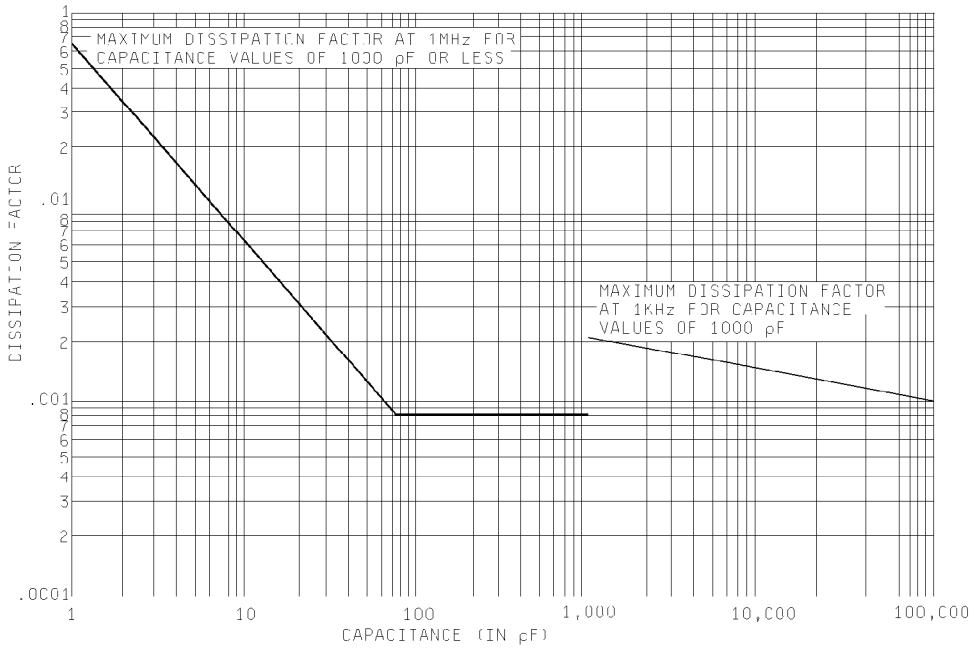

FIGURE 2. Capacitance versus dissipation factor.

3.15 Thermal shock and immersion. When tested as specified in 4.7.11, the capacitors shall meet the following requirements:

Dielectric withstanding voltage:	As specified in 3.6.
Insulation resistance:	Shall be not less than 30 percent of initial requirement (see 3.8).
Capacitance:	The capacitance change shall not exceed 1 percent or 1 pF, whichever is greater, from the reference measurement (see 4.3.2.1).
Dissipation factor:	Shall not exceed 150 percent of the initial requirement specified in 3.10.
Visual examination:	No visible evidence of deterioration, permanent damage to leads or case, nor corrosion on leads.

3.16 Shock, specified pulse. When the capacitors are tested as specified in 4.7.12, there shall be no intermittent contacts of 0.5 ms or greater duration, or momentary arcing, or other indication of breakdown, nor shall there be any open-circuiting or short-circuiting or evidence of mechanical damage.

3.17 Terminal strength. When the capacitors are tested as specified in 4.7.13, the terminals shall not loosen or rupture and no other damage shall result. Chipping of the resinous coating on the leads, in the "R" dimension area only (see 3.1), shall not be considered as a failure.

3.18 Moisture resistance. When tested as specified in 4.7.14, capacitors shall meet the following requirements:

Dielectric withstanding voltage:	As specified in 3.6.
Insulation resistance:	Shall be not less than 25 percent of initial requirement (see 3.8).
Capacitance:	The capacitance change shall not exceed 1 percent or 1 pF, whichever is greater, from the reference measurement (see 4.7.2.1).
Dissipation factor:	Shall not exceed 150 percent of the initial requirement specified in 3.10.
Visual examination:	No visible evidence of deterioration, permanent damage to leads or case, nor corrosion on leads.

3.19 Life. When tested as specified in 4.7.15, capacitors shall meet the following requirements:

Dielectric withstanding voltage:	As specified in 3.6.
Insulation resistance:	Shall be not less than the applicable value specified on figure 1.
Capacitance:	The capacitance change shall not exceed ±1 percent or ±1 pF, whichever is greater, from the initial measurement.
Dissipation factor:	Shall not exceed 150 percent of the initial requirement specified in 3.10.
Visual examination:	No visible evidence of deterioration, permanent damage to leads or case, arcing, or breakdown.

3.20 Fungus. The manufacturer shall certify that all external materials are fungus resistant or shall perform the test specified in 4.7.16. When the capacitors are tested as specified in 4.7.16, examination shall disclose no evidence of fungus growth on the external surface of the capacitor.

3.21 Resistance to solvents. When the capacitors are tested as specified in 4.7.17, marking shall remain legible and shall not smear or rub off. In addition, there shall be no visible indication of damage or deterioration to the capacitor body.

3.22 Resistance to soldering heat. When tested as specified in 4.7.18, capacitors shall meet the following requirements:

Insulation resistance:	Shall be not less than the initial requirement (see 3.8).
Capacitance:	The capacitance change shall not exceed ±5 percent or ±5 pF, whichever is greater, from the initial measurement.
Dissipation factor:	Shall not exceed the initial requirement.

3.23 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

3.24 Marking. Marking of capacitors shall conform to method I of MIL-STD-1285, and unless otherwise specified (see 3.1), shall include the type designation, "JAN" brand, trademark, source code, date code (inspection lot of 4.6.1), rated voltage, capacitance tolerance, and highest rated temperature. Capacitors shall be marked as specified (see 3.1).

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

4. VERIFICATION

4.1 QPL system. The manufacturer shall establish and maintain a QPL system as described in 3.3. Evidence of such compliance is a prerequisite for qualification and retention of qualification.

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

a. Qualification inspection (see 4.4).

b. Verification of qualification (see 4.5).

c. In-process inspection and 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" section of MIL-STD-202.

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°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 applicable applied test voltage. The power supply used for dc leakage current measurements shall be stabilized to at least ±100 ppm. No voltage fluctuations shall occur during measurements that would produce a variation in the current measurement.

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. The decision as to whether or not the product will be included in the QPL will be made after successful completion of the 2,000-hour life test.

4.4.1 Sample size. The number of sample units comprising a sample of the capacitors to be submitted for qualification inspection shall be as specified in table IV, or in appendix A to this specification. The sample shall be taken from a production run and shall be produced with equipment and procedures normally used in production. Each capacitor style shall be qualified separately.

4.4.2 Test routine. Sample units shall be subjected to the qualification inspection specified in table IV, in the order shown. All sample units shall be subjected to the group I and group II tests. These sample units shall then be divided as shown in table IV for group III to group VI inclusive, and subjected to the tests for that particular group.

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

4.4.4 Qualification. A manufacturer shall be considered qualified for the CMS03, CMS04, CMS05, CMS06, and CMS07 if they are presently qualified to the R failure level of MIL-PRF-39001/5 for the CMR04, CMR05, and CMR06 and meets the following conditions:

a. Passes the qualifying activity audit for CMS style capacitors.

b. Successfully completes group C inspection (table VIII) for the lowest (lowest value need not be less than 47 pF) and highest capacitance values for each different style manufactured.

TABLE IV. Qualification inspection.

Inspection	Requirement Paragraph	Method paragraph	Number of sample units to be inspected	Number of defectives allowed 1/
Group I 2/				
Dielectric withstanding voltage	3.6	4.7.2	125	0
High voltage stabilization	3.11	4.7.7		
Group II 2/				
Visual and mechanical examination 3/	3.1, 3.4 to 3.5.2 inclusive, 3.24 to 3.25 inclusive	4.7.1	125 4/	0
Barometric pressure	3.7	4.7.3		
Insulation resistance	3.8	4.7.4		
Capacitance	3.9	4.7.5		
Dissipation factor	3.10	4.7.6		
Group III				
Solderability	3.12	4.7.8	18	1
Vibration, high frequency	3.13	4.7.9		
Temperature coefficient and capacitance drift	3.14	4.7.10		
Thermal shock and immersion	3.15	4.7.11		
Group IV				
Shock, specified pulse	3.16	4.7.12	18	1
Terminal strength	3.17	4.7.13		
Moisture resistance	3.18	4.7.14		
Group V				
Life (accelerated conditions)	3.19	4.7.15.1	79	1
Group VI				
Fungus 5/	3.20	4.7.16	5	0
Resistance to solvents	3.21	4.7.17	5	
Resistance to soldering heat	3.22	4.7.18		

1/ A sample unit having one or more defects shall be considered as a single defective.
2/ Nondestructive tests.
3/ Marking defects are based on visual examination only and shall be charged only for illegible, incomplete, or incorrect marking.
4/ Sample units shall be those that have passed group I inspection.
5/ Certification of fungus resistance may be substituted for testing.

4.5 Verification of qualification. To retain qualification, every 12 months the manufacturer shall provide verification of qualification to the qualifying activity. Continued qualification is based on meeting the following:

a. MIL-STD-790 program.

b. The capacitor design has not been modified.

c. Lot rejection for group A, subgroup1, inspection does not exceed 5 percent.

d. The requirements for group C inspections are met.

In the event that there is no production of a single style device during a reporting period and the manufacturer is listed for more than one style on the QPL, the manufacturer shall certify that they retain the capabilities and facilities necessary to produce that product. If during two consecutive reporting periods there has been no production of a given style, the manufacturer may be required, at the discretion of the qualifying activity, to submit a representative product of that style to testing.

4.6 In-process inspection and conformance inspection.

4.6.1 Inspection lot. An inspection/production lot shall consist of all the capacitors of a single nominal capacitance/voltage rating of one design, and processed as a single lot continuously through all manufacturing steps on the same equipment, and identified with the same date and lot code designation. The lot may contain all available capacitance tolerances for the nominal capacitance value as well as adjacent values. In addition, the lot shall conform to the following:

a. Materials such as silver, foil, terminations, solder, lead material, etc., shall be uniform in quality and from a single supplier.

b. The lot code number shall be assigned at or before assembly.

c. Traceability to the operator and the date each operation was performed shall be maintained.

d. Lot identity shall be maintained from the time the lot is assembled to the time it is accepted.

e. The tests of solderability and resistance to solvents shall be made on each production lot according to table VII.

4.6.2 In-process inspection. As part of the MIL-STD-790 QPL system, the manufacturer shall establish and document a 100 percent inspection procedure for the following:

a. Silvered mica visual inspection (4X minimum magnification) prior to assembly.

b. Pre-encapsulation inspection (4X minimum magnification) which shall include lead attachment and general workmanship.

4.6.2.1 Rework. Rework is not allowed on any operation except for marking and lead rework unless approved by the qualifying activity.

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

4.6.3.1 Group A inspection.

4.6.3.1.1 Subgroup 1. Subgroup 1 tests of Table V shall be performed on 100 percent of the product supplied under this specification. Failure to meet a 5 percent defective allowable (PDA) shall be cause for lot rejection and the lot shall not be resubmitted.

4.6.3.1.2 Subgroup 2. Subgroup 2 tests of Table V shall be performed on a sample selected in accordance with table VI based on the size of the lot. In the event of one or more failures, the lot shall be rejected and not supplied to this specification. The manufacturer has the option of 100 percent screening the lot for the quality characteristic found defective in the sample and any defective unit removed. A new sample of parts shall then be randomly selected in accordance with 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.

4.6.3.1.3 Subgroup 4 and subgroup 5. The number of sample units required by table V shall be performed on sample units from lots that have been subjected to and have passed subgroup 1 and subgroup 2 tests.

TABLE V. Group A inspection.

Inspection	Requirement Paragraph	Method Paragraph	Sampling Procedure
Subgroup 1			
Thermal shock and immersion	3.15	4.7.11.1	
High voltage stabilization	3.11	4.7.7	
Dielectric withstanding voltage	3.6	4.7.2	100 percent 2/ 3/
Insulation resistance (+25°C)	3.8.1	4.7.4.1	
Capacitance 1/	3.9	4.7.5	
Dissipation factor	3.10	4.7.6	
Subgroup 2			
Visual and mechanical examination	3.1, 3.4 to 3.5.2 incl 3.24 to 3.25 incl	4.7.1	see table VI
Subgroup 3			
Insulation resistance at +25°C and +125°C	3.8	4.7.4	20 samples 0 failures
Moisture resistance	3.18	4.7.14	20 samples 1 failure
Subgroup 4			
Life test (250 hours accelerated)	3.19	4.7.15.2.1	20 samples 0 failures
Subgroup 5 4/			
Resistance to solvents	3.21	4.7.17	5 samples 0 failures
Solderability 5/	3.12	4.7.8	10 samples 1 failure

1/ Capacitance values outside the initial limits by 1 percent or 1 pF, whichever is greater, shall be used for PDA lot rejection.
2/ Dissipation factor greater than 130 percent of the initial limit shall be used for PDA lot rejection.
3/ All capacitors delivered to this specification shall meet the nominal requirements.
4/ The same samples can be used for resistance to solvents and solderability.
5/ 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.

TABLE VI. Sampling plans for group A subgroup 2.

Lot size	Sample size
1 - 150	13
151 - 280	20
281 - 500	29
501 - 1,200	34
1,201 - 3,200	42
3,201 - 10,000	50

4.6.4 Periodic group C inspection. Except where the results of this inspection show noncompliance with the applicable requirements, delivery of products which have passed group A inspections shall not be delayed pending the results of these periodic inspections. Group C inspection shall consist of the tests specified in table VII in the order shown. Samples having group C testing shall be selected from lots that have passed group A. Samples shall be selected periodically as described in the sampling plan paragraphs below. Group C samples and documentation shall be maintained by the manufacturer for 3 years.

4.6.4.1 Subgroup 1 and subgroup 3. Samples shall be selected every 12 months. Each two month production period shall be represented as far as practical in the sample.

4.6.4.2 Subgroup 2 and subgroup 4. Samples shall be selected every two months. Capacitance values manufactured during the period shall be represented as far as practical in the approximate ratio of production.

4.6.4.3 Subgroup 4 Failure analysis. If any of the sample units subjected to the group C life test fail, a detailed failure analysis shall be conducted to establish the cause of failure and the corrective actions. A failure is categorized as "lot oriented" if its occurrence is apparently related to an identified lot or lots. A failure is categorized as "not lot oriented" if its occurrence is random and it cannot be related to a specific lot or lots. Each failure is further identified as "screenable" or "not screenable" from the completed production items. If the failure analysis shows that the failure mechanism is "screenable", the entire failed lot may be screened and the group C life test shall be repeated. If a failure occurs during the second group C life test, the entire production lot shall be rejected. If the failure mechanism is "screenable", all prior and subsequent production lots that may contain the identified failure mechanism shall also be screened. If the failure mechanism is "lot oriented" and "not screenable", all production lots that may contain the identified failure mechanism shall be rejected unless other disposition is directed by the contracting officer.

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

4.6.4.5 Noncompliance. If a sample fails to pass group C inspection, the manufacturer shall take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, processes, etc., and which are considered subject to the same failure. Acceptance of the product shall be discontinued until corrective action, acceptable to the Government, has been taken. After the corrective action has been taken, group C inspection shall be repeated on additional sample units (all inspection, or the inspection which the original sample failed, at the option of the Government). In the event of failure after reinspection, information concerning the failure and corrective action taken shall be furnished to the cognizant inspection activity and the qualifying activity.

TABLE VII. Group C periodic inspection.

Inspection	Requirement Paragraph	Test method paragraph	Sampling Procedure
Subgroup 1 Vibration, high frequency	3.13	4.7.9	20 samples 1 failure
Subgroup 2 Temperature coefficient and capacitance drift Thermal shock (25 cycles) and immersion Terminal strength	 3.14 3.15 3.17	 4.7.10 4.7.11 4.7.13	20 samples 1 failure 1/
Subgroup 3 Shock, specified pulse	3.16	4.7.12	20 samples 1 failure
Subgroup 4 Life test (2,000 hours accelerated)	3.19	4.7.15.2.2	20 samples 0 failures 2/

1/ One failure allowed into the adjoining characteristic. If capacitance drifts more than the adjoining characteristic, the lot shall be recalled.
2/ See failure analysis.

4.7 Methods of inspection.

4.7.1 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 through 3.5.2 inclusive, and 3.24 through 3.25 inclusive).

4.7.2 Dielectric withstanding voltage (see 3.6). 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: 200 percent of rated dc voltage.

b. Duration of application of test voltage: Not less than 1 second nor more than 5 seconds. The duration of the test shall begin when 95 percent of the test potential is reached.

c. Points of application of test voltage: Between terminals.

d. Limiting value of surge current: Shall not exceed 50 milliamperes (mA) during charging and discharging.

e. Examination after test: Capacitors shall be examined for evidence of damage, arcing, and breakdown.

4.7.3 Barometric pressure (see 3.7). Capacitors shall be tested in accordance with method 104 of MIL-STD-202. The following details shall apply:

a. Method of mounting: Not applicable.

b. Test condition: D (100,000 feet).

c. Tests during subjection to reduced pressure: A test potential of 100 percent of rated dc voltage for style CMS04; 500 volts and 150 percent for all other styles and voltages shall be applied between the terminals for 60 seconds, +15 seconds, -0 seconds. Surge current shall not exceed 50 mA.

d. Examination after test: Capacitors shall be examined for evidence of damage, arcing, and breakdown.

4.7.4 Insulation resistance.

4.7.4.1 At room ambient temperature (see 3.8.1). Capacitors shall be tested in accordance with method 302 of MIL-STD-202. The following details shall apply:

a. Test condition: A. (At the option of the manufacturer, a higher voltage may be used.)

b. Points of measurement: From terminal to terminal. (Condensed moisture may be removed by a blast of air.)

c. Electrification time: Not less than 10 seconds and not more than 2 minutes.

4.7.4.2 At high ambient temperature (see 3.8.2). Capacitors shall be subjected to the high ambient temperature, 125°C, +5°C, -0°C for a period of time sufficient to reach thermal stability and shall be measured as specified in 4.7.4.1.

4.7.5 Capacitance (see 3.9). Capacitance shall be measured in accordance with method 305 of MIL-STD-202. The following details shall apply:

a. Test frequency: One megahertz (MHz) ±1,000 hertz (Hz) when the nominal capacitance is 1,000 pF or less, and 1 kilohertz (kHz) ±100 Hz when the nominal capacitance is greater than 1,000 pF. At the option of the manufacturer, capacitance measurements may be made at any frequency from 1 kHz to 1MHz and referred to measurements at 1 MHz and 1kHz, as applicable.

b. Limit of accuracy: Shall be ±0.2 percent of nominal capacitance value or ±0.2 pF, whichever is greater.

4.7.6 Dissipation factor (see 3.10). Dissipation factor shall be measured at a frequency of 1 MHz ±1,000 Hz when the nominal capacitance is 1,000 pF or less, and 1 kHz ±100 Hz when the nominal capacitance is greater than 1,000 pF. Measurement accuracy shall be within ±2 percent for dissipation factor and within ±5 Hz for frequency.

4.7.7 High voltage stabilization (see 3.11). The capacitors shall be subjected to 200 percent of rated dc voltage at a minimum temperature of 125°C for a minimum of 168 hours. During the test, the capacitors shall be adequately protected against voltage surges of 25 percent of more of test voltage and surge current shall not exceed 50 ma. Capacitors shall be examined for evidence of damage, arcing, and breakdown. If over 5 percent of the capacitors fail during this test (any part blowing a fuse or tripping the protective device shall be considered a failure), the lot shall be rejected.

4.7.8 Solderability (see 3.12). The capacitors shall be tested in accordance with method 208 of MIL-STD-202. The following details shall apply:

a. Number of terminations of each part to be tested: Two.

b. Depth of immersion in flux and solder: To a point at which exposed metal is solderable.

4.7.9 Vibration, high frequency (see 3.13). Capacitors shall be tested in accordance with method 204 of MIL-STD-202. The following details and exceptions shall apply:

a. Mounting: Capacitors shall be rigidly mounted by the body to a vibration-test apparatus.

b. Test condition: B.

c. 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.

d. Examination and measurements after test: Capacitors shall be examined for evidence of mechanical damage.

4.7.10 Temperature coefficient and capacitance drift (see 3.14).

4.7.10.1 For qualification inspection. Capacitance measurements shall be made in accordance with 4.7.5 (a frequency of 100 kHz ±10 percent may be used as an alternate) at the temperatures in table VIII, in the order listed. The measurement at each temperature shall be recorded when two successive readings taken at 5-minute intervals at that temperature indicate no change in capacitance. An accuracy of ±0.25 percent of nominal capacitance +0.05 pF shall be maintained for measurement of capacitance change.

TABLE VIII. Voltage-temperature limit cycle.

Step	Temperature °C	Step	Temperature °C
1	+25 ± 2	6	+45 ± 2
2	-55 +0, -2	7	+65 ± 2
3	-40 ± 2	8	+85 +2, -0
4	-10 ± 2	9	+125 +2, -0
5	+25 ± 2	10	+25 ± 2

4.7.10.1.1 Temperature coefficient. The temperature coefficient shall be computed as follows:

$$TC = \frac{(C_x - C_5)\,10^6}{(T_2 - T_1)\,C_5}$$

Where: TC = Temperature coefficient in ppm/°C.
C_x = Capacitance at test temperature in pF.
C_5 = Capacitance at step 5 temperature in pF.
T_1 = 25°C.
T_2 = Test temperature in degrees C.

4.7.10.1.2 Capacitance drift. Capacitance drift shall be computed by dividing the greatest single difference between any two of the three values recorded at 25°C by the step 5 value recorded at 25°C.

4.7.10.2 For conformance inspection. Capacitance measurements shall be made as specified in 4.7.10.1. except that measurements shall be made only for steps 1, 2, 5, 9 and 10.

4.7.10.3 Continuous-curve temperature coefficient. As an alternate to the measurements specified in 4.7.10.1, a continuous curve of capacitance versus temperature may be produced by subjecting the capacitors to a slowly varying temperature. The temperature shall be varied from 25°C to -55°C, to 125°C, and to 25°C. A temperature-sensing device shall be embedded in a dummy capacitor in a manner to assure accurate internal readings in the capacitor under test. The temperature shall be varied slowly enough to produce a smooth, uniform curve with no loops at -55°C or 125°C. Measurements shall be made at a frequency of 100 kHz ±10 kHz. Accuracy shall be as specified in 4.7.10.1.

4.7.11 Thermal shock and immersion (see 3.15).

4.7.11.1 Thermal shock. The capacitors shall be tested in accordance with method 107 of MIL-STD-202. The following details and exceptions shall apply:

a. Test condition: A, for group A and group A-1, for qualification and group C, except that step 3 shall be 125°C +3°C, -0°C.

b. Measurement before cycling: Capacitance.

c. Measurement after cycling: Not applicable.

4.7.11.2 Immersion. The temperature cycling shall be followed by immersion cycling in accordance with method 104 of MIL-STD-202, test condition B. The capacitors shall be visually examined for evidence of deterioration, permanent damage to leads and case, and corrosion on the leads. Dielectric withstanding voltage, insulation resistance, capacitance, and dissipation factor shall then be measured as specified in 4.7.2, 4.7.4.1, 4.7.5, and 4.7.6, respectively.

4.7.12 Shock, specified pulse (see 3.16). The capacitors shall be tested in accordance with method 213 of MIL-STD-202. The following details shall apply:

a. Mounting: The capacitors shall be rigidly mounted by the body.

b. Test condition: I (100 g's (pk), sawtooth).

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. Measurements after shock: Capacitors shall be examined for evidence of mechanical damage.

4.7.13 Terminal strength (see 3.17).

4.7.13.1 Pull test. All terminals shall be subjected for 5 seconds ±1 second, to pull of 5 pounds +2 ounces, -0 ounces in a direction perpendicular to the leads.

4.7.13.2 Twist test. The capacitors shall be tested in accordance with method 211 of MIL-STD-202, test condition D.

4.7.14 Moisture resistance (see 3.18). Capacitors shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

a. Number of cycles: The capacitors shall be subjected to twenty continuous temperature cycles.

b. Mounting: The capacitors shall be mounted by the leads in a manner that will keep the capacitor body from touching the test fixture during test or measurement.

c. Conditioning prior to test: The capacitors shall be tested as specified in 4.7.11.1.

d. Polarization: A dc potential of 100 volts shall be applied across the capacitor terminals of 50 percent of the units under test and no voltage applied to the other 50 percent.

e. Vibration: The vibration requirement of steps 7a and 7b shall not apply.

f. Final measurements: After completion of step 6 of the final cycle, the capacitors shall be maintained at 25°C ±5°C, and 50 percent ±5 percent relative humidity for a period of 4 hours to 24 hours. Insulation resistance, dielectric withstanding voltage, capacitance, and dissipation factor shall then be measured as specified in 4.7.4.1, 4.7.2, 4.7.5, and 4.7.6, respectively. The capacitors shall then be examined for evidence of deterioration, permanent damage to the leads or case, and corrosion on the leads.

4.7.15 Life. The capacitors shall be preconditioned for life test by subjecting them to a temperature of -55°C +0°C, -10°C for a minimum period of 48 hours. The capacitors shall then be subjected to the tests specified in 4.7.15.1 or 4.7.15.2, as applicable.

4.7.15.1 For qualification inspection (2,000 hour) (see 3.19). The capacitors shall be subjected to a minimum of 150 percent of rated dc voltage at 125°C ±3°C for 2,000 hours +72 hours, -0 hours. During the test, the surge current shall be limited to 50 milliamperes. At the conclusion of the test, capacitors shall be returned to the inspection conditions specified in 4.3.1, and shall be visually examined for evidence of mechanical damage; the dielectric withstanding voltage, insulation resistance, capacitance, and dissipation factor shall then be measured as specified in 4.7.2, 4.7.4, 4.7.5, and 4.7.6 respectively (see 3.19).

4.7.15.2 For conformance inspection (see 3.19).

4.7.15.2.1 250 hours (group A inspection). The capacitors shall be tested as specified in 4.7.15.1, except that the duration of the test shall be 250 hours +48 hours, -0 hours. The measurements specified in 4.7.15.1 shall be made at the conclusion of 250 hours of life test.

4.7.15.2.2 2,000 hour (group C inspection). The capacitors shall be tested as specified in 4.7.15.1. The measurements specified in 4.7.15.1 shall be made at the conclusion of 250 hours and 2,000 hours of life test.

4.7.16 Fungus (see 3.20). The capacitors shall be tested in accordance with method 508 of MIL-STD-810. Pretest and post test measurements are not required.

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

a. Portion of specimen to be brushed: That portion on which marking is present.

b. Number of specimens to be tested: As specified in table IV.

c. Permissible extent of damage: As specified in 3.21.

4.7.18 Resistance to soldering heat (see 3.22). The capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details and exceptions shall apply:

a. Depth of immersion: Within .250 inch (6.35 mm) of the case.

b. Test condition: B (260 °C ±5°C; 10 seconds ±1 second).

c. Cooling time prior to final measurement: 1 minute ±10 seconds.

d. Measurements after test: Insulation resistance, capacitance, and dissipation factor shall be measured as specified in 4.7.4, 4.7.5, and 4.7.6 respectively.

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.

6. NOTES

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

6.1 Intended use. The capacitors covered by this specification are intended for use in space, launch vehicles, or other high reliability applications. Capacitors covered by this specification are unique due to the fact that these devices must be able to operate satisfactorily in high reliability military systems under the following demanding conditions: 15 Gs of high frequency vibration, 100 Gs of shock (specified pulse), and wide temperature fluctuations. These capacitors also offer very high reliability that is verified under a qualification system. Commercial components are not designed to withstand these military environmental conditions.

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of the specification, specification sheet, and the complete PIN (see 1.2.1 and 3.1).

b. Issue of DoDISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.2).

c. Packaging requirements (see 5.1).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in the Qualified Products List whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products may be obtained from the Defense Supply Center Columbus (DSCC-VQP), 3990 East Broad Street, Columbus, OH 43213. Application for qualification tests shall be made in accordance with SD-6, "Provisions Governing Qualification", copies of which may be obtained on application to Defense Automated Printing Service, Bldg. 4D (DPM-DODSSP), 700 Robbins AVE, Philadelphia PA 19111-5094.

6.4 Tin plated finishes. Tin plating is prohibited (see 3.5.1) 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 8545, "Standard Specification for Electrodeposited Coating of Tin."

6.5 PIN. This specification requires a PIN that describes codification and/or classification and appropriate references to associated documents (see 1.2 and 3.1).

6.6 Subject term (key word) listing.

Capacitance
Dissipation factor
Insulation resistance
Thermal shock

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

PROCEDURE FOR QUALIFICATION INSPECTION

A.1 SCOPE

A.1.1 Scope. This appendix details the procedure for submission of samples for initial qualification inspection of capacitors covered by this specification. The procedure for extending qualification of the required sample to other capacitors covered by this specification is also outlined herein. There shall be no combining of styles; each shall be qualified separately. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

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

A.3 SUBMISSION

A.3.1 Qualification based upon similar established reliability (ER) style. A manufacturer shall be considered qualified for each CMS style for which they are presently qualified to the "R" FR level of a similar ER style (see table IX) and the following conditions:

a. Passes the qualifying activity audit.

b. Successfully complete group C inspection (table VII) for the lowest (lowest value need not be less than 47 pF) and highest capacitance values for each different style manufactured.

TABLE IX. Similar styles.

CMS style	Similar style
CMS03	CMR03
CMS04	CMR04
CMS05	CMR05
CMS06	CMR06
CMS07	CMR07

A.3.2 Qualification not based upon similar ER style. A sample of the size required in table IV of the highest and lowest (lowest value need not be less than 47 pF) capacitance value in each style for which qualification is sought shall be submitted.

A.4 EXTENT OF QUALIFICATION

A.4.1 Restrictions upon qualification. Capacitance-range qualification will be restricted to values equal to and less than the capacitance value submitted. Capacitance-tolerance qualification will be restricted to tolerance equal to and wider than the tolerance submitted. DC rated voltage qualification will be restricted to that submitted. Characteristic qualification will be restricted to characteristics equal to and wider than the characteristic submitted.

Custodians:
Army - CR
Navy - EC
Air Force - 19
DLA - CC

Review activities:
Air Force - 11

Preparing activity:
DLA-CC

(Project 5910-1982)

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 block1s 4, 5, 6, and 7, and send to preparing activity.

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-87164A	**2. DOCUMENT DATE** (YYMMDD)

3. DOCUMENT TITLE
CAPACITORS, FIXED, MICA DIELECTRIC, HIGH RELIABILITY, GENERAL SPECIFICATION FOR

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER		
a. NAME (Last, First, Middle initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Incl Area Code) (1) Commercial (2) DSN (If applicable)	7. DATE SUBMITTED (YYYYMMDD)

8. PREPARING ACTIVITY	
a. NAME Defense Supply Center, Columbus ATTN: VAM	b. TELEPHONE (Include Area Code) (1) Commercial (2) DSN
c. ADDRESS (Include Zip Code) 3990 East Broad Street Columbus, OH 43213-1199	**IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT:** Defense Standardization Program Office (DLSC-LM) 8725 John J. Kingman Road, Suite 2533 Fort Belvoir, Virginia 22060-6221 Telephone (703) 767-6888 DSN 427-6888