CLASS 300

ELECTRICAL-CHARACTERISTICS TESTS

METHOD 301

DIELECTRIC WITHSTANDING VOLTAGE

1. PURPOSE. The dielectric withstanding voltage test (also called high-potential, over potential, voltage-breakdown, or dielectric-strength test) consists of the application of a voltage higher than rated voltage for a specific time between mutually insulated portions of a component part or between insulated portions and ground. This is used to prove that the component part can operate safely at its rated voltage and withstand momentary overpotentials due to switching, surges, and other similar phenomena. Although this test is often called a voltage breakdown or dielectric-strength test, it is not intended that this test cause insulation breakdown or that it be used for detecting corona, rather, it serves to determine whether insulating materials and spacing in the component part are adequate. When a component part is faulty in these respects, application of the test voltage will result in either disruptive discharge or deterioration. Disruptive discharge is evidenced by flashover (surface discharge), sparkover (air discharge), or breakdown (puncture discharge). Deterioration due to excessive leakage currents may change electrical parameters or physical characteristics.

1.1 Precautions. The dielectric withstanding voltage test should be used with caution particularly in inplant quality conformance testing, as even an overpotential less than the breakdown voltage may injure the insulation and thereby reduce its safety factor. Therefore, repeated application of the test voltage on the same specimen is not recommended. In cases when subsequent application of the test potential is specified in the test routine, it is recommended that the succeeding tests be made at reduced potential. When either alternating-current (ac) or direct-current (dc) test voltages are used, care should be taken to be certain that the test voltage is free of recurring transients or high peaks. Direct potentials are considered less damaging than alternating potentials which are equivalent in ability to detect flaws in design and construction. However, the latter are usually specified because high alternating potentials are more readily obtainable. Suitable precautions must be taken to protect test personnel and apparatus because of the high potentials used.

1.2 Factors affecting use. Dielectric behavior of gases, oils, and solids is affected in various degrees by many factors, such as atmospheric temperature, moisture, and pressure; condition and form of electrodes; frequency, waveform, rate of application, and duration of test voltage; geometry of the specimen; position of the specimen (particularly oil-filled components); mechanical stresses; and previous test history. Unless these factors are properly selected as required by the type of dielectric, or suitable correction factors can be applied, comparison of the results of individual dielectric withstanding voltage tests may be extremely difficult.

2. APPARATUS

2.1 High voltage source. The nature of the potential (ac or dc) shall be as specified. When an alternating potential is specified, the test voltage provided by the high voltage source shall be nominally 60 hertz in frequency and shall approximate, as closely as possible, a true sine wave in form. Other commercial power frequencies may be used for inplant quality conformance testing, when specified. All alternating potentials shall be expressed as root-mean-square values, unless otherwise specified. The kilovolt-ampere rating and impedance of the source shall be such as to permit operation at all testing loads without serious distortion of the waveform and without serious change in voltage for any setting. When the test specimen demands substantial test source power capacity, the regulation of the source shall be specified. When a minimum kilovoltampere rating is required, it shall be specified. When a direct potential is specified, the ripple content shall not exceed 5 percent rms of the test potential. When required, a suitable current-limiting device shall be used to limit current surges to the value specified.

2.2 Voltage measuring device. A voltmeter shall be used to measure the applied voltage to an accuracy of at least 5 percent, unless otherwise specified. When a transformer is used as a high voltage source of alternating potential, a voltmeter connected across the primary side or across a tertiary winding may be used provided it is previously determined that the actual voltage across the test specimen will be within the allowable tolerance under any normal load condition.

2.3 Leakage current measuring device. When any leakage current requirement is specified, a suitable method shall be used to measure the leakage current to an accuracy of at least 5 percent of the specified requirement.

2.4 Fault indicator. Suitable means shall be provided to indicate the occurrence of disruptive discharge and leakage current in case it is not visually evident in the specimen. The voltage measuring device of 2.2, the leakage current measuring device of 2.3, or an appropriate indicator light or an overload protective device may be used for this purpose.

3. PROCEDURE

3.1 Preparation. When special preparations or conditions such as special test fixtures, reconnections, grounding, isolation, or immersion in water are required, they shall be specified.

3.2 Test voltage. Specimens shall be subjected to a test voltage of the magnitude and nature (ac or dc) specified.

3.3 Points of application. The test voltage shall be applied between mutually insulated portions of the specimen or between insulated portions and ground as specified. The method of connection of the test voltage to the specimen should be specified only when it is a significant factor.

3.4 Rate of application. The test voltage shall be raised from zero to the specified value as uniformly as possible, at a rate of approximately 500 volts (rms or dc) per second, unless otherwise specified. At the option of the manufacturer, the test voltage may be applied instantaneously during inplant quality conformance testing.

3.5 Duration of application. Unless otherwise specified, the test voltage shall be maintained at the specified value for a period of 60 seconds for qualification testing. For inplant quality conformance testing, when specified, reduced time with a possible correlated higher test voltage may be used. Specimens with movable parts shall be tested as specified, in a manner to assure that repeated stresses are not applied to the same dielectric. Upon completion of the test, the test voltage shall be gradually reduced to avoid surges. At the option of the manufacturer, the test voltage may be removed instantaneously during inplant quality conformance testing.

3.6 Examination and measurement of specimen. During the dielectric withstanding voltage test, the fault indicator shall be monitored for evidence of disruptive discharge and leakage current. Following this, the specimen shall be examined and measurements shall be performed to determine the effect of the dielectric withstanding voltage test on specific operating characteristics, when specified.

4. SUMMARY. The following details are to be specified in the individual specification:

a. Special preparations or conditions, if required (see 3.1).

b. Magnitude of test voltage (see 3.2).

   (1) Test voltage, and duration for inplant quality conformance testing, if different than for qualification testing (see 3.5).

c. Nature of potential (ac or dc) (see 2.1).

d. Duration of application of test voltage for qualification testing if other than 60 seconds (see 3.5).

e. Points of application of test voltage (see 3.3).

   (1) Method of testing specimens with movable parts (see 3.5).

f. Method of connection of test voltage to specimen, if significant (see 3.3).

g. Regulation, when applicable (see 2.1).

h. Minimum kilovolt-ampere rating of high voltage source, if required. (see 2.1).

i. Limiting value of surge current, if applicable (see 2.1).

j. Maximum leakage current requirement, if applicable (see 2.3).

k. Measurements after dielectric withstanding voltage test, if required (see 3.6).

METHOD 302

INSULATION RESISTANCE

1. PURPOSE. This test is to measure the resistance offered by the insulating members of a component part to an impressed direct voltage tending to produce a leakage of current through or on the surface of these members. A knowledge of insulation resistance is important, even when the values are comparatively high, as these values may be limiting factors in the design of high-impedance circuits. Low insulation resistances, by permitting the flow of large leakage currents, can disturb the operation of circuits intended to be isolated, for example, by forming feedback loops. Excessive leakage currents can eventually lead to deterioration of the insulation by heating or by direct-current electrolysis. Insulation resistance measurements should not be considered the equivalent of dielectric withstanding voltage or electric breakdown tests. A clean, dry insulation may have a high insulation resistance, and yet possess a mechanical fault that would cause failure in the dielectric withstanding voltage test. Conversely, a dirty, deteriorated insulation with a low insulation resistance might not break down under a high potential. Since insulating members composed of different materials or combinations of materials may have inherently different insulation resistances, the numerical value of measured insulation resistance cannot properly be taken as a direct measure of the degree of cleanliness or absence of deterioration. The test is especially helpful in determining the extent to which insulating properties are affected by deteriorative influences, such as heat, moisture, dirt, oxidation, or loss of volatile materials.

1.1 Factors affecting use. Factors affecting insulation resistance measurements include temperature, humidity, residual charges, charging currents of time constant of instrument and measured circuit, test voltage, previous conditioning, and duration of uninterrupted test voltage application (electrification time). In connection with this last-named factor, it is characteristic of certain components (for example, capacitors and cables) for the current to usually fall from an instantaneous high value to a steady lower value at a rate of decay which depends on such factors as test voltage, temperature, insulating materials, capacitance, and external circuit resistance. Consequently, the measured insulation resistance will increase for an appreciable time as test voltage is applied uninterruptedly. Because of this phenomenon, it may take many minutes to approach maximum insulation resistance readings, but specifications usually require that readings be made after a specified time, such as 1 or 2 minutes. This shortens the testing time considerably while still permitting significant test results, provided the insulation resistance is reasonably close to steady-state value, the current versus time curve is known, or suitable correction factors are applied to these measurements. For certain components, a steady instrument reading may be obtained in a matter of seconds. When insulation resistance measurements are made before and after a test, both measurements should be made under the same conditions.

2. APPARATUS. Insulation resistance measurements shall be made on an apparatus suitable for the characteristics of the component to be measured such as a megohm bridge, megohm-meter, insulation resistance test set, or other suitable apparatus. Unless otherwise specified, the direct potential applied to the specimen shall be that indicated by one of the following test condition letters, as specified:

Test condition	Test potential
A	100 volts ±10%
B	500 volts ±10%
C	1,000 volts ±10%

For inplant quality conformance testing, any voltage may be used provided it is equal to or greater than the minimum potential allowed by the applicable test condition. Unless otherwise specified, the measurement error at the insulation resistance value required shall not exceed 10 percent. Proper guarding techniques shall be used to prevent erroneous readings due to leakage along undesired paths.

3. PROCEDURE. When special preparations or conditions such as special test fixtures, reconnections, grounding, isolation, low atmospheric pressure, humidity, or immersion in water are required, they shall be specified. Insulation resistance measurements shall be made between the mutually insulated points or between insulated points and ground, as specified. When electrification time is a factor, the insulation resistance measurements shall be made immediately after a 2 minute period of uninterrupted test voltage application, unless otherwise specified. However, if the instrument reading indicates that an insulation resistance meets the specified limit, and is steady or increasing, the test may be terminated before the end of the specified period. When more than one measurement is specified, subsequent measurements of insulation resistance shall be made using the same polarity as the initial measurements.

4. SUMMARY. The following details are to be specified in the individual specification:

a. Test condition letter, or other test potential, if required (see 2).

b. Special preparations or conditions, if required (see 3).

c. Points of measurement (see 3).

d. Electrification time, if other than 2 minutes (see 3).

e. Measurement error at the insulation resistance value required, if other than 10 percent (see 2).

METHOD 303

DC RESISTANCE

1. PURPOSE. This test is to measure the direct-current (dc) resistance of resistors, electromagnetic windings of components, and conductors. It is not intended that this test apply to the measurement of contact resistance.

1.1. Precautions. The temperature at which the dc resistance measurement is made will affect the final value of resistance. In addition, resistance values may vary with the measuring voltage.

2. PROCEDURE. DC resistance shall be measured with a resistance bridge or other suitable test equipment. The limit of error in the bridge or other test equipment shall not exceed one-tenth of the specified tolerance on the measured resistance (for example, the limit of error in the bridge or other test equipment shall not exceed ±0.5 percent if the specified tolerance on the measured resistance is ±5 percent), unless otherwise specified. For inplant quality conformance testing, the accuracy of the measurement shall be such to insure that the resistance value is within the required tolerance. If a plus or minus tolerance is not specified, the limit of error in the bridge or other test equipment shall not exceed ±2 percent. The test current through the specimen shall be as small as practical considering the sensitivity of the indicating instruments, unless the test current or voltage is specified. When it is important that the temperature of the specimen shall not rise appreciably during the measurement, the test voltage shall be applied uninterruptedly for as short a time as practicable, but in no case for more than 5 seconds, unless otherwise specified. The measurement shall be made at or corrected to 25°C.

3. SUMMARY. The following details are to be specified in the individual specification:

a. Limit of error of measuring apparatus, if other than one-tenth of specified tolerance (see 2).

b. Test voltage or current, if applicable (see 2).

c. Maximum period of uninterrupted test-voltage application, if other than 5 seconds (see 2).

METHOD 304

RESISTANCE-TEMPERATURE CHARACTERISTIC

1. PURPOSE. It is the purpose of this test to determine the percentage change in direct-current (dc) ohmic resistance from the dc ohmic resistance at the reference temperature, per unit temperature difference between the test temperature and the reference temperature. The equation (see 3) used to calculate this characteristic, commonly called the "temperature coefficient of resistance", is based on an assumed straight-line relationship between resistance and temperature over a range of specified test temperatures.

2. PROCEDURE.

2.1 Preparation. Test leads used to connect the specimens to the resistance-measuring devices shall be firmly fastened to the specimens. Precautions shall be taken to minimize errors in resistance measurement due to such factors as lead resistance, spurious electromotive forces, condensation of moisture, etc., throughout the range of test temperatures, by utilization of suitable test-lead materials and measurement techniques or by applying appropriate corrections.

2.2 Test temperatures. The reference temperature shall be 25°C or as specified. There shall be two standard series of test temperatures. The first series shall be 25°, 0°, -15°, and -55°C; the second series shall be 25°, 50°, 75°, 100°, 125°, 200°, 275°, and 350°C. The tolerance on each temperature in both series shall be ±3°C. The lowest test temperature in the first series, and the highest test temperature in the second series, shall be as specified. Measurements for each series of temperatures shall be performed in the order shown without interruption. However, a lapse of time not to exceed 24 hours is permitted between the end of the first series and the start of the second series.

2.3 Measurements. The resistance of each specimen shall be measured 30 to 45 minutes after the chamber temperature has become stable to within ±0.5°C at a test temperature. However, it will be permissible to measure the resistance before the end of this period if the resistance has become stable to within ±0.1 percent as determined by preliminary measurements made at 5 minute intervals after stabilization of the chamber temperature. Unless otherwise specified, the temperature at the time of measurement shall be measured to an accuracy of ±1 percent of the temperature difference between the nominal test temperature and the nominal reference temperature +0.5°C. Resistance measurements shall be made in accordance with method 303 of this standard.

3. RESULTS. The resistance-temperature characteristic, in percent change in resistance per degree centigrade, at each test temperature shall be computed as follows:

$$\textit{Resistance-temperature characteristic} = \frac{R_2 - R_1}{R_1(t_2 - t_1)} \times 100$$

Where:
R_1 = resistance at reference temperature (in same series as test temperature) in ohms.
R_2 = resistance at test temperature in ohms.
t_1 = reference temperature in degrees celsius.
t_2 = test temperature in degrees celsius.

4. SUMMARY. The following details are to be specified in the individual specification:

a. Reference temperature, if other than that specified (see 2.2).

b. Lowest and highest test temperature (see 2.2).

c. Accuracy of temperature measurement if other than that specified (see 2.3).

METHOD 305

CAPACITANCE

1. PURPOSE. The purpose of this test is to measure the capacitance of component parts. Preferred test frequencies for this measurement are 60 Hz, 120 Hz, 1 kHz, 100 kHz, and 1 MHz.

2. PROCEDURE. The capacitance of the specimen shall be measured at or referred to an ambient temperature of 25°C with a capacitance bridge or other suitable method at the frequency specified. The inherent accuracy of the measurement shall be ±(0.5 percent +0.2 picofarad) unless otherwise specified. Suitable measurement technique shall be used to minimize errors due to the connections between the measuring apparatus and the specimen. The alternating-current (ac) voltage actually impressed across the specimen shall be as low as practicable. When a direct-current (dc) polarizing voltage is required, it shall be as specified and shall exceed the peak ac voltage impressed across the specimen; however, the sum of the peak ac and the dc voltages shall not exceed the voltage rating of the specimen.

3. SUMMARY. The following details are to be specified in the individual specification:

a. Test frequency (see 2).

b. Limit of accuracy, if other than that specified (see 2).

c. Magnitude of polarizing voltage, if applicable (see 2).

d. Magnitude of AC rms test signal, if applicable (see 2).

METHOD 306

QUALITY FACTOR (Q)

1. PURPOSE. The purpose of this test is to measure the quality factor, commonly called Q, of electronic parts such as capacitors and inductors. By definition, the factor Q expresses the ratio of reactance to effective resistance of a circuit element. This numerical ratio is considered a "figure of merit" for a reactive component (or a resonant circuit utilizing such components) as it is a measure of the ability of the component (or circuit) to store energy compared to the energy it wastes. For this reason, Q is called "storage factor". Q is thus equal to the inverse of the dissipation factor. Relationship also exists between Q and the properties of a tuned circuit, such as the resonant rise in voltage phenomena. Each of the relationships involving Q mentioned above can be applied to the direct or indirect measurement of Q.

2. PROCEDURE. The quality factor or Q of the specimen shall be measured using a suitable instrument providing an accuracy of measurement within 10 percent of the specified value of Q. Measurements shall be made at the specified frequency. Suitable measurement techniques shall be used to minimize errors due to the connections between the measuring apparatus and the specimen.

3. SUMMARY. The following detail is to be specified in the individual specification:

a. Test frequency (see 2).

METHOD 307

CONTACT RESISTANCE

1. PURPOSE. The purpose of the contact resistance test is to determine the resistance offered to a flow of current during its passage between the electrical contacting surfaces of connecting components, such as plugs, jacks, connectors, and sockets, or between the electrical contacts of current controlling components, such as switches, relays, and circuit breakers. For practical reasons, lead and terminal resistances may be included in the actual measurement, as well as the contact resistance proper. In many applications it is required that the contact resistance be low and stable, so that the voltage drop across the contacts does not affect the accuracy of the general circuit conditions. If large currents are passed through high resistance contacts, excessive energy losses and dangerous overheating of the contacts may occur.

1.1 Precautions. Contact resistance values between two contacting surfaces are influenced by such factors as the resistivities of the surface materials; contact pressure; area; shape; condition (including relative cleanliness, smoothness, and hardness) of surfaces; current; open circuit voltage appearing at the contacts during interruption of current; temperature; and thermal conductivity of leads. These factors should be considered in designing test jigs or clamps, or in performing contact resistance measurements. Contact resistances are usually measured by a 4-terminal procedure, using a Kelvin bridge, or by the voltmeter-ammeter method. The test current used is usually the maximum rated current for the contacting surfaces involved. In measuring contact resistance, it is important to keep the specimen free from vibration, and to prevent changes in normal contact pressure which might result from improper application of test jigs or clamps.

2. PROCEDURE. The resistance of the contacts may be measured directly using a Kelvin bridge, or indirectly using the voltmeter-ammeter method, ammeter-potentiometer method, or other suitable means. The maximum allowable measurement error shall be 5 percent. The point of measurement shall be the point at which the external leads are normally connected to the terminals. Connections between the specimens and the measuring apparatus shall be made as specified, using suitable connecting jigs or clamps, where required. The magnitude of direct current to be passed through the contacts during the measurement and, when necessary, the maximum open circuit test voltage shall be as specified. A series resistor may be used provided the specified open circuit test voltage is not exceeded. The number of activations to cleanse the contacts prior to measurement, the number of test activations, and the number of measurements per activations to be made on each contact shall be as specified.

3. SUMMARY. The following details are to be specified in the individual specification:

a. Method of connection (see 2).

b. Test current (see 2).

c. Maximum open circuit test voltage, if applicable (see 2).

d. Number of activations prior to measurement (see 2).

e. Number of test activations (see 2).

f. Number of measurements per activation (see 2).

METHOD 308

CURRENT-NOISE TEST FOR FIXED RESISTORS

1. PURPOSE. This resistor noise test method is performed for the purpose of establishing the "noisiness" or "noise quality" of a resistor in order to determine its suitability for use in electronic circuits having critical noise requirements. This method is intended as a standard reference for the determination of current noise present in a resistor, for use in an application with specific current-noise requirements. It is not intended as a general specification requirement. Interference caused by the generation of spurious noise signals in parts tends to mask the desired output signal, thus resulting in loss of information. For low-level audio frequency and other low-frequency circuits, where low-noise parts are used, resistors may become an important source of interfering noise. One source of noise in a resistor is molecular thermal motion which generates a fluctuation voltage termed "thermal noise". It is not necessary to determine the magnitude of thermal noise by measurement since the mean-square value of the fluctuation voltage is predictable from Nyquist's equation, which shows the mean-square value to be proportional to the product of resistance, temperature, and the pass band of the measuring system. Generally, an increase in fluctuation voltage appears when direct current (dc) is passed through resistive circuit elements. The increase in fluctuation voltage is termed "excess noise" or "current noise". The magnitude of current noise is dependent upon many inherent properties of the resistor such as resistive material and other factors such as processing, fabrication, size and shape of resistive element, etc. Since there is no apparent functional relationship between current noise and many of these factors, current noise generally cannot be predicted from physical constants. Therefore, it is necessary to measure current noise to determine its magnitude. The method employed in this test has been designed to evaluate accurately the "noisiness" or "noise quality" of individual resistors in terms of a noise-quality index. The noise-quality index, expressed in decibels (dB), is a measure of the ratio of the root-mean-square (rms) value of current-noise voltage, in microvolts (μv), to the applied dc voltage, in volts. The pass band associated with the noise-quality index is one frequency decade, geometrically centered at 1,000 hertz (Hz). This index is termed the "microvolts-per-volt-in-a-decade" index. In the design of circuits, an added advantage accrues from the definitiveness of the index which allows the estimation of interference attributable to current noise. Conversely, for a given limit of current-noise interference in a particular circuit design, a maximum acceptable value of the index may be established. Ordinarily, it is not necessary to duplicate the operating conditions of the particular circuit design when measuring the current noise. The noise quality of populations of resistors may be reasonably estimated by measurement of the index of representative groups of resistors using suitable sampling procedures. Measurements on sample groups tend to have a normal distribution and once representative parameter values for the distribution have been established (the mean and standard deviation), such parameter values would serve as norms in judging "noisiness" and product uniformity insofar as noise is concerned.

1.1 Precautions. Adherence to the ambient temperature specified in 3.1 is emphasized as an important consideration of this method. It is also necessary, in making noise measurements, using the apparatus of this method, to delay reading the noise meter for a period of time no less than four times the effective time constant of the detector to allow the meter sufficient time to reach at least 98 percent of the representative average value. The effective time constant of the apparatus is normally adjusted to a value close to 1 second and therefore, a minimum time delay of 4 seconds is normally required for the noise meter to indicate a valid average. Immediately after this 4 second delay, the meter should be read even though it continues to fluctuate as the noise signal varies. Normally, the operator in making a visual reading of the fluctuating meter pointer, should estimate an average for a short duration, in the order of 1/2 to 1 second.

2. APPARATUS. Noise measurements should be made on Quan-Tech Laboratories, Inc., Model 315 Resistor-Noise Test Set, or equal, built in conformance with specifications recommended by the National Bureau of Standards (NBS) and detailed in a report entitled "A Recommended Standard Resistor-Noise Test System," by G.T. Conrad, Jr., N. Newman, and A.P. Stansbury published in the IRE Transactions of the Professional Group on Component Parts, Volume CP-7, Number 3, September 1960. The NBS-test system provides a means for establishing direct current through the resistor under test and measuring the resulting dc voltage and noise voltage appearing at the terminals of the resistor. These two voltages are indicated simultaneously on scales calibrated in db. Instrumentation is so arranged that the associated value of the "microvolts-per-volt-in-a-decade" index may be readily determined in accordance with 3.3.

2.1 Test system. The test system shall be as shown in the simplified block diagram on figure 308-1. The dc portion of the system consists of a variable dc power supply and a dc vacuum-tube voltmeter (VTVM). The alternating-current (ac) portion of the system consists of a calibration signal source and an indicating amplifier. The interconnecting leads, as well as the resistor under test, should be adequately shielded.

2.1.1 DC measurement considerations. The variable dc power supply furnishes dc loading power through an isolation resistor to the resistor under test. The isolation resistor prevents noise, appearing at the terminals of the resistor under test, from being severely attenuated by the very low, parallel impedance presented by the output terminals of the dc power supply. The isolation resistor must be free of current noise. Quiet wirewound-type resistors are suitable. One of four values for the isolation resistor, Rm, (1,000 ohms, 10,000 ohms, 100,000 ohms, or 1 megohm (mego)) is selected, depending on the resistance of the resistor under test, RT. The dc voltage appearing across the resistor under test is indicated by the dc VTVM. The meter has two scales - one showing the dc voltage across the resistor under test, V, and the other indicating the quantity D-20 log V, in dB. The scale simplifies computation of the current-noise index. The choice of value of the dc voltage is not critical, however, to avoid subjecting the resistor under test, and the isolation resistor as well, to excessive dc power dissipation or voltage, or both, standard nominal values of dc voltage and values for the isolation resistor are given in table 308-1.

2.1.2 AC measurement considerations. Noise voltage appearing at the terminals of the resistor under test is amplified and its rms magnitude is shown by the ac indicating amplifier. The indicating amplifier consists of a high-gain, low-noise amplifier, a filter, an rms detector, and an output meter. The filter restricts the frequency response of the amplifier to a flat-top, 1,000 Hz pass band, geometrically centered at 1,000 Hz. The output-meter scale, like that of the dc VTVM, is calibrated in dB to simplify calculations.

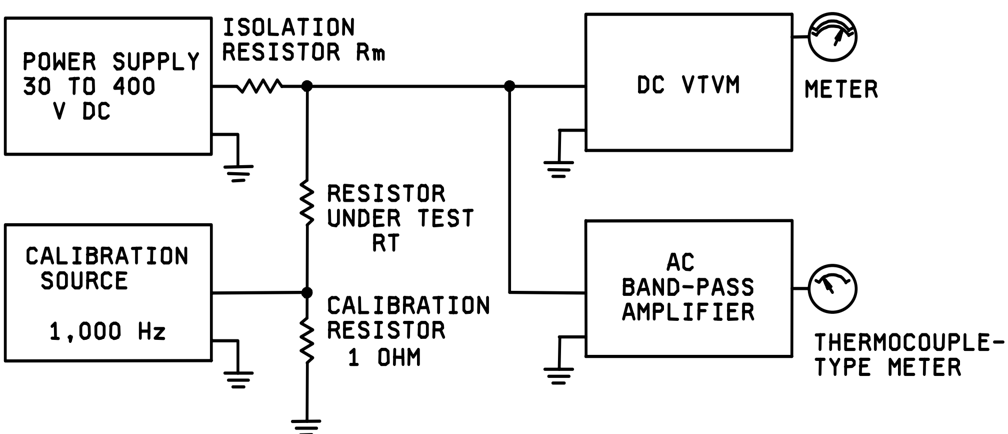


FIGURE 308-1. Block diagram of system.

2.1.3 Calibration technique. The calibration technique consists of first applying a predetermined value of 1,000 Hz, sine-wave signal across a 1 ohm resistor located in series with the resistor under test, and then adjusting the gain of the amplifier, by means of a variable attenuator, until the output meter deflects to the "calibrate" line. This procedure standardizes the gain of the system and calibrates the indicating amplifier. It should be noted that since the calibration setting depends upon the impedance at 1,000 Hz of the resistor under test, resistors having the same dc resistance may not calibrate alike. The resistance of the calibration resistor (1 ohm) is considered negligible compared to that of any resistor under test (100 ohms to 22 mego); therefore, the effect of the calibration voltage appearing at the terminals of a zero-impedance generator located in series with the resistor under test. The magnitude of the calibration voltage is so chosen that the indicated output is equal to that which would be obtained if the calibration voltage were a noise voltage having an rms value of 1,000 µv in a decade. Such a signal should produce a reading of 60 dB when the system is properly calibrated; thus, 0 dB means 1 µv in a decade.

2.2 Synopsis. To summarize, this apparatus provides a measure of the rms value of the current-noise voltage generated in the resistor under test and transmitted in a frequency decade. The calibration technique refers the measured noise voltage to the terminals of an essentially zero-impedance noise-voltage generator located in series with the resistor under test. The noise voltage so measured, when corrected for the presence of system noise, is the "open circuit" current-noise voltage of the resistor under test. Since both the current-noise voltage and dc voltage are expressed in dB, the value of the “microvolts-per-volt-in-a-decade" index is obtained by subtracting the dc reading from the corrected noise reading. The corrected noise reading is discussed in 3.3.

3. PROCEDURE.

3.1 Operating conditions. The test shall be performed at an ambient temperature of 25°C ±2°C, unless otherwise specified. The specimen under test shall be stabilized at room ambient temperature prior to test. No special preparations of the specimen are required other than that its leads be clean. Standard operating conditions, based on the resistance value of the specimen to be tested, are given in table 308-1. The values of the isolation resistor, Rm, and the dc voltage, V, should be observed, although they are not critical, because the index is reasonably independent of the values of the isolation resistor and the dc voltage over a broad range. Therefore, it is not necessary to obtain the exact value of dc voltage given in table 308-1, rather to set it near the value, and to read carefully and record its value at the time of the measurement. In no case shall the ratings of the resistor under test be exceeded.

3.2 Measurements. After the operating conditions have been established, the measurement operation shall be performed in three steps, as follows:

(1) Calibration (see 3.2.1).

(2) Measurement of system noise (see 3.2.2).

(3) Simultaneous measurement of the dc voltage and the resulting total noise (see 3.2.3).

Generally, the measurements should be made in the order listed. The precautions in 1.1 should be observed.

3.2.1 Calibration. The calibration technique (see 2.1.3) standardizes the gain of the ac system for the particular resistor under test. For the noise measurements in steps 2 and 3 which follow, the sum of the ac attenuator setting and the ac meter reading, in dB, is a direct indication of the noise present in terms of an "open-circuit" rms noise voltage appearing across the terminals of the resistor under test.

TABLE 308-1. Standard operating conditions.

Resistance		Resistors 1/2 watt and higher			Resistors 1/4, 1/8, and 1/10 watt		
Resistor under test (Rt)	Isolation resistor (Rm)	20 log V(D)	DC voltage (V) 1/	DC power dissipation (Pdc)	20 log V(D)	DC voltage (V) 1/	DC power dissipation (Pdc)
Ohms	Ohms	dB	Volts	Milliwatts	dB	Volts	Milliwatts
100	1,000	10.1	3.2	100	10.1	3.2	100
120	1,000	11.6	3.8	120	10.9	3.5	100
150	1,000	13.5	4.7	150	11.8	3.9	100
180	1,000	15.1	5.7	180	12.5	4.2	100
220	1,000	16.9	7.0	220	13.4	4.7	100
270	1,000	18.3	8.2	250	14.3	5.2	100
330	1,000	19.2	9.7	250	15.1	5.7	100
390	1,000	19.9	9.9	250	15.8	6.2	100
470	1,000	20.7	10.8	250	16.7	6.9	100
560	1,000	21.4	11.8	250	17.5	7.5	100
680	1,000	22.3	13.0	250	18.3	8.2	100
820	1,000	23.1	14.3	250	19.2	9.1	100
1,000	1,000	24.0	15.8	250	20.0	10.0	100
1,200	1,000	24.8	17.3	250	20.8	11.0	100
1,500	1,000	25.8	19.4	250	21.7	12.2	100
1,800	1,000	26.6	21.2	250	22.5	13.4	100
2,200	1,000	27.4	23.4	250	23.4	14.8	100
2,700	10,000	28.3	26.0	250	24.3	16.4	100
3,300	10,000	29.2	28.7	250	25.2	18.2	100
3,900	10,000	29.9	31.2	250	25.9	19.7	100
4,700	10,000	30.8	34.3	250	26.7	21.7	100
5,600	10,000	31.5	37.4	250	27.5	23.7	100
6,800	10,000	32.3	41.2	250	28.3	26.1	100
8,200	10,000	33.2	45.3	250	29.1	28.6	100
10,000	10,000	34.0	50.0	250	30.1	32.0	100
12,000	10,000	34.8	54.8	250	30.9	35.0	100
15,000	10,000	35.8	61.2	250	31.8	39.0	100
18,000	10,000	36.6	67.1	250	32.5	42.0	100
22,000	10,000	37.4	74.2	250	33.4	47.0	100
27,000	0.10 mego	38.3	82.2	250	34.3	52.0	100
33,000	0.10 mego	39.2	90.8	250	35.1	57.0	100
39,000	0.10 mego	40.0	98.7	250	35.8	62.0	100
47,000	0.10 mego	40.7	108	250	36.7	69.0	100
56,000	0.10 mego	41.5	118	250	37.5	75.0	100
68,000	0.10 mego	42.3	130	250	38.3	82.0	100
82,000	0.10 mego	43.1	143	250	39.2	91.0	100

See footnote at end of table.

TABLE 308-1. Standard operating conditions - Continued.

Resistance		Resistors 1/2 watt and higher			Resistors 1/4, 1/8, and 1/10 watt		
Resistor under test (Rt)	Isolation resistor (Rm)	20 log V(D)	DC voltage (V) 1/	DC power dissipation (Pdc)	20 log V(D)	DC voltage (V) 1/	DC power dissipation (Pdc)
Ohms	Ohms	dB	Volts	Milliwatts	dB	Volts	Milliwatts
0.10 mego	0.10 mego	44.0	158	250	40.0	100	100
0.12 mego	0.10 mego	44.8	173	250	40.8	110	100
0.15 mego	0.10 mego	45.8	194	250	41.7	122	100
0.18 mego	0.10 mego	46.5	212	250	42.5	134	100
0.22 mego	0.10 mego	47.5	234	250	43.4	148	100
0.27 mego	1.0 mego	38.6	85.0	26.8	38.6	85.0	26.8
0.33 mego	1.0 mego	40.0	99.0	29.7	40.0	99.0	29.7
0.39 mego	1.0 mego	41.0	112	32.2	41.0	112	32.2
0.47 mego	1.0 mego	42.1	127	34.3	42.1	127	34.3
0.56 mego	1.0 mego	43.1	143	36.5	43.1	143	36.5
0.68 mego	1.0 mego	44.2	161	38.1	44.2	161	38.1
0.82 mego	1.0 mego	45.1	180	39.5	45.1	180	39.5
1.0 mego	1.0 mego	46.0	200	40.0	46.0	200	40.0
1.2 mego	1.0 mego	46.8	218	39.6	46.8	218	39.6
1.5 mego	1.0 mego	47.6	240	38.4	47.6	240	38.4
1.8 mego	1.0 mego	48.0	250	34.7	48.0	250	34.7
2.2 mego	1.0 mego	48.0	250	28.4	48.0	250	28.4
2.7 mego	1.0 mego	48.0	250	23.2	48.0	250	23.2
3.3 mego	1.0 mego	48.0	250	18.9	48.0	250	18.9
3.9 mego	1.0 mego	48.0	250	16.0	48.0	250	16.0
4.7 mego	1.0 mego	48.0	250	13.3	48.0	250	13.3
5.6 mego	1.0 mego	48.0	250	11.2	48.0	250	11.2
6.8 mego	1.0 mego	48.0	250	9.2	48.0	250	9.2
8.2 mego	1.0 mego	48.0	250	7.6	48.0	250	7.6
10 mego	1.0 mego	48.0	250	6.2	48.0	250	6.2
12 mego	1.0 mego	48.0	250	5.2	48.0	250	5.2
15 mego	1.0 mego	48.0	250	4.2	48.0	250	4.2
18 mego	1.0 mego	48.0	250	3.5	48.0	250	3.5
22 mego	1.0 mego	48.0	250	2.8	48.0	250	2.8

1/ DC voltage across the resistors under test for the measurement of total noise.

3.2.2 System noise (S). System noise is the background noise present when direct current is not present in the resistor under test. System noise is indicated after turning off the calibration voltage. The algebraic sum of the ac attenuator setting and the ac meter reading gives the magnitude of system noise, S, in dB.

3.2.3 Total noise (T). Both the dc voltage and the total noise are measured simultaneously. The value of dc voltage is given in table 308-1. The application of excessive dc voltage should be avoided by setting the dc voltage control to its minimum before applying the voltage, and when the voltage is applied, it should be increased to the desired value. The magnitude of the dc voltage is given by the sum, D, of the dc attenuator setting and the dc meter reading in dB. D equals 20 log V, where V is the dc voltage, in volts, applied to the terminals of the resistor under test. The associated noise measurement indicates the total noise present, i.e., the quadratic sum of the system noise and the current noise. This total noise is indicated by T, in dB.

3.3 Determination of the "microvolts-per-volt-in-a-decade" index. The current-noise index to be compared with the required index (see 5) shall be computed from the three measured quantities S, T, and D, in accordance with the following formula:

(Index), in dB = T-f(T-S)-D.

Where:

$$f(T - S) = -10 \log \left(1 - 10^{-\left[\frac{T - S}{10}\right]}\right)$$

The quantity f(T-S) is a correction for the presence of system noise while T is being measured. Values of f(T-S) are given in table 308-2 as a function of T-S. The quantity T-S represents the indicated increase in noise resulting from the presence of direct current. When this increase, T-S, is greater than 15.0 dB, then f(T-S) is essentially zero, and T alone is the measure of current noise.

4. ERRORS. Accuracy and repeatability of determinations of the current-noise index are influenced by the combined effects of many factors including the following - characteristics of the test set, ambient temperature, inherent fluctuations in current noise, relative magnitude of current noise as compared to system noise, and delay between the application of dc voltage and observation of meter deflection. Therefore, in the interest of a better understanding of the significance of the measurement, a discussion of errors is included. The error associated with the determination of the index is a function of two independent errors, one a bias-type or constant error, and the other a random-type or variable error. The bias error is constant for any particular measuring condition. The maximum bias error introduced by the test set should not exceed 0.4 dB. A conservative estimate of the bias error introduced by the permissible departure of ambient temperature from 25°C as stated in 3.1, is at most 0.2 dB. The "worst case" bias error for these two factors is the sum of their absolute values, 0.6 dB. Although the bias error for any particular measurement is not known, for purposes of this discussion the "worst case" condition is assumed, and 0.6 dB will be considered the magnitude of bias error associated with the index. The random error associated with the index is that of the current noise, [T-f(T-S)]. The index will be considered for two cases; the more simple case where the current noise is relatively large, i.e., T-S>15.0 dB for which f(T-S)≈0, and therefore current noise is represented by T alone; and the second case where the current noise is not relatively large and is represented by [T-f(T-S)], with f(T-S) being significant. In either case, the probable error of the index is approximately equal to the error component which predominates, whether it be bias error or random error. For the first case, the only significant quantity which varies is T, therefore the random-error component of the index error is equal to the random error associated with the measurement of the total noise, T. The random error of T is evidenced by fluctuations of the meter pointer and tends to have a normal distribution. The magnitude of the probable random error of T cannot be given explicitly because its value is necessarily a function of the resistor under test and must be determined from measurements. The probable random error of T for different resistors may range from values as low as approximately 0.2 dB to values as high as several dB in resistors having large noise variations.

For resistors having a probable random error of T less than 0.6 dB, the probable error of the index is approximately equal to the bias error, assuming the bias error is the "worst case", i.e., 0.6 dB. This means that on the average, one-half of the measurements would have an error no greater than 0.6 dB. On the other hand, when the probable random error of T is greater than the bias error, the probable error of the index is equal to that of T. For the second case, the probable random-error component of the index is greater than that of T alone. This follows because the magnitude of current noise is determined from the difference between two measurements, T and S, each of which fluctuates, rather than from T alone. Measurements indicate that the probable random error of S should be in the order of 0.2 dB. Assuming that this is the case, the probable random-error component of the index is approximately double that of T for the measurement condition T-S = 3 dB, and approximately four times that of T for the condition T-S = 1.5 dB. The limit of sensitivity for measuring the current-noise index is approached as the current noise approaches values too small to cause an increase as much as 1.0 dB, i.e., T-S equal to 1.0 dB. However, the test method may serve as a qualitative means for comparing resistors having relatively low values of current noise where T-S is less than 1.0 dB. Another possible source of measurement uncertainty is the transitory variations in current noise which may immediately follow application of dc voltage. Certain types of resistors tend to display very little, if any, transitory variations, whereas other types tend to display such variations to a measurable degree. For those resistors which exhibit such variations, the current noise usually settles to a more stable value after a short time, from 1 to several seconds. In some cases, the current-noise variations may continue to be relatively large and unstable for extended periods of time. Such resistors are usually very noisy. By adhering to the precautions regarding the procedures stated in 1.1, the effects of such variations on repeated measurements are reduced.

5. SUMMARY. The following requirement and details are to be provided when this method is specified:

a. Required values of the "microvolts-per-volt-in-a-decade" index (see 3.3).

b. Ambient temperature, if other than that specified (see 3.1).

c. Value of dc voltage, if other than those stated in table 308-1 (see 2.1.1 and 3.1).

TABLE 308-2. Correction factor for presence of "system noise".

T-S dB	f(T-S) Correction factor	T-S dB	f(T-S) Correction factor
1.0	6.9	4.3	2.0
1.1	6.5	4.4	1.9
1.2	6.2	4.5	1.9
1.3	5.9	4.6	1.8
1.4	5.6	4.7	1.8
1.5	5.3	4.8	1.7
1.6	5.1	4.9	1.7
1.7	4.9	5.0	1.6
1.8	4.7	5.1	1.6
1.9	4.5	5.2	1.5
2.0	4.3	5.3	1.5
2.1	4.1	5.4	1.4
2.2	3.9	5.5	1.4
2.3	3.8	5.6	1.4
2.4	3.6	5.7	1.3
2.5	3.5	5.8	1.3
2.6	3.4	5.9	1.3
2.7	3.3	6.0	1.2
2.8	3.2	6.1	1.2
2.9	3.1	6.2	1.2
3.0	3.0	6.3	1.1
3.1	2.9	6.4	1.1
3.2	2.8	6.5 to 6.9	1.0
3.3	2.7	7.0 to 7.3	0.9
3.4	2.6	7.4 to 7.9	0.8
3.5	2.5	8.0 to 8.5	0.7
3.6	2.4	8.6 to 9.3	0.6
3.7	2.4	9.4 to 9.9	0.5
3.8	2.3	10.0 to 11.5	0.4
3.9	2.2	11.6 to 12.7	0.3
4.0	2.2	12.8 to 14.5	0.2
4.1	2.1	14.6 to 15.0	0.1
4.2	2.0	M15.0	≈ 0

METHOD 309

VOLTAGE COEFFICIENT OF RESISTANCE DETERMINATION PROCEDURE

1. PURPOSE. Certain types of resistors exhibit a variation of resistance with changes in voltage across the resistor. This is a measurable characteristic; a test to determine the magnitude of such a characteristic is the Voltage Coefficient of Resistance Determination Procedure.

2. PROCEDURE. The voltage coefficient is applicable only to resistors of 1,000 ohms and over. Unless otherwise specified in the individual specification, all measurements and tests shall be made at a temperature of 25°C ±5°C. Adjust the resistance measuring device to apply 0.1 X rated continuous working voltage to the resistor. Measure the resistance by applying this voltage intermittently for not more than the total of 0.5 second in any 5 second interval. Readjust the resistance measuring device to apply 1.0 X rated continuous working voltage to the resistor and repeat the above intermittent measuring procedure. Compute the Voltage Coefficient (VC) as follows:

$$VC = \frac{(R - r)100}{0.9Er}$$

Where:

R	=	Resistance at rated continuous working voltage.
r	=	Resistance at 0.1 rated continuous working voltage.
E	=	Rated continuous working voltage.

3. PRECAUTIONS. Adherence to 2, applying voltage intermittently for not more than the total of 0.5 seconds in any 5 second interval is emphasized as an important consideration of this method. Failure to comply would result in a voltage coefficient of vast variations. A resistance measuring device capable of withstanding high voltage applications should be used. Certain types of resistors exhibit a variation of resistance with changes in potential difference, this effect being separate and distinct from the change in resistance due to heating effect whether from applied voltage or ambient conditions.

4. SUMMARY. The following detail is to be specified in the individual specification:

The continuous working voltage (see 2).

METHOD 310

CONTACT-CHATTER MONITORING

1. PURPOSE. This test is conducted for the purpose of detecting contact-chatter in electrical and electronic component parts having movable electrical contacts, such as relays, switches, circuit breakers, etc., where it is required that the contacts do not open or close momentarily, as applicable, for longer than a specified time-duration (see 4.3) under environmental test conditions, such as vibration, shock, or acceleration. This test method provides standard test procedures for monitoring such "opening of closed contacts" or "closing of open contacts".

2. TEST CIRCUITS.

2.1 Selection. In this method there are two test-circuits: A (see 3.1), and B (see 3.2). The selection of the test-circuit depends largely upon the type of electrical contacts to be tested. Test-circuit B is preferred, whenever possible, to avoid contact contamination caused by the formation of carbonaceous deposits on the contacts. The individual specification shall specify the test-circuit and time-duration (see 4.3) required in connection with monitoring of shock and vibration tests. The test-circuits listed herein are "recommended" reference circuits. Any comparable test-circuit which meets the test requirements and the calibration procedures as stated herein, may be used for this test.

2.1.1 Selection of test-circuit A. Test-circuit A is for monitoring test-specimens with a single set of contacts, for the opening of normally-closed contacts or false closures of normally-opened contacts (see figure 310-1). Test-circuit A should not be specified for specimens whose capability includes low-level or dry-circuit ratings (10 milliamperes or less and 2 volts or less for openings or closings less than 10 microseconds); since the current through the electrical contacts under test from the test-circuit may cause arcing, thus damaging the contacts.

2.1.2 Selection of test-circuit B. Test-circuit B is for monitoring test-specimens with a single set of contacts, for the opening of normally-closed contacts and false closures of normally-open contacts (see figure 310-3). Test-circuit B should not be used for openings or closings of less than 10 microseconds. Test-circuit B does not allow current in excess of 20 milliamperes or an open-circuit voltage in excess of 2-volts during monitoring; which insures that there will be no arcing, which will cause damage, to low-level and dry-circuit test specimens.

3. TEST SYSTEMS.

3.1 Test-circuit A. The test circuit shall be the thyratron circuit shown on figure 310-1 or an approved equivalent circuit. The values for R1, C1, and the suppressor grid-cathode voltage, controlled by R7, principally controls the firing of the thyratron and are so chosen that the thyratron will fire when the duration of the contact-opening exceeds the time-duration specified in the individual specification (see 4.3 and 5). For the longer time-durations, such as above 1 millisecond, it may be necessary to change the values of R2, R5, and R6.

a. To monitor normally-closed contacts, the normally-closed contacts are connected to BP1 and BP2, with switch S1 in the "normally-closed position". The grid of the thyratron is placed at ground potential. The cathode of the thyratron is at a positive potential (depending on the setting of R7), thus providing sufficient negative bias to cut the thyratron "off". Any contact chatter (opening of closed contacts) will cause the grid of the thyratron to rise exponentially to +150 volts at a rate determined by the preselected time constant of R1 and C1. As long as the contacts remain open, the grid potential will continue to rise. If the contacts remain "open" for longer than the specified interval, the grid potential rises to the point at which the thyratron conducts and ionizes, thus lighting DS1. Since, in a thyratron, the grid loses control of conduction as soon as the tube conducts, the contacts being monitored can reclose at any time thereafter without affecting the monitoring circuit. Thus, lamp DS1 will remain "on" until the thyratron is manually reset by operation of switch S2.

b. To monitor normally-open contacts for false closures, it is necessary to operate switch S1 to the "normally-open position", so that the connection between the +150 volts and the time-constant charging circuit is "open". When open contacts are connected to BP1 and BP2 and the connection is made, these contacts "close". At contact closure, voltage is applied to the charging circuit, starting a build-up in the same manner as described in (a) for normally-closed contacts. At the conclusion of the test, if lamp DS1 is "off", then there has been a no-chatter interval exceeding the specified duration; if the lamp is "on", then there was at least one-interval when the specified time-duration was exceeded. After an indication of failure, the thyratron circuit shall be restarted by operation of switch S2.

3.1.1 Calibration procedure for test-circuit A. The calibration-circuit shown on figure 310-2 may be used to calibrate the monitoring-circuit shown on figure 310-1 by using the following procedure:

a. Make the proper connections of the monitoring-circuit to the calibration-circuit as shown, and set switch S1 to position A.

b. Calibrate the oscilloscope triggering input as follows:

(1) Set switch S4 to position A, so that the trigger input is connected to the Y-axis input of the oscilloscope.

(2) Set the time-base control of the oscilloscope for approximately 20-percent of the time-duration for which the calibration is being made.

(3) Set the Y-amplitude of the oscilloscope for 1-volt per centimeter.

(4) Set the triggering coupling to ac sensitivity.

(5) Open the switch S3 and adjust the triggering level and stability control so that the trace on the oscilloscope will trigger at 0.5-volt or less. The closer the trigger-level is to zero, the greater the accuracy of calibration.

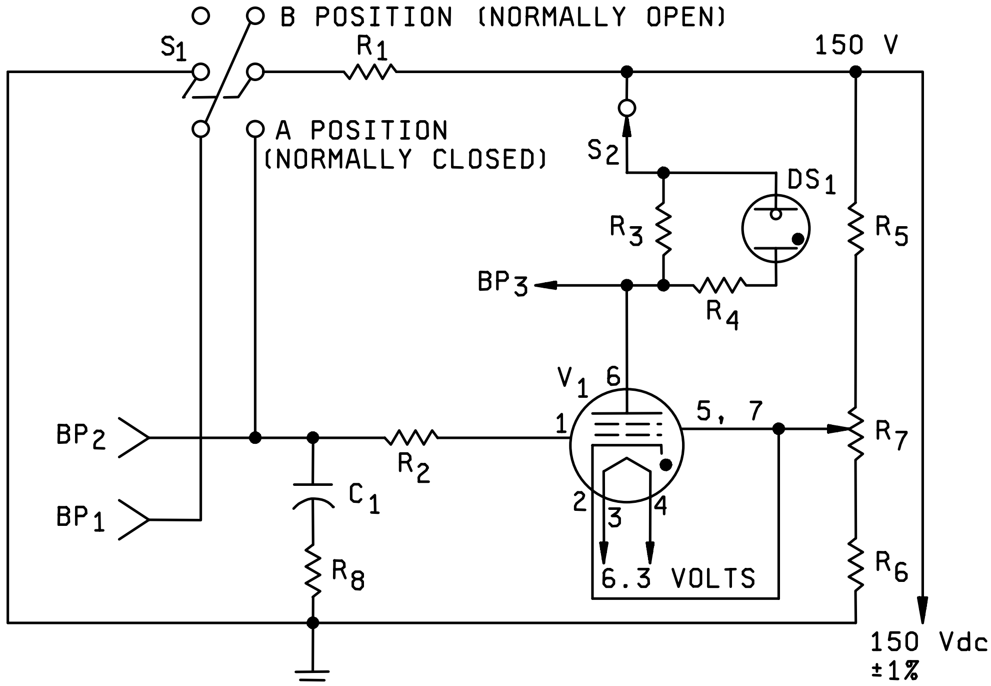
c. Set switch S4 to position B, so that the Y-axis input of the oscilloscope is connected through capacitor C4 to the plate of the thyratron in the test circuit.

d. Close switch S3.

e. Set the Y-amplitude of the oscilloscope for a usable display, and the time-base as in preceding (b) (2).

f. Depress monitor-circuit reset switch S2 of figure 310-1 to set the circuit in the "ready" position, i.e., with the circuit being calibrated and lamp DS1 extinguished.

g. Open switch S3; the observed trace of the oscilloscope should move across the screen at a positive amplitude until it is deflected downward by the negative pulse created when the thyratron fires. The time interval between the start of the trace and the negative pulse is the detection time. Adjust R7 of figure 310-1 to the time-duration specified in the individual specification.

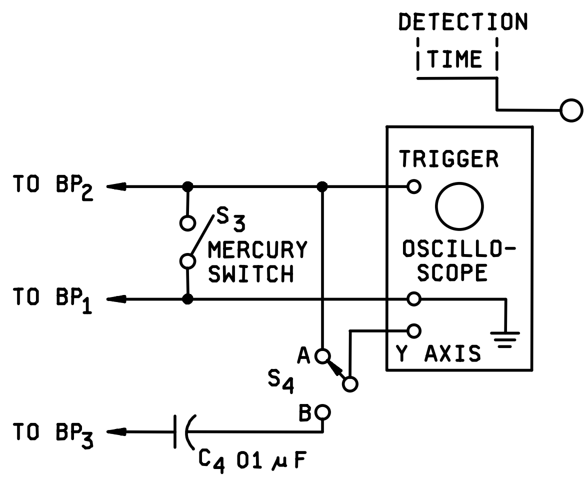


Resistors	Capacitors
R_1 - 35K 1/2W, 1% (see note 1)	C_1 - .0022µF, 600 VDCW (see note 1)
R_2 - 27K 1/2W, 5%	
R_3 - 47K 1W, 5%	Miscellaneous
R_4 - 200K 1/2W, 5%	
R_5 - 70K 1W, 5%	DS_1 - NE-51
R_6 - 2.4K 1W, 5%	S_1 - DPDT
R_7 - 5K 1W	S_2 - SPSTNC 125V 1 amp (push)
R_8 - 500 1/2W, 5%	V_1 - JAN-5727/2D21W

NOTES:

1. These values are to be chosen to obtain the desired time-duration for the applicable test condition (see 4.3). These particular values are applicable to 10 microseconds time-duration only.

FIGURE 310-1. Test-circuit A; monitor circuit for contact-opening and closing.



NOTE: The oscilloscope shall have an accuracy of ±3 percent or better on time base and have provision for external triggering.

FIGURE 310-2. Calibration circuit for test-circuit A.

3.2 Test circuit B. The monitor-circuit shown on figure 310-3 permits detection of contact-chatter of closed contacts and false closure of open contacts, independently or simultaneously. The low contact-load levels (see 2.1.2) insure that there will be no arcing of the contacts during monitoring.

a. The chatter portion of figure 310-3, resistors R3 and R4 form a voltage divider with their junction at +2 volts. The closed contacts of the component under test, short-circuit R4 and place the base of transistor amplifier Q1 to ground potential. When the contacts under test "chatter" (open), resistor R4 is no longer short-circuited and capacitor C1 starts to charge through R2 and R7 to +2 volts. The time necessary for C1 to charge to the correct bias-level is determined by the resistance of R2 and R7 and the capacitance value of C1. As transistor Q1 draws current through the gate of SCR1, the unit will fire and turn-on lamp DS1. Since in a silicon-controlled rectifier, the gate loses control after it is turned "on", the contacts can reclose at any time thereafter without affecting the monitoring circuit. The time-delay, before turn-on, can be adjusted by varying R2 and selecting the capacitance value of C1. (For example: C1 = .002 µF gives a 10-microsecond open-contact time.)

b. In the false-make portion of figure 310-3, transistor-amplifier Q2 is normally "on" with the gate of SCR2 being effectively held at ground potential by the low-output impedance of transistor Q2. When a "false-make" occurs, the base of Q2 transistor is grounded, turning Q2 "off". This allows the gate of the SCR2, which is tied to the collector of transistor Q2, to rise to +12 volts. The rate of increase is determined by the value of C2 and R8. (For example: C2 = .002 µF gives a 10-microsecond false-make time.) When the voltage reaches the gate turn-on level of SCR2, lamp DS2 will light, indicating a false closure of the open contacts.

c. When this circuit is being used to simultaneously monitor both the open and closed contacts of a double set of contacts:

(1) If DS1 "lights", it is an indication of contact chatter.

(2) If DS1 and DS2 "lights", it is an indication of false transfer or possible bridging, i.e., the movable contact of the open circuit "closes" but the closed circuit has not opened.

(3) If DS2 "lights", it is an indication of bridging.

d. Restoration of the circuit for an indication of failure is accomplished by the operation of S1.

3.2.1 Calibration procedure for test-circuit B. The calibration-circuit shown on figure 310-4 may be used to calibrate the monitoring-circuit shown on figure 310-3 by using the following procedure:

a. Make the proper connections of the monitoring-circuit to the calibration-circuit.

(1) BP1 and BP2 for contact-chatter calibration.

(2) BP1 and BP3 for false contact-make calibration.

b. Select the appropriate 5 volt square-wave "pulse-polarity" and "pulse-width" to be furnished by the pulse generator and monitor the pulse on the oscilloscope, as follows:

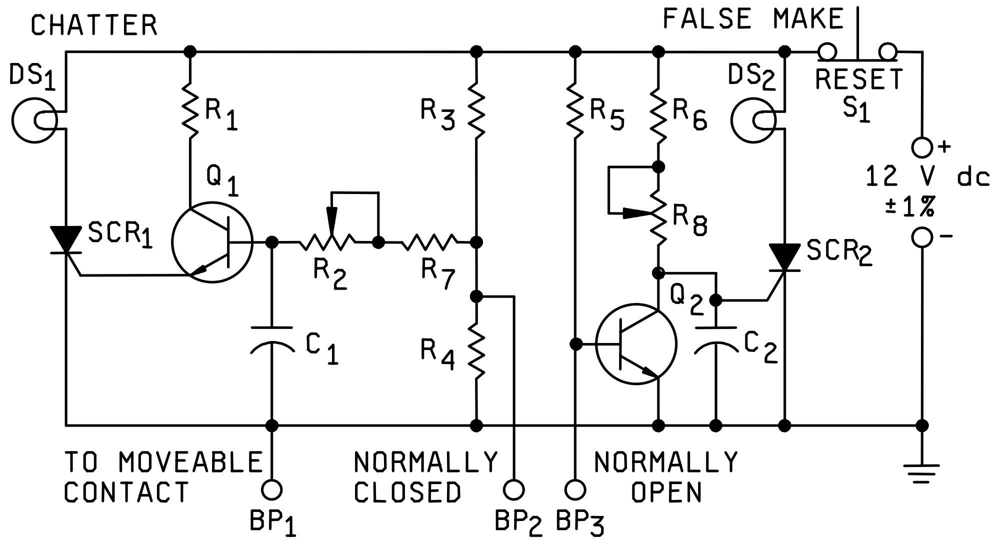
(1) For contact-chatter calibration: Negative pulse.

(2) For false contact-make calibration: Positive pulse.

(3) Pulse width for either of the preceding (1) or (2) equal to the required detection time.

c. If DS1 or DS2 (as applicable) "lights", adjust R2 or R8 until the light is extinguished.

d. Slowly adjust R2 and R8 (as applicable) to the time-duration specified in the individual specification, as indicated by the first point at which DS1 or DS2 "lights".

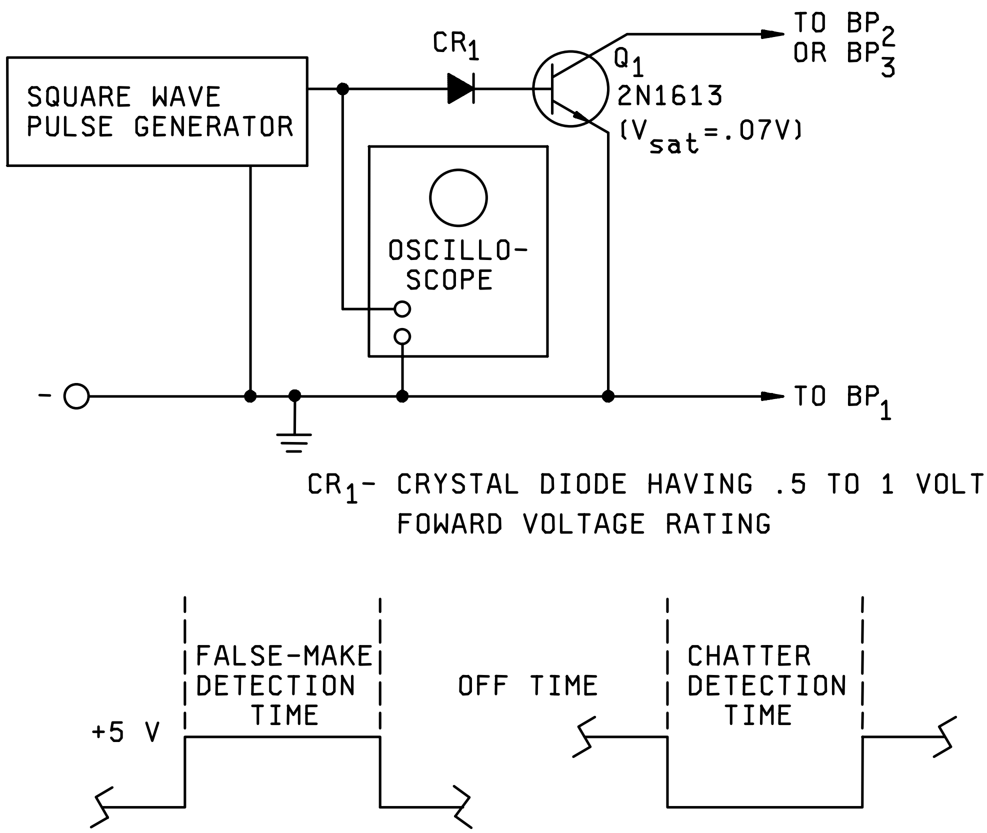


C_1, C_2	- Choose for specified time (see note 1)	R_6	- 1,000 ohms 1/4W, 5%
DS_1, DS_2	- No. 344 Lamp	R_7	- 100 ohms 1/4W, 5%
R_1	- 750 ohms 1/4W, 5%	R_8	- 200 ohms pot.
R_2	- 2,000 ohms pot.	Q_1, Q_2	- 2N332A or equivalent
R_3, R_5	- 10,000 ohms 1/4W, 5%	SCR_1, SCR_2	- 2N1595 or equivalent
R_4	- 2,500 ohms 1/4W, 5%	S_1	- SPST NC Push

NOTE:

1. Use .0022 µF for 10 microsecond time-duration. Other time-duration will require larger capacitors.

FIGURE 310-3. Test-circuit B; monitor circuit for contact-chatter and false closures.



NOTES:
1. The square-wave pulse generator and oscilloscope shall have an accuracy of ±3 percent or better.
2. The ratio of off-time to detection-time shall be 10:1 or better.

FIGURE 310-4. Calibration circuit for test-circuit B.

4. PROCEDURE.

4.1 Preparation. The monitor-circuits of figures 310-1 and 310-3 shall be calibrated, immediately prior to use, using the applicable calibration-circuit (see figures 310-2 and 310-4, respectively). The calibration-circuit shall then be disconnected from the monitoring-circuit.

4.2 Points of connection. The contacts of the test-specimen being monitored shall be connected to points BP1 and BP2 for test circuit A for both contact-chatter and false-make contact conditions. For test circuit B, the points of connection shall be BP1 and BP2 for contact-chatter condition and to points BP1 and BP3 for false-make contact condition. The test specimen shall then be subjected to the shock, vibration, acceleration, or other environmental test during which this contact-chatter monitoring test method is to be used. If specified in the individual specification, test specimens having normally-closed contacts may be wired in series to monitor for opening of contacts, and those having normally-open contacts may be wired in parallel to monitor for closing of contacts. In this case, if contact opening or closing is indicated, it will then be necessary to reset each test specimen separately and monitor it individually to determine which one is defective.

4.3 Test conditions. Test specimens shall be subjected to one of the following test conditions, as specified in the individual specification:

Test condition	Time duration
A	10 microseconds
B	100 microseconds
C	1 millisecond
D	5 milliseconds
E	20 milliseconds

5. SUMMARY. The following details are to be specified in the individual specification:

a. Test circuit letter (see 2.1, 3.1, and 3.2).

b. Test condition letter for maximum allowable time-duration of contact-opening or closing, as applicable (see 4.3).

c. Whether series-connection (of normally-closed contact test-specimens) or parallel-connection (of normally-open contact test-specimens) may be allowed (see 4.2).

METHOD 311

LIFE, LOW LEVEL SWITCHING

1. PURPOSE. This test is conducted for the purpose of determining electrical contact reliability under low-level switching conditions in the environment in which the contacts operate. A low level switching circuit is one in which the voltage and stored energy are sufficiently small so that the resistance of a pair of contacts is not affected by electrical phenomena associated with the electrical current flow or the switching. Such a circuit is also one where the voltage or the current is too low to cause any physical change in the contacts; contact resistance can only be affected by changes in the contacts caused by mechanical action on the contacts. Electrical loads, which result in arcing across electrical contacts, affect contact surfaces in many ways, mostly favorable to reduction of contact resistance, since insulating films and small rough raised areas on the contact are burned away or melted down, to reform as a more even and larger contact surface. Under low-level conditions, the advantages, as well as the occasional disadvantages of this arcing will be absent. If low-level loads and intermediate or power loads are to be applied to different pairs of contacts on the same component part simultaneously, reliability of the low-level conditions can be impaired due to deposition of foreign materials resulting from vaporization surrounding the contacts operating at larger loads in the same enclosure or in an adjacent area, because of this fact, and because low-level contacts may develop films as a function of their environment, the contacts are tested in an environment similar to that in which they are used. This test in no way reflects the contact capability in the intermediate or "minimum" current area and shall not be considered as a substitute for testing in this area when specified.

2. APPARATUS.

2.1 Test circuit. Monitoring of the contact resistance of each pair of contacts shall be accomplished on each cycle. A separate monitoring indicator shall be used for each pair of contacts. The apparatus, which cyclically operates the contacts, shall be capable of automatically cycling the contacts at the rate specified. The power source for the open-circuit voltage shall not exceed 30 millivolts dc maximum or peak ac at 10 milliamperes (mA) maximum. Open-circuit voltage is defined as the voltage that would appear at the contacts, when the circuit is energized and when the contacts are open. One means of generating this voltage is to pass a stable adjustable current through a low-ohmage resistor (such as a shunt resistor for an ammeter). This means will provide the low impedance, low voltage, controllable, and well defined voltage source necessary. The current shall be adjusted so that the current through the pair of contacts, when closed is limited to 10 milliamperes, maximum.

2.2 Monitoring apparatus. The monitoring apparatus shall be capable of indicating resistances greater than a particular value, as specified. Care should be exercised so as to minimize any loading effects by the monitoring apparatus such as current surges as a result of shunt capacitance of shield wire or instrumentation current to the monitoring indicator. During each closure, the contact potential shall be monitored for at least 50 percent of the time contacts are closed. The apparatus shall provide and record, either manually or automatically, the following information:

a. Number of contact closures with contact load applied.

b. If required, number of times the contacts have performed as specified prior to the first failure to perform as specified.

c. Number of times the contacts have failed to perform as specified, i.e., the number of "misses".

d. Sticking of contacts, when in the "open" condition, unless otherwise specified. Sticking of contacts shall be defined as failure to reach 90 percent of the open-circuit voltage.

3. PROCEDURE. Each pair of contacts shall be operated for the number of cycles specified at the specified cycling rate with the required test load (see 2) applied. The contact resistance shall be continuously monitored using the apparatus in 2.1 and 2.2.

4. SUMMARY. The following details are to be specified in the individual specification:

a. If applicable, specify environment, e.g., temperature, humidity, pressure, composition of atmosphere, and any other special environmental conditions (see 1).

b. Number of "misses" allowed which will be considered a failure (see 2).

c. Maximum contact resistance allowed (see 2.1).

d. If monitoring of contacts for sticking is not applicable (see 2.2).

e. Number of cycles of operation and cycling rate (see 3).

METHOD 312

INTERMEDIATE CURRENT SWITCHING

1. PURPOSE. This test is conducted for the purpose of determining the electrical contact reliability of such items as electromechanical relays, switches, etc., under intermediate current (formerly known as "minimum current") switching conditions under which the contacts operate. An intermediate current switching circuit is one in which there is insufficient voltage and stored energy to cause contact arcing during opening or closing of mating contacts, but which have sufficient energy to cause melting of the contact material. Normal arcing of contacts at rated load levels often act to burn off any oxide or other film on the contacts or provide localized melting at the point of contact, so that contact resistance does not rise drastically. Without this arcing of the contacts, oxides and other contaminant films can build up on contacts in component parts which have not been sealed adequately or which have contaminating materials and vapors trapped within the enclosure due to improper manufacturing techniques. Such contacts will develop unacceptably high contact resistance under intermediate current loads, unless the contact force and wipe are sufficiently heavy to overcome any effect of contamination. Intermediate current switching is the range in which a large percentage of loads occur. Therefore, it is extremely important that an intermediate current switching test be imposed on all electromechanical relays and switches, which are to be used in this range. Relays and switches, which pass both low level and full rated load tests, frequently fail when used in the intermediate current switching range.

2. PRECAUTIONS. Full rated load and low level life tests are not a substitute for the intermediate current switching test. Successful testing at low level and full rated loads in no way reflects the capability of the relay or switch at intermediate current loads. Statements or titles for component parts, such as "low level to full rated load" shall not be used in specifications, unless intermediate current switching capability has been demonstrated by the requirement for testing by this method.

CAUTION: A low-level run-in test is not equivalent to intermediate current testing and conversely intermediate current capability does not indicate low level capability.

3. APPARATUS.

3.1 Test circuit. Monitoring of the specified contact resistance of each pair of mating contacts shall be accomplished on each cycle. Each contact shall be monitored on each closure. The apparatus, which cyclically operates the contacts, shall be capable of automatically cycling the contacts at the rate specified. Resistive load voltage shall be applied to the contacts and shall be 3.0 V dc to 10.0 V dc at 100 $\pm$10.0 milliamperes (mA) such as by means of a well regulated power supply which will provide the low voltage, controllable, and well defined voltage source. Voltage, when required to energize coils in order to actuate the contacts, shall be as specified. Both normally open and normally closed contacts of double-throw switching parts shall be tested. Multipole contacts shall be connected with all normally open pairs of contacts loaded and all normally closed pairs of contacts loaded.

3.2 Monitoring apparatus. The monitoring apparatus shall be capable of indicating resistances greater than a particular value specified. During each closure, the contact potential shall be monitored 10 milliseconds (ms) or more after the end of specified contact bounce. The apparatus shall provide and record either manually or automatically, the following information:

a. Number of contact closures with contact load applied.

b. If required, number of times contacts have performed as specified prior to failure to perform as specified.

c. Sticking of contacts, when intended to be in the "open" condition, unless otherwise specified. Sticking of contacts shall be defined as any failure of closed contacts to open as required during the cycling, or indication across such contacts of less than 90 percent of the applied open-circuit contact voltage.

4. PROCEDURE. Each pair of contacts shall be operated for 25,000 cycles (see note below) at the specified cycling rate. The duty cycle shall be approximately 50 percent "on" and 50 percent "off". The component parts shall be tested in a temperature chamber at the rated maximum ambient operating temperature with the required test load (see 3.1). When specified, the final half of the test cycles shall be tested at room ambient temperature. Each pair of contacts shall be individually monitored on each operation for failure-to-break (FTB) and for failure-to-make (FTM) the test load, using the apparatus in 3.1 and 3.2. FTB shall be defined as a voltage drop across the contacts of less than 90 percent of the applied voltage when the contacts are intended to be open. FTM shall be defined as a voltage drop across the contacts greater than 0.1 times the maximum allowable contact resistance (in ohms), when the contacts are intended to be closed. The voltage drop across the contacts shall be monitored for at least 50 percent of the time the contacts are closed and for at least 50 percent of the time the contacts are open, unless the monitoring apparatus can be demonstrated to be capable of settling to a stable reading in a shorter period of time. Any FTB or FTM shall either be recorded or shall automatically stop the actuating apparatus.

NOTE: Because the test is conducted for only 25,000 operations, it must not be inferred that the relays or switches, so tested, are suitable for only 25,000 operations in the intermediate current range. Quite the contrary, if the 25,000 operations test is passed satisfactorily, the relays or switches can be expected to be capable of switching intermediate current loads well beyond the full rated load life cycles specified.

5. SUMMARY. The following details are to be specified in the individual specification:

a. Maximum contact resistance allowed (see 3.1).

b. Coil energizing voltage (see 3.1).

c. Cycling rate (see 3.1).

d. Contact bounce, if applicable (see 3.2).

e. If monitoring of contacts for sticking is not applicable (see 3.2c).

f. Whether final half of cycles is to be tested at room ambient temperature (see 4).

g. Rated maximum operating ambient temperature (see 4).

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.

2. The submitter of this form must complete blocks 4, 5, 6, and 7, and send to preparing activity.

3. The preparing activity must provide a reply within 30 days from receipt of the form.
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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-STD-202G	2. DOCUMENT DATE (8 February 2002)

3. DOCUMENT TITLE
TEST METHOD STANDARD, ELECTRONIC AND ELECTRICAL COMPONENT PARTS

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

5. REASON FOR RECOMMENDATION

6. SUBMITTER

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

8. PREPARING ACTIVITY

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c. ADDRESS (Include Zip Code) Defense Supply Center Columbus P.O. BOX 3990 Columbus, OH 43216-5000	IF YOU DO NOT RECEIVE A REPLY WITHIN 45 DAYS, CONTACT: Defense Standardization Program Office Attn: J-330, Suite 4235 8725 John J. Kingman Road Fort Belvoir, Virginia 22060-6221 Telephone (703) 767-6888 DSN 427-6888