MILITARY STANDARD

CAPACITORS, SELECTION AND USE OF

TO ALL HOLDERS OF MIL-STD-198E:

1. THE FOLLOWING PAGES OF MIL-STD-198E HAVE BEEN REVISED AND SUPERSEDE THE PAGES LISTED:

NEW PAGE	DATE	SUPERSEDED PAGE	DATE
v	16 September 1988	v	29 MAY 1984
vi	29 MAY 1984	vi	REPRINTED WITHOUT CHANGE
3	16 September 1988	3	29 MAY 1984
4	29 MAY 1984	4	REPRINTED WITHOUT CHANGE
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903.14	16 September 1988	NEW	---
903.15	16 September 1988	NEW	---
903.16	16 September 1988	NEW	---
903.17	16 September 1988	NEW	---
903.18	16 September 1988	NEW	---
903.19	16 September 1988	NEW	---
903.20	16 September 1988	NEW	---
903.21	16 September 1988	NEW	---
903.22	16 September 1988	NEW	---
903.23	16 September 1988	NEW	---
903.24	16 September 1988	NEW	---

2. RETAIN THIS NOTICE PAGE AND INSERT BEFORE THE TABLE OF CONTENTS.

16 September 1988

3. Holders of MIL-STD-198E will verify that page changes and additions indicated on the previous page have been entered. The notice page will be ratained as a check sheet. This issuance, together with appended pages, is a separate publication. Each notice is to be retained by stocking points until the military standard is completely revised or canceled.

CONCLUDING MATERIAL

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

Review activities:
Army - AR
Navy - AS, OS
Air Force - 17, 99
DLA - ES

User activities:
Navy - CG, MC, SH
Air Force - 19

Preparing activity:
Army - ER

Agent:
DLA - ES

(Project 5910-1601)

CROSS REFERENCE
(Specification Number to Section Number)

MIL-C-5	102
MIL-C-20	902
MIL-C-62	201
MIL-C-81	401
MIL-C-10950	101
MIL-C-11015	301
MIL-C-14409	402
MIL-C:19978	801
MIL-C-23183	501
MIL-C-23269	601
MIL-C-39001	602
MIL-C-39003	701
MIL-C-39006	702
MIL-C-39014	901
MIL-C-39018	202 and 704
MIL-C-39022	802
MIL-C-55365	703
MIL-C-55514	803
MIL-C-55681	903
MIL-C-83421	804

MILITARY - Continued

MIL-C-55365	-	Capacitors, Chip, Fixed, Tantalum, Established Reliability, General Specification For.
MIL-C-55514	-	Capacitors, Fixed, Plastic (or Metallized Plastic) Dielectric, DC or DC-AC, in Nonmetal Cases, Established Reliability, General Specification For.
MIL-C-55681	-	Capacitors, Chip, Multiple Layer, Fixed, Unencapsulated, Ceramic Dielectric, Established Reliability, General Specification For.
MIL-C-83421	-	Capacitors, Supermetallized Plastic Film Dielectric, (DC, AC, or DC and AC), Hermetically Sealed in Metal Cases, Established Reliability, General Specification For.

STANDARDS

MILITARY

MIL-STD-1131	-	Storage Shelf Life and Reforming Procedures for Aluminum Electrolytic Fixed Capacitors.

(Copies of specifications, standard, handbooks, drawings, and publications required by manufacturers in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting officer.)

3. DEFINITIONS

3.1 Rating and design application terms. A list of common terms used in the rating and design application of capacitors is as follows:

(a) Ambient temperature. Average or mean temperature of the medium (air, gas, liquid, etc.,) surrounding an object.

(b) Anode. Positive electrode of a capacitor.

(c) Capacitance. Property of a capacitor which determines its ability to store electrical energy when a given voltage is applied, measured in farads, microfarads, or picofarads.

(d) Capacitance tolerance. The part manufacturer's guaranteed maximum deviation (expressed in percent) from the specified nominal value at standard (or stated) environmental conditions.

(e) Capacitive reactance. Opposition offered to the flow of an alternating or pulsating current by capacitance, measured in ohms.

(f) Capacitor. Electronic component part consisting essentially of two conduction surfaces separated by an insulating (dielectric) material. A capacitor stores electrical energy, blocks the flow of direct current, and permits the flow of alternating or pulsating current to a degree dependent on the capacitance and the frequency.

(1) Capacitor, liquid-filled. A capacitor in which a liquid impregnant occupies substantially all of the case volume not required by the capacitor element and its connections. (Space may be allowed for the expansion of the liquid under temperature variations.)

(2) Capacitor, liquid-impregnated. A capacitor in which a liquid impregnant is dominantly contained within the foil- and paper-winding, _. but does not occupy substantially all of the case volume.

(3) Capacitor, temperature-compensating. A capacitor whose capacitance baries with temperature in a known and predictable manner.

(g) Cathode. Negative electrode of a capacitor.

(h) DC leakage (DCL). Stray direct current of relatively small value which flows through or across the surface of solid or liquid insulation when a voltage is impressed across the insulation.

(i) Dielectric. The insulating material (e.g., air, paper, mica, oil, etc.,) between the plates of a capacitor.

(j) Dielectric absorption. Property of an imperfect dielectric whereby all electric charges within the body of the material caused by an electric field are not returned to the field.

(k) Dielectric constant. Property of a dielectric material that determines how much electrostatic energy can be stored per unit volume when unit voltage is applied. (It is the ratio of the capacitance of a capacitor filled with a given dielectric to that of the same capacitor having a vacuum dielectric.)

(l) Dielectric strength. Maximum voltage that a dielectric material can withstand without rupturing. (The value obtained for the dielectric strength will depend on the thickness of the material and on the method and conditions of test.)

(m) Disipation factor (DF). The ratio of resistance to reactance, measured in percent.

(n) Electrolyte. Current-conducting solution (liquid or solid) between two electrodes or plates of a capacitor at least one of which is covered by a dielectric film.

(o) Equivalent series resistance (ESR). The square root of the difference between the impedance squared and the reactance squared.

(p) Flashpoint of impregnant. The temperature to which the impregnant (liquid or solid) must be heated in order to give off sufficient vapor to form a flammable mixture.

(q) Impedance (Z). Total opposition offered to the flow of an alternating or pulsating current, measured in ohms. (Impedance is the vector sum of the resistance and the capacitive reactance, i.e., the complex ratio of voltage to current.)

(r) Impregant. A substance, usually liquid, used to saturate paper dielectric and to replace the air between its fibers. (Impregnation increases the dielectric strength and the dielectric constant of the assembled capacitor.)

(s) Inactive for new design. May be used on systems designed before, but shall not be used on systems designed after the date of inactivation. Applicable to military specifications, specification sheets, and parts covered therein.

(t) Insulation resistance (IR). Direct current resistance between two conductors that are separated by an insulating material.

NOTE: Capacitors are commonly subjected to two insulation resistance tests. One test determines the insulation resistance from terminal to terminal while the other test determines the insulation resistance from one or more terminals to the exterior case or insulating sleeve.

(u) Partially inactive for new design. Containing both active and inactive military specification sheets (for or military specifications), or both active and inactive parts (for military specification sheets).

(v) Power factor (PF). The ratio of resistance to impedance, measured in percent.

(w) Quality factor (Q). The ratio of capacitive reactance to resistance.

(x) Radio interference. Undesired conducted or radiated electrical disturbances, including transients, which may interfere with the operation of electrical or electronic communications equipment or other electronic equipment.

(y) Ripple voltage (or current). The ac component of a uni-directional voltage or current (the ac component is small in comparison with the dc component).

(z) Stability. The ability of a part to resist changes of characteristic values and (or) coefficients.

(aa) Surge voltage (or current). Transient variation in the voltage or current at a point in the circuit; a voltage or current of large magnitude and short duration caused by a discontinuity in the circuit.

(bb) Temperature coefficient (TC). Change in capacitance of a capacitor per degree change in temperature. It may be positive, negative, or zero and is usually expressed in parts per million per degree Celsius (ppm/°C).

4. GENERAL REQUIREMENTS

4.1 Choice of capacitor types. The variety of capacitor types used in any particular wquipment shall be the minimum necessary to obtain satisfactory performance. where more than one type of capacitor may be used in a given application (i.e., molded mica or glass types), consideration should be given to cost and availability (use of strategic materials, multiple sources, etc.). The capacitors identified in this standard meet all the criteria for standard types (see 1.1 and 4.4 and Table I).

4.1.1 Reliability. Where quantitative reliability requirements are specified as part of the equipment requirements and are such that the use of parts with established reliability is dictated, such parts shall be selected from the established reliability sections of this standard.

4.1.2 Qualified sources. After a preliminary selection of the desired capacitor has been made, reference should be made to the applicable qualified products list for listing of qualified sources.

4.2 Item identification. A type designation for any capacitor referenced herein may be constructed as indicated in the example given in the applicable section. The part number assignments, where applicable,shall be as spedified in the individual capacitor specification.

4.3 Conflict of requirements. In the event of conflict between technical require-ments of capacitors described in this standard and the applicable specification, the specification shall govern; however, this standard will be up-dated concurrently to reflect specification changes.

4.4 Criteria for inclusion in this standard. The criteria for the inclusion of capacitor types in this standard are as follows:

(a) The capacitor shall be the best type available for general use in military equipment.

(b) Coordinated military specifications shall be available (see 2.1).

(c) Capacitors shall be in or shall have been in production.

(d) Where possible, only capacitors that will remain in this standard for a minimum of 1 year shall be included.

CAPACITORS, FIXED, ELECTROLYTIC (ALUMINUM OXIDE) STYLE CU15

(APPLICABLE SPECIFICATION: MIL-C-39018)

1. SCOPE. This section covers nonpolarized, electrolytic (aluminum oxide), fixed capacitors enclosed in metal cases, suitably protected against high humidity.

2. APPLICABLE INFORMATION

2.1 Use. Aluminum electrolytic capacitors are intended for use in filter, coupling, and by-pass applications where large capacitance values are required in small cases and where excesses of capacitance over the nominal value can be tolerated.

Aluminum electrolytic capacitors provide the smallest volume, mass, and cost per microfarad of any type of capacitor with the exception of the tantalum electrolytic capacitor.

These capacitors are not recommended for airborne equipment applications since they should not be subjected to low barometric pressure and low temperatures at high altitudes. These aluminum electrolytic capacitors can be derated only for a short period since derating for any length of time may result in the necessity for re-forming. Even though they have vents designed to open at dangerous pressures, explosions can occur because of gas pressure or a spark ignition of free oxygen and hydrogen liberated at the electrodes. Provisions should be made to protect surrounding parts.

These capacitors are generally used where low frequency, pulsating, dc signal components are to be filtered out, and as cathode by-pass capacitors in self-biasing circuits. These capacitors are designed for applications where accuracy of capacitance is relatively unimportant.

As a rule, for selection of emitter by-pass capacitors, a ratio of bias resistance to by-pass reactance of about 10 to 1 is allowed. Ratios up to 20 to 1 may be used in high-fidelity-amplifier work or where space and economical considerations permit. Electrolytic capacitors provide the equipment designer with an unusually lightweight unit of high capacitance in a compact container.

2.2 Construction. The construction of these capacitors is basically the same as that specified in Section 201 (MIL-C-62). However, advancements in the manufacture of aluminum electrolytic capacitors have made possible an increased foil purity, improved oxide system, and an increase in etch ratios. Other contributing factors to the advancement in the manufacture of aluminum capacitors are an improved capacitor seal and the development of an electrolyte with a non-aqueous base.

The metal cases for these capacitors are provided with an insulating sleeve which has an insulation resistance of at least 100 megohms.

It should be noted that the insulation resistance refers to the sleeve and not to the resistance between the terminals and the case. The circuit diagram for style CU15 capacitors shows an indeterminate resistance between the outer-foil terminal and the case since the electrolyte cannot be completely fsolated. For safer performance, the insulating sleeve should remain over the case for all applications.

2.3 Voltage rating. The thickness of the oxide film which is formed both initially on the foil and during the forming operations on the completed capacitor determines the maximum peak or surge voltage which may be applied. For macimum reliability and long life, the dc working voltage should not be more than approximately 80 percent of full rating so that surges can be kept within the full-rated working voltage. The time of surge-voltage application should not be more than 30 seconds every 10 minutes.

Style CU15 capacitors cover a voltage range of 7 to 250 V dc at 85°C derated to 5 to 200 V dc at 125°C.

2.4 Operating temperature range. Style CU15 capacitors are suitable for operation over a temperture range of -55°C to +85°C, derated to +125°C.

2.5 Derating. Style CU15 capacitors may be voltage derated in order to operate at temperaures up to +125°C. The percent of derating varies from approximately 20 to 33 percent depending on the particular voltage rating involved.

2.6 Seal. Even though these capacitors have vents designed to open at dangerous pressures, explosions can occur because of gas pressure or a spark ignition of free oxygen and hydrogen liberated at the electrodes. Provisions should be made to protect surrounding parts.

2.7 Surge voltabe. The surge voltage is the maximum voltage to which the capacitor should be subjected under any condition. This includes transients and peak ripple at the highest line voltage.

2.8 Polarization, Nonpolarized capacitors, style CU15, should be used in applications where reversal of potential occurs. Ploarized capacitors, styles CUR13, CUR17, CUR19, CUR71, and CUR91 (see section 704) should be used only in dc circuits with polarity properly observed. If ac components are present, the sum of the peak ac voltage PIUS the applied dc voltage must not exceed the dc rating. The peak ac value should also be less than the applied dc voltage so that polarity may be maintained, even on negative peaks, to avoid overheating and damage.

2.9 Cleaning solvents. Recommended solvents include all those free of halogen or halogen groups, such as toluene, menthanol, methylcellosolve, alkinox and water, and naptha. Chlorinated or fluorinated hydrocarbon solvents are prohibited.

3. ITEM IDENTIFICATION

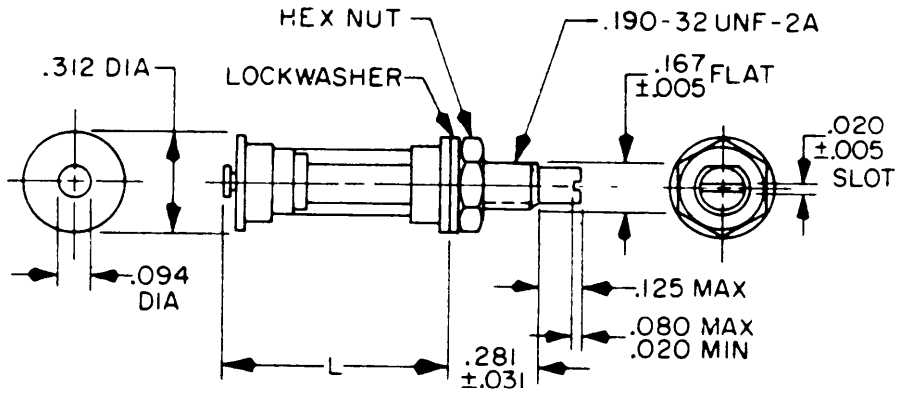
3.1 Standard capacitors. The standard capacitors available in this Section are shown in figure 202-1. (The figure gives the electrical characteristics, case sizes, and Military part numbers of capacitors which are standard for design.)

STANDARD CAPACITORS

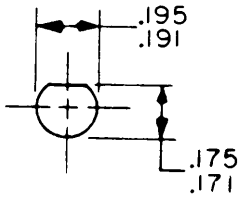
STYLE PC39

OPERATING TEMPERATURE RANGE -55° TO +125°C -- DC RATED VOLTAGE 1,000 VOLTS

Capacitance		Q (Min)	Dimension	Temperature coefficient
Minimum	Maximum		L ±.031 (.79 mm)	
pF	pF		Inches	ppm/°C
1.0	16	750	.469 (11.91)	±150
1.0	36	550	.703 (17.86)	±150
1.0	52	350	.922 (23.42)	±150
1.0	75	250	1.172 (29.77)	±150
1.0	120	250	1.766 (44.86)	±50



Inches	mm
.005	0.13
.020	0.51
.031	0.79
.080	2.03
.094	2.39
.125	3.18
.167	4.24
.171	4.34
.175	4.45
.191	4.85
.195	4.95
.281	7.14
.312	7.92



SUGGESTED PANEL MOUNTING HOLE

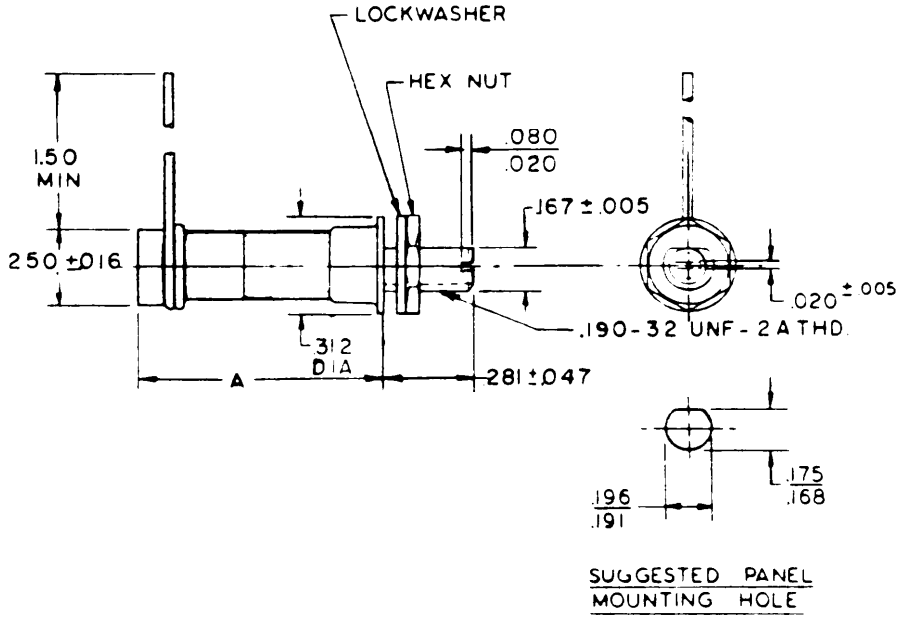
NOTES:
1. Unless otherwise specified, tolerance is ±.016 (.41 mm).
2. The flat on the mounting bushing extends to the mounting surface or the shoulder.
3. The turret cap is soldered to the cylinder with high temperature solder having a minimum melting point of 232°C.

FIGURE 402-2. Piston-type, tubular trimmer, variable capacitors - Continued.

STANDARD CAPACITORS

OPERATING TEMPERATURE RANGE -55° TO +150°C -- DC RATED VOLTAGE 750 VOLTS -- TEMPERATURE COEFFICIENT +50, -0

Type designation	Capacitance		Dimension A +.047, -.031 (+1.19, -.79)	Q
	Min	Max		
	pF	pF		
PC40Q1R8	0.6	1.8	.297 (7.54)	1,500
PC40Q5R5	0.6	5.5	.547 (13.89)	1,500
PC40Q9R5	0.6	9.5	.984 (24.99)	1,500
PC40Q160	0.8	16.0	1.594 (40.49)	1,500



Inches	mm
.005	0.13
.016	0.41
.020	0.51
.047	1.19
.080	2.03
.167	4.24
.168	4.27
.175	4.45
.190	4.83
.191	4.85
.196	4.98
.250	6.35
.281	7.14
.312	7.92
1.50	38.10

NOTE: Unless otherwise specified, tolerance is ±.016 (.41 mm).

FIGURE 502-2. Piston type, tubular trimmer, variable capacitors - Continued.

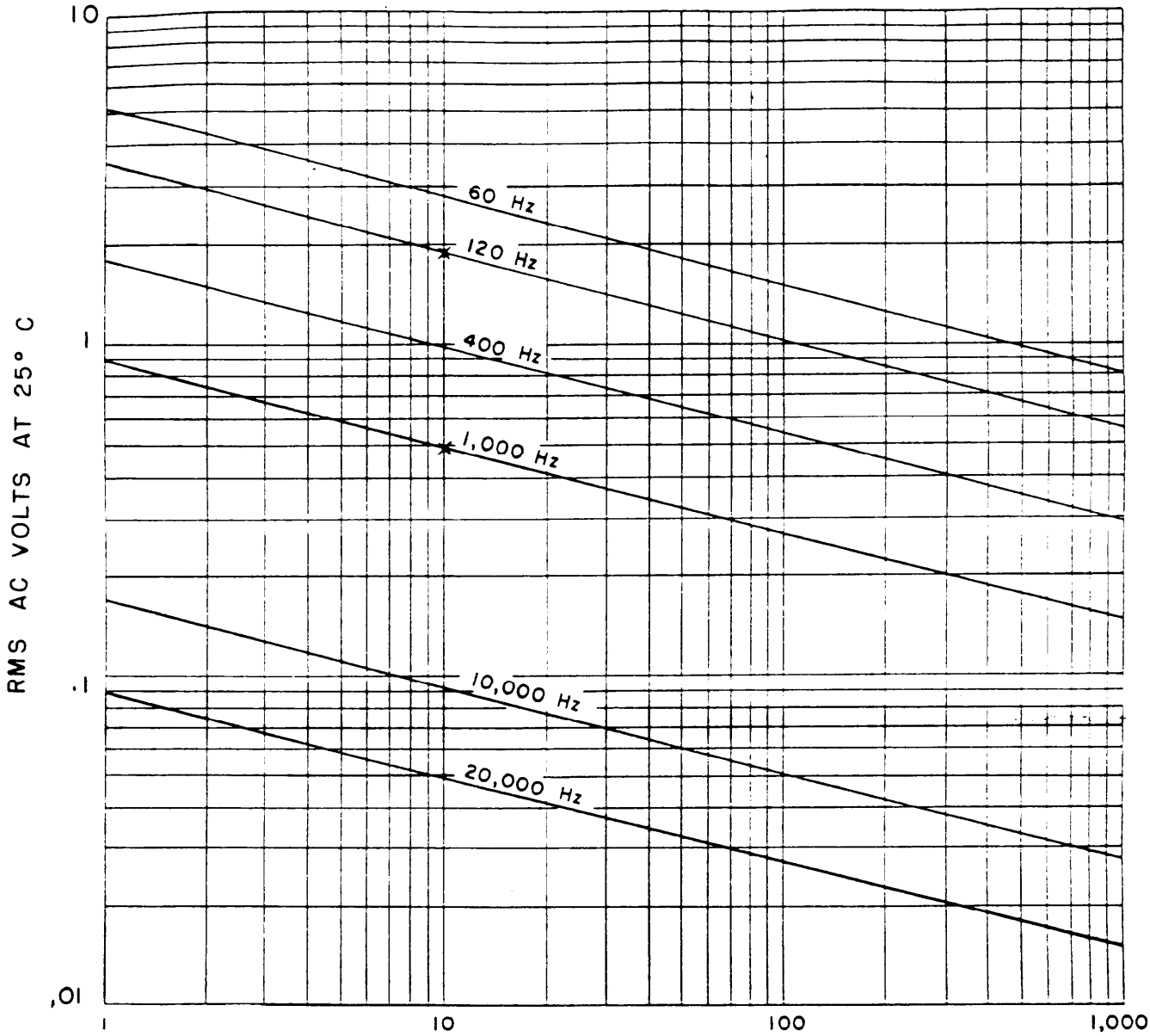


FIGURE 701-2. Permissible ripple voltage versus capacitance and frequency at 25°C.

2.8 Series and parallel networks:

2.8.1 Series. It is recommended that when these capacitors are connected in series, the maximum voltage across the network should not be greater than the lowest voltage rating of any capacitor in the network, or that voltage divider resistors be used to prevent over voltage on one or more units of the series capacitor group.

2.8.2 Parallel. To obtain a higher capacitance than can be obtained from a single capacitor, a number of units may be connected in parallel. However, the sum of the peak ripple and the applied dc voltage should not exceed the dc working voltage of the unit with the lowest voltage rating. The connecting leads of the parallel network should be large enough to carry the combined currents without reducing the effective capacitance due to series lead resistance.

2.9 Dielectric absorption. Dielectric absorption may be observed by the reappearance of potential across the capacitor after it has been shorted and the short removed. This characteristic is important in RC timing circuits, triggering systems, and phase-shift networks. The curves shown on figure 701-3 were established by charging capacitors for 1 hour at rated voltage and then discharging them through a dead short for 1 minute.

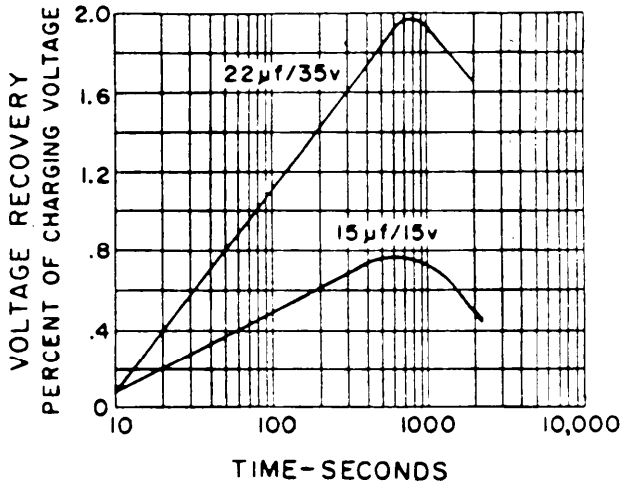


FIGURE 701-3. Typical dielectric absorption of solid electrolyte tantalum capacitors at 25°C.

Voltage recovery was measured with a high-impedance electrometer at the intervals given on the curves. Increasing the ambient temperature shifts the curves to the left and decreases the amplitude but does not affect the shape. Shortening charge time, lengthening discharge time, or decreasing charging voltage results in reduction of the peak amplitude of the curve,but has little effect on its shape or relative position.

2.10 Comparison with aluminum electrolytic. Tantalum solid electrolytic capacitors differ from aluminum electrolytic in several important aspects; namely, substantially indefinite shelf life, superior low temperature characteristics, complete freedom from electrolyte leakage, and higher operating temperatures. However, because tantalum electrolytic capacitors generally are more costly than aluminum electrolytic capacitors, consideration should be given to the use of aluminum electrolytic capacitors if their performance characteristics and physical sizes are suitable and if the application will permit.

2.11 Monunting. Supplementary mounting means should be used where the application of these capacitors involves vibration frequencies above 55 Hz.

2.12 Increased reliability. Failure rate is a function of temperature, applied voltage, and circuit impedance. Increased reliability may be obtained by derating the temperature and applied voltage and increasing circuit impedances.

DC leakage current increases when either voltage or temperature is increased; the rate of increase is greater at the higher values of voltage and temperature. A point can be reached where the dc leakage current will avalanche and attain proportions that will permanently damage the capacitor. Consequently, capacitors should never be operated above their rated temperature and rated voltage for that temperature.

By increasing the circuit impedance, the leakage current is reduced. in life testing the solid tantalum capacitor, the capacitance and dissipation factor are very stable over long periods of time and hence are not a suitable measure of deterioration. Leakage current variation is a better indicator of capacitor condition. In the life test in MIL-C-39003, a maximum impedance of 1 ohm is allowed. It is recommended that a minimum circuit impedance of 1 ohm per applied volt be utilized to attain improved reliability.

SECTION 702

CAPACITORS, FIXED, ELECTROLYTIC (NONSOLID ELECTROLYTE), TANTALUM, ESTABLISHED RELIABILITY

STYLES CLR25, CLR27, CLR35, CLR37, CLR79, AND CLR81

(APPLICABLE SPECIFICATION: MIL-C-39006)

1. SCOPE. This section covers established reliability, tantalum, electrolytic (nonsolidelectroltye), fixed capacitors (insulated),polarized and nonpolarized, hermetically sealed. Capacitors covered by this section have failure rate levels ranging from 1.0 to 0.001 percent per 1,000 hours. The failure rate levels are established at a 60 percent confidence level and are based on full rated voltage at 85°C.

2. APPLICATION INFORMATION.

2.1 Use. The use of these capacitors is determined by the two basic types of tantalum (foil and sintered slug) employed in their construction.

2.1.1 Foil types. The foil types are the most versatile of all electrolytic capacitors. They are available in plain or etched foil and in polarized or nonpolarized construction, which makes them suitable for many applications; however, the foil types are limited by their great variation of characteristics and design tolerances. They are not suitable for timing or precision circuits due to several factors leading to very wide design tolerances. Because of the difference in construction, etched-foil types have as much as 10 times the capacitance per unit area as the plain-foil types for a given size; therefore, the etched-foil type is generally the better choice between the two. In some cases the plain-foil type is a more desirable choice since it will withstand approximately 30 percent higher ripple current, has better capacitance-temperature characteristics, and has low power factor.

2.1.1.1 Polarized (styles CLR25 and CLR35). The polarized foil types are essentially used where low-frequency pulsating dc components are to be bypassed or filtered out and for other uses in electronic-equipment where large capacitance values are required and comparatively wide capacitance tolerances can be tolerated. When used for low-frequency coupling in vacuum-tube and transistor circuits, allowance should be made for the leakage current. This leakage current could cause improper positive bias to be applied across the grid circuits or excessive base, emitter, or collector currents. These polarized capacitors should be used only in dc circuits with polarity properly observed. If ac components are present, the sum of the peak ac voltage plus the applied dc voltage must not exceed the dc voltage rating. The peak ac voltage should also be less than the applied dc voltage so that polarity may be maintained, even on negative pesks, to avoid overheating and damage. Even though those units rated at 6 volts and above can withstand a maximum of 3 volts in the reverse direction, it is recommended that they not be used in circuits where this reversal is repetitious. Examples of where these units may be used are (1) in power supplies in which up to 300 volts dc are applied to the filter input, (2) at plate and screen circuit decoupling connection points, and (3) for cathode resistor by-pass circuits. When used as cathode by-pass capacitors, a ratio of bias resistance to capacitive reactance of 10 to 1 is allowed. Ratios up to 20 to 1 may be used in high-fidelity amplifier work or where space and economical considerations permit. In circuits where linear amplification is required, the amount of capacitive reactance shunting a cathode resistor will depend on the percentage of degenerative feedback desired.

2.1.1.2 Nonpolarized (styles CLR27 and CLR37). The nonpolarized types are primarily suitable for ac applications or where dc voltage reversals occur. Examples of these uses are in (1) tuned low-frequency circuits, (2) phasing of low voltage ac motors, (3) computer circuits where reversal of dc voltage occurs, and (4) servo systems.

2.1.2 Sintered slug type (styles CLR9 and CLR81. These capacitors are limited to low voltage applications. Their primary use is in low voltage power supply filtering circuits. Their low leakage current (lowest of all the tantalum types) is not appreciable below +85°; and at ordinary operating temperatures is comparable to good quality paper capacitors, yet they are much smaller in size. Styles CLR79 and CLR81 capacitors are for dc applications only; however, They will withstand up to 3 volts of reverse bias.

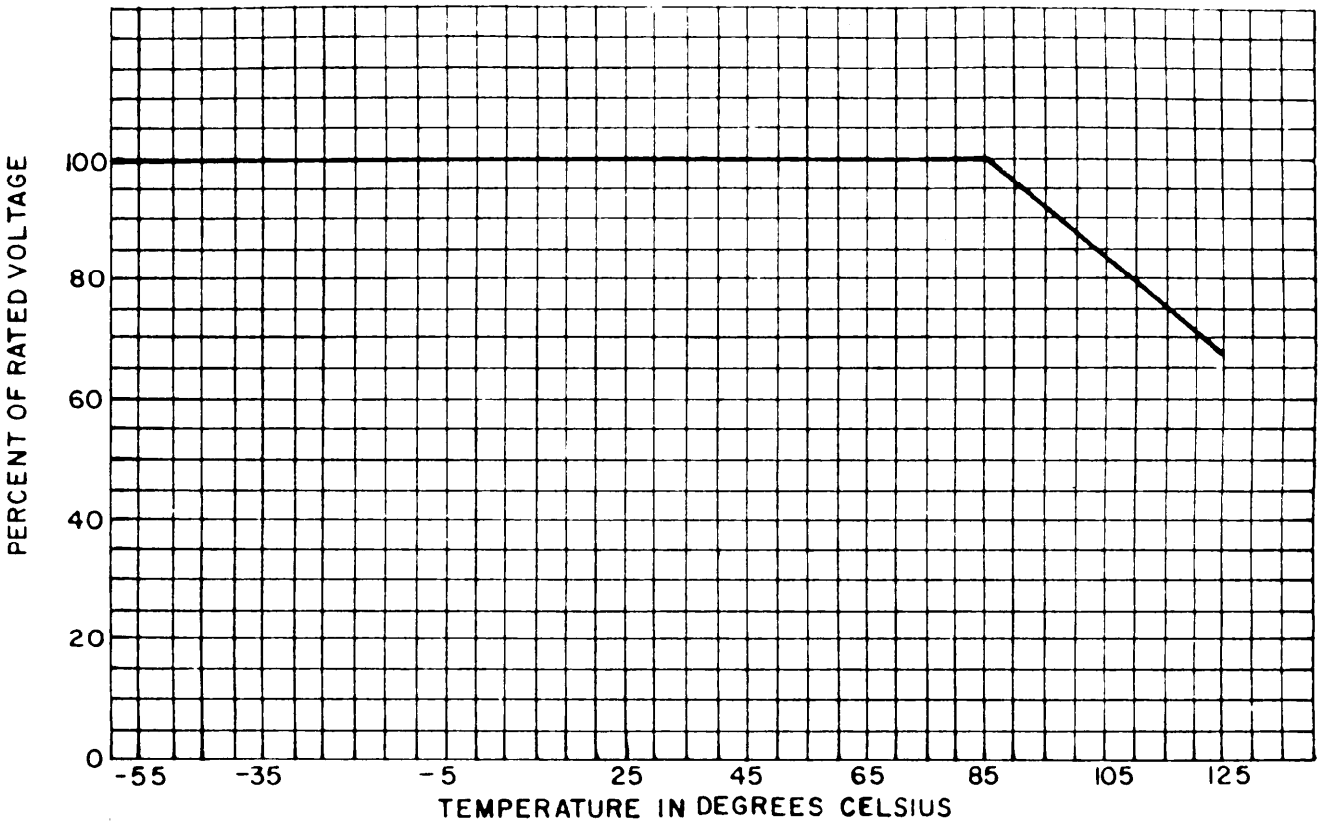


FIGURE 702-1. Voltage derating with temperature.

2.2 Construction:

2.2.1 Foil types. These capacitors consist of a tantalum foil, acting as the anode, shich is electromechanically treated to form a layer of tantalum oxide dielectroc. Porous spacer material is used to form a conventional cylindrical capacitor section with axial tantalum wires on either end. The section is impregnated with a suitable electrolyte (usually a weak acid or base) and then sealed in a suitable container. Solderable leads were welded to the tantalum leads.

2.2.2 Sintered-slug types. These capacitors consist of a sintered-slug, acting as the anode, which is electrochemically treated to form a layer of tantalum oxide dielectric.

2.3 Physical size comparison:

2.3.1 With paper capacitors. These capacitors may utilize only 15 percent of the area normally required by a paper capacitor of the same capacitance value.

2.3.2 With aluminum electrolytic capacitors. The larger the dielectric constant the larger the cpacitance shich can be realized in a given space, thus a size advantage can be realized since the dielectric constant of tantalum oxide film is approximately 24 as compared to 8 for an aluminum oxide. Because of sifferences in foil and paper-thickness requirements, the actual size ratio will vary with different capacitances and voltage ratings and may be much more than 2:1 in favor of the tantalum capacitor.

2.4 Voltage ratings. The maximum dc rated voltages for styles included in this section are shown in table 702-1.

TABLE 702-1. Voltage ratings.

Style	Anode	Voltage range
		Volts
CLR25	Etched foil	15 to 150
CLR27	Etched foil	15 to 150
CLR35	Plain foil	15 to 450
CLR37	Plain foil	15 to 375
CLR79	Sintered	6 to 125
CLR81	Sintered	6 to 125

2.5 Operating temperature range (with full rated voltage applied). These capacitors are suitable for operation over a temperature range of -55°C to +85°C.

2.6 Detrating. These capacitors may be operated up to +125°C when properly voltage derated (see figure 702-1).

2.7 Series and paralled applications:

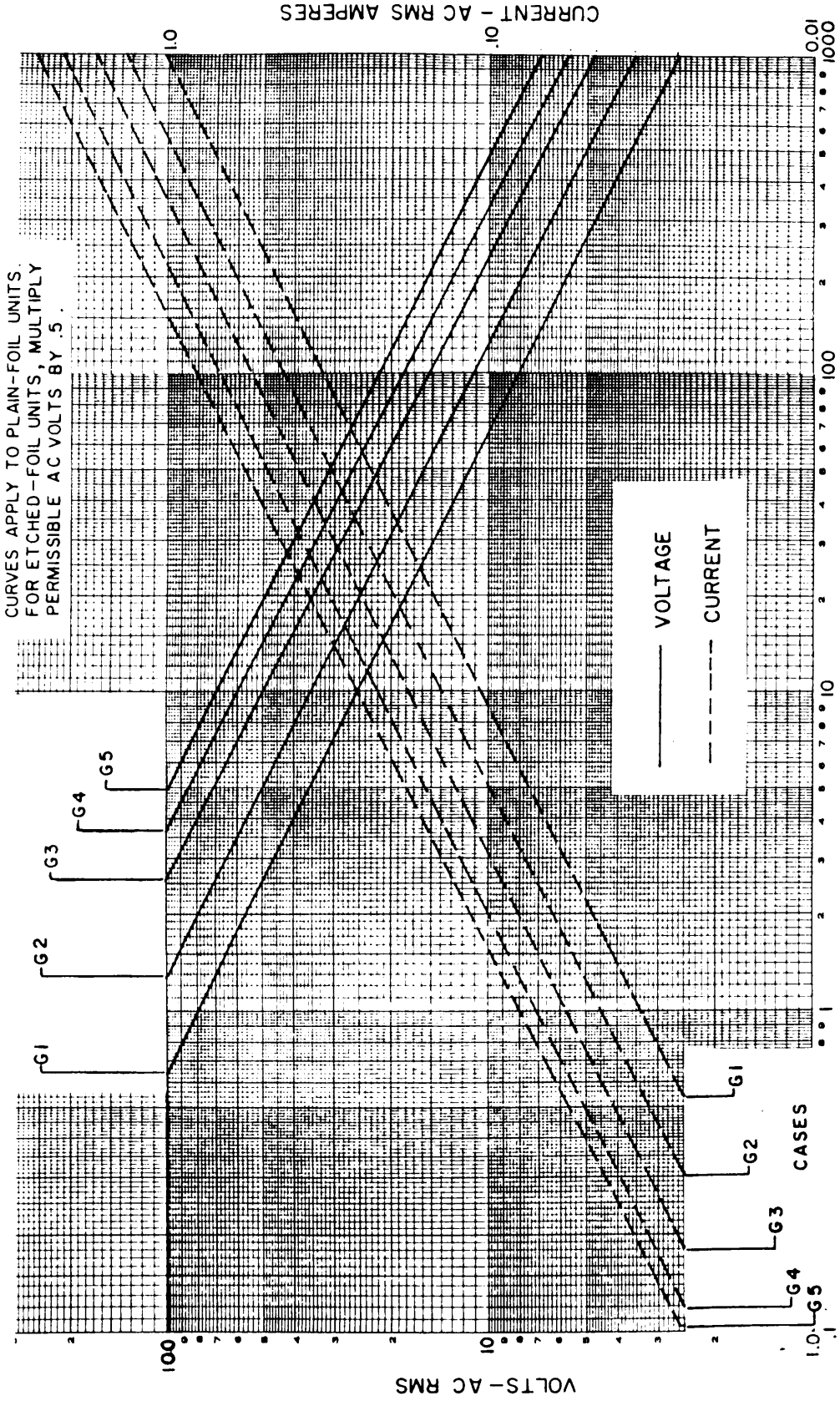
2.7.1 Series operation. Whenever tantalum capacitors are connected in series for higher voltage operation, a resistor should be paralleled across each unit. Unless a shunt resistor is used, the dc rated voltage can easily be exceeded on the capacitor in the series network with the lowest dc leakage current. To prevent capacitor destruction, a resistance value not exceeding a certain maximum should be used; this value will depend on capacitance, average dc leakage, and capacitor construction. For example: For styles CLR79 and CLR81, size T1 units will require a maximum resistance, in meghoms, equal to 3.4 divided by the square root of the capacitance (in µF); size T2, $5.2/\sqrt{C}$; size T3, $6.5/\sqrt{C}$; and size T4, $7.5/\sqrt{C}$. Plain-foil types use 5/C and etched-foil use 15/C.

2.7.2 Parallel operation. To obtain a higher capacitance than can be obtained from a single capacitor, a number of units may be connected in parallel. However, the sum of the peak ripple and the applied dc voltage should not exceed the dc rated voltage. The connecting leads of the parallel network should be large enough to carry the combined currents without reducing the effective capacitance due to series lead resistance.

2.8 Stability and life. Tantalum electrolytic capacitors have excellent life and shelf life chatacteristics. Life, at higher temperatures than with aluminum electrolytic, will show a comparatively lower decrease in capacitance. With rated voltage applied, more than 10,000 hours of life can be expected at +85°C. All styles may be expected to operate at least 2,000 hours at +85°C with less than 10 percent loss of capacitance.

Because the more stable tantalum oxide film is less subject to dissolving the surrounding electrolyte than the film in an aluminum capacitor, the shelf life of the tantalum unit is much longer, and less re-forming is required. After storage for long periods, the re-forming current is low and the time is comparatively short; it may be expected to take less than 10 minutes. These properties are affected by the storage temperature to a significant degree, being excellent at temperatures from -55 C to +25 C; good at +65 C; and relatively poor at +85°C.

Some style CLR25 capacitors may exhibit capacitance change and dissipation factor changes when exposed to low dc bias levels (O to 2.2 volts de). Care should be exercised when applications require these voltage levels.



NOTE: See page 702.10, 702.12, 702.14, or 702.16 for case size definitions.

FIGURE 702-2. Maximum allowable ripple voltage for styles CLR25, 27, 35, and 37.

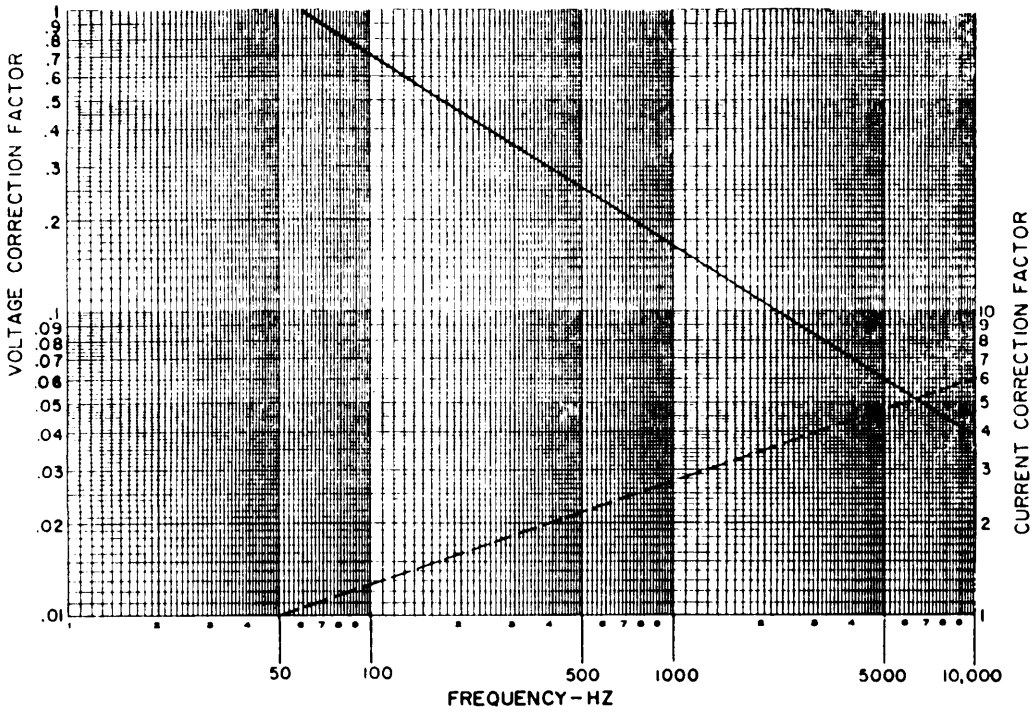


FIGURE 702-3. Correction factor for maximum allowable ripple voltage/current vs frequency for tantalum foil capacitors.

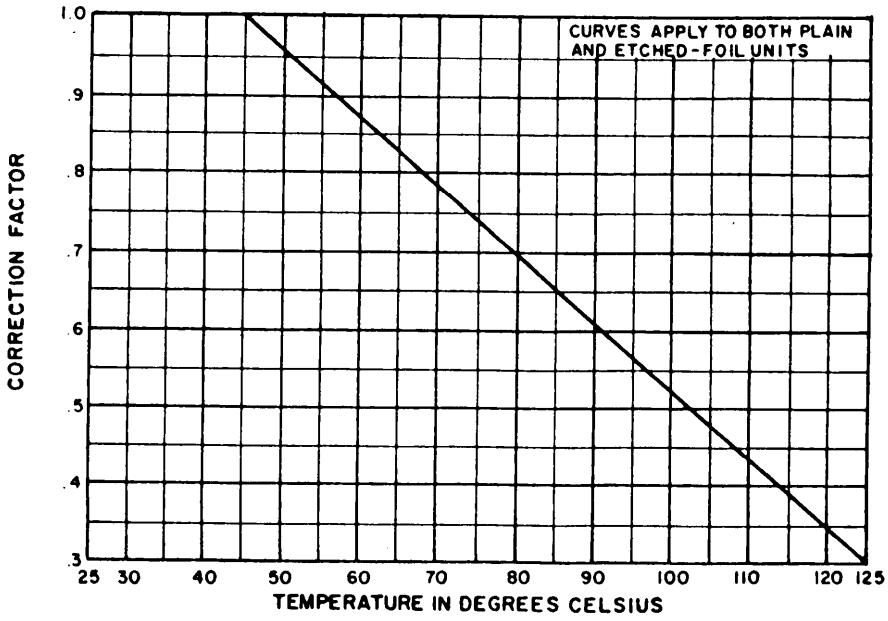


FIGURE 702-4. Correction factor for maximum allowable ripple voltage/current vs temperature for tantallum toll capacitors.

2.9 AC ripple. Tantalum foil capacitors are the only electrolytic capacitors capable of operating continuously on unbiased ac voltages. The ac ripple capability curves on figures 702-2 and 702-3 are applicable for unbiased ac voltages on nonpolar units, and biased ac ripple voltages on polar units. Peak ac voltages up to 150 volts are permissible provided that the dc voltage rating is not exceeded. The only limitation is the I^2R heating effect. Due to higher power factor, etched foil capacitors have only half the ac capability of plain foil capacitors.

2.9.1 Foil types. Figure 702-2 indicates the maximum allowable rms voltage or current for tubular plain foil capacitors. For tubular etched foil types, use one-half the values shown on figure 702-2. All values referenced indicate allowable voltages and currents at +25 C and 60 Hz.

To determine ac capability at some other frequency, multiply the voltage or current values obtained from figure 702-2 by a correction value from figure 702-3.

To determine ac capability at some other temperature, multiply the voltage or current value from figures 702-2 and 702-3, if applicable, by a correction value from figure 702-4.

2.9.2 Sintered slug type. To determine ac capability of styles CLR79 and CLR81 capacitors at some other trequency or temperature, multiply the current values obtained from figure 702-10 by the correction value from table 702-11.

2.9.3 Complex ware-shapes. Uhen complex ripple wave-shapes are involved, they should be measured on an oscilloscope or by some other method which will give the peak rating. These capacitors should be limited to operation at ripple frequencies between 60 and 10,000 Hz (above 10,000 Hz, effective capacitance rapidly drops off). At frequencies of only a few hundred kHz, these tantalum units act as practically pure resistance.

2.10 Failure-rate level determination (foil units only). The curves presented on figure 702-8 are the best engineering approximation of the reliability characteristics (random failures) for foil capacitors when employed repeatedly, within their specification ratings, in complex electronic equipment. These reliability characteristics are based on ground-level severity experience. Failures are considered to be opens, shorts, or radical departures from initial characteristics. The failures are considered to be occurring in an unpredictable manner and in too short a period of time to permit detection through normal preventive maintenance. The curves shown on figure 702-8 are based on "catastrophic failures" and will differ from the failure rates established in the specification, since the established failure rates are based on "parametric failures" over long term life tests at rated conditions. This figure has been extracted form MIL-HDBK-217, "Reliability Stress and Failure Rate Data for Electronic Equipment." The curves have been modified from their original version in that the ordinate has been normalized in order to provide multiplier factors in place of discrete failure rate levels and in order that the multiplying factor for a failure rate at rated conditions is unity. As indicated, these curves are the best estimates based on "catastrophic failures"; however, they can provide an estimate of the relative effect of operating under conditions other than rated.

3. ITEM IDENTIFICATION

3.1 Standard capacitors. The standard capacitors available in this section are shown on figure 702-9. The figure gives the electrical characteristics, case sizes, failure rate levels, and military part numbers which are standard for design.)

STANDARD CAPACITORS

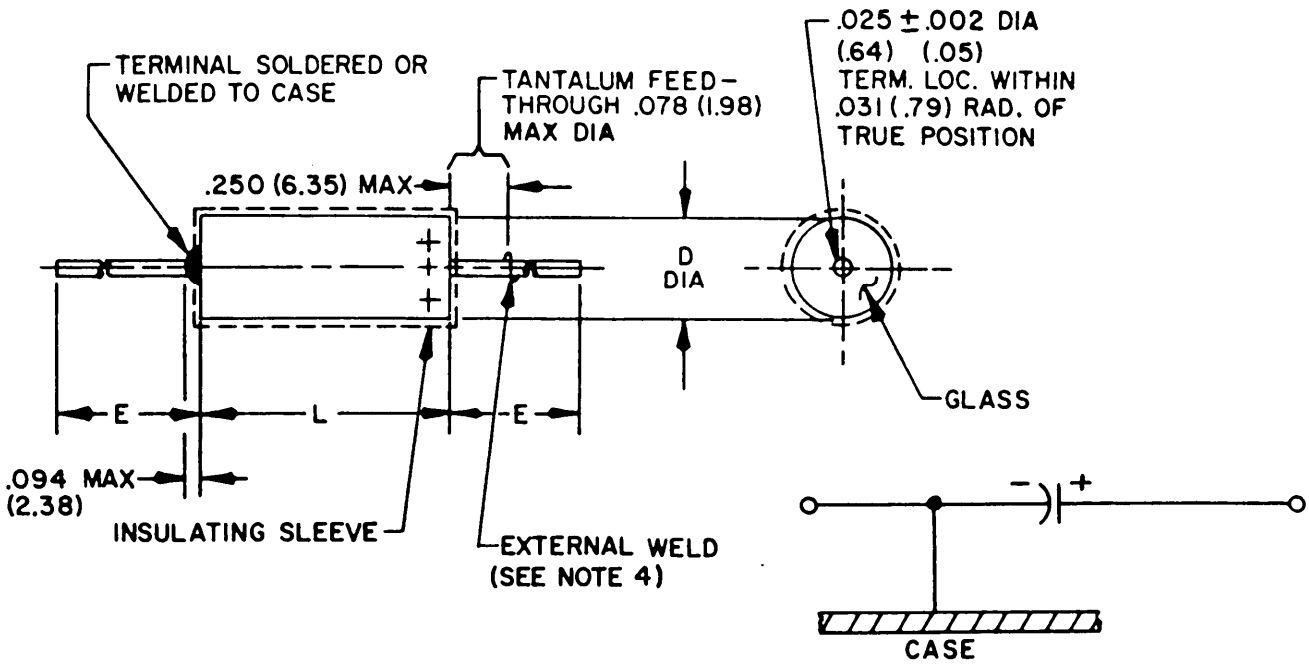
STYLE CLR37 (MIL-C-39006/4)

NONPOLARIZED, PLAIN FOIL -- OPERATING TEMPERATURE RANGE -55°C TO +85°C (VOLTAGE DERATED TO +125°C)

Rated voltage (85°C)	Cap.	Cap. tolerance	DC leakage (max) 25°C	DC leakage (max) 85°C & 125°C	Derated voltage (125°C)	Surge voltage (85°C)	Impedance (max)	Case size	Part No. M39006/04- Failure rate level for (%/1,000 hr) M(1.0)	P(0.1)	R(0.01)	S(0.001)
HERMETICALLY SEALED												
V dc	µF	%	µA	µA	V dc	V dc	Ohms					
15	2.5	±20	1	2	10	17.2	893	G1	2711	2722	2733	2744
15	10.0	±20	2	4	10	17.2	223	G2	1245	1290	1335	1380
15	35.0	±20	2	10	10	17.2	64	G3	1246	1291	1336	1381
15	70.0	±20	4	20	10	17.2	32	G4	1247	1292	1337	1382
15	100.0	±20	5	30	10	17.2	23	G5	1248	1293	1338	1383
25	1.5	±20	1	3	15	28.8	1487	G1	2712	2723	2734	2745
25	6.0	±20	2	6	15	28.8	372	G2	1249	1294	1339	1384
25	20.0	±20	2	10	15	28.8	112	G3	1250	1295	1340	1385
25	40.0	±20	4	20	15	28.8	56	G4	1251	1296	1341	1386
25	60.0	±20	5	30	15	28.8	37	G5	1252	1297	1342	1387
50	0.8	±20	1	4	30	57.5	2790	G1	2714	2725	2736	2747
50	3.0	±20	2	6	30	57.5	743	G2	1257	1302	1347	1392
50	10.0	±20	2	12	30	57.5	223	G3	1258	1303	1348	1393
50	20.0	±20	4	24	30	57.5	112	G4	1259	1304	1349	1394
50	30.0	±20	6	36	30	57.5	75	G5	1260	1305	1350	1395
75	0.5	±20	1	4	50	86.2	4460	G1	2715	2726	2737	2748
75	2.0	±20	2	6	50	86.2	1115	G2	1261	1306	1351	1396
75	7.0	±20	2	13	50	86.2	319	G3	1262	1307	1352	1397
75	14.0	±20	4	24	50	86.2	159	G4	1263	1308	1353	1398
75	20.0	±20	6	36	50	86.2	112	G5	1264	1309	1354	1399
100	0.4	±20	1	3.5	65	115.0	5580	G1	2716	2727	2738	2749
100	1.5	±20	2	6	65	115.0	1487	G2	1265	1310	1355	1400
100	5.0	±20	2	13	65	115.0	446	G3	1266	1311	1356	1401
100	10.0	±20	4	24	65	115.0	223	G4	1267	1312	1357	1402
100	15.0	±20	6	36	65	115.0	149	G5	1268	1313	1358	1403
150	0.25	±20	1	4	100	172.0	8909	G1	2718	2729	2740	2751
150	1.0	±20	2	6	100	172.0	2227	G2	1269	1314	1359	1404
150	3.5	±20	3	13	100	172.0	638	G3	1271	1316	1361	1406
150	7.0	±20	4	24	100	172.0	319	G4	1272	1317	1362	1407
150	10.0	±20	6	36	100	172.0	223	G5	1273	1318	1363	1408
200	0.15	±20	4	25	150	230.0	14000	G1	2719	2730	2741	2752
200	0.75	±20	8	32	150	230.0	2700	G2	1274	1319	1364	1409
200	2.5	±15	16	64	150	230.0	800	G3	1275	1320	1365	1410
200	5.0	±15	28	112	150	230.0	400	G4	1276	1321	1366	1411
200	7.5	±15	40	160	150	230.0	260	G5	1277	1322	1367	1412
300	0.12	±15	4	25	200	345.0	17500	G1	2720	2731	2742	2753
300	0.47	±15	10	50	200	345.0	4500	G2	1282	1327	1372	1417
300	1.5	±15	20	100	200	345.0	1500	G3	1283	1328	1373	1418
300	3.3	±15	35	175	200	345.0	643	G4	1284	1329	1374	1419
300	4.7	±15	50	250	200	345.0	450	G5	1285	1330	1375	1420
375	0.1	±15	8	80	250	431.0	23500	G1	2721	2732	2743	2754
375	0.39	±15	10	100	250	431.0	5620	G2	1286	1331	1376	1421
375	1.2	±15	20	225	250	431.0	1880	G3	1287	1332	1377	1422
375	2.2	±15	35	250	250	431.0	900	G4	1288	1333	1378	1423
375	3.9	±15	50	325	250	431.0	562	G5	1289	1334	1379	1424

FIGURE 702-9. Established reliability, tantalum, electrolytic (nonsolid electrolyte), fixed capacitors - Continued.

STYLE CLR79



CIRCUIT DIAGRAM

Case size	Dimensions			
	Basic case		Insulated Case	
	L 1/ +.031(0.79) -.015(0.41)	D +.016(0.41)	D max	E +.250(6.35)
T1	.453(11.51)	.188(4.78)	.219 (5.56)	1.500(38.10)
T2	.641(16.28)	.281(7.14)	.312 (7.92)	2.250(57.15)
T3	.766(19.46)	.375(9.52)	.406 (10.31)	2.250(57.15)
T4	1.062(26.97)	.375(9.52)	.406 (10.31)	2.250(57.15)

1/ Length of basic case sleeving shall be as specified in MIL-C-39006.

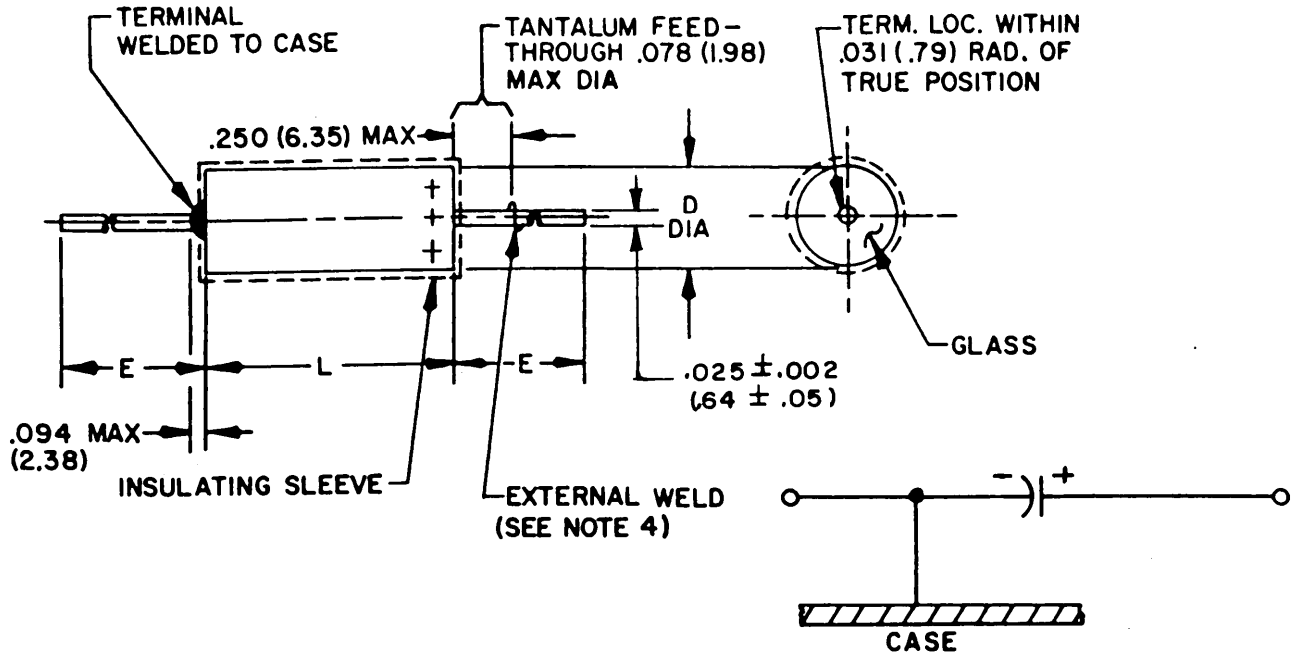
NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. Metric equivalents are in parentheses.
4. The weld is not enclosed in the end seal.

FIGURE 702-9. Established reliabiltiy, tantalum, electrolytic (nonsolid electrolyte), fixed capacitors - Continued.

TABLE 702-II. Rippled current multipliers vs frequency, temperature, and aplied peak voltage.

Frequency of applied ripple current		120 Hz				300 Hz				10 kHz				40 kHz				100 kHz			
Ambient still air		≤55°C	85°C	105°C	125°C	≤55°C	85°C	105°C	125°C	≤55°C	85°C	105°C	125°C	≤55°C	85°C	105°C	125°C	≤55°C	85°C	105°C	125°C
% of 85°C rated peak voltage	100%	.60	.39	--	--	.71	.43	--	--	.88	.55	--	--	1.0	.63	--	--	1.1	.69	--	--
	90%	.60	.46	--	--	.71	.55	--	--	.88	.67	--	--	1.0	.77	--	--	1.1	.85	--	--
	80%	.60	.52	.35	--	.71	.62	.42	--	.88	.76	.52	--	1.0	.87	.59	--	1.1	.96	.65	--
	70%	.60	.58	.44	--	.71	.69	.52	--	.88	.85	.64	--	1.0	.97	.73	--	1.1	1.07	.80	--
	≤ 66 2/3%	.60	.60	.46	.27	.71	.71	.55	.32	.88	.88	.68	.40	1.0	1.0	.77	.45	1.1	1.1	.85	.50

STYLE CLR81



CIRCUIT DIAGRAM

Case size	Dimensions			
	Basic case		Insulated Case	
	L 1/ +.031(0.79) -.015(0.41)	D +.016(0.41)	D max	E +.250(6.35)
T1	.453(11.51)	.188(4.78)	.219 (5.56)	1.500(38.10)
T2	.641(16.28)	.281(7.14)	.312 (7.92)	2.250(57.15)
T3	.766(19.46)	.375(9.52)	.406 (10.31)	2.250(57.15)
T4	1.062(26.97)	.375(9.52)	.406 (10.31)	2.250(57.15)

1/ Length of basic case sleeving shall be as wpecified in MIL-C-39006.

NOTES:
1. Dimensions are in inches.
2. Metric equivalents are in parentheses.
3. Metric equivalents are given for general information only.
4. The weld shall not be enclosed in the end seal.

FIGURE 702-9. Established relability, tantalum, electrolytic (nonsolid electrolyte), fixed capacitors - Continued.

STANDARD CAPACITORS

STYLE CLR81 (MIL-C-39006/25)

TANTALUM ANODE AND CATHODE

POLARIZED SINTERED SLUG -- OPERATING TEMPERATYRE RANGE -55° TO +85°c (VOLTAGE DERATED TO 125°C)

1/ Rated voltage (+85°C)	Cap.	Cap. tolerance	DC leakage (max)		Dissipation factor (max)	1/ Derated voltage (+125°C)	Surge voltage (+85°C)	Impedance (max)	Capacitance change at			Max 2/ 85°C 40 kHz ripple current	Case size	Part No. M39006/25- Failure rate level for (%/1,000 hr)			
			+25°C	+85°C & +125°C					-55°C	+85°C	+125°C			M(1.0)	P(0.1)	R(0.01)	S(0.001)
V dc	µF	%	µA	µA	%	V dc	V dc	Ohms	%	%	%	mA rms					
6	220	±20	2	9	50	4	6.9	36	-64	+13	+16	1000	T1	0001-	0089-	0177-	0265-
6	220	±10	2	9	50	4	6.9	36	-64	+13	+16	1000	T1	0002-	0090-	0178-	0266-
6	820	±20	3	14	155	4	6.9	18	-88	+16	+20	1500	T2	0003-	0091-	0179-	0267-
6	820	±10	3	14	155	4	6.9	18	-88	+16	+20	1500	T2	0004-	0092-	0180-	0268-
6	1500	±20	5	20	172	4	6.9	18	-90	+20	+25	1900	T3	0005-	0093-	0181-	0269-
6	1500	±10	5	20	172	4	6.9	18	-90	+20	+25	1900	T3	0006-	0094-	0182-	0270-
6	2200	±20	6	24	170	4	6.9	13	-90	+25	+30	2300	T4	0007-	0095-	0183-	0271-
6	2200	±10	6	24	170	4	6.9	13	-90	+25	+30	2300	T4	0008-	0096-	0184-	0272-
8	180	±20	2	9	41	5	9.2	45	-60	+13	+16	1000	T1	0009-	0097-	0185-	0273-
8	180	±10	2	9	41	5	9.2	45	-60	+13	+16	1000	T1	0010-	0098-	0186-	0274-
8	680	±20	3	14	130	5	9.2	22	-83	+16	+20	1500	T2	0011-	0099-	0187-	0275-
8	680	±10	3	14	130	5	9.2	22	-83	+16	+20	1500	T2	0012-	0100-	0188-	0276-
8	1500	±20	5	20	170	5	9.2	18	-90	+20	+25	1900	T3	0013-	0101-	0189-	0277-
8	1500	±10	5	20	170	5	9.2	18	-90	+20	+25	1900	T3	0014-	0102-	0190-	0278-
8	1800	±20	7	25	138	5	9.2	14	-90	+25	+30	2300	T4	0015-	0103-	0191-	0279-
8	1800	±10	7	25	138	5	9.2	14	-90	+25	+30	2300	T4	0016-	0104-	0192-	0280-
10	150	±20	2	9	34	7	11.5	54	-55	+13	+16	900	T1	0017-	0105-	0193-	0281-
10	150	±10	2	9	34	7	11.5	54	-55	+13	+16	900	T1	0018-	0106-	0194-	0282-
10	560	±20	3	16	106	7	11.5	27	-77	+16	+20	1450	T2	0019-	0107-	0195-	0283-
10	560	±10	3	16	106	7	11.5	27	-77	+16	+20	1450	T2	0020-	0108-	0196-	0284-
10	1200	±20	5	20	137	7	11.5	18	-88	+20	+25	1850	T3	0021-	0109-	0197-	0285-
10	1200	±10	5	20	137	7	11.5	18	-88	+20	+25	1850	T3	0022-	0110-	0198-	0286-
10	1500	±20	7	25	114	7	11.5	15	-88	+15	+30	2300	T4	0023-	0111-	0199-	0287-
10	1500	±10	7	25	114	7	11.5	15	-88	+15	+30	2300	T4	0024-	0112-	0200-	0288-
15	100	±20	2	9	30	10	17.2	72	-44	+13	+16	900	T1	0025-	0113-	0201-	0289-
15	100	±10	2	9	30	10	17.2	72	-44	+13	+16	900	T1	0026-	0114-	0202-	0290-
15	390	±20	3	16	74	10	17.2	31	-66	+16	+20	1450	T2	0027-	0115-	0203-	0291-
15	390	±10	3	16	74	10	17.2	31	-66	+16	+20	1450	T2	0028-	0116-	0204-	0292-
15	820	±20	6	24	111	10	17.2	22	-77	+20	+25	1800	T3	0029-	0117-	0205-	0293-
15	820	±10	6	24	111	10	17.2	22	-77	+20	+25	1800	T3	0030-	0118-	0206-	0294-
15	1000	±20	8	32	92	10	17.2	17	-77	+25	+30	2300	T4	0031-	0119-	0207-	0295-
15	1000	±10	8	32	92	10	17.2	17	-77	+25	+30	2300	T4	0032-	0120-	0208-	0296-
25	68	±20	2	9	22	15	28.8	90	-40	+12	+15	850	T1	0033-	0121-	0209-	0297-
25	68	±10	2	9	22	15	28.8	90	-40	+12	+15	850	T1	0034-	0122-	0210-	0298-
25	270	±20	3	16	55	15	28.8	33	-62	+13	+16	1400	T2	0035-	0123-	0211-	0299-
25	270	±10	3	16	55	15	28.8	33	-62	+13	+16	1400	T2	0036-	0124-	0212-	0300-
25	560	±20	7	28	76	15	28.8	24	-72	+20	+25	1750	T3	0037-	0125-	0213-	0301-
25	560	±10	7	28	76	15	28.8	24	-72	+20	+25	1750	T3	0038-	0126-	0214-	0302-
25	680	±20	8	32	63	15	28.8	19	-72	+25	+30	2100	T4	0039-	0127-	0215-	0303-
25	680	±10	8	32	63	15	28.8	19	-72	+25	+30	2100	T4	0040-	0128-	0216-	0304-
30	56	±20	2	9	22	20	34.5	100	-38	+12	+16	800	T1	0041-	0129-	0217-	0305-
30	56	±10	2	9	22	20	34.5	100	-38	+12	+15	800	T1	0042-	0130-	0218-	0306-
30	220	±20	3	16	42	20	34.5	36	-60	+13	+16	1200	T2	0043-	0131-	0219-	0307-
30	220	±10	3	16	42	20	34.5	36	-60	+13	+16	1200	T2	0044-	0132-	0220-	0308-
30	470	±20	8	32	64	20	34.5	25	-65	+20	+25	1500	T3	0045-	0133-	0221-	0309-
30	470	±10	8	32	64	20	34.5	25	-65	+20	+25	1500	T3	0046-	0134-	0222-	0310-
30	560	±20	9	36	55	20	34.5	20	-65	+25	+30	2000	T4	0047-	0135-	0223-	0311-
30	560	±10	9	36	55	20	34.5	20	-65	+25	+30	2000	T4	0048-	0136-	0224-	0312-
50	33	±20	2	9	12.3	30	57.5	135	-29	+10	+12	700	T1	0049-	0137-	0225-	0313-
50	33	±10	2	9	12.3	30	57.5	135	-29	+10	+12	700	T1	0050-	0138-	0226-	0314-
50	120	±20	4	24	22.5	30	57.5	49	-42	+12	+15	1200	T2	0051-	0139-	0227-	0315-
50	120	±10	4	24	22.5	30	57.5	49	-42	+12	+15	1200	T2	0052-	0140-	0228-	0316-
50	270	±20	8	32	37	30	57.5	29	-46	+20	+25	1450	T3	0053-	0141-	0229-	0317-
50	270	±10	8	32	37	30	57.5	29	-46	+20	+25	1450	T3	0054-	0142-	0230-	0318-
50	330	±20	9	36	38	30	57.5	22	-46	+25	+30	1900	T4	0055-	0143-	0231-	0319-
50	330	±10	9	36	38	30	57.5	22	-46	+25	+30	1900	T4	0056-	0144-	0232-	0320-
60	27	±20	3	12	10.2	40	69.0	144	-24	+10	+12	700	T1	0057-	0145-	0233-	0321-
60	27	±10	3	12	10.2	40	69.0	144	-24	+10	+12	700	T1	0058-	0146-	0234-	0322-
60	100	±20	4	20	19	40	69.0	54	-36	+12	+15	1100	T2	0059-	0147-	0235-	0323-
60	100	±10	4	20	19	40	69.0	54	-36	+12	+15	1100	T2	0060-	0148-	0236-	0324-
60	220	±20	8	32	30	40	69.0	29	-40	+16	+20	1400	T3	0061-	0149-	0237-	0325-
60	220	±10	8	32	30	40	69.0	29	-40	+16	+20	1400	T3	0062-	0150-	0238-	0326-

See footnotes at end of figure.

FIGURE 702-9. Established reliability, tantalum, electrolytic (nonsolid eletrolyte), fixed capacitors - Continued.

STANDARD CAPACITORS

STYLE CLR81 (MIL-C-39006/25)
TANTALUM ANODE AND CATHODE
POLARIZED SINTERED SLUG -- OPERATING TEMPERATURE RANGE -55° TO +85°C (VOTAGE DERATED TO 125°C)

1/ Rated voltage (+85°C)	Cap.	Cap. tolerance	DC Leakage (max) +25°C	DC Leakage (max) +85°C & +125°C	Dissipation factor (max)	1/ Derated voltage (+125°C)	Surge voltage (+85°C)	Impedance (max)	Capacitance change at -55°C	Capacitance change at +85°C	Capacitance change at +125°C	Max 2/ 85°C 40 kHz ripple current	Case size	Part No. 39006/25- Failure rate level for (%/1,000 hr) M(1.0)	P(0.1)	R(0.01)	S(0.001)
V dc	µF	%	µA	µA	%	V dc	V dc	Ohms	%	%	%	mA rms					
60	270	±20	9	36	27	40	69.0	23	-45	+20	+25	1850	T4	0063-	0151-	0239-	0327-
60	270	±10	9	36	27	40	69.0	23	-45	+20	+25	1850	T4	0064-	0152-	0240-	0328-
75	22	±20	3	12	8.5	50	86.2	157	-19	+10	+12	600	T1	0065-	0153-	0241-	0329-
75	22	±10	3	12	8.5	50	86.2	157	-19	+10	+12	600	T1	0066-	0154-	0242-	0330-
75	82	±20	4	24	15.2	50	86.2	63	-30	+12	+15	1000	T2	0067-	0155-	0243-	0331-
75	82	±10	4	24	15.2	50	86.2	63	-30	+12	+15	1000	T2	0068-	0156-	0244-	0332-
75	180	±20	9	36	24.4	50	86.2	30	-35	+16	+20	1300	T3	0069-	0157-	0245-	0333-
75	180	±10	9	36	24.4	50	86.2	30	-35	+16	+20	1300	T3	0070-	0158-	0246-	0334-
75	220	±20	10	40	37.0	50	86.2	24	-40	+20	+25	1800	T4	0071-	0159-	0247-	0335-
75	220	±10	10	40	37.0	50	86.2	24	-40	+20	+25	1800	T4	0072-	0160-	0248-	0336-
100	10	±20	3	12	4.5	65	115.0	200	-17	+10	+12	800	T1	0073-	0161-	0249-	0337-
100	10	±10	3	12	4.5	65	115.0	200	-17	+10	+12	800	T1	0074-	0162-	0250-	0338-
100	39	±20	5	24	10.4	65	115.0	80	-20	+12	+15	1300	T2	0075-	0163-	0251-	0339-
100	39	±10	5	24	10.4	65	115.0	80	-20	+12	+15	1300	T2	0076-	0164-	0252-	0340-
100	68	±20	10	40	11.3	65	115.0	40	-30	+14	+16	1600	T3	0077-	0165-	0253-	0341-
100	68	±10	10	40	11.3	65	115.0	40	-30	+14	+16	1600	T3	0078-	0166-	0254-	0342-
100	120	±20	12	48	25	65	115.0	30	-35	+15	+17	2000	T4	0079-	0167-	0255-	0343-
100	120	±10	12	48	25	65	115.0	30	-35	+15	+17	2000	T4	0080-	0168-	0256-	0344-
100	6.8	±20	3	12	6.0	85	144.0	300	-14	+10	+12	700	T1	0081-	0169-	0257-	0345-
100	6.8	±10	3	12	6.0	85	144.0	300	-14	+10	+12	700	T1	0082-	0170-	0258-	0346-
100	27	±20	5	24	7.2	85	144.0	90	-18	+12	+15	1200	T2	0083-	0171-	0259-	0347-
100	27	±10	5	24	7.2	85	144.0	90	-18	+12	+15	1200	T2	0084-	0172-	0260-	0348-
100	47	±20	10	40	7.9	85	144.0	50	-26	+14	+16	1500	T3	0085-	0173-	0261-	0349-
100	47	±10	10	40	7.9	85	144.0	50	-26	+14	+16	1500	T3	0086-	0174-	0262-	0350-
100	82	±20	12	48	17.4	85	144.0	32	-30	+15	+17	1900	T4	0087-	0175-	0263-	0351-
100	82	±10	12	48	17.4	85	144.0	32	-30	+15	+17	1900	T4	0088-	0176-	0264-	0352-

1/ Reverse voltage rating at 85°C is 3 Vdc, and at 125°C is 2 Vdc.
2/ For ripple current limits at various temperatures, voltages, and frequencies, see table II.
3/ Dash number will include the letter "H" to indicate the optional vibration and shock requirements (i.e., g random vibration, 80 g sinusoidal vibration, and 500 g shock) or "-" will be derated.

FIGURE 702-9. Established reliability, tantalum, electrolytic (nonsolid electrolyte), fixed capacitors - Continued.

TABLE 702-III. Ripple current multipliers vs frequency, temperature, and applied peak voltage.

Frequency of applied ripple current		120 Hz				600 Hz				1 kHz				10 kHz				40 kHz				100 kHz			
Ambient still air		≤55°C	85°C	105°C	125°C	≤55°C	85°C	105°C	125°C	≤55°C	85°C	105°C	125°C	≤55°C	85°C	105°C	125°C	≤55°C	85°C	105°C	125°C	≤55°C	85°C	105°C	125°C
% of 85°C rated peak voltage	100%	.60	.39	--	--	.71	.43	--	--	.72	.45	--	--	.88	.55	--	--	1.0	.63	--	--	1.1	.69	--	--
	90%	.60	.46	--	--	.71	.55	--	--	.72	.55	--	--	.88	.67	--	--	1.0	.77	--	--	1.1	.85	--	--
	80%	.60	.52	.35	--	.71	.62	.42	--	.72	.62	.42	--	.88	.76	.52	--	1.0	.87	.59	--	1.1	.96	.65	--
	70%	.60	.58	.44	--	.71	.69	.52	--	.72	.70	.52	--	.88	.85	.64	--	1.0	.97	.73	--	1.1	1.07	.80	--
	≤ 66 2/3%	.60	.60	.46	.27	.71	.71	.55	.32	.72	.72	.55	.32	.88	.88	.68	.40	1.0	1.0	.77	.45	1.1	1.1	.85	.50

1. At125°C the rated voltage of the capacitors decreases to 66 2/3% of the 85° rated voltage.
2. The peak of the applied ac ripple voltage plus the applied dc voltage rating of the capacitor either forward ofr reverse.
3. The ripple current listed in table I represents a rating calculated using a maximum internal temperature rise (ΔT) of 50°C at 40 kHz at 85°C ambient with a maximum peak rated voltage of 66 2/3% of the 85°C peak voltage rating.
4. The maximum allowable internal temperature rixe (ΔT) decreases linearly to a calculated 10°C rise at 125°C ambient.
5. The internal tempaerature rise is directly proportional to the ESR of the capicitor, and ESR increases with decrasing frequency.

SECTION 704

CAPACITORS, FIXED, ELECTROLYTIC (ALUMINUM OXIDE), ESTABLISHED RELIABILITY

STYLES CUR13, CUR17, CUR19, CUR71, AND CUR91
(APPLICABLE SPECIFICATION: MIL-C-39018)

1. SCOPE. This section covers established reliability, aluminum oxide, electrolytic, fixed capacitors, insulated and polarized. Capacitors covered by this section have failure rate levels ranging from 1.0 to 0.001 percent per 1,000 hours. The failure rate levels are established at a 60-percent confidence level and are maintained at a 10-percent producer's risk and are based on full rated voltage at 85°C.

2. APPLICATION INFORMATION.

2.1 Use. Aluminum electrolytic capacitors are intended for use in filter, coupling, and by-pass applications where large capacitance values are required in small cases and where excesses of capacitance over the nominal value can be tolerated. For polarized capacitors, the applied ac peak voltage should never exceed the applied dc voltage; the sum of the applied ac peak and dc voltages should never exceed the dc working voltage.

Aluminum electrolytic capacitors provide the smallest volume, mass, and cost per microfarad of any type of capacitor with the exception of the tantalum electrolytic capacitor. These capacitors are nonhermetically sealed but do use elastomer seals. As is common with all electrochemical devices containing water, these capacitors can evolve small amounts of hydrogen during operation which, in most cases, is not sufficient to be considered hazardous. It is recommended that capacitores having more than three years storage be checked at room ambient temperature for leakage current in accordance with the applicable requirement before being placed in service. Information on storage limitations may be found in MIL-STD-1131.

These capacitors are generally used where low frequency, pulsating, dc signal components are to be filtered out, such as in B power supplies up to 350 dc working volts, at such points as plate and screen connections to B+, and as cathode by-pass capacitors in self-biasing circuits. These capacitors are designed for applications where accuracy of capacitance is relatively unimportant.
As a rule, for selection of emitter by-pass capacitors, a ratio of bias resistance to by-pass reactance of about 10 to 1 is allowed. Ratios up to 20 to 1 may be used in high-fidelity-amplifier work or where space and economical considerations permit. Electrolytic capacitors provide the equipment designer with an unusually lightweight unit of high capacitance in a compact container. Failure mode of these types is typically gradual loss of capacity and increased dissipation factor at life times beyond the 10,000 hours 85°C life.

The 4-terminal axial leaded capacitor is designed for high frequency applications where low equivalent series resistance, inductance, and impedance are required. The advantahge of 4-terminal construction over 2-terminal construction is that the impedance decreases above 10 kHz. Unlike 2-terminal capacitors, the dc current flows through the capacitor and contributes to the operating temperature. The temperature rise (T_L) due to the dc current may be determined from figure 704-1. The ability of the external leads to carry the desired current should be taken into consideration. Lead length and heat sink qualities of the printed circuit board and capacitor will affect the current capability.

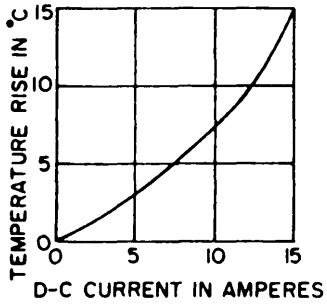


FIGURE 704-10 DC current vs temperature rise.

2.2 Construction. The construction of these capacitors is basically the same as that specified in Section 201 (MIL-C-62). However, advancements in the manufacture of aluminum electrolytic capacitors have made possible an increased foil purity, improved oxide system,and an increase in etch ratios. Other contributing factors to the advancement in the manufacture of aluminum capacitors are an improved capacitor seal and the development of an electrolyte with a non-aqueous, non-acid base.

The metal cases for these capacitors are provided with an insulating sleeve which has an insulation resistance of at least 100 megohms and will withstand 2000 volts dc minumum without breakdown.

It should be noted that the insulation resistance refers to the sleeve and not to the resistance between the terminals and the case. The circuit diagram for styles CUR19, CUR71, and CUR91 capacitors shows an indeterminate resistance between the outer-foil terminal and the case since the electrolyte cannot be completely isolated. For safer performance,the insulating sleeve should remain over the case for all applications. The negative terminal is shorted to the case on styles CUR13 and CUR17 capacitors.

2.3 Voltage rating. The thickness of the oxide film which is formed both initially on the foil and during the forming operations on the completed capacitor determines the maximum peak or surge voltage shich may be applied. For maximum reliability and long life, the dc working voltage should not be more than approximately 80 percent of full rating so that surges can be kept within the full-rated working voltage. The time of surge-voltage application should not be more than 30 seconds every 10 minutes.

Styles CUR13 and CUR17 have a 3-volt reverse voltage characteristic for units rated 10 volts or greater. Styles CUR19, CUR71, and CUR91 have a 1.5-volt reverse voltage characteristic.

TABLE 704-1. DC voltage.

Style	DC voltage range -55°C to +85°C	Derated dc voltage range at +125°C	DC surge voltage range -55°C to 85°C	Derated dc surge voltage at +125°C
CUR13	7 to 350	5 to 275	10 to 375	7 to 300
CUR17	7 to 350 1/	_____	10 to 375	_____
CUR19	5 to 200 1/	_____	7 to 250	_____
CUR71	5 to 350 1/	_____	7 to 400	_____
CUR91	5 to 150 1/	_____	7 to 200	_____

1/ DC voltage range -55°C to +105°C, not derated to +125°C.
2/ DC voltage range -55°C to +85°C, not derated to +125°C.

2.4 Operating temperature range. Style CUR13 capacitors are suitable for operation over a temperature range of -55°C to +85°C. Styles CUR17, CUR19, and CUR91 capacitors are designed to operate over a temperature range of -55°C to +105°C. Style CUR71 capacitors are suitable for operation over a temperature range of -55°C to +85°C.

2.5 Derating. Style CUR13 capacitors may be voltage derated in order to operate at temperatures up to +125°C. The percent of derating varies from approximately 20 to 33 percent depending on the particular voltage rating involved.

2.6 Surge voltage. The surge voltage is the maximum voltage to which the capacitor should be subjected under any condition. This includes transients and peak ripple at the highest line voltage.

2.7 Seal. The capacitors listed in this standard are supplied using nonhermetic seals and even though these capacitors have vents designed to open at dangerous pressures, explosions can occur because of gas pressure or a spark ignition of free oxygen and hydrogen liberated at the electrodes. Provisions should be made to protect surrounding parts.

STYLE CFR12 - Continued

Type designation	Capacitance	Rated voltage at 85°C	Capacitance tolerance	Type designation	Capacitance	Rated voltage at 85°C	Capacitance tolerance
		volts, dc				volts, dc	
CFR12RRJ104--	.10	25	F,J,K	CFR12RRH822--	.0082	150	F,J,K
CFR12RRJ823--	.082	"	"	CFR12RRH682--	.0068	150	"
CFR12RRJ683--	.068	"	"	CFR12RRC562--	.0056	200	"
CFR12RRA563--	.056	50	"	CFR12RRC472--	.0047	"	"
CFR12RRA473--	.047	"	"	CFR12RRC392--	.0039	"	"
CFR12RRA393--	.039	"	"	CFR12RRK332--	.0033	250	"
CFR12RRA333--	.033	"	"	CFR12RRK272--	.0027	"	"
CFR12RRG273--	.027	75	"	CFR12RRK222--	.0022	"	"
CFR12RRG223--	.022	75	"	CFR12RRK182--	.0018	"	"
CFR12RRB183--	.018	100	"	CFR12RRK152--	.0015	"	"
CFR12RRB153--	.015	"	"	CFR12RRK122--	.0012	"	"
CFR12RRB123--	.012	"	"	CFR12RRK102--	.0010	"	"
CFR12RRB103--	.010	"	"				

Applicaiton note: Care must be taken during wave soldering to assure that style CFR12 capacitors are not damaged from overheating. During wave soldering operation the capacitors shall not be exposed to conditions in excess of the resistance to soldering heat requirements of MIL-C-55514.

FIGURE 803-2. Established reliability, plastic (or metallized plastic) dieledtric, In nonmetal cases, fixed capacitors - Continued.

CAPACITORS, FIXED, SUPERMETALLIZED, PLASTIC FILM DIELECTRIC, (DC, AC, OR DC AND AC), HERMETICALLY SEALED IN METAL CASES, ESTABLISHED RELIABILITY

STYLES CRHO1, CRH02, CRH03, CRH04, CRH05, CRH11, CRH12, AND CRH13 (INSULATED)

(APPLICABLE SPECIFICATION: MIL-C-83421)

1. SCOPE. This section covers established reliability, metallized, plastic film dielectric, fixed capacitors, hermetically sealed in metal cases. These capacitors have failure rate levels ranging from 1.0 percent to 0.001 percent per 1,000 hours. The failure rate levels are established at a 90-percent confidence level and are based on full rated voltage at the maximum rated temperature.

2. APPLICATION INFORMATION.

2.1 Use. Capacitors covered by this specification are primarily intended for use in circuit applications which require non-polar behavior, relatively high insulation resistance, low dielectric absorption, low capacitance change with temperature, and low capacitance drift over the temperature range. Styles covered by this specification are rated for continuous operation under ac sinusoidal conditions in addition to continuous operation under dc conditions. These capacitors can exhibit periods of low insulation resistance and should only be used in circuits that can tolerate occasional momentary breakdowns. They should not be used in high impedance, low voltage applications.

2.2 Construction. Metallized plastic film capacitors differ from plastic foil types which have separate layers of metal foil (capacitor plates) and plastic dielectric. The metal comprising the metallized capacitor plates is a thin conductive coating on one side of the plastic dielectric by means of a metallizing process. This technique results in an overall size reduction for metallized plastic capacitors when compared to plastic foil capacitors of equal voltage rating and capacitance value. Typically, a 1 µF, 50 volts dc metallized polycarbonate capacitor will occupy approximately one third the volume of a similar polycarbonate foil capacitor.

Another advantage resulting from the metallizing technique is that the capacitors are self-healing. Generally, the voltage breakdown occurs through a small hole or thin spot in the dielectric with the fault current melting away the conductive metal coating adjacent to the fault area. After clearing, the capacitors will continue to operate normally with the possibility of reduced insulation resistance, increased dielectric absorption and no significant change to capacitance value or dissipation factor. Clearing will occur only if there is sufficient energy available from the circuit and/or stored in the capacitor. Minimum stored energy in the range of 100 to 500 microjoules is recommended to insure clearing. Applications for these capacitors should be limited to circuits that will provide sufficient energy to insure clearing and are insensitive to momentary breakdowns (clearing actions). In the conventional plastic-foil types (where the foil is thicker), sustained conduction can occur on a breakdown causing a large area of the plastic surrounding the breakdowns to be carbonized resulting in a permanent short-circuit.

The breakdown of the metallized plastic capacitor can be either of two types; i.e., (1) a complete breakdown lasting for only a moment (momentary breakdown) or (2) a sharp reduction in insulation resistance lasting for an extended period of time, but eventually returning to normal (period of low insulation). The general characteristics of the metallized plastic type, aside from the breakdowns, are similar to the conventional plastic type except for a significantly lower insulation resistance, approximately in the order of 10 to 1.

2.3 Voltage rating.

3.1 DC voltage ratings. DC ratings are 30 V dc to 400 V dc from -55°C to +1OO°C.

2.3.2 AC voltage rating. AC ratings are 22 V rms to 240 V rms at 400 Hz from -55°C to +100°C. Maximum ac current for each capacitor value and rating is shown in the table of figure 804-1, in the 40 KHz column. Operation at frequencies above the below 40 kHz is permissible provided the rms voltage limit at 400 Hz or the rms current limit at 40 KHz is not exceed.

2.3.3 Voltage derating ablve 100°C. For operation beyond +1OO°C and Up to +125°C, derated ac and dc voltage linearly from 100 percent at +1OO°C to 50 percent at +125°C.

2.3.4 Combined dc and ac voltage. The combined dc and ac peak voltage should not exceed the dc tating of the capacitors.

2.4 Temperature range

2.4.1 Storage. Storage temperature range is -65°C to +125°C.

2.4.2 Operating. Operating temperature tange is -55°C to +125°C with voltage derating (see 2.3.3).

2.5 Prevention of corona. All metal parts, fittings, conductors, and attachments which operate at higher potential than other adjacent parts of the housing, should be carefully finished in order to insure that all sharp corners and edges are removed to minimize the possibility of corona discharge. Parts, from which the removal of sharp corners and edges would be impractical, such as conductors, should be spaced in such a manner as to prevent harmful corona discharges.

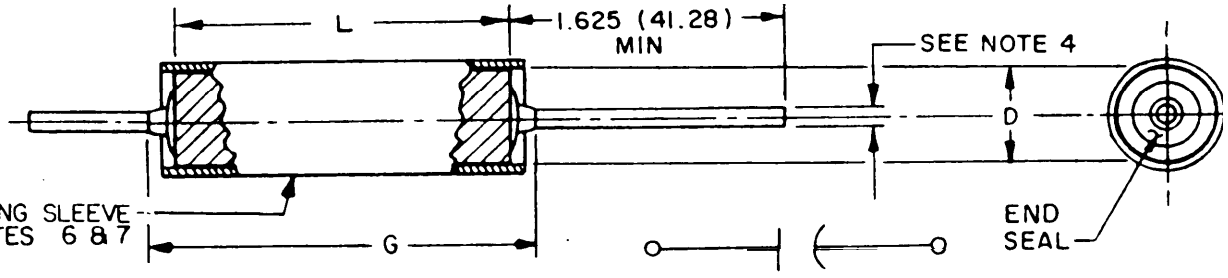
2.6 Mounting. Capacitors with dimension L or D of 1.375 or 0.670 inches, respectively, and greater. should not be supported by their leads. These capacitors should be provided with a supplementary means for mounting, such as a tangential bracket.

3. ITEM IDENTIFICATION.

3.1 Standard capacitors. The standard capacitors available in this section are shown on figure 804-1. (The figure gives the electrical characteristics, failure rate levels, and military part numbers which are standard for design.)

STYLES CRHO1, CRH02, CRH03, CRH04, and CRHO5

(MIL-C-83421/1)

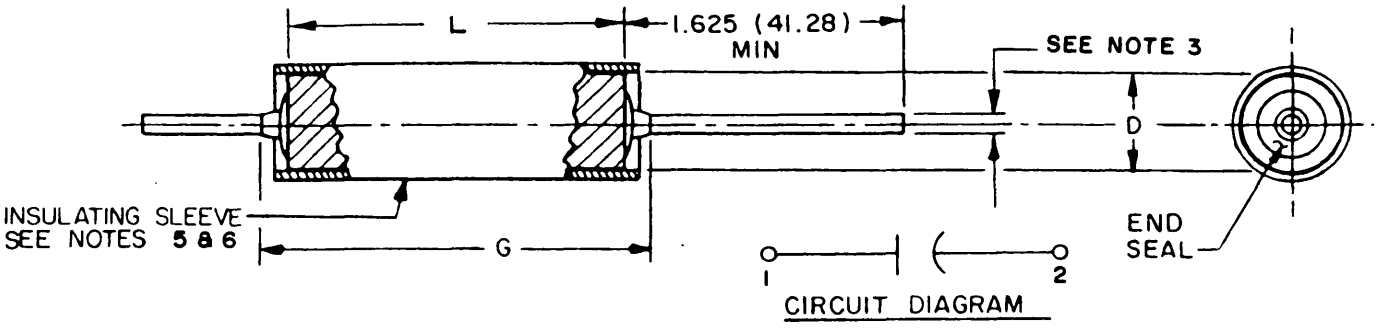


CIRCUIT DIAGRAM

NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only.
3. Metric equivalents are in parentheses.
4. .025 ± .002 for case diameters of .312 (7.92 mm) and less.
   .032 ± .002 for case diameters of .400 (10.16 mm) and .500 (12.70 mm).
   .040 ± .002 for case diameters of .562 (14.27 mm) and over.
5. See table I for additional dimensions.
6. Insulating sleeve shall extend beyond the capacitor body. Insulating sleeve thickness shall not exceed .005 (0.13 mm) inch.
7. Plastic insulating sleeve shall be transparent; marking shall be applied to the capacitor case.
8. Lead length may be a minimum of one inch for use in tape and reel packaging, when specified in the ordering data.

FIGURE 804-1. Established reliability, metallized plastic dielectric, fixed capacitors.

STYLES CRH11, CRH12, and CRH13 (MIL-C-83421/2)



NOTES:
1. Dimensions are in inches.
2. Metric equivalents are in parentheses and are given for general information only.
3. Number 18 AWG wire .040 inch ± .002 (1.02 ± 0.05 mm).
4. See table I for additional dimensions.
5. Insulating sleeve shall extend beyond the capacitor body. Insulating sleeve thickness shall not exceed .005 inch (0.13 mm).
6. Plastic insulating sleeve shall be transparent; marking shall be applied to the capacitor case.

FIGURE 804-1. Established reliability, metalized plastic dielectric, fixed capacitors - Continued.

Capacitance value (nom) (in µF)	Dimensions 1/ (in inches with mm in parentheses) L ±.030 (0.76) -.090 (2.29)	D ±.020 (0.51) -.010 (0.25)	G (max)	Dash number 2/ Capacitance tolerance value (in %) ±0.25	±0.5	±1.0	±2.0	±5.0	±10.0	ESR 20 kHz 100 kHz (ohms maximum)	AC rating maximum 400 Hz	Ripple current 20 kHz to 100 kHz (amperes rms) maximum case temperature °C 3/ 25	35	45	55	65	75	85	95	105
CRH11 - 100 volts (dc rating)																				
0.47	0.875 (22.23)	0.400 (10.16)	1.075 (27.31)	1001-	1002-	1003-	1004-	1005-	1006-	0.025	60 volts rms	5.3	4.9	4.6	4.2	3.7	3.2	2.6	1.9	0.8
0.56	"	0.500 (12.70)	"	1007-	1008-	1009-	1010-	1011-	1012-	0.024	"	6.0	5.6	5.2	4.8	4.3	3.7	3.0	2.1	1.0
0.68	"	"	"	1013-	1014-	1015-	1016-	1017-	1018-	0.023	"	6.2	5.8	5.4	4.9	4.4	3.8	3.1	2.2	1.0
0.82	"	"	"	1019-	1020-	1021-	1022-	1023-	1024-	0.022	"	6.3	5.9	5.5	5.0	4.5	3.9	3.2	2.2	1.0
1.0	0.906 (23.01)	0.562 (14.27)	1.106 (28.09)	1025-	1026-	1027-	1028-	1029-	1030-	0.017	"	7.7	7.2	6.7	6.1	5.4	4.7	3.9	2.7	1.2
2.0	1.094 (27.80)	0.670 (17.02)	1.294 (32.87)	1031-	1032-	1033-	1034-	1035-	1036-	0.014	"	10.3	9.7	8.9	8.2	7.3	6.3	5.2	3.7	1.6
3.0	1.094 (27.80)	0.750 (19.05)	1.294 (32.87)	1037-	1038-	1039-	1040-	1041-	1042-	0.013	"	11.4	10.7	9.9	9.0	8.1	7.0	5.7	4.0	1.8
5.0	1.406 (35.70)	0.750 (19.05)	1.606 (40.79)	1043-	1044-	1045-	1046-	1047-	1048-	0.012	"	13.6	12.7	11.8	10.7	9.6	8.3	6.8	4.8	2.1
10.0	1.687 (42.85)	1.000 (25.40)	1.887 (47.93)	1049-	1050-	1051-	1052-	1053-	1054-	0.010	"	15.0	15.0	15.0	14.3	12.8	11.1	9.1	6.4	2.9
20.0	2.437 (61.90)	1.000 (25.40)	2.637 (66.98)	1055-	1056-	1057-	1058-	1059-	1060-	0.009	"	15.0	15.0	15.0	15.0	15.0	14.1	11.5	8.2	3.6
CRH12 - 200 volts (dc rating)																				
0.18	0.875 (22.23)	0.400 (10.16)	1.075 (27.31)	2001-	2002-	2003-	2004-	2005-	2006-	0.031	120 volts rms	4.8	4.5	4.1	3.8	3.4	2.9	2.4	1.7	0.8
0.22	"	0.500 (12.70)	"	2007-	2008-	2009-	2010-	2011-	2012-	0.030	"	5.4	5.1	4.7	4.3	3.8	3.3	2.7	1.9	0.9
0.27	"	"	"	2013-	2014-	2015-	2016-	2017-	2018-	0.029	"	5.5	5.2	4.8	4.4	3.9	3.4	2.8	2.0	0.9
0.33	"	"	"	2019-	2020-	2021-	2022-	2023-	2024-	0.028	"	5.6	5.3	4.9	4.5	4.0	3.5	2.8	2.0	0.9
0.39	0.906 (23.01)	0.562 (14.27)	1.106 (28.09)	2025-	2026-	2027-	2028-	2029-	2030-	0.026	"	6.2	5.8	5.4	4.9	4.4	3.8	3.1	2.2	1.0
0.47	1.094 (27.80)	"	1.294 (32.87)	2031-	2032-	2033-	2034-	2035-	2036-	0.025	"	7.0	6.5	6.1	5.5	4.9	4.3	3.5	2.5	1.1
0.56	"	"	"	2037-	2038-	2039-	2040-	2041-	2042-	0.024	"	7.2	6.7	6.2	5.7	5.1	4.4	3.6	2.5	1.1
0.68	"	0.670 (17.02)	"	2043-	2044-	2045-	2046-	2047-	2048-	0.023	"	8.0	7.5	6.9	6.3	5.7	4.9	4.0	2.8	1.3
0.82	"	"	"	2049-	2050-	2051-	2052-	2053-	2054-	0.022	"	8.2	7.7	7.1	6.5	5.8	5.0	4.1	2.9	1.3
1.0	"	"	"	2055-	2056-	2057-	2058-	2059-	2060-	0.021	"	8.4	7.9	7.3	6.7	6.0	5.2	4.2	3.0	1.3
2.0	1.406 (35.70)	0.750 (19.05)	1.606 (40.79)	2061-	2062-	2063-	2064-	2065-	2066-	0.017	"	11.1	10.4	9.6	8.8	7.8	6.8	5.5	3.9	1.8
3.0	1.437 (36.50)	1.000 (25.40)	1.637 (41.58)	2067-	2068-	2069-	2070-	2071-	2072-	0.015	"	13.9	13.0	12.0	11.0	9.8	8.5	7.0	4.9	2.2
5.0	1.687 (42.85)	1.000 (25.40)	1.887 (47.93)	2073-	2074-	2075-	2076-	2077-	2078-	0.013	"	15.0	15.0	14.2	12.9	11.6	10.0	8.2	5.8	2.6
CRH13 - 400 volts (dc rating)																				
0.056	0.875 (22.23)	0.400 (10.16)	1.075 (27.31)	3001-	3002-	3003-	3004-	3005-	3006-	0.058	240 volts rms	3.6	3.3	3.0	2.8	2.5	2.1	1.7	1.2	0.6
0.068	"	0.500 (12.70)	"	3007-	3008-	3009-	3010-	3011-	3012-	0.046	"	4.4	4.1	3.8	3.5	3.1	2.7	2.2	1.5	0.7
0.082	"	"	"	3013-	3014-	3015-	3016-	3017-	3018-	0.039	"	4.7	4.4	4.1	3.7	3.4	2.9	2.4	1.7	0.7
0.10	"	"	"	3019-	3020-	3021-	3022-	3023-	3024-	0.035	"	5.0	4.7	4.4	4.0	3.6	3.1	2.5	1.8	0.8
0.12	0.906 (23.01)	0.562 (14.27)	1.106 (28.09)	3025-	3026-	3027-	3028-	3029-	3030-	0.033	"	5.6	5.2	4.8	4.4	3.9	3.4	2.8	2.0	0.9
0.15	"	0.670 (17.02)	"	3031-	3032-	3033-	3034-	3035-	3036-	0.032	"	6.2	5.8	5.3	4.9	4.4	3.8	3.1	2.2	1.0
0.18	"	"	"	3037-	3038-	3039-	3040-	3041-	3042-	0.031	"	6.3	5.9	5.4	5.0	4.4	3.8	3.1	2.2	1.0
0.22	1.094 (27.80)	"	1.294 (32.87)	3043-	3044-	3045-	3046-	3047-	3048-	0.030	"	7.0	6.6	6.1	5.6	5.0	4.3	3.5	2.5	1.1
0.27	"	"	"	3049-	3050-	3051-	3052-	3053-	3054-	0.029	"	7.2	6.7	6.2	5.7	5.1	4.4	3.6	2.5	1.1
0.33	"	"	"	3055-	3056-	3057-	3058-	3059-	3060-	0.028	"	7.3	6.8	6.3	5.8	5.2	4.5	3.7	2.6	1.2
0.39	"	0.750 (19.05)	"	3061-	3062-	3063-	3064-	3065-	3066-	0.026	"	7.9	7.4	6.8	6.2	5.6	4.8	3.9	2.8	1.2
0.47	"	"	"	3067-	3068-	3069-	3070-	3071-	3072-	0.025	"	8.1	7.6	7.0	6.4	5.7	4.9	4.0	2.9	1.3
0.56	1.406 (35.70)	"	1.606 (40.79)	3073-	3074-	3075-	3076-	3077-	3078-	0.025	"	9.2	8.6	7.9	7.2	6.5	5.6	4.6	3.2	1.4
0.68	1.406 (35.70)	"	1.606 (40.79)	3079-	3080-	3081-	3082-	3083-	3084-	0.024	"	9.4	8.8	8.1	7.4	6.6	5.7	4.7	3.3	1.5
0.82	1.656 (42.06)	"	1.856 (47.14)	3085-	3086-	3087-	3088-	3089-	3090-	0.023	"	10.4	9.7	9.0	8.2	7.4	6.4	5.2	3.7	1.6
1.0	1.656 (42.06)	"	1.856 (47.14)	3091-	3092-	3093-	3094-	3095-	3096-	0.022	"	10.7	10.0	9.3	8.5	7.6	6.5	5.3	3.8	1.7
2.0	1.938 (49.23)	1.000 (25.40)	2.138 (54.31)	3097-	3098-	3099-	3100-	3101-	3102-	0.017	"	15.0	14.1	13.0	11.9	10.6	9.2	7.5	5.3	2.4

1/ L and D are bare case dimensions (see figure 1).

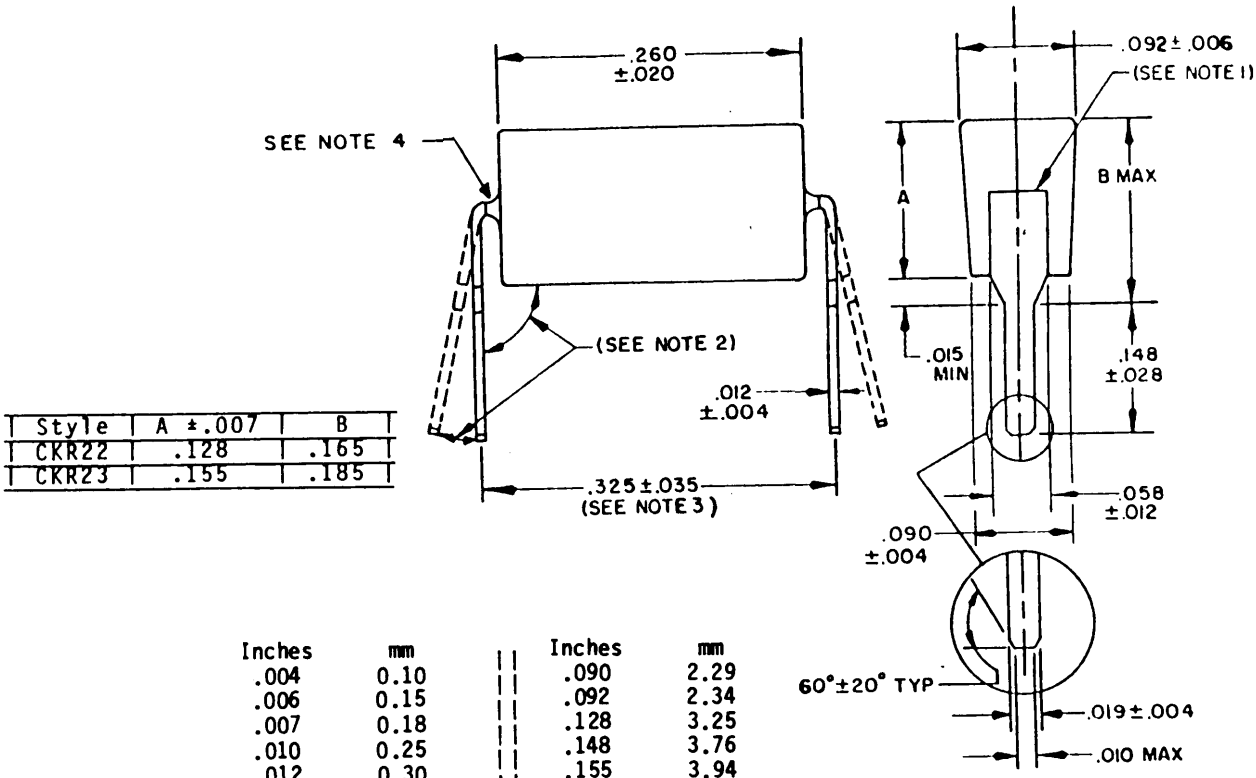
2/ The complete dash number will include the applicable letter completing the FR level symbol (M = M, P = P, etc.)

3/ This is the ambient case temperature prior to the application of current.

FIGURE 804.1 Established reliability, metallized plastic dielectric, fixed capacitors - Continued.

STANDARD CAPACITORS

STYLE CKR22 AND CKR23

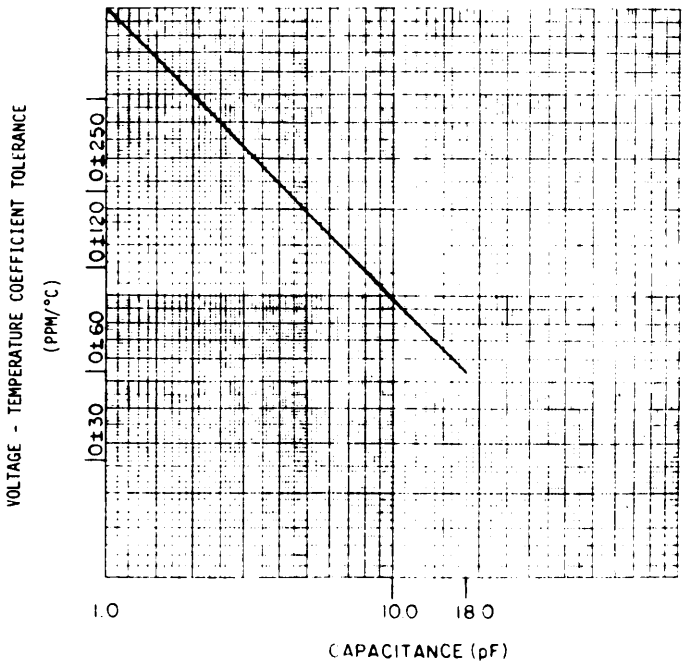


Style	A ±.007	B
CKR22	.128	.165
CKR23	.155	.185

Inches	mm	Inches	mm
.004	0.10	.090	2.29
.006	0.15	.092	2.34
.007	0.18	.128	3.25
.010	0.25	.148	3.76
.012	0.30	.155	3.94
.015	0.38	.165	4.19
.019	0.48	.185	4.70
.020	0.51	.260	6.60
.028	0.71	.283	7.19
.035	0.89	.320	8.13
.058	1.47	.325	8.26

NOTES:
1. Leads shall be centered within ±.005 inches (0.13 mm).
2. The angle shall be 95° +10°, -5°.
3. The distance between the centers of the mounting holes will be .300 ± .010 inches (7.62 ±0.25mm).
4. Nonconductive material shall not extend beyond .030 inches (0.76 mm) from the edge of the capacitor body.

FIGURE 901-2. Established reliability, general purpose, ceramic dielectric, fixed capacitors - Continued.



STANDARD CAPACITORS

STYLE CCR05

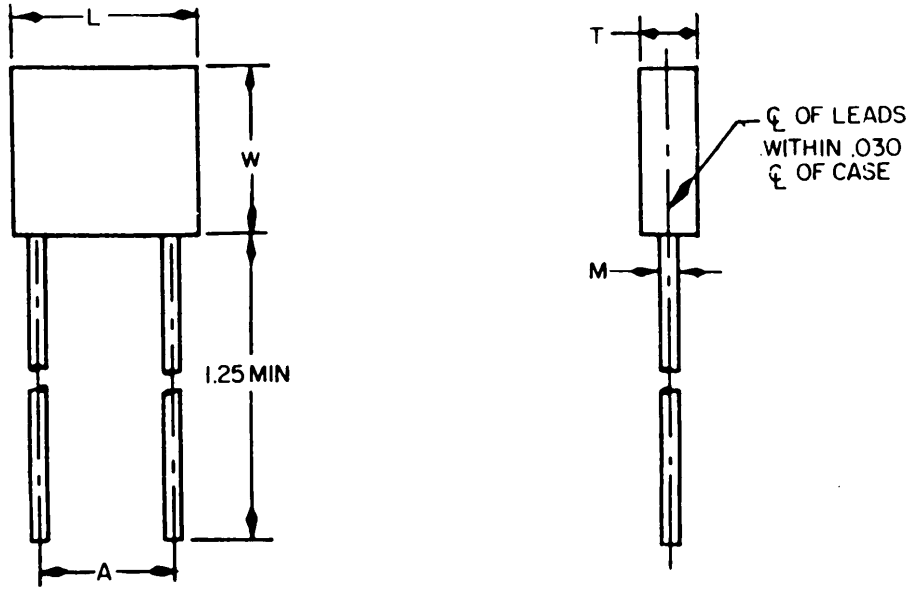
OPERATING TEMPERATURE RANGE -55°C TO +125°C --
FAILURE RATE LEVEL M (1.0%), P (0.01%), R (0.01%), OR S (0.001%)

Type designation 1/	Rated voltage	Nom. cap.	Cap. tol.	Type designation 1/	Rated voltage	Nom. cap.	Cap. tol.
	(volts, dc)	(pF)			(volts, dc)	(pF)	
CCR05CH1R0--	200	1.0	CD	CCR05CG680--	200	68	FGJ
CCR05CH1R2--	200	1.2	CD	CCR05CG820--	200	82	FGJ
CCR05CH1R5--	200	1.5	CD	CCR05CG101--	200	100	FGJ
CCR05CH1R8--	200	1.8	CD	CCR05CG121--	200	120	FGJ
CCR05CH2R2--	200	2.2	CD	CCR05CG151--	200	150	FGJ
CCR05CH2R7--	200	2.7	BCD	CCR05CG181--	200	180	FGJ
CCR05CH3R3--	200	3.3	BCD	CCR05CG221--	200	220	FGJ
CCR05CH3R9--	200	3.9	BCD	CCR05CG271--	200	270	FGJ
CCR05CH4R7--	200	4.7	BCD	CCR05CG331--	200	330	FGJ
CCR05CH5R6--	200	5.6	BCD	CCR05CG361--	100	360	FGJ
CCR05CH6R8--	200	6.8	BCD	CCR05CG391--	100	390	FGJ
CCR05CH8R2--	200	8.2	BCD	CCR05CG471--	100	470	FGJ
CCR05CH100--	200	10	FGJ	CCR05CG561--	100	560	FGJ
CCR05CG120--	200	12	FGJ	CCR05CG681--	100	680	FGJ
CCR05CG150--	200	15	FGJ	CCR05CG821--	100	820	FGJ
CCR05CG180--	200	18	FGJ	CCR05CG102--	100	1,000	FGJ
CCR05CG220--	200	22	FGJ	CCR05CG122--	100	1,200	FGJ
CCR05CG270--	200	27	FGJ	CCR05CG152--	100	1,500	FGJ
CCR05CG330--	200	33	FGJ	CCR05CG182--	100	1,800	FGJ
CCR05CG390--	200	39	FGJ	CCR05CG222--	50	2,200	FGJ
CCR05CG470--	200	47	FGJ	CCR05CG272--	50	2,700	FGJ
CCR05CG560--	200	56	FGJ	CCR05CG332--	50	3,300	FGJ

1/ Complete type designation will include additional symbols to indicate capacitance tolerance and failure rate level.

FIGURE 902-2. Established reliability, ceramic dielectric (temperature compensating), fixed capacitors - Continued.

STYLES CCR06, CCR07, AND CCR08



Inches	mm	Inches	mm
.001	0.03	.090	2.29
.004	0.10	.140	3.56
.010	0.25	.200	5.08
.015	0.38	.240	6.10
.020	0.51	.290	7.37
.025	0.64	.400	10.16
.027	0.69	.480	12.19
.030	0.76	1.25	31.75

Standard style	Dimension (inches)				
	L	W	T ±.010	A	M
CCR06	.290 ±.010	.290 ±.010	.090	.200 ±.015	.020 to .027
CCR07	.480 ±.020	.480 ±.020	.140 1/	.400 ±.020	.025 +.004 -.001
CCR08	.480 ±.020	.480 ±.020	.240	.400 ±.020	.025 +.004 -.001

1/ T = .200 max. for 100,000 pF.

FIGURE 902-2. Established reliability, ceramic dielectric (temperature compensating), fixed capacitors - Continued.

16 September 1988

SECTION 903

CAPACITORS, CHIP, MULTIPLE LAYER, FIXED, CERAMIC DIELECTRIC, ESTABLISHED RELIABILITY

STYLES CDRO1, CDR02, CDR03, CDR04, CDR11, CDR12, CDR13, CDR14, CDR26, CDR27, CDR28, CDR29, CDR30, CDR31, CDR32, CDR33, CDR34, and CDR35

(APPLICABLE SPECIFICATION: MIL-C-55681)

1. SCOPE. This section covers established reliability, ceramic dielectric, multiple layer, fixed chip capacitors. These capacitors have failure rate levels of 1.0 to 0.001 percent per 1,000 hours. The failure rate levels are established at a 90-percent confidence level and are based on operation at maximum rated voltage at the maximum rated temperature.

2. APPLICABLE INFORMATION.

2.1 Use. Ceramic chip capacitors are intended to be used in surface mount, and in thin or thick film hybrid circuits.

2.1.1 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.

2.2 Metallized terminations. It should be noted that when pure silver is used for the terminations, 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 temination by the lead-tin bonding solder also will retard the tendency toward silver termination. Addition of about 3 percent of silver to the lead-tin bonding solder will tend to reduce the leaching of the silver from a silver termination during the solder bonding operation.

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

3. ITEM IDENTIFICATION (see figures 903-1 and 903-2).

3.1 Type designation. The type designation is used for identifying the capacitors as shown in figure 903-1.

3.2 Standard capacitors. The standard capacitors available in this section are shown in figure 903-2.

CDR01 BP 100 B J S M

STYLE - The three-letter symbol "CDR" identifies established reliability, ceramic dielectric, fixed chip capacitors; the two-digit number identifies the dimensions.

RATED TEMPERATURE AND VOLTAGE-TEMPERATURE LIMITS - The two-letter symbol identifies the rated temperature and voltage-temperature limits. The first letter "B" indicates the rated temperature of -55°C to +125°C; the second letter identifies the voltage-temperature limits as follows:

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

CAPACITANCE - The three-digit number identifies the nominal capacitance value, expressed in picofarads (pF); 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).

RATED VOLTAGE - The single-letter symbol identifies the dc rated voltage as follows:

Symbol	DC rated voltage
A - - - -	50
B - - - -	100
C - - - -	200

CAPACITANCE TOLERANCE - The single-letter symbol identifies the capacitance tolerance as follows:

Symbol	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

TERMINATION FINISH - The single-letter symbol identifies the termination finish as follows:

Symbol	Finish
M	Palladium-Silver
N	Silver-Nickel-Gold
P	Silver-Copper-Gold
Q	Palladium-Gold
S	Solder coated, final
T	Silver
U	Base metallization: Barrier metal, solder coated. 1/
W	Base metallization: Barrier metal, tinned (tin or tin/lead alloy).

1/ Solder shall have a melting point of 200°C or less.

FAILURE RATE LEVEL - The single letter symbol identifies the failure rate level as follows:

Symbol	Failure rate level (%/1,000 hr)
M - - - -	1.0
P - - - -	0.1
R - - - -	0.01
S - - - -	0.001

FIGURE 903-1. Type designation example.

STANDARD CAPACITORS

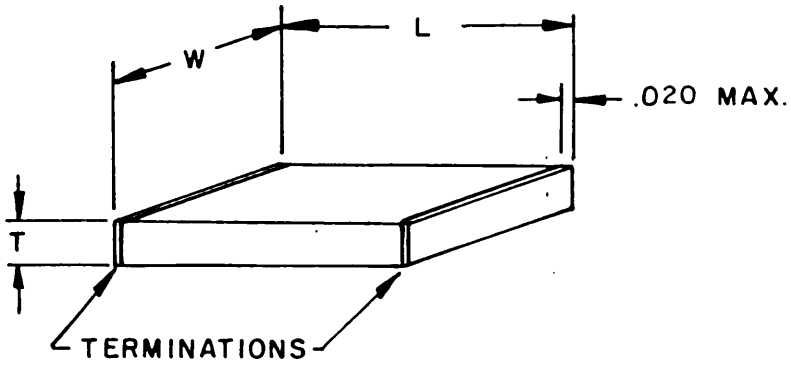
STYLES CDR13 AND CDR14 - Continued
OPERATING TEMPERATURE RANGE -55°C TO +125°C

Type designation 1/	Capacitance	Capacitance tolerance	Rated temperature and voltage-temperature limits	Rated voltage
	pF			volts, dc
CDR1-BP202A---	2,000	F,G,J,K,M	BP	50
CDR1-BP222A---	2,200	"	"	"
CDR1-BP242A---	2,400	"	"	"
CDR1-BP272A---	2,700	"	"	"
CDR1-BP302A---	3,000	"	"	"
CDR1-BP332A---	3,300	"	"	"
CDR1-BP362A---	3,600	"	"	"
CDR1-BP392A---	3,900	"	"	"
CDR1-BP432A---	4,300	"	"	"
CDR1-BP472A---	4,700	"	"	"
CDR1-BP502A---	5,000	"	"	"
CDR1-BP512A---	5,100	"	"	"

1/ Complete type designation will include additional symbols to indicate style, voltage-temperature limits, capacitance tolerance (where applicable), termination finish (M for style CDR13 and S, U, or W for style CDLR14), and failure rate level.

FIGURE 903-2. Established reliability ceramic dielectric multiple layer, fixed chip capacitors - Continued.

STYLES CDR26, CDR27, CDR28, CDR29, AND CDR30.



Dimensions				
Style	L	W	T	
			Min.	Max.
CDR26	.150 ±.015	.150 ±.015	.060	.120
CDR27	.190 ±.019	.190 ±.019	.060	.120
CDR28	.330 ±.033	.330 ±.033	.060	.120
CDR29	.400 ±.040	.400 ±.040	.060	.120
CDR30	.540 ±.054	.400 ±.040	.060	.120

Inches	mm
.015	0.38
.019	0.48
.020	0.51
.033	0.84
.040	1.02
.054	1.37
.060	1.52
.120	3.05
.150	3.81
.190	4.83
.330	8.38
.400	10.16
.540	13.72

NOTES:
1. Dimensions are in inches.
2. Metric equivalents are given for general information only.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.

STANDARD CAPACITORS

STYLES CDR26, CDR27, CDR28, CDR29, AND CDR30
OPERATING TEMPERATURE RANGE -55°C TO +125°C

Type designation 1/	Capacitance	Capacitance tolerance	Rated temperature and voltage-temperature limits	Rated voltage
	pF			volts, dc
CDR26BP151J---	150	F, G, J	BP	4,000
CDR26BP181H---	180	"	"	3,000
CDR26BP221H---	220	"	"	"
CDR26BP271H---	270	"	"	"
CDR26BP331H---	330	"	"	2,000
CDR26BP391H---	390	"	"	"
CDR26BP471H---	470	"	"	"
CDR26BP561H---	560	"	"	"
CDR26BP681F---	680	"	"	1,000
CDR26BP821F---	820	"	"	"
CDR26BP102F---	1,000	"	"	"
CDR26BP122F---	1,200	"	"	"
CDR26BP152F---	1,500	"	"	"
CDR26BP182F---	1,800	"	"	"
CDR26BP222F---	2,200	"	"	"
CDR27BP271J---	270	"	"	4,000
CDR27BP331J---	330	"	"	4,000
CDR27BP391H---	390	"	"	3,000
CDR27BP471H---	470	"	"	"
CDR27BP561H---	560	"	"	"
CDR27BP681G---	680	"	"	2,000
CDR27BP821G---	820	"	"	"
CDR27BP102G---	1,000	"	"	"
CDR27BP122G---	1,200	"	"	"
CDR27BP272F---	2,700	"	"	1,000
CDR27BP322F---	3,300	"	"	"
CDR27BP392F---	3,900	"	"	"
CDR27BP472F---	4,700	"	"	"
CDR28BP391J---	390	"	"	4,000
CDR28BP471J---	470	"	"	"
CDR28BP561J---	560	"	"	"
CDR28BP681J---	680	"	"	"
CDR28BP821H---	820	"	"	3,000
CDR28BP102H---	1,000	"	"	"
CDR28BP122H---	1,200	"	"	"
CDR28BP152G---	1,500	"	"	2,000
CDR28BP182F---	1,800	"	"	"
CDR28BP222G---	2,200	"	"	"
CDR28BP272G---	2,700	"	"	"
CDR28BP562F---	5,600	"	"	1,000
CDR28BP682F---	6,800	"	"	"
CDR28BP822F---	8,200	"	"	"
CDR28BP103F---	10,000	"	"	"
CDR28BP123F---	12,000	"	"	"
CDR29BP821J---	820	"	"	4,000
CDR29BP102J---	1,000	"	"	4,000

See footnote at end of figure.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.

STYLES CDR26, CDR27, CDR28, CDR29, AND CDR30 - CONTINUED
OPERATING TEMPERATURE RANGE -55°C TO +125°C

Type designation 1/	Capacitance	Capacitance tolerance	Rated temperature and voltage-temperature limits	Rated voltage
	pF			volts, dc
CDR29BP122J---	1,200	F, G, J	BP	4,000
CDR29BP152H---	1,500	"	"	3,000
CDR29BP182H---	1,800	"	"	"
CDR29BP222H---	2,200	"	"	"
CDR29BP332G---	3,300	"	"	2,000
CDR29BP392G---	3,900	"	"	"
CDR29BP472G---	4,700	"	"	"
CDR29BP562G---	5,600	"	"	"
CDR29BP153F---	15,000	"	"	1,000
CDR29BP223F---	22,000	"	"	1,000
CDR30BP152J---	1,500	"	"	4,000
CDR30BP182J---	1,800	"	"	"
CDR30BP222J---	2,200	"	"	"
CDR30BP272H---	2,700	"	"	3,000
CDR30BP332H---	3,300	"	"	3,000
CDR30BP682G---	6,800	"	"	2,000
CDR30BP882G---	8,200	"	"	2,000
CDR30BP273F---	27,000	"	"	1,000
CDR30BP333F---	33,000	"	"	1,000
CDR26BX151J---	150	K, M	BX	4,000
CDR26BX181J---	180	"	"	"
CDR26BX221J---	220	"	"	"
CDR26BX271J---	270	"	"	"
CDR26BX331J---	330	"	"	"
CDR26BX391J---	390	"	"	"
CDR26BX471J---	470	"	"	"
CDR26BX561H---	560	"	"	3,000
CDR26BX681H---	680	"	"	"
CDR26BX921H---	820	"	"	"
CDR26BX102G---	1,000	"	"	2,000
CDR26BX122G---	1,200	"	"	"
CDR26BX152G---	1,500	"	"	"
CDR26BX182G---	1,800	"	"	"
CDR26BX222G---	2,200	"	"	"
CDR26BX272F---	2,700	"	"	1,000
CDR26BX332F---	3,300	"	"	"
CDR26BX392F---	3,900	"	"	"
CDR26BX472F---	4,700	"	"	"
CDR26BX562F---	5,600	"	"	"
CDR26BX682F---	6,800	"	"	"
CDR26BX822F---	8,200	"	"	"
CDR26BX103F---	10,000	"	"	"
CDR27BX561J---	560	"	"	4,000
CDR27BX681J---	680	"	"	"
CDR27BX821J---	820	"	"	"
CDR27BX102J---	1,000	"	"	"

See footnote at end of figure.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.

STANDARD CAPACITORS

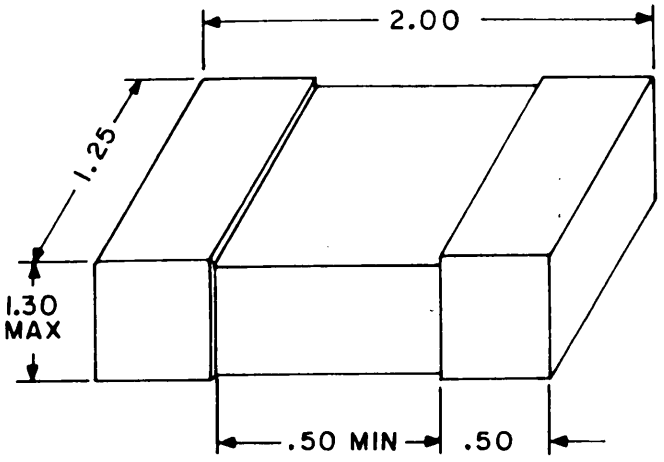
STYLES CDR26, CDR27, CDR28, CDR29, AND CDR30 - CONTINUED
OPERATING TEMPERATURE RANGE -55°C TO +125°C

Type designation 1/	Capacitance	Capacitance tolerance	Rated temperature and voltage-temperature limits	Rated voltage
	pF			volts, dc
CDR27BX122J---	1,200	K, M	BX	4,000
CDR27BX152H---	1,500	"	"	3,000
CDR27BX182H---	1,800	"	"	3,000
CDR27BX272G---	2,700	"	"	2,000
CDR27BX332G---	3,300	"	"	"
CDR27BX392G---	3,900	"	"	"
CDR27BX472G---	4,700	"	"	"
CDR27BX562G---	5,600	"	"	"
CDR27BX123F---	12,000	"	"	1,000
CDR27BX153F---	15,000	"	"	"
CDR27BX223F---	22,000	"	"	"
CDR28BX152J---	1,500	"	"	4,000
CDR28BX182J---	1,800	"	"	"
CDR28BX222J---	2,200	"	"	"
CDR28BX272H---	2,700	"	"	3,000
CDR28BX332H---	3,300	"	"	"
CDR28BX292H---	3,900	"	"	"
CDR28BX682G---	6,800	"	"	2,000
CDR28BX822G---	8,200	"	"	"
CDR28BX103G---	10,000	"	"	"
CDR28BX123G---	12,000	"	"	"
CDR28BX273F---	27,000	"	"	"
CDR28BX333F---	33,000	"	"	1,000
CDR28BX393F---	39,000	"	"	"
CDR28BX473F---	47,000	"	"	"
CDR29BX272J---	2,700	"	"	4,000
CDR29BX332J---	3,300	"	"	"
CDR29BX392J---	3,900	"	"	"
CDR29BX472H---	4,700	"	"	3,000
CDR29BX562H---	5,600	"	"	"
CDR29BX682H---	6,800	"	"	"
CDR29BX822H---	8,200	"	"	"
CDR29BX153G---	15,000	"	"	2,000
CDR29BX223G---	22,000	"	"	2,000
CDR29BX563F---	56,000	"	"	1,000
CDR29BX823F---	82,000	"	"	1,000
CDR30BX103H---	10,000	"	"	3,000
CDR30BX123H---	12,000	"	"	3,000
CDR30BX273G---	27,000	"	"	2,000
CDR30BX333G---	33,000	"	"	2,000
CDR30BX104F---	100,000	"	"	1,000
CDR30BX124F---	120,000	"	"	"
CDR30BX154F---	150,000	"	"	"

1/ Complete type designation will include additional symbols to indicate tolerance, termination finish, and failure rate level.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.

STYLE CDR31 (METRIC)



mm	Inches
0.20	.008
0.30	.012
0.50	.020
1.25	.049
1.30	.051
2.00	.078

NOTES:
1. Dimensions are in millimeters.
2. Dimensions are for bare chips, for solder coated terminations add .50 to the length and .30 to the width and thickness.
3. Unless otherwise specified, tolerance is ±.20.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.

STANDARD CAPACITORS

STYLE CDR31 (METRIC)
OPERATING TEMPERATURE RANGE -55°C TO +125°C

Type designation 1/	Capacitance	Capacitance tolerance	Rated temperature and voltage-temperature limits	Rated voltage
	pF			volts, dc
CDR31BP1R0B---	1.0	B, C	BP	100
CDR31BP1R1B---	1.1	"	"	"
CDR31BP1R2B---	1.2	"	"	"
CDR31BP1R3B---	1.3	"	"	"
CDR31BP1R5B---	1.5	"	"	"
CDR31BP1R6B---	1.6	"	"	"
CDR31BP1R8B---	1.8	"	"	"
CDR31BP2R0B---	2.0	"	"	"
CDR31BP2R2B---	2.2	"	"	"
CDR31BP2R4B---	2.4	"	"	"
CDR31BP2R7B---	2.7	B, C, D	"	"
CDR31BP3R0B---	3.0	"	"	"
CDR31BP3R3B---	3.3	"	"	"
CDR31BP3R6B---	3.6	"	"	"
CDR31BP3R9B---	3.9	"	"	"
CDR31BP4R3B---	4.3	"	"	"
CDR31BP4R7B---	4.7	"	"	"
CDR31BP5R1B---	5.1	"	"	"
CDR31BP5R6B---	5.6	"	"	"
CDR31BP6R2B---	6.2	"	"	"
CDR31BP6R8B---	6.8	"	"	"
CDR31BP7R5B---	7.5	"	"	"
CDR31BP8R2B---	8.2	"	"	"
CDR31BP9R1B---	9.1	"	"	"
CDR31BP100B---	10	F, J, K	"	"
CDR31BP110B---	11	"	"	"
CDR31BP120B---	12	"	"	"
CDR31BP130B---	13	"	"	"
CDR31BP150B---	15	"	"	"
CDR31BP160B---	16	"	"	"
CDR31BP180B---	18	"	"	"
CDR31BP200B---	20	"	"	"
CDR31BP220B---	22	"	"	"
CDR31BP240B---	24	"	"	"
CDR31BP270B---	27	"	"	"
CDR31BP300B---	30	"	"	"
CDR31BP330B---	33	"	"	"
CDR31BP360B---	36	"	"	"
CDR31BP390B---	39	"	"	"
CDR31BP430B---	43	"	"	"
CDR31BP470B---	47	"	"	"
CDR31BP510B---	51	"	"	"
CDR31BP560B---	56	"	"	"
CDR31BP620B---	62	"	"	"
CDR31BP680B---	68	"	"	"
CDR31BP750B---	75	"	"	"
CDR31BP820B---	82	"	"	"
CDR31BP910B---	91	"	"	"

See footnote at end of figure.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.

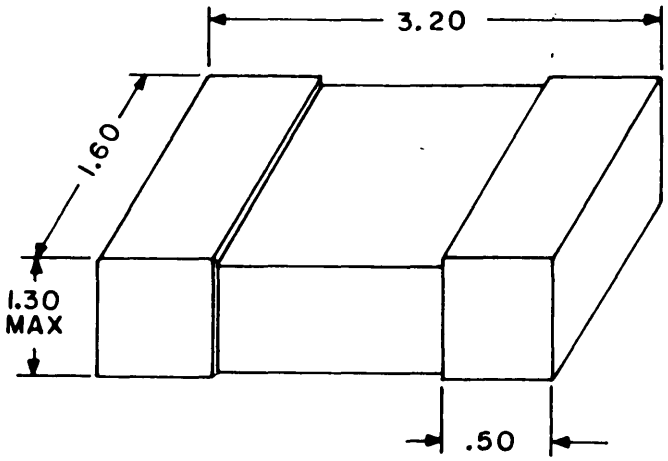
STYLE CDR31 (METRIC) - CONTINUED
OPERATING TEMPERATURE RANGE -55°C TO +125°C

Type designation 1/	Capacitance	Capacitance tolerance	Rated temperature and voltage-temperature limits	Rated voltage
	pF			volts, dc
CDR31BP101B---	100	F, J, K	BP	100
CDR31BP111B---	110	"	"	"
CDR31BP121B---	120	"	"	"
CDR31BP131B---	130	"	"	"
CDR31BP151B---	150	"	"	"
CDR31BP161B---	160	"	"	"
CDR31BP181B---	180	"	"	"
CDR31BP201B---	200	"	"	"
CDR31BP221B---	220	"	"	"
CDR31BP241B---	240	"	"	"
CDR31BP271B---	270	"	"	"
CDR31BP301B---	300	"	"	"
CDR31BP331B---	330	"	"	"
CDR31BP361B---	360	"	"	"
CDR31BP391B---	390	"	"	"
CDR31BP431B---	430	"	"	"
CDR31BP471B---	470	"	"	"
CDR31BP511A---	510	"	"	50
CDR31BP561A---	560	"	"	"
CDR31BP621A---	620	"	"	"
CDR31BP681A---	680	"	"	"
CDR31BX471B---	470	K, M	BX	100
CDR31BX561B---	560	"	"	"
CDR31BX681B---	680	"	"	"
CDR31BX821B---	820	"	"	"
CDR31BX102B---	1,000	"	"	"
CDR31BX122B---	1,200	"	"	"
CDR31BX152B---	1,500	"	"	"
CDR31BX182B---	1,800	"	"	"
CDR31BX222B---	2,200	"	"	"
CDR31BX272B---	2,700	"	"	"
CDR31BX332B---	3,300	"	"	"
CDR31BX392B---	3,900	"	"	"
CDR31BX472B---	4,700	"	"	"
CDR31BX562A---	5,600	"	"	50
CDR31BX682A---	6,800	"	"	"
CDR31BX822A---	8,200	"	"	"
CDR31BX103A---	10,000	"	"	"
CDR31BX123A---	12,000	"	"	"
CDR31BX153A---	15,000	"	"	"
CDR31BX183A---	18,000	"	"	"

1/ The complete part number will include additional symbols to indicate capacitance tolerance, termination, and failure rate level.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.

STYLE CDR32 (METRIC)



mm	Inches
0.20	.008
0.30	.012
0.50	.020
1.30	.051
1.60	.062
3.20	.125

NOTES:
1. Dimensions are in millimeters.
2. Dimensions are for bare chips, for solder coated terminations add .50 to the length and .30 to the width and thickness.
3. Unless otherwise specified, tolerance is ±.20.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.

STANDARD CAPACITORS

STYLE CDR32 (METRIC)
OPERATING TEMPERATURE RANGE -55°C TO +125°C

Type designation 1/	Capacitance	Capacitance tolerance	Rated temperature and voltage-temperature limits	Rated voltage
	pF			volts, dc
CDR32BP1R0B---	1.0	B, C	BP	100
CDR32BP1R1B---	1.1	"	"	"
CDR32BP1R2B---	1.2	"	"	"
CDR32BP1R3B---	1.3	"	"	"
CDR32BP1R5B---	1.5	"	"	"
CDR32BP1R6B---	1.6	"	"	"
CDR32BP1R8B---	1.8	"	"	"
CDR32BP2R0B---	2.0	"	"	"
CDR32BP2R2B---	2.2	"	"	"
CDR32BP2R4B---	2.4	"	"	"
CDR32BP2R7B---	2.7	B, C, D	"	"
CDR32BP3R0B---	3.0	"	"	"
CDR32BP3R3B---	3.3	"	"	"
CDR32BP3R6B---	3.6	"	"	"
CDR32BP3R9B---	3.9	"	"	"
CDR32BP4R3B---	4.3	"	"	"
CDR32BP4R7B---	4.7	"	"	"
CDR32BP5R1B---	5.1	"	"	"
CDR32BP5R6B---	5.6	"	"	"
CDR32BP6R2B---	6.2	"	"	"
CDR32BP6R8B---	6.8	"	"	"
CDR32BP7R5B---	7.5	"	"	"
CDR32BP8R2B---	8.2	"	"	"
CDR32BP9R1B---	9.1	"	"	"
CDR32BP100B---	10	F, J, K	"	"
CDR32BP110B---	11	"	"	"
CDR32BP120B---	12	"	"	"
CDR32BP130B---	13	"	"	"
CDR32BP150B---	15	"	"	"
CDR32BP160B---	16	"	"	"
CDR32BP180B---	18	"	"	"
CDR32BP200B---	20	"	"	"
CDR32BP220B---	22	"	"	"
CDR32BP240B---	24	"	"	"
CDR32BP270B---	27	"	"	"
CDR32BP300B---	30	"	"	"
CDR32BP330B---	33	"	"	"
CDR32BP360B---	36	"	"	"
CDR32BP390B---	39	"	"	"
CDR32BP430B---	43	"	"	"
CDR32BP470B---	47	"	"	"
CDR32BP510B---	51	"	"	"
CDR32BP560B---	56	"	"	"
CDR32BP620B---	62	"	"	"
CDR32BP680B---	68	"	"	"
CDR32BP750B---	75	"	"	"
CDR32BP820B---	82	"	"	"
CDR32BP910B---	91	"	"	"

See footnote at end of figure.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.

STANDARD CAPACITORS

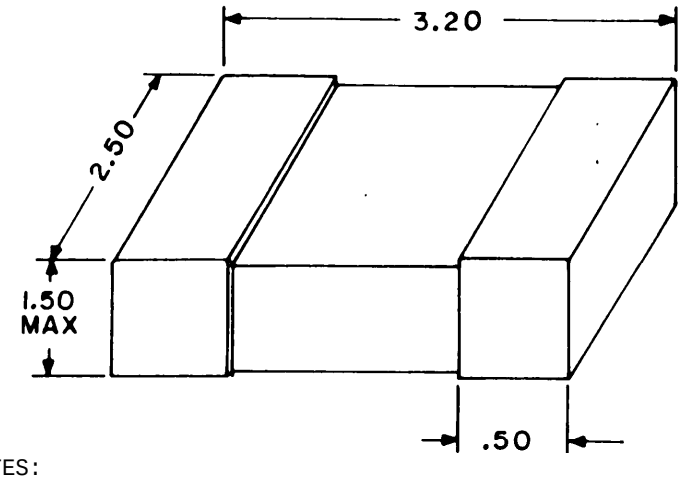
STYLE CDR32 (METRIC) - CONTINUED
OPERATING TEMPERATURE RANGE -55°C TO +125°C

Type designation 1/	Capacitance	Capacitance tolerance	Rated temperature and voltage-temperature limits	Rated voltage
	pF			volts, dc
CDR32BP101B---	100	F, J, K	BP	100
CDR32BP111B---	110	"	"	"
CDR32BP121B---	120	"	"	"
CDR32BP131B---	130	"	"	"
CDR32BP151B---	150	"	"	"
CDR32BP161B---	160	"	"	"
CDR32BP181B---	180	"	"	"
CDR32BP201B---	200	"	"	"
CDR32BP221B---	220	"	"	"
CDR32BP241B---	240	"	"	"
CDR32BP271B---	270	"	"	"
CDR32BP301B---	300	"	"	"
CDR32BP331B---	330	"	"	"
CDR32BP361B---	360	"	"	"
CDR32BP391B---	390	"	"	"
CDR32BP431B---	430	"	"	"
CDR32BP471B---	470	"	"	"
CDR32BP511B---	510	"	"	"
CDR32BP561B---	560	"	"	"
CDR32BP621B---	620	"	"	"
CDR32BP681B---	680	"	"	"
CDR32BP751B---	750	"	"	"
CDR32BP821B---	820	"	"	"
CDR32BP911B---	910	"	"	"
CDR32BP102B---	1,000	"	"	"
CDR32BP112A---	1,100	"	"	50
CDR32BP122A---	1,200	"	"	"
CDR32BP132A---	1,300	"	"	"
CDR32BP152A---	1,500	"	"	"
CDR32BP162A---	1,600	"	"	"
CDR32BP182A---	1,800	"	"	"
CDR32BP202A---	2,000	"	"	"
CDR32BP222A---	2,200	"	"	"
CDR32BX472B---	4,700	K, M	BX	100
CDR32BX562B---	5,600	"	"	"
CDR32BX682B---	6,800	"	"	"
CDR32BX822B---	8,200	"	"	"
CDR32BX103B---	10,000	"	"	"
CDR32BX123B---	12,000	"	"	"
CDR32BX153B---	15,000	"	"	"
CDR32BX183A---	18,000	"	"	50
CDR32BX223A---	22,000	"	"	"
CDR32BX273A---	27,000	"	"	"
CDR32BX333A---	33,000	"	"	"
CDR32BX393A---	39,000	"	"	"

1/ The complete part number will include additional symbols to indicate capacitance tolerance, termination, and failure rate level.

FIGURE 903-2. Established reliability, ceramic deilectric multiple layer, fixed chip capacitors - Continued.

STYLE CDR33 (METRIC)



mm	Inches
0.25	.010
0.30	.012
0.50	.020
0.60	.023
1.50	.059
2.50	.098
3.20	.125

NOTES:
1. Dimensions are in millimeters.
2. Dimensions are for bare chips, for solder coated terminations add .60 to the length and .30 to the width and thickness.
3. Unless otherwise specified, tolerance is ±.25.

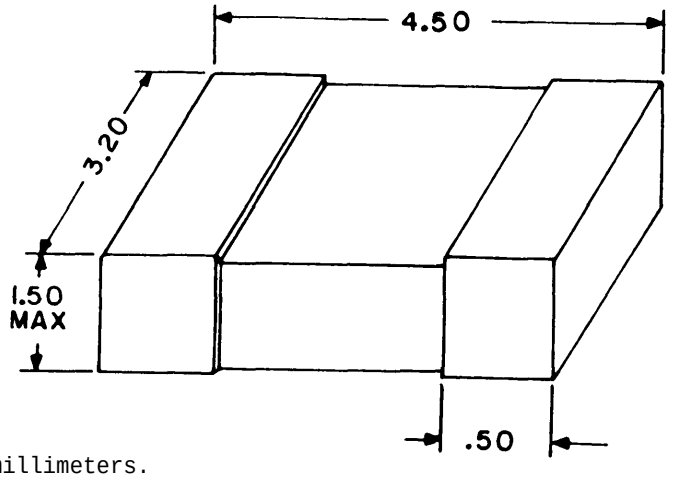
OPERATING TEMPERATURE RANGE -55°C TO +125°C

Type designation 1/	Capacitance	Capacitance tolerance	Rated temperature and voltage-temperature limits	Rated voltage
	pF			volts, dc
CDR33BP102B---	1,000	F, J, K	BP	100
CDR33BP112B---	1,100	"	"	"
CDR33BP122B---	1,200	"	"	"
CDR33BP132B---	1,300	"	"	"
CDR33BP152B---	1,500	"	"	"
CDR33BP162B---	1,600	"	"	"
CDR33BP182B---	1,800	"	"	"
CDR33BP202B---	2,000	"	"	"
CDR33BP222B---	2,200	"	"	"
CDR33BP242A---	2,400	"	"	50
CDR33BP272A---	2,700	"	"	"
CDR33BP302A---	3,000	"	"	"
CDR33BP332A---	3,300	"	"	"
CDR33BX153B---	15,000	K, M	BX	100
CDR33BX183B---	18,000	"	"	"
CDR33BX223B---	22,000	"	"	"
CDR33BX273B---	27,000	"	"	"
CDR33BX393A---	39,000	"	"	50
CDR33BX473A---	47,000	"	"	"
CDR33BX563A---	56,000	"	"	"
CDR33BX683A---	68,000	"	"	"
CDR33BX823A---	82,000	"	"	"
CDR33BX104A---	100,000	"	"	"

1/ The complete part number will include additional symblos to indicate capacitance tolerance, termination, and failure rate level.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.

STYLE CDR34 (METRIC)



mm	Inches
0.25	.010
0.30	.012
0.50	.020
0.60	.023
1.50	.059
3.20	.125
4.50	.176

NOTES:
1. Dimensions are in millimeters.
2. Dimensions are for bare chips, for solder coated terminations add .60 to the length and .30 to the width and thickness.
3. Unless otherwise specified, tolerance is ±.25.

OPERATING TEMPERATURE RANGE -55°C to +125°C

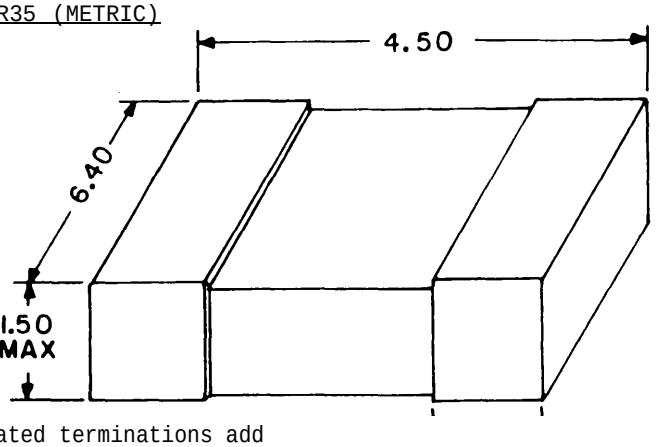
Type designation 1/	Capacitance	Capacitance tolerance	Rated temperature and voltage-temperature limits	Rated voltage
	(pF)			volts, dc
CDR34BP222B---	2,200	F, J, K	BP	100
CDR34BP242B---	2,400	"	"	"
CDR34BP272B---	2,700	"	"	"
CDR34BP302B---	3,000	"	"	"
CDR34BP332B---	3,300	"	"	"
CDR34BP362B---	3,600	"	"	"
CDR34BP392B---	3,900	"	"	"
CDR34BP432B---	4,300	"	"	"
CDR34BP472B---	4,700	"	"	"
CDR34BP512A---	5,100	"	"	50
CDR34BP562A---	5,600	"	"	"
CDR34BP622A---	6,200	"	"	"
CDR34BP682A---	6,800	"	"	"
CDR34BP752A---	7,500	"	"	"
CDR34BP822A---	8,200	"	"	"
CDR34BP912A---	9,100	"	"	"
CDR34BP103A---	10,000	"	"	"
CDR34BX273B---	27,000	K, M	BX	100
CDR34BX333B---	33,000	"	"	"
CDR34BX393B---	39,000	"	"	"
CDR34BX473B---	47,000	"	"	"
CDR34BX563B---	56,000	"	"	"
CDR34BX104A---	100,000	"	"	50
CDR34BX124A---	120,000	"	"	"
CDR34BX154A---	150,000	"	"	"
CDR34BX184A---	180,000	"	"	"

1/ The complete part number will include additional symbols to indicate capacitance tolerance, termination and failure rate level.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.

STYLE CDR35 (METRIC)

mm	Inches
0.30	.012
0.50	.020
0.60	.023
1.50	.059
4.50	.176
6.40	.250



NOTES:
1. Dimenisions are in millimeters.
2. Dimentsions are for bare chips, for solder coated terminations add .60 to the length and .30 to the width and thickness.
3. Unless otherwise specified, tolerance is ±.30.

OPERATING TEMPERATURE RANGE -55°C to +125°C

Type designation 1/	Capacitance	Capacitance tolerance	Rated temperature and voltage-temperature limits	Rated voltage
	(pF)			volts, dc
CDR35BP472B---	4,700	F, J, K	BP	100
CDR35BP512B---	5,100	"	"	"
CDR35BP562B---	5,600	"	"	"
CDR35BP622B---	6,200	"	"	"
CDR35BP682B---	6,800	"	"	"
CDR35BP752B---	7,500	"	"	"
CDR35BP822B---	8,200	"	"	"
CDR35BP912B---	9,100	"	"	"
CDR35BP103B---	10,000	"	"	"
CDR35BP113A---	11,000	"	"	50
CDR35BP123A---	12,000	"	"	"
CDR35BP133A---	13,000	"	"	"
CDR35BP153A---	15,000	"	"	"
CDR35BP163A---	16,000	"	"	"
CDR35BP183A---	18,000	"	"	"
CDR35BP203A---	20,000	"	"	"
CDR35BP223A---	22,000	"	"	"
CDR35BX563B---	56,000	K, M	BX	100
CDR35BX683B---	68,000	"	"	"
CDR35BX823B---	82,000	"	"	"
CDR35BX104B---	100,000	"	"	"
CDR35BX124B---	120,000	"	"	"
CDR35BX154B---	150,000	"	"	"
CDR35BX184A---	180,000	"	"	50
CDR35BX224A---	220,000	"	"	"
CDR35BX274A---	270,000	"	"	"
CDR35BX334A---	330,000	"	"	"
CDR35BX394A---	390,000	"	"	"
CDR35BX474A---	470,000	"	"	"

1/ The complete part number will include additional symbols to indicate capacitance tolerance, termination and failure rate level.

FIGURE 903-2. Established reliability, ceramic dielectric multiple layer, fixed chip capacitors - Continued.