

PERFORMANCE SPECIFICATION

RESISTOR, VARIABLE, WIREWOUND, PRECISION
GENERAL SPECIFICATION FOR

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

1. SCOPE

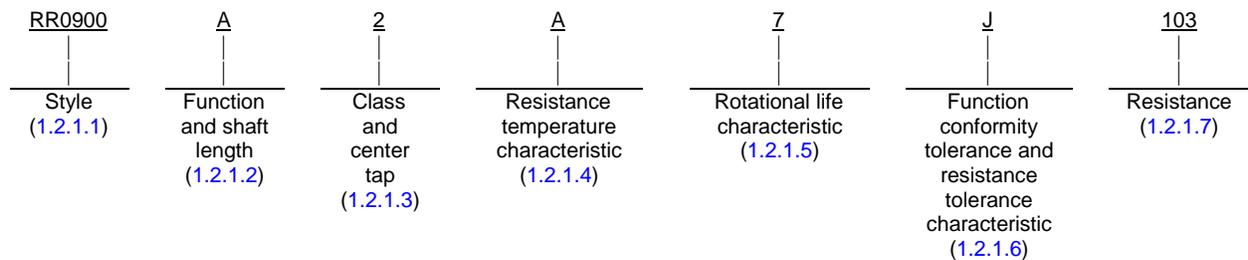
1.1 Scope This specification covers the general requirements for precision, wirewound, variable resistors whose electrical output (in terms of percent of applied voltage) are linear or nonlinear with respects to the angular position of the shaft. This specification includes requirements for linear and nonlinear, single turn and multiturn, single-section (cup) and multisection variable resistors. These resistors are capable of full-load operation at maximum ambient temperatures of 70°C and 85°C and are suitable for continuous operation, when properly derated, to maximum temperatures of 125°C and 150°C (see 3.1, 6.2, and figure 10). This specification includes requirements for category I, category II, and category III precision resistors as described herein (see 3.2).

1.2 Classification:

1.2.1 Part or Identifying Number (PIN).

- a. Category I resistors: The PIN completely describes the category I resistors of this specification.

Single-section (cup) resistors



- b. Category II resistors: The PIN of 1.2.1 is modified by changes in style designation (see 1.2.1.1), when used to describe a category II resistor. The PIN in this case does not fully describe the individual resistor. The resistor in this case is completely identified only by the addition of a drawing number in the marking (see 3.34 and 6.2.2).

RR09XXA2A7J103

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

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- c. Multisectioned (ganged) resistors (category III): For multisectioned (ganged) resistors, the PIN includes the PIN for each section (cup), preceded by a digit denoting the number of sections (cups) in the gang, as indicated in the following example:

3RR09XXA2A7J103
3RR09XXA2A7J104 ganged (three cups)
3RR09XXA2A7J103

The PIN is listed in the order in which the sections (cups) are stacked (ganged), beginning with the section (cup) nearest the mounting surface.

1.2.1.1 Style. The style is identified by the two-letter symbol “RR” followed by a four-digit number. The letters “RR” identify precision, variable, wirewound resistors. The first two digits in the number identifies physical size, the last two digits identifies a category I or category II resistor. The digits for a category I resistor should be “00”. The digits for a category II resistor will be “XX”. Example:

RR0900 - Category I resistor
RR09XX - Category II resistor

The category III item is not identified by a single number, but is described in the user's drawing.

1.2.1.2 Function and shaft length. The type of function and shaft length are identified in accordance with table I (see 3.1).

TABLE I. Function and shaft length.

Length ^{1/} _{2/}				
Symbol	Servo mounted	Bushing mounted (single turn)	Bushing mounted (multi-turn)	Function
A	0.375 (9.53)	0.750 (19.05)	-	Linear
B	0.500 (12.70)	0.875 (22.23)	-	
C	0.625 (15.88)	1.000 (25.40)	0.625 (15.88)	
D	0.750 (19.05)	1.125 (28.58)	0.750 (19.05)	
E	0.875 (22.23)	1.250 (31.75)	0.875 (22.23)	
F	1.000 (25.40)	1.375 (34.93)	1.000 (25.40)	
X	As specified			

^{1/} Length of shaft from mounting surface of resistor, nominal.

^{2/} Dimension in inches, metric equivalents are in parentheses. Tolerance is ± 0.031 (± 0.787)

1.2.1.3 Class and center tap. The class and center tap is identified by a single digit in accordance with table II and as specified (see 3.1).

1.2.1.4 Resistance temperature characteristic. The resistance temperature characteristic of the completed resistor is identified by a single letter in accordance with table III.

1.2.1.5 Rotational life characteristic. The rotational life characteristic is identified by a single digit in accordance with table IV (see 3.1).

1.2.1.6 Function conformity tolerance and resistance tolerance characteristic. The function conformity tolerance and resistance tolerance characteristic is identified by a single letter in accordance with table V (see 3.1).

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TABLE II. Class and center tap.

Symbol	Class 1		Center tap <u>1/</u>
	Maximum ambient temperature at rated wattage	Maximum ambient operating temperature	Tap located at center of resistive element (± 1 degree)
2	70°C	125°C	Not applicable
4			Applicable
3	85°C	150°C	Not applicable
5			Applicable
X	As specified		

1/ Applicable only to linear function resistors.

TABLE III. Resistance temperature characteristic.

Symbol	Resistance-temperature characteristic in percent per °C <u>1/</u>
A	± 0.003
B	± 0.005
C	± 0.010
D	± 0.016
E	± 0.026
F	± 0.040
G	± 0.070
H	$\pm 0.100+$
X	As specified

1/ Referred to an ambient temperature at 25°C.

TABLE IV. Rotational life characteristic.

Symbol	Rotational life (cycles) <u>1/</u> <u>2/</u> <u>3/</u>			
	Single turn	3 turn	5 turn	10 turn
7	125,000	85,000	50,000	25,000
8	250,000	175,000	100,000	50,000
9	500,000	350,000	200,000	100,000
X	As specified			

1/ A cycle consists of travel through 95 percent of actual electrical travel and return to starting point.

2/ For qualification only.

3/ Minimum number of cycles required.

TABLE V. Resistance tolerance and function conformity tolerance.

Resistance Tolerance (in percent \pm) ^{1/}				Function conformity tolerance (in percent \pm)
<u>5</u>	<u>3</u>	<u>2</u>	<u>1</u>	
Symbol				
A	G	M	S	1.000
B	H	N	T	0.500
C	I	O	U	0.250
D	J	P	V	0.100
E	K	Q	W	0.050
F	L	R	Y	0.025
X				As Specified

^{1/} The preferred resistance tolerances are 1 and 3 percent.

1.2.1.7 Resistance. The nominal total resistance value expressed in ohms 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 of an ohm, or values of less than 10 ohms are required, the letter "R" is substituted for one of the significant digits to represent the decimal point. When the letter "R" is used, the succeeding digits of the group represent significant figures, as shown in the following example"

3R0 signifies 3.0 ohms

1.2.1.8 Example of PIN (category I resistor). The PIN RR0900A2A7J103 signifies:

- RR0900 - Precision, wirewound, variable resistor (single-turn) of the dimensions specified (see 3.1).
- A - Linear function and 0.375 inch (9.53 mm) shaft length.
- 2 - Resistance to moisture, and capable of rated-wattage operation at 70°C maximum, and when derated, at 125°C maximum (see figure 10).
- A - Resistance temperature characteristic of ± 0.003 percent per °C.
- 7 - Capable of 125,000 cycles of rotational life.
- J - Function conformity tolerance of ± 0.10 percent and resistance tolerance of ± 3 percent.
- 103 - Nominal total resistance value of 10,000 ohms.

1.2.1.9 Example of PIN (category II resistor). The PIN RR09XXA2A7J103 signifies:

- RR09XX - Precision, wirewound, variable resistor (single-turn) with requirements as specified on acquisition document.
- A - Linear function and 0.375 inch (9.53 mm) shaft length.
- 2 - Resistance to moisture, and capable of rated-wattage operation at 70°C maximum, and when derated, at 125°C maximum (see figure 10).
- X - Resistance temperature characteristic of ± 0.003 percent per °C.
- 7 - Capable of 125,000 cycles of rotational life.
- J - Function conformity tolerance of ± 0.10 percent and resistance tolerance of ± 3 percent.
- 103 - Nominal total resistance value of 10,000 ohms.

2. APPLICABLE DOCUMENTS

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

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract (see 6.2).

DEPARTMENT OF DEFENSE SPECIFICATION

(See supplement 1 for list of specification sheets.)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-202	-	Test Methods Standard Electronics and Electrical Components Parts.
MIL-STD-810	-	Environmental Engineering Considerations and Laboratory Tests.
MIL-STD-1285	-	Marking of Electrical and Electronic Parts.

DEPARTMENT OF DEFENSE HANDBOOKS

FED-STD-H28	-	Screw Thread Standards for Federal Services.
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(Copies of these documents are available online at <http://quicksearch.dla.mil>).

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

INTERNATIONAL ORGANIZATION for STANDARDS (ISO)

ISO 10012	-	Measurement Management Systems - Requirements for Measurement Processes and Measuring Equipment
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(Copies of this document are available online at <http://www.iso.org/> or should be addressed to the American National Standards Institute, 11 West 42nd Street New York, NY 10036.)

NATIONAL CONFERENCE OF STANDARDS LABORATORIES

NCSL Z540.3	-	Calibration of Measuring and Test Equipment, Requirements for
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(Copies of this document are available from <http://www.ncsli.org/> or from the National Conference of Standards Laboratories (NCSL) International, 1800 30th Street, Suite 305, Boulder, CO 80301-1026.).

2.4 Order of precedence. Unless otherwise noted herein or in the contract, in the event of a conflict between the text of this document and the references cited herein (except for related specification sheets), the text of this document takes precedence unless otherwise noted. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of this specification and the specification sheet, the latter shall govern (see 6.2).

3.2 Resistor categories. Resistors furnished under this specification shall be category I, category II, or category III, as defined herein.

3.2.1 Category I resistor. A part that meets all requirements specified on a given specification without any exception, can be completely described by a PIN, (see 1.2.1) is covered by the family of products on the Qualified Products List (QPL), and is produced on an approved production line. Acquisition of these resistors shall be confined to sources whose family of products are listed on the QPL.

3.2.2 Category II resistor. A category II resistor is a part which is covered by the scope of a family of products qualification on an approved production line, but which differs from the category I item within the limits of similarity defined in 4.5.3. Acquisition of these resistors shall be confined to sources whose family of products are listed on the QPL.

3.2.3 Category III resistor. These resistors are of such a design, material, or construction that they cannot be considered to fall within the scope of qualification (see 6.2.3).

3.3 Qualification. Resistors furnished under this specification shall be products that are manufactured by a manufacturer authorized by the qualifying activity for listing on the applicable qualified manufacturers list before contract award (see 4.4 and 6.3).

3.4 Materials. Materials shall be used which will enable the resistors to meet the performance requirements of this specification. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.

3.4.1 Fungus. All external materials shall be nonnutrient to fungus growth or shall be suitably treated to retard fungus growth. The manufacturers shall certify that all external materials are fungus resistant or shall perform the test specified in 4.7.28. There shall be no evidence of fungus growth on the external surface as a result of the test.

3.4.2 Pure tin. The use of pure tin, as an underplate or final finish, is prohibited both internally and externally. Tin content of resistor components and solder shall not exceed 97 percent, by mass. Tin shall be alloyed with a minimum of 3 percent lead, by mass (see 6.10).

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

3.5.1 Operating shaft. All operating shafts shall be corrosion resistant.

3.5.1.1 Style. Unless otherwise specified, standard operating shafts shall be round (see 3.1 and 6.2).

3.5.1.2 Length. Unless otherwise specified, the lengths of standard operating shafts shall be in accordance with table I (see 3.1 and 6.2).

3.5.2 Contact arm assembly. Contact pressure on the resistance element shall be maintained by uniform positive pressure and shall permit smooth electrical and mechanical control of the resistor over the entire range of continuity travel (applicable to resistors with stops). The moving contact shall have continuous electrical contact with its terminal throughout the entire mechanical travel and shall be insulated from the operating shaft, bushing, and case.

3.5.3 Stops. Stops employed to limit the mechanical travel of the contact arm assembly may be part of, but shall not complete, any electrical circuit. In no case shall the mechanical stop contact the electrical pick off portion of the contact assembly.

3.5.4 Detachable sections. When detachable individual sections are used, their shaft extensions and contact arm shall be firmly coupled when ganged, but shall be capable of being detached without incurring either electrical or mechanical damage to the ganged assembly.

3.5.5 Phasing. Unless otherwise specified (see 3.1 and 6.2), the alignment of the functional angles of the individual cups of a ganged assembly shall be performed by the manufacturer, at the time of assembly so that the voltage ratios of all cups of the assembly fall within their respective specified functional characteristics at any angle of operating shaft rotation.

3.5.6 Terminals. Terminals shall be located as shown in the associated specification sheets, (see 3.1 and 6.2). The terminals shall be suitably treated to facilitate soldering.

3.5.6.1 Designations. Terminals shall be numbered with number 2 as the contact arm terminal, number 1 as the counterclockwise terminal, and number 3 as the clockwise terminal. Taps shall be numbered in sequence with terminal number 4 nearest the counterclockwise end (see figure 1).

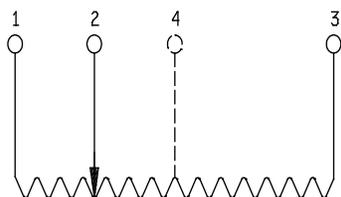


FIGURE 1. Circuit diagram.

3.5.7 Threaded parts. All external threaded parts shall be in accordance with [FED-STD-H28](#), and as specified herein.

3.5.8 Hardware (for bushing mounted units). Each resistor shall be furnished with a corrosion resistant, internal tooth lock washer and a hexagonal mounting nut. Unless otherwise specified, the hardware shall be assembled on the resistor (see 3.1).

3.5.9 Enclosure. Resistors shall have suitable enclosures for protection against mechanical damage and shall be dustproof.

3.6 Lateral runout. When resistors are tested as specified in 4.7.2, the lateral runout shall not exceed 0.002 inch per inch (0.05 mm) of mounting surface radius or 0.001 inch (0.03 mm), whichever is greater.

3.7 Shaft runout. When resistors are tested as specified in 4.7.3, the shaft runout shall not exceed 0.002 inch per inch (0.05 mm) of shaft length, from mounting surface to point of measurement or 0.001 inch (0.03 mm) total, whichever is greater.

3.8 Pilot surface runout. When resistors are tested as specified in 4.7.4, the pilot surface runout shall not exceed 0.001 inch (0.05 mm).

3.9 Radial play. When resistors are tested as specified in 4.7.5, the radial play shall not exceed 0.002 inch (0.05 mm).

3.10 End play. Unless otherwise specified (see 3.1 and 6.2), when resistors are tested as specified in 4.7.6, the end play shall not exceed 0.005 inch (0.13 mm).

3.11 Mechanical travel (applicable to resistors with stops). When resistors are tested as specified in 4.7.7, the mechanical travel shall be as specified (see 3.1 and 6.2).

3.12 Torque (see 4.7.8).

3.12.1 Starting (see 4.7.8.1).

3.12.1.1 Initial. Unless otherwise specified (see 6.2), the maximum torque required to initiate rotation of the contact arm shall be as specified (see 3.1).

3.12.1.2 Running. Unless otherwise specified (see 4.7.8.2 and 6.2), the maximum running torque shall be as specified (see 3.1).

3.12.2 Degradation. The torque required to initiate or sustain rotation of the contact arm shall not increase more than 50 percent of the initial specified value (see 3.1).

3.12.3 Stop (when applicable). When resistors are tested as specified in 4.7.8.3, there shall be no mechanical damage to the contact arm and stop, and the total mechanical travel shall not increase by more than 1 degree.

3.13 Power rating. The resistors shall have power rating based on a continuous full load operation at the ambient temperature specified for the applicable characteristic (see 3.1 and table II). Power ratings as specified (see 3.1) are applicable only when the maximum resistance is engaged in the circuit. When only a portion of the resistance element is engaged in the circuit, the power rating is reduced in approximately the same proportion as the resistance.

3.14 Voltage rating. The theoretical calculated rated continuous working voltage or the voltage equivalent to power rating (rated wattage) shall be determined from the following formula:

$$E = \sqrt{PR}$$

Where:

E = Rated dc or root mean square (rms) continuous working voltage.

P = Power rating.

R = Nominal total resistance.

The rated voltage shall not exceed the maximum continuous working voltage (see 3.1).

3.15 DC resistance (see 4.7.9).

3.15.1 Total.

3.15.1.1 Initial resistance. When measured as specified in 4.7.9.1, the total direct current (dc) resistance shall not deviate from the specified nominal resistance value by more than plus or minus the resistance tolerance (see 3.1 and 6.2).

3.15.2 Absolute minimum resistance. Unless otherwise specified (see 3.1 and 6.2), when measured as specified in 4.7.9.2, the absolute minimum resistance shall not exceed 1 percent of the nominal total resistance value or 5 ohms, whichever is greater.

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3.15.2.1 Resistance value deviations. All maximum deviations as specified in this section are to be considered absolute limits with the exception of the contact resistance adjustment.

3.16 End voltage. Unless otherwise specified (see 3.1 and 6.2), when measured as specified in 4.7.10, the end voltage shall not be more than 0.5 percent of the total applied voltage.

3.17 Taps (when applicable). When resistors are tested as specified in 4.7.11, taps shall be located as specified (see table II, 3.1, and 6.2).

3.18 Insulation resistance.

3.18.1 Initial. When resistors are tested as specified in 4.7.12, the insulation resistance shall not be less than 1,000 megohms.

3.18.2 Degradation. When resistors are tested as specified 4.7.12, the insulation resistance shall not be less than 100 megohms.

3.19 Dielectric withstanding voltage. When resistors are tested as specified in 4.7.13, there shall be no damage, arcing, or breakdown. The leakage current shall not exceed 1 milliampere (mA).

3.20 Function conformity tolerance.

3.20.1 Initial. When resistors are tested as specified in 4.7.14, the function conformity tolerance shall be as specified (see table V and 3.1). The actual effective electrical travel shall be as specified (see 3.1 and 6.2).

3.20.2 Degradation. Unless otherwise specified (see 3.1 and 6.2), when resistors are tested as specified in 4.7.14, the function conformity tolerance shall be not more than 150 percent of the value specified in 3.20.1.

3.21 Peak noise.

3.21.1 Initial. Unless otherwise specified (see 3.1 and 6.2), when resistors are tested as specified in 4.7.15, the peak noise resistance shall not exceed 100 ohms.

3.21.2 Degradation. Unless otherwise specified (see 3.1 and 6.2), when resistors are tested as specified in 4.7.15, the peak noise resistance shall not exceed 500 ohms.

3.22 Mechanical backlash. When resistors are tested as specified in 4.7.16, the operating shaft shall not move in excess of the applicable value specified in table VI, or the specified value (see 3.1 and 6.2), without moving the contact arm.

TABLE VI. Mechanical backlash.

Mechanical backlash (angular degrees)					
Function conformity tolerance %	Single turn	3 turn	5 turn	10 turns	
				RR1000 RR4000	RR1400 RR2100 RR4100
1.000	0.50	0.50	1.00	1.50	1.00
0.500	0.25				
0.250	0.10	0.10	0.50	1.00	0.50
0.100					
0.050					
0.025				0.50	0.25

3.23 Terminal strength. When resistors are tested as specified in 4.7.17, there shall be no evidence of mechanical damage.

3.24 Thermal shock. Unless otherwise specified (see 3.1 and 6.2), when resistors are tested as specified in 4.7.18, there shall be no evidence of mechanical damage, and the total resistance change shall not exceed 5 percent of the initial resistance value (see 3.15.1).

3.25 Resistance temperature characteristic. When resistors are tested as specified in 4.7.19, the resistance temperature characteristic, referred to an ambient temperature of 25°C, shall be within the limits of the values specified in table III, or as specified (see 3.1 and 6.2).

3.26 Rotational load life. Unless otherwise specified (see 3.1 and 6.2), when resistors are tested as specified in 4.7.20, there shall be no evidence of mechanical damage or opening of the winding, and the total resistance change shall not exceed 5 percent between the initial resistance value (see 3.15.1.1), measured at the rated ambient temperature previous to the rotational load life test, and any of the succeeding measurements.

3.27 Low temperature operation. When resistors are tested as specified in 4.7.21, electrical and mechanical connections shall not be adversely affected. Unless otherwise specified (see 3.1 and 6.2), the torque required to effect rotation shall not exceed two times the specified torque (see 3.1), and the total resistance change shall not exceed 5 percent of the initial resistance value (see 3.15.1.1).

3.28 Low temperature exposure. Unless otherwise specified (see 3.1 and 6.2), when resistors are tested as specified in 4.7.22, there shall be no evidence of mechanical damage, and the total resistance change shall not exceed 5 percent of the initial resistance value (see 3.15.1.1).

3.29 High temperature exposure. When resistors are tested as specified 4.7.23, there shall be no evidence of mechanical damage, and the total resistance change shall not exceed 5 percent of the initial resistance value (see 3.1 and 6.2).

3.30 Shock, specified pulse. When resistors are tested as specified in 4.7.24, there shall be no evidence of mechanical or electrical damage, or momentary discontinuity.

3.31 Vibration, high frequency. When resistors are tested as specified in 4.7.25, there shall be no evidence of mechanical or electrical damage, or momentary discontinuity. The total resistance change shall not exceed 5 percent of the initial resistance value (see 3.15.1.1)

3.32 Salt spray (corrosion). When resistors are tested as specified 4.7.26, there shall be no appreciable corrosion.

3.33 Moisture resistance. Unless otherwise specified (see 3.1 and 6.2), when resistors are tested as specified in 4.7.27, the insulation resistance shall not be less than 10 megohms, and the total resistance shall not exceed 3 percent of the initial resistance value (see 3.15.1.1).

3.34 Marking. Resistors shall be marked with the following minimum information:

- a. PIN (see 1.2.1) category I resistor.
- b. Acquisition drawing number. Category II and III (on category II items, the original equipment manufacturer's drawing number shall be marked on the unit and the specification style number shall be marked on the units, the specification style number shall also be shown in the drawing (see 1.2.1b).
- c. Manufacturer's name, Commercial and Government Entity (CAGE) code symbol or trade mark.
- d. Manufacturer's part number.
- e. Terminal identification shall be marked in accordance with 3.5.6.1.
- f. Date code in accordance with MIL-STD-1285. When the date code does not provide specific production lot identification, the resistor shall be marked with a code symbol in accordance with MIL-STD-1285.

All markings shall be visible on the cylindrical surface of the resistor. There shall be no space between symbols which comprise the PIN. Each resistor of a multisection (ganged) units shall be similarity marked. All markings shall remain legible at the end of all tests.

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

3.36 Workmanship. Resistors shall be processed in such a manner as to be uniform in quality and shall be free from other defects that will affect life, serviceability, or appearance.

4. VERIFICATION

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

- a. Qualification inspection (see 4.4).
- b. Retention of qualification (see 4.5).
- c. Conformance inspection (see 4.6).

4.2 Test equipment and inspection facilities. The manufacturer shall establish and maintain a calibration system in accordance with NCSL Z540.3, ISO 10012, or equivalent system as approved by the qualifying activity.

4.3 Inspection conditions and precautions.

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

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4.3.2 Precautions. Adequate precautions shall be taken during inspection to prevent condensation of moisture on resistors. Precautions shall also be taken to prevent damage by heat when soldering resistor leads to terminals. The theoretically calculated continuous working voltage or the voltage equivalent to power rating (rated wattage) shall be determined from the following formula:

$$E = \sqrt{PR}$$

Where:

- E = Rated dc or root-mean-square (rms) ac continuous working voltage at commercial-line frequency and waveform.
- P = Power rating.
- R = Nominal total resistance.

In no case shall the rated voltage exceed the maximum continuous working voltage specified (see 3.1). Adequate precautions shall be taken during tests to prevent condensation of moisture on resistors except during the moisture-resistance and temperature-cycling tests.

4.4 Qualification. Qualification inspection shall be performed at a laboratory acceptable to the Government (see 6.3) on sample units produced with equipment and procedures normally used in production.

4.4.1 Sample size. The number of sample units comprising a sample of resistors to be subjected for qualification inspection shall be as specified in the appendix to this specification.

4.4.2 Inspection routine (category I resistors). Sample units shall be subjected to the qualification inspection specified in table VII, in the order shown. Eighteen sample units shall be subjected to the inspection of group I. An additional sample unit shall be subjected to the inspection of group II and if applicable, two additional units shall be subjected to group VII. After the inspection of group I, the 18 sample units shall then be divided as specified in table VII for groups III to VI inclusive. The sample units shall then be subjected to the inspection for their particular group.

When servo mount types are submitted for qualification, and qualification is desired for bushing mounted units of the same physical size and construction (except for faceplate), three additional sample units with bushing mounts shall be submitted to inspection of group I of table VII. In a like manner, three additional sample units with servo mounts shall be subjected to group I of table VII, when bushing types are submitted for qualification. Extension of qualification from one case and winding from material to a different material will require complete qualification inspection.

4.4.3 Defective. Failure of a resistor in one or more tests of a group shall be charged as a single failure. No failures shall be allowed for groups I, II, and VII. One failure shall be allowed for groups III, IV, V, and VI combined. Failures in excess of those allowed shall be cause for refusal to grant qualification.

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TABLE VII. Qualification inspection.

Inspection <u>1/</u>	Requirement paragraph	Method paragraph	Number of samples	Number of defectives	
<u>Group I</u>					
Visual and mechanical examination <u>2/</u> , <u>3/</u>	3.1, 3.4 to 3.5.9 inclusive and 3.34 to 3.36 inclusive	4.7.1	18	0	
Lateral runout <u>3/</u>	3.6	4.7.2			
Shaft runout <u>3/</u>	3.7	4.7.3			
Pilot surface runout <u>3/</u>	3.8	4.7.4			
Radial play <u>3/</u>	3.9	4.7.5			
End play <u>3/</u>	3.10	4.7.6			
Mechanical travel (applicable to resistors with stops) <u>3/</u>	3.11	4.7.7			
Torque <u>3/</u>	3.12	4.7.8			
Total resistance <u>3/</u>	3.15.1	4.7.9.1			
Absolute minimum resistance <u>3/</u>	3.15.2	4.7.9.2			
End voltage <u>3/</u>	3.16	4.7.10			
Taps (when applicable) <u>3/</u>	3.17	4.7.11			
Insulation resistance <u>3/</u>	3.18	4.7.12			
Dielectric withstanding voltage <u>3/</u>	3.19	4.7.13			
Functional conformity tolerance <u>3/</u>	3.20	4.7.14			
Peak noise <u>3/</u>	3.21	4.7.15			
Mechanical backlash <u>3/</u>	3.22	4.7.16			
Terminal strength	3.23	4.7.17			
<u>Group II</u>					
Visual and mechanical examination	3.1, 3.4 to 3.4.1 inclusive, 3.5.2, 3.5.3, 3.5.9, 3.34 to 3.36 inclusive	4.7.1	1	0	
<u>Group III</u>					
Thermal shock <u>3/</u>	3.24	4.7.18	6	1	
Resistance temperature characteristic <u>3/</u>	3.25	4.7.19			
Rotational load life	3.26	4.7.20			
Functional conformity tolerance	3.20	4.7.14			
Peak noise	3.21	4.7.15			
Insulation resistance	3.18	4.7.12			
Dielectric withstanding voltage	3.19	4.7.13			
Torque	3.12	4.7.8			
<u>Group IV</u>					
Thermal shock	3.24	4.7.18	3		
Low temperature operation	3.27	4.7.21			
Low temperature exposure	3.28	4.7.22			
Functional conformity tolerance	3.20	4.7.14			
Peak noise	3.21	4.7.15			
Torque	3.12	4.7.8			
High temperature exposure	3.29	4.7.23			
Functional conformity tolerance	3.20	4.7.14			
Peak noise	3.21	4.7.15			
Insulation resistance	3.18	4.7.12			
Dielectric withstanding voltage	3.19	4.7.13			
Torque	3.12	4.7.8			

See footnotes at end of table.

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TABLE VII. Qualification inspection - Continued.

Inspection <u>1/</u>	Requirement paragraph	Method paragraph	Number of samples	Number of defectives	
<u>Group V</u>					
Thermal shock	3.24	4.7.18	3	1	
Shock (specified pulse)	3.30	4.7.24			
Vibration, high frequency	3.31	4.7.25			
Functional conformity tolerance	3.20	4.7.14			
Peak noise	3.21	4.7.15			
End play	3.10	4.7.6			
Torque	3.12	4.7.8			
Salt spray (corrosion)	3.32	4.7.26			
<u>Group VI</u>					
Thermal shock	3.24	4.7.18	6		
Moisture resistance	3.33	4.7.27			
Functional conformity tolerance <u>4/</u>	3.20	4.7.14			
Peak noise <u>4/</u>	3.21	4.7.15			
Torque <u>4/</u>	3.12	4.7.8			
<u>Group VII</u>					
Fungus	3.4.1	4.7.28	2	0	

1/ The requirement for qualification inspection shall be those specified herein (and not those in the contract or order).

2/ Marking shall be considered defective only if the marking is illegible.

3/ Nondestructive tests.

4/ These tests shall be performed immediately following the moisture resistance tests.

4.5 Retention of qualification. Every 12 months, the manufacturer shall verify the retention of qualification to the qualifying activity. In addition, the manufacturer shall immediately notify the qualifying activity whenever the group B inspection results indicate failures of the qualified product to meet the requirements of this specification. Verification shall be based on meeting the following requirements:

- a. The manufacturer has not modified the design of the item.
- b. The specification requirements for the item have not been amended so far as to affect the character of the item.
- c. Lot rejection for group A inspection does not exceed the group A sampling plan.
- d. The requirements for group B inspection are met.

When group B requirements were not met and the manufacturer has taken corrective action satisfactory to the Government, group B inspection retesting shall be instituted.

4.5.1 Category II resistors. The inspections applicable to category II resistors (in addition to the qualification of the associated family of products) shall be the groups A and B conformance tests specified herein (see 6.1), and any other additional conformance test specified in the acquisition document.

4.5.2 Category III resistors. All acquisition documents shall specify testing, which shall consist of requirements specified on the drawing and all tests listed in table VII. Requirements for these tests shall be modified as necessary in the acquisition document. Groups A and B conformance tests shall be specified in addition to any other tests considered necessary (see 6.1).

4.5.3 Scope of family of products qualification. Family of products qualification shall cover all resistors similar to the category I resistor which passed qualification requirements. Resistors meeting this criteria are designated as category II resistors. In order to be considered similar to the category I resistor, the category II resistor shall be within the following restrictions:

- a. The category II resistor shall have been produced on the same production line approved for the category I resistors.
- b. Material: All materials and finishes used in the manufacture of the category II resistor shall be the same as those used in the corresponding category I resistor submitted. This includes, but is not necessarily limited to, the materials used for the housing or case, shaft, mounting, construction, winding form, slip rings, rotors, or sliders. There shall be no restriction on the resistance wire or contact (wiper) materials provided the resistor meets all performance requirements. In all cases, the materials shall meet the requirements specified in 3.4.
- c. Interface and physical dimensions: The interface and physical dimensions of the category II resistor shall be the same as that of the corresponding category I resistor and shall meet the requirements of 3.5 to 3.5.9 inclusive. The only exceptions shall be tap and terminal design and construction which are unrestricted. Servo and bushing mounting interface and physical dimensions may vary, however, the basic interface and physical dimensions of the shaft bearing shall be similar to the category I resistor.
- d. External dimensions: The external dimensions of the housing or case of the category II resistor shall not deviate more than ± 10 percent of those of the corresponding category I resistor.
- e. Wattage rating: Category II resistors shall have wattage ratings equal to or less than that of corresponding category I resistors.
- f. Noise: Category II resistors shall have noise content the same or greater than the corresponding category I resistor.
- g. Rotational load life: Category II resistors shall have rotational load life requirements equal to or less stringent than the corresponding category I resistor.
- h. Temperature rating: The maximum ambient and operating temperatures of the category II resistor shall not exceed those of the corresponding category I resistor.
- i. Multiturn: Category II resistors shall have the same nominal number of turns as the corresponding category I resistor.
- j. Multisection: Each section of a multisection resistor shall be considered separately and compared to, corresponding category I resistors to determine similarity. If each section meets this criteria, the entire multisection resistor shall be considered a category II resistor.
- k. The category II resistor may vary from the corresponding category I resistor without restriction in the following parameters for general requirements specified herein:
 - (1) Linearity and conformity.
 - (2) Actual electrical travel angle.
 - (3) Taps and tap location.
 - (4) Mechanical travel.

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- (5) Length, diameter, and configuration of operating shaft.
- (6) Resistance and resistance tolerance.
- (7) Absolute minimum resistance.
- (8) Temperature coefficient.
- (9) Running, starting, and stop torque.
- (10) End play.

4.6 Conformance inspection.

4.6.1 Inspection of product for delivery. Inspection of product for delivery shall consist of groups A and B inspections.

4.6.1.1 Inspection lot. An inspection lot, as far as practicable, shall consist of all the resistors of the same style, or styles representing a group (see Appendix [table A-II](#)). The sample units shall be of the same class provided under essentially the same conditions, and offered for inspection at one time.

4.6.1.2 Group A inspection. Group A inspection shall consist of the inspections and tests specified in table VIII, and shall be made on the same set of sample units, in the order shown.

TABLE VIII. Group A inspection.

Inspection	Requirement paragraph	Method paragraph	Sampling plan
Dimensions	3.1	4.7.1	4.6.1.2.1
Lateral runout	3.6	4.7.2	
Shaft runout	3.7	4.7.3	
Pilot surface runout	3.8	4.7.4	
Radial play	3.9	4.7.5	
End play	3.10	4.7.6	
Mechanical travel (applicable to resistors with stops)	3.11	4.7.7	
Torque	3.12	4.7.8	
Marking	3.34	4.7.1	
Workmanship	3.36	4.7.1	
Total resistance	3.15.1	4.7.9.1	
Absolute minimum resistance	3.15.2	4.7.9.2	
End voltage	3.16	4.7.10	
Taps (when applicable)	3.17	4.7.11	
Insulation resistance	3.18	4.7.12	
Dielectric withstanding voltage	3.19	4.7.13.1	
Function conformity tolerance	3.20	4.7.14	
Peak noise	3.21	4.7.15	
Mechanical backlash	3.22	4.7.16	

4.6.1.2.1 Sampling plan. A sample of parts from each inspection lot shall be randomly selected in accordance with [table IX](#). If one or more defects are found, the lot shall be rescreened and defects removed. After screening and removal of defects, a new sample of parts shall be randomly selected in accordance with [table IX](#). If one or more defects are found in the second sample, the lot shall be rejected and shall not be supplied to this specification.

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TABLE IX. Sampling plan.

Lot size		Sample size
1	to 12	100 percent
13	to 150	13
151	to 280	20
281	to 500	29
501	to 1,200	34
1,201	to 3,200	42
3,201	to 10,000	50
10,001	to 35,000	60
35,001	to 150,000	74
150,001	to 500,000	90
500,001	to over	102

4.6.1.3 Group B inspection. Group B inspection shall consist of the inspections specified in table X, in the order shown. The inspection shall be performed on sample units which have been subjected to and passed group A inspection.

4.6.1.3.1 Sampling plan. Two sample units per lot shall be subjected to group B inspection with no failures permitted.

4.6.1.4 Small quantity production. If no more than 75 resistors of the same style or group of styles, defined for lot formation (see 4.6.1.1), are produced during a continuous 3-month period, the entire 3 month production may be submitted as one lot. In the case of failure, the entire lot shall be rejected and all units involved shall be subject to corrective action.

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

TABLE X. Group B inspection. 1/

Inspection <u>2/</u>	Requirement paragraph	Method paragraph	Sampling plan
Terminal strength	3.23	4.7.17	4.6.1.3.1
Thermal shock	3.24	4.7.18	
Rotational load life <u>3/</u>	3.26	4.7.20	
Functional conformity tolerance	3.20	4.7.14	
Peak noise	3.21	4.7.15	
Insulation resistance	3.18	4.7.12	
Dielectric withstanding voltage	3.19	4.7.13	
Torque	3.12	4.7.8	

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

2/ Failure of a resistor in one or more tests shall be charged as a single defective.

3/ This is the rotation portion (see [4.7.20.1](#)), of the rotational load life test only and shall be performed 2/ on the limited basis specified in [table XV](#).

4.6.2 Noncompliance. If a sample fails to pass group B inspection, the supplier shall take corrective action on the materials or processes, or both, as warranted, and on all units of product which can be corrected and which were manufactured under essentially the same conditions, with essentially the same materials, 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 B inspection shall be repeated on additional sample units (all inspection, or the inspection which the original sample failed, at the option of the Government). Group A inspections may be reinstated; however, final acceptance shall be withheld until group B 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 cognizant inspection activity and the qualifying activity.

4.7 Methods of examination and test.

4.7.1 Visual and mechanical examination. Resistors shall be examined to verify that the interface, physical dimensions, marking, and workmanship are in accordance with the applicable requirements (see 3.1, 3.4 to 3.5.9 inclusive, 3.34 and 3.36).

4.7.2 Lateral runout (see 3.6). This test shall be performed in accordance with figure 2. The operating shaft shall be clamped vertically in a suitable device. The dial gauge is positioned such that its probe contacts the smooth portion of mounting surface of the potentiometer less than 0.125 inch (3.18 mm) from the outside edge of the mounting surface. The probe should be depressed sufficiently to insure a proper positive and negative indication. Unless corrections are made in the gross force, the force due to pressure and operation of dial gauges shall not exceed 0.34 ounce. A 0.5 pound load is applied normal to the centerline of the shaft axis on the potentiometer body within 0.125 inch (3.18 mm) of the mounting surface. Simultaneously, a 0.5-pound load is applied axially on the centerline of the potentiometer. The resistor body shall be rotated through the mechanical travel or 360 degrees whichever is less. The lateral runout shall be determined from the maximum positive and negative deviations added together without regard to algebraic signs. The dial reading should then be divided by the mounting surface radius, at the point of dial measurement.

4.7.3 Shaft runout (see 3.7 and 6.7). This test shall be performed in accordance with figure 3. The resistors shall be mounted by their normal mounting means in a horizontal position with a dial indicator positioned so that the probe will contact the operating shaft within 0.125 inch (3.18 mm) from the end of the shaft with a 0.5 pound load applied radially near the end of the shaft. Unless corrections are made in the gross force, the force due to pressure and operation of dial gauges shall not exceed 0.34 ounce. The operating shaft shall be rotated through the mechanical travel or 360 degrees, whichever is less. The shaft runout shall be determined from the maximum positive and negative deviations added together without regard to algebraic signs. The dial reading should then be divided by the length of shaft from the mounting surface to the point of dial measurement.

4.7.4 Pilot surface runout (see 3.8 and 6.7). The test shall be performed in accordance with figure 4. The operating shaft shall be clamped in a suitable device, within 0.125 inch (3.18 mm) of the front surface of the potentiometer. The dial indicator is positioned such that its probe contacts the periphery of the pilot surface near the midpoint of the surface. The probe is depressed sufficiently to insure a proper positive and negative indication. Unless corrections are made in the gross force, the force due to pressure and operation of dial gauges shall not exceed 0.34 ounce. A 0.5 pound load is applied normal to the centerline of the shaft axis on the potentiometer body within 0.125 inch (3.18 mm) of the mounting surface. The resistor body shall be rotated through the mechanical travel or 360 degrees, whichever is less. The runout of the pilot surface shall be the maximum positive and negative deviations added together without regard to algebraic signs.

4.7.5 Radial play (see 3.9). This test shall be performed in accordance with figure 5. The resistors shall be mounted horizontally by their normal mounting means with a dial indicator positioned so that the probe will contact the operating shaft within 0.125 inch (3.18 mm) of the front surface of the potentiometer. Unless corrections are made in the gross force, the force due to pressure and operation of dial gauges shall not exceed 0.34 ounce. A 0.5 pound load shall be applied radially to the operating shaft 0.5 inch (12.7 mm) from the mounting surface in two opposite directions, one at a time, first in the vertical plane and then in the horizontal plane. The radial play shall be the maximum positive and negative deviations added together without regard to algebraic signs.

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4.7.6 End play (see 3.10). This test shall be performed in accordance with figure 6. The dial gauge is positioned with its probe parallel (or normal if pointer indicator is used) to the axis of the shaft and in contact with the end of the shaft on the centerline. The probe is depressed sufficiently to insure a proper positive and negative indication. Unless corrections are made in the gross force, the force due to pressure and operation of dial gauges shall not exceed 0.34 ounce. A 0.5 pound load is applied alternately in opposite directions along the axis of the shaft. The shaft end play is the total indicated reading determined by adding the maximum positive and negative readings without regard to algebraic signs.

4.7.7 Mechanical travel (applicable to resistors with stops) (see 3.11). Resistors shall be placed in a suitable angle indicating device, and the operating shaft shall be rotated from one stop to the other and held against the stops with a torque of approximately 1 ounce-inch. The mechanical travel shall be determined from the number of degrees traversed between stops.

4.7.8 Torque (see 3.12).

4.7.8.1 Starting (see 3.12.1). The maximum torque to rotate the contact arm on the resistance element shall be determined throughout the entire range of electrical continuity travel by the torque wrench method or by any other method acceptable to the Government.

4.7.8.2 Running (see 3.12.1.2). The maximum torque required to sustain rotation (at 4 rpm) of the contact arm on the resistance element shall be determined throughout the entire range of electrical continuity travel by the torque wrench method or by any other method acceptable to the Government.

4.7.8.3 Stop (when applicable) (see 3.12.3). Resistors shall be mounted on a metal panel by their normal mounting means. The total mechanical travel shall be measured. The contact arm shall then be rotated to each extreme limit of mechanical travel, and a specified static torque (see 3.1) shall be applied through the operating shaft to the stops. The total mechanical travel shall again be measured, and the contact arm and stop shall be examined for damage.

4.7.9 DC resistance (see 3.15). Resistors shall be tested in accordance with method 303 of MIL-STD-202. The following details shall apply:

- a. Measuring apparatus: Different types of measuring test equipment (multimeters, bridges, or equivalent) are permitted to be used on the initial and final readings of this test, provided the equipment is the same style, model, or it can be shown that the performance of the equipment is equivalent to or better.
- b. Test voltage for bridges: See table XI.

TABLE XI. DC resistance test voltages.

Total resistance, nominal Ohms	Maximum test voltage across the resistor ^{1/} Volts
10 and less	0.3
Over 10 to 100 incl	1.0
Over 100 to 1,000 incl	3.0
Over 1,000 to 10,000 incl	10.0
Over 10,000 to 0.1 megohm	30.0
Over 0.1 megohm	100.0

^{1/} The voltage used for the initial test shall be used for all subsequent tests.

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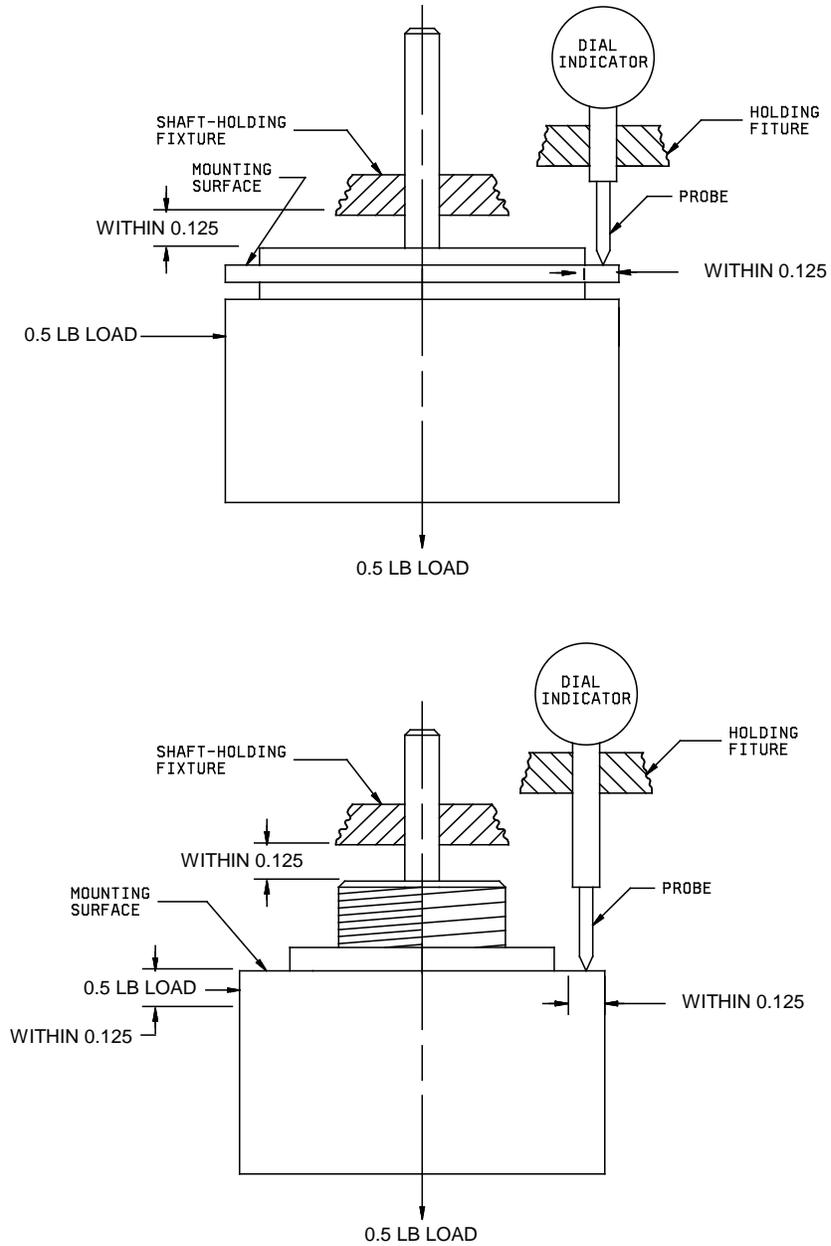


FIGURE 2. Measurement of lateral runout.

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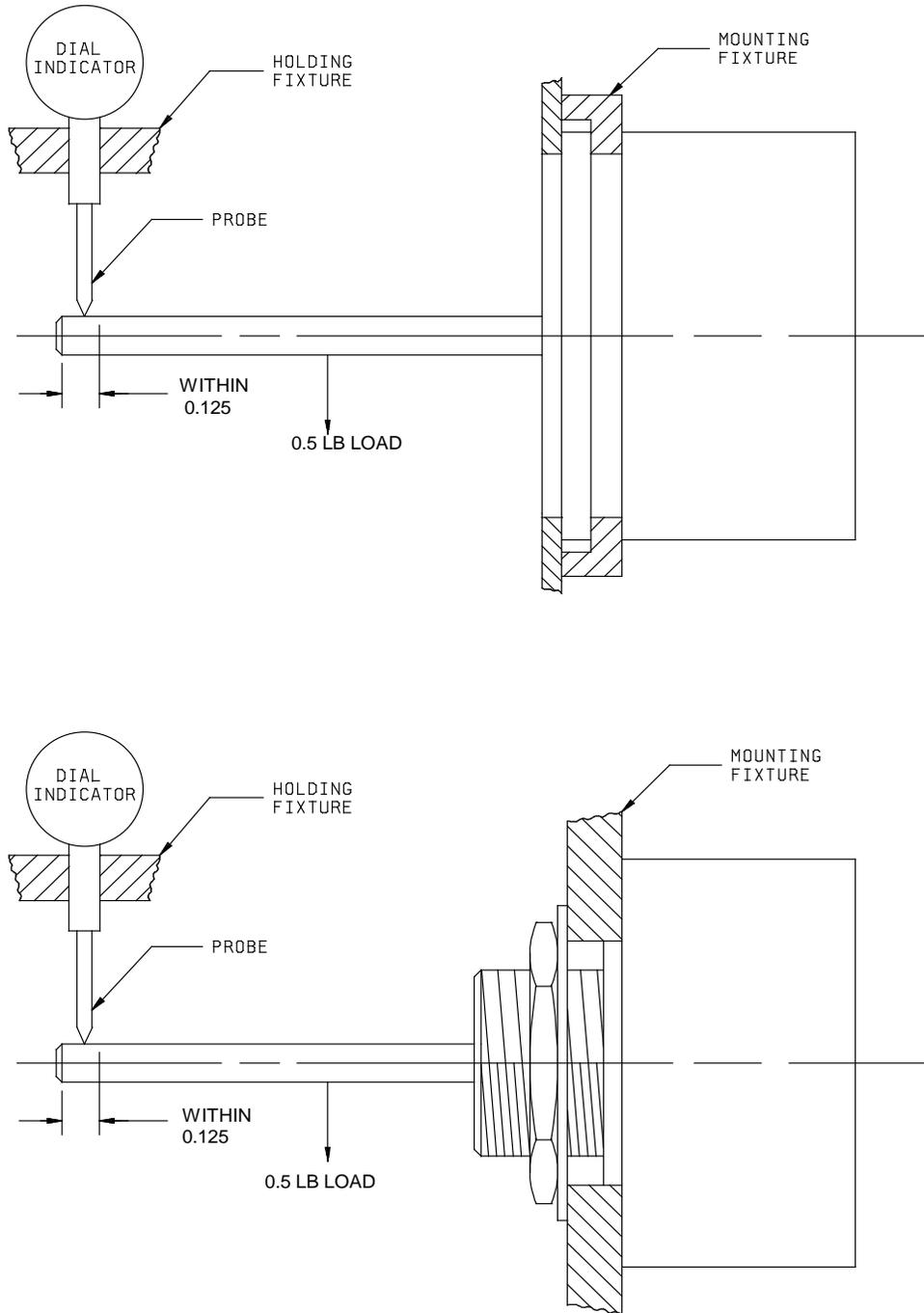


FIGURE 3. Measurement of shaft runout.

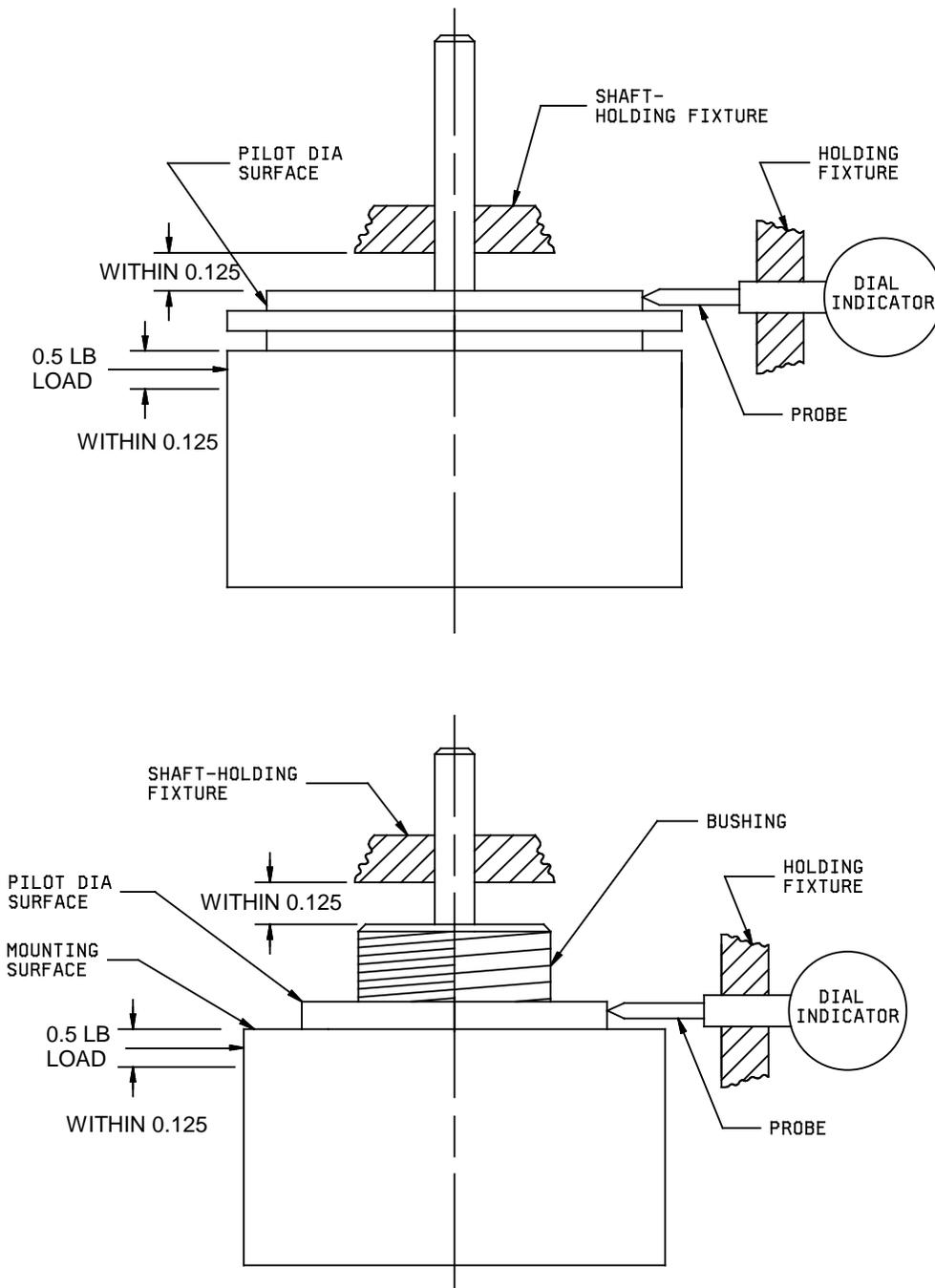


FIGURE 4. Measurement of pilot surface runout.

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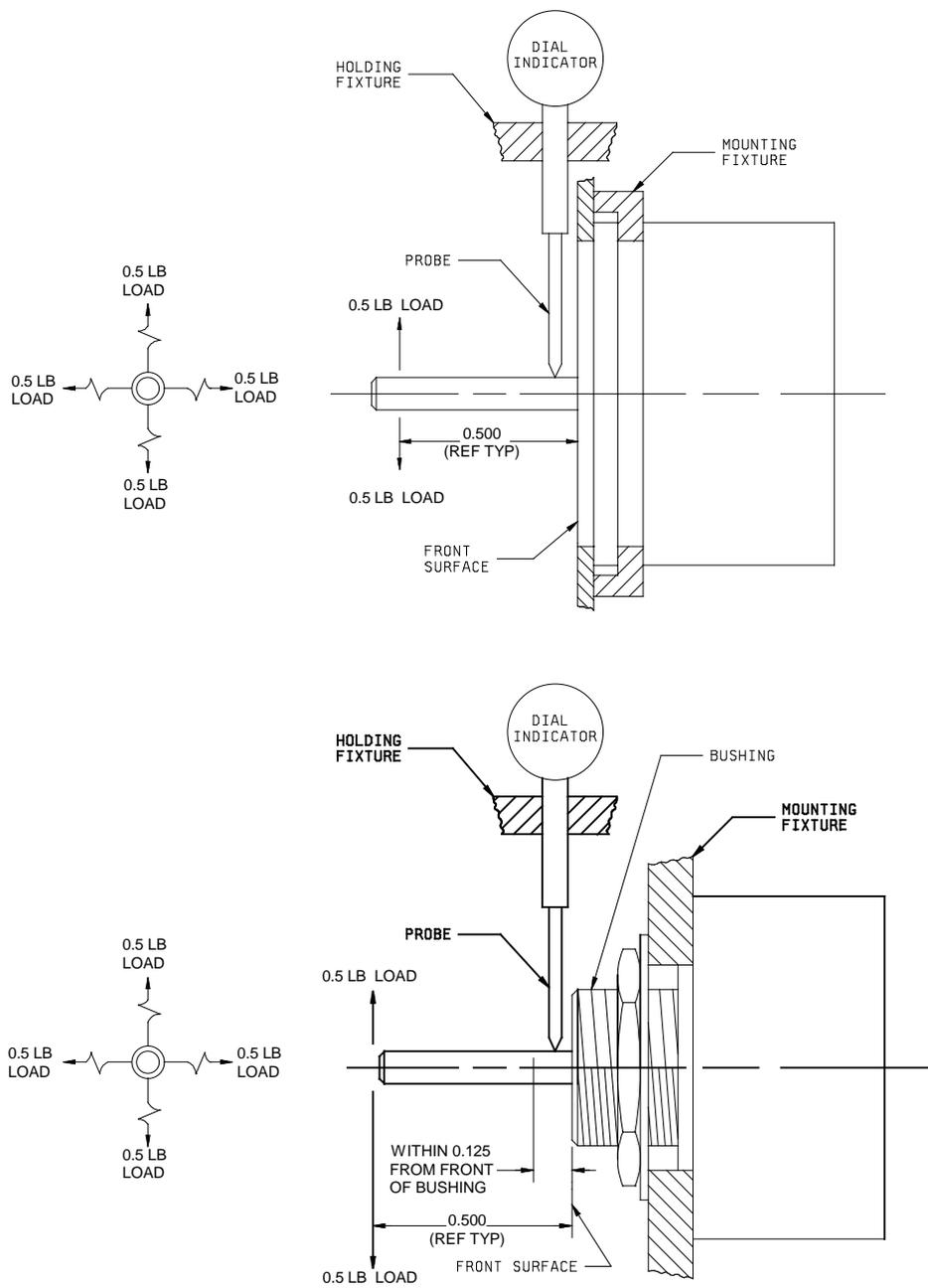


FIGURE 5. Measurement of radial play.

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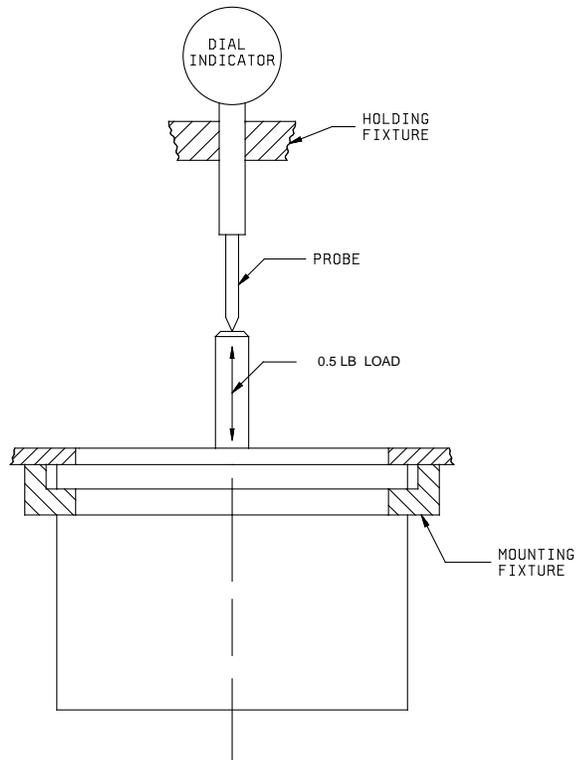


FIGURE 6. Measurement of end play.

4.7.9.1 Total resistance (see 3.15.1). Total resistance shall be measured as specified in 4.7.9. Before each measurement of total resistance, the operating shaft may be rotated through ten 360 degree rotations or ten times through the mechanical travel, whichever is less. Total resistance shall be measured between the resistance element end terminals, with the contact arm positioned off the effective winding or against a stop, when applicable. The positioning of the contact arm and terminal shall be the same for all subsequent measurements of the total resistance on the same specimen.

4.7.9.2 Absolute minimum resistance (see 3.15.2). Absolute minimum resistance shall be measured as specified in 4.7.9. The contact arm shall be positioned at one end of the resistance element so that a minimum value of resistance is measured between the contact arm and the corresponding end terminal. The same procedure shall be followed for the other end of the resistance element. Rated current through the resistance winding shall not be exceeded during this measurement.

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4.7.10 End voltage (see 3.16). Resistors shall be connected in a circuit similar to that shown on figure 7. The contact arm shall be so positioned at the counterclockwise limit so that minimum voltage exists between it and the corresponding end terminal. The voltage shall be measured between the counterclockwise terminal and the contact arm terminal. The contact arm shall then be positioned at the clockwise limit of actual electrical travel. With the contact arm in this position, the voltage between the right terminal and the contact arm terminal shall be measured.

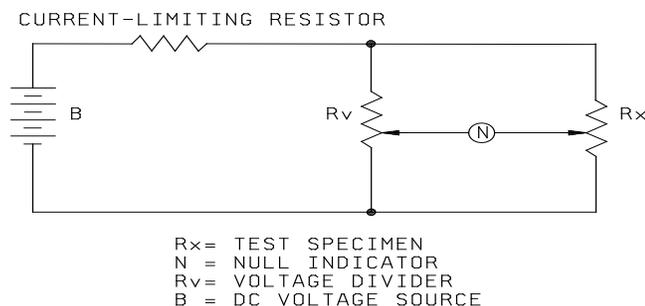


FIGURE 7. Measurement of mechanical backlash.

4.7.11 Taps (when applicable) (see 3.17). Resistors shall be mounted in a suitable angle indicating device. A suitable resistance-indicating device shall be connected between the contact arm terminal and each of the remaining terminals in turn. Angular location of each of the resistance element connections shall be measured with respect to the end terminal from which an increase in resistance is indicated as the operating shaft is rotated in a clockwise direction when viewed from the mounting surface. A tap is indicated by a minimum resistance reading between the contact arm terminal and another terminal. If a tap extends over an appreciable area, the location of the tap shall be considered as being at the midpoint of the tap. During this test, precaution shall be taken to insure that the maximum current of the resistance element is not exceeded.

4.7.12 Insulation resistance (see 3.18). Resistors shall be tested in accordance with [method 302](#) of [MIL-STD-202](#). The following details shall apply:

- a. Test condition B.
- b. Mounting: For qualification inspection, the resistors shall be mounted on metal plates of sufficient size to extend beyond the resistor extremities. For all other testing, the use of the metal plate is optional. The metal plates and the shaft shall make electrical contact with each other. The terminals of each section shall be tied together.
- c. Points of measurements: For single section resistors; between the terminals connected and the shaft; for multisection resistors, between the terminals of adjacent sections and between the terminals of each section and the shaft.

4.7.13 Dielectric withstanding voltage (see 3.19).

4.7.13.1 At atmospheric pressure. Resistors shall be tested in accordance with [method 301](#) of [MIL-STD-202](#). The following details and exceptions shall apply:

- a. Mounting: As specified in [4.7.12b](#).
- b. Magnitude of test voltage: 750 volts root mean square (rms) for resistors of 1.125 inches (28.58 mm) diameter and smaller; 1,000 volts rms for resistors having diameters larger than 1.125 inches (28.58 mm).
- c. Nature of potential: From alternating current (ac) supply at commercial line frequency and waveform. This potential shall be applied for 1 minute.
- d. Points of application of test voltage: As specified in [4.7.12c](#).
- e. Measurement and examination during test: The leakage current shall be measured; resistors shall be examined for evidence of arcing and breakdown.
- f. Examination after test: Resistors shall be examined for evidence of damage.

4.7.13.2 At reduced barometric pressure. Following the test specified in 4.7.13.1, resistors shall be tested in accordance with [method 105](#) of [MIL-STD-202](#). The following details and exception shall apply:

- a. Method of mounting: As specified in [4.7.12b](#).
- b. Test condition C.
- c. Period of time at reduced pressure prior to application of potential: 1 minute.
- d. Tests during subjection to reduced pressure: A potential from an ac supply at commercial line frequency and waveform shall be applied for 1 minute, as follows: 250 volts rms for resistors of 1.125 inches (28.58 mm) diameter and smaller; 350 volts rms for resistors having diameters larger than 1.125 inches (28.58 mm).
- e. Point of application: As specified in [4.7.12c](#).
- f. Measurement and examination during test: As specified in [4.7.13.1e](#).
- g. Examination after test: As specified in [4.7.13.1f](#).

4.7.14 Function conformity tolerance (see 3.20). Conformity measurements shall be performed at intervals of not more than 2.5 percent of the actual electrical travel or 45 degrees, whichever is less. Unless otherwise specified (see 6.1), the resistor shall be tested without load. Measurements shall be performed by using a dc potential of low enough value to insure that its application for the time necessary to obtain readings does not appreciably affect the measured values. For linear functions the method employed for the measurement of conformity shall be such that the combined inherent errors of the measuring instruments shall not exceed the values specified in [table XII](#). For nonlinear functions, the combined inherent errors of the measuring instruments shall not exceed the values specified (see 6.1). When ganged units are submitted, conformity measurements shall be performed on each individual cup of the gang, indexed against the front cup, and each cup of the gang shall be required to be within its tolerance.

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TABLE XII. Conformity.

Function tolerance (linear) <u>1/</u> <u>Percent</u>	Required accuracy of measurement <u>Percent</u>
1.0	0.100
0.5	0.050
0.25	0.025
0.10	0.010
0.05	0.005
0.025	0.0025

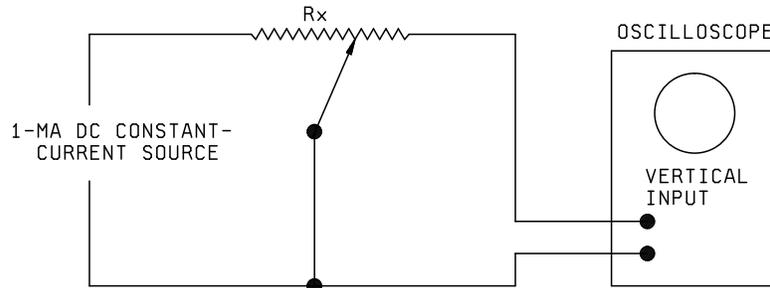
1/ These tolerances shall be considered standard values.

4.7.15 Peak noise (see 3.21). Unless otherwise specified (see 3.1), the operating shaft may be rotated 10 cycles. Peak-noise resistance shall then be measured with the measuring circuit shown on figure 8, or its equivalent. During this test, the operating shaft shall be rotated in both directions at an angular rate of 4 revolutions ± 1 revolutions per minute (rpm). The equivalent resistance shall be calculated using the following formula:

$$\text{Noise} = \frac{E_{pn}}{0.001}$$

Where:

E_{pn} = the peak noise signal voltage presented on the oscilloscope screen.



R_x - TEST SPECIMEN
OSCILLOSCOPE BANDWIDTH - DC TO 50 KILOCYCLES
MINIMUM INPUT IMPEDANCE - 1.0 MEGOHM AT 400 CYCLES

FIGURE 8. Peak noise measuring circuit.

4.7.16 Mechanical backlash (see 3.22). Resistors shall be mounted in a suitable angle indicating device, and the operating shaft shall be rotated to approximately 40 percent to 60 percent of actual electrical travel (not in tap area). For nonlinear functions the shaft shall be rotated to the area of the best resolution. Resistor shall then be connected in a circuit similar to that shown on figure 7. The voltage divider shall be adjusted to obtain zero indication on the null indicator. The operating shaft shall be rotated in clockwise direction to 10 percent to 20 percent of actual electrical travel and shall then be rotated in a counterclockwise direction until the null indicator first reads zero. The angular position of the operating shaft shall be noted. The operating shaft shall be rotated in a counterclockwise direction to 10 percent to 20 percent of actual electrical travel. The operating shaft shall now be rotated in a clockwise direction until the null indicator again reads zero, and shall be continued in the same direction until a perceptible change in the null reading occurs. The angular position of the operating shaft shall again be noted. The angular difference between the two operating shaft positions shall be the backlash.

4.7.17 Terminal strength (see 3.23). Unless otherwise specified (see 6.1), each terminal shall be subjected to a gradual pull until it reaches 2 pounds, applied radially and tangentially, and maintained at its maximum value for 30 seconds \pm 2 seconds. Resistors shall then be examined for evidence of mechanical damage.

4.7.18 Thermal shock (see 3.24). Resistors shall be tested in accordance with method 107 of MIL-STD-202. The following details and exceptions shall apply:

- a. Special mounting: Resistors shall be mounted by their normal means in such a manner that there is at least 1.00 inch (25.4 mm) of free air space around each resistor. The mounting shall be so positioned with respect to the air stream that it offers the least obstruction of the flow of air across and around the resistors.
- b. Measurements before cycling: Not applicable.
- c. Test condition: As specified in table XIII.
- d. Number of cycles: 5 minimum.
- e. Measurements after cycling: Total resistance shall be measured as specified in 4.7.9.1 and resistors shall be examined for evidence of mechanical damage.

TABLE XIII. Thermal shock test conditions.

Step	Temperature ($^{\circ}$ C)						Time
	Class						
	2		3				Minutes
1	-65	+0	-5	-65	+0	-5	30
2	25	+10	-5	25	+10	-5	10 to 15
3	125	+3	-0	150	+3	-0	30
4	25	+10	-5	25	+10	-5	10 to 15

4.7.19 Resistance temperature characteristic (see 3.25). Resistors shall be tested in accordance with method 304 of MIL-STD-202. The following details shall apply:

- a. Test temperatures: As specified in table XIV.
- b. Measurements at the end of each period: Total resistance shall be measured as specified in 4.7.9.1, at the temperature maintained during the period.

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TABLE XIV. Resistance temperature characteristic test temperatures.

Sequence	Temperature (°C)	
	Class	
	2	3
1	25 ± 3 <u>1/</u>	25 ± 3 <u>1/</u>
2	0 ± 3	0 ± 3
3	-15 ± 3	-15 ± 3
4	-55 ± 3	-55 ± 3
5	-65 ± 3	-65 ± 3
6	25 ± 3 <u>2/</u>	25 ± 3 <u>2/</u>
7	50 ± 3	50 ± 3
8	75 ± 3	75 ± 3
9	105 ± 3	105 ± 3
10	125 ± 3	125 ± 3
11		150 ± 3

- 1/ This temperature shall be considered the reference temperature for each of the temperatures in sequences 2 to 5 inclusive.
- 2/ This temperature shall be considered the reference temperature for each of the temperatures in sequences 7 to 11 inclusive.

NOTE: At the option of the manufacturer, the reverse sequence of table XIV may be as follows:

1	25 ± 3°C	
2	50 ± 3°C	
3	75 ± 3°C	
4	105 ± 3°C	
5	125 ± 3°C	
6	150 ± 3°C	(class 3 only)
7	25 ± 3°C	
8	0 ± 3°C	
9	-15 ± 3°C	
10	-55 ± 3°C	
11	-65 ± 3°C	

4.7.20 Rotational load life (see 3.26).

4.7.20.1 Rotation.

4.7.20.1.1 Mounting. Resistors shall be securely mounted by their normal mounting means.

4.7.20.1.2 Test conditions. This test shall be conducted within 2°C of the maximum ambient temperature at rated wattage in accordance with the required class (see table II). The chamber dimensions shall be such that they permit a minimum spacing of 6 inches (152.4 mm) between any two adjacent resistors and 4 inches (101.6 mm) between any resistor and the chamber walls. The method of support used to restrain the resistor body from rotating shall be such that it will minimize heat transfer through the support.

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4.7.20.1.3 Procedure. After stability has been attained, total resistance shall be measured as specified in 4.7.9.1, at rated ambient temperature. A dc potential of 100 volts shall be applied across the end terminals of each resistor whose total resistance is 10,000 ohms or more. Resistors with a total resistance of less than 10,000 ohms shall have sufficient dc potential applied to cause 10 milliamperes (mA) ± 1 mA to flow through the entire resistive element. In instances where 100 volts or 10 mA exceed the power rating, the rated voltage shall be used (see 3.14). The resistive contact arm load shall be chosen so that the contact arm current varies from a minimum value to a maximum value of 0.50 mA \pm 0.10 mA. The voltage specified above shall be applied intermittently, one and one-half hours on one-half hour off, for the duration of the test. The operating shaft shall be continuously cycled through not less than 95 percent of actual electrical at a rate of 40 rpm \pm 5 rpm. A cycle shall consist of travel through 95 percent of actual electrical travel and return to the starting point. The minimum number of cycles to be performed for qualification inspection shall be as specified in table IV; for product-for-delivery, as specified in table XV.

4.7.20.2 Load.

4.7.20.2.1 Mounting. Resistors shall be mounted as specified in 4.7.20.1.1.

4.7.20.2.2 Test conditions. Test conditions shall be as specified in 4.7.20.1.2, except the resistors shall be so arranged that the temperature of any one resistor shall not appreciably influence the temperature of any other resistor. The contact arm shall be positioned at approximately 50 percent of actual electrical travel.

4.7.20.2.3 Procedure. Within 24 hours \pm 4 hours after completion of the test specified in 4.7.20.1, resistors shall be subjected to rated dc voltage specified (see 3.14). In no case shall the rated voltage exceed the maximum continuous working voltage specified (see 3.1). This potential shall be applied between end terminals intermittently, one and one-half hours "on" and one-half hour "off", for a total of 900 hours \pm 12 hours. Total resistance shall be measured as specified in 4.7.9.1, in the test chamber at the end of one-half hour "off" periods, after 100 hours \pm 8 hours, 250 hours \pm 12 hours, 500 hours \pm 12 hours, 750 hours \pm 12 hours, and 900 hours \pm 12 hours have elapsed. The resistors shall then be removed from the test chamber and within 24 hours \pm 4 hours after removal, the total resistance shall again be measured as specified in 4.7.9.1. The resistors shall also be examined for evidence of mechanical damage and opening of windings.

TABLE XV. Rotational life cycles.

Characteristic	Rotational life cycles <u>1/ 2/ 3/</u>			
	Single turn	3 turn	5 turn	10 turn
7	25,000	20,000	10,000	5,000
8	50,000	40,000	20,000	10,000
9	100,000	80,000	40,000	20,000

1/ A cycle consists of travel through 95 percent of actual electrical travel and return to starting point.

2/ For product-for delivery inspection only.

3/ Minimum number of cycles required

Total resistance shall be measured as specified in 4.7.9.1, in the test chamber at the end of the test, and after the following intervals:

	Qualification <u>Inspection</u>	Product-for-delivery <u>inspection</u>
Single turn	125,000 cycles	25,000 cycles
3 turn	85,000 cycles	20,000 cycles
5 turn	50,000 cycles	10,000 cycles
10 turn	25,000 cycles	5,000 cycles

4.7.21 Low temperature operation (see 3.27). The contact arm shall be positioned at approximately 50 percent of the actual effective electrical travel. The resistors shall be subjected to a temperature of $-65^{\circ}\text{C} +0^{\circ}\text{C}$, -5°C for a period of 4 hours ± 15 minutes. During this period, and after the resistors have been stabilized for 1 hour ± 15 minutes, the total resistance shall be measured as specified 4.7.9.1, and the rated voltage (see 4.3.2) shall be applied for 45 minutes between the end terminals. In no case shall the rated voltage exceed the maximum continuous working voltage specified (see 3.1). At the end of the 4 hour period, while the resistors are still in the chamber, starting torque and total resistance tests shall be performed as specified in 4.7.8.1 and 4.7.9.1, respectively. The electrical and mechanical connections shall then be examined for damage.

4.7.22 Low temperature exposure (see 3.28). Resistors shall be placed in a cold chamber at room temperature. The temperature shall be decreased to $-65^{\circ}\text{C} +0^{\circ}\text{C}$, -5°C within a minimum period of 3 hours. For product for delivery inspection only, at the option of the supplier, the resistors may be placed in the cold chamber when the chamber is already at the extreme low temperature. Twenty-four hours after the resistors have reached this temperature, the temperature shall be gradually increased to room temperature within a period of not more than 8 hours. The resistors shall be removed from the chamber and maintained at room temperature for a period of approximately 24 hours, after which the total resistance shall be measured as specified in 4.7.9.1, and the resistors examined for evidence of mechanical damage.

4.7.23 High temperature exposure (see 3.29). Resistors shall be exposed at an ambient temperature of $125^{\circ}\text{C} +3^{\circ}\text{C}$, -0°C for class 2, and $150^{\circ}\text{C} +3^{\circ}\text{C}$, -0°C , for class 3, for a period of 1,000 hours ± 12 hours. At least 2 hours after the end of the exposure period, the resistors shall be examined for evidence of mechanical damage, and the total resistance shall be measured as specified in 4.7.9.1 at room ambient temperature.

4.7.24 Shock (specified pulse) (see 3.30). Resistors shall be tested in accordance with method 213 of MIL-STD-202. The following details and exceptions shall apply:

- a. Special mounting means: Resistors shall be mounted by their normal mounting means on an appropriate mounting fixture, with the contact arm set at approximately 50 percent of electrical travel, and the shaft locked (locking device shall prevent rotational movement only and shall not restrict axial movement.) at the start of the test. The mounting fixture shall be constructed in such a manner as to ensure that the mounting supports remain in a static condition with reference to the shock table. Also, resistors shall be mounted in such a manner that the stress applied is in the direction which would be considered most detrimental. The resistor mounting surface shall be considered the front of the resistor, and the terminal block shall be considered the top of the resistor. In one of the directions the resistor contact arm shall be positioned so that the applied stress tends to force it away from the resistance element.
- b. Test condition: I (unless otherwise specified (see 6.2)).
- c. Measurements during shock: Each resistor shall be monitored to determine momentary discontinuity of the element, and between the contact arm and element, by a method which shall at least be sensitive enough to monitor or register automatically any momentary discontinuity having a duration of 0.1 millisecond (ms), or less, as well as those of greater duration.
- d. Examination after shock: Resistors shall be examined for evidence of mechanical and electrical damage.

4.7.25 Vibration, high frequency (see 3.31). Resistors shall be tested in accordance with [method 204](#) of [MIL-STD-202](#). The following details and exceptions shall apply:

- a. Mounting of specimens: Resistors shall be mounted by their normal mounting means on a vibration test jig. The contact arm shall be set at approximately 50 percent of electrical travel, and the operating shaft locked (locking device shall prevent rotational movement only and shall not restrict axial movement). The jig shall be constructed so as to preclude any resonances within the test range. Resistors shall be mounted in relation to the test equipment in such a manner that the stress applied is in the direction which would be considered most detrimental. In one of the directions, the resistor contact arm shall be positioned so that the applied stress tends to force it away from the resistance element.
- b. Test condition B (unless otherwise specified (see 6.2)).
- c. Measurements during vibration: Each resistor shall be monitored to determine momentary discontinuity of the element, and between the contact arm and element, by a method which shall at least be sensitive enough to monitor or register automatically any momentary discontinuity having a duration of 0.1 ms or less, as well as those of greater duration.
- d. Measurement and examinations after vibration: Total resistance between end terminals shall be measured as specified in 4.7.9.1. Resistors shall then be examined for evidence of mechanical and electrical damage.

4.7.26 Salt spray (corrosion) (see 3.32). Resistors shall be tested in accordance with [method 101](#) of [MIL-STD-202](#). The following details shall apply:

- a. Special mounting: On an aluminum panel.
- b. Test condition A.
- c. Examination after test: Resistors shall be thoroughly washed for 1 minute in free running tap water, the temperature of which shall not exceed 38°C. The resistors shall then be placed in an oven maintained at 50°C ±3°C, for a period of 24 hours ±4 hours. At the end of this period, resistors shall be removed from the oven and examined for corrosion.

4.7.27 Moisture resistance (see 3.33). Resistors shall be tested in accordance with [method 106](#) of [MIL-STD-202](#). The following details and exceptions shall apply:

- a. Mounting: Resistors shall be mounted by their normal mounting means on an aluminum panel so that the resistor body shall not contact the floor of the test chamber.
- b. Initial measurements: Total resistance shall be measured as specified in 4.7.9.1.
- c. Loading and polarization voltage: One-half of the specimens shall be subjected to load and remaining half to polarization.
 - (1) Load: During the first 2 hours each steps 1 and 4, rated dc wattage, derated in accordance with [figure 1](#) to the temperature attained at the end of the 2-hour period, shall be applied to each resistor. In no case shall the rated voltage exceed the maximum continuous working voltage specified (see 3.1). The negative terminal shall be grounded to the mounting surface of the panel.
 - (2) Polarization: During steps 2, 3, 5, and 6 inclusive, a 100 volt dc potential shall be applied to the positive side connected to the terminals tied together, and the negative side connected to the operating shaft.
- d. Final measurements at high humidity: The total resistance and insulation resistance shall be measured as specified in 4.7.9.1 and 4.7.12, respectively.

4.7.28 Fungus (see 3.4.1). Resistors shall be tested in accordance with [method 508](#) of [MIL-STD-810](#). Resistors shall be examined for evidence of mechanical damage.

5. PACKAGING.

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activity within the Military Service or Defense Agency, or within the military services system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

6. NOTES

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

6.1 Intended use. The resistors covered by this specification are military unique due to the fact that these devices must be able to operate satisfactorily in military systems under the following demanding conditions: 15 Gs of high frequency vibration, 100 Gs of shock (specified pulse), 25,000 cycles of endurance at the maximum temperature, thermal shock (with no more than 5 percent deviation in initial resistance), low temperature coefficient of resistance, and resistant to salt corrosion. In addition, these military requirements are verified under a qualification system. Commercial components are not designed to withstand these military environmental conditions.

6.2 Acquisition requirements. Acquisition documents must specify the following.

6.2.1 Category I resistors (resistors covered by this specification (see 3.2.1)).

- a. Title, number, date of this specification, the applicable associated specification sheet, and the complete PIN.
- b. Unless otherwise specified (see 2.1), the versions of the individual documents referenced will be those in effect on the date of release of the solicitation.
- c. Packaging requirements (see 5.1).

6.2.2 Category II resistors (see 3.2.2).

- a. Title, number, date of this specification, the applicable associated specification sheet for similar category I resistor, and the complete PIN for category II item.
- b. Unless otherwise specified (see 2.1), the versions of the individual documents referenced will be those in effect on the date of release of the solicitation.
- c. Packaging requirements (see 5.1).
- d. Manufacturer's part number of category II items.
- e. Variations within limits specified in 4.5.3 from category I resistor requirements as specified in the associated specification sheet.
- f. Inspections, if any, to verify specified variations from category I resistor (see 4.4.2). Acquisition of resistors will be limited to sources whose family of products is listed on the QPL for MIL-PRF-12934.
 - (1) Tests to be performed, requirements, and acceptance criteria.
 - (2) The laboratory at which inspection is to be performed.
 - (3) Sample size (three are recommended).
 - (4) Submission of samples and data, if other than specified.

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- g. Conformance inspection should consist of groups A and B inspection and any other requirement if other than specified herein.
- h. Acquisition document will specify the applicable requirements and include a dimensional drawing as indicated in 6.2.3. In addition, the document should state that the unit is a category II item of MIL-PRF-12934. Acquisition of resistors will be limited to sources whose family of products is listed on the QPL for [MIL-PRF-12934](#).

6.2.3 Category III resistors (see [3.2.3](#)). For resistors not covered by an associated specification sheet, the following should be specified.

- a. Title, number, date of this specification, the applicable associated specification sheet for similar category I item, and the complete PIN.
- b. Unless otherwise specified (see [2.1](#)), the versions of the individual documents referenced will be those in effect on the date of release of the solicitation.
- c. Packaging requirements (see [5.1](#)).
- d. Applicable dimensions and information for drawings as specified on [figure 9](#).
- e. Requirement specifying that the resistor will meet all requirements of this specification with exception of any variations or deviations required in the application specified on the acquisition document.
- f. Inspection required to verify conformance of resistor with specified requirements.
 - (1) Tests to be performed, requirements, and acceptance criteria. Use all tests of [table VII](#) as a minimum.
 - (2) The laboratory at which inspection is to be performed.
 - (3) Sample size.
 - (4) Submission of samples and data if other than specified.
- g. For multisection resistors, the number of sections.
- h. Phasing (see [3.5.5](#)).
- i. Total resistance _____ ohms (see [3.15.1](#)).
- j. Absolute minimum resistance (see [3.15.2](#)).
- k. Resistance tolerance \pm _____ percent (see [table V](#)).
- l. Class (see [1.2.1.3](#)).
- m. Resolution _____ percent or _____ degree.
- n. Resistance temperature characteristic \pm _____ percent/^oC (see [3.25](#)).
- o. Theoretical function, function formula, or point by point information, as applicable.
- p. Type of function conformity, and conformity tolerance for linear conformity (see [table XII](#)) for linear conformity accuracy of measurements) (see [3.20.1](#) and [3.20.2](#)).
- q. Conformity tolerance and accuracy of measurements for nonlinearity conformity (see [3.20.1](#), [3.20.2](#), and [4.7.14](#)).
- r. Maximum continuous working voltage ac or dc _____ volts. Frequency _____.
- s. Voltage breakdown: ac or dc _____ volts.
- t. Wattage: _____ watts (see [3.1](#)).

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- u. Taps:
 - (1) Number and location (see 3.17).
 - (2) Width.
 - (3) Tolerance.
- v. Mechanical backlash: _____ degrees (see 3.22).
- w. Peak noise: _____ ohms (see 3.21.1 and 3.21.2).
- x. Thermal shock (change in resistance): _____ percent (see 3.24).
- y. Rotational life change (change in resistance): _____ percent (see 3.26).
- z. Mechanical travel: 360 degrees continuous or stops at _____ degrees or \pm _____ degrees (see 3.11).
- aa. Number of turns.
- ab. Maximum starting torque: _____ ounce-inches (see 3.12.1.1).
- ac. Maximum running torque: _____ ounce-inches (see 3.12.1.2).
- ad. Weight.
- ae. End voltage _____ (see 3.16).
- af. Terminal strength pull (see 4.7.17).
- ag. End play _____ (see 3.10).
- ah. Bearing information.
- ai. Shaft style, length, and diameter (see 3.1, 3.5.1.1, and 3.5.1.2).
- aj. Terminals: Number and location (see 3.5.6).
- ak. Actual electrical travel: 350 degrees \pm 2 degrees (see 3.20.1).
- al. Electrical overtravel: _____ degrees, if applicable.
- am. Wiper load value and linearity compensating shunt resistors value _____.
- an. Integral resistor limitation, if any.
- ao. Application: Used as voltage divider _____. Rheostat _____.
- ap. AC applications, if any _____.
- aq. Levels of preservation and packaging and packing, and applicable marking.
- ar. Any other requirement applicable that is not listed above.

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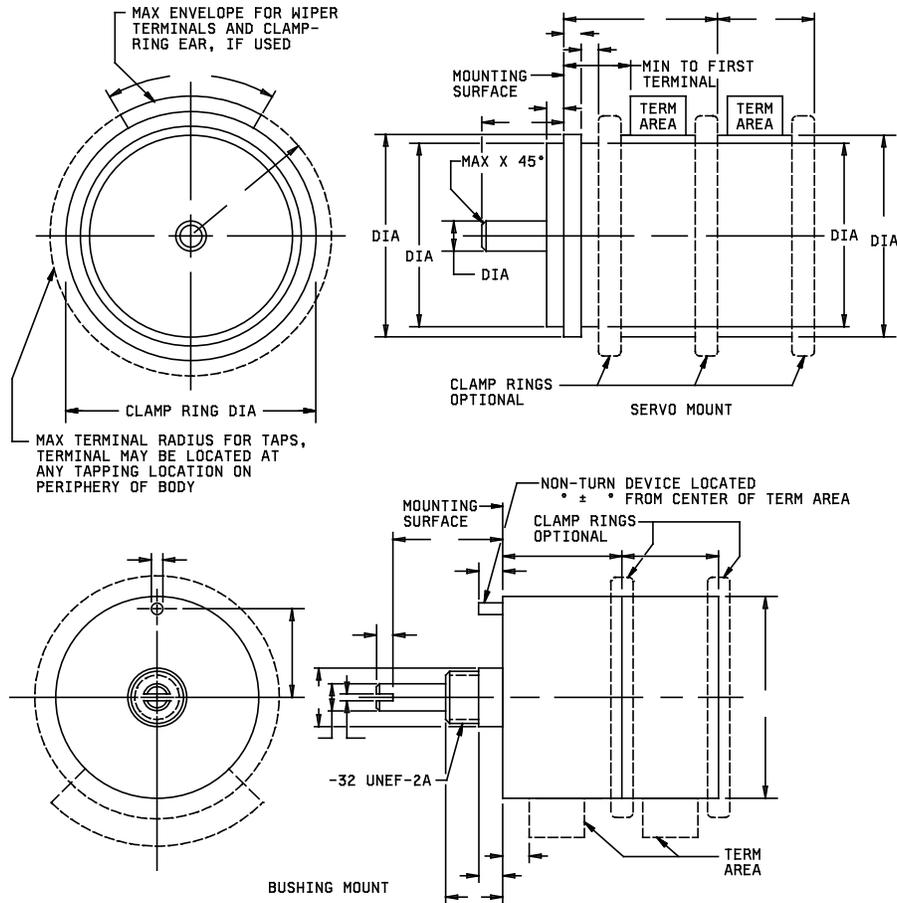


FIGURE 9. Dimensions and drawing information

6.3 Qualification. Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in Qualified Product List 12934 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity responsible for the QPL and, information pertaining to qualification of products may be obtained from the DLA Land and Maritime, ATTN: VQP, Post Office Box 3990, Columbus, OH 43218-3990. An online listing of products qualified to this specification may be found in the Qualified Products Database (QPD) at <https://assist.dla.mil> or <http://www.landandmaritime.dla.mil/Programs/QmlQpl/>.

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6.4 Derating. If it is desired to operate resistors at ambient temperatures greater than 70°C for class 2, and 85°C for class 3, the resistors should be derated in accordance with figure 10.

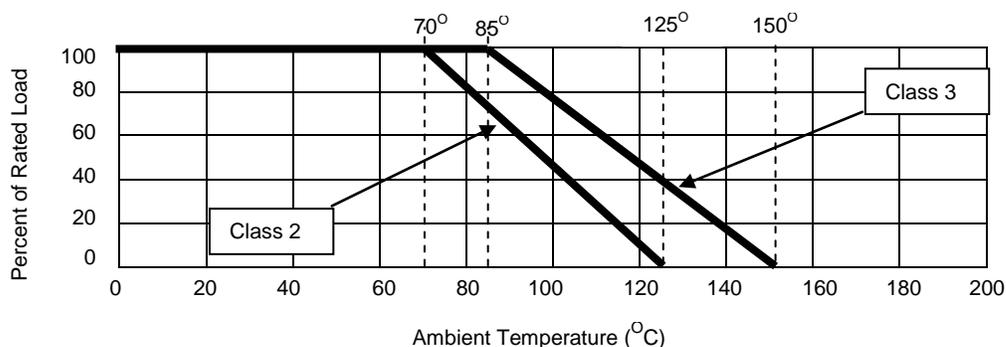


FIGURE 10. Derating-curves for high ambient temperatures.

6.5 Resistance tolerance. Resistance tolerances are available in ± 1 percent, ± 2 percent, ± 3 percent, and ± 5 percent; however ± 1 percent and ± 3 percent are preferred.

6.6 Voltage rating. The formula specified in 3.14 is correct only when voltage is applied to the fixed end terminals, with the contact arm and taps open circuited. When current is drawn from the contact arm or taps, power dissipation is not uniform along the resistance element.

6.7 Shaft runout and pilot surface runout. The 0.5 pound load should not be applied to the operating shaft at a distance of more than 3.5 inches (88.9 mm) from the bearing of resistors with 0.125 inch (3.18 mm) diameter operating shafts.

6.8 Definitions.

6.8.1 Precision potentiometer. A precision potentiometer is a mechanical electrical transducer dependent upon the relative position of a moving contact (wiper) and a resistance element for its operation. It delivers a voltage output that is some specified function of applied voltage and shaft position, to a high degree of accuracy.

6.8.2 Cup. A cup is a single mechanical section of a potentiometer which may contain one or more electrical resistance elements.

6.8.3 Gang. A gang is an assembly of two or more cups on a common operating shaft.

6.8.4 Shaft. The shaft is the mechanical input element of the potentiometer.

6.8.5 Shaft position. The shaft position is an indication of the relative position of the wiper to a reference point.

6.8.6 Terminal. The terminal is an external device used to provide electrical access to the potentiometer resistance element.

6.8.7 Integral resistor. The integral resistor is an external resistor preconnected to the electrical element and forming an integral part of the cup assembly to provide a desired electrical characteristic.

6.8.8 Test point. The test point is an additional terminal used only to facilitate measurements.

6.8.9 Input and output terms.

6.8.9.1 Total applied voltage. The total applied voltage is the voltage applied between input terminals.

6.8.9.2 Total variable output. The total variable output is the difference between the maximum and minimum output ratios (see figure 11).

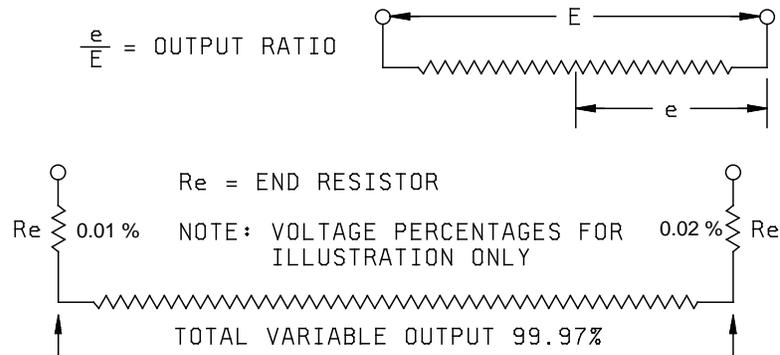


FIGURE 11. Total variable output.

6.8.9.3 Output ratio. The output ratio is the ratio of the output (e) to the total applied voltage (E).

6.8.9.4 Loading error. The loading error is the difference between the actual output ratios at a specified shaft position with some specified wiper load in place of an infinite wiper load (see figure 12).

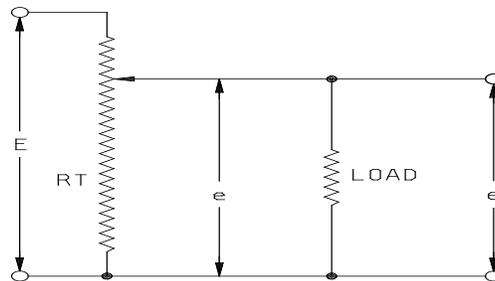


FIGURE 12. Loading error.

6.8.10 Resistance terms.

6.8.10.1 Total resistance. The total resistance is the dc resistance between the input terminals with the shaft positioned so as to give a maximum resistance value.

6.8.10.2 Minimum resistance. The minimum resistance is the resistance measured between the wiper terminal and any terminal with the shaft positioned to give a minimum value.

6.8.10.3 End resistance. The end resistance is measured between the wiper terminal and an end terminal with the shaft positioned at the end corresponding end point.

6.8.10.4 Temperature coefficient of resistance. The temperature coefficient of resistance is the unit change in resistance per degree centigrade change from a reference temperature and expressed in parts per million per degree centigrade as follows:

$$TC = \frac{R_2 - R_1}{R_1(T_2 - T_1)} \times 10^6$$

Where:

R_1 = Resistance at reference temperature in ohms.

R_2 = Resistance at test temperature in ohms

T_1 = Reference temperature in degrees centigrade ($^{\circ}C$)

T_2 = Test temperature in degrees centigrade ($^{\circ}C$)

6.8.11 Conformity and linearity.

6.8.11.1 Functional characteristic. The functional characteristic is the relationship between the output ratios and the shaft position.

6.8.11.2 Conformity. Conformity is the fidelity of the relationship between the actual function characteristic and the theoretical function characteristic (see figure 13).

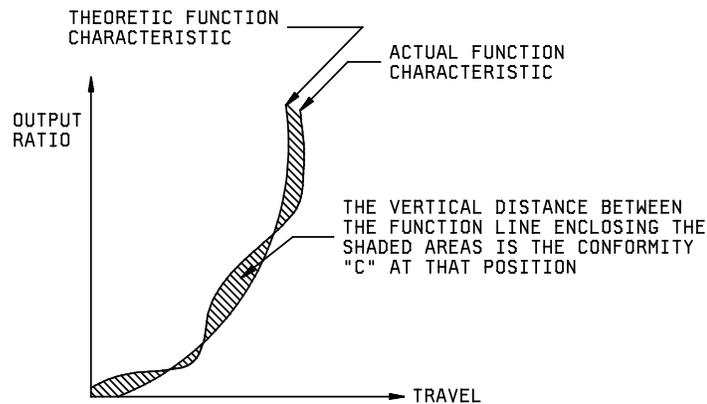


FIGURE 13. Conformity.

6.8.11.3 Absolute conformity. Absolute conformity is the maximum deviation expressed as a percent of the total applied voltage, of the actual function characteristic from a theoretical function characteristic extending between the specified output ratios which are separated by the theoretical electrical travel. An index point on the actual output is required (see figure 14).

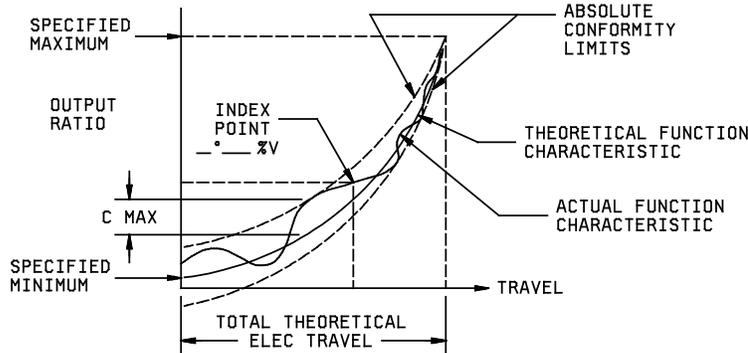


FIGURE 14. Absolute conformity.

NOTE: The theoretical function characteristic is assumed to be a smooth curve when it can be described by a mathematical expression. When empirical data are provided, the points are assumed to be joined by straight line segments.

6.8.11.4 Linearity. Linearity is a specific type of conformity where the theoretical function characteristic is a straight line (see figure 15).

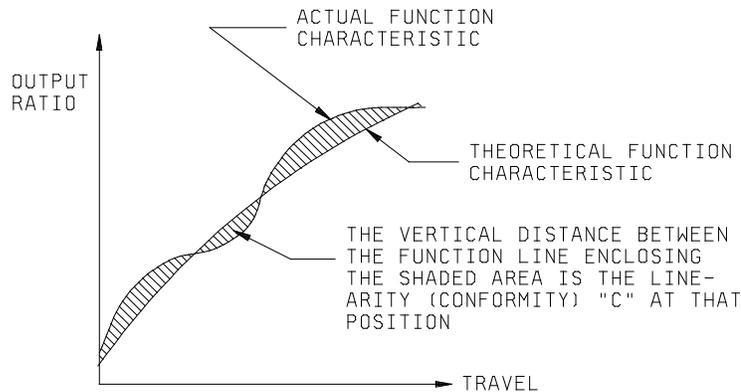


FIGURE 15. Linearity.

6.8.11.5 Absolute linearity. Absolute linearity is the maximum deviation expressed as a percent of the total applied voltage, of the actual functional characteristic from a straight reference line drawn through the specified minimum and maximum output ratios which are separated by the theoretical electrical travel. Unless otherwise specified, minimum and maximum are respectively zero and 100 percent total applied voltage. An index point on the actual output is required (see figure 16).

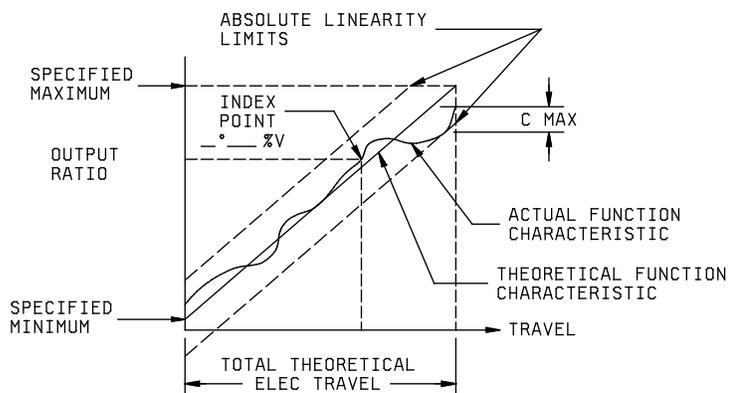


FIGURE 16. Absolute linearity.

6.8.11.6 Terminal based linearity. Terminal based linearity is the maximum deviation, expressed as a percent of the applied voltage, of the actual function characteristic from a straight reference line drawn through its specified minimum and maximum output ratios which are separated by the actual electrical travel. Unless otherwise specified, minimum and maximum output ratios are respectively zero and 100 percent of the total applied voltage (see figure 17).

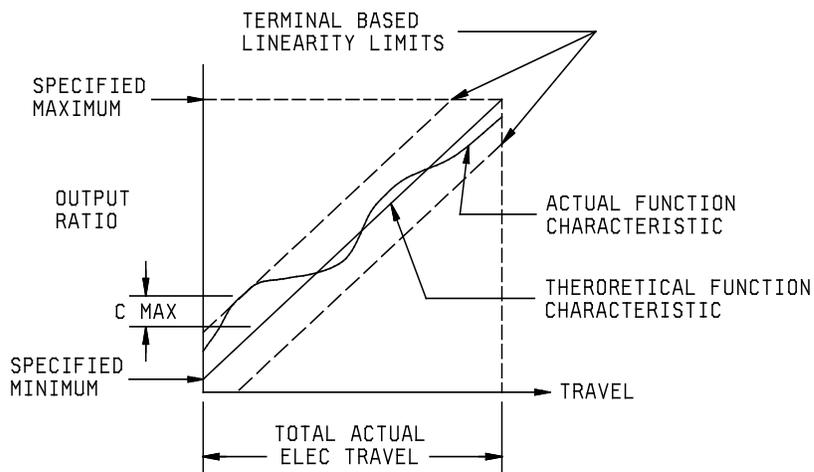


FIGURE 17. Terminal based linearity.

6.8.11.7 Zero based linearity. Zero based linearity is the maximum deviation expressed as a percentage of the total applied voltage of the actual function characteristic from a straight reference line drawn through the specified minimum output ratio, extended over the actual electrical travel and rotated to minimize the maximum deviations. Any specified end voltage requirements limits the rotation of the reference line. Unless otherwise specified, the specified minimum output will be zero (see figure 18).

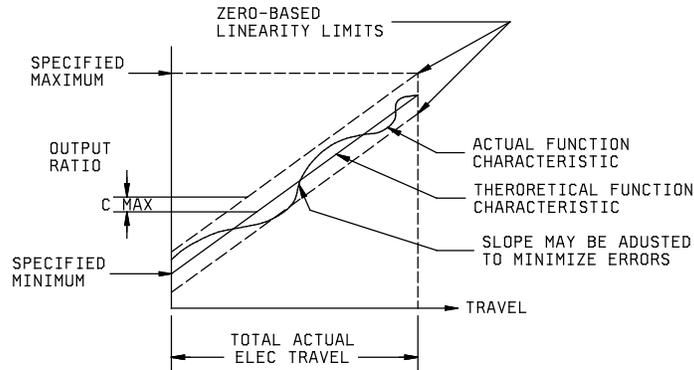


FIGURE 18. Zero based linearity.

6.8.11.8 Independent linearity (best straight line). The independent linearity is the maximum deviation, expressed as a percent of the total applied voltage, of the actual function characteristic from a straight reference line with its scope and position chosen to minimize deviations over the actual electrical travel, or any specified portion thereof. (End voltage requirements, when specified, will limit the scope and position of the reference line. (See figure 19.))

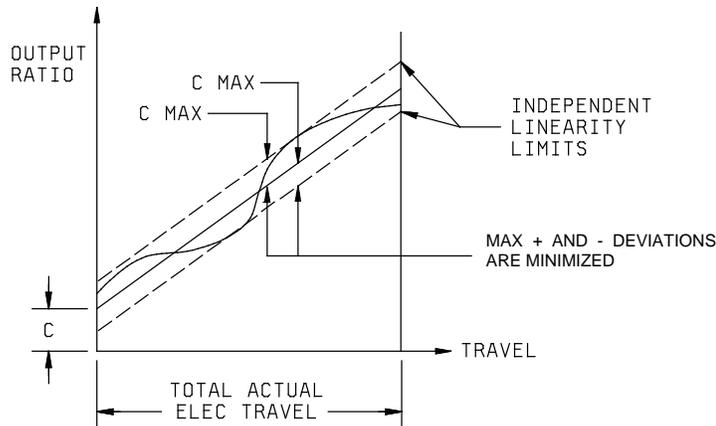


FIGURE 19. Independent linearity.

6.8.12 Tolerance limits; alternate methods.

6.8.12.1 Constant limits. The constant limits are taken as a percentage of the total applied voltage.

6.8.12.2 Proportional limits. The proportional limits are taken as a percentage of the theoretical output voltage ratio.

6.8.12.3 Modified proportional limits. Modified proportional limits are a combination of constant limits and proportional limits. (Proportional limits may become impossibly restrictive in the vicinity of zero output, and should be modified in such cases to provide a practical tolerance in that region.) (See figure 20.)

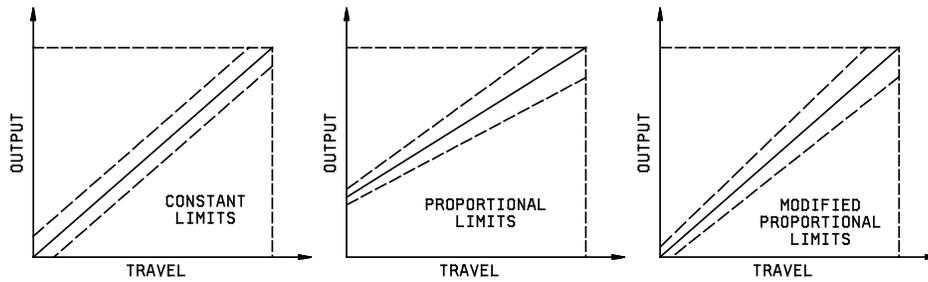


FIGURE 20. Modified proportional limits.

6.8.13 Indexing, phasing, and tracking.

6.8.13.1 Index point. The index point is a point of reference fixing the relationship between a specified shaft position and output ratio. It is used to establish a shaft position reference (see figure 21).

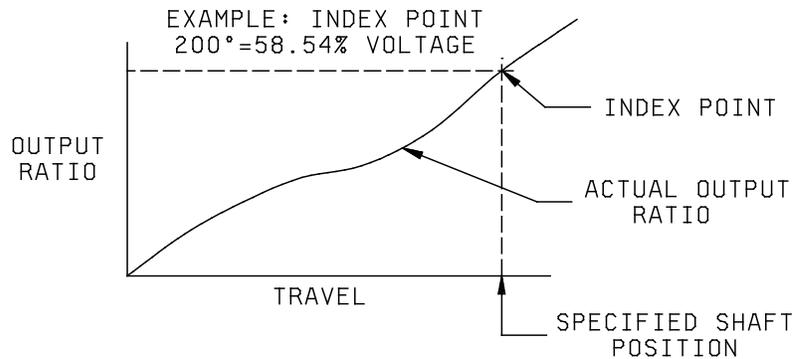


FIGURE 21. Index point.

6.8.13.2 Phasing point. The phasing point is a point of reference on each electrical element used to describe the relative alignment of the cups and for electrical elements of a gang with respect to the portion of the wipers on their relative electrical elements.

6.8.13.3 Phasing. Phasing is the relative alignment of the cups and for electrical elements of a gang with respect to the position of the wipers on their respective electrical elements (see figure 22).

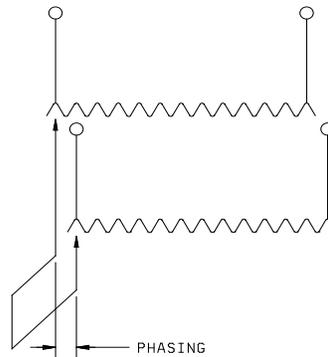


FIGURE 22. Phasing.

6.8.13.4 Simultaneous conformity phasing. Simultaneous conformity phasing is the alignment of the electrical elements of a gang potentiometer such that the output ratios fall within their respective conformity limits over the theoretical electrical travel, using a common index point. This definition applies only to potentiometers with absolute conformity or absolute linearity functions specification.

6.8.13.5 Voltage tracking error. The voltage tracking error is the difference at any shaft position between the output ratios of any two common actuated similar electrical elements expressed as a percentage of the single total voltage applied to them.

6.8.14 Noise. Noise is any spurious variation in the electrical output not present in the input, defined quantitatively in terms of an equivalent parasitic, transient resistance in ohms, appearing between the contact and the resistance element when the shaft is rotated or translated. The equivalent noise resistance is defined independently of the resolution, the functional characteristics, and the total travel. The magnitude of the equivalent noise resistance is the maximum departure from a specified reference line. The wiper of the potentiometer is required to be excited by a specified current and moved at a specified speed.

6.8.15 Resolution. Resolution is a measurement of the sensitivity to which the output ratios of the potentiometer may be set.

6.8.15.1 Theoretical resolution. Theoretical resolution is used in wirewound linear potentiometers only. It is the reciprocal of the number of turns of wire in resistance winding in the actual electrical travel and is expressed as a percentage.

$$\frac{1}{N} \times 100 = \text{Theoretical resolution percent}$$

Where:

N = Total number of resistance wire turns

6.8.15.2 Travel resolution. Travel resolution is the maximum value of shaft travel in one direction per increased voltage step in any specified portion of the resistance element.

6.8.15.3 Voltage resolution. Voltage resolution is the maximum incremental change in output ratio with shaft travel in one direction in any specified portion in the resistance element (see figure 23).

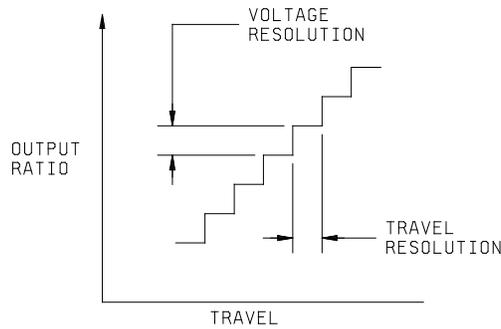


FIGURE 23. Voltage resolution.

6.8.16 End voltage. End voltage is the voltage between the wiper terminal and an end terminal when the shaft is positioned at the corresponding end point. It is usually expressed as a percentage of the total applied voltage.

6.8.16.1 Jumpoff voltage. The jumpoff voltage is the magnitude of the first measurable voltage change as the wiper moves from the overtravel region onto the actual electrical travel region. It is usually expressed as a percentage of the total applied voltage (see figure 24).

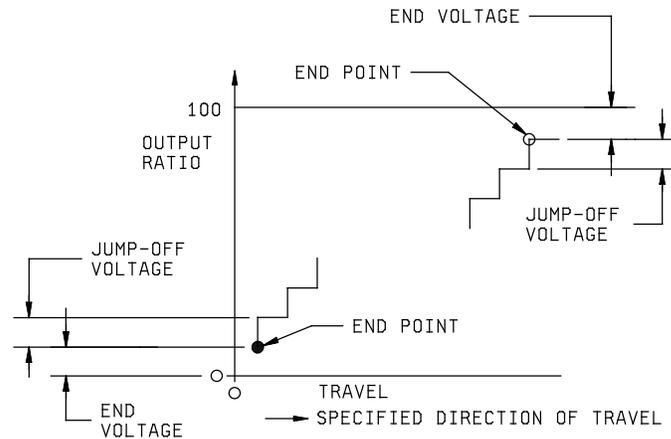
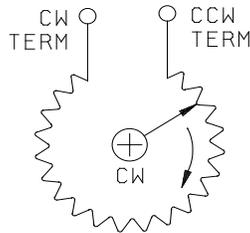


FIGURE 24. Jumpoff voltage.

6.8.17 Rotation.

6.8.17.1 Direction of travel. The shaft travel is defined as clockwise (CW) or counterclockwise (CCW) for rotary potentiometers when viewing the specified mounting end of the potentiometer. The designation of the terminals in the figure corresponds to the direction of the shaft travel, and is shown for reference only (see figure 25).



VIEW OF SHAFT AND ELEMENT FROM
THE SPECIFIED MOUNTING END.

FIGURE 25. Direction of travel.

6.8.17.2 Total mechanical travel. The mechanical travel is the total travel of the shaft between integral stops, under specified stop load. In potentiometers without stops, the mechanical travel is continuous.

6.8.17.3 Electrical continuity travel. Electrical continuity is the total travel of the shaft over which electrical continuity is maintained between the wiper and the resistance element (see figure 26).

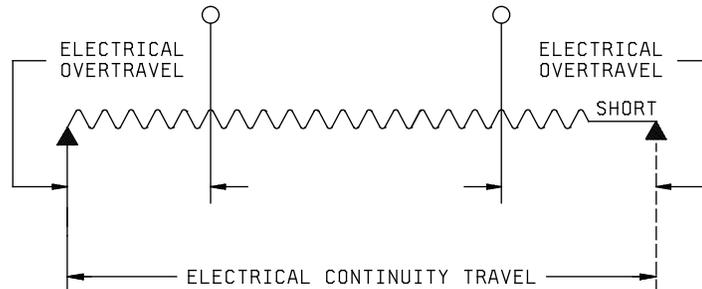


FIGURE 26. Electrical continuity travel.

6.8.17.4 End point. The end point is the shaft position immediately before the first and after the last measurable change(s) in output ratio, after wiper continuity has been established, as the shaft moves in a specified direction.

6.8.17.5 Actual electrical travel. The actual electrical travel is the total travel of the shaft between end stops.

6.8.17.6 Theoretical electrical travel. The theoretical electrical travel is the shaft travel over which the theoretical function characteristic extends as determined from the index point (see figure 27).

6.8.17.7 Electrical overtravel. The electrical overtravel is the shaft travel over which there is continuity between the wiper terminal and the resistance element beyond each end of the actual electrical travel. (In cases where absolute linearity or absolute conformity is specified, theoretical electrical travel should be substituted for actual electrical travel in this definition.)

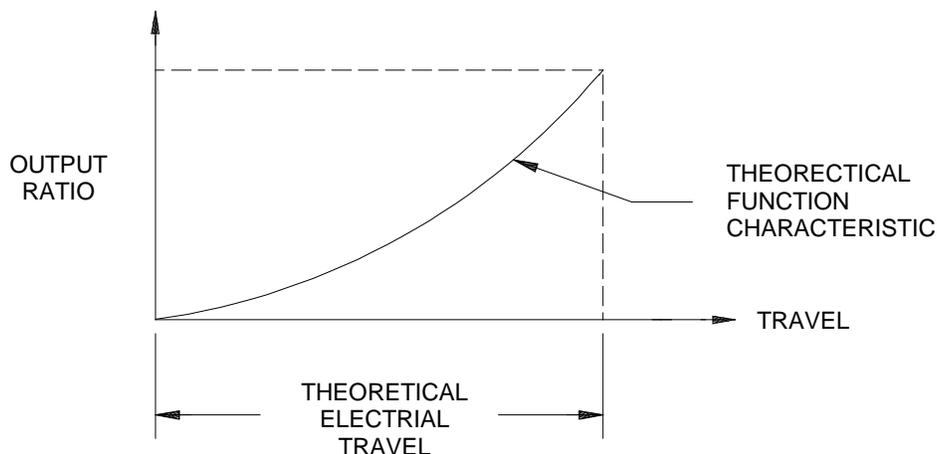


FIGURE 27. Theoretical electrical travel.

6.8.17.8 Mechanical overtravel. The mechanical overtravel is the shaft travel between each end point (or limit of theoretical electrical travel) and its adjacent corresponding limit of total mechanical travel (see figure 28).

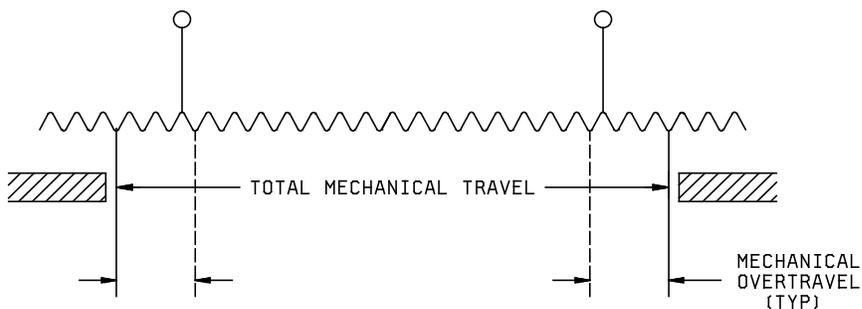


FIGURE 28. Mechanical overtravel.

6.8.18 Taps. A tap is a fixed electrical connection made to the resistance element.

6.8.18.1 Tap location. The tap location is the position of a tap relative to some reference. This is commonly expressed in terms of resistance, voltage ratio, or shaft position. When a shaft position is specified, the tap position is the center of the effective tap width.

6.8.18.2 Effective tap width. The effective tap width is the travel of the shaft, during which the voltage at the wiper terminal and tap terminal are essentially the same, as the wiper is moved past the tap in one direction (see figure 29).

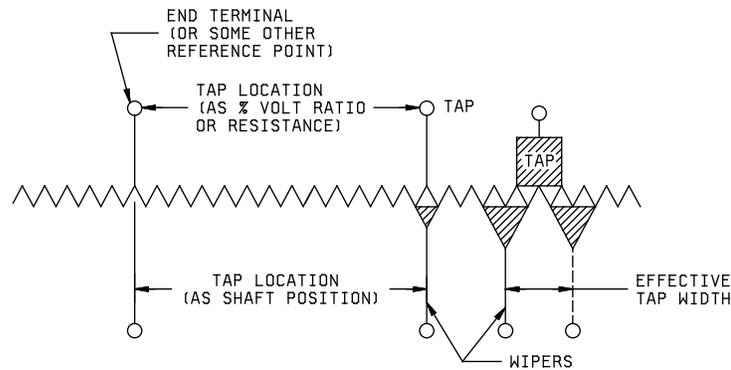


FIGURE 29. Effective tap width.

6.8.19 Shaft runout. The shaft runout is the eccentricity of the shaft diameter with respect to the rotational axis of the shaft, expressed in inches, and measured at a specified distance from the end of the shaft when the body of the potentiometer is held and the shaft rotated while a specified load is applied radially to the shaft.

6.8.20 Lateral runout. The lateral runout is the perpendicularity of the mounting surface with respect to the rotational axis of the shaft, expressed in inches, and measured on the mounting surface at a specified distance from the outside edge of the mounting surface when the shaft is held and the body of the potentiometer is rotated while specified loads are applied radially and axially to the body of the potentiometer.

6.8.21 Pilot diameter runout. The pilot diameter runout is the eccentricity of the pilot diameter with respect to the rotational axis of the shaft, expressed inches, and measures on the pilot diameter when the shaft is held and the body of the potentiometer is rotated while a specified load is applied radially to the body of the potentiometer.

6.8.22 Shaft radial play. The shaft radial play is the total radial excursion of the shaft, expressed in inches, and measured at a specified distance from the front surface of the unit, with a specified radial load applied alternately in opposite directions at a specified point.

6.8.23 Shaft end play. The shaft end play is the total axial excursion of the shaft, expressed in inches, and measured at the end of the shaft with a specified axial load applied alternately in opposite directions.

6.8.24 Starting torque. The starting torque is the maximum moment in the clockwise and counterclockwise directions required to initiate shaft rotation anywhere in the total mechanical travel.

6.8.25 Running torque. The running torque is the maximum moment in the clockwise and counterclockwise directions required to sustain uniform shaft rotation anywhere in the total mechanical travel.

6.8.26 Backlash. The backlash is the maximum difference in shaft position that occurs when the shaft is moved to the same actual output ratio point from opposite directions. This measurement excludes the effects of resolution and contact width (see [figure 30](#)).

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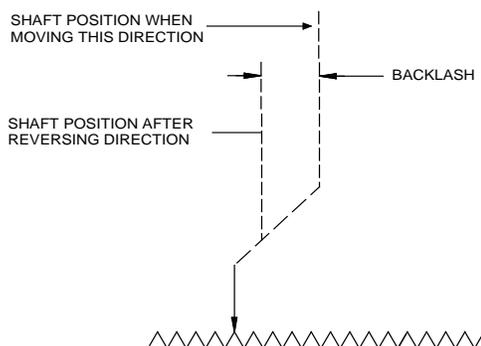


FIGURE 30. Backlash.

6.9 Deletion of class and grade characteristics. Class and grade characteristics 1, 4, 5 and 6 inclusive, have been deleted from this specification. For replacement purposes, use the following:

<u>Class replacement characteristics</u>	<u>Replaced class and grade characteristics</u>
2	1, 4 and 5
3	6

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

6.11 Subject term (key word) listing.

Linearity	Rotational load
Multisection	Single section
Multiturn	Single turn
Peak noise	

6.12 Environmentally preferable material. Environmentally preferable materials should be used to the maximum extent possible to meet the requirements of this specification. As of the dating of this document, the U.S. Environmental Protection Agency (EPA) is focusing efforts on reducing 31 priority chemicals. The list of chemicals and additional information is available on their website <http://www.epa.gov/osw/hazard/wastemin/priority.htm>. Use of these materials should be minimized or eliminated unless needed to meet the requirements specified herein (see Section 3).

6.13 PIN. This specification requires a PIN that describes technology and appropriate references to associated documents (see 1.2.1 and 3.1).

6.14 Amendment notification. The margins of this specification are marked with vertical lines to indicate modification generated by this amendment. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship.

APPENDIX A

PROCEDURE FOR QUALIFICATION INSPECTION

A.1 SCOPE

A.1.1 Scope. This appendix details the procedure for submission of sample, for qualification inspection of category I resistors covered by this specification. The procedure for extending qualification of the required sample to other resistors covered by this specification is also outlined herein. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

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

A.3. SUBMISSION

A.3.1 Sample. A sample consisting of 19 sample units will be submitted in accordance with table A-I, in each style, or style representing a group (table A-II), highest class, and highest rotational life and mechanical characteristics, and in each type of winding from material, and case material, for which qualification is sought. When servo-mounted types are submitted for qualification, and qualification is desired for bushing mounted units of the same physical size and construction (except for faceplate), three additional sample units with bushing mounts will be submitted. In a like manner, three additional sample units with servo mounts will be submitted, when bushing types are submitted for qualification.

TABLE A-I. Requirements for qualification.

Description	Requirement	
	Single-turn	Multi-turn
Linear	--	--
Function conformity tolerance (independent linearity)	0.5 percent	0.25 percent for 0.875 inch (22.23 mm) diameter and 0.1 percent for all others
Resistance-temperature characteristic	+0.026 percent/ ^o C	
Total electrical travel	350 ^o ± 2 ^o	As applicable
Total mechanical travel	Continuous	
Shaft style and length (from mounting surface)	Servo mounted - 1 inch (25.4 mm) (round) Bushing mounted - 1.375 inch (34.93 mm) (round)	Servo and bushing - 1 inch (round)
Location of taps (when applicable)	50 percent ± 2 percent of the effective electrical travel	50 percent ± 2 percent of the actual electrical travel
Total resistance (ohms)		
0.875 inch (22.23 mm) diameter	10,000	20,000
1.0625 inch (26.99 mm) diameter	10,000	30,000
1.4375 inch (36.51 mm) diameter	20,000	30,000
2.000 inch (50.80 mm) diameter	20,000	50,000
3.000 inch (76.20 mm) diameter	30,000	---
Resistance tolerance	± 3 percent	

APPENDIX A

A.4. EXTENT OF QUALIFICATION

A.4.1 Extent of qualification. The extent of qualification will be as indicated in table A-II, and will cover a resistance range above and below those values submitted for qualification inspection, provided the units are of the same general materials and construction. The extent of qualification of servo mounted units to bushing mounted units and of bushing mounted units, as indicated in table A-II, is based on the units being of the same physical size and construction except for the faceplate provided that the requirements of appendix A.3.1 are met (see 4.4.2). The extent of qualification on the resistance temperature characteristic will cover all the values above and below the value submitted for qualification. The extent of qualification of the shaft length will cover all shaft lengths shorter and longer than the shaft length submitted for qualification (see 4.4.2).

TABLE A-II. Extent of qualification.

Style	Will qualify styles(s)	Qualification of class, and rotational life characteristic	Will qualify the following	
			Class	Rotational life characteristic
RR0900	RR0900, RR1100, RR3100, RR3200, RR1300, RR2000, RR3000, RR3300, RR3400, RR3500	3	2, 3	
RR3100	RR3100, RR0900, RR1100, RR3200	2	2	
RR1100	RR1100, RR3200			
RR3200	RR3200, RR1100			
RR1300	RR1300, RR2000, RR3000, RR3300, RR3400, RR3500			
RR3300	RR3300, RR1300, RR2000, RR3000, RR2400, RR3500			
RR2000	RR2000, RR3000, RR3400, RR3500	9		9, 8, 7
RR3400	RR3400, RR3000, RR2000, RR3500	8		8, 7
RR3000	RR3000, RR3500	7		7
RR3500	RR3500, RR3000			
RR1000	RR1000, RR3600, RR3700, RR3800, RR3900, RR4000, RR1400, RR2100, RR4100			
RR1400	RR1400, RR2100			
RR2100	RR2100, RR1400			
RR3600	RR3700			
RR3800	RR3900			
2RR2100	2RR3100			

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Custodians:

Army - CR
Navy - EC
Air Force - 85
DLA - CC

Preparing activity:
DLA - CC

(Project 5905-2013-051)

Review activities:

Army - AR, AT, AV, CR4, MI
Navy - AS, CG, MC, OS
Air Force - 19, 99

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