INCH-POUND

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SUPERSEDING
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MILITARY SPECIFICATION

CAPACITOR, CHIP, MULTIPLE LAYER, FIXED, UNENCAPSULATED, CERAMIC DIELECTRIC, 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 established reliability, ceramic dielectric, multiple layer, chip capacitors. Capacitors covered by this specification have failure rate levels ranging from 1.0 to 0.001 percent per 1,000 hours. These failure rate levels are established at a 90-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. An acceleration factor of 8:1 has been used to relate life test data obtained at 200 percent of rated voltage at maximum rated temperature, to rated voltage at rated temperature. A part per million (PPM) quality system is used for documenting and reporting the average outgoing quality of capacitors supplied to this specification. Statistical Process Control (SPC) techniques are required in the manufacturing process to minimize variation in production of capacitors supplied to the requirements of this specification.

1.2 Classification.

1.2.1 Part or Identifying Number (PIN). The PIN shall be in the following form, and as specified (see 3.1).

CDR01	BX	100	A	K	S	M
Style (see 1.2.1.1)	Rated temperature and voltage-temperature limits (see 1.2.1.2)	Capacitance (see 1.2.1.3)	Rated voltage (see 1.2.1.4)	Capacitance tolerance (see 1.2.1.5)	Termination finish (see 1.2.1.6)	Failure rate level (see 1.2.1.7)

1.2.1.1 Style. The style is identified by the three-letter symbol "CDR" followed by a two-digit number. The letters identify established reliability, ceramic dielectric, fixed, chip capacitors.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: U S Army Research Laboratory, Electronics and Power Sources Directorate, ATTN: AMSRL-EP-RD, Fort Monmouth, NJ 07703-5601, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of the document, or by letter.

AMSC N/A
FSC 5910

1.2.1.2 Rated temperature and voltage-temperature limits. The rated temperature and voltage-temperature limits are identified by a two-digit symbol. The first letter "B" indicates the rated temperature of -55°C to +125°C; the second letter indicates the voltage-temperature limits as shown in table I.

TABLE I. Voltage-temperature limits.

Symbol	Capacitance change with reference to +25°C	
	Steps A through D of table XIII	Steps E through G of table XIII
G	90 ±20 PPM/°C	90 ±20 PPM/°C
P 1/	0 ±30 PPM/°C	0 ±30 PPM/°C
X	+15 -15 percent	+15 -25 percent

1/ At measurement point F of table XIII, the capacitance measurement may be ± 0.1 percent or ± 0.05 pF, whichever is greater, from the + 25°C reference.

1.2.1.3 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(s) of the group shall represent significant figure(s). For example, 1R0 indicates 1.0 pF and 0R5 indicates 0.5 pF.

1.2.1.4 Rated 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	Related Voltage
A	50
B	100
K	150
C	200
D	300
E	500
F	1000
G	2000
H	3000
J	4000

1.2.1.5 Capacitance tolerance. The capacitance tolerance is identified by a single letter as shown in table III.

TABLE III. Capacitance tolerance.

Symbol 1/	Capacitance tolerance (±)
B	.10 pF
C	.25 pF
D	.50 pF
F	1 percent
G	2 percent
J	5 percent
K	10 percent
M	20 percent

1/ Symbols B, C, and D are applicable for capacitance values of less than 10 pF only. For capacitance values of .10 pF through .50 pF, the capacitance shall never be zero.

1.2.1.6 Termination finish. The termination finish is identified by a single letter as shown in table IV.

TABLE IV. Termination finish.

Symbol	Finish
M	Palladium-silver
N 1/	Silver-nickel-gold
P	Silver-copper-gold
Q	Palladium-gold
S	Solder coated, final
T	Silver
U	Base metallization-barrier metal-solder coated 2/ 3/
W 3/ 4/	Base metallization-barrier metal-tinned (tin or tin/lead alloy)
Y 4/	Base metallization-barrier metal-tin (100 percent) 3/
Z	Base metallization-barrier metal-tinned (tin/lead alloy, with a minimum of 4 percent lead) 3/

1/ See 6.4.1.
2/ Solder shall have a melting point of +200°C or less. Solder coat thickness shall be a minimum of 60 microinches.
3/ At the option of the user, U, W, Y, and Z termination finishes may be substituted for the other termination finishes. W and Y terminations finishes are not substitutable for Z termination finish.
4/ See 6.11.

1.2.1.7 Failure rate level. The failure rate level (based on life tests performed at maximum rated voltage and temperature) is identified by a single letter as shown in table V.

TABLE V. Failure rate level.

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

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents shall be 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

FEDERAL

QQ-S-571 - Solder, Electronic (96 to 485°C).

MILITARY

MIL-F-14256 - Flux, Soldering, Liquid, Paste Flux, Solder Paste and Solder-Paste flux, (For Electronic/Electrical Use) General Specification for.
MIL-C-39028 - Capacitors, Packaging of.

STANDARDS

MILITARY

MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.
MIL-STD-690 - Failure Rate Sampling Plans and Procedures.
MIL-STD-790 - Reliability Assurance Program for Electronic Parts Specifications.
MIL-STD-810 - Environmental Test Methods.

(See supplement 1 for list of specification sheets.)

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

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

ELECTRONIC INDUSTRIES ASSOCIATION (EIA)

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

(Application for copies should be addressed to the Electronic Industries Association, Engineering Department, 2001 Pennsylvania Avenue NW, Washington, DC 20006-1813.)

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

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein (except for related associated detail 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 sheets. In the event of any conflict between requirements of this specification and the specification sheet, the latter shall govern.

3.2 Qualification. Capacitors furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list (QPL) at the time of award of contract (see 4.4 and 6.3). Authorized distributors that are approved to MIL-STD-790 distributor requirements by QPL manufacturers are listed on the QPL.

3.3 Reliability and quality.

3.3.1 Reliability. Reliability of capacitors furnished under this specification shall be established and maintained in accordance with the procedures and requirements specified in MIL-STD-690 and MIL-STD-790, with details in 4.1.2, 4.4.4.1, and 4.5.

3.3.2 Quality.

3.3.2.1 Statistical process control. The contractor shall implement and use statistical process control techniques in the manufacturing process for parts covered by this specification. The SPC program shall be developed and maintained in accordance with EIA-557. The SPC program shall be documented and maintained as part of the overall reliability assurance program as specified in MIL-STD-790. Processes for application of SPC techniques should include but are not limited to the following:

a. Raw material mixing and blending.

b. Dielectric sheet manufacturing.

c. Stacking and electrode printing.

d. Laminating and dicing.

e. Chip firing.

f. Termination.

g. Packaging.

In addition, the manufacturer shall demonstrate control of the voltage-temperature limits of capacitance in the process.

3.3.2.2 Quality levels. The quality of lots that have been subjected to and have passed the subgroup 1, 100 percent screening inspections of the group A inspection shall be established and maintained in accordance with 4.6.1.2.2 and EIA-554, method B. Individual PPM defect levels (i.e., PPM-2 and PPM-3) and an overall PPM defect level (i.e., PPM-5) shall be established based on the tests prescribed in the subgroup 2 tests of the group A inspections. The defect level for PPM-2 shall be less than 100 PPM. Data shall not be excluded from the appropriate PPM calculation unless specifically authorized by the qualifying activity. Guidance for exclusion of data is specified in EIA-554.

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

3.4 Materials. Materials shall be as specified herein. However, when a definite material is not specified, a material shall be used which enables 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 Soldering flux. Soldering flux shall be in accordance with MIL-F-14256. No acid, acid salts, or type RA fluxes shall be used in preparation for or during soldering.

3.5 Design and construction. Capacitors shall be of the design, construction, and physical dimensions specified (see 3.1).

3.5.1 Body structure. The body structure shall be in a monolithic form which shall meet the requirements specified herein (see 3.1 and 6.4).

3.5.2 Terminations. The terminations shall be of solderable metals or metal alloys. Termination finishes, as identified in 1.2.1.6, shall be as specified (see 3.1).

3.5.2.1 Reprocessing of terminations for solderability enhancement. The manufacturer may reprocess the terminations of capacitors supplied to this specification for the purpose of solderability enhancement, provided the termination process has been approved by the qualifying activity.

3.5.2.1.1 Reprocessing option. If the manufacturer reprocesses the terminations of the capacitors as a part of normal production, or as a corrective action for solderability failure, the reprocessed lot shall be subject to the group A, subgroup 1 electrical tests.

3.6 Voltage conditioning. When tested as specified in 4.7.3, capacitors shall meet the following requirements:

a. Dielectric withstanding voltage (at +25°C): Shall be as specified in 3.12, with the following exceptions:
   For capacitors with a voltage rating of 500 volts, 150 percent of rated voltage shall be applied.
   For capacitors with a voltage rating or 1000 volts or greater, 120 percent of rated voltage shall be applied.
   Not applicable if the optional voltage conditioning was performed at or above 250 percent of rated voltage.

b. Insulation resistance (at +25°C): Shall be as specified in 3.9.

c. Capacitance (at +25°C): Shall be as specified in 3.7.

d. Dissipation factor (at +25°C): Shall be as specified in 3.8.

3.7 Capacitance. When measured as specified in 4.7.4, the capacitance shall be within the applicable tolerance specified (see 3.1).

3.8 Dissipation factor. When measured as specified in 4.7.5, the dissipation factor shall not exceed 2.5 percent for the BX characteristic, 0.15 percent for the BP characteristic, and 0.05 percent for the BG characteristic.

3.9 Insulation resistance. When measured as specified in 4.7.6, the insulation resistance shall be not less than the following:

a. At +25°C (except high frequency styles) (see 3.1): 100,000 megohms or 1,000 megohm-microfarads, whichever is less.

b. At +125°C (except high frequency styles) (see 3.1):

   (1) BX characteristic: Shall be not less than 10,000 megohms or 100 megohm-microfarads, whichever is less (see 3.1).

   (2) BP characteristic: Shall be not less than 1,000 megohms or 10 megohm-microfarads, whichever is less (see 3.1).

   (3) BG characteristic: Shall be as specified (see 3.1).

3.10 Equivalent series resistance (UHF) (when specified, see 3.1). When tested in accordance with 4.7.7, the ESR shall be less than the limits shown in appendix A, figures 3 and 4.

3.11 Equivalent series resistance (RF) (when specified, see 3.1). When tested in accordance with 4.7.8, the ESR shall be less than the limits shown in appendix A, figures 5 and 6.

3.12 Dielectric withstanding voltage. When capacitors are tested as specified in 4.7.9, there shall be no evidence of breakdown or visible evidence of arcing or damage.

3.13 Solderability. Capacitors shall be tested as specified in 4.7.10. Nonbarrier metal capacitors shall utilize Sn62 solder; barrier metal capacitors (types U, W, Y, and Z) shall utilize Sn60, Sn62, or Sn63 solder (see 3.1), in accordance with QQ-S-571 and the immersed metallized surface shall be 95 percent covered with a smooth solder coating.

3.14 Voltage-temperature limits (not applicable to high frequency capacitors). When capacitors are tested as specified in 4.7.11, the capacitance change shall not exceed the applicable limits specified in table I.

3.15 Thermal shock and immersion. When tested as specified in 4.7.12, capacitors shall meet the following requirements:

a. Visual examination: There shall be no mechanical damage.

b. Dielectric withstanding voltage: Shall be as specified in 3.12.

c. Insulation resistance (at +25°C): Shall be not less than 30 percent of the initial requirement (see 3.9).

d. Capacitance change:

(1) BX characteristic: Shall change not more than ±10 percent from the initial measured value.

(2) BG and BP characteristics: Shall change not more than 0.5 percent of the nominal value or 0.5 pF, whichever is greater, from the initial measured value.

e. Dissipation factor: Shall be as specified in 3.8.

3.16 Resistance to soldering heat. When tested as specified in 4.7.13, capacitors shall meet the following requirements:

a. Visual examination: There shall be no evidence of mechanical damage or delamination or exposed electrodes. Leaching shall be a maximum of 25 percent on each edge of mounting area (see figure 1).

b. Insulation resistance (at +25°C): Shall not be less than the initial 25°C requirement.

c. Capacitance change:

(1) BX characteristic: Shall change not more than -1.0 percent to +6.0 percent from the initial measured value.

(2) BG characteristic: Shall change not more than 0.5 percent of the nominal value or 0.5 pF, whichever is greater, from the initial measured value.

(3) BP characteristic: Shall change not more than -1.0 percent to +2.0 percent from the initial measured value.

d. Dissipation factor: Shall not exceed the initial limits.

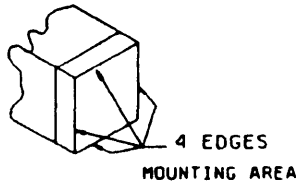


FIGURE 1. Mounting areas

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

a. Visual examination: There shall be no mechanical damage, and marking shall remain legible.

b. Dielectric withstanding voltage: Shall be as specified in 3.12.

c. Insulation resistance (at +25°C): Shall be not less than 30 percent of the initial requirement (see 3.9).

d. Capacitance change:

(1) BX characteristic: Shall change not more than ±10 percent from the initial measured value.

(2) BP and BG characteristics: Shall change not more than 0.5 percent of the nominal value or 0.5 pF, whichever is greater, from the initial measured value.

3.18 Humidity, steady state, low voltage. When tested as specified in 4.7.15, capacitors shall meet the following requirements:

a. Visual examination: There shall be no mechanical damage, and marking shall remain legible.

b. Insulation resistance (at +25°C): Shall meet the initial 25°C requirement specified in 3.9.

c. Capacitance change:

(1) BX characteristic: Shall not change more than ±10 percent from the initial measured value.

(2) BP and BG characteristics: Shall not change more than 0.3 percent of the nominal value or 0.3 pF, whichever is greater, from the initial measured value.

3.19 Life (at elevated ambient temperature). When tested as specified in 4.7.16, capacitors shall meet the following requirements:

a. Visual examination: There shall be no mechanical damage.

b. Insulation resistance:

(1) (At +25°C): Shall be not less than 30 percent of the initial requirement (see 3.9).

(2) (At maximum rated temperature): Shall be not less than 30 percent of the initial requirement (see 3.9).

c. Capacitance change:

(1) BX characteristic: Less than ±10 percent from the initial measured value.

(2) BP and BG characteristics: Shall change not more than 2.0 percent of the nominal value or 0.5 pF, whichever is greater, from the initial measured value.

d. Dissipation factor:

(1) BX characteristic: Less than 3.0 percent.

(2) BP and BG characteristics: Less than 0.2 percent.

3.20 Fungus. The manufacturer shall certify that all materials are fungus resistant or shall perform the test specified in 4.7.17. When capacitors are tested as specified in 4.7.17, examination shall not disclose evidence of fungus growth or damage.

3.21 Series resonance (when specified, see 3.1). When tested as specified in 4.7.18, capacitors shall meet or exceed the series resonance frequency as shown on figure 2.

3.22 Terminal strength (when specified, see 3.1). When capacitors are tested as specified in 4.7.19, there shall be no loosening, rupturing, or permanent damage to the terminals.

3.23 Temperature coefficient and capacitance drift (high frequency capacitors only).

3.23.1 Temperature coefficient. When capacitors are tested as specified in 4.7.20, the capacitance change shall not exceed the applicable limits specified in table I.

Parts per million per degree Celsius can be calculated with the following equation:

$$PPM/°C = \frac{C_2 - C_1}{C_1(T_2 - T_1)} \times 10^6$$

, where: C_2 = Capacitance at test temperature
C_1 = Capacitance at 25°C
T_2 = Test temperature
T_1 = 25°C

3.23.2 Capacitance drift. The capacitance drift shall be within ± (0.2 percent or 0.05 pF), whichever is greater.

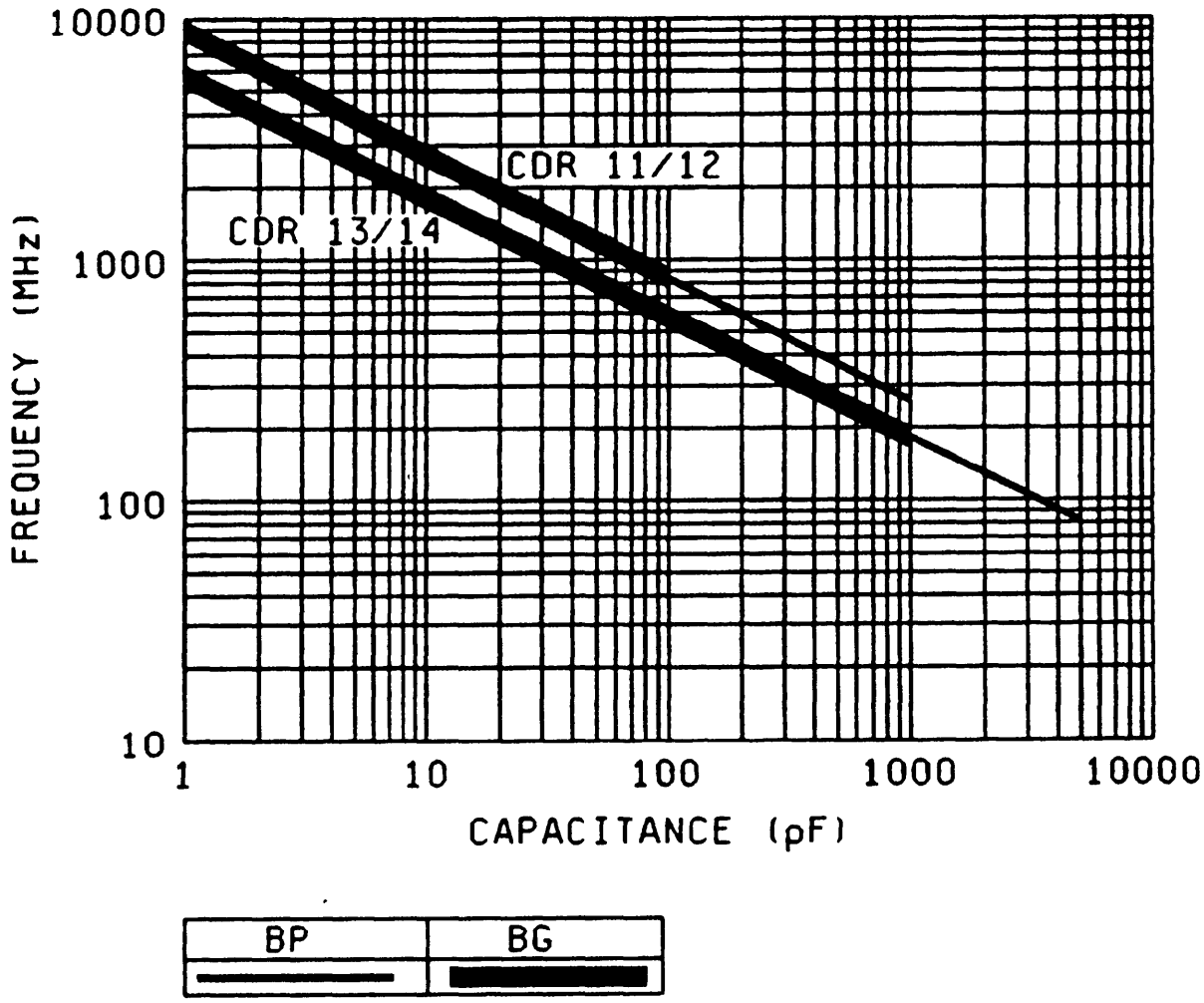


FIGURE 2. Series resonance frequency versus nominal capacitance value.

3.24 Marking (all styles except high frequency). Packaging containers shall be marked with the PIN, capacitance, capacitance tolerance, voltage, "JAN" brand, lot date code, and the Commercial and Government Entity (CAGE) code. Other markings which in any way interfere with, obscure, or confuse those specified herein are prohibited. When specified in the ordering data, see 6.2, capacitors shall be legibly marked in accordance with table VI. A two character marking system shall be used. The first character shall be an alphabetic symbol and shall designate the first and second significant figures. The second character shall be a numerical digit and shall designate the decimal multiplier of capacitance in pF (Examples: A1 = 1 x 10^1 = 10 pF, J5 = 2.2 x 10^5 = 0.22 x 10^6 = 0.22 µF).
The marking shall appear in black or legible contrast. The size and orientation of the marking shall be at the option of the manufacturer. At the option of the manufacturer, the capacitor may be laser marked with the manufacturer's trademark or symbol and the capacitance code in accordance with table VI. Additional marking may appear provided that it does not interfere with the required marking.

TABLE VI. Marking for chip capacitors.

First character				Second character	
Alphabetic character	Significant figures	Alphabetic character	Significant figures	Numerical character	Decimal multiplier
A	1.0	T	5.1	0	10^0
B	1.1	U	5.6	1	10^1
C	1.2	V	6.2	2	10^2
D	1.3	W	6.8	3	10^3
E	1.5	X	7.5	4	10^4
F	1.6	Y	8.2	5	10^5
G	1.8	Z	9.1	6	10^6
H	2.0	a	2.5	7	10^7
J	2.2	b	3.5	8	10^8
K	2.4	d	4.0	9	10^9
L	2.7	e	4.5		
M	3.0	f	5.0		
N	3.3	m	6.0		
P	3.6	n	7.0		
Q	3.9	t	8.0		
R	4.3	y	9.0		
S	4.7				

3.24.1 Marking (styles CDR11, CDR12, CDR13, CDR14, CDR21, CDR22, CDR23, CDR24, and CDR25). These capacitors shall be marked with a contrasting color dot placed on the side of the capacitor to indicate the vertical plate orientation to that side. When parts are laser marked, the marking shall be on the surface which is parallel to the plane of the embedded electrodes (this is the larger area which is normally the imprint area). If the capacitor is so marked, the vertical plate orientation is defined; therefore, the contrasting color dot on the capacitor to indicate the vertical plate orientation to that side may be an option.

Capacitors may be laser marked with the manufacturer's trademark or symbol, the two-digit or three digit capacitance code, and the tolerance code as follows:

XXX
100 (or A1 for two-digit)
F

Where space does not permit, the manufacturer's trademark or symbol may be omitted.

3.24.2 Substitutability of failure rate levels. A manufacturer may supply to those failure rate levels, as listed in table VII, higher than that to which he is qualified. Parts with lower FRL's are substitutable, with the acquiring agency approval, for higher FRL's as shown in table VII, provided the lot date codes of the parts are not changed.

TABLE VII. Failure rate level substitutability.

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

3.24.3 Substitutability of capacitance tolerance and rated voltage. Parts qualified and marked (if applicable) to tighter capacitance tolerance or qualified to a higher rated voltage are substitutable, with acquiring agency approval, for parts qualified and marked (if applicable) to looser capacitance tolerance, or qualified to a lower rated voltage, provided all other values, such as case size, characteristic, and leads or terminations remain the same. The substitutable parts shall not be remarked (if applicable) unless specified in the contract or purchase order (see 6.2). In the event the capacitance tolerance is changed and remarked (if applicable) or the voltage rating is changed, the lot date codes of the parts shall not be changed and the workmanship criteria shall be met.

3.24.4 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 military specifications. Accordingly, items acquired to, and meeting all of the criteria specified herein and in applicable specifications shall bear the certification mark "JAN", except that items too small to bear the certification mark "JAN" shall bear the letter "J". The "JAN" and "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 purchase orders which either permit or require deviation from the conditions or requirements specified herein or in applicable specifications shall not bear "JAN" or "J". In the event an item fails to meet the requirements of this specification and the applicable specification sheets or associated detail specifications, the manufacturer shall remove the "JAN" or the "J" from the sample tested and also from all items represented by the sample. The "JAN" or "J" certification mark shall not be used on products acquired to contractor drawings or specifications. The United States Government has obtained Certificate of Registration Number 504,860 for the certification mark "JAN".

3.25 Workmanship. Capacitors shall be so processed that when inspected under 20X to 40X magnification, they shall be uniform in quality and shall be free from pits, cracks, rough edges, adhered foreign material, and other defects which will affect life or serviceability. The capacitors shall exhibit no delamination (separation in the layers of ceramic) or demetallization (lift-off) on the terminations.

4. QUALITY ASSURANCE PROVISIONS

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

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

4.1.2 Reliability assurance program. A reliability assurance program shall be established and maintained in accordance with MIL-STD-790.

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

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

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

4.3 Inspection conditions.

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

4.3.2 Methods.

4.3.2.1 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° ±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 or insulation resistance measurements shall be stabilized to at least ±100 parts per million. No voltage fluctuations shall occur during measurements that would produce a variation in the current or resistance 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.

4.4.1 Sample size. The number of sample units comprising a sample of capacitors to be submitted for qualification inspection shall be as specified in table VIII, or in appendix B to this specification. The sample shall be taken from a production run and shall be produced with equipment and procedures normally used in production.

4.4.2 Test routine. Sample units shall be subjected to the qualification inspection specified in table VIII, in the order shown. All sample units shall be subjected to the group I tests. These sample units shall then be divided as shown in table VIII for groups II through VIII, and subjected to the tests for their particular group.

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

4.4.4 Failure rate level and quality level verification.

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

a. Procedure I: Qualification at the initial FR level. Level M (1.0 percent) of FRSP-90 shall apply. Sample units shall be subjected to the qualification inspection specified in group I, table VIII (see 4.4.2).

b. Procedure II: Extension of qualification to lower FR levels. To extend qualification to the P (0.1 percent), R (0.01 percent), and S (0.001 percent) FR levels, data from two or more voltages within style and of similar construction may be combined. For FR levels R and S, two or more styles of similar construction (see 4.6.1.1.1) may be combined.

c. Procedure III: Maintenance of FR level qualification. Maintenance period B of FRSP-10 shall apply. Regardless of the number of production lots produced during this period, the specified number of unit hours shall be accumulated to maintain qualification (see 4.5f).

4.4.4.2 Quality level maintenance. The contractor is responsible for establishing a quality system to verify the PPM defect level of lots that are subjected to subgroup 2 tests of the group A inspections. The following groupings of styles shall be used for the maintenance of PPM defect level:

Group	Styles
1	CDR01, CDR02, CDR03, CDR04, CDR05, CDR06, CDR31, CDR32, CDR33, CDR34, CDR35
2	CDR11, CDR12, CDR13, CDR14, CDR21, CDR22, CDR23, CDR24, CDR25
3	CDR26, CDR27, CDR28, CDR29, CDR30

The PPM defect level shall be based on a 6-month moving average. The contractor shall verify and report individual PPM categories (i.e., PPM-2 and PPM-3) and an overall PPM defect level (i.e., PPM-5). In the event that the contractor meets or exceeds 100 PPM for PPM-2, the qualifying activity shall take the actions specified in 4.4.4.3.

TABLE VIII. Qualification inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of defectives permitted
Group I				
Voltage conditioning	3.6	4.7.3	85 2/ 3/	Not applicable
Dielectric withstanding voltage	3.12	4.7.9		
Insulation resistance (elevated temperature) 1/	3.9	4.7.6		
Capacitance 1/	3.7	4.7.4		
Dissipation factor 1/	3.8	4.7.5		
Insulation resistance 1/	3.9	4.7.6		
Equivalent series resistance (UHF) (high frequency only) 4/	3.10	4.7.7		
Equivalent series resistance (RF) (high frequency only) 4/	3.11	4.7.8		
Dielectric withstanding voltage	3.12	4.7.9		
Visual and mechanical examination	3.1, 3.4, 3.5.1, 3.5.2, 3.24 through 3.25, incl	4.7.2		
Group II				
Solderability	3.13	4.7.10	6	1
Group III				
Voltage-temperature limits 5/	3.14	4.7.11	18	
Temperature coefficient and capacitance drift (High frequency only)	3.23	4.7.20		
Thermal shock and immersion	3.15	4.7.12		
Group IV				
Resistance to soldering heat	3.16	4.7.13	9	
Moisture resistance	3.17	4.7.14	9	
Group V				
Life (at elevated ambient temperature)	3.19	4.7.16	25	1
Group VI				
Fungus 2/	3.20	4.7.17	6	0
Group VII				
Series resonance (when specified, see 3.1)	3.21	4.7.18	18 3/	0
Terminal strength (when specified, see 3.1)	3.22	4.7.19		
Group VIII				
Humidity, steady state, low voltage	3.18	4.7.15	12	0

1/ Performed as part of the voltage conditioning test.
2/ Only 79 samples are needed if certification is given for fungus (see 3.20).
3/ When group VII inspection is specified, 18 additional samples will be required.
4/ Not applicable to high frequency styles below 1 pF.
5/ Not applicable to high frequency capacitors.

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

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

a. Verification by the qualifying activity that the manufacturer meets the requirements of MIL-STD-790.

b. The manufacturer has not modified the design of the item.

c. The specification requirements for the item have not been amended so as to affect the character of the item.

d. Lot rejection for group A inspection does not exceed 10 percent or one lot, whichever is greater.

e. The requirements of group C inspection are met.

f. The records of all tests combined substantiate the M (1.0 percent) or P (0.1 percent) FR level has been maintained or that the manufacturer continued to meet the R (0.01 percent) or S (0.001 percent) FR level for which qualified, although the total component hours of testing does not, as yet, meet he requirements of 4.4.4.1c.

g. The contractor shall provide documentation to the qualifying activity pertaining to PPM calculations including numbers of part types tested, individual PPM defect categories (i.e., PPM-2 and PPM-3) and the overall PPM defect rate (PPM-5). This information shall be submitted in accordance with style groupings listed in 4.4.4.2.

If group C test requirements were not met and the manufacturer has taken corrective action satisfactory to the Government, the manufacturer shall submit a verification of qualification report within 30 days after completion of the group C testing. In this case, the qualifying activity shall be notified within the time the original verification of qualification report was due. All reports shall be certified by the responsible company official. The qualifying activity shall be contacted for report format.

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

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

In the event that no production occurred during the reporting period, a report shall be submitted certifying that the manufacturer still has the capabilities and facilities necessary to produce the item. The manufacturer, however, must maintain the required number of unit hours in the specified maintenance period in order to remain qualified to the applicable failure rate levels. The manufacturer must also produce enough parts during any reporting period in order to perform all applicable group C tests.

4.5.1 Record. Maintenance of life tests and FR level records shall be as specified in MIL-STD-690.

4.6 Quality 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 the same voltage-temperature characteristic, produced under essentially the same conditions with the same basic materials, and offered for inspection at one time. The samples selected from the inspection lot shall be representative of the capacitance values and voltages in the approximate ratio of production.

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

4.6.1.2 Group A inspection. Group A inspection shall consist of the examination and tests specified in table IX, in the order shown.

4.6.1.2.1 Subgroup 1 test. Subgroup 1 tests shall be performed on a production lot basis on 100 percent of the product supplied under this specification. Capacitors failing the tests of subgroup 1 shall be removed from the lot. If during the 100 percent inspection, screening requires that more than 8 percent of the capacitors be discarded, the entire production lot shall be rejected.

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

a. Tests conducted by the manufacturer during production shall be clearly identical to or more stringent than that specified for subgroup 1. Test conditions shall be equal to or more stringent than those specified for subgroup 1 tests. (Note: Includes optional voltage conditioning (see 4.7.3.2)).

b. Manufacturer subjects 100 percent of the product supplied under this specification to his production tests.

c. The parameters measured and the failure criteria shall be the same or more stringent than those specified herein.

d. The lot rejection criteria is the same or more stringent than that specified herein.

e. The manufacturer shall make available all information concerning the test procedures and instrumentation used in the production tests which are a substitute for subgroup 1 tests. This data shall be provided as part of the evaluation required for MIL-STD-790. The manufacturer shall also make available to the Government all records of all detail test data resulting from production tests which are a substitute for subgroup 1 tests.

f. Once approved, the manufacturer shall not change the test procedures or criteria without prior notification and concurrence by the qualifying activity.

4.6.1.2.1.2 Rejected lots. Production lots exceeding the 8 PDA of group A, subgroup 1 inspection shall be segregated from new lots and lots that have passed inspection. Lots rejected may be offered for acceptance only if the manufacturer 100 percent retests to the requirements of subgroup 1. Resubmitted lots shall be kept separate and shall be clearly identified as resubmitted lots. If, during the 100 percent reinspection to subgroup 1, the lot exceeds 3 percent defective, the lot shall be rejected and shall not be resubmitted.

TABLE IX. Group A inspection.

Inspection	Requirement paragraph	Test method paragraph	Sampling procedure
Subgroup 1			
Voltage conditioning 1/	3.6	4.7.3	100 percent inspection
Subgroup 2 (PPM)			
Dielectric withstanding voltage (PPM-2)	3.12	4.7.9	See table X
Insulation resistance (+25°C) (PPM-2)	3.9	4.7.6	See table X
Insulation resistance (elevated temperature) (+125°C) (PPM-2)	3.9	4.7.6	See table X
Capacitance (PPM-2)	3.7	4.7.4	See table X
Dissipation factor (PPM-2) 1/	3.8	4.7.5	See table X
Mechanical examination (Physical dimensions only)(PPM-3)	3.5	4.7.2	See table X
Subgroup 3			
Equivalent series resistance (UHF) (when specified, see 3.1) 2/	3.10	4.7.7	6 samples 0 failures
Equivalent series resistance (RF) (when specified, see 3.1) 2/	3.11	4.7.8	6 samples 0 failures
Subgroup 4			
Visual examination	3.1, 3.4, 3.5.1, 3.5.2, 3.24 through 3.25, incl.	4.7.2	13 samples 0 failures
Subgroup 5			
Solderability	3.13	4.7.10	13 samples 0 failures

1/ For CDR11 through CDR14 and CDR21 through CDR25 capacitors of less than 10 pF, the dissipation factor shall not exceed 0.25 percent for the BP characteristic and 0.15 percent for the BG characteristic. A negative reading is not considered a failure.

2/ Not applicable to styles CDR11 through CDR14 and CDR21 through CDR25 below 1 pF.

TABLE X. Sampling plans for PPM categories.

Lot size	Sample Size	
	PPM-2	PPM-3
1 - 13	100%	100%
14 - 125	100%	13
126 - 150	125	13
151 - 280	125	20
281 - 500	125	29
501 - 1,200	125	34
1,201 - 3,200	125	42
3,201 - 10,000	192	50
10,001 - 35,000	294	60
35,001 - 150,000	294	74
150,001 - 500,000	345	90
500,001 - UP	435	102

4.6.1.2.2 Subgroup 2 tests (PPM categories).

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

4.6.1.2.2.2 Rejected lots. The rejected lot shall be segregated from new lots and those lots that have passed inspection. The rejected lot shall be 100 percent inspected for those quality characteristic 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 X. If one or more defects are found in this second sample, the production lot shall be rejected and shall not be supplied to this specification.

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

Stable capacitance standards may be used, at the option of the manufacturer, to eliminate or reduce capacitance bridge and fixturing error when measuring capacitance of less than 100 pF. The method used for making these measurements shall be included in the manufacturer's program plan in accordance with MIL-STD-790.

4.6.1.2.3 Subgroups 3 and 4 tests. Subgroups 3 and 4 shall be performed on an inspection lot basis. The sampling procedures shall be as specified in table IX.

4.6.1.2.3.1 Rejected lots. The rejected lots shall be segregated from new lots and those lots that have passed inspection. Lots rejected because of failures in subgroup 3 shall be reinspected, using the sampling procedures specified in table IX. 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 IX. If one or more defects are found in the second sample for subgroups 3 or 4, 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.

4.6.1.2.4 Subgroup 5 (Solderability).

4.6.1.2.4.1 Sampling plan. Thirteen samples shall be selected randomly from every inspection lot and subjected to the subgroup 5 solderability test. The manufacturer may use electrical rejects from the subgroup 1 screening tests for all or part of the samples to be used for the solderability testing. If there are one or more defects, the lot shall be considered to have failed.

4.6.1.2.4.2 Rejected lots. In the event of one or more defects, the inspection lot shall be rejected. The manufacturer may use one of the following options to rework the lot:

a. Each production lot that was used to form the failed inspection lot shall be individually submitted to the solderability test as required in 4.6.1.2.4.1. Production lots failing the solderability test can be reworked only if submitted to the reprocessing procedure in 4.6.1.2.4.2b.

b. The manufacturer shall submit the failed production lot to 100 percent reprocessing of the terminations, using an approved process in accordance with 3.5.2.1. Following the reprocessing, the electrical measurements required in the group A, subgroup 1 test shall be repeated on 100 percent of the lot. The PDA for electrical measurements shall be as for the subgroup 1 tests. Thirteen additional samples shall then be selected and subjected to the solderability test with no defects allowed. If the lot fails this solderability test, the lot shall be considered rejected and shall not be furnished against the requirements of this specification.

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

4.6.2 Periodic inspection. Periodic inspection shall consist of group C inspection. Except where the results of this inspection show noncompliance with the applicable requirements (see 4.6.2.1.1.5), delivery of products which have passed group A inspection shall not be delayed pending the results of this periodic inspection.

4.6.2.1 Group C inspection. Group C inspection shall consist of the tests specified in table XI, in the order shown. Group C inspection shall be made on sample units randomly selected from inspection lots which have passed group A inspection.

4.6.2.1.1 Sampling plan.

4.6.2.1.1.1 Subgroups 1, 2, and 5 (all FR levels). Forty-two sample units of each voltage-temperature characteristic shall be selected from the first inspection lot produced every 6 months.

4.6.2.1.1.2 Subgroup 3 (all FR levels). A minimum of 25 sample units per style of the highest capacitance value produced shall be selected from the first inspection lot produced during a 6-month period. Permitted failures shall be as specified in MIL-STD-690. The accumulated data shall be used for maintenance and extension of failure rate qualification.

4.6.2.1.1.3 Subgroup 4 (all FR levels) (high frequency only). Twelve sample units of each voltage-temperature characteristic shall be selected from the first lot produced.

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

TABLE XI. Group C inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of defective permitted
Subgroup 1				
Temperature coefficient and capacitance drift	3.23	4.7.20	12	0
Voltage-temperature limits 1/ 2/	3.14	4.7.11		
Thermal shock and immersion 3/	3.15	4.7.12		
Subgroup 2				
Resistance to soldering heat	3.16	4.7.13	12	0
Moisture resistance	3.17	4.7.14		
Subgroup 3				
Life (at elevated ambient temperature)	3.19	4.7.16	25 minimum	See 4.6.2.1.1.2
Subgroup 4				
Terminal strength (when specified, see 3.1) 3/	3.22	4.7.19	12	0
Series resonance (when specified, see 3.1)	3.21	4.7.18		
Subgroup 5				
Humidity, steady state, low voltage 3/	3.18	4.7.15	18	0

1/ If the manufacturer can demonstrate that this test has been performed five consecutive times with zero failures, the frequency of this test, with the approval of the qualifying activity, can be performed on an annual basis. If the design, material, construction or processing of the part is changed or, if there are any quality problems or failures, the qualifying activity may require resumption of the original test frequency.

2/ Not applicable to high frequency capacitors.

3/ If the manufacturer can demonstrate that this test has been performed five consecutive times with zero failures, this test, with the approval of the qualifying activity, can be deleted. The manufacturer, however, shall perform this test every three years after the deletion as part of long term design verification. 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 specified testing. Deletion of testing does not relieve the manufacturer from meeting the test requirement in case of dispute.

4.6.2.1.1.5 Noncompliance. If a sample fails to pass group C inspection, the manufacturer shall notify the qualifying activity and cognizant inspection activity of such failure and take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same materials, and which are considered subject to the same failure. Acceptance and shipment of the product shall be discontinued until corrective action, acceptable to the qualifying activity has been taken. After the corrective action has been taken, group C inspection shall be repeated on additional sample units (all inspection, or the inspection which the original sample failed, at the option of the qualifying activity). Group A inspection may be reinstituted; however, final acceptance and shipment shall be withheld until the group C inspection has shown that the corrective action was successful. In the event of failure after reinspection, information concerning the failure shall be furnished to the cognizant inspection activity and the qualifying activity.

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

4.7 Methods of inspection.

4.7.1 Mounting for testing. When specified in the test procedures, the chip capacitors shall be mounted on a suitable substrate (e.g., 96 percent alumina or FR4 glass epoxy). The substrate and mounting process shall be such that it will not be the cause of, nor contribute to, failure of any test for which it may be used. The capacitors shall be mounted on the substrate as follows:

a. A substrate shall be prepared with metallized surface land areas of proper spacing to permit mounting of chips by soldering the terminations of the chips to the substrate land areas. The dimensions of the test card are optional.

b. Solder paste, type SN60, SN62, or SN63 in accordance with QQ-S-571, shall be used.

c. The chip capacitor shall be soldered to the substrate using a solder reflow process. Conductive belt reflow and IR reflow processes are suggested. The temperature range of the peak reflow temperature shall be between 220°C and 260°C. Recommended ramp rates during preheating should not exceed 4°C per second. The substrates and capacitors shall be allowed to cool at room temperature.

d. The substrate shall be cleaned to remove flux residue, if applicable. Any residue which degrades capacitor electrical performance shall be removed.

4.7.1.1 Test rack. When specified, the substrate shall be mounted on a test rack which shall be so designed as to permit readout for electrical parameters at +25°C and +125°C and to monitor each chip under test for failure. This will insure uniform and uninterrupted voltage and heat stresses.

4.7.2 Visual and mechanical inspection. Capacitors shall be examined to verify that the materials, design, construction, physical dimensions, and workmanship are in accordance with the applicable requirements (see 3.1, 3.4, 3.5, and 3.24 through 3.25, inclusive).

4.7.3 Voltage conditioning (see 3.6). One of the voltage conditioning tests in 4.7.3.1 or 4.7.3.2 shall be performed. The lot traveler shall indicate which test is used. When the optional voltage conditioning test of 4.7.3.2 is used, the traveler shall include the specific accelerated voltage used and the test time.

4.7.3.1 Standard voltage conditioning. A minimum of twice the rated voltage shall be applied to the unit at the maximum rated temperature +4°C, -0°C for 100 +25 , -4 hours. After completion of the exposure period, the unit shall be stabilized at room temperature and the dielectric withstanding voltage (see 3.6a), insulation resistance, capacitance 1/, and dissipation factor shall be measured as specified in 4.7.9, 4.7.6, 4.7.4, and 4.7.5, respectively.

4.7.3.2 Optional voltage conditioning (Capacitors with voltage ratings of 200 volts or less only). The manufacturer, with approval from the qualifying activity, may perform an optional voltage conditioning test instead of the standard voltage conditioning test of 4.7.3.1. All conditions of 4.7.3.1 apply, with the exception of the voltage applied and the test time. The minimum time duration, T(test), shall be calculated as follows:

$$T(\text{test}) = \frac{800}{(E\ \text{test}/E\ \text{rated})^3}$$

Where: $2 \times E\ \text{rated} \leq E\ \text{test} \leq 4 \times E\ \text{rated}$

T(test) = Minimum test time in hours

E test = Applied voltage

E rated = Rated voltage of the capacitor

4.7.4 Capacitance (see 3.7) (for high frequency styles, see 3.1). Unmounted capacitors shall be tested in accordance with method 305 of MIL-STD-202. The following details and exception shall apply:

a. Test frequency: 1 MHz ±50 kHz (for all BP and BG characteristic capacitors ≤ 1000 pF, and for all BX characteristic capacitors ≤ 100 pF); or 1 kHz ±50 Hz for all other capacitors.

b. Test voltage: 1.0 ±0.2 volt rms.

1/ Due to the deaging characteristic of ceramic, this measurement may be delayed (applicable to BX characteristic only).

4.7.5 Dissipation factor (see 3.8). Dissipation factor shall be measured with a bridge or other suitable equipment at the frequency and voltage specified in 4.7.4. The capacitors shall be unmounted.

4.7.6 Insulation resistance (see 3.9). Unmounted capacitors shall be tested in accordance with method 302 of MIL-STD-202. The following details shall apply:

Precautionary note: Prior to performing this test, capacitors shall be carefully cleaned to remove any contamination including fingerprints. Care must be taken to maintain cleanliness in test chamber and while making measurements.

a. Test conditions: Rated voltage as specified (see 3.1) applied through a series resistor sufficient to limit the charging current to a maximum of 50 milliamperes (mA).

b. Special conditions: If a failure occurs at a relative humidity above 50 percent, the insulation resistance may be measured again at any relative humidity less than 50 percent.

c. Points of measurement: Between the terminations (metallized ends) or leads.

4.7.7 Equivalent series resistance (UHF) (when specified, see 3.1) (see 3.10). The UHF equivalent series resistance shall be measured in accordance with appendix A and table XII. Leaded devices shall be characterized as having the same equivalent series resistance as equivalent nonleaded devices manufactured from the same dielectric/metallization material lot.

TABLE XII. Equivalent series resistance (UHF) test frequency range.

Capacitance range	Frequency range	Wavelength
100 pF or less	910-1050 MHz	7/4
101-330 pF	640-660 MHz	5/4
331-1000 pF	380-400 MHz	3/4

4.7.8 Equivalent series resistance (RF) (when specified, see 3.1) (see 3.11). The RF equivalent series resistance shall be measured in accordance with appendix A at one quarter wavelength in a frequency range of 130 MHz to 260 MHz. Leaded devices shall be characterized as having the same equivalent series resistance as equivalent nonleaded devices manufactured from the same dielectric/metallization material lot.

4.7.9 Dielectric withstanding voltage (see 3.12). Unmounted capacitors shall be tested in accordance with method 301 of MIL-STD-202. The following details and exceptions shall apply:

a. Magnitude and nature of test voltage: Unless otherwise specified (see 3.1), 250 percent of rated voltage.

b. Duration of application of test voltage: 5 ±1 seconds.

c. Points of application of test voltage: Unless otherwise specified (see 3.1), between the capacitor-element terminals.

d. Limiting value of surge current: Shall not exceed 50 mA.

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

4.7.10 Solderability (see 3.13). Capacitors shall be tested in accordance with method 208 of MIL-STD-202. The following detail and exceptions shall apply:

a. For capacitors without leads, each terminal shall be immersed to a depth of .020 + .010, -000 inch (0.51 +0.25, -0.00 mm), or the entire capacitor may be immersed.

b. For capacitors with leads, each terminal shall be immersed to a distance of .030 ±.020 inch (0.76 ± 0.51 mm) to the capacitor body.

c. Examination of terminations shall be in accordance with 3.13. In case of dispute, the percent coverage with pinholes or rough spots shall be determined by actual measurement of these areas, as compared to the total area.

4.7.11 Voltage-temperature limits (not applicable to high frequency capacitors)(see 3.14). The temperature of each capacitor shall be varied as specified in table XIII. Capacitance measurements shall be made at the frequency specified in 4.7.4. The dc rated voltage need only be applied to the capacitor in each of steps E through G until voltage stability is reached and the capacitance measurement made. Capacitance measurements shall be made at each step specified in table XIII and at a sufficient number of intermediate points between steps B and G to establish a true characteristic curve. Capacitance measurements at each temperature shall be taken at five-minute intervals and shall be stopped and recorded when two successive readings indicate a capacitance change of less than one percent. These measurements need be performed only on capacitors having a value of 10 pF or greater. Capacitors of less than 10 pF shall be characterized as having the same voltage-temperature limits as those of 10 pF or more manufactured from the same dielectric material lot. For voltage ratings above 200 V, an approved alternate test method based on volts/mil stress of the same dielectric lot is allowed.

TABLE XIII. Voltage-temperature limit cycle.

Step 1/	Voltage	Temperature
	Volts, dc	°C
A	None	+25 ± 2
B	None	-55 ± 2
C (reference)	None	+25 ± 2
D	None	Maximum rated temperature +4, -0
E	Rated voltage (see 3.1)	Maximum rated temperature +4, -0
F	Rated voltage (see 3.1)	+25 ± 2
G	Rated voltage (see 3.1)	-55 ± 2

1/ Steps A through D and step F (without voltage) only for BP and BG characteristics.

4.7.12 Thermal shock and immersion (see 3.15).

4.7.12.1 Thermal shock. Capacitors shall be tested in accordance with method 107 of MIL-STD-202. The following details shall apply:

a. Test condition: Test condition A, except that in step 3, sample units shall be tested at the maximum rated temperature (see 1.2.1.2).

b. Measurements before and after cycling: Not applicable.

4.7.12.2 Immersion. Following thermal shock, capacitors shall be tested in accordance with method 104 of MIL-STD-202. The following detail and exception shall apply:

a. Test condition: Test condition B.

b. Examinations and measurements after final cycle: Capacitors shall meet the requirements of 3.15.

4.7.13 Resistance to soldering heat (see 3.16). Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details and exceptions shall apply:

a. Mounting of specimens: The capacitors shall be mounted on a substrate using the methods of 4.7.1, except the post pre-heat hot-plate temperature shall be +260°C ±5°C for a duration of 5 ±0.5 seconds. Tunnel ovens shall not be used to provide the soldering heat, since an observation is recommended during the test.

b. Test condition: B for leaded capacitors and C, procedure 1 or 2, for unleaded capacitors.

c. Examination after test: Capacitors shall be examined for evidence of mechanical damage.

4.7.14 Moisture resistance (see 3.17). Capacitors shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

a. Initial measurements: Capacitance as specified in 3.7.

b. Number of cycles: Twenty continuous cycles except that steps 7a and 7b shall be omitted.

c. Polarizing voltage shall be 50 V dc.

d. Examinations and final measurements: On completion of step 6 of the final cycle, capacitors shall be conditioned at 25°C ±5°C and a maximum relative humidity of 60 percent for a period of 18 hours minimum to 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 4.7.4, 4.7.9, and 4.7.6, respectively.

4.7.15 Humidity, steady state, low voltage (see 3.18). Capacitors shall be tested in accordance with method 103, condition A of MIL-STD-202. The following details and exceptions shall apply:

Note: At no time during test shall voltage greater than 1.55 volts be applied to any capacitor under test.

a. Initial measurements: Capacitance shall be measured in accordance with 4.7.4.

b. Tests: Capacitors shall be subjected to an environment of +85°C with 85 percent relative humidity for 240 hours minimum. Cycling shall not be performed. A dc potential of 1.3 ±0.25 volts shall be applied continuously through a 100 kilohm resistor.

c. Final measurements: On completion of test, remove the capacitors from the chamber and allow 3 hours, 30 minutes, ±30 minutes for drying and stabilization at 25°C before performing insulation resistance (through a 100 kilohm resistor at 1.3 ±0.25 volts) and capacitance in accordance with 4.7.6 and 4.7.4, respectively. The capacitors shall then be examined for evidence of mechanical damage and obliteration of marking.

d. Leads may be attached to chip capacitors for mounting and loading purposes. Mechanical loading is acceptable.

4.7.16 Life (at elevated ambient temperature)(see 3.19). Capacitors shall be tested in accordance with method 108 of MIL-STD-202. The following details and exceptions shall apply:

a. Capacitors shall be mounted as specified in 4.7.1 and 4.7.1.1.

b. Test temperature and tolerance: At the maximum rated temperature, +125°C +4°C, -0°C.

c. Operating conditions: Capacitors shall be subjected to a minimum of 200 percent of rated voltage (see 3.1). The surge current shall not exceed 50 mA. When necessary, a suitable current-limiting resistor shall be inserted into the circuit.

d. Test condition: Test condition F (2,000 hours).

e. Measurements during and after exposure: After 1,000 hours and at the conclusion of this test and while the capacitors are still held at the maximum rated temperature, insulation resistance shall be measured as specified in 4.7.6. The capacitors shall then be returned to the inspection conditions specified in 4.3 and shall be visually examined for evidence of mechanical damage; capacitance, dissipation factor, and insulation resistance shall be measured as specified in 4.7.4, 4.7.5, and 4.7.6, respectively.

f. Final measurement: Capacitors shall meet the requirements of 3.19.

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

4.7.18 Series resonance (when specified, see 3.1)(see 3.21). Capacitors shall be mounted as specified in 4.7.1 and tested to determine minimum series resonance frequency. Measurement frequency shall be varied smoothly between 100 and 10,000 MHz.

4.7.19 Terminal strength (when specified, see 3.1) (see 3.22). Capacitors shall be tested in accordance with method 211 of MIL-STD-202. The following details and exceptions shall apply:

a. Test condition: B (five bends).

b. Examination after test: Visual examination for loosening, rupturing, and permanent damage to the terminals.

4.7.20 Temperature coefficient and capacitance drift (high frequency capacitors only)(see 3.23).

4.7.20.1 Temperature coefficient. Capacitance measurements shall be made as specified in 4.7.4 and at the temperatures specified in table XIII.

4.7.20.2 Capacitance drift. Capacitance drift shall be computed by dividing the greatest single difference between any two of the three capacitance values recorded at 25°C by the value determined at the reference temperature (see table XIII).

5. PACKAGING

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

6. NOTES

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

6.1 Intended use. Ceramic chip capacitors are intended to be used in thin and thick film hybrid circuits where micro-circuitry is indicated for filter by-pass coupling applications, and where variation in capacitance with respect to temperature (-55°C to +125°C), voltage, frequency, and life can be tolerated. This specification also covers another established reliability capacitor, using ceramic dielectric, primarily intended for use in resonant circuits with high Q factor and stability of capacitance with respect to temperature (-55°C to +125°C), frequency, and life.

6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number, and date of the specification.

b. Issue of DODISS to be cited in the solicitation, and if required, the specific issue of individual documents referenced (see 2.1).

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

d. Capacitor marking (see 3.24).

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 applicable Qualified Products List whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity responsible for the Qualified Products List is the U S Army Laboratory Command, Electronics and Power Sources Directorate, ATTN: AMSRL-EP-RD, Fort Monmouth, NJ 07703-5601; however, information pertaining to qualification of products may be obtained from Defense Electronics Supply Center (DESC-EL), 1507 Wilmington Pike, Dayton, OH 45444-5270.

6.4 Metallized terminations. It should be noted that when pure silver is used for the termination, silver migration between the terminations may occur under conditions of simultaneous application of high humidity and dc voltage. This produces a troublesome electrical leakage path across the capacitor chip. Addition of about 20 percent of palladium to the silver to form an alloy will retard the tendency toward silver migration. Complete overcoating of the silver termination by the lead-tin bonding solder also will retard the tendency toward silver migration. Addition of about 3 percent of silver to the lead-tin bonding solder will tend to reduce the leaching of silver from the silver termination during the solder bonding operation.

6.4.1 Termination finish N. Solder embrittlement may take place if termination finish N is used with tin-lead solder.

6.5 Ambient operating conditions. Designers are cautioned to give consideration to the change in dielectric constant with temperature, shelf aging, and electric-field intensity, and should recognize that the insulation resistance may vary with humidity and organic contamination of the ceramic chip surfaces. Care should be taken to assure that the capacitors are properly and thoroughly cleansed of organic contamination, especially before the insulation resistance test.

6.6 Barometric pressure test. These units are not subject to the barometric pressure test since the likelihood of their failure is remote.

6.7 Effect of mounting on reliability. Voltage-temperature limits and resistance to thermal shock, and reliability may be affected as a result of mounting on substrate with dissimilar coefficients of expansion from capacitor material. Care should be taken in the selection of substrate material.

6.8 Supersession data. Capacitors of this specification are not intended to be used for replacement purposes. Therefore, no interchangeability and substitution data are offered.

6.9 Selection and use information. Equipment designers should refer to MIL-STD-198, "Capacitors, Selection and Use of", for a selection of standard capacitor types and values for new equipment design. Additional application and use information concerning these capacitors are also provided in MIL-STD-198.

6.10 Supplying for logistic support. Chip components require use of sophisticated equipment to remove from and install on printed wiring boards. Only requisitioners with in-house or contracted capability to replace surface mounted components should be supplied with chip components, in accordance with their specification.

6.11 Tin plated (100 percent) finishes. MIL-C-55681 capacitors have not historically had a problem with tin whisker growth. However, tin whisker growth could adversely effect the operation of electronic equipment systems. For additional information, see ASTM B545, "Standard Specification for Electrodeposited Coating of Tin".

6.12 Subject term (key word) listing.

Statistical process control

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

APPENDIX A

EQUIVALENT SERIES RESISTANCE (ESR) MEASUREMENT CRITERIA FOR HIGH FREQUENCY CAPACITOR STYLES CDR11 THROUGH CDR14 AND CDR21 THROUGH CDR25

10. SCOPE

10.1 Scope. This appendix specifies the method to determine high frequency loss as measured by equivalent series resistance. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS

20.1 Other publications. The following document forms a part of the specification to the extent specified herein.

ELECTRONIC INDUSTRIES ASSOCIATION

RS-483 - Standard Method of Test for Effective Series Resistance.

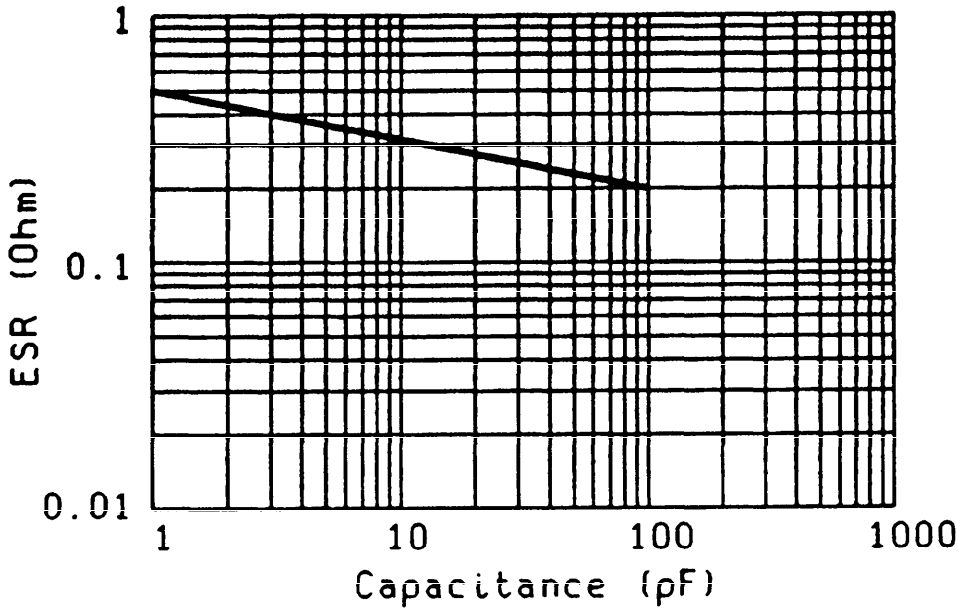
(Application for copies should be addressed to the Electronic Industries Association (EIA), 2001 Pennsylvania Avenue, N.W., Washington, DC 20006-1813.)

30. PROCEDURES FOR TEST

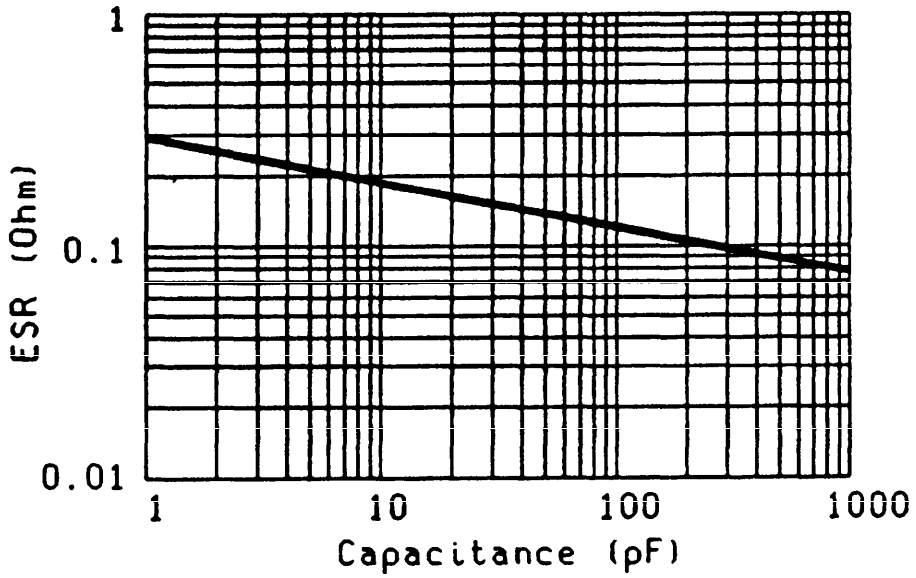
30.1 Equivalent series resistance. When specified, the equivalent series resistance shall be measured in accordance with EIA RS-483.

40. TEST CRITERIA

40.1 Equivalent series resistance. When equivalent series resistance is tested in accordance with 30.1, ESR shall be less than the limits shown on figures 3 through 6 at the specified measurement frequency range.

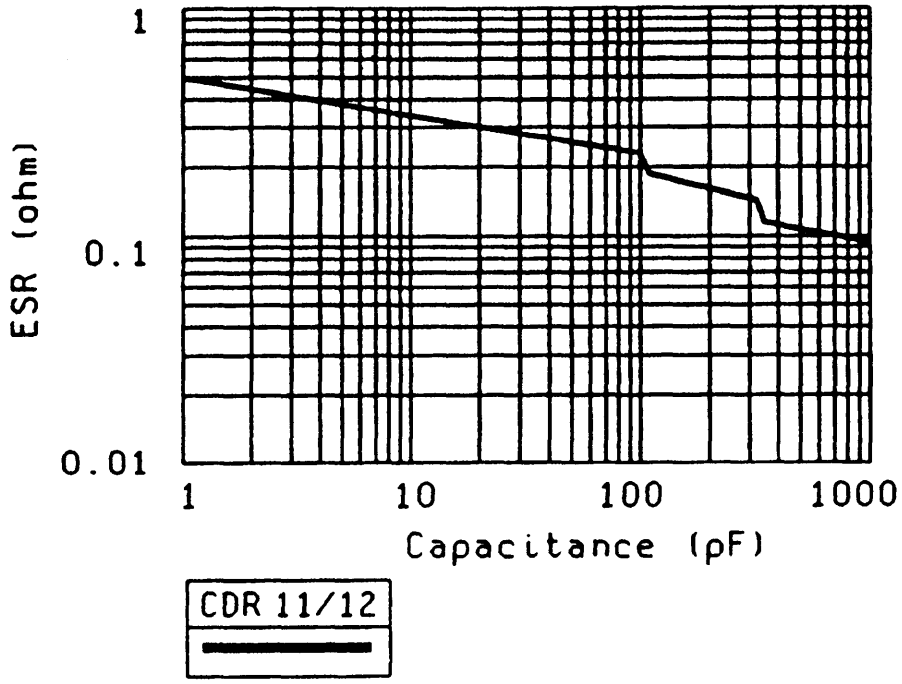


CDR 11/12



CDR 13/14 AND
CDR21 THROUGH CDR25

FIGURE 3. Equivalent series resistance (UHF) (BG characteristic).



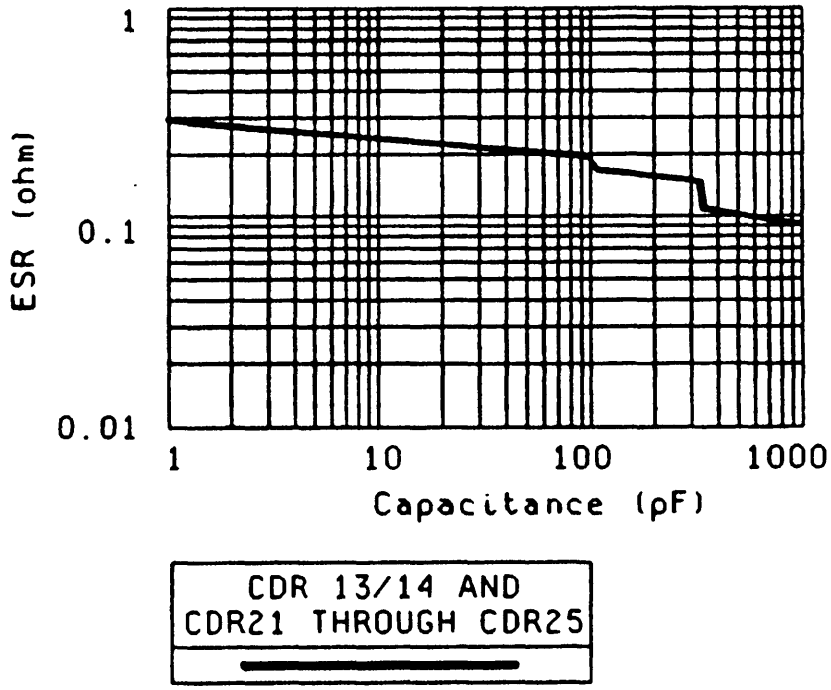
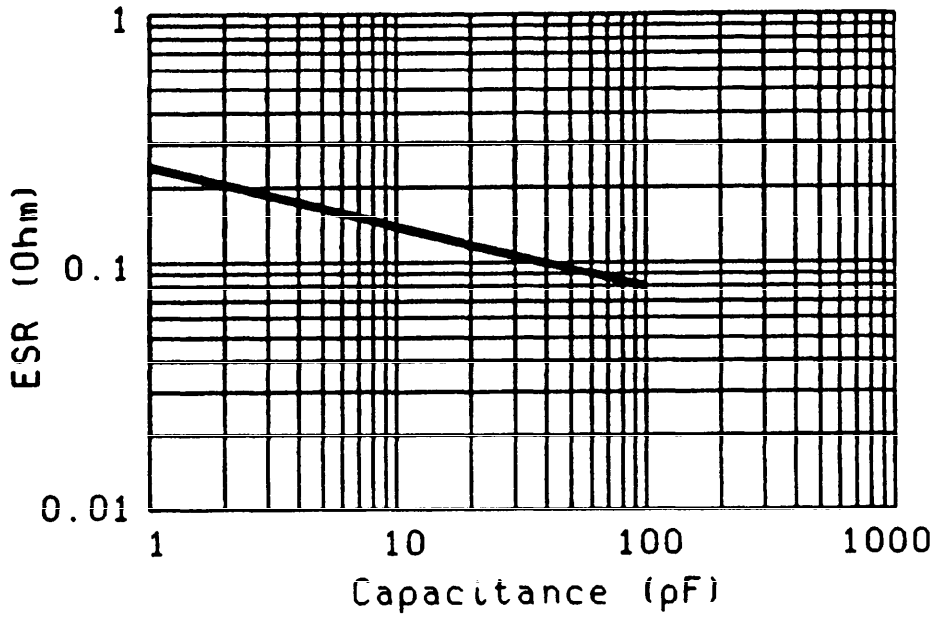
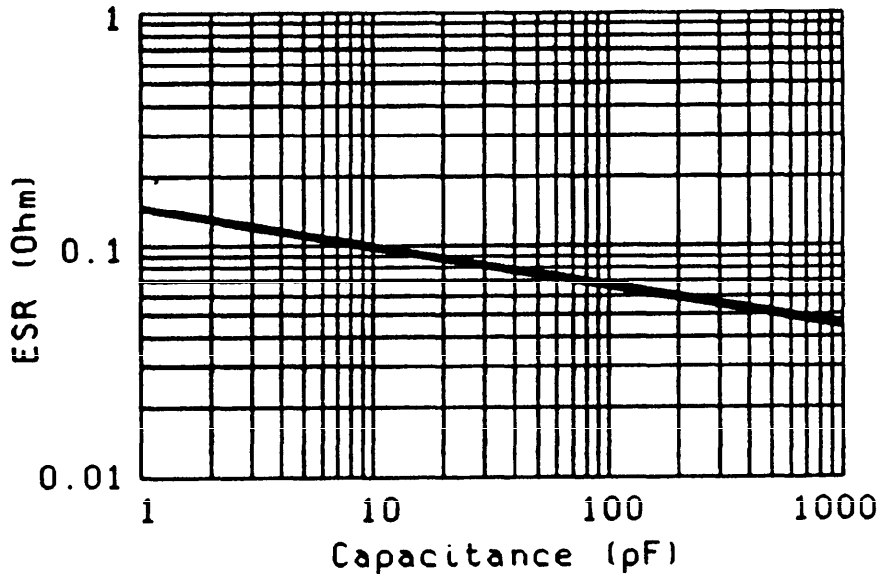


FIGURE 4. Equivalent series resistance (UHF) (BP characteristic).

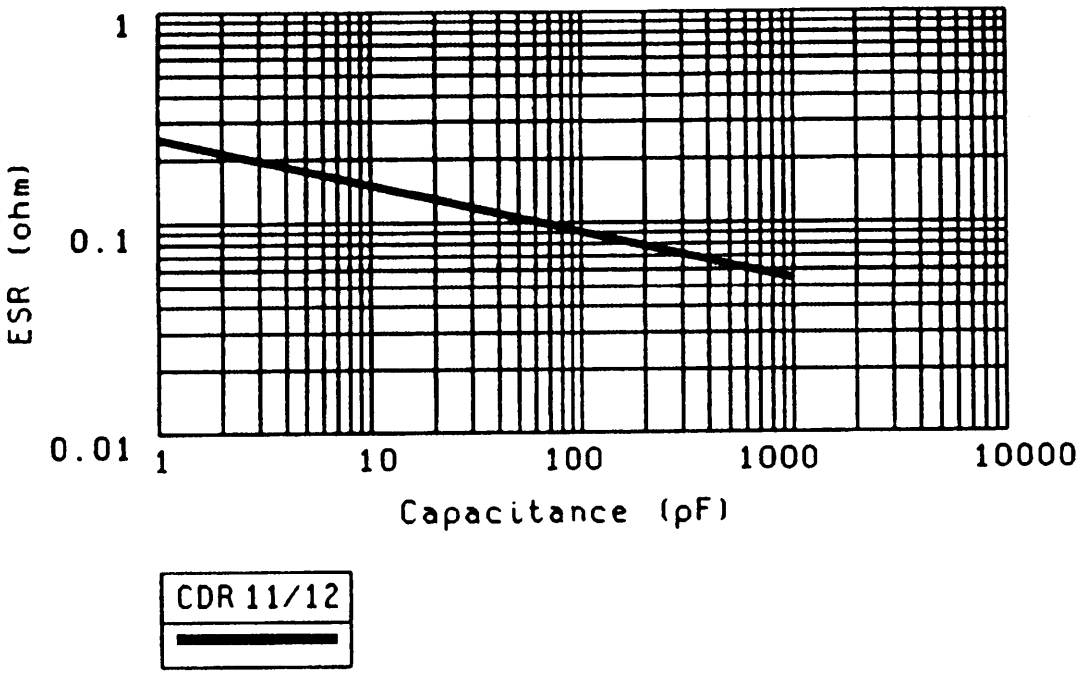


CDR 11/12



CDR 13/14 AND
CDR21 THROUGH CDR25

FIGURE 5. Equivalent series resistance (RF) (BG characteristic).



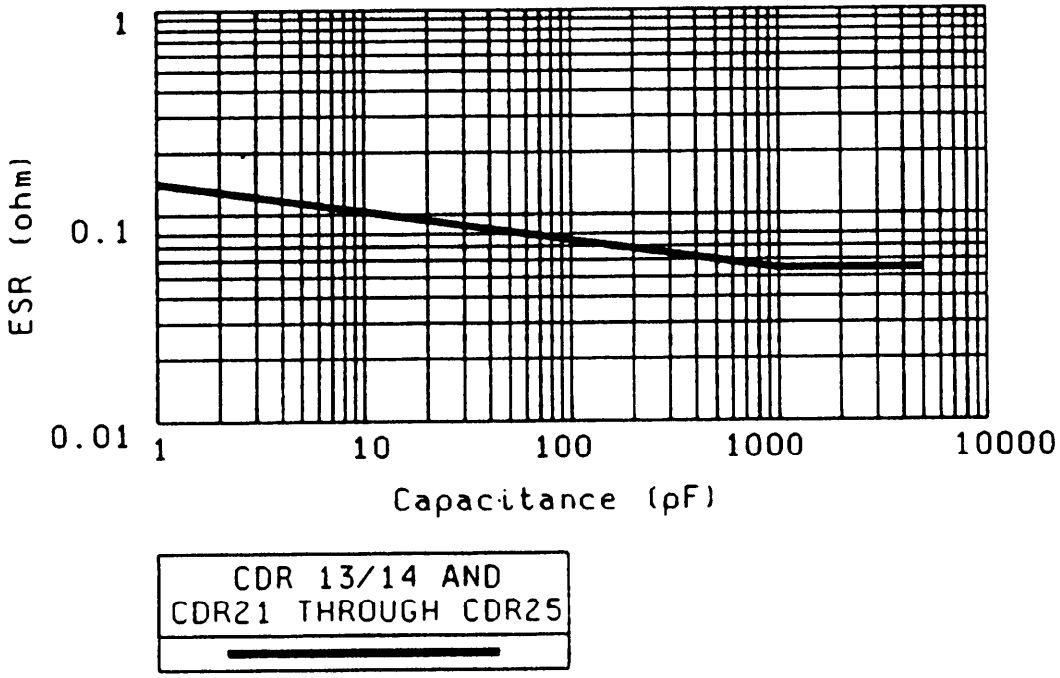


FIGURE 6. Equivalent series resistance (RF) (BP characteristic).

APPENDIX B

PROCEDURE FOR QUALIFICATION INSPECTION

10. SCOPE

10.1 This appendix details the procedure for submission of samples, with related data, for 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. The information contained herein is intended for compliance.

20. APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

30. SUBMISSION

30.1 Sample.

30.1.1 Single-style submission. A sample consisting of 103 sample units of the highest capacitance value in each voltage rating, in each rated temperature and voltage-temperature limits, in each style for which qualification is sought shall be submitted.

30.1.2 Combined-voltage submission. A sample consisting of sample units of the highest capacitance value in each voltage rating, in each rated temperature and voltage-temperature limits, in each style for which qualification is sought shall be submitted (see table XIV).

30.2 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 VIII. 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.

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

30.4 Description of item. The contractor shall submit a detailed description of the capacitors being submitted for inspection, including body, electrode material, terminal leads, etc.

40. EXTENT OF QUALIFICATION

40.1 Single-style submissión. 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. Voltage rating qualification will be restricted to that submitted. Rated temperature and voltage-temperature limit qualification will be restricted to that submitted.

40.2 Combined-voltage 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. Voltage rating qualification will be restricted to those submitted.

APPENDIX B

TABLE XIV. Combined-voltage submission.

Style	PIN	Number of units 1/	Rated voltage
CDR01	BP181BJ-M	85	100
	BX332BK-M	43 2/	100
	BX472AK-M	43 2/	50
CDR02	BX271BJ-M	85	100
	BX103BK-M	43 2/	100
	BX223AK-M	43 2/	50
CDR03	BP102BJ-M	85	100
	BX333BK-M	43 2/	100
	BX683AK-M	43 2/	50
CDR04	BP332BJ-M	85	100
	BX563BK-M	43 2/	100
	BX184AK-M	43 2/	50
CDR05	BP562BJ-M	85	100
	BX154BK-M	43 2/	100
	BX334AK-M	43 2/	50
CDR06	BP103BJ-M	85	100
	BX474AK-M	85	50
CDR11 and CDR12	B-101K--M 3/	43	150
	BP102A--M	43	50
CDR13 and CDR14	B-101E--M	85	500
	B-201D--M	43	300
	B-471C--M 3/	43 2/	200
	B-621B--M	43	100
	B-102A--M	43	50
	BP512A--M	43	50
CDR21 and CDR22	B-101E-TM	85	500
	B-201D-TM	43	300
	B-471C-TM 3/	43 2/	200
	B-621B-TM	43	100
	B-102A-TM	43	50
	BP512A-TM	43	50
CDR23 and CDR24	B-101E--M	85	500
	B-201D--M	43	300
	B-471C--M 3/	43 2/	200
	B-621B--M	43	100
	B-102A--M	43	50
	BP512A--M	43	50

See footnotes at end of table.

APPENDIX B

TABLE XIV. Combined-voltage submission - Continued.

Style	PIN	Number of units 1/	Rated voltage
CDR25	B-101E-SM	85	500
	B-201D-SM	43	300
	B-471C-SM 3/	43 2/	200
	B-621B-SM	43	100
	B-102A-SM	43	50
	BP512A-SM	43	50
CDR26	BP151J--M	43 2/	4000
	BX471J--M	43 2/	4000
CDR27	BP331J--M	43 2/	4000
	BX122J--M	43 2/	4000
CDR28	BP681J--M	43 2/	4000
	BX222J--M	43 2/	4000
CDR29	BP122J--M	43 2/	4000
	BX392J--M	43 2/	4000
CDR30	BP222J--M	43 2/	4000
	BX123H--M	43 2/	3000
CDR31	BP471BF-M	40	100
	BP681AF-M	40	50
	BX472BK-M	40 4/	100
	BX183AK-M	40	50
CDR32	BP102BF-M	40	100
	BP222AF-M	40	50
	BX153BK-M	40 4/	100
	BX393AK-M	40	50
CDR33	BP222BF-M	40	100
	BP332AF-M	40	50
	BX273BK-M	40 4/	100
	BX104AK-M	40	50
CDR34	BP472BF-M	40	100
	BP103AF-M	40	50
	BX563BK-M	40 4/	100
	BX184AK-M	40	50
CDR35	BP103BF-M	40	100
	BP223AF-M	40	50
	BX154BK-M	40 4/	100
	BX474AK-M	40	50

1/ Number of samples may vary with style (see table VIII). The number of units shown shall be submitted for each termination finish.
2/ Table VIII, group V samples may be split 12-13 or 13-12.
3/ The PIN will include either a letter P or G (see 1.2.1).
4/ The number 40 is derived from the qualification inspection table: 85 total, minus 6 (for fungus test) divided by 2 and rounded off to 40.

CONCLUDING MATERIAL

Custodians:
Army - ER
Navy - EC
Air Force - 85

Review activities:
Army - MI
Navy - AS, MC, OS, SH
Air Force - 19, 99
DLA - ES

Preparing activity:
Army - ER

Agent:
DLA - ES

(Project 5910-1751)

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-C-55681D	2. DOCUMENT DATE (YYMMDD)

3. DOCUMENT TITLE

CAPACITOR, CHIP, MULTIPLE LAYER, FIXED, UNENCAPSULATED, CERAMIC DIELECTRIC, ESTABLISHED RELIABILITY, GENERAL SPECIFICATION FOR

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

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	d. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

8. PREPARING ACTIVITY

a. NAME U S Army Research Laboratory Electronics and Power Sources Directorate	b. TELEPHONE (Include Area Code) (1) Commercial 908-544-3148 (2) AUTOVON 995-3148
c. ADDRESS (Include Zip Code) ATTN: AMSRL-EP-RD Fort Monmouth, NJ 07703-5601	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Quality and Standardization Office 5203 Leesburg Pike, Suite 1403, Falls Church, VA 22041-3466 Telephone (703) 756-2340 AUTOVON 289-2340