INCH-POUND
MIL-PRF-32700
21 March 2022

PERFORMANCE SPECIFICATION

CAPACITOR, FIXED, ELECTROLYTIC (CONDUCTIVE POLYMER TANTALUM), SURFACE MOUNT, NON-ESTABLISHED RELIABILITY AND ESTABLISHED RELIABILITY, GENERAL SPECIFICATION FOR

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

1. SCOPE

1.1 Scope. This specification covers the general requirements for non-established reliability (non-ER) and established reliability (ER) conductive polymer, surface mount capacitors. The ER capacitors have calculated failure rate levels (FRLs) based on a reliability assessment performed on each production lot. FRLs are of the form percentage of failures per 1,000 hours at dc rated voltage and +85°C.

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

1.2.1 Part or Identifying Number (PIN). Capacitors specified herein (see 3.1) are identified by a PIN which consists of the number of the performance specification, the performance specification sheet number, and a series of coded characters. The coded characters provide information concerning the capacitors' case size, capacitance value, capacitance tolerance, rated voltage, termination finish, product level, and surge current option. The PIN is in the following form:

M32700	01	D	157	M	B	H	X	C
Performance specification number	Specification sheet number	Case size (see 1.2.1.1)	Capacitance (see 1.2.1.2)	Capacitance tolerance (see 1.2.1.3)	Rated voltage (see 1.2.1.4)	Termination finish (see 1.2.1.5)	Product level (see 1.2.1.6)	Surge current option (see 1.2.1.7)

1.2.1.1 Case size. The case size is identified by a single letter. This letter corresponds to the case code designation specified in the applicable specification sheets (see 3.1).

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

1.2.1.3 Capacitance tolerance. The capacitance tolerance is identified by a single letter, K = ± 10%, M = ± 20 percent.

1.2.1.4 Voltage. The voltage (rated and derated) is identified by a single letter as shown in table I.

Comments, suggestions, or questions on this document should be addressed to DLA Land and Maritime, ATTN: VAT, Post Office Box 3990, Columbus, OH 43218-3990, or emailed to capacitorfilter@dla.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at https://assist.dla.mil/.

AMSC N/A
FSC 5910

TABLE I. Voltage.

Symbol	Voltage (V_{dc})	
	Rated (+85°C)	Derated (+125°C)
A	2.5	1.7
B	3	2.0
C	4	2.7
D	6.3	4.2
F	10	6.7
H	16	10.7
J	20	13.3
K	25	16.7
L	30	20.0
M	35	23.3
N	50	33.3
P	63	42.0

1.2.1.5 Termination finish. The termination finish is identified by a single letter as follows:

Symbol	Termination finish
G	Gold plated (5 microinch maximum) 1/
H	Solder plated (100 microinch minimum)

1/ Intended for solder attach.

1.2.1.6 Product level designator. The product level designator is identified by a single letter as shown in table II.

TABLE II. Product level designator.

Product level	FRL (% per 1,000 hours)
A	non-ER
X	0.1
Y	0.01
Z	0.001

1.2.1.7 Surge current option. The optional surge current tests are described in table III. This table reflects the required test temperature(s) as well as whether the surge current test is to be performed before or after the voltage aging test. The surge current option is identified by a single letter.

TABLE III. Surge current option.

Option letter	Temperatures	Sequence
A	(+25°C ± 5°C)	After voltage aging
B	(-55°C -5°C, +0°C and +85°C ±5°C)	After voltage aging
C	(-55°C -5°C, +0°C and +85°C ±5°C)	Before voltage aging
Z	No surge current test	Not applicable

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 cited in the solicitation or contract.

DEPARTMENT OF DEFENSE SPECIFICATION

MIL-PRF-32700/1	-	Capacitor, Fixed, Electrolytic (Conductive Polymer), Surface Mount, Non-Established Reliability and Established Reliability, Molded, Single Anode
MIL-PRF-32700/2	-	Capacitor, Fixed, Electrolytic (Conductive Polymer), Surface Mount, Non-Established Reliability and Established Reliability, Molded, Multiple Anode

(Copies of these documents are available online at https://quicksearch.dla.mil/.)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-202	-	Test Methods Standard Electronic and Electrical Component Parts
MIL-STD-202-103	-	Method 103, Humidity (Steady State)
MIL-STD-202-107	-	Method 107, Thermal Shock
MIL-STD-202-108	-	Method 108, Life (at Elevated Ambient Temperature)
MIL-STD-202-204	-	Method 204, Vibration, High Frequency
MIL-STD-202-208	-	Method 208, Solderability
MIL-STD-202-210	-	Method 210, Resistance to Soldering Heat
MIL-STD-202-215	-	Method 215, Resistance to Solvents
MIL-STD-202-305	-	Method 305, Capacitance
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-1285	-	Marking of Electrical and Electronic Parts

(Copies of these documents are available online at https://quicksearch.dla.mil/.)

2.3 Non-Government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES (IPC)

IPC/JEDEC J-STD-002	-	Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires
IPC/JEDEC J-STD-020	-	Moisture/Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices

(Copies of these documents are available online at https://www.ipc.org/.)

SAE INTERNATIONAL (SAE)

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

(Copies of these documents are available online at https://www.sae.org/.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein (except for related specification sheets), 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 (see 6.2).

3.2 Qualification. Capacitors furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list (QPL) before contract award (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. In addition, the manufacturer shall also establish a Statistical Process Control (SPC) and Part Per Million (ppm) system that meets the requirements as detailed in 3.3.1 and 3.3.2 respectively

3.3.1 SPC system. As part of the overall MIL-STD-790 QPL system, the manufacturer shall establish an SPC system that meets the requirements of SAE EIA-557. Typical manufacturing processes include: Pressing, sintering, electrochemical processing, encapsulating, and packaging.

3.3.2 PPM system. As part of the overall MIL-STD-790 QPL system, the manufacturer shall establish a ppm system of assessing the average outgoing quality of lots in accordance with SAE EIA-554-1. Data exclusion, in accordance with SAE EIA-554-1 may be used with approval of the qualifying activity. The ppm system shall identify the ppm rate at the end of each month and shall be based on a 6-month moving average. Style reporting may include non-established reliability, established reliability, and high reliability style combinations.

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

3.4.1 Pure tin. The use of pure tin, as an underplate or final finish, is prohibited both internally and externally. Tin content of capacitor components and solder shall not exceed 97 percent, by mass. Tin shall be alloyed with a minimum of 3 percent lead, by mass (see 6.6).

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

3.5.1 Body structure. The body structure shall be of molded form.

3.5.2 Terminals. Unless otherwise specified (see 3.1), terminals shall be of a solid conductor, of the dimensions specified (see 3.1), and shall be suitably treated to facilitate soldering.

3.6 DC leakage. When measured as specified in 4.7.1, the dc leakage shall not exceed the applicable value specified (see 3.1).

3.7 Capacitance. When measured as specified in 4.7.2, the capacitance shall be within the applicable tolerance specified (see 3.1).

3.8 Dissipation factor. When measured as specified in 4.7.3, the dissipation factor shall not exceed the value specified (see 3.1).

3.9 Equivalent series resistance. When measured as specified in 4.7.4, the equivalent series resistance shall not exceed the specified value (see 3.1).

3.10 Reflow conditioning. Capacitors shall be conditioned as specified in 4.7.5.

3.11 Thermal shock. Capacitors shall be conditioned as specified in 4.7.6.

3.12 Surge current option (when specified, see 1.2.1.7). When tested as specified in 4.7.7, capacitors shall meet the following requirements:

a. DC leakage: As specified in 3.6.

b. Capacitance: As specified in 3.7.

c. Dissipation factor: As specified in 3.8.

3.13 Voltage aging. When tested as specified in 4.7.8, capacitors shall meet the following requirements:

a. DC leakage: As specified in 3.6.

b. Capacitance: As specified in 3.7.

c. Dissipation factor: As specified in 3.8.

d. Equivalent series resistance: As specified in 3.9.

3.14 Stability at low and high temperatures. When tested as specified in 4.7.10, capacitors shall meet the following requirements:

a. Step 1 (+25°C):

(1) DC leakage: As specified in 3.6.

(2) Capacitance: As specified in 3.7.

(3) Dissipation factor: As specified in 3.8.

(4) Equivalent series resistance: As specified in 3.9.

b. Step 2 (-55°C):

(1) Capacitance: Shall change not more than ±10 percent from the step 1 measured value. For capacitors rated less than 6 V_{dc}, shall change not more than +10 percent, -20 percent from the step 1 measured value.

(2) Dissipation factor: As specified in 3.8.

(3) Equivalent series resistance: Shall not exceed 120 percent of the initial requirement.

c. Step 3 (+25°C):

(1) DC leakage: As specified in 3.6.

(2) Capacitance: Shall change not more than ±10 percent from the step 1 measured value.

(3) Dissipation factor: As specified in 3.8.

(4) Equivalent series resistance: As specified in 3.9.

d. Step 4 (+85°C):

(1) DC leakage: Shall not exceed 10 times the initial requirement.

(2) Capacitance: Shall change not more than +30 percent, -10 percent from the step 1 measured value.

(3) Dissipation factor: Shall not exceed 120 percent of the initial requirement.

(4) Equivalent series resistance: Shall not exceed 120 percent of the initial requirement.

e. Step 5 (+125°C):

(1) DC leakage: Shall not exceed 10 times the initial requirement.

(2) Capacitance: Shall change not more than +40 percent, -10 percent from the step 1 measured value.

(3) Dissipation factor: Shall not exceed 150 percent of the initial requirement.

(4) Equivalent series resistance: Shall not exceed 150 percent of the initial requirement.

f. Step 6 (+25°C):

(1) DC leakage: As specified in 3.6.

(2) Capacitance: Shall change not more than ±10 percent from the step 1 measured value.

(3) Dissipation factor: As specified in 3.8.

(4) Equivalent series resistance: As specified in 3.9.

3.15 Solderability. When capacitors are tested as specified in 4.7.11, the dipped portion of the terminations shall conform to the solid-wire termination criteria of MIL-STD-202-208. Solderable surfaces shall be as specified (see 3.1).

3.16 Reliability assessment (when specified, see 1.2.1.6). If applicable (see 1.2.1), a FRL shall be established for each production lot as specified in 4.7.12.

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

a. DC leakage: As specified in 3.6.

b. Capacitance: Shall change not more than ±20 percent from the initial measured value.

c. Dissipation factor: As specified in 3.8.

d. Visual examination: There shall be no evidence of mechanical damage.

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

a. DC leakage: Shall not exceed 200 percent of the requirement specified in 3.6.

b. Capacitance: Shall change not more than +35 percent, -5 percent from the initial measured value.

c. Dissipation factor: Shall not exceed 150 percent of the requirement specified in 3.8.

d. Equivalent series resistance: Shall not exceed 200 percent of the specified value (see 3.1).

e. Visual examination: There shall be no mechanical damage and the marking shall remain legible.

3.19 Resistance to solvents. When tested as specified in 4.7.15, capacitors shall meet the requirements of MIL-STD-202-215 and 3.25. Marking shall remain legible and shall not smear.

3.20 Life. When tested as specified in 4.7.16, capacitors shall meet the following:

a. At +25°C:

(1) DC leakage: Shall not exceed 125 percent of the specified value (see 3.1).

(2) Capacitance: Shall change not more than +10 percent, -20 percent from the initial measured value.

(3) Dissipation factor: As specified in 3.8.

(4) Equivalent series resistance:

(a) Life (at +85°C): Shall not exceed 200 percent of the specified value (see 3.1).

(b) Life (at +125°C): Shall not exceed 500 percent of the specified value (see 3.1).

b. At +85°C or +125°C, as applicable: DC leakage shall not exceed 200 percent of the specified value (see 3.1).

c. Visual examination: There shall be no evidence of harmful corrosion, obliteration of marking, or mechanical damage.

3.21 Vibration, high frequency (qualification only). When capacitors are tested as specified in 4.7.17, there shall be no intermittent contacts of 0.5 ms or greater duration, or arcing, or other indication of breakdown, nor shall there be any open-circuiting or short-circuiting or evidence of mechanical damage.

3.22 Moisture sensitivity level (MSL). When determining the MSL as specified in 4.7.18, capacitors shall meet the following:

a. DC leakage: As specified in 3.6.

b. Capacitance: Shall change not more than ±20 percent from the initial measured value.

c. Dissipation factor: As specified in 3.8.

d. ESR: As specified in 3.9.

e. Final visual inspection: There shall be no visible external cracks.

3.23 Marking.

3.23.1 Capacitor marking. Capacitors shall be marked in accordance with method I of MIL-STD-1285 and as shown below. Print orientation is optional. At the option of the manufacturer, the date code and lot symbol may be marked on the top of the case for any case size. Additional marking may appear provided that it does not interfere with the required marking.

J	(+)	polarity stripe, J = JAN
105	-	capacitance in picofarad code (see 1.2.1.2)
35X	-	rated voltage and manufacturer's source code

For smaller case sizes (see 3.1), capacitors may be marked as follows:

J	(+)	polarity stripe, J = JAN
105X	-	capacitance in picofarad code (see 1.2.1.2) and manufacturer's source code

Or,

X	(+)	polarity stripe, X = manufacturer's source code
105J	-	capacitance in picofarad code (see 1.2.1.2), J = JAN

3.23.2 Package marking. At a minimum, the following information shall be marked on the packaging.

a. "JAN" brand.

b. PIN (see 1.2.1).

c. Manufacturer's source code in accordance with MIL-STD-1285.

d. Date code.

e. Lot symbol.

f. MSL rating.

3.23.3 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 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" 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 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, 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 2,577,735 for the certification mark "J".

3.23.4 Substitution of product levels. The manufacturer may substitute, with acquiring activity approval, product levels in accordance with table IV. Note: If a manufacturer possesses inventory that has been tested to a higher product level than that ordered, the manufacturer may supply it against that order for a lesser product level in accordance with table IV. In this case, the product level marking shall match that ordered.

TABLE IV. Product level substitutability.

Product level	May be substituted for product level
Z	A, X, and Y
Y	A and X
X	A

3.23.5 Substitution of capacitance tolerance and rated voltage. Capacitors qualified and marked to tighter capacitance tolerance or higher rated voltage, with acquiring activity approval, are substitutable for parts marked to looser capacitance or lower rated voltage, provided all other values, such as case size, termination finish, product level, surge current option, and the additional testing option shall remain the same. Unless otherwise specified in the contract or order (see 6.2), the substitutable parts shall not be remarked. In the event the capacitance tolerances or

rated voltages are remarked, the lot number date codes on the parts shall not be changed and the workmanship (see 3.24) criteria shall be met.

3.23.6 Surge current option substitutability. At the option of the manufacturer, surge current options may be substituted for other surge current options as shown below. All other values, as listed in 3.22.4, shall remain the same. Unless otherwise specified in the contract or order (see 6.2), the parts shall not be remarked.

Surge current code	May be substituted for surge current code
C	A, B, Z
B	A, Z
A	Z

3.24 Recycled, recovered, environmentally preferable, or biobased materials. Recycled, recovered, environmentally preferable, or biobased 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.

3.25 Workmanship. Capacitors shall be processed in such a manner that, when examined under 10X magnification, they shall be uniform in quality and shall be free from pits, cracks, rough edges, and other defects that will affect life, serviceability, or function. The capacitors shall exhibit no de-metallization (lift-off) on the terminations.

4. VERIFICATION

4.1 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. Conformance inspection (see 4.6).

d. Periodic inspection (see 4.6.3).

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

4.3 Inspection conditions and reference measurements.

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

4.3.2 AC measurements. AC measurements shall be made at the frequency specified. The magnitude of the ac voltage shall be equal to or less than 1.0 volt root mean square (rms). The maximum dc bias voltage shall be equal to or less than 2.2 volts.

4.3.3 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 ±3°C prior to conditioning. Unless reference measurements have been made within 30 days prior to the beginning of conditioning, they shall be repeated.

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

4.3.5 Mounting. Mounting is optional for test environments; however, when specified in the test procedures, the capacitors shall be mounted on a suitable substrate (e.g., 96 percent alumina, G30 or FR4 glass epoxy). The substrate material shall be such that it shall 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 “test card” land areas.

b. Solder paste shall be applied to terminals and substrates as applicable or alternative reflow techniques may be used.

c. The capacitor shall then be placed across the metallized land areas of the test substrate so as to make contact between chip and substrate land areas.

d. The substrate shall be exposed to +135°C ±15°C for a minimum of 1 minute. The substrate shall then be transitioned to +245°C ±5°C. The substrate shall remain at +245°C ±5°C until the solder paste melts and reflows forming a homogenous solder bond to the metallized substrate.

e. All excess flux or solder shall be removed.

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. Qualification approval will be based on the successful completion of the tests specified in table V.

4.4.1 Sample size. The number of capacitors to be subjected to qualification inspection shall be as specified in table V and appendix A of this specification.

4.4.2 Inspection routine. The sample shall be subjected to the inspections specified in table V. All sample units shall be subjected to the inspections of group I. The sample units successfully completing group I inspection shall then be divided in accordance with table V as applicable. Group I through group VI may be omitted if the lot has successfully passed group A inspection (see table VI) prior to qualification testing.

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

4.5 Verification of qualification. Every 12 months, the manufacturer shall provide verification of qualification to the qualifying activity. Continuation of qualification shall be based on meeting the following requirements:

a. MIL-STD-790 program.

b. The capacitor design has not been modified.

c. Lot rejection for group A does not exceed 5 percent or one lot, whichever is greater.

d. Periodic inspection.

f. PPM assessment. The ppm level defect shall be maintained for each performance specification sheet.

In the event that no production occurred during the reporting period, the manufacturer shall certify that it retains the capabilities and facilities necessary to produce the item. If during 2 consecutive reporting periods there has been no production, the manufacturer may be required, at the discretion of the qualifying activity, to submit the products to testing in accordance with the qualification inspection requirements.

TABLE V. Qualification inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of sample units to be inspected	Number of failures allowed 1/
Group I (screening) 2/				
Reflow conditioning	3.10	4.7.5		
Thermal shock	3.11	4.7.6		
Surge current option C 3/	3.12	4.7.7	100% 1/	N/A
Voltage aging	3.13	4.7.8		
Surge current options A or B 3/	3.12	4.7.7		
Group II 2/				
Visual examination				
Materials	3.4	4.7.9	table VII	0
Marking	3.23		5/	
Workmanship	3.25			
Group III 2/				
Mechanical examination	3.5	4.7.9	5	0
Group IV 2/				
Stability at low and high temperature	3.14	4.7.10	13	0
Group V 2/				
Solderability	3.15	4.7.11	13	0
Group VI 2/				
Reliability assessment 4/	3.16	4.7.12	100 (min.)	1
Group VII				
Resistance to soldering heat	3.17	4.7.13	18	1
Biased humidity	3.18	4.7.14		
Group VIII				
Resistance to solvents	3.19	4.7.15	8	0
Group IX				
Life (at +85°C)	3.20	4.7.16	45	1
Group X				
Life (at +125°C)	3.20	4.7.16	24	1
Group XI				
Vibration, high frequency	3.21	4.7.17	12	1
Group XII				
Moisture sensitivity level	3.22	4.7.18	22	6/

1/ The number of capacitors submitted to group I shall be sufficient to meet the sampling requirements for group II through group XII, as applicable, and the number of failures allowed.
2/ Group I through group VI may be omitted if the lot has successfully passed group A inspection (see table VI) prior to qualification testing.
3/ The surge current option performed, if applicable, shall be the option for which qualification is being sought (see A.3.5).
4/ The FRL used in the reliability assessment calculation (see 4.7.12) shall be the FRL of the product level (see table II) for which qualification is being sought (see A.3.6).
5/ The number of capacitors submitted to group II shall be based on the number of capacitors submitted to group I and table VII.
6/ In accordance with J-STD-020. No failures allowed. If there are failures during testing for a particular MSL, testing may be repeated for a different level.

4.6 Conformance inspection.

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

4.6.1.1 Inspection and production lot.

4.6.1.1.1 Inspection lot. An inspection lot shall consist of capacitors of the same specification sheet (see 3.1), from the same production line or lines, of the same basic design, produced under essentially the same conditions, and offered for inspection during a single month. The capacitance values and voltages produced shall be represented in the lot in approximately the ratio of production.

4.6.1.1.2 Production lot. A production lot shall consist of all capacitors of the same voltage rating, nominal capacitance value, case size, 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. All anodes shall be fabricated from a single identifiable powder lot.

4.6.2 Group A inspection. Group A inspection shall consist of the inspections specified in table VI and shall be made on the same set of sample units. Subgroups 2 through 6 may be performed in any order after subgroup 1.

4.6.2.1 Manufacturer's additional inspection. The manufacturer may perform additional proprietary tests as a part of the group A inspection. The following criteria shall be complied with:

a. The additional inspection shall be approved by the qualifying activity and shall be included in the approved manufacturing flow. Future changes require approval from the qualifying activity.

b. One hundred percent of the product shall be subjected to this inspection.

TABLE VI. Group A inspection.

Inspection	Requirement paragraph	Test method paragraph	Number of units to be inspected	Number of defectives permitted
Subgroup 1 (screening) Reflow conditioning Thermal shock (unmounted) Surge current option C Voltage aging Surge current options A or B	 3.10 3.11 3.12 3.13 3.12	 4.7.5 4.7.6 4.7.7 4.7.8 4.7.7	100%	1/
Subgroup 2 Visual examination Materials Marking Workmanship	 3.4 3.23 3.25	 4.7.9	 table VII	 0
Subgroup 3 Mechanical examination	3.5	4.7.9	5	0
Subgroup 4 Stability at low and high temperature	3.14	4.7.10	13	0
Subgroup 5 Solderability	3.15	4.7.11	13	0
Subgroup 6 Reliability assessment (when applicable, see 1.2.1.6)	3.16	4.7.12	100 (minimum)	1

1/ Percent defectives allowable (PDA) for subgroup 1 is 5 percent; rejects shall not be delivered on the contract or order. Surge current failures do not count against the PDA.

TABLE VII. Sampling plans for visual examination.

Lot size			Sample size
1	-	13	100%
14	-	150	13
151	-	280	20
281	-	500	29
501	-	1,200	34
1,201	-	3,200	42
3,201	-	10,000	50
10,001	-	35,000	60
35,001	-	150,000	74
150,001	-	500,000	90
500,001	-	UP	102

4.6.2.2 Subgroup 1. Subgroup 1 tests shall be performed on a production lot basis on 100 percent of the product supplied under this specification. Capacitors failing the tests of subgroup 1 shall be removed from the lot. If during the 100 percent inspection, screening requires that more than 5 percent (5 percent PDA) of the capacitors be discarded due to catastrophic or dc leakage failures, the entire lot shall be rejected. Surge current failures do not count against the PDA.

4.6.2.2.1 Manufacturer's production inspection. If the manufacturer performs tests similar to those specified in group A, subgroup 1, as the final step of the manufacturing process, the subgroup 1 test may be eliminated when approved by the qualifying activity. The following criteria shall be complied with:

a. The manufacturer production tests are identical or more stringent than those specified for subgroup 1 tests.

b. One hundred percent of the product shall be subjected to these tests.

c. Failure criteria are identical, the same as, or more stringent than, the subgroup 1 tests.

d. Lot rejection criteria are identical to, or more stringent than, the subgroup 1 tests.

e. Once approved, future changes require approval from the qualifying activity.

4.6.2.3 Subgroup 2. Subgroup 2 shall be performed on an inspection lot basis in accordance with table VI based on the size of the inspection lot. In the event of one or more failures, the lot shall be rejected.

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

4.6.2.4 Subgroup 3. Subgroup 3 tests shall be performed on an inspection lot basis. In the event of one or more failures, the lot shall be rejected.

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

4.6.2.5 Subgroup 4. Subgroup 4 shall be performed on an inspection lot basis on 13 sample units with no failures allowed.

4.6.2.5.1 Rejected lots. If there are one or more defects, the lot shall be rejected. Rejected lots may be reprocessed using one or more of the following options:

a. The individual production lot, or lots, from which the defect originated shall be individually subjected to the subgroup 4 test as required in group A inspection, subgroup 4. Production lots that pass the subgroup 4 test are available for shipment. Production lots that fail subgroup 4 may be reprocessed.

b. The manufacturer shall submit the failed inspection lot to a 100 percent reprocessing. Thirteen additional samples shall then be selected and subjected to the subgroup 4 test with no defects allowed. If the inspection lot fails this test, the inspection lot shall be considered rejected and shall not be furnished against the requirements of this specification.

4.6.2.6 Subgroup 5. Subgroup 5 shall be performed on an inspection lot basis on 13 sample units with no failures allowed. The manufacturer may use electrical rejects from the subgroup 1 screening tests for all or part of the samples to be used for solderability testing.

4.6.2.6.1 Rejected lots. If there are one or more defects, the lot shall be rejected. The individual production lot or lots, from which the defect(s) originated shall be individually subjected to the solderability test as required in 4.6.2.6. Production lots that pass the solderability test are available for shipment. Production lots that fail the solderability test shall not be supplied on the contract or order.

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

4.6.2.7 Subgroup 6. The reliability assessment shall be performed on a production lot basis for product levels X, Y, and Z. In the event of two or more failures, the lot shall be rejected.

4.6.2.7.1 Rejected lots. Rejected lots shall not be furnished against the requirements of this specification for the product level tested (see 1.2.1.6). At the option of the manufacturer, the reliability assessment may be repeated to a lower product level. In the event of two or more failures during this second assessment, the lot shall be considered rejected and shall not be furnished against the requirements of this specification.

4.6.2.8 PPM calculations. The manufacturer shall establish a ppm system in accordance with 3.3.2 for assessing and calculating average outgoing quality of capacitors. A ppm rate combining dc leakage, capacitance, dissipation factor, and ESR shall be assessed for lots that have passed the group A inspection. The manufacturer's ppm system shall also address rectification procedures for lots failing ppm assessment. Data from the rectification process shall not be used to calculate ppm.

4.6.3 Group B inspection (periodic). Group B inspection shall consist of the tests specified in table VIII and shall be performed on sample units selected from inspection lots which have passed group A inspection. Except where the results of this inspection show noncompliance with the applicable requirements (see 4.6.3.3), delivery of capacitors which have passed group A inspection shall not be delayed pending the results of this inspection.

4.6.3.1 Sampling plan.

4.6.3.1.1 Subgroup 1 through subgroup 3. The number of sample units required by table VIII shall be selected from production every 6 months. The maximum and minimum case sizes from each specification sheet (see 3.1) manufactured during that 6-month period shall be represented in the sample in at least the approximate ratio of production. Allowable failures shall be as specified in table VIII.

4.6.3.1.2 Subgroup 4. The number of sample units required by table VIII shall be selected from production every 3 years. The maximum and minimum case sizes from each specification sheet (see 3.1) manufactured during that 3-year period shall be represented in the sample in at least the approximate ratio of production. Allowable failures shall be as specified in table VIII.

4.6.3.1.3 Subgroup 5. The number of sample units required by table VIII shall be selected from production every 12 months. A separate sample shall be selected for each MSL level applicable to the manufacturer. The maximum and minimum case sizes from each specification sheet (see 3.1) manufactured during that 12-month period shall be represented in the sample in at least the approximate ratio of production. Allowable failures shall be as specified in table VIII.

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

4.6.3.3 Noncompliance. If the sample fails to pass group B inspection, the supplier 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 and processes, 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 B inspection shall be repeated on additional sample units (all inspections or the inspection that the original sample failed, at the option of the Government). Group A inspection may be reinstituted; however, final acceptance shall be withheld until the group B re-inspection has shown the corrective action was successful. In the event of failure after re-inspection, information concerning the failure and corrective action taken shall be furnished to the cognizant inspection activity and the qualifying activity.

TABLE VIII. Group B inspection (periodic).

Inspection	Requirement paragraph	Test method paragraph	Number of units to be inspected	Number of defectives permitted
Subgroup 1				
Resistance to soldering heat	3.17	4.7.13	18	1
Biased humidity	3.18	4.7.14		
Subgroup 2				
Resistance to solvents 1/	3.19	4.7.15	8	0
Subgroup 3				
Life (at +85°C)	3.20	4.7.16	24	1
Subgroup 4				
Life (at +125°C)	3.20	4.7.16	24	1
Subgroup 5				
Moisture sensitivity level 1/	3.22	4.7.18	22	2/

1/ If the manufacturer can demonstrate that this test has been performed five consecutive times with zero failures, this test can be deleted with the approval of the qualifying activity. 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.

2/ In accordance with J-STD-020. No failures allowed. If there are failures during testing for a particular MSL, testing may be repeated for a different level.

4.7 Methods of inspection.

4.7.1 DC leakage (see 3.6). DC leakage shall be measured using the applicable dc rated voltage (see table I) ±2 percent at the applicable test temperature (see 3.1), after a maximum electrification period of 5 minutes. A 1,000 ohm resistor shall be placed in series with the capacitor to limit the charging current. A steady source of power, such as a regulated power supply shall be used. Unless otherwise specified (see 3.1), measurement accuracy shall be within ±2 percent or 0.02 microampere (μA), whichever is greater (see 4.3.3).

If the dc leakage exceeds the specified limit (see 3.1), a second measurement is permitted and shall be considered the official measurement. This second measurement shall be taken immediately following the initial measurement

and following a shorting and re-electrification of the capacitor. If the second dc leakage measurement exceeds the limit specified (see 3.1), the part shall be considered a failure. Both the initial and second measurement shall be included in the test report.

4.7.2 Capacitance (see 3.7) Capacitors shall be tested in accordance with MIL-STD-202-305. Unless otherwise specified (see 3.1), the following details shall apply:

a. Test frequency: 120 Hz ±5 Hz.

b. Limit of accuracy: Measurement accuracy shall be within ±2 percent of the reading.

c. Magnitude of polarizing voltage: Maximum dc bias shall be 2.2 volts for all ac measurements. The magnitude of the ac voltage shall be limited to 1.0 volt rms.

4.7.3 Dissipation factor (see 3.8). Unless otherwise specified (see 3.1), the dissipation factor shall be measured at a frequency of 120 Hz ±5 Hz by means of a polarized capacitance bridge. The bridge shall provide a dial reading of 0.1 percent dissipation factor and a measuring accuracy of ± (2 percent of the measured dissipation factor plus 0.1 percent).

4.7.4 Equivalent series resistance (see 3.9). The Equivalent series resistance shall be measured at the applicable test temperature in accordance with the following:

a. Test frequency: 100kHz ±5 kHz.

b. Limit of accuracy: Measurement accuracy shall be within ±5.0 percent of the reading.

c. Magnitude of polarizing voltage: Unless otherwise specified (see 3.1), the maximum dc bias shall be 2.2 volts for all ac measurements. The magnitude of the ac voltage shall be limited to 0.5 volt rms maximum.

4.7.5 Reflow conditioning (see 3.10). Reflow conditioning is a screening process to help remove components with weak internal bonds. The following details should not be used as a production assembly guideline. Capacitors shall be conditioned as follows:

a. Mounting of specimens: Not applicable.

b. Measurements before and after conditioning: Not applicable.

c. Number of cycles: 1.

d. Peak temperature: +230°C minimum.

e. Time above +183°C: 45 seconds minimum.

f. Time at +230°C or above: 5 seconds minimum.

g. Ramp rate (+183°C to peak temperature): 1°C per second to 4°C per second.

h. Examination after test: Not applicable.

4.7.6 Thermal shock (see 3.11). Capacitors shall be tested in accordance with MIL-STD-202-107. The following details and exceptions shall apply:

a. Mounting of specimens: Not applicable.

b. Initial measurements: Not applicable.

c. Test condition letter: A (5 cycles), except that in step 3, sample units shall be tested at +125°C +3°C, -0°C. At the option of the manufacturer, step 3 may be performed at +150°C +3°C, -0°C. At the option of the manufacturer, step 1 may be performed at -65°C +0°C, -5°C.

d. Measurements after thermal shock: Not applicable.

e. Examination after test: Not applicable.

4.7.7 Surge current option (see 3.12). When specified (see 1.2.1.7), surge current shall be performed on a 100 percent basis either before or after voltage aging (see 3.12) as indicated in 4.7.7a. Capacitors shall be subjected to ten cycles at each temperature:

a. Temperature: Option A (after voltage aging): +25°C ±5°C
Option B (after voltage aging): -55°C -5°C, +0°C and +85°C ±5°C
Option C (before voltage aging): -55°C -5°C, +0°C and +85°C ±5°C
Option Z or no option: No test required.

b. An individual test circuit is required for each capacitor under test.

c. Applied voltage: Rated dc voltage ±2 percent from a power source having a minimum energy storage bank of 20 times the capacitor under test across the output terminals.

d. Charge cycle: 1 second minimum.

e. Discharge cycle: 1 second, minimum, to a voltage below 1 percent of rated voltage.

f. The total dc resistance (excluding the capacitor) including the wiring, fixturing, and output impedance of the regulated power supply to each test position during the charging cycle shall be a maximum of 1.0 ohm.

g. The minimum peak charge/discharge current value shall be:

$V_r/(1 + ESR_{CAP})$

Where: At +25°C and +85°C, ESR_{CAP} = ESR as specified (see 3.1)
At -55°C, ESR_{CAP} = 2 x ESR as specified (see 3.1)

h. Failure criteria: A failure is specified as any capacitor that draws 1 ampere after the appropriate charge time (see 4.7.7i).

i. Charge time:

Maximum Charge time (ms)	Capacitance value (µF)
10	<47
25	≥ 47 and <100
100	≥ 100

j. Measurements after test: After the final cycle, the dc leakage, capacitance, and dissipation factor shall be measured as specified in 4.7.1, 4.7.2, and 4.7.3, respectively.

4.7.8 Voltage aging (see 3.13). Capacitors shall be subjected to a minimum of 100 percent of dc rated voltage for 40 hours, minimum, at a temperature of +85°C ±5°C. The voltage aging circuit shall have a series resistance of 3.0 ohms, maximum. Capacitors shall then be stabilized at room temperature and the dc leakage, capacitance, dissipation factor, and equivalent series resistance shall then be measured as specified in 4.7.1, 4.7.2, 4.7.3, and 4.7.4, respectively.

4.7.9 Visual and mechanical inspection. Capacitors shall be examined to verify that the materials, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.4, 3.5, 3.23, and 3.25).

4.7.10 Stability at low and high temperatures (see 3.14). Capacitors shall be dried at +125°C ±5°C for 30 minutes +4 minutes, -0 minutes, prior to start of test. DC leakage, capacitance, dissipation factor, and equivalent series resistance shall then be measured as specified in 4.7.1, 4.7.2, 4.7.3, and 4.7.4, respectively, at each of the temperatures specified in table IX, except that dc leakage measurements at -55°C (step 2) are not required. After the measurements of capacitance and dissipation factor have been made at the -55°C temperature (step 2), rated voltage shall be applied through a 33-ohm resistor for the minimum of 5 minutes. The capacitors shall be brought to thermal stability at each temperature.

TABLE IX. Temperature for stability test.

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

4.7.11 Solderability (see 3.15). Capacitors shall be tested in accordance with MIL-STD-202-208. The following details and exceptions shall apply:

a. Test method: B.

b. Coating durability: 2 as specified in J-STD-002, except preconditioning category C (8 hours ±15 minutes steam conditioning).

c. Procedure: Mounting surfaces shall be dipped to cover the normal mounting surfaces (see 3.1). After the test, the solderable surfaces shall be examined. At the option of the manufacturer, following steam conditioning, the samples may have a 30 minute bake out at +150°C prior to solder dipping.

4.7.12 Reliability assessment (when specified, see 1.2.1.6) (see 3.16). Capacitors shall be tested in accordance with MIL-STD-202-108. The following detail and exceptions shall apply.

a. Mounting: Capacitors shall be mounted using 2 reflows as specified in 4.3.5.

b. Test temperature and tolerance: Capacitors shall be tested at temperatures between +85°C and +129°C.

c. Operating conditions: Regardless of the test temperature, a minimum of 1 times the +85°C dc rated voltage (see 3.1) shall be applied gradually (not to exceed 5 minutes either by a slow buildup of the voltage or through a resistor which shall be shorted out within 5 minutes). A maximum of 2 times the dc rated voltage shall be used. Voltage shall be applied continuously. The impedance of the voltage source, as seen from the terminals of each capacitor, shall not exceed 3 ohms. Storage batteries or an electronic power supply capable of supplying at least 1 ampere when a capacitor is shorted shall be used.

d. Test condition letter: Not applicable.

e. Duration of test: The duration of the test shall be determined by the manufacturer depending the failure rate level desired (see 1.2.1.6), but shall be a minimum of 100 hours.

f. Failure determination: There shall be a 1-amp fuse in line with each capacitor on test. Slow blow fuses shall not be used. Failures shall be determined by blown fuses. All failures shall be counted, including those that occur during the voltage ramp.

g. Failure rate level calculation: The lot FRL shall be calculated as follows:

$$FRL = \frac{Fx10^5}{(N)(T_{test})(A_V)(A_T)}$$

Where:
FRL = failure rate level in percent per 1,000 hours at dc rated voltage and +85°C.
F = number of failures as determined in 4.7.12f.
N = number of capacitors on test.
T_{test} = test duration in hours (see 4.7.12e).
A_V = voltage acceleration factor. 1/
A_T = temperature acceleration factor. 1/

Example:

For FRL Z (0.001%/1,000 hrs.), 1 failure is permitted in 10^8 accumulated part hours. If the test involves 100 capacitors on test for 100 hours, the product of the $A_V x A_T$ must be 10^4. If $F=0$, 1 failure shall be assumed.

1/ A_V and A_T shall be calculated as specified in appendix B.

4.7.13 Resistance to soldering heat (see 3.17). Capacitors shall be tested in accordance with MIL-STD-202-210. The following details and exception shall apply:

a. Mounting of specimens: Capacitors shall be mounted on a substrate as specified in 4.3.5.

b. Measurements prior to test: DC leakage, capacitance, and dissipation factor shall be measured as specified in 4.7.1, 4.7.2, and 4.7.3, respectively.

c. Test condition letter: J, except with only one heat cycle. The combination of the mounting process and one heat cycle is effectively equivalent to two heat cycles.

d. Measurements after test: After completion of the cleaning process and following a minimum 3 hour cooling period, the dc leakage, capacitance, and dissipation factor shall be measured as specified in 4.7.6, 4.7.7, and 4.7.8, respectively.

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

4.7.14 Biased humidity (see 3.18). Capacitors shall be tested in accordance with MIL-STD-202-103. The following details and exceptions shall apply:

a. Initial conditioning: Not required.

b. Test duration: As specified (see 3.1).

c. Initial measurements: Capacitance in accordance with 4.7.2.

d. Operating conditions: Capacitors shall be subjected to an environment of +85°C ± 2°C with 85 to 95 percent relative humidity for the specified test duration (see 3.1). The dc rated voltage (see 3.1) shall be applied continuously.

e. Final measurements: 24 hours ±4 hours after the completion of test, dc leakage, capacitance, dissipation factor, and equivalent series resistance shall be measured at room ambient conditions as specified in 4.7.1, 4.7.2, 4.7.3, and 4.7.4, respectively.

f. Examination after test: Capacitors shall be visually examined for evidence of harmful corrosion, mechanical damage, and obliteration of marking.

4.7.15 Resistance to solvents (see 3.19). Capacitors shall be tested in accordance with MIL-STD-202-215.

4.7.16 Life (see 3.20). Capacitors shall be tested in accordance with MIL-STD-202-108. The following details and exceptions shall apply:

a. Method of mounting: As specified in 4.3.5.

b. Test temperature and tolerance.

(1) Qualification group IX (see table V) and group B subgroup 3 (see table VIII): +85°C +4°C, -0°C.

(2) Qualification group X (see table V) and group B subgroup 4 (see table VIII): +125°C +4°C, -0°C.

c. Operating conditions: A minimum of dc rated voltage at +85°C or dc derated voltage at +125°C, as applicable (see 3.1 and table I) shall be applied gradually (not to exceed 5 minutes either by a slow buildup of the voltage or through a resistor which shall be shorted out within 5 minutes). Voltage shall be applied continuously, except for measurement periods. The impedance of the voltage source, as seen from the terminals of each capacitor, shall not exceed 3 ohms. Storage batteries or an electronic power supply capable of supplying at least 1 ampere when a capacitor is shorted shall be used.

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

e. Measurements during the exposure: DC leakage at the applicable high test temperature shall be measured as specified in 4.7.1 at 0 hour; 240 hours +72, -24 hours; 1,000 hours +72, -24 hours; and 2,000 hours +96, -0 hours.

f. Measurement after exposure: Capacitors shall be returned to the inspection conditions specified in 4.3, and visually examined for evidence of mechanical damage; dc leakage, capacitance, dissipation factor, and equivalent series resistance shall be measured as specified in 4.7.1, 4.7.2, 4.7.3, and 4.7.4, respectively.

4.7.17 Vibration, high frequency (qualification only) (see 3.21). Capacitors shall be tested in accordance with MIL-STD-202-204. The following details and exceptions shall apply:

a. Mounting of specimens: Capacitors shall be mounted on a substrate as specified in 4.3.5.

b. Electrical-load conditions: During the test, the specified dc rated voltage (see 3.1) shall be applied to the capacitors.

c. Test condition letter: D (20g).

d. Duration and direction of motion: 4 hours in each of two mutually perpendicular directions (total of 8 hours), one parallel and the other perpendicular to the axis.

e. Measurements during vibration: During the last cycle of each plane, electrical measurements shall be made to determine the intermittent open or short circuits. Intermittent contact and arcing shall also be determined. Detecting equipment shall be sufficiently sensitive to detect any interruption with a duration of 0.5 ms or greater.

f. Measurements after vibration: Not applicable

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

4.7.18 Moisture Sensitivity level (see 3.22). The MSL of the capacitors specified herein shall be determined in accordance with J-STD-020. The following details and exceptions shall apply:

a. Initial electrical test: DC leakage, capacitance, dissipation factor, and ESR shall be measured as specified in 4.7.1, 4.7.2, 4.7.3, and 4.7.4 respectively. Capacitors that fail the initial measurements shall be replaced.

b. Initial inspection: Capacitors shall be inspected at a magnification of 40X for cracks. Capacitors showing external cracks shall be replaced. Acoustic microscopy is not applicable.

c. Bake: In accordance with J-STD-020.

d. Moisture soak: In accordance with J-STD-020.

e. Reflow: In accordance with the tin/lead profile in J-STD-020.

f. Final visual inspection: In accordance with J-STD-020.

g. Final electrical test: DC leakage, capacitance, DF, and ESR shall be measured at room temperature as specified in 4.7.1, 4.7.2, 4.7.3, and 4.7.4 respectively within 72 hours of reflow.

h. Final acoustic microscopy: Not applicable.

5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be in accordance with the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. 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. Tantalum chip capacitors are intended to be used in surface mount applications. These capacitors are not hermetically sealed or moisture proof. These capacitors are suited to harsh environment applications under 20 Gs of high frequency vibration and over a wide temperature range (-55°C to +125°C). These capacitors also offer reliability grading that is verified under a qualification system. Many 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 this specification, the applicable specification sheet, and the complete PIN (see 1.2.1).

b. Packaging requirements (see 5.1).

c. Capacitor marking (see 3.23).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products that are, at the time of award of contract, qualified for inclusion in 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 DLA Land and Maritime, ATTN: VAT, PO Box 3990, Columbus, OH 43218-3990, or by email to vqp.chief@dla.mil.

6.3.1 Copies of SD-6, "Provisions Governing Qualification", are available online at https://quicksearch.dla.mil/.

6.4 Soldering heat. Caution should be exercised when subjecting these sample units to soldering heat. Preheat and soldering exposure times and temperatures should be held to a minimum.

6.5 Subject term (key word) listing.

Dissipation factor
Statistical process control (SPC)
Anomalous charging current

6.6 Tin whisker growth. The use of alloys with a tin content greater than 97 percent, by mass, may exhibit tin whisker growth problems after manufacture. Tin whiskers may occur anytime from a day to years after manufacturer and can develop under typical operating conditions, on products that use such materials. Conformal coatings applied over top of a whisker prone surface will not prevent the formation of tin whiskers. Alloys of 3 percent lead, by mass, have been shown to inhibit the growth of tin whiskers. For additional information on this matter, refer to ASTM-B545 (Standard Specification for Electrodeposited Coatings of Tin).

6.7 Moisture and handling sensitivity. Capacitors qualified to this specification may be sensitive to moisture induced stress if exposed to humidity for extended periods of time (see 6.8 and 6.9). J-STD-020 (Moisture/Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices) provides a procedure to identify the moisture sensitivity level rating for non-hermetic surface mount devices so that they can be properly packaged, stored, and handled. The MSL ratings for the capacitors qualified to this specification are based on the tin/lead reflow profile specified in J-STD-020. If humidity exposure exceeds J-STD-020 limits, users may consult J-STD-033 (Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices) for general bake out and handling procedures; however, individual capacitor manufacturers may have more specific recommendations, especially for those capacitors packaged in tape and reel. Passing the criteria specified in J-STD-020 is not sufficient by itself to provide assurance of long-term reliability.

6.8 Solder reflow. Capacitors qualified to this specification may become susceptible to damage during solder reflow due to moisture absorption (see 6.7). Vapor pressure of moisture inside a non-hermetic package increases greatly when exposed to the high temperature of solder reflow, potentially resulting in internal cracking or damage to the capacitor. In the most severe cases, the internal pressure can cause external package cracks, commonly referred to as the “popcorn” phenomenon.

6.9 ESR drift. ESR will drift upward over time in an oxygen environment due to oxidation. The higher the temperature exposure, the faster the ESR will drift. Users should contact the manufacturer for drift characteristics. The ESR of capacitors qualified to this specification may also increase due to moisture absorption (see 6.7). Moisture can penetrate the non-hermetic package and be absorbed by the cathode elements. This absorption can reduce conductivity of the contact points which increases the resistance.

6.10 Anomalous charging current (ACC). Capacitors qualified to this specification may be susceptible to anomalous charging currents. Anomalous charging current is a higher amount of current flowing into a capacitor while charging than would be predicted by C dv/dt + reasonable leakage current. This can occur when the capacitor is in a dry state (loss of water bound to polymer), such as after reflow soldering or in a vacuum. Users should contact the manufacturer for ACC characteristics.

6.11 Capacitance decrease in dry conditions. Capacitors qualified to this specification may be susceptible to a decrease in capacitance in dry conditions. Users should contact the manufacturer for more information.

6.12 Derating. It is recommended that capacitors with voltage ratings up to 10V be derated by 10 percent (90 percent of rated voltage) and capacitors with voltage ratings greater than 10V be derated by 20 percent (80 percent of rated voltage). Users should contact the manufacturer for more information.

6.13 Changes from previous issue. Not applicable.

APPENDIX A

PROCEDURES FOR QUALIFICATION INSPECTION

A.1 SCOPE

A.1.1 Scope. This appendix details the procedures for submission of samples for qualification inspection of capacitors covered by this specification. The procedures for extending qualification of the required sample to other capacitors covered by this specification are also obtained herein. This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

A.2 SUBMISSION

A.2.1 Sample.

A.2.1.1 Single-style submission. A sample of the size required in table V, of the highest capacitance value in each voltage rating in each style for which qualification is sought, shall be submitted.

A.2.1.2 Combined-voltage submission. Samples shall be submitted in accordance with table A-I for each style for which qualification is sought. Each voltage group (see below) shall be qualified separately. The break down is the highest capacitance value in the smallest and largest case size, and lowest voltage and highest voltage. Voltage groups shall be as follows:

Group	Voltage rating (V_{dc})
I	2.5 to 10, inclusive
II	16 to 35, inclusive
III	≥ 50

A.3 EXTENT OF QUALIFICATION

A.3.1 Single-style submission. Capacitance-range qualification will be restricted to values equal to or less than the capacitance value submitted. Voltage rating qualification shall be restricted to those submitted.

A.3.2 Combined voltage submission. Capacitance range qualification will be restricted to values equal to or less than the capacitance value submitted. Voltage rating qualification shall be restricted to those groups submitted (see A.2.1.2).

A.3.3 Non-ER capacitors (product level A, see table II). Qualification of the A level (non-ER) is predicated upon meeting the qualification requirements for the product level X (see table II).

A.3.4 Termination finishes. Termination qualification will be restricted to that submitted.

A.3.5 Surge current option. Surge current qualification will extend in accordance with the following:

Qualification of surge current option:	Will qualify option:
C	A, B, Z
B	A, Z
A	Z

APPENDIX A

A.3.6 Product level. Product level qualification will extend in accordance with the following:

Qualification of product level	Will qualify level(s):
Z	A, X, Y
Y	A, X
X	A

TABLE A-I. Combined-voltage submission.

Specification sheet	PIN 1/	Number of sample units (minimum)	Rated voltage	Voltage group
/1 (single anode)	M3270001D337 - A - - -	280	2.5	I
	M3270001B336 - F - - -	280	10	I
	M3270001D157 - F - - -	280	10	I
	M3270001D107 - H - - -	280	16	II
	M3270001D156 - M - - -	280	35	II
	M3270001D106 - N - - -	280	50	III
	M3270001D475 - P - - -	280	63	III
/2 (multi-anode)	M3270002D687 - A - - -	280	2.5	I
	M3270002E158 - A - - -	280	2.5	I
	M3270002D227 - F - - -	280	10	I
	M3270002E477 - F - - -	280	10	I
	M3270002E337 - H - - -	280	16	II
	M3270002E476 - M - - -	280	35	II
	M3270002E336 - N - - -	280	50	III
	M3270002E156 - P - - -	280	63	III

1/ Complete PIN shall include additional symbols to indicate capacitance tolerance, termination finish, product level, and surge current option.

APPENDIX B

PROCEDURES FOR ESTABLISHING ACCELERATION FACTORS

B.1 SCOPE

B.1.1 Scope. This appendix details the procedures for establishing the voltage acceleration factor (A_V) and the temperature acceleration factor (A_T) of capacitors covered by this specification. The A_V and the A_T are part of the FRL calculation specified in the reliability assessment procedure (see 4.7.12g). This appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

B.2 GROUPING

B.2.1 Grouping. The voltage and temperature acceleration factors shall be established for each group of capacitors. A group shall be determined by, but not limited to: The tantalum powder type and the polymerization process.

B.2.2 Procedure. A group shall be created for each tantalum powder type and then further narrowed down based on the polymerization process used (i.e., chemical, electrochemical, pre-polymerized dispersions, or any combination of the three).

B.2.3 Design changes. If the manufacturing process for a part type is changed such that it no longer meets the group definition, it may be moved to an existing group provided the new process parameters fit that group. Otherwise, the acceleration factors shall be established for the new design.

B.3 TEMPERATURE ACCELERATION FACTOR

B.3.1 Temperature acceleration factor. The temperature acceleration factor between +85°C and the test temperature is calculated using the Arrhenius equation and the experimentally determined activation energy (E_a) based on dielectric wear-out. If a manufacturer plans to only test at +85°C, they will not need to determine an activation energy and a value of 1 shall be used for A_T. If the manufacturer plans to use a test temperature other than +85°C and then derate to +85°C, they will need to determine the activation energy. To determine the activation energy, a minimum of 3 production lots of one part type per group shall be tested at two different temperatures and the same voltage. Using the equation from B.3.3c, the E_a shall be calculated. Using the equation in B.3.3d., the A_T shall be calculated utilizing the determined E_a. Based on experimental data, an average E_a per group shall be determined and become the standard E_a for that group for all production lots. Dielectric wear-out is characterized by an increasing failure rate and for the purposes of this document is defined as Weibull $\beta>2$ as determined by a sample of no less than 20 consecutive data points which includes the median on a Weibull plot of times-to-failure.

B.3.2 Sampling. A minimum of 3 production lots of capacitors for a minimum of one part type (i.e., capacitance value, voltage rating, case size) shall be selected from each group (see B.2.1).

B.3.3 Procedure.

a. Test temperature: Capacitors shall be tested at a minimum of two test temperatures. The minimum difference between the maximum and minimum test temperatures shall be ≥ 20°C.

b. Test voltage: The voltage shall remain constant between the two test temperatures for the capacitors selected in section B.3.3a.

c. Activation energy equation:

$$E_a = k * \ln(\frac{t1}{t2}) * (\frac{T2 * T1}{T2 - T1})$$

Where:
E_a = activation energy
k = Boltzmann's constant, 8.617E-5 eV/K
$t1$ = median time to fail at temperature condition 1
$t2$ = median time to fail at temperature condition 2
$T1$ = test temperature 1 in kelvin (K)
$T2$ = test temperature 2 in K.

d. Temperature acceleration factor equation:

$$A_T = e^{(\frac{E_a}{k}(\frac{1}{358} - \frac{1}{T2}))}$$

Where:
A_T = acceleration factor due to temperature (unitless)
E_a = activation energy
k = Boltzmann's constant, 8.617E-5 eV/K
$T2$ = test temperature 2 in K

B.4 VOLTAGE ACCELERATION FACTOR

B.4.1 Voltage acceleration factor. The voltage acceleration factor is equal to the ratio of the test voltage to the rated voltage with an experimentally determined exponent based on dielectric wear-out. The voltage ratio exponent (VRE) should be determined at the same temperature to be used for the production lot acceptance test on a minimum of 2 part types per group. Using a power law model, the VRE shall be calculated from the equation in B.4.3c. Based on experimental data, an average VRE per group shall be determined and become the standard VRE for that group for all production lots. Dielectric wear-out is characterized by an increasing failure rate and for the purposes of this document is defined as Weibull β>2 as determined by a sample of no less than 20 consecutive data points which includes the median on a Weibull plot of times-to-failure. The maximum value of the VRE shall be 19. A default VRE of 14 may be used until the experimental VRE values are established provided the reliability assessment is performed at +85°C.

B.4.2 Sampling. A minimum of 3 production lots of capacitors for a minimum of 2 part types (i.e., capacitance value, voltage rating, case size) shall be selected from each group (see B.2.1). If a group only has 1 part type, that part type shall be used.

B.4.3 Procedure.

a. Test voltage: Capacitors shall be tested at a minimum of two test voltages. The minimum difference between the maximum and minimum test voltages shall be ≥ 0.2Vr.

b. Test temperature: The temperature shall remain constant between the two test voltages for the capacitors selected in section B.4.3a.

c. Voltage ratio exponent equation:

$$n = \ln(\frac{t1}{t2}) / \ln(\frac{V2}{V1})$$

Where:
n = Voltage Ratio Exponent
t1 = median time to failure at voltage condition 1
t2 = median time to failure at voltage condition 2
V1 = voltage applied in condition 1
V2 = voltage applied in condition 2

d. Voltage acceleration factor equation:

$$Av = (\frac{V1}{V2})^n$$

Where:
A_V = voltage acceleration factor
V1 = voltage applied in condition 1 (Note: For the purpose of the equation in B.4.3d, *V1* is rated voltage)
V2 = voltage applied in condition 2

Custodians:
Army – CR
Navy - EC
Air Force – 85
DLA - CC

Preparing activity:
DLA - CC

(Project 5910-2020-033)

Review activities:
Army - AR, MI
Navy - AS, MC, OS, SH
Air Force - 19
Other – MDA, NA

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST Online database at https://assist.dla.mil.