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PERFORMANCE SPECIFICATION  
CAPACITORS, VARIABLE (PISTON TYPE, TUBULAR TRIMMER),  
GENERAL SPECIFICATION FOR

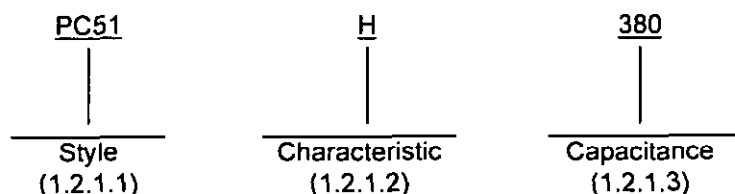
This specification is approved for use by all Departments and Agencies of the Department of Defense.

## 1. SCOPE

1.1 Scope. This specification covers the general requirements for tubular-trimmer, piston-type, variable capacitors intended primarily for use in high-frequency trimming applications where relatively few adjustments are required during the effective life of the equipment.

### 1.2 Classification.

1.2.1 Type designation. The type designation shall be in the following form, and as specified (see 3.1 and 6.1):



1.2.1.1 Style. The style is identified by the two-letter symbol "PC" followed by a two-digit number; the letters identify tubular-trimmer, piston-type, variable capacitors, and the number identifies the shape or differentiating electrical characteristics of the capacitor.

1.2.1.2 Characteristic. The characteristic is identified by a single letter in accordance with table I.

TABLE 1. Characteristic.

Symbol	Operating temperature range	Temperature coefficient referred to an ambient temperature of 25°C	Capacitance drift
	°C	Parts/million/°C	
G ———	-55 to +125	±150	±.5% of maximum rated value
H ———	-55 to +125	±100	±.2% of maximum rated value or .04 pF (whichever is greater)
J ———	-55 to +125	±50	±.15% of maximum rated value or .02 pF (whichever is greater)
Q ———	-55 to +150	+50, -0	±.1% of maximum rated value or .01 pF (whichever is greater)
T ———	-65 to +125	±20	±.1% of maximum rated value or .01 pF (whichever is greater)
L ———	-55 to +125	50 ±50	±.1% of maximum rated value or .01 pF (whichever is greater)

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1.2.1.3 Capacitance. The nominal maximum rated capacitance value expressed in picofarads (pF) is identified by a three-digit number; the first two digits represent significant figures and the last digit specifies the number of zeros to follow. When fractional values are required, the letter "R" shall be used to indicate the decimal point. For example: 8RS indicates 8.5 pF.

## 2. APPLICABLE DOCUMENTS

2.1 The following documents, of the issue in effect on date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein.

### SPECIFICATIONS

#### MILITARY

- MIL-C-39028 - Capacitors, Packaging of.
- MIL-C-45662 - Calibration System Requirements.

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

### STANDARDS

#### MILITARY

- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
- MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.
- MIL-STD-1285 - Marking of Electrical and Electronic Parts.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

2.2 Other publications. The following document forms a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal shall apply.

#### NATIONAL BUREAU OF STANDARDS

- Handbook H28 - Screw-Thread Standards for Federal Services.

(Application for copies should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.)

## 3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheets. In the event of any conflict between requirements of this specification and the specification sheets, the latter shall govern (see 6.1).

3.2 Qualification. Capacitors furnished under this specification shall be products which are qualified for listing on the applicable qualified products list at the time set for opening of bids (see 4.4 and 6.2).

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

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

3.4.1 Threaded parts. All threaded parts shall be in accordance with Handbook H28, and shall be as specified (see 3.1).

3.4.2 Locking of screw-thread assemblies. All screw-thread mounting assemblies shall be rendered resistant to loosening under vibration. If needed, lockwashers of phosphor bronze, beryllium copper, or stainless steel shall be provided with the nuts.

3.4.3 Terminals. All terminals shall be coated, electro-tin plated, or hot tin dipped with a solder having a minimum tin content of 40 percent or shall be gold plated.

3.4.4 Connections. Electrical connections shall not depend upon wires, lugs, terminals, and the like clamped between a metallic member and an insulating material. Such connections shall be soldered.

3.5 Thermal shock. When capacitors are tested as specified in 4.6.1, there shall be no evidence of fracture or loosening of mechanical connections. In addition, corrosion of exposed metallic surfaces shall not exceed 10 percent. (Discoloration and tarnishing alone shall not be cause for rejection.)

3.6 Burn-in (styles PC21, PC22, PC23, PC24, PC26, PC27, PC28, PC29, PC30, PC32 and PC34). When capacitors are tested as specified in 4.6.2, capacitance change shall not exceed 1 percent or 0.05 picofarad, whichever is greater.

3.7 Capacitance. When measured as specified in 4.6.4, the minimum capacitance shall be not more and the maximum not less than the value specified (see 3.1). The capacitance range may be broader than that specified, provided it encompasses the specified range.

3.8 Change of capacitance. When capacitors are tested as specified in 4.6.5, the rate of change of capacitance as a function of the change of adjustment shall not change sign over the entire range of adjustment.

3.9 Insulation resistance. When capacitors are tested as specified in 4.6.6, the insulation resistance shall be not less than the value specified (see 3.1).

3.10 Dielectric withstanding voltage. When capacitors are tested as specified in 4.6.7, there shall be no evidence of damage, arcing, or breakdown.

3.11 Quality factor (Q). When capacitors are tested as specified in 4.6.8, the Q shall exceed the value specified (see 3.1).

#### 3.12 Torque.

3.12.1 Driving torque. When measured as specified in 4.6.9.1, the torque required to start and maintain rotation of the rotor shall be greater than or equal to 1 and less than or equal to 10 ounce-inches at all temperatures, unless otherwise specified (see 3.1).

3.12.2 Torque bushing strength (panel mount units only). When capacitors are tested as specified in 4.6.9.2, there shall be no evidence of bushing breakage, thread stripping, or other visible mechanical damage.

3.13 Temperature coefficient and capacitance drift. Unless otherwise specified, when capacitors are tested as specified in 4.6.10, the temperature coefficient and capacitance drift shall be within the limits specified in table I (see 3.1).

3.14 Immersion (sealed units only) (see 3.1). When capacitors are tested as specified in 4.6.11, the following requirements shall be met:

Capacitance (maximum) - - - - - Shall change not more than .5 pF or 5 percent, whichever is greater.

Insulation resistance at room

ambient temperature - - - - - Shall be not less than 100,000 megohms.

Dielectric withstanding voltage - - As specified in 3.10.

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**3.15 Salt spray (corrosion).**

**3.15.1 Salt spray (corrosion) (sealed units only) (see 3.1).** When capacitors are tested as specified in 4.6.12.1, the following requirements shall be met:

Insulation resistance at room  
 ambient temperature- - - - - Shall be not less than 100,000 megohms.  
 Dielectric withstanding voltage- - As specified in 3.10.  
 Driving torque at room  
 ambient temperature- - - - - As specified in 3.12.1.

Corrosion of exposed metallic surfaces shall not exceed 10 percent. Discoloration and tarnishing alone shall not be cause for rejection.

**3.15.2 Salt spray (corrosion) (unsealed units only).** When capacitors are tested as specified in 4.6.12.2, corrosion of exposed metallic surfaces shall not exceed 10 percent. Discoloration and tarnishing alone shall not be cause for rejection.

**3.16 Low-temperature storage.** When capacitors are tested as specified in 4.6.13, there shall be no visible mechanical damage to the capacitors.

**3.17 Shock (specified pulse).** When capacitors are tested as specified in 4.6.14, there shall be no intermittent contacts of 0.5 milliseconds (ms) or greater duration, or momentary arcing, open or short-circuiting, or any evidence of fractures, loosening of parts, or other visible mechanical damage.

**3.18 Vibration, high frequency.** When capacitors are tested as specified in 4.6.15, there shall be no intermittent contacts of 0.5 ms or greater duration, or momentary arcing, open or short-circuiting, or any evidence of fracture, loosening of parts, or other mechanical damage visible under 10 power magnification. The capacitance change shall be not more than 1 percent or 0.05 pF, whichever is greater, from the initial value obtained when measured as specified in 4.6.15.

**3.19 Barometric pressure (reduced).** Unless otherwise specified (see 3.1), when capacitors are tested as specified in 4.6.16, they shall withstand a potential of 50 percent of the dc rated voltage or 500 volts, whichever is less without damage, arcing, or breakdown.

**3.20 Moisture resistance.** When capacitors are tested as specified in 4.6.17, the following requirements shall be met:

Insulation resistance at room  
 ambient temperature- - - - - Shall be not less than 100,000 megohms.  
 Dielectric withstanding voltage- - As specified in 3.10.  
 Driving torque at room ambient  
 temperature- - - - - As specified in 3.12.1.

Corrosion of exposed metallic surfaces shall not exceed 10 percent. Discoloration and tarnishing alone shall not be cause for rejection.

**3.21 Terminal strength.** When capacitors are tested as specified in 4.6.18, there shall be no loosening or rupturing of the terminals or other damage to the terminals or capacitor body. A slight separation (not exceeding 1/16 inch) of wire leads from the cylinder body at the point the lead leaves the cylinder is acceptable.

**3.22 Resistance to soldering heat (printed circuit mount types only, see 3.1).** When capacitors are tested as specified in 4.6.19, they shall meet the following requirements after resistance to soldering heat:

- (a) There shall be no evidence of mechanical damage.
- (b) Dielectric withstanding voltage shall be as specified in 3.10.
- (c) Capacitance shall be as specified in 3.7.
- (d) Quality factor shall be as specified in 3.11.

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3.23 Seal (sealed units only) (see 3.1). When capacitors are tested as specified in 4.6.20, there shall be no evidence of dye penetration and they shall meet the following requirements:

Capacitance (maximum) - - - - -	Shall change not more than .5 pf or 5 percent, whichever is greater.
Insulation resistance at room ambient temperature - - - - -	Shall be not less than 100,000 megohms.
Dielectric withstanding voltage - - - - -	As specified in 3.10.

3.24 Rotational life. When capacitors are tested as specified in 4.6.21, the following requirements shall be met:

Dielectric withstanding voltage - - - - -	As specified in 3.10.
Contact resistance - - - - -	Shall not exceed 0.01 ohm after test.
Capacitance change versus rotation - - - - -	Capacitance change versus rotation of the rotor shall not deviate from a straight line by more than 10 percent and shall show no reversals in direction unless otherwise specified (see 3.1).
Driving torque at room ambient temperature - - - - -	As specified in 3.12.1.

3.25 Solderability (all solderable terminals). When capacitors are tested as specified in 4.6.22, the dipped surface of the leads shall be at least 95 percent covered with a new, smooth, solder coating. The remaining 5 percent of the lead surface shall show only small pinholes or rough spots; these shall not be concentrated in one area. Bare base metal and areas where the solder dip failed to cover the original coating are indications of poor solderability, and shall be cause for failure. In case of dispute, the percent of coverage with pinholes or rough spots shall be determined by actual measurement of these areas, as compared to the total area.

3.26 Marking. Marking of capacitors shall conform to method I of MIL-STD-1285 and shall include the type designation, date and source codes, and manufacturer's symbol or trademark. The marking shall not be placed on the mounting surface. There shall be no space between symbols which comprise the type designation. If space limitation requires it, the type designation may appear on two lines. In this event, the type designation shall be divided between the style and the characteristic symbols and shall appear on two lines as shown in the following example:

PC51  
H380

Marking shall remain legible after all tests.

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

3.27.1 Soldering. Flux for soldering shall be rosin, rosin and alcohol, or rosin and turpentine. No acid or acid salts shall be used in preparation for or during soldering; however, exception is permitted for preliminary tinning of electrical connections and for tinning or soldering of mechanical joints not used to complete electrical circuits. In no case shall the acid salts permitted above be used where they can come in contact with insulation material, unless they are removed in the processing. Where acid and acid salts are used, they shall be completely neutralized and removed immediately after use. All excess solder shall be removed.

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## 4. QUALITY ASSURANCE PROVISIONS

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

4.1.1 Test equipment and inspection facilities. The supplier shall establish and maintain a calibration system in accordance with MIL-C-45662.

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

- (a) Qualification inspection (see 4.4).
- (b) Quality conformance inspection (see 4.5).

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

4.4 Qualification inspection. Qualification inspection will be performed at a laboratory acceptable to the Government (see 6.2) on sample units produced with equipment and procedures normally used in production.

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

4.4.2 Inspection routine. The sample shall be subjected to the inspections specified in table II, in the order shown. All sample units shall be subjected to the inspections of group I. The sample shall then be divided equally into the remaining groups shown in table II and shall be subjected to the inspection for their particular group.

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

4.4.4 Retention of qualification. To retain qualification, the supplier shall forward, at 12-month intervals, to the qualifying activity, a summary of the results of groups A and B tests, indicating as a minimum the number of lots which passed and the number which failed, and a summary of the results of group C tests, including the number and type of any part failures. The summary shall include those tests performed during that 12-month period. If the summary of the test results indicates nonconformance with specification requirements, action shall be taken to remove the failing product from the qualified products list. Failure to submit the summary shall result in loss of qualification for that product. In addition to the periodic submission of inspection data, the supplier shall immediately notify the qualifying activity at any time during the 12-month period that the inspection data indicates failure of the qualified product to meet the requirements of this specification. In the event that no production occurred during the reporting period, a report shall be submitted certifying that the company still has the capabilities and facilities necessary to produce the item.

4.5 Quality conformance inspection.

4.5.1 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A and B inspection. Except as specified in 4.5.1.1.3.1.4, delivery of products which have passed the groups A and B inspection shall not be delayed pending the results of group C inspection.

TABLE II. Qualification inspection.

Examination or test	Requirement paragraph	Method paragraph	Number of sample units to be inspected	Number of failures 1/
Group I				
Thermal shock (styles PC21, PC22, PC23, PC24, PC26, PC27, PC28, PC29, PC30, PC32 and PC34) - - -	3.5	4.6.1	49 4/	1
Burn-in (styles PC21, PC22, PC23, PC24, PC26, PC27, PC28, PC29, PC30, PC32 and PC34) - - - - -	3.6	4.6.2		
Visual and mechanical examination 2/ 3/ - - - - -	3.1, 3.3 to 3.4.4 incl, and 3.26 to 3.27.1 incl	4.6.3		
Capacitance 3/- - - - -	3.7	4.6.4		
Change of capacitance - - - - -	3.8	4.6.5		
Insulation resistance 3/- - - - -	3.9	4.6.6		
Dielectric withstanding voltage 3/- - - - -	3.10	4.6.7		
Quality factor (Q) 3/ - - - - -	3.11	4.6.8		
Driving torque 3/ - - - - -	3.12.1	4.6.9.1		
Group II				
Temperature coefficient and capacitance drift - - - - -	3.13	4.6.10	12	1
Thermal shock - - - - -	3.5	4.6.1		
Immersion 5/ - - - - -	3.14	4.6.11		
Salt spray (corrosion) - - - - -	3.15	4.6.12		
Group III				
Torque, bushing strength 6/ - - -	3.12.2	4.6.9.2	12	1
Low-temperature storage - - - - -	3.16	4.6.13		
Shock (specified pulse) - - - - -	3.17	4.6.14		
Vibration, high frequency - - - - -	3.18	4.6.15		
Group IV				
Barometric pressure (reduced) (when applicable) - - - - -	3.19	4.6.16	12	1
Moisture resistance - - - - -	3.20	4.6.17		
Terminal strength - - - - -	3.21	4.6.18		
Resistance to soldering heat (printed circuit mount types only, see 3.1) - - - - -	3.22	4.6.19		
Group V				
Seal 5/ - - - - -	3.23	4.6.20	12	1
Rotational life - - - - -	3.24	4.6.21		
Solderability 7/- - - - -	3.25	4.6.22		

- 1/ A sample unit having one or more defects will be charged as a single failure.  
2/ Marking will be considered defective only if it becomes illegible as a result of the inspection.  
3/ Nondestructive test.  
4/ One additional sample unit is included in each sample of 49 capacitors to permit substitution for the allowable failure in group I.  
5/ Sealed units only.  
6/ Panel-mount units only.  
7/ All solderable terminals.

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4.5.1.1 Inspection lot. An inspection lot, shall consist of all capacitors of the same style and characteristic, produced under essentially the same conditions, and offered for inspection at one time, except combinations of the two styles represented by individual groups X, XI, XII, or XIII of table IX may be grouped and considered an inspection lot provided the capacitors are of the same characteristic, produced under essentially the same conditions, and offered for inspection at one time; i.e., PCS0J and PCS1J. This definition shall apply to Group A and Group B tests only.

4.5.1.1.1 Group A inspection. Group A inspection shall consist of the examinations and tests specified in table III, in the order shown.

TABLE III. Group A inspection.

Examination or test	Requirement paragraph	Test method paragraph	AQL (percent defective)	
			Major	Minor
Thermal shock (styles PC21, PC22, PC23, PC24, PC26, PC27, PC28, PC29, PC30, PC32 and PC34) - - -	5.5	4.6.1	Not applicable 100% inspection	
Burn-in (styles PC21, PC22, PC23, PC24, PC26, PC28, PC29, PC30, PC32 and PC34) - - - - -	5.6	4.6.2		
Visual and mechanical examination:	---	4.6.3	1.0	4.0
Material - - - - -	5.3	---		
Body dimensions - - - - -	5.4	---		
Design and construction (other than body dimensions) - - - - -	5.1, 5.4 to 5.4.4 incl	---		
Marking 1/- - - - -	3.26	---		
Workmanship - - - - -	3.27 and 3.27.1	---	1.0	---
Capacitance - - - - -	5.7	4.6.4		
Change of capacitance - - - - -	5.8	4.6.5		
Insulation resistance (at 25°C) - -	5.9	4.6.6		
Dielectric withstanding voltage 2/- - - - -	5.10	4.6.7		
Quality factor (Q) - - - - -	5.11	4.6.8	4.6.9.1.2.1	
Driving torque (room ambient temperature) - - - - -	5.12.1	4.6.9.1.2.1		

- 1/ Marking defects are based on visual examination only, and will be charged only for illegible, incomplete, or incorrect marking. Any subsequent electrical defects will not be used as a basis for determining marking defects.
- 2/ Dielectric withstanding voltage will be during capacitor cycle.

4.5.1.1.1.1 Sampling plan. Statistical sampling and inspection shall be in accordance with MIL-STD-105 for general inspection level II. The acceptable quality levels (AQL) shall be as specified in table III. Major and minor defects shall be as defined in MIL-STD-105.

4.5.1.1.1.2 Rejected lots. If an inspection lot is rejected, the lot shall not be resubmitted.

4.5.1.1.2 Group B inspection. Group B inspection shall consist of the tests specified in table IV, in the order shown.



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TABLE IV. Group E inspection.

Test	Requirement paragraph	Test method paragraph
Seal (sealed units only) - - - -	3.23	4.6.20
Torque, bushing strength (panel-mount units only) - - - -	3.12.2	4.6.9.2
Solderability (all solderable terminals) - - - - -	3.25	4.6.22

4.5.1.1.2.1 Sampling plan. The sampling plan shall be in accordance with MIL-STD-105 for special inspection level S-4. The AQL shall be 4.0 percent defective.

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

4.5.1.1.3 Periodic inspection. Periodic inspection shall consist of group C inspection.

4.5.1.1.3.1 Group C inspection. Group C inspection shall consist of the tests specified in table V, in the order shown. Group C inspection shall be made on sample units selected from inspection lots which have passed groups A and B inspection.

TABLE V. Group C inspection.

Test	Requirement paragraph	Test method paragraph
<u>Subgroup I</u>		
Insulation resistance (at high temperature) - - - -	3.9	4.6.6
Temperature coefficient and capacitance drift - - -	3.13	4.6.10
Thermal shock 1/- - - - -	3.5	4.6.1
<u>Subgroup II</u>		
Driving torque- - - - -	3.12.1	4.6.9.1.2.2
Terminal strength - - - - -	3.21	4.6.18
Resistance to soldering heat 1/ - - - - -	3.22	4.6.19
<u>Subgroup III</u>		
Immersion (sealed units only) - - - - -	3.14	4.6.11
Salt spray (corrosion) 1/ - - - - -	3.15	4.6.12
<u>Subgroup IV</u>		
Moisture resistance 1/- - - - -	3.20	4.6.17
<u>Subgroup V</u>		
Barometric pressure (reduced) (when applicable) - -	3.19	4.6.16
Low temperature storage - - - - -	3.16	4.6.13
Shock (specified pulse) - - - - -	3.17	4.6.14
Vibration, high frequency 1/- - - - -	3.18	4.6.15

1/ Capacitance, insulation resistance, and quality factor will follow last test of each subgroup.

4.5.1.1.3.1.1 Sampling plan. Sample units shall be tested in accordance with table V. The number of sample units to be selected for the specified sampling periods shall be in accordance with table VI. A separate sample shall be selected for each subgroup. Sample units shall be selected without regard to their quality. The quantity selected for each type shall be proportional to the total quantity of all types within a style produced during any one sampling period.

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TABLE VI. Selection of sample units and defectives allowed.

Test group	Test period	Sample size to be tested	Number of failures
Subgroup I	Monthly	12 Note 1	1 Note 1
Subgroup II	Quarterly	12 Note 2	1 Note 2
Subgroup III	Semiannually	12 Note 2	1 Note 2
Subgroup IV	Semiannually	12 Note 2	1 Note 2
Subgroup V	Annually	12 Note 2	1 Note 2

Note 1 - per characteristic.

Note 2 - per mounting style per characteristic group.

4.5.1.1.3.1.2 Defectives. If the number of defectives exceeds the number allowed in table VI, the sample shall be considered to have failed.

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

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

4.5.2 Inspection of preparation for delivery. Sample packages or packs and the inspection of the preservation, packaging, packing, and marking for shipment and storage shall be in accordance with the requirements of MIL-C-39028.

#### 4.6 Methods of examination and test.

4.6.1 Thermal shock (see 3.5). Capacitors shall be tested in accordance with method 107 of MIL-STD-202. The following details shall apply:

- (a) Test condition - B (styles PC21, PC22, PC23, PC24, PC26, PC28, PC29, PC32 and PC34) or A (all other styles), except that in step 3, capacitors shall be tested at the high test temperature,  $\pm 5^{\circ}\text{C}$  (see 3.1).
- (b) Measurements before and after cycling - Not applicable.

After the test, capacitors shall be visually examined for evidence of fracture, corrosion, or loosening of mechanical connections.

4.6.2 Burn-in (styles PC21, PC22, PC23, PC24, PC26, PC27, PC28, PC29, PC30, PC32 and PC34) (see 3.6). Capacitors shall be mounted by their normal mounting means and set at approximately the maximum rated capacitance value during the entire test. Parts shall be subjected to 150 percent of rated voltage (see 3.1) at an ambient temperature of  $125 \pm 3^{\circ}\text{C}$ . Voltage shall be applied for a minimum of 24 hours.

4.6.3 Visual and mechanical examination. Capacitors shall be examined to verify that the material, design, construction, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.3 to 3.4.4 inclusive, and 3.26 to 3.27.1 inclusive).

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4.6.4 Capacitance (see 3.7). Capacitors shall be tested in accordance with method 305 of MIL-STD-202. Measurements shall be made using a test jig incorporating a guard provision. The following details and exception shall apply:

- (a) Test frequency - Minimum and maximum rated capacitance shall be measured at a frequency of 1 megahertz (MHz)  $\pm 100$  kilohertz (kHz).
- (b) Limit of accuracy - Shall be within  $\pm 1$  percent or 0.05 pF, whichever is greater.

4.6.5 Change of capacitance (see 3.8). The rate of change of capacitance shall be monitored by any suitable method while the capacitance is adjusted from the minimum rated value to the maximum rated value and back to the minimum rated value. The rate of change of capacitance as a function of the change of adjustment shall be monitored for change of sign.

4.6.6 Insulation resistance (see 3.9). Capacitors shall be tested in accordance with method 302 of MIL-STD-202. The following details and exceptions shall apply:

- (a) Test condition - As specified (see 3.1).
- (b) Special conditions - Measurements shall be made at room ambient temperature and at the applicable high test temperature. The relative humidity shall be between 20 and 50 percent; however, at the manufacturer's option, measurements may be made at a relative humidity up to 80 percent.
- (c) Points of measurement - Insulation resistance shall be measured at the maximum rated capacitance setting between the mutually insulated points.
- (d) Electrification time - 1 minute.

4.6.7 Dielectric withstanding voltage (see 3.10). Capacitors shall be tested in accordance with method 301 of MIL-STD-202. The following details shall apply:

- (a) Magnitude and nature of test voltage - 200 percent of dc rated voltage (see 3.1).
- (b) Points of application of test voltage - Capacitors shall be set at maximum rated capacitance and the potential applied between the terminals.

4.6.8 Quality factor (Q) (see 3.11). Capacitors shall be tested in accordance with method 306 of MIL-STD-202. The following details and exceptions shall apply:

- (a) Test frequency - Capacitors shall be set at maximum rated capacitance as specified in 4.6.4 and Q shall be measured at a frequency of 20 MHz  $\pm 200$  kHz, unless otherwise specified (see 3.1).
- (b) Condition - The mounting means shall be snugly fitted against the capacitor when making measurements.
- (c) Measurements - Shall be made using a test jig designed for minimum stray capacitance effects.
- (d) Measurement accuracy - Shall be sufficient to guarantee the minimum Q specified.

#### 4.6.9 Torque.

4.6.9.1 Driving torque (see 3.12.1). The torque required to start and maintain rotation of the rotor shall be measured by a gradually applied force sufficient to turn the rotor through at least 50 percent of the total number of rotations.

4.6.9.1.1 For qualification inspection. The test specified in 4.6.9.1 shall be performed at room ambient temperature,  $-55^{\circ} \pm 0^{\circ}$  C, and at the applicable high test temperature,  $+5^{\circ}$  to  $+0^{\circ}$  C.

#### 4.6.9.1.2 Quality conformance inspection.

4.6.9.1.2.1 Group A inspection. The test specified in 4.6.9.1 shall be performed at room ambient temperature.

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4.6.9.1.2.2 Group C inspection. The test specified in 4.6.9.1 shall be performed at  $-55^{\circ} \pm 0^{\circ} \text{ } ^{\circ}\text{C}$  and at the applicable high test temperature,  $+5^{\circ} \text{ } ^{\circ}\text{C}$ .

4.6.9.2 Torque, bushing strength (panel mounts only) (see 3.12.2). The capacitor shall be mounted through the suggested hole (see 3.1) in a metal panel of 1/8 inch maximum thickness, while the applicable torque specified in table VII is applied to the nut. The torque shall be applied in the direction which will tighten the nut and shall be held at its specified value for a period of not less than 3 seconds. It shall be applied repeatedly to the nut until a total of five twists have been applied. After the test, the capacitor shall be visually examined for evidence of bushing breakage, thread stripping, or other visible mechanical damage.

TABLE VII. Torque.

Bushing size	Torque $\pm 0.1$ (pound-inches)
15/64 inch	5.0
10-32	6.0
1/4 inch	8.0

4.6.10 Temperature coefficient and capacitance drift (see 3.13).

4.6.10.1 For qualification inspection.

4.6.10.1.1 Temperature coefficient. With capacitors set at approximately 75 percent of maximum rated capacitance, capacitance measurements shall be made at a frequency of 1 MHz  $\pm 100$  kHz and at the temperatures specified in table VIII. Each measurement shall be made after thermal stability has been reached. (Thermal stability has been reached when no further change in capacitance is obtained between two successive measurements taken at 5 minute intervals.) Accuracy of measurements shall be within  $\pm 0.01$  pF.

TABLE VIII. Temperature coefficient and capacitance-drift cycle.

Steps	Qualification inspection temperature	Quality conformance inspection temperature
	$^{\circ}\text{C}$	$^{\circ}\text{C}$
(a) - - - - -	$25 \pm 2$	$25 \pm 2$
(b) - - - - -	$-55 \pm 0$	$-55 \pm 0$
(c) - - - - -	$-10 \pm 2$	$25 \pm 2$ 1/
(d) - - - - -	$25 \pm 2$ 1/	$125 \pm 2$
(e) - - - - -	$85 \pm 2$	$150 \pm 2$ 2/
(f) - - - - -	$125 \pm 2$	$25 \pm 2$
(g) - - - - -	$150 \pm 2$ 2/	
(h) - - - - -	$25 \pm 2$	

1/ This temperature shall be considered as the reference temperature.

2/ For characteristic Q only.

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4.6.10.1.1.1 Computation of temperature coefficient. The temperature coefficient shall be computed as follows:

$$TC = \frac{(C_2 - C_1) 10^6}{(T_2 - T_1) C_1}$$

Where:

TC = Temperature coefficient in parts per million per degree C.

C<sub>1</sub> = Capacitance at 25°C in pF.

C<sub>2</sub> = Capacitance at test temperature in pF.

T<sub>1</sub> = 25°C.

T<sub>2</sub> = Test temperature in degrees C.

4.6.10.1.2 Capacitance drift. Capacitance drift shall be the greatest difference between any two of the three values recorded at 25°C (see table VIII).

4.6.10.2 For quality conformance inspection.

4.6.10.2.1 Temperature coefficient. Capacitance measurements shall be made as specified in 4.6.10.1.1 and table VIII.

4.6.10.2.2 Capacitance drift. Capacitance drift shall be computed as specified in 4.6.10.1.2.

4.6.11 Immersion (sealed units only) (see 3.14). Capacitors shall be tested in accordance with method 104 of MIL-STD-202. The following details shall apply:

- (a) Test condition - A.
- (b) Measurements after final cycle - Maximum rated capacitance, insulation resistance, and dielectric withstanding voltage shall be measured as specified in 4.6.4, 4.6.6, and 4.6.7, respectively.

4.6.12 Salt spray (corrosion).

4.6.12.1 Salt spray (corrosion) (sealed units only) (see 3.15.1). Capacitors shall be tested in accordance with method 101 of MIL-STD-202. The following details shall apply:

- (a) Test condition - B.
- (b) Measurements between 4 and 24 hours after exposure - Insulation resistance, dielectric withstanding voltage, and driving torque at room ambient temperature shall be measured as specified in 4.6.6, 4.6.7, and 4.6.9.1.2.1, respectively.

Capacitors shall be examined for evidence of corrosion.

4.6.12.2 Salt spray (corrosion) (unsealed units only) (see 3.15.2). Capacitors shall be tested in accordance with method 101, test condition B, of MIL-STD-202. Capacitors shall be examined for evidence of corrosion.

4.6.13 Low-temperature storage (see 3.16). Capacitors shall be subjected to storage at -62° ± 5°C for a period of 48 ± 4 hours. Capacitors shall then be examined for evidence of mechanical damage.

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

- (a) Mounting - Capacitors shall be mounted by their normal mounting means.

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- (b) Number and direction of applied shocks - Twenty; ten in each of two mutually perpendicular directions (five blows in each of two directions). One of the test planes shall be parallel and the other perpendicular to the cylindrical axis of the rotor.
- (c) Test condition - I.
- (d) Electrical load during shock - A potential of 125 percent of the specified dc rated voltage (see 3.1) shall be applied between rotor and stator with the capacitor set at approximately 75 percent of maximum rated capacitance.
- (e) Examination during and after shock - During the test, observation shall be made for momentary arcing or intermittent contacts of 0.5 ms or greater duration. After test capacitors shall be visually examined for evidence of breakdown, arcing, fractures, loosening of parts, or other visible mechanical damage.

4.6.15 Vibration, high frequency (see 3.18). Capacitors shall be tested in accordance with method 204 of MIL-STD-202. The following details and exceptions shall apply:

- (a) Mounting - Capacitors shall be mounted by their normal mounting means. Lead-mounted capacitors designed for printed-circuit mounting shall be seated firmly against a printed-wiring board or comparable support to withstand forces encountered in service. Leads shall pass through mounting holes in the board and shall be soldered on the opposite side of the printed-wiring board.
- (b) Measurements prior to vibration - Capacitors shall be set at approximately 75 percent of maximum rated capacitance and capacitance shall then be measured as specified in 4.6.4.
- (c) Electrical-load conditions - During the test while capacitors are set as specified in (b) above, a potential of 125 percent of the dc rated voltage shall be applied between rotor and stator. Observation shall be made for intermittent contacts of 0.5 ms or greater duration, momentary arcing, open or short circuiting.
- (d) Test condition - 8.
- (e) Direction of motion - In two directions; one perpendicular and one parallel to the axis of the rotor shaft.
- (f) Final measurements - After vibration, capacitance shall again be measured as specified in 4.6.4.

After completion of test, capacitors shall be examined for evidence of fracture, loosening of parts, or other mechanical damage visible under 10 power magnification.

4.6.16 Barometric pressure (reduced) (see 3.19). Unless otherwise specified (see 3.1), capacitors shall be tested in accordance with method 105 of MIL-STD-202. The following details shall apply:

- (a) Method of mounting - Capacitors shall be mounted by their normal mounting means.
- (b) Test condition - D.
- (c) Test during subjection to reduced pressure - A dc potential equal to 50 percent of the dc rated voltage or 500 volts, whichever is less, shall be applied, for not less than 1 second nor more than 5 seconds, between the terminals.

Capacitors shall be visually examined for evidence of damage, arcing, or breakdown.

4.6.17 Moisture resistance (see 3.20). Capacitors shall be tested in accordance with method 106 of MIL-STD-202. The following details and exceptions shall apply:

- (a) Mounting - Capacitors shall be mounted by their normal mounting means and set at approximately 75 percent of maximum rated capacitance.
- (b) Polarization and loading voltage - Not applicable.

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- (c) Final measurements - Upon completion of step 6 of the final cycle capacitors shall be maintained at a temperature of  $25^{\circ} \pm 10^{\circ} \text{C}$  and a relative humidity of  $50 \pm 5$  percent for a period of 4 to 24 hours. Insulation resistance, dielectric withstanding voltage, and driving torque at room ambient temperature shall then be measured as specified in 4.6.6, 4.6.7, and 4.6.9.1.2.1, respectively.

After completion of test, capacitors shall be examined for evidence of corrosion.

**4.6.18 Terminal strength (see 3.21).** A load shall be gradually applied perpendicular to the initial position of the wire lead in the opposite direction of the winding (or perpendicular to the center line for flat and printed circuit terminals) until the applied load reaches 2 pounds. The 2-pound load shall be applied for at least 5 seconds at a point within 1/4 inch of the open end of the wire lead and printed circuit terminals and from the lead hole itself in the flat terminals. The capacitors shall then be examined for evidence of lead separation, loosening or rupturing of the terminal, and any other damage to terminals and the capacitor body.

**4.6.18.1 Bend test (wire leads only).** Leads shall be clamped 1/4 inch from the body of the capacitor and shall be bent at an angle  $90^{\circ}$  each side of the center (total  $-180^{\circ}$ ) 3 times. The radius of curvature at the  $90^{\circ}$  bend shall be approximately 1/32 inch.

**4.6.18.2 Bend test (flat terminals only).** Capacitors with flat terminals shall be tested in accordance with method 211 of MIL-STD-202. The following details shall apply:

- (a) Test condition - B.
- (b) Number of bends - 2.

**4.6.19 Resistance to soldering heat (printed circuit mount types only, see 3.1) (see 3.22).** Capacitors shall be tested in accordance with method 210 of MIL-STD-202. The following details and exceptions shall apply:

- (a) Depth of immersion in molten solder - Leads shall be immersed to within 0.125 inch of the body of the capacitor.
- (b) Test condition - A.
- (c) Cooling time prior to measurement after test - Sufficient time to allow the capacitor temperature to return to  $25 \pm 5^{\circ}\text{C}$ .
- (d) Measurements after test - Capacitance, dielectric withstanding voltage, and quality factor shall be measured as specified in 4.6.4, 4.6.7, and 4.6.8, respectively.

Capacitors shall then be examined for evidence of mechanical damage.

**4.6.20 Seal (see 3.23).** Capacitors shall be placed in a sealed enclosure filled with water with sufficient noncorrosive dye, Rhodamine B (tetraethylrhodamine). Air pressure shall be applied inside the sealed enclosure to a pressure level of 40 pounds per square inch gage for a total period of 15 minutes. After completion of this period of time, the capacitors shall be removed from the sealed enclosure, cleaned, dried thoroughly, and then examined for presence of dye. Maximum rated capacitance, insulation resistance, and dielectric withstanding voltage shall then be measured as specified in 4.6.4, 4.6.6, and 4.6.7, respectively. (If necessary to determine the presence of dye internally, the units may be disassembled after performing the rotational life test) (see 4.6.21).

**4.6.21 Rotational life (see 3.24).** Capacitors shall be mounted by their normal mounting means with the adjusting screw set at approximately 20 percent of maximum rated capacitance. The screw shall be rotated four complete revolutions in the direction of increasing capacitance, then four complete revolutions in the direction of decreasing capacitance. This cycle shall be repeated 75 times at a rate of 5 cycles per minute. Following the final cycle, dielectric withstanding voltage shall be measured as specified in 4.6.7. Then capacitors shall be set at approximately

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10 percent of the maximum rated capacitance value above the minimum rated capacitance value or 1.0 pF, whichever is greater, and then the rotor shall be rotated in steps of two turns until 90 percent of maximum rated capacitance is reached. Capacitance measurements at a minimum of three steps shall be recorded. Capacitance shall be measured after each step at a frequency of 0.001 or 1.0 MHz  $\pm 10$  percent and shall be continuously monitored for reversals. The accuracy of the rotation shall be within  $\pm 5^\circ$  per revolution. Reproducibility of the measurements shall be within  $\pm 0.1$  percent or 0.01 pF, whichever is greater. Following measurement of capacitance change versus rotation, driving torque at room ambient temperature shall be measured as specified in 4.6.9.1. Without further rotation after the driving torque measurement contact resistance shall be measured between the rotor screw and the mounting base. Disassembly may be necessary for this measurement.

4.6.22 Solderability (see 3.25). Capacitors shall be tested in accordance with method 208 of MIL-STD-202. All solderable terminations of each part shall be tested.

## 5. PREPARATION FOR DELIVERY

Capacitors shall be prepared for delivery in accordance with MIL-C-39028.

## 6. NOTES

6.1 Ordering data. Procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Title, number, and date of the applicable specification sheet, and the complete type designation (see 1.2.1 and 3.1).
- (c) Levels of preservation and packaging and packing, and applicable marking (see section 5).
- (d) Number of unit packages if other than that specified in section 5.

6.2 Qualification. With respect to products requiring qualification, awards will be made only for products which are at the time set for opening of bids, qualified for inclusion in the applicable qualified products list whether or not such products have actually been so listed by that date. The attention of the suppliers is called to this requirement, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. The activity responsible for the qualified products list is U.S. Army Electronics Command, Fort Monmouth, New Jersey 07703; however, information pertaining to qualification of products may be obtained from Defense Electronics Supply Center, (DESC-E), ATTN: EQ, Dayton, Ohio 45444.

6.3 Substitutability data. For a cross reference of the substitutability relationship of superseded styles PC38, PC40, PC41, PC42, PC46, and PC47 characteristics J and H only, see the applicable specification sheet (see 3.1).

6.4 Mounting. It is recommended that the capacitor bodies have adequate heat sink during mounting operation with high temperature solder.



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**Custodians:**

Army - EL  
Navy - EC  
Air Force - 11

**Review activities:**

Army -  
Navy - AS, OS  
Air Force -  
DSA - ES

**User activities:**

Army -  
Navy - CG, NC  
Air Force -

**Preparing activity:**

Army - EL

**Agent:**

DSA - ES

(Project 5910-1128)

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## APPENDIX

## QUALIFICATION-SUBMITTAL PLANS

## 10. SCOPE

10.1 This appendix details the qualification-submittal plans for capacitors to be subjected to the qualification inspection specified in this specification. These plans specify the sample size, sampling criteria, and limits of coverage for the type of qualification sought.

## 20. SUBMITTAL PLANS

20.1 Single type. The following details apply:

- (a) Sample size - As specified in table II (49 sample units).
- (b) Sampling criteria - Sample units of the same style, characteristic and nominal maximum rated capacitance.
- (c) Limits of coverage - Qualification coverage will be restricted to the type designation submitted.

20.2 Combined-type submission.

- (a) Sample size - As specified in table IX.
- (b) Sampling criteria - The lowest and highest maximum rated capacitance units in each style and characteristic may be submitted for qualification of each group. However, in groups X, XI, and XII styles PC44 and PC45, PC48 and PC52, PC50 and PC51 are combined to allow only the lowest capacitance value in one style and each characteristic and the highest capacitance value in the other style and each characteristic to be submitted. Submission may also be divided between styles PC25 and PC26 in group XIII for qualification.
- (c) Extent of qualification - Qualification will be extended to all intermediate capacitance ratings when submitted in accordance with the above and table IX.
- (d) Note: In the event characteristic H units of style PC36 meet characteristic J requirements, submission of qualification of characteristic J units are waived.

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

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

20.5 Description of items. The supplier shall submit a detailed description of the capacitors being submitted for inspection, including the design and construction, and the materials for the base, rotor, and electrodes.

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TABLE IX. Specimens for complete qualification submissions.

Group	Style	Characteristic	Types to be submitted	Number of sample units to be submitted
I	PC35	H	PC35H4R5	25
			PC35H400	25
II	PC36	J	PC36J050	25
			PC36J100	25
		H	PC36H140	25
			PC36H130	25
III	PC37	Q	PC37Q4R5	25
			PC37Q210	25
IV	PC38	Q	PC38Q1R8	25
			PC38Q160	25
V	PC39	G	PC39G160	25
			PC39G121	25
VI	PC40	Q	PC40Q1R8	25
			PC40Q160	25
VII	PC41	Q	PC41Q1R8	25
			PC41Q160	25
VIII	PC42	Q	PC42Q1R8	25
			PC42Q160	25
IX	PC43	G	PC43G160	25
			PC43G121	25
X	PC44	H	PC44H050	25
	PC45	H	PC45H190	25
XI	PC48	J	PC48J5R5	25
		H	PC48H160	25
	PC52	J	PC52J110	25
		H	PC52H380	25
XII	PC50	J	PC50J5R5	25
		H	PC50H160	25
	PC51	J	PC51J110	25
		H	PC51H380	25
XIII	PC25	J	PC25J100	25
	PC26	J	PC26J100	25
XIV	PC31	T	PC31T060	25
			PC31T200	25
XV	PC27	J	PC27J3R5	25
XVI	PC28	T	PC28T3R5	25
XVII	PC29	T	PC29T3R5	25
		J	PC29J100	25
XVIII	PC30	J	PC30J3R5	25
XIX	PC32	T	PC32T140	25
XX	PC34	T	PC34T100	25
XXI	PC21	L	PC21L1R2	25
			PC21L800	25
XXII	PC22	L	PC22L1R2	25
			PC22L300	25
XXIII	PC23	L	PC23L1R2	25
			PC23L800	25
XXIV	PC24	L	PC24L1R2	25
			PC24L800	25

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SPECIFICATION ANALYSIS SHEET		Form Approved Budget Bureau No. 22-R255
<b>INSTRUCTIONS:</b> This sheet is to be filled out by personnel, either Government or contractor, involved in the use of the specification in procurement of products for ultimate use by the Department of Defense. This sheet is provided for obtaining information on the use of this specification which will insure that suitable products can be procured with a minimum amount of delay and at the least cost. Comments and the return of this form will be appreciated. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments and suggestions submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or serve to amend contractual requirements.		
<b>SPECIFICATION</b> MIL-C-14409D CAPACITORS, VARIABLE (PISTON TYPE, TUBULAR TRIMMER), GENERAL SPECIFICATION FOR		
<b>ORGANIZATION</b>		
<b>CITY AND STATE</b>	<b>CONTRACT NUMBER</b>	
<b>MATERIAL PROCURED UNDER A</b> <input type="checkbox"/> DIRECT GOVERNMENT CONTRACT <input type="checkbox"/> SUBCONTRACT		
<b>1. HAS ANY PART OF THE SPECIFICATION CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?</b> <b>A. GIVE PARAGRAPH NUMBER AND WORDING.</b>		
<b>B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES</b>		
<b>2. COMMENTS ON ANY SPECIFICATION REQUIREMENT CONSIDERED TOO RIGID</b>		
<b>3. IS THE SPECIFICATION RESTRICTIVE?</b> <input type="checkbox"/> YES <input type="checkbox"/> NO (If "yes", in what way?)		
<b>4. REMARKS</b> (Attach any pertinent data which may be of use in improving this specification. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity)		
<b>SUBMITTED BY</b> (Printed or typed name and activity - Optional)		<b>DATE</b>

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