

**MIL-STD-202B**

**14 March 1960**

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**SUPERSEDING**

**MIL-STD-202A**

**24 October 1956**

**MILITARY STANDARD**

**TEST METHODS FOR ELECTRONIC  
AND ELECTRICAL COMPONENT PARTS**



**UNITED STATES  
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**MIL-STD-202B**  
**Notice 4**  
**24 September 1962**

**SUPERSEDING**  
**Notice 3**  
**18 May 1962**

**MILITARY STANDARD**

**TEST METHODS FOR ELECTRONIC AND  
 ELECTRICAL COMPONENT PARTS**

**TO ALL ACTIVITIES:**

1. The following page of MIL-STD-202B has been revised and supersedes the page listed below:

<i>New page</i>	<i>Date</i>	<i>Superseded page</i>	<i>Date</i>
3	24 Sep 1962	3 (Numerical Index of Test Methods)	18 May 1962

2. The following methods are to be added:

<i>New methods</i>	<i>Date</i>
210	24 Sep 1962
211	30 July 1962

3. The following is a cumulative list of earlier changes:

<i>New page</i>	<i>Date</i>	<i>Superseded page</i>	<i>Date</i>
3	18 May 1962	3 (Numerical Index of Test Methods)	4 April 1962
3	4 April 1962	3 (Numerical Index of Test Methods)	29 November 1961
3	29 November 1961	3 (Numerical Index of Test Methods)	14 March 1960
4	4 April 1962	4 (Method 106A)	31 May 1957
3	4 April 1962	3 (Method 109)	14 March 1960
2	4 April 1962	2 (Method 202A)	24 October 1956
	<i>New methods</i>		<i>Date</i>
	112		4 April 1962
	111		29 November 1961
	208		29 November 1961
	209		18 May 1962
	308		29 November 1961

4. Retain this notice and insert before the table of contents.

5. Holder of MIL-STD-202B will verify that Page changes and new methods indicated above have been entered and will destroy the previous notice. Activities which stock these notices for issue are warned that each notice, together with its appended revised pages, is in effect a separate publication to be retained until the military standard is completely revised or canceled.

**MIL-STD-202B**

Notice 3  
18 May 1962

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SUPERSEDING  
Notice 2  
4 April 1962

**MILITARY STANDARD**

**TEST METHODS FOR ELECTRONIC AND  
ELECTRICAL COMPONENT PARTS**

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1. The following page of MIL-STD-202B has been revised and supersedes the page listed below:

<i>New page</i>	<i>Date</i>	<i>Superseded page</i>	<i>Date</i>
8	18 May 1962	8 (Numerical Index of Test Methods)	4 April 1962

2. The following method is to be added:

<i>New method</i>	<i>Date</i>
209	18 May 1962

3. The following is a cumulative list of earlier changes:

<i>New page</i>	<i>Date</i>	<i>Superseded page</i>	<i>Date</i>
8	4 April 1962	8 (Numerical Index of Test Methods)	29 November 1961
8	29 November 1961	8 (Numerical Index of Test Methods)	14 March 1960
4	4 April 1962	4 (Method 106A)	31 May 1957
3	4 April 1962	3 (Method 109)	14 March 1960
2	4 April 1962	2 (Method 202A)	24 October 1956

<i>New methods</i>	<i>Date</i>
112 .....	4 April 1962
111 .....	29 November 1961
208 .....	29 November 1961
308 .....	29 November 1961

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 Notice 1  
 29 November 1961

MILITARY STANDARD

TEST METHODS FOR ELECTRONIC AND  
 ELECTRICAL COMPONENT PARTS

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8	29 November 1961	8	14 March 1960

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111	29 November 1961
208	29 November 1961
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2. Retain this notice and insert before the table of contents.

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**14 March 1960**

**ARMED FORCES SUPPLY SUPPORT CENTER**  
**WASHINGTON 25, D. C.**

**Test Methods for Electronic  
and Electrical Component Parts**  
**MIL-STD-202B**

**14 March 1960**

- 1. This standard has been approved by the Department of Defense and is mandatory for use by the Departments of the Army, the Navy, and the Air Force, effective 14 March 1960.**
- 2. In accordance with established procedure, the Signal Corps, Bureau of Ships, and Air Force have been designated as Army-Navy-Air Force custodians of this standard.**
- 3. Recommended corrections, additions, or deletions should be addressed to the Standardization Division, Armed Forces Supply Support Center, Tempo X, Washington 25, D. C.**

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## 1. INTRODUCTION

**1.1 Scope.** This standard establishes uniform methods for testing electronic and electrical component parts, including basic environmental tests to determine resistance to deleterious effects of natural elements and conditions surrounding military operations, and physical and electrical tests. For the purpose of this standard, the term "component parts" includes such items as capacitors, resistors, switches, relays, transformers, and jacks. This standard is intended to apply only to small parts, such as transformers and inductors, weighing up to 300 pounds or having a root-mean-square test voltage up to 50,000 volts unless otherwise specifically invoked. The test methods described herein have been prepared to serve several purposes:

- (a) To specify suitable conditions obtainable in the laboratory which give test results equivalent to the actual service conditions existing in the field, and to obtain reproducibility of the results of tests. The tests described herein are not to be interpreted as an exact and conclusive representation of actual service operation in any one geographic location, since it is known that the only true test for operation in a specific location is an actual service test at that point.
- (b) To describe in one standard all of the test methods of a similar character which now appear in the various joint-services electronic and electrical component-parts specifications, so that these methods may be kept uniform and thus result in conservation of equipment, man-hours, and testing facilities. In achieving this objective, it is necessary to make each of the general tests

adaptable to a broad range of electronic and electrical component parts.

- (c) The test methods described herein for environmental, physical, and electrical testing of electrical and electronic parts shall also apply, when applicable, to parts not covered by an approved military specification, military sheet-form standard, specification sheet, or drawing.

**1.2 Numbering system.** The test methods are designated by numbers assigned in accordance with the following system:

**1.2.1 Class of tests.** The tests are divided into three classes: Test methods numbered 101 to 199, inclusive, cover environmental tests; those numbered 201 to 299, inclusive, cover physical-characteristics tests; and those numbered 301 to 399, inclusive, cover electrical-characteristics tests. Within each class, test methods are serially numbered in the order in which they are introduced into this standard.

**1.2.2 Revision of test methods.** Revisions of test methods are indicated by a letter following the method number. For example, the original number assigned to the temperature-cycling test method is 102; the first revision of that method is 102A, the second revision, 102B, etc.

**1.3 Method of reference.** When applicable, test methods contained herein shall be referenced in the individual specification by specifying this standard, the method number, and the details required in the summary paragraph of the applicable method. To avoid the necessity for changing specifications which refer to this standard, the letter following the method number shall not be used when referencing test methods. For example, use 102, not 102A.

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## 2. GENERAL REQUIREMENTS

**2.1 Test requirements.** The requirements which must be met by the component parts subjected to the test methods described herein are specified in the individual specifications, as applicable, and the tests shall be applied as specified therein. Whenever this standard conflicts with the individual specification, the latter shall govern.

**2.2 Test conditions.** Unless otherwise specified herein, or in the individual specification, all measurements and tests shall be made at room ambient temperature, atmospheric pressure, and relative humidity. Whenever these conditions must be closely controlled in order to obtain reproducible results, reference temperature, relative humidity, and atmospheric pressure conditions of 23°C. (73.4°F.), 50 percent, and 30 inches of mercury respectively, shall be specified, together with whatever tolerances are required to obtain the desired precision of measurement.

**2.2.1 Permissible temperature variation in environmental chambers.** When chambers are used, specimens under test shall be located only within the working area defined as follows:

- (a) **Time variation within working area:** The controls for the chamber shall be capable of maintaining the temperature of any single reference point within the working area within  $\pm 2^{\circ}\text{C}$ .
- (b) **Space variation within working area:** Chambers shall be so constructed that, at any given time, the temperature of any point within the working area shall not deviate more than  $3^{\circ}\text{C}$ . from the reference point, except for the immediate vicinity of specimens generating heat.

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### 3. NUMERICAL INDEX OF TEST METHODS

Method No.	Date	Title
<i>Environmental tests</i> (100 class)		
101A	24 Oct. 1956	Salt spray (corrosion).
102A	24 Oct. 1956	Temperature cycling.
103A	24 Oct. 1956	Humidity (steady state).
104A	24 Oct. 1956	Immersion.
105B	14 Mar. 1960	Barometric pressure
106A	31 May 1957	Moisture resistance.
107A	14 Mar. 1960	Thermal shock
108	14 Mar. 1960	Life (at elevated ambient temperature).
109	14 Mar. 1960	Explosion
110	14 Mar. 1960	Sand and dust.
111	29 Nov. 1961	Flammability (external flame).
112	4 Apr. 1962	Seal.
<i>Physical-characteristics tests</i> (200 class)		
201A	24 Oct. 1956	Vibration.
202A	24 Oct. 1956	Shock (specimens weighing not more than 4 pounds).
203	24 Oct. 1956	Random drop.
204A	14 Mar. 1960	Vibration, high frequency.
205B	24 Apr. 1959	Shock, medium impact.
206	14 Mar. 1960	Life (rotational).
207	14 Mar. 1960	High-impact shock.
208	29 Nov. 1961	Solderability.
209	18 May 1962	Radiographic inspection.
210	24 Sep. 1962	Resistance to soldering heat.
211	30 July 1962	Terminal strength.
<i>Electrical-characteristics tests</i> (300 class)		
301	6 Feb. 1956	Dielectric withstanding voltage.
302	6 Feb. 1956	Insulation resistance.
303	6 Feb. 1956	DC resistance.
304	24 Oct. 1956	Resistance-temperature characteristic.
305	24 Oct. 1956	Capacitance.
306	24 Oct. 1956	Quality factor (Q).
307	24 Oct. 1956	Contact resistance.
308	29 Nov. 1961	Current-noise test for fixed resistors.

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

(Copies of this standard for military use may be obtained as indicated in the foreword to, or the general provisions of, the Index of Military Specifications and Standards.)

(The title and identifying symbol should be stipulated when requesting copies of military standards.)

Notice. When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

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 Army—SigC

Supersedes page 3, 18 May 1962.

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## METHOD 101A SALT SPRAY (CORROSION)

1. **Purpose.** The salt-spray test, in which specimens are subjected to a fine mist of salt solution, has several more or less useful purposes when utilized with full recognition of its deficiencies and limitations. Originally proposed as an accelerated laboratory corrosion test simulating the effects of seacoast atmospheres on metals, with or without protective coatings, this test has been erroneously considered by many as an all-purpose accelerated corrosion test, which if "withstood successfully" will guarantee that metals or protective coatings will prove satisfactory under any corrosive condition. Experience has since shown that there is seldom a direct relationship between resistance to salt-spray corrosion and resistance to corrosion in other media, even in so-called "marine" atmospheres and ocean water. However, some idea of the relative service life and behavior of different samples of the same (or closely related) metals or of protective coating-base metal combinations in marine and exposed seacoast locations can be gained by means of the salt-spray test, provided accumulated data from correlated field service tests and laboratory salt-spray tests show that such a relationship does exist, as in the case of aluminum alloys. (Such correlation tests are also necessary to show the degree of acceleration, if any, produced by the laboratory test.) The salt-spray test is generally considered unreliable for comparing the general corrosion resistance of different kinds of metals or coating-metal combinations, or for predicting their comparative service life. The salt-spray test has received its widest acceptance as a test for evaluating the uniformity (specifically, thickness and degree of porosity) of protective coatings, metallic and nonmetallic, and has served this purpose with varying amounts

of success. In this connection, the test is useful for evaluating different lots of the same product, once some standard level of performance has been established. The salt-spray test is especially helpful as a screening test for revealing particularly inferior coatings. When used to check the porosity of metallic coatings, the test is more dependable when applied to coatings which are cathodic rather than anodic toward the basic metal. This test can also be used to detect the presence of free iron contaminating the surface of another metal, by inspection of the corrosion products. The test is essentially the same as the salt-spray (fog) test described in Federal Specification QQ-M-151a, Metals; General Specification for Inspection of.

2. **Apparatus.** Apparatus used in the salt-spray test shall include the following:

- (a) Exposure chamber with racks for supporting specimens.
- (b) Salt-solution reservoir.
- (c) Means for atomizing the salt solution, including suitable nozzles and compressed-air supply.
- (d) Chamber-heating means and control.
- (e) Means for humidifying the air at a temperature above the chamber temperature.

2.1 **Chamber.** The chamber and all accessories shall be made of material which will not affect the corrosiveness of the fog, such as glass, hard rubber, plastic, or wood other than plywood. In addition, all parts which come in contact with test specimens shall be

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of materials that will not cause electrolytic corrosion. The chamber and accessories shall be so constructed and arranged that there is no direct impinging of the spray or dripping of the condensate on the specimens, so that the spray circulates freely about all specimens to the same degree, and so that no liquid which has come in contact with the test specimens returns to the salt-solution reservoir. The chamber shall be properly vented.

**2.2 Atomizers.** The atomizer or atomizers used shall be of such design and construction as to produce a finely divided, wet, dense fog.

**2.3 Air supply.** The compressed air entering the atomizers shall be free from all impurities such as oil and dirt. Means shall be provided to humidify and warm the compressed air as required to meet the operating conditions. The air pressure shall be suitable to produce a finely divided dense fog with the atomizer or atomizers used. To insure against clogging the atomizers by salt deposition, the air should have a relative humidity of at least 85 percent for the 20-percent solution and between 95 and 98 percent for the 5-percent solution at the point of release from the nozzle. A satisfactory method is to pass the air in very fine bubbles through a tower containing heated water. The temperature of the water should be 95°F. (35°C.) and often higher. The permissible temperature increases with increasing volume of air and with decreasing heat insulation of the chamber and temperature of its surroundings. It should not exceed a value above which an excess of moisture is introduced into the chamber (for example, 110°F. (43.3°C.) at an air pressure of 12 pounds per square inch), or a value which makes it impossible to meet the requirement for operating temperature.

**3. Salt solution.** The salt-solution concentration shall be 20 percent or 5 percent, as specified. When no solution concentration is specified, the 20-percent solution shall be used. The salt used shall be sodium chloride containing on the dry basis not more than 0.1 percent of sodium iodide, and not more than 0.3 percent of total impurities. The 20-percent solution shall be prepared by dissolving  $20 \pm 2$  parts by weight of salt in 80 parts by weight of distilled or other water. The 5-percent solution shall be prepared by dissolving  $5 \pm 1$  parts by weight of salt in 95 parts by weight of distilled or other water. Distilled or other water used in the preparation of solutions shall contain not more than 200 parts per million of total solids. The solution shall be kept free from solids by filtration or decantation. The solution shall be adjusted to and maintained at a specific gravity of from 1.126 to 1.157 for the 20-percent solution and 1.0268 to 1.0413 for the 5-percent solution. The pH shall be maintained between 6.5 and 7.2 when measured at a temperature between 93° and 97°F. (33.9° and 36.1°C.). Only cp grade hydrochloric acid or sodium hydroxide shall be used to adjust the pH. The pH measurement shall be made electrometrically using a glass electrode with a saturated potassium-chloride bridge or by a colorimetric method such as bromo-thymol blue, provided the results are equivalent to those obtained with the electrometric method.

**4. Preparation of specimens.** Specimens shall be given a minimum of handling, particularly on the significant surfaces, and shall be prepared for test immediately before exposure. Unless otherwise specified, uncoated metallic or metallic-coated specimens shall be thoroughly cleaned of oil, dirt, and grease as necessary until the surface is free from water break. The cleaning methods shall not include the use of corrosive solvents

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nor solvents which deposit either corrosive or protective films, nor the use of abrasives other than a paste of pure magnesium oxide. Specimens having an organic coating shall not be solvent cleaned. Those portions of specimens which come in contact with the support and, unless otherwise specified in the case of coated specimens or samples, cut edges and surfaces not required to be coated, shall be protected with a suitable coating of wax or similar substance impervious to moisture.

## 5. Procedure

**5.1 Location of specimens.** Unless otherwise specified, flat specimens and, where practicable, other specimens shall be supported in such a position that the significant surface is approximately  $15^\circ$  from the vertical and parallel to the principal direction of horizontal flow of the fog through the chamber. Other specimens shall be positioned so as to insure most uniform exposure. Whenever practicable, the specimens shall be supported from the bottom or from the side. When specimens are suspended from the top, suspension shall be by means of glass or plastic hooks or wax string; if plastic hooks are used, they shall be fabricated of material which is nonreactive to the salt solution such as lucite. The use of metal hooks is not permitted. Specimens shall be positioned so that they do not contact each other, so that they do not shield each other, from the freely settling fog, and so that corrosion products and condensate from one specimen do not fall upon another.

## 5.2 Operating conditions.

**5.2.1 Temperature.** The test shall be conducted with a temperature in the exposure zone maintained at  $95^\circ \pm 2^\circ$  F. ( $35^\circ \pm 1.1^\circ$  C.). Satisfactory methods for controlling the

temperature accurately are by housing the apparatus in a properly controlled constant-temperature room, by thoroughly insulating the apparatus and preheating the air to the proper temperature prior to atomization, and by jacketing the apparatus and controlling the temperature of the water or of the air used. The use of immersion heaters for the purpose of maintaining the temperature within the chamber is prohibited.

**5.2.2 Atomization.** The conditions maintained in all parts of the exposure zone shall be such that a suitable receptacle placed at any point in the exposure zone will collect from 0.5 to 3.0 milliliters of solution per hour for each 80 square centimeters of horizontal collecting area (10 centimeters diameter) based on an average run of at least 16 hours. When the 20-percent solution is used, the solution thus collected shall have a sodium-chloride content of from 18 to 22 percent (specific gravity of from 1.126 to 1.157 when measured at a temperature between  $93^\circ$  and  $97^\circ$  F. ( $33.9^\circ$  and  $36.1^\circ$  C.)). When the 5-percent solution is used, the solution thus collected shall have a sodium-chloride content of from 4 to 6 percent (specific gravity of from 1.0268 to 1.0413 when measured at a temperature between  $93^\circ$  and  $97^\circ$  F. ( $33.9^\circ$  and  $36.1^\circ$  C.)). At least two clean fog-collecting receptacles shall be used, one placed near any nozzle and one placed as far as possible from all nozzles. Receptacles shall be fastened so that they are not shielded by specimens and so that no drops of solution from specimens or other sources will be collected. With nozzles made of material nonreactive to the salt solution, suitable atomization has been obtained in boxes having a volume of less than 12 cubic feet with the following conditions:

- (a) Nozzle pressure of from 12 to 18 pounds per square inch.

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- (b) Orifices of from 0.02 to 0.03 inch in diameter.
- (c) Atomization of approximately 3 quarts of the salt solution per 10 cubic feet of box volume per 24 hours.

When using large-size boxes having a volume considerably in excess of 12 cubic feet, the above conditions may have to be modified in order to meet the requirements for operating conditions.

**5.3 Length of test.** The length of the salt-spray test shall be that indicated in one of the following test conditions, as specified:

<i>Test condition</i>	<i>Length of test</i>
A .....	96 hours
B .....	48 hours

Unless otherwise specified, the test shall be run continuously for the time indicated or until definite indication of failure is observed, with no interruption except for ad-

justment of the apparatus and inspection of the specimen.

**6. Measurements.** At the completion of the exposure period, measurements shall be made as specified. To aid in examination, specimens shall be prepared in the following manner, unless otherwise specified: Salt deposits shall be removed by a gentle wash or dip in running water not warmer than 100°F. (37.8°C.) and a light brushing, using a soft-hair brush or plastic-bristle brush.

**7. Summary.** The following details must be specified in the individual specification:

- (a) Applicable salt solution (see 3).
- (b) Special mounting and details, if applicable (see 5.1).
- (c) Test-condition letter (see 5.3).
- (d) Measurements after exposure (see 6).

**METHOD 101A**  
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TEMPERATURE CYCLING

1. **Purpose.** This test is conducted for the purpose of determining the resistance of a part to the shock of repeated surface exposures to extremes of high and low temperatures for comparatively short periods of time, such as would be experienced when equipment or parts are transferred to and from heated shelters in arctic areas. These conditions may also be encountered in equipment operated intermittently in low-temperature areas. It is not required that the specimen reach thermal stability at the temperature of the test chamber during the short exposure time specified. Permanent changes in operating characteristics and physical damage produced during temperature cycling result principally from variations in dimensions and other physical properties, and from alternate condensation and freezing of atmospheric moisture. Effects of temperature cycling include cracking and delamination of finishes, embedding compounds, and other materials, opening of terminal seals and case seams, and changes in electrical characteristics due to moisture effects or to mechanical displacement of conductors or of insulating materials.

2. **Apparatus.** Separate chambers shall be used for the extreme temperature conditions of steps 1 and 3. The air temperature of the two chambers shall be held at each of the extreme temperatures by means of circulation and sufficient hot- or cold-chamber thermal capacity so that the ambient temperature shall reach the specified temperature within 2 minutes after the specimens have been transferred to the appropriate chamber.

3. **Procedure.** Specimens shall be placed in such a position with respect to the air

stream that there is substantially no obstruction to the flow of air across and around the specimen. When special mounting is required, it shall be specified. The specimen shall then be subjected to the specified test condition of table 102-1, for a total of five cycles performed continuously. Specimens shall not be subjected to forced circulating air while being transferred from one chamber to another. Direct heat conduction to the specimen should be minimized.

TABLE 102-1. Temperature-cycling test conditions

Test condition A <sup>1</sup> (not preferred)			Test condition B <sup>1</sup> (not preferred)	
Step	Temperature	Time	Temperature	Time
	°C.	Minutes	°C.	Minutes
1 . . . .	85 +3 —0	30	65 +3 —0	30
2 . . . .	25 +10 —5	10 to 15	25 +10 —5	10 to 15
3 . . . .	—55 +0 —3	30	—55 +0 —3	30
4 . . . .	25 +0 —5	10 to 15	25 +10 —5	10 to 15
Test condition C (preferred)			Test condition D (preferred)	
	°C.	Minutes	°C.	Minutes
1 . . . .	—65 +0 —5	30	—55 +0 —3	30
2 . . . .	25 +10 —5	10 to 15	25 +10 —5	10 to 15
3 . . . .	125 +3 —0	30	85 +3 —0	30
4 . . . .	25 +10 —5	10 to 15	25 +10 —5	10 to 15

<sup>1</sup> Not recommended for use in new or revised specifications.

4. **Measurements.** Specified measurements shall be made prior to the first cycle and upon completion of the final cycle, except that failures shall be based on measurements made after the specimen has returned to thermal stability at room ambient temperature following the final cycle.

5. **Summary.** The following details must

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be specified in the individual specification:

(a) Special mounting, if applicable  
(see 3).

(b) Test-condition letter (see 3).

(c) Measurements before and after  
cycling (see 4).

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## METHOD 103A HUMIDITY (STEADY STATE)

**1. Purpose.** This test is performed to evaluate the properties of materials used in components as they are influenced by the absorption and diffusion of moisture and moisture vapor. This is an accelerated environmental test, accomplished by the continuous exposure of the specimen to high relative humidity at an elevated temperature. These conditions impose a vapor pressure on the material under test which constitutes the force behind the moisture migration and penetration. Hygroscopic materials are sensitive to moisture, and deteriorate rapidly under humid conditions. Absorption of moisture by many materials results in swelling, which destroys their functional utility, and causes loss of physical strength and changes in other important mechanical properties. Insulating materials which absorb moisture may suffer degradation of their electrical properties. This method, while not necessarily intended as a simulated tropical test, is of use in determining moisture absorption of insulating materials.

### 2. Procedure.

**2.1 Conditioning.** The specimens shall be conditioned in a dry oven at a temperature of  $40^{\circ} \pm 5^{\circ}\text{C}$ . for a period of 24 hours. At the end of this period, measurements shall be made as specified.

**2.2 Chamber.** The chamber and accessories shall be constructed and arranged in such a manner as to avoid condensate dripping on the specimens under test.

**2.3 Exposure.** The specimens shall be placed in a chamber and subjected to a relative humidity of 90 to 95 percent and a temperature of  $40^{\circ} \pm 2^{\circ}\text{C}$ . for the period

of time indicated in one of the following test conditions, as specified:

<i>Test condition</i>	<i>Length of test</i>
A .....	240 hours
B .....	96 hours

When specified, a direct-current potential of 100 volts or rated voltage, whichever is less, shall be applied to the specimens during the exposure period. The length of time for the application of voltage and the points of application shall be as specified.

### 3. Final measurements.

**3.1 At high humidity.** Upon completion of the exposure period, and while the specimens are still in the chamber, the specified measurements shall be performed.

**3.2 After drying period.** Upon completion of the exposure period or following measurements at high humidity if applicable, the specimens shall be conditioned at room ambient conditions for a period of 4 hours unless otherwise specified, after which the specified measurements shall be performed at room ambient conditions.

**4. Summary.** The following details must be specified in the individual specification:

- (a) Measurements after conditioning (see 2.1).
- (b) Test-condition letter (see 2.3).
- (c) The length of time and points of application of polarizing voltage, if applicable (see 2.3).
- (d) Final measurements:
  1. At high humidity, if applicable (see 3.1).
  2. After drying period (see 3.2).

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## METHOD 104A IMMERSION

**1. Purpose.** This test is performed to determine the effectiveness of the seal of component parts. The immersion of the part under evaluation into liquid at widely different temperatures subjects it to thermal and mechanical stresses which will readily detect a defective terminal assembly, or a partially closed seam or molded enclosure. Defects of these types can result from faulty construction or from mechanical damage such as might be produced during physical or environmental tests. The immersion test is generally performed immediately following such tests because it will tend to aggravate any incipient defects in seals, seams, and bushings which might otherwise escape notice. This test is essentially a laboratory test condition, and the procedure is intended only as a measurement of the effectiveness of the seal following this test. The choice of fresh or salt water as a test liquid is dependent on the nature of the component part under test. When electrical measurements

are made after immersion cycling to obtain evidence of leakage through seals, the use of a salt solution instead of fresh water will facilitate detection of moisture penetration. This test provides a simple and ready means of detection of the migration of liquids. Effects noted can include lowered insulation resistance, corrosion of internal parts, and appearance of salt crystals. The test described is not intended as a thermal-shock or corrosion test, although it may incidentally reveal inadequacies in these respects.

**2. Procedure.** This test consists of successive cycles of immersions, each cycle consisting of immersion in a hot bath of fresh (tap) water at a temperature of  $65^{\circ} \pm 5^{\circ}$  C. followed by immersion in a cold bath. The number of cycles, duration of each immersion, and the nature and temperature of the cold bath shall be as indicated in the applicable test condition listed in table 104-1, as specified.

TABLE 104-1. *Immersion test conditions*

Test condition	Number of cycles	Duration of each immersion	Immersion bath (cold)	Temperature of cold bath
				°C
A .....	2	<i>Minutes</i> 15	Fresh (tap) water .....	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$
B .....	2	15	Saturated solution of sodium chloride and water .....	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$
C .....	5	60	Saturated solution of sodium chloride and water .....	0 ± 3

The transfer of specimens from one bath to another shall be accomplished as rapidly as practicable. After completion of the final cycle, specimens shall be thoroughly and quickly washed and all surfaces wiped or air-blasted clean and dry.

**3. Measurements.** Unless otherwise speci-

fied, measurements shall be made at least 4 hours, but not more than 24 hours, after completion of the final cycle. Measurements shall be made as specified.

**4. Summary.** The following details must be specified in the individual specification:

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- (a) Test-condition letter (see 2).
- (b) Time after final cycle allowed for measurements, if other than that

- specified (see 3).
- (c) Measurements after final cycle (see 3).

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28 October 1956

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14 March 1960

## METHOD 105B BAROMETRIC PRESSURE

**1. Purpose.** The barometric-pressure test is performed under conditions simulating the low atmospheric pressure encountered in the nonpressurized portions of aircraft in high-altitude flight. This test is intended primarily to determine the ability of component parts and materials to avoid dielectric withstanding voltage failures due to the lowered insulating strength of air and other insulating materials at reduced pressures. Even when low pressures do not produce complete electrical breakdown, corona and its undesirable effects, including losses and ionization, are intensified. Low barometric pressures also serve to decrease the life of electrical contacts, since intensity of arcing is increased under these circumstances. For this reason, endurance tests of electromechanical components are sometimes conducted at reduced pressures. Low-pressure tests are also performed to determine the ability of seals in components to withstand rupture due to the considerable pressure differentials which may be developed under these conditions. The simulated high-altitude conditions of this test can also be employed to investigate the influence on components' operating characteristics, of other effects of reduced pressure, including changes in dielectric constants of materials; reduced mechanical loading on vibrating elements, such as crystals; and decreased ability of thinner air to transfer heat away from heat-producing components.

**2. Apparatus.** The apparatus used for the barometric-pressure test shall consist of a vacuum pump and a suitable sealed chamber

having means for visual observation of the specimen under test when necessary. A suitable pressure indicator shall be used to measure the simulated altitude in feet in the sealed chamber.

**3. Procedure.** The specimens shall be mounted in the test chamber as specified and the pressure reduced to the value indicated in one of the following test conditions, as specified. Previous references to this method do not specify a test condition; in such cases, test condition B shall be used. While the specimens are maintained at the specified pressure, and after sufficient time has been allowed for all entrapped air in the chamber to escape, the specimens shall be subjected to the specified tests.

<i>Test condition</i>	<i>Altitude (feet)</i>	<i>Pressure (inches of mercury)</i>
A .....	30,000 .....	8.88
B .....	50,000 .....	3.44
C .....	70,000 .....	1.31
D .....	100,000 .....	0.315
E .....	150,000 .....	0.043

**4. Summary.** The following details must be specified in the individual specification:

- (a) Method of mounting (see 3).
- (b) Test-condition letter (see 3).
- (c) Tests during subjection to reduced pressure (see 3).
- (d) Tests after subjection to reduced pressure, if applicable (see 3).
- (e) Exposure time prior to measurements, if applicable (see 3).

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## METHOD 106A

### MOISTURE RESISTANCE

**1. Purpose.** The moisture-resistance test is performed for the purpose of evaluating, in an accelerated manner, the resistance of component parts and constituent materials to the deteriorative effects of the high-humidity and heat conditions typical of tropical environments. Most tropical degradation results directly or indirectly from absorption of moisture vapor and films by vulnerable insulating materials, and form surface wetting of metals and insulation. These phenomena produce many types of deterioration, including corrosion of metals; physical distortion and decomposition of organic materials; leaching out and spreading of constituents of materials; and detrimental changes in electrical properties. This test differs from the steady-state humidity test (method 103 of this standard) and derives its added effectiveness in its employment of temperature cycling, which provides alternate periods of condensation and drying essential to the development of the corrosion processes and, in addition, produces a "breathing" action of moisture into partially sealed containers. Increased effectiveness is also obtained by use of a higher temperature, which intensifies the effects of humidity. The test includes low-temperature and vibration subcycles that act as accelerants to reveal otherwise undiscernible evidences of deterioration since stresses caused by freezing moisture and accentuated by vibration tend to widen cracks and fissures. As a result the deterioration can be detected by the measurement of electrical characteristics (including such tests as dielectric withstanding voltage and insulation resistance) or by performance of a test for sealing. Provision is made for the application of a polarizing voltage across insulation to investigate the possibility of electrolysis, which can promote eventual di-

electric breakdown. This test also provides for electrical loading of certain components, if desired, in order to determine the resistance of current-carrying components, especially fine wires and contacts, to electrochemical corrosion. Results obtained with this test are reproducible and have been confirmed by investigations of field failures. This test has proved reliable for indicating those parts which are unsuited for tropical field use.

**2. Procedure.** Specimens shall be tested in accordance with 2.1 to 2.6, inclusive, and figure 106-1 or 106-2. If a specimen fails to meet requirements when tested in accordance with figure 106-2, retest of a similar specimen in accordance with figure 106-1 shall be permitted.

**2.1 Mounting.** Specimens shall be mounted by their normal mounting means, in their normal mounting position.

**2.2 Initial measurements.** Prior to step 1 the first cycle, the specified initial measurements shall be made at room ambient conditions, or as specified.

**2.3 Number of cycles.** Specimens shall be subjected to 10 continuous cycles, each as shown on figure 106-1 or 106-2.

**2.4 Subcycle.** During step 7, at least 1 hour but not more than 4 hours after step 7 begins, the specimens shall be either removed from the humidity chamber, or the temperature of the chamber shall be reduced, for performance of step 7a. After step 7b, the specimens shall be returned to 25° C. at 90 to 98 percent relative humidity (RH) and kept there until the next cycle begins. This

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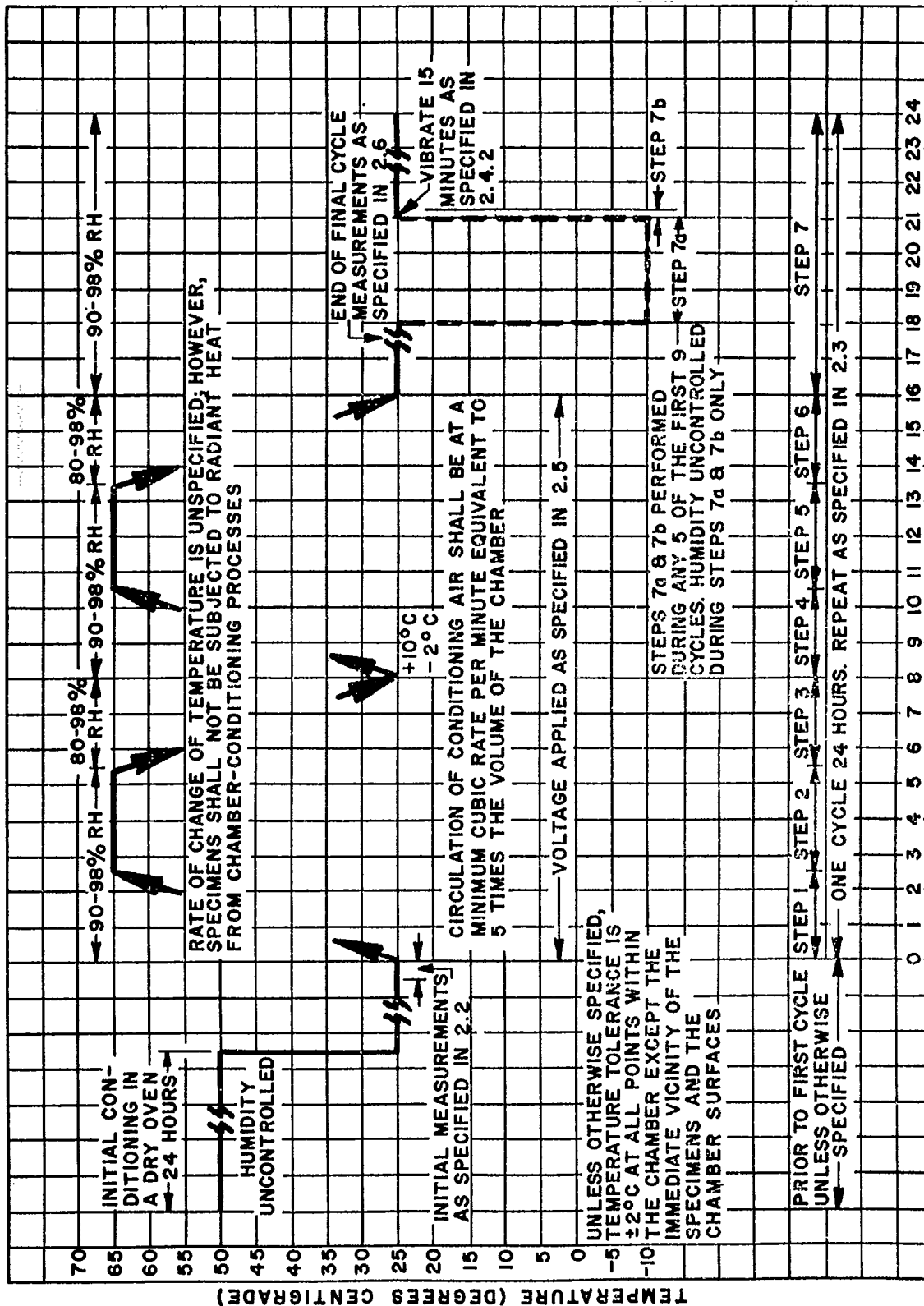


FIGURE 106-1. Graphical representation of moisture-resistance test.

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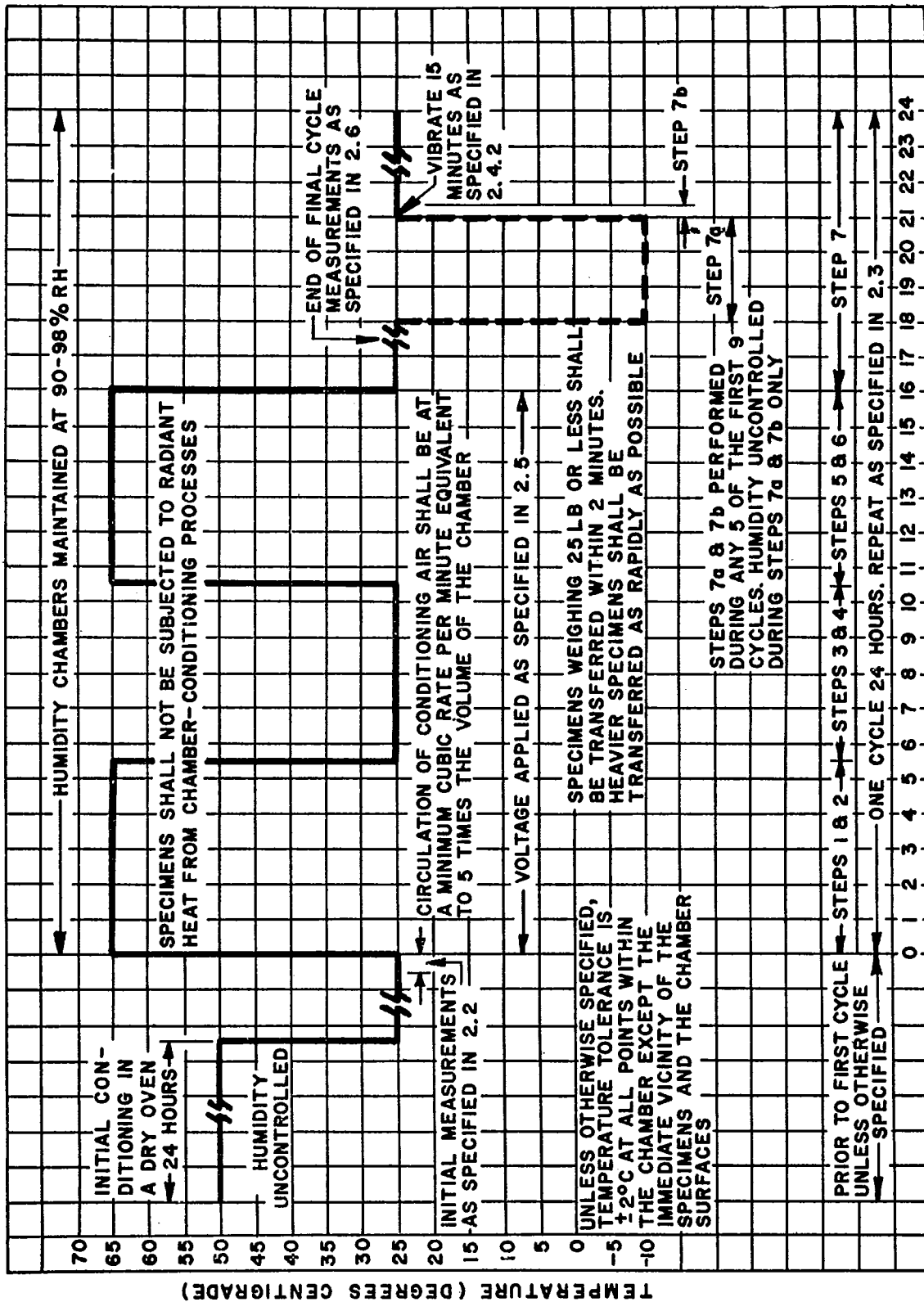


FIGURE 106-2. Graphical representation of moisture-resistance test (alternate method).

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subcycle shall be performed during any five of the first nine cycles.

**2.4.1 Step 7a.** At least 1 hour but not more than 4 hours after the beginning of step 7, the specimens shall be either removed from the humidity chamber, or the temperature of the chamber shall be reduced. Specimens shall then be conditioned at  $-10^{\circ} \pm 2^{\circ}$  C., with humidity not controlled, for 3 hours as indicated on figure 106-1 or 106-2. When a separate cold chamber is not used, care should be taken to assure that the specimens are held at  $-10^{\circ} \pm 2^{\circ}$  C. for the full 3-hour period.

**2.4.2 Step 7b.** Within 15 minutes after completion of step 7a and with humidity not controlled, specimens shall be vibrated for 13 minutes at room ambient temperature, using a simple harmonic motion having an amplitude of 0.03 inch (0.06-in. max. total excursion), the frequency being varied uniformly between the approximate limits of 10 and 55 cycles per second (cps). The entire frequency range, from 10 to 55 cps and return to 10 cps, shall be traversed in approximately 1 minute.

**2.5 Polarization and load.** When applicable, polarization voltage shall be 100 volts, or as specified. The loading voltage shall be as specified.

**2.6 Final measurements.**

**2.6.1 At high humidity.** Upon completion of step 6 of the final cycle, when measurements at high humidity are specified, the specimens shall be maintained at a temperature of  $25^{\circ} \pm 2^{\circ}$  C. and an RH of 90 to 98 percent for a period of  $1\frac{1}{2}$  to  $3\frac{1}{2}$  hours, after which the specified measurements shall be made. Due to the difficulty in making measurements under high-humidity conditions, the individual specification shall specify particular precautions to be followed in making measurements under such conditions.

**2.6.2 After drying period.** Following step 6 of the final cycle, or following measurements at high humidity if applicable, specimens shall be conditioned for 24 hours at the ambient conditions specified for the initial measurements (see 2.2) after which the specified measurements shall be made. Measurements may be made during the 24-hour conditioning period; however, failures shall be based on the 24-hour period only.

**3. Summary.** The following details must be specified in the individual specifications:

- (a) Initial measurements, and conditions if other than room ambient (see 2.2).
- (b) When applicable, the polarization voltage if other than 100 volts (see 2.5).
- (c) Loading voltage (see 2.5).
- (c) Final measurements (see 2.6).

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METHOD 107A  
THERMAL SHOCK

1. Purpose.<sup>1</sup> This test is conducted for the purpose of determining the resistance of a part to exposures at extremes of high and low temperatures, and to the shock of alternate exposures to these extremes, such as would be experienced when equipment or parts are transferred to and from heated shelters in arctic areas. These conditions may also be encountered in equipment operated noncontinuously in low-temperature areas or during transportations. Although it is preferred that the specimen reach thermal stability at the temperature of the test chamber during the exposure specified, in the interest of saving test time, parts may be tested at the minimum exposure durations specified, which will not insure thermal stability, but only an approach thereto. Permanent changes in operating characteristics and physical damage produced during thermal shock result principally from variations in dimensions and other physical properties. Effects of thermal shock include cracking and delamination of finishes, cracking and crazing of embedding and encapsulating

<sup>1</sup> Methods 102 and 107 have substantially the same purpose. Method 107 has been found useful in testing larger components (e.g., transformers) where it is desirable to extend the duration of exposure periods in relation to the weight of the component.

compounds, opening of terminal seals and case seams, leakage of filling materials, and changes in electrical characteristics due to mechanical displacement or rupture of conductors or of insulating materials.

2. Apparatus. Separate chambers shall be used for the extreme temperature conditions of steps 1 and 3. The air temperature of the two chambers shall be held at each of the extreme temperatures by means of circulation and sufficient hot- or cold-chamber thermal capacity so that the ambient temperature shall reach the specified temperature within 2 minutes after the specimens have been transferred to the appropriate chamber.

3. Procedure. Specimens shall be placed in such a position with respect to the airstream that there is substantially no obstruction to the flow of air across and around the specimen. When special mounting is required, it shall be specified. The specimen shall then be subjected to the specified test condition of table 107-1, for a total of five cycles performed continuously. Specimens shall not be subjected to forced circulating air while being transferred from one chamber to another. Direct heat conduction to the specimen should be minimized.

TABLE 107-1. Thermal-shock test conditions

Step	Test condition A		Test condition B		Test condition C	
	Temperature	Time	Temperature	Time	Temperature	Time
	°C.	Minutes	°C.	Minutes	°C.	Minutes
1	-55 $\begin{smallmatrix} +0 \\ -3 \end{smallmatrix}$	(See table 107-2)	-65 $\begin{smallmatrix} +0 \\ -5 \end{smallmatrix}$	(See table 107-2)	-65 $\begin{smallmatrix} +0 \\ -5 \end{smallmatrix}$	(See table 107-2)
2	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$	10 to 15	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$	5 max.	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$	5 max.
3	85 $\begin{smallmatrix} +3 \\ -0 \end{smallmatrix}$	(See table 107-2)	125 $\begin{smallmatrix} +3 \\ -0 \end{smallmatrix}$	(See table 107-2)	200 $\begin{smallmatrix} +5 \\ -0 \end{smallmatrix}$	(See table 107-2)
4	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$	10 to 15	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$	5 max.	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$	5 max.

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TABLE 107-1. Thermal-shock test conditions—Continued

Step	Test condition D		Test condition E	
	Temperature	Time	Temperature	Time
	°C	Minutes	°C	Minutes
1 .....	-65 $\begin{smallmatrix} +0 \\ -5 \end{smallmatrix}$	(See table 107-2)	-65 $\begin{smallmatrix} +0 \\ -5 \end{smallmatrix}$	(See table 107-2)
2 .....	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$	5 max.	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$	5 max.
3 .....	350 $\begin{smallmatrix} +5 \\ -0 \end{smallmatrix}$	(See table 107-2)	500 $\begin{smallmatrix} +5 \\ -0 \end{smallmatrix}$	(See table 107-2)
4 .....	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$	5 max.	25 $\begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$	5 max.

TABLE 107-2. Exposure time at temperature extremes

Weight of specimen	Minimum time (for steps 1 and 3)
Pounds	Hours
0.3 and below .....	1/2
Above 0.3 to 3, incl .....	1
Above 3 to 30, incl .....	2
Above 30 to 300, incl .....	4
Above 300 .....	8

4. Measurements. Specified measurements shall be made prior to the first cycle and upon completion of the final cycle, except

that failures shall be based on measurements made after the specimen has returned to thermal stability at room ambient temperature following the final cycle.

5. Summary. The following details must be specified in the individual specification:

- (a) Special mounting, if applicable (see 3).
- (b) Test-condition letter (see 3).
- (c) Measurements before and after cycling (see 4).

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## METHOD 108

### LIFE

(AT ELEVATED AMBIENT TEMPERATURE)

**1. Purpose.** This test is conducted for the purpose of determining the effects on electrical and mechanical characteristics of a part, resulting from exposure of the part to an elevated ambient temperature for a specified length of time, while the part is performing its operational function. This test method is not intended for testing parts whose life is expressed in the number of operations. Evidence of deterioration resulting from this test can at times be determined by visual examination; however, the effects may be more readily ascertained by measurements or tests prior to, during, or after exposure. Surge current, total resistance, dielectric strength, insulation resistance, and capacitance are types of measurements that would show the deleterious effects due to exposure to elevated ambient temperatures.

**2. Apparatus.** A suitable chamber shall be used which will maintain the temperature at the required test temperature and tolerance (see 3.2) to which the parts will be subjected. Temperature measurements shall be made within a specified number of unobstructed inches from any one part or group of like parts under test. In addition, the temperature measurement shall be made at a position where the effects of heat generated by the parts have the least effect on the recorded temperature. Chamber construction shall minimize the influence of radiant heat on the parts being tested. Chambers which utilize circulating liquid as a heat

exchanger, free-convection (gravity-type) chambers, and circulating-air chambers may be used providing that the other requirements of this test method are met. When specified, this test shall be made in still air. (Still air is defined as surrounding air with no circulation other than that created by the heat of the part being operated.) The employment of baffling devices and the coating of their surfaces with a heat-absorbing finish are permitted. When a test is conducted on parts that do not have the still-air requirement, there shall be no direct impingement of the forced-air supply upon the parts.

### 3. Procedure

**3.1 Mounting.** Specimens shall be mounted as specified by their normal mounting means. When groups of specimens are to be subjected to test simultaneously, the mounting distance between specimens shall be as specified for the individual groups. When the distance is not specified, the mounting distance shall be sufficient to minimize the temperature of one specimen affecting the temperature of another. Specimens fabricated of different materials, which may have a detrimental effect on each other and alter the results of this test, shall not be tested simultaneously.

**3.2 Test temperature.** Specimens shall be subjected to one of the following test temperatures with accompanying tolerances, as specified:

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Temperature and tolerance <sup>1</sup>		Temperature and tolerance <sup>1</sup>	
°C.	°F.	°C.	°F.
55 ± 2	(131 ± 3.6)	<sup>2</sup> 150 ± 3	(302 ± 5.4)
70 ± 2	(158 ± 3.6)	200 ± 5	(392 ± 9)
85 ± 2	(185 ± 3.6)	350, tolerance, as specified.	(662, tolerance as specified).
<sup>2</sup> 100 ± 2	(212 ± 3.6)	500, tolerance as specified.	(932, tolerance as specified).
125 ± 3	(257 ± 5.4)		

<sup>1</sup> For tests on resistors only, in a still-air environment, the maximum temperature tolerance shall be ±5° C. (±9° F.).

<sup>2</sup> Not preferred and not recommended for use in new or revised specifications.

**3.3 Operating conditions.** The test potential, duty cycle, load, and other operating conditions, as applicable, applied to the specimen during exposure shall be as specified.

**3.4 Length of test.** Specimens shall be subjected to one of the following test conditions, as specified:

Test condition	Length of test, hours
A .....	96
B .....	250
C .....	500
D .....	1,000
E .....	1,500
F .....	2,000
G .....	3,000
H .....	5,000

**4. Measurements.** Specified measurements shall be made prior to, during, or after exposure, as specified. If applicable, frequency of measurements, and portion of the duty cycle in which measurements are to be made, while the specimen is subjected to test, shall be as specified.

**5. Summary.** The following details must be specified in the individual specification:

- (a) Distance of temperature measurements from specimens, in inches (see 2).
- (b) Still-air requirement, when applicable (see 2).
- (c) Method of mounting and distance between specimens, if required (see 3.1).
- (d) Test temperature and tolerance (see 3.2).
- (e) Operating conditions (see 3.3).
- (f) Test-condition letter (see 3.4).
- (g) Measurements (see 4).
  1. Prior to, during, or after exposure (see 4).
  2. Frequency of measurements, and portion of duty cycle during test, if applicable (see 4).

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## METHOD 109 EXPLOSION

1. **Purpose.** The purpose of this method is to determine if a part, while operating, will ignite an ambient explosive atmosphere. This environment is prevalent in aircraft; therefore, the test is conducted at ground level and various reduced barometric pressures. The parts subjected to this type of test are not enclosed in casings designed to prevent flame or explosion propagation. This test method is taken from Military Specification MIL-E-5272, Environmental Testing, Aeronautical and Associated Equipment, General Specification For.

2. **Apparatus.** An explosion chamber equivalent to that designed in accordance with Military Specification MIL-C-9435, Chamber, Explosion-Proof Testing, shall be used in this method. The equipment to vaporize the gasoline fuel for use in the explosion test should be so designed that a small quantity of air and gasoline vapor will be heated together to a temperature such that the gasoline vapor shall not condense as it is drawn from the vaporizer into the chamber.

2.1 **Fuel.** The fuel used to form an explosive atmosphere shall be aviation gasoline, grade 100/130, conforming to Military Specification MIL-G-5572; Gasoline, Aviation: Grades 80/87, 91/96, 100/130, 115/145.

### 3. Procedure.

#### 3.1 Test preparation.

3.1.1 **Mounting.** The specimen to be tested shall be mounted in the test chamber in such a manner that normal electrical operation is possible and so that mechanical controls may be operated through the pressure seals from

the exterior of the chamber. All external covers of the test specimen shall be removed or opened to insure adequate circulation of the explosive mixture. The test specimen shall then be operated to determine that it is functioning properly and to observe the location of any sparking or high temperature spots which may constitute potential explosion hazards.

3.1.2 **Loading.** The applicable mechanical and electrical loads applied to the specimen shall be as specified. Proper precaution shall be taken to duplicate the normal load in respect to torque, voltage, current, inductive reactance, etc. In all instances it shall be considered preferable to operate the specimen as it normally functions during service use.

#### 3.2 Test.

3.2.1 **Temperature conditions.** The test chamber shall be sealed and the temperature raised to  $71 \pm 3^\circ \text{C}$ . ( $160 \pm 5^\circ \text{F}$ .), or to a lower temperature as specified, if the specimen is designed to operate at a lower temperature. The temperature of the test specimen and the chamber walls shall be permitted to rise to within  $11^\circ \text{C}$ . ( $20^\circ \text{F}$ .) of that of the chamber ambient air, prior to introduction of the explosive mixture.

3.2.2 **Reduced pressure.** The internal test chamber pressure shall be reduced sufficiently to simulate an altitude approximately 10,000 feet above the desired test altitude (see 3.3).

3.2.3 **Fuel weight.** The weight of fuel necessary to produce an air-vapor ratio of 13 to 1 at the desired test altitude shall be

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determined from consideration of chamber volume, fuel temperature and specific gravity, chamber-air and wall temperature, test altitude, etc. (see 3.4). A time of  $3 \pm 1$  minutes shall be allowed for introduction and vaporization of the fuel. Air shall be admitted into the chamber until a simulated altitude of 5,000 feet above the test altitude is attained. At this time the potential explosiveness of the resulting air-vapor mixture shall be verified by a sampling method which has been approved by the Government.

**3.2.4 Operation of specimens.** Operation of the test specimen shall be started at this time, with all "marking" and "breaking" electrical contacts being actuated. If no explosion results, air shall be admitted into the chamber so as to steadily reduce the altitude below the desired test altitude to an elevation 5,000 feet below that altitude, or as close thereto as permitted by local ground level altitude. If no explosion has occurred as a result of operation of the specimen under test, by the time the simulated altitude has been reduced to 5,000 feet below the test altitude, the potential explosiveness of the air-vapor mixture shall again be verified by a sampling method which has been approved by the Government. If the air-vapor mixture is not found to be explosive at this time, the test shall be considered void and the entire procedure repeated. The operation of the test specimen shall be continuous throughout this

period of altitude reduction and all "making" and "breaking" electrical contacts shall be operated as frequently as possible.

**3.3 Test altitudes.** The test (see 3.2.1, 3.2.2, 3.2.3, and 3.2.4) shall be accomplished at simulated test altitudes of local ground level to 5,000 feet, 10,000, 20,000, 30,000, 40,000, and 50,000 feet. However, if an explosion occurs at an altitude of less than 50,000 feet further testing shall be discontinued.

**3.4 Example of gasoline weight determinations.** In illustration of the procedure for calculating the weight of 100/130 octane gasoline required to produce the desired 13 to 1 air-vapor ratio, the following sample problem is presented:

Required information:

- a. Chamber air temperature during test: 80° F.
- b. Fuel temperature: 75° F.
- c. Specific gravity of fuel at 60° F.: 0.704.
- d. Test altitude: 20,000 feet ( $P = 6.75 \text{ lbs./in.}^2$ ).
- e. Air-vapor ratio (desired): 13 to 1.

**3.4.1 Step 1.** Employing the following equation, calculate the apparent air-vapor ratio:

$$\text{AAV} = \frac{\text{A-V (Desired)}}{P} = \frac{13}{1.04 \frac{6.75}{14.696} - .04} = 29.68$$

Where AF = Air-fuel ratio  
 AAV = Apparent air-vapor ratio  
 AV = Desired air-vapor ratio  
 P = Pressure equivalent of altitude, lbs./in.<sup>2</sup>

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*Note.* At or above 10,000 feet altitude, with chamber-air temperature above 60° F. and at A—V ratio of 5 or greater, Air-vapor ratio = Air-fuel ratio for 100/130 octane fuel. Since the conditions of the explosion test under consideration will always be well above these values AV will equal AF in all cases.

3.4.2 *Step 2.* Since AV=AF, use figure 109-1 to determine weight of air and divide by AAV to obtain uncorrected weight of fuel required.

$$WFU = \frac{W_a}{29.68} = \frac{3.455}{29.68} = 0.116 \text{ lbs., fuel weight (uncorrected)}$$

3.4.3 *Step 3.* Knowing fuel temperature and specific gravity at 60° F., use figure 109-2 to determine specific gravity at given temperature.

3.4.4 *Step 4.* Using figure 109-3 read from specific gravity determined under Step 3 to obtain the correction factor k. Apply factor.

$$WFC = WFU \times k = 0.116 \times 1.01 = 0.0117 \text{ lb., fuel weight (corrected)}$$

*Note.* Figure 109-2 pertains to a specific test chamber and may not be used for all such test facilities. It is utilized herein for illustration of the method of employment only. Each test chamber must have its own chamber volume chart.

(a) Mechanical and electrical load (see 3.1.2).

(b) Chamber temperature condition, if lower than 71±3° C. (160±5° F.) (see 3.2.1).

4. **Summary.** The following details shall be specified in the individual specification.

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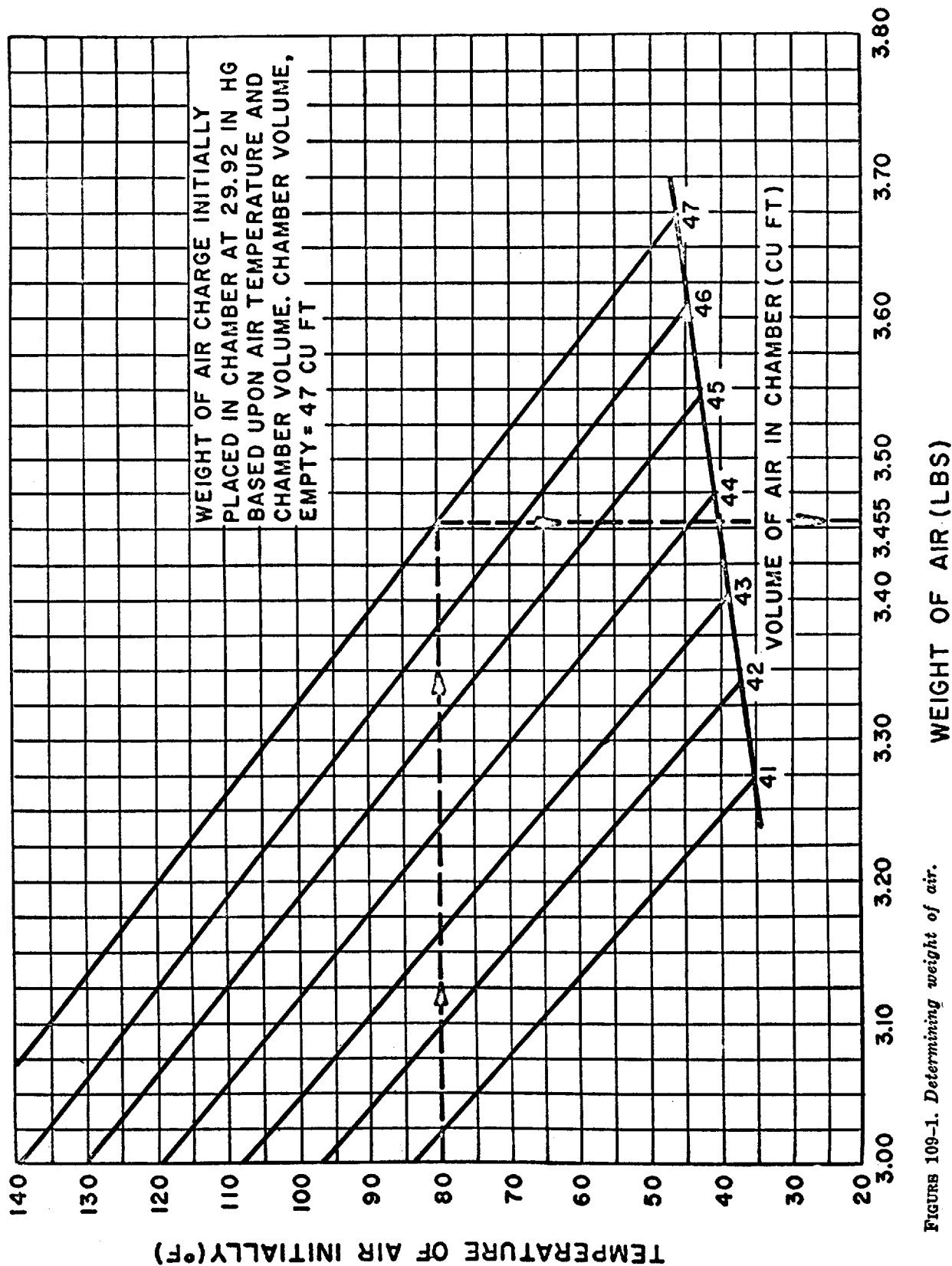


FIGURE 109-1. Determining weight of air.

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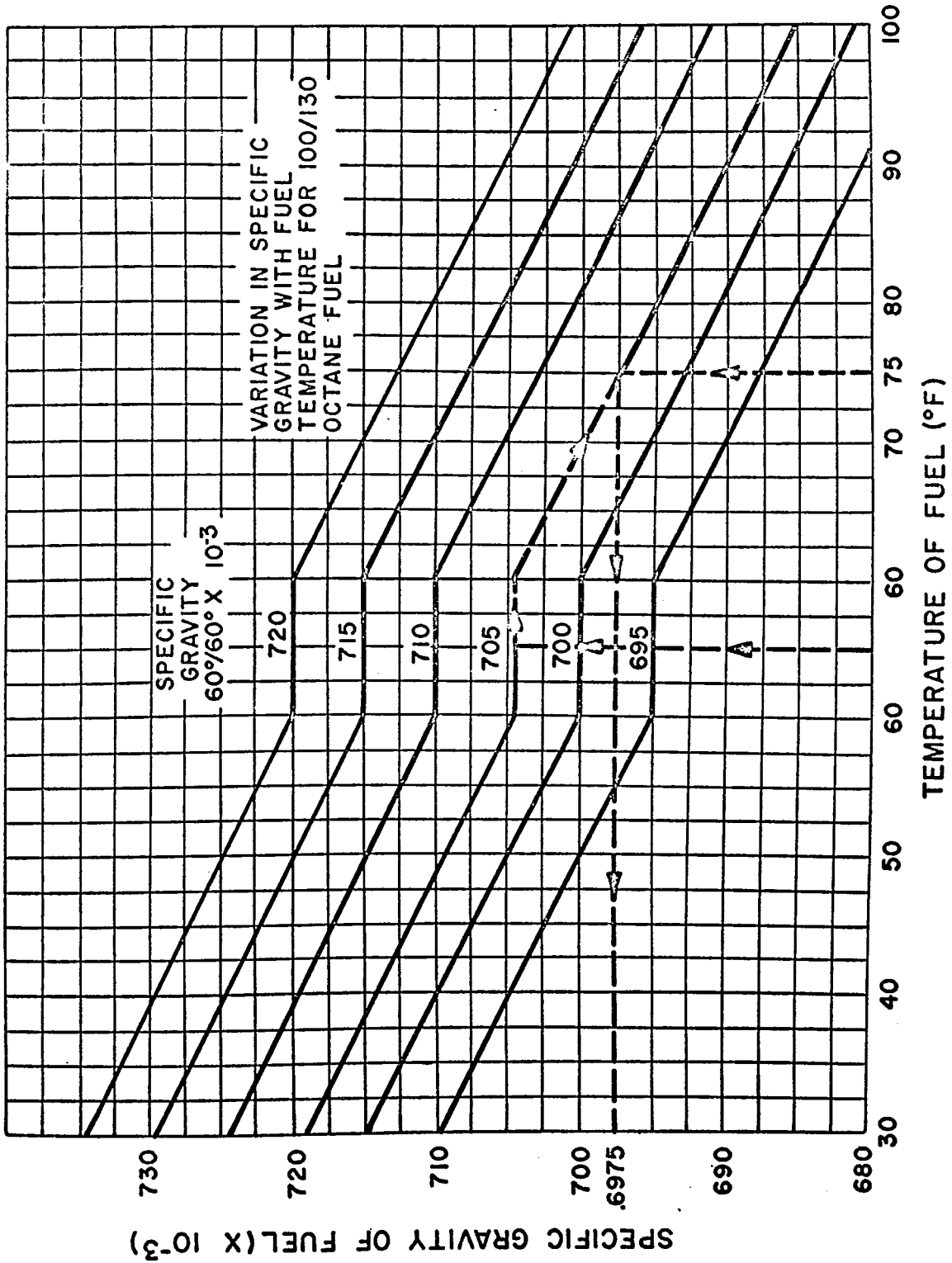


FIGURE 109-2. Determining specific gravity.

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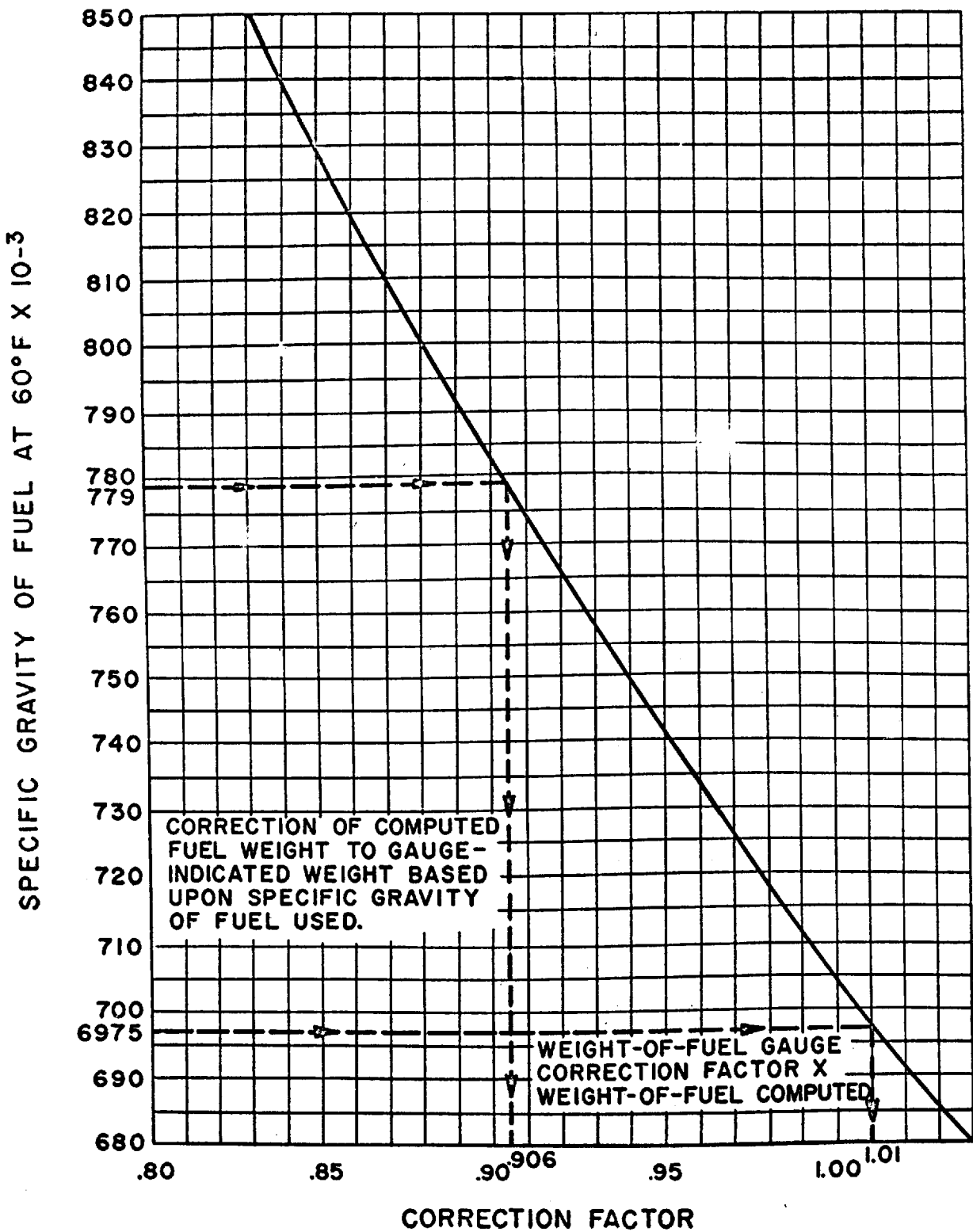


FIGURE 109-3. Correction factor.

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## METHOD 110

### SAND AND DUST

1. **Purpose.** The purpose of this method is to determine the electrical and mechanical effects upon parts from being exposed to a dust-laden atmospheric environment. This method is taken from the sand and dust tests which appear in Military Specification MIL-E-5272; Environmental Testing, Aeronautical and Associated Equipment, General Specification For.

2. **Apparatus.** A test chamber equivalent to that designed in accordance with Military Specification MIL-C-9436; Chamber, Sand and Dust Testing, shall be used in this method.

2.1 **Sand and dust.** The sand and dust used in this test shall be of angular structure and that known commercially as "140-mesh silica flour." Sand and dust (140-mesh silica flour) produced by the Fenton Foundry Supply Company, Dayton, Ohio, and Ottawa Silica Company, Ottawa, Illinois, or equal, shall be used in the performance of these tests.

2.1.1 **Characteristics.** The sand and dust shall have characteristics as follows:

- (a) 100 percent of the sand and dust shall pass through a 100-mesh screen, U.S. Standard Sieve Series.
- (b)  $98 \pm 2$  percent of the sand and dust shall pass through a 140-mesh screen, U.S. Standard Sieve Series.
- (c)  $90 \pm 2$  percent of the sand and dust shall pass through a 200-mesh screen, U.S. Standard Sieve Series.

- (d)  $75 \pm 2$  percent of the sand and dust shall pass through a 325-mesh screen, U.S. Standard Sieve Series.

2.1.1.1 **Chemical analysis.** The chemical analysis of the dust shall be as follows:

Substance	Percent by weight
Si O <sub>2</sub>	97 to 99
Fe <sub>2</sub> O <sub>3</sub>	0 to 2
Al <sub>2</sub> O <sub>3</sub>	0 to 1
Ti O <sub>2</sub>	0 to 2
Mg O	0 to 1
Ign losses	0 to 2

3. **Procedure.** The specimen shall be subjected to either test condition A, B, or C as specified.

#### 3.1 Test condition A.

3.1.1 **Part I.** The specimen shall be placed in a test chamber which has been vented to the atmosphere. The internal temperature of the chamber shall be maintained at 25° C. (77° F.) with a relative humidity that shall not exceed 30 percent at any time during test. The sand and dust density shall be raised and maintained at 0.1 to 0.5 gram per cubic foot within the test space. The sand and dust velocity through the test chamber shall be between 100 to 500 feet per minute (fpm). When specified, the velocity shall be  $2,500 \pm 500$  fpm. This portion of the test shall be continued for 6 hours.

3.1.2 **Part II.** At the completion of the 6-hour period stated in 3.1.1, the temperature shall then be raised to and maintained at 71° C. (160° F.) for an additional 6 hours with all other conditions remaining the same as in part I.

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**3.2 Test condition B.** This test shall be conducted in accordance with part I only (see 3.1.1) of Test Condition A.

**3.3 Test condition C.** This test shall be conducted in accordance with part I only (see 3.1.1) of Test Condition A, except that the dust concentration shall be 0.1 to 0.25 gram per cubic foot, the velocity shall be  $2,500 \pm 500$  fpm, and the duration of the test shall be 3 hours.

**3.4 Removal of dust.** Upon completion of the exposure period, the specimen shall be removed from the chamber and allowed to cool to room temperature. The accumulated dust shall be removed by brushing, wiping,

or shaking, with care being taken to avoid introduction of additional dust into the specimen. Under no circumstance shall dust be removed by airblast or vacuum cleaning.

**4. Measurements.** The specimens shall be operated and measurements made as specified.

**5. Summary.** The following details shall be specified in the individual specification:

- (a) Test-condition letter (see 3).
- (b) Dust velocity of  $2,500 \pm 500$  fpm for Condition A, when applicable (see 3.1.1).
- (c) Measurements (see 4).

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## METHOD 111

### FLAMMABILITY (EXTERNAL FLAME)

**1. PURPOSE.** This test is performed for the purpose of determining the flammability of a part exposed to an external flame. Flammability is defined as the ability of a part to support combustion. This can be determined by the following: The time it takes for a part to become self-extinguishing after application of a flame; that the part does not support violent burning; that exposure of a part to a flame does not result in an explosive-type fire; or that spreading of surface burning on larger parts is deterred. The principal factors which affect the results of an external flame test are — the heat of the flame at the point of impingement; the size of the flame; the time of exposure to the flame; the volume of the part and other heat-sink effects; the presence of circulating air; and variations of the materials and surfaces of the parts.

#### 2. APPARATUS

**2.1 Test chamber.** An enclosure protected from air currents, but provided with means for venting fumes and admitting an adequate supply of fresh air at the bottom, shall be used. A standard chemistry hood with the exhaust fan turned off, or a metal box about 2 feet wide by 3 feet high and 2 feet deep, with a removable front, a viewing window, and holes for air intake and venting of fumes, is satisfactory. Adequate safety precautions should be taken to protect personnel from possible explosion of the test specimens.

**2.2 Mounting apparatus.** Within the test chamber, a support stand with suitable adjustable vertical brackets or other mounting clamps shall be used to hold the specimens at the specified distance and position (see 3) with respect to the applied flame. Mounting clamps, in order not to act as heat sinks,

shall be thermally insulated from the specimens. The flame shall not impinge on the clamp(s) or other devices which hold the specimens.

**2.3 Propane torch.** A propane torch, having a nozzle assembly conforming to Model TX-1 of "Otto Bernz Company," or equal, shall be the source of the flame. "Cracked" propane gas shall be used as the fuel.

**2.4 Timing device.** A timing device, which can indicate time in seconds, shall be used to determine the time of application of the flame and the time of burning of visible flame on the specimen.

**3. PROCEDURE.** The specimen shall be mounted in the test chamber (see 2.1) with the mounting apparatus therein (see 2.2) and at the distance and position specified. The torch shall be placed so that the axis of the flame is in the vertical direction, unless otherwise specified in the individual specification. When the torch is ignited, and after the flame is stable, the flow of gas through the nozzle of the torch (see 2.3) shall be adjusted so that the inner-cone length is  $\frac{1}{2}$  inch between the inner-cone tip and a point in the plane of the nozzle rim. The specimen shall be placed so that the point of impingement of the flame on the specimen is  $1\frac{1}{2}$  inches from the nozzle rim along the flame axis. The point of impingement of the flame shall be as specified in the individual specification. The flame shall be applied to the specimen for a period of 15 second unless otherwise specified in the individual specification, as determined by the timing device (see 2.4), and then removed. Upon removal of the applied flame, the time of burning of visible flame on the specimen, as determined by the

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timing device, shall be recorded. The recorded time shall then be compared with the allowable time specified in the individual specification. Any violent burning of the specimen or explosive-type fire shall be recorded.

4. **CLEANING.** In order to clearly observe the burned area, carbon from the propane gas may be removed by brushing or buffing the specimen.

5. **MEASUREMENTS.** Upon completion of the test, measurements shall be made as specified in the individual specification.

6. **SUMMARY.** The following details must be specified in the individual specification:

- (a) Direction of axis of flame, if other than vertical (see 3).
- (b) Point of impingement of applied flame (see 3).
- (c) Time of application of flame, if other than 15 seconds (see 3).
- (d) Allowable time for burning of visible flame on specimen (see 3).
- (e) Measurements after test (see 5).

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## METHOD 201A VIBRATION

**1. Purpose.** The vibration test is used to determine the effects on component parts of vibration within the predominant frequency ranges and magnitudes that may be encountered during field service. Most vibration encountered in field service is not of a simple harmonic nature, but tests based on vibrations of this type have proved satisfactory for determining critical frequencies, modes of vibration and other data necessary for planning protective steps against the effects of undue vibration. Vibration, by causing loosening of parts or relative motion between parts in the specimen, can produce objectionable operating characteristics, noise, wear, and physical distortion, and often results in fatigue and failure of mechanical parts.

**2. Procedure.** Prior to vibration, the specified tests or measurements shall be made. The specimens shall be mounted as specified using suitable mounting apparatus to assure that mounting is free from resonances over the test frequency range. The specimens shall be subjected to a simple harmonic motion having an amplitude of 0.03 inch (0.06-inch maximum total excursion), the frequency being varied uniformly between the approximate limits of 10 and 55 cycles per

second (cps). The entire frequency range, from 10 to 55 cps and return to 10 cps, shall be traversed in approximately 1 minute. Unless otherwise specified, this motion shall be applied for a period of 2 hours in each of 3 mutually perpendicular directions (total of 6 hours).<sup>1</sup> If applicable, this test shall be made under electrical-load conditions.

**3. Measurements.** The specified measurements shall be made during and after vibration.

**4. Summary.** The following details must be specified in the individual specification:

- (a) Tests and measurements prior to vibration (see 2).
- (b) Method of mounting (see 2).
- (c) Duration of vibration, if other than that specified (see 2).
- (d) Direction of motion, if other than that specified (see 2).
- (e) Electrical-load conditions, if applicable (see 2).
- (f) Tests and measurements during and after vibration (see 3).

<sup>1</sup>In the previous issue of this method, test conditions A and B referred to a length of test of 5 hours and 2½ hours, respectively.

## METHOD 202A SHOCK

(SPECIMENS WEIGHING NOT MORE THAN 4 POUNDS)

1. **Purpose.** The shock test is intended to determine the suitability of small parts, with or without auxiliary protection, for use in electronic equipment which may be subjected to moderately severe shocks as a result of suddenly applied forces or abrupt changes in motion produced by rough handling, transportation, or field operation. Shocks of this type may disturb operating characteristics or cause damage similar to that resulting from excessive vibration, particularly if the shock pulses are repetitive. The apparatus employed in this test was originally designed for shock testing of electrical-indicating instruments and its use was later extended to other small parts. This device provides a standard laboratory means of creating reproducible shocks of moderate severity such as parts might experience when equipment is dropped on a hard surface or bounced in a vehicle. The apparatus does not duplicate the magnitude-time duration relationship of all kinds of shock pulses experienced in field service; tests performed with it have proved reasonably adequate for evaluation purposes and for providing data for the design of protective and corrective measures. The basic pulse duration of this test machine as used in most component specifications is about 7 milliseconds, which is virtually independent of drop height, but which does vary somewhat with component weight. These variations are too small to affect reproducibility.

2. **Apparatus.** The shock-testing apparatus specified herein and shown on figures 202-1 to 202-6, inclusive, shall be used. The main structure consists of a cast-iron base to which upright channels are securely bolted. The tops of the upright channels are secured to a top channel which also supports rods to

guide the movable carriage assembly. The other ends of the guide rods are screwed into the base. The carriage assembly carries on its under side a stiff calibrated spring resiliently mounted but at the same time having helical compression springs sufficiently strong to hold the calibrated spring in contact with the effective cylindrical bearings.

2.1 **Base.** The cast-iron base shall be a single piece constructed so that it has no practical yielding.

2.2 **Movable carriage assembly.** The prime requisite in the construction of the movable carriage assembly is rigidity. For this reason  $\frac{1}{4}$ -inch-thick steel shall be used. After being securely fastened together with screws, the carriage parts shall be welded so as to give the equivalent of single-piece construction.

2.3 **Mounting accessories.** Mounting accessories which will assure rigid fastening of the specimens to the carriage assembly shall be used. Since special tests may require special mounting fixtures, the carriage test plate shall be provided with a number of extra holes. The top of the carriage frame shall be provided with a hoding bolt to facilitate the rigid clamping necessary.

2.4 **Stationary anvil.** The stationary anvil shall be made of hardened tool steel with a radius of curvature of  $1\frac{1}{2}$  inches and shall be bolted tightly to the base.

2.5 **Calibrated spring.** The calibrated spring shall be made of first-quality carbon tool steel, spring-tempered, and having a

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hardness of 85 to 95, Rockwell B scale. It shall be annealed and ground flat stock of the following composition:

	<i>Percent</i>
Carbon .....	1.08 to 1.18
Chromium .....	0.40 to 0.50
Manganese .....	.20 to .30
Silicon .....	.20 to .30
Phosphorus and sulfur .....	.025 maximum

The spring shall be 1 3/4 inches wide and approximately 0.150 inch thick, and shall have an overall length of 7 1/2 inches. The approximate spring constant (K) shall be between 5,000 and 5,500 pounds-per-inch deflection.

**3. Calibration.** The actual calibration shall be made on the completely assembled machine. Static loads up to 500 pounds shall be applied to the top of the carriage frame, and the spring deflections measured by means of a dial gage or height gage. The gage shall be mounted on the top surface of the cast-iron base as one reference surface, and measurements shall be taken at the center of the carriage test plate. The

$$\text{Spring constant (K)} = \frac{\text{load in pounds}}{\text{inches deflection}}$$

For a spring constant of 5,000, the deflection for a 500-pound load would be 0.100 inch.

**3.1 Calibration curves.** Use of the shock-testing mechanism is facilitated by plotting calibration curves for various weights of specimens. Ordinarily, parallel curves for specimen weights of 0.5 pound and 2.0 pounds will be adequate, and intermediate weights can be estimated. Figure 202-6 shows such curves arbitrarily calculated on the basis of a mean spring constant (K) of 5,250 and a total carriage-and-mounting-fixture weight of 9 3/4 pounds.

**3.2 Computation of acceleration (G).** The following formula for obtaining the required acceleration or shock, in terms of gravity

units (G), is utilized for variations of component weight and spring constant (K):

$$G = \sqrt{\frac{2hK}{w}}$$

(When G is specified, the necessary height may be determined from:

$$h = \frac{G^2 w}{2K} )$$

Where:

- G = nominal value of acceleration (gravity units).
- h = height from which carriage is dropped (inches).
- K = spring constant (pounds-per-inch deflection).
- w = weight of carriage and its test load (pounds).

**4. Procedure.** The shock-testing apparatus shall be mounted on a sturdy laboratory table or equivalent base and leveled before use. The specimen shall be rigidly mounted on the carriage. For each blow, the carriage shall be raised to the height necessary for obtaining the required acceleration and then allowed to fall. Means shall be provided to prevent the carriage from striking the anvil a second time. The mounting method, the required acceleration, the number of blows, and the electrical-load conditions, if applicable, shall be as specified.

**5. Measurements.** Upon completion of the required number of blows, measurements shall be made as specified.

**6. Summary.** The following details must be specified in the individual specification:

- (a) Mounting method and accessories (see 2.3 and 4).
- (b) Acceleration requirements (see 4).
- (c) Number of blows (see 4).
- (d) Electrical-load conditions, if applicable (see 4).
- (e) Measurements after shock (see 5).

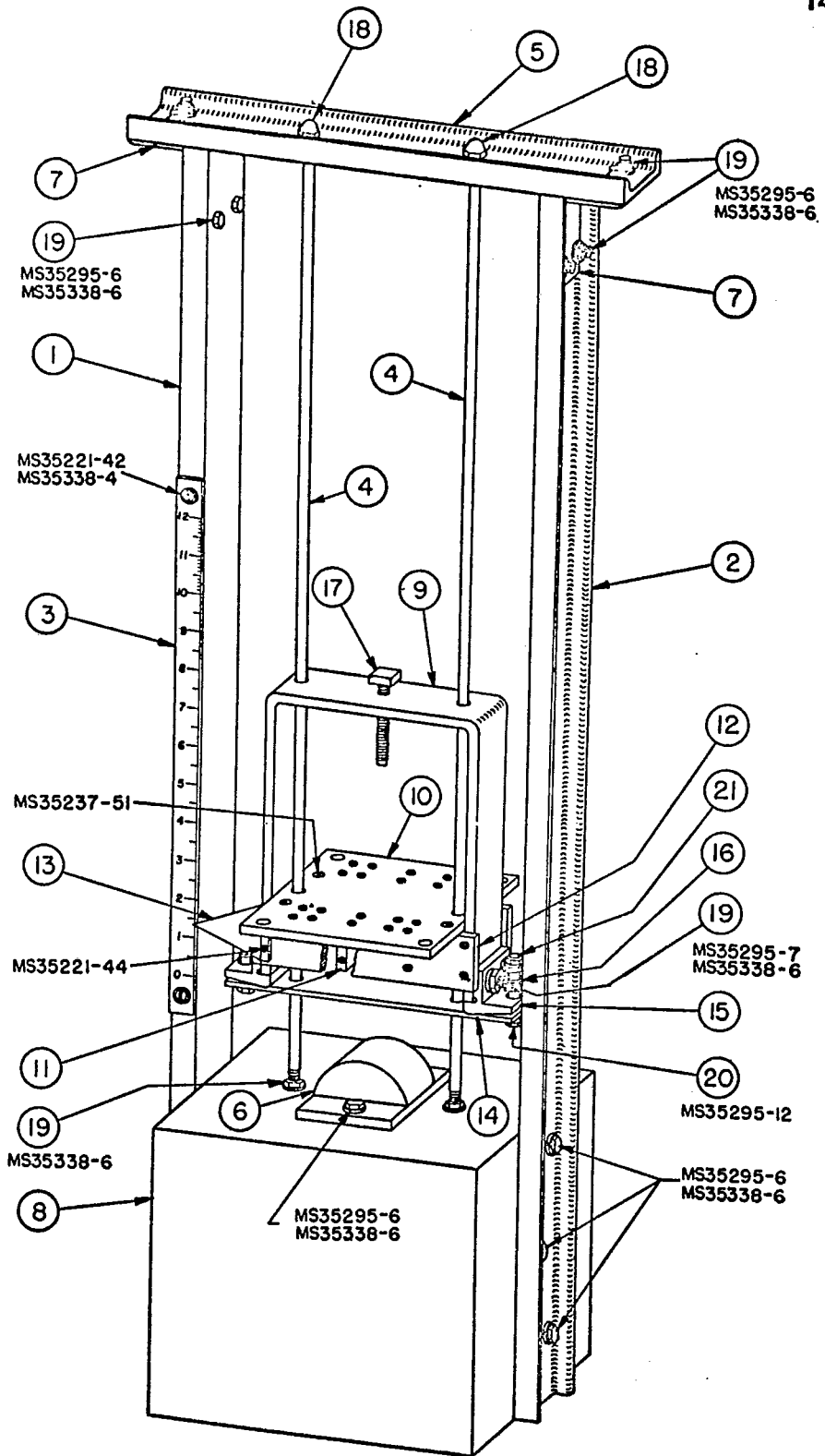
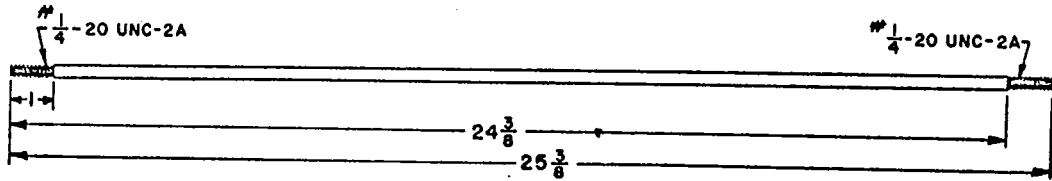


FIGURE 202-1. General assembly of shock-testing apparatus. (See fig. 202-5 for notes and bill of materials.)

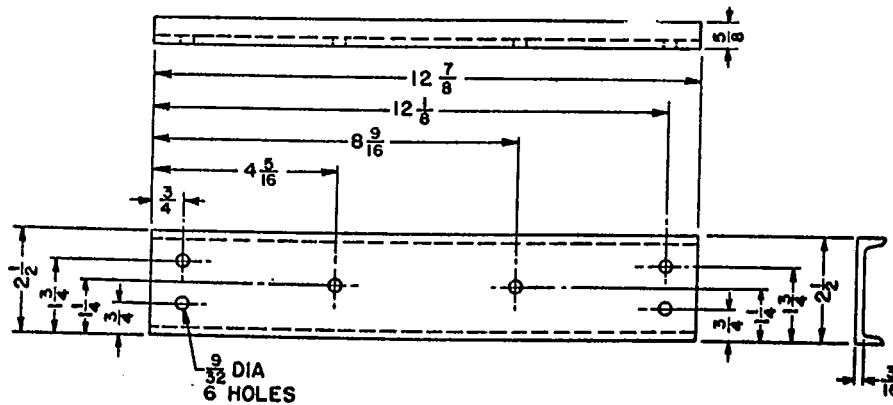
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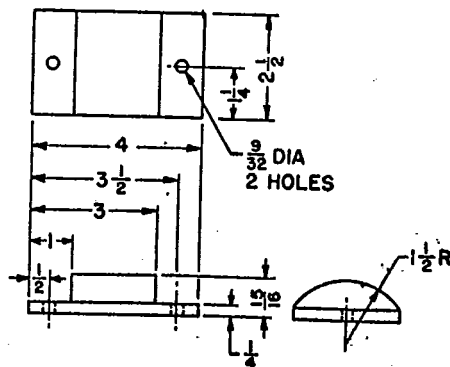
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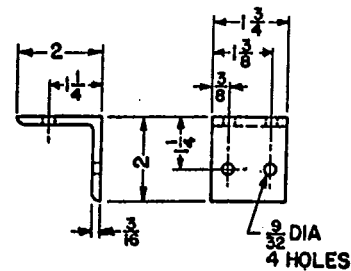
④ GUIDE ROD  
STEEL  
2 REQ



⑤ TOP CHANNEL  
STEEL-HOT ROLLED  
1 REQ



⑥ ANVIL  
TOOL STEEL-HARDEN & DRAW 60-62  
ROCKWELL C  
1 REQ

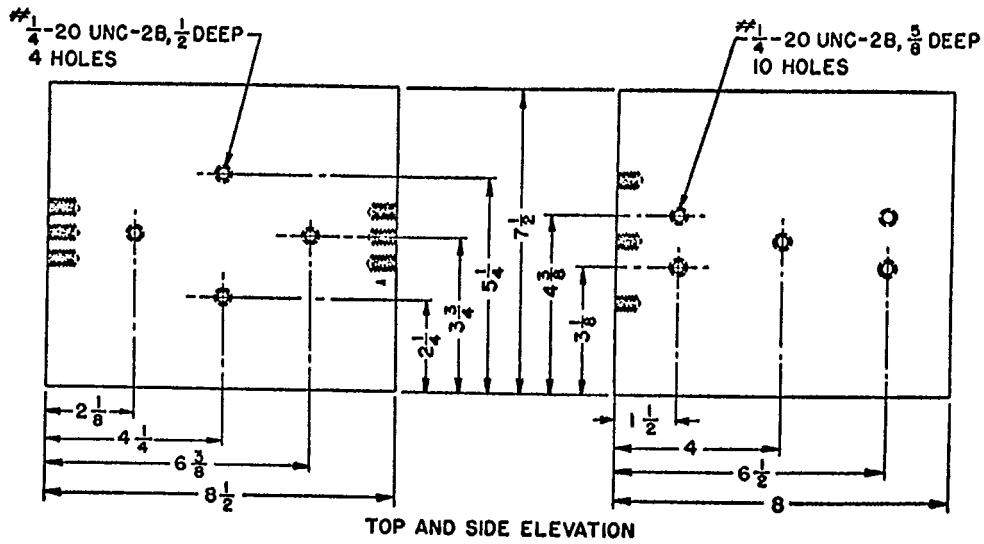


⑦ TOP ANGLE  
STEEL-HOT ROLLED  
2 REQ

FIGURE 202-2-Continued

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8 BASE  
CAST IRON-NORMALIZE  
I REQD

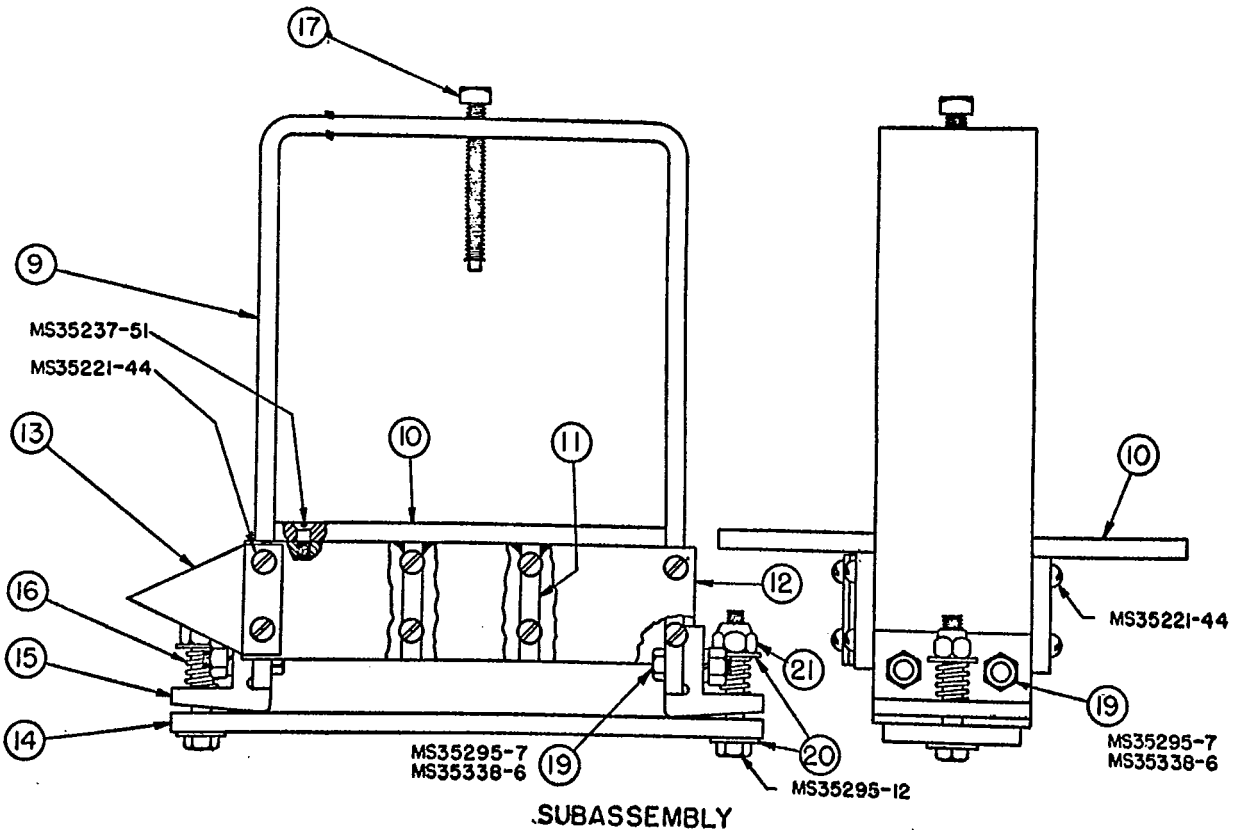


FIGURE 202-3. Carriage-assembly and base details. (See fig. 202-5 for notes and bill of materials.)

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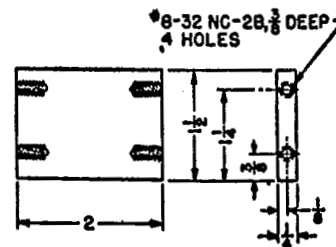
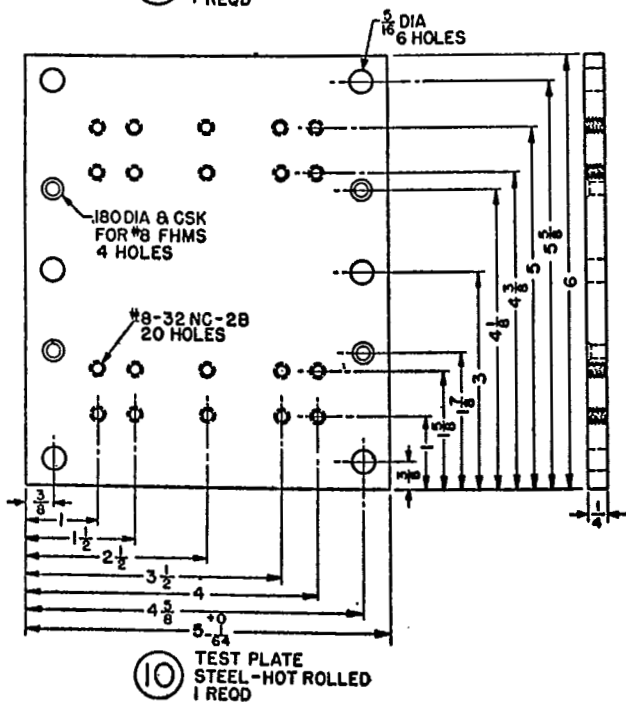
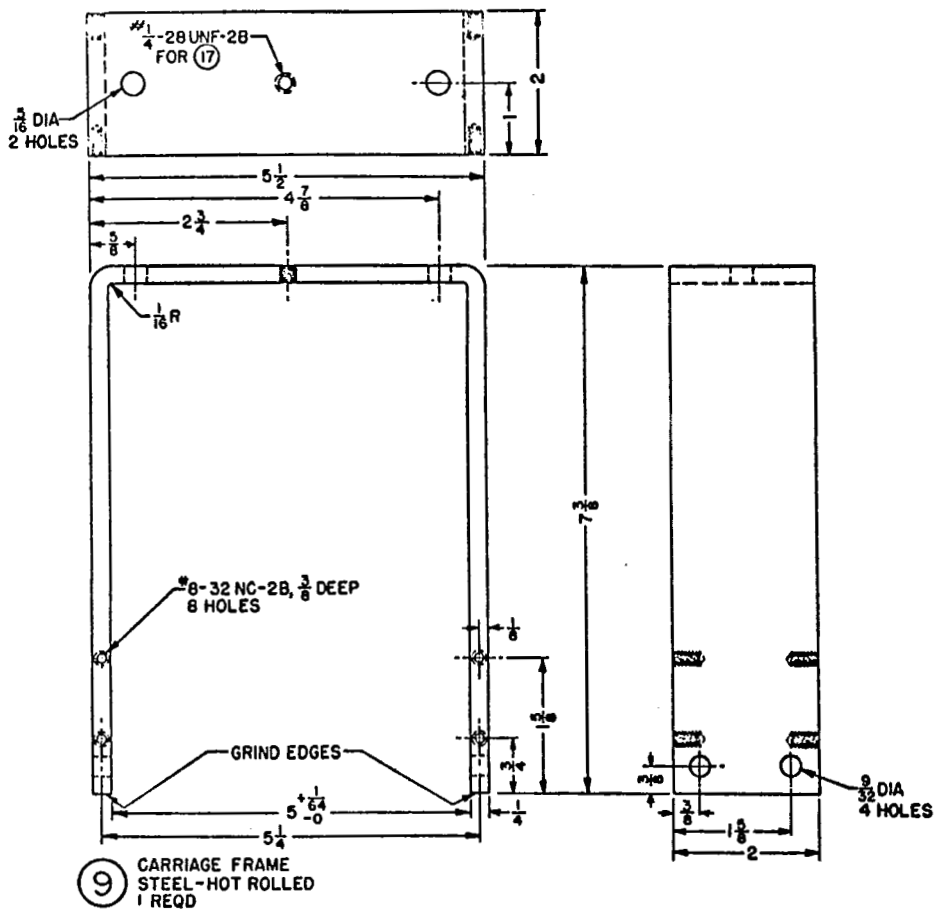


FIGURE 202-4. Carriage details. (See fig. 202-5 for notes and bill of materials.)



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Item No. or MS part No.	Description	Quantity
1	Left-side channel .....	1
2	Right-side channel .....	1
3	Scale .....	1
4	Guide rod .....	2
5	Top channel .....	1
6	Anvil .....	1
7	Top angle .....	2
8	Base .....	1
9	Carriage frame .....	1
10	Test plate .....	1
11	Brace .....	2
12	Side plate .....	2
13	Pointer .....	1
14	Spring, calibrated .....	1
15	Pivot .....	2
16	Spring, compression .....	2
17	Squarehead bolt, # ¼-28 UNF-2A x 2 long, steel, modified	1
18	Acorn nut, # ¼-20 UNC-2B, steel .....	2
19	Hexagon nut, # ¼-20 UNC-2B, steel .....	14
20	Flat washer, ¼, steel .....	4
21	Stop nut, per note 5 .....	2
MS35221-42	Screw .....	2
MS35221-44	Screw .....	16
MS35237-51	Screw .....	4
MS35295-6	Bolt .....	20
MS35295-7	Bolt .....	4
MS35295-12	Bolt .....	2
MS35338-4	Lockwasher .....	2
MS35338-6	Lockwasher .....	26

- All dimensions in inches.
- Unless otherwise specified, tolerances are  $\pm 1/64$  on fractions,  $\pm .005$  on decimals, and  $\pm 1/2^\circ$  on angles.
- Finish: The general assembly and the carriage shall be given a light spray coat of metal primer and then finished with a full spray coat of lusterless gray enamel. The mounting fixtures shall be cadmium- or nickel-plated. The spring, part 14, anvil, part 6, and pivots, part 15, shall be flash-dip nickeled.
- Develop thickness experimentally so that spring constant will be 5,000 to 5,500 pounds-per-inch deflection when hardened and drawn.
- Stop nut shall be catalog No. 29U040, as made by Elastic Stop Nut Corporation, Union, N. J., or equal.
- The materials specified herein have been found satisfactory, but any suitable material may be used.
- Scale shall be graduated in tenths of an inch. Fill black.

FIGURE 202-5. Notes and bill of materials

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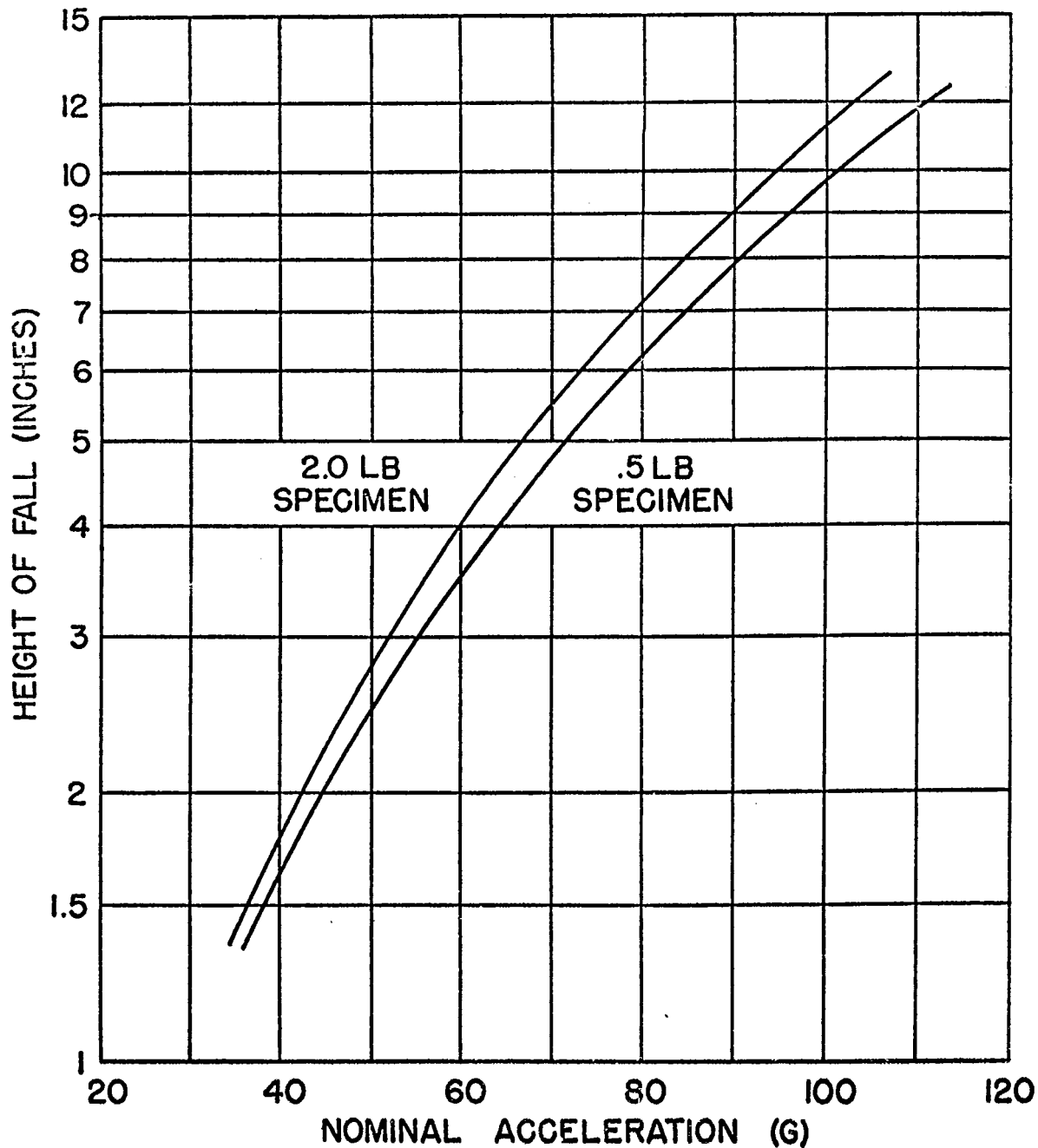


FIGURE 202-6. Typical calibration curves.

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## METHOD 203 RANDOM DROP

1. **Purpose.** The random-drop test is used to determine the effects on component parts of random, repeated impact due to handling, shipping, and other field service conditions. The test is an accelerated test designed to indicate structural and mechanical weaknesses of types not necessarily detected in shock and vibration tests.

2. **Apparatus.** The random-drop-test machine consists of an assembly of either two or four steel cages as shown on figure 203-2, with provisions for rotation about a common axis. The interior of each cage shall be as shown on figure 203-3. A typical 4-cage machine is shown on figure 203-1. Steel sleeves as shown on figure 203-4 shall be used to mount the specimen.

3. **Procedure.** The specimen shall be rigidly mounted by the normal mounting means in the steel sleeve so that no part of the specimen, including terminals or external hard-

ware of the component, will extend beyond the sleeve. When necessary, a suitable adapter may be used within the sleeve. End caps shall not be used on the sleeves. Through bolts may be employed as needed to mount the specimens in the sleeve. Only one sleeve shall be placed in each cage during test. The number of specimens mounted in each sleeve shall be limited only by the available space. Specimens shall be subjected to the random-drop test for a period of 45 minutes at a speed of approximately 5 revolutions per minute. The machine shall be rotated in the direction shown on figure 203-3.

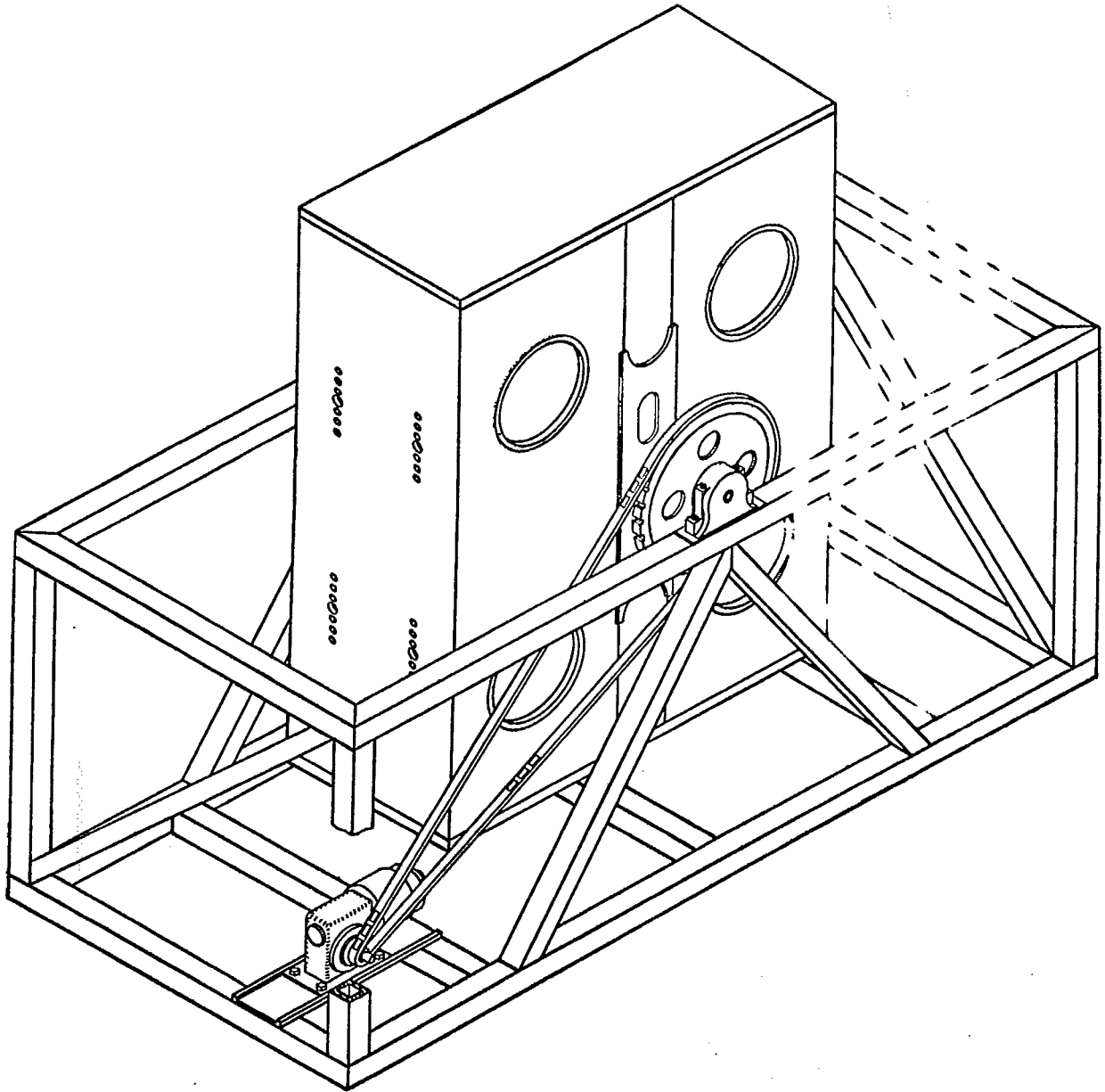
4. **Measurements.** Upon completion of the test, measurements shall be made as specified.

5. **Summary.** The following detail must be specified in the individual specification:

(a) Measurements after test (see 4).

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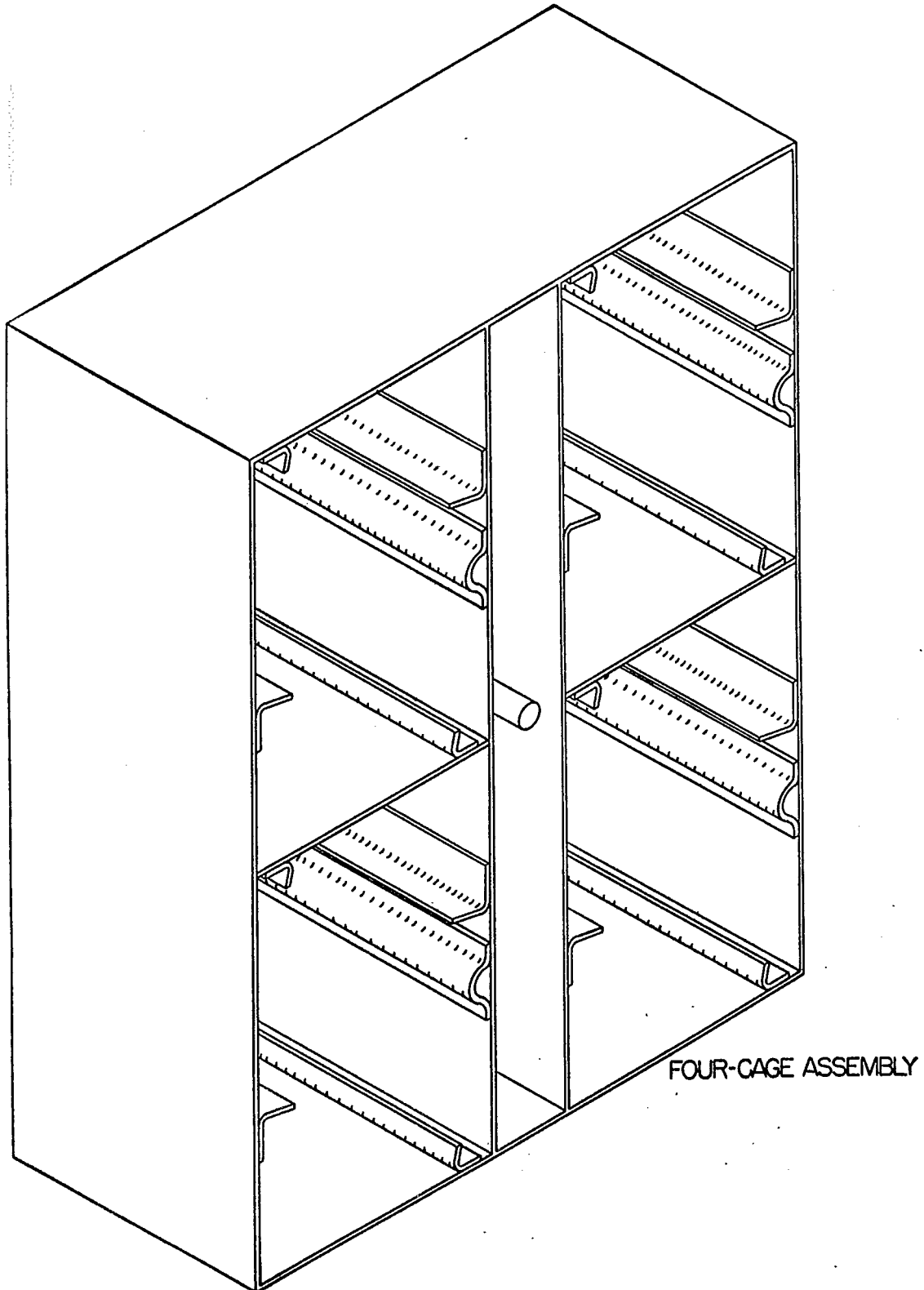
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**FIGURE 203-1.** *Typical assembly of four-cage random-drop-test machine.*

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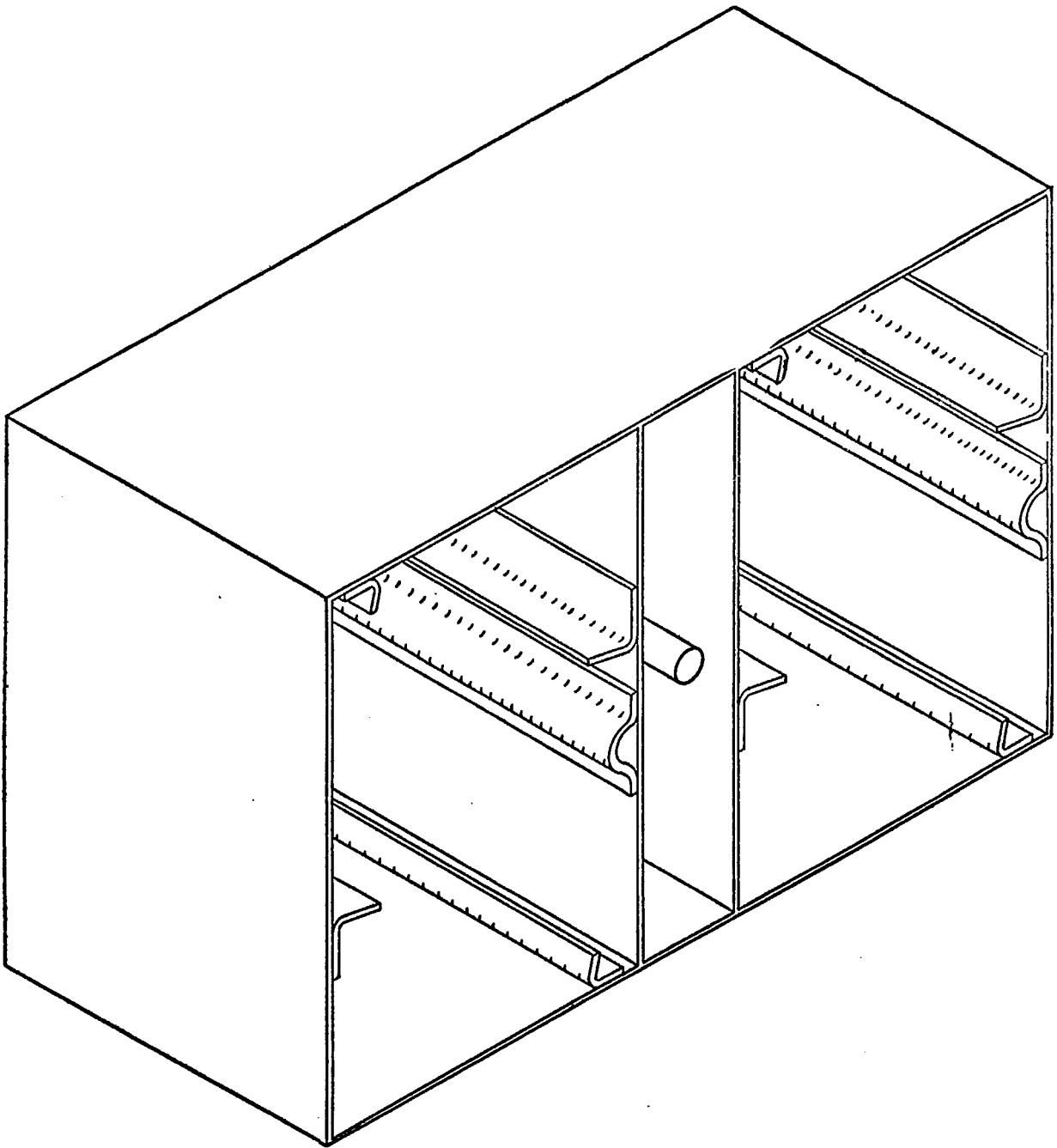


FOUR-CAGE ASSEMBLY

FIGURE 203-2. Cage assembly (outaway view).

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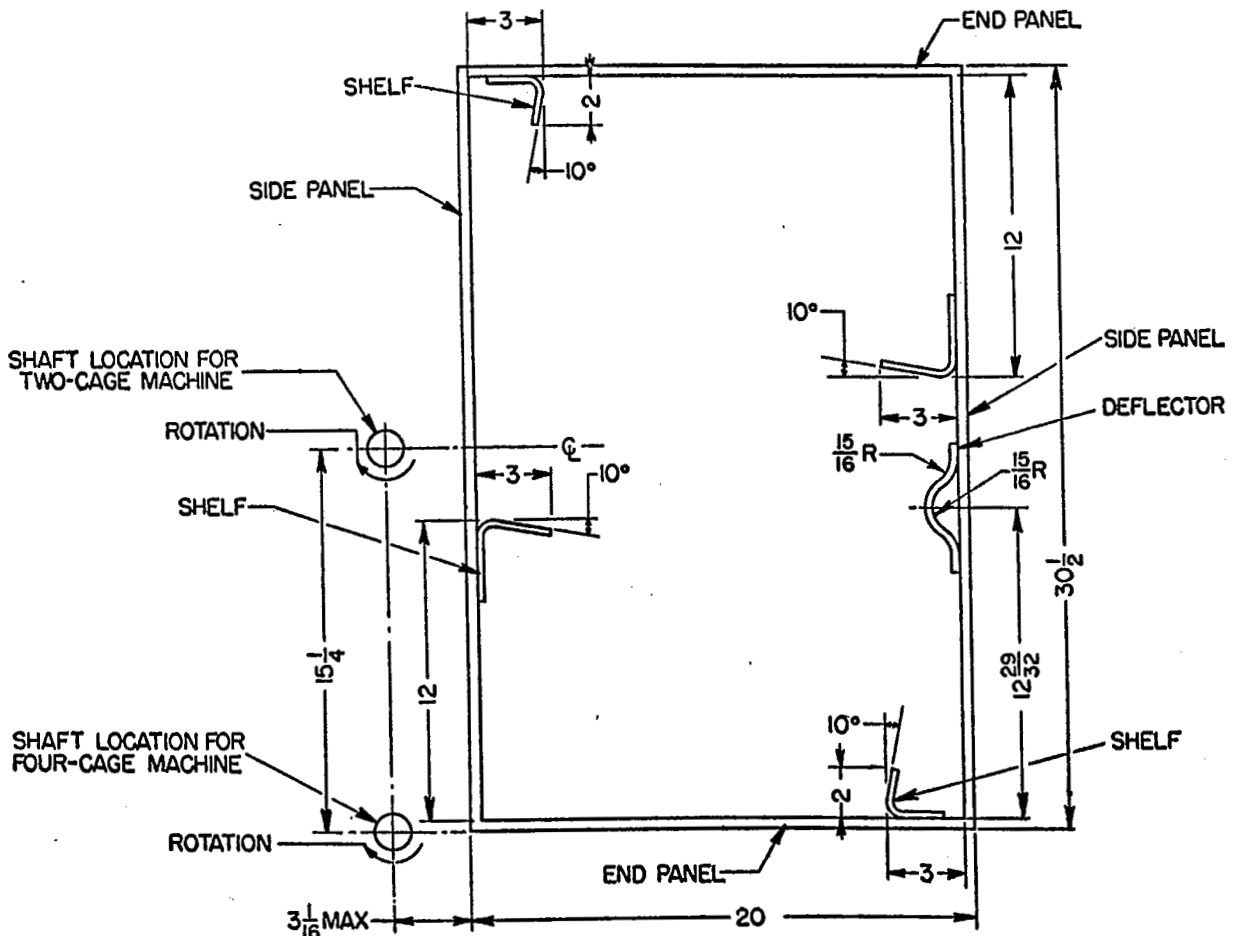
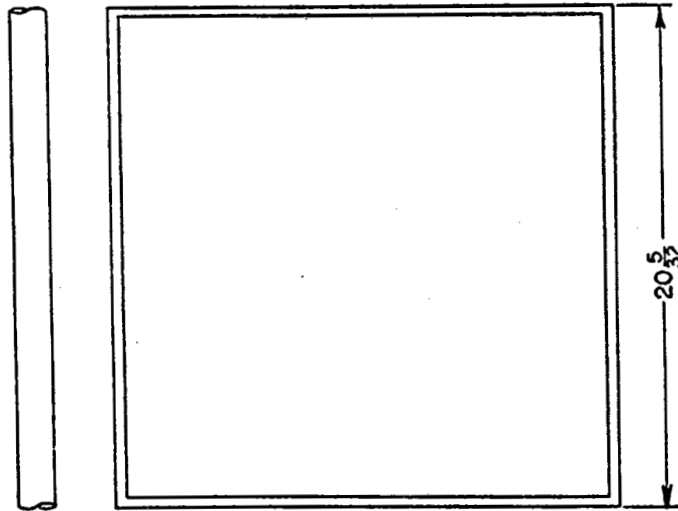
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**TWO-CAGE ASSEMBLY**

**FIGURE 203-2.—Continued**

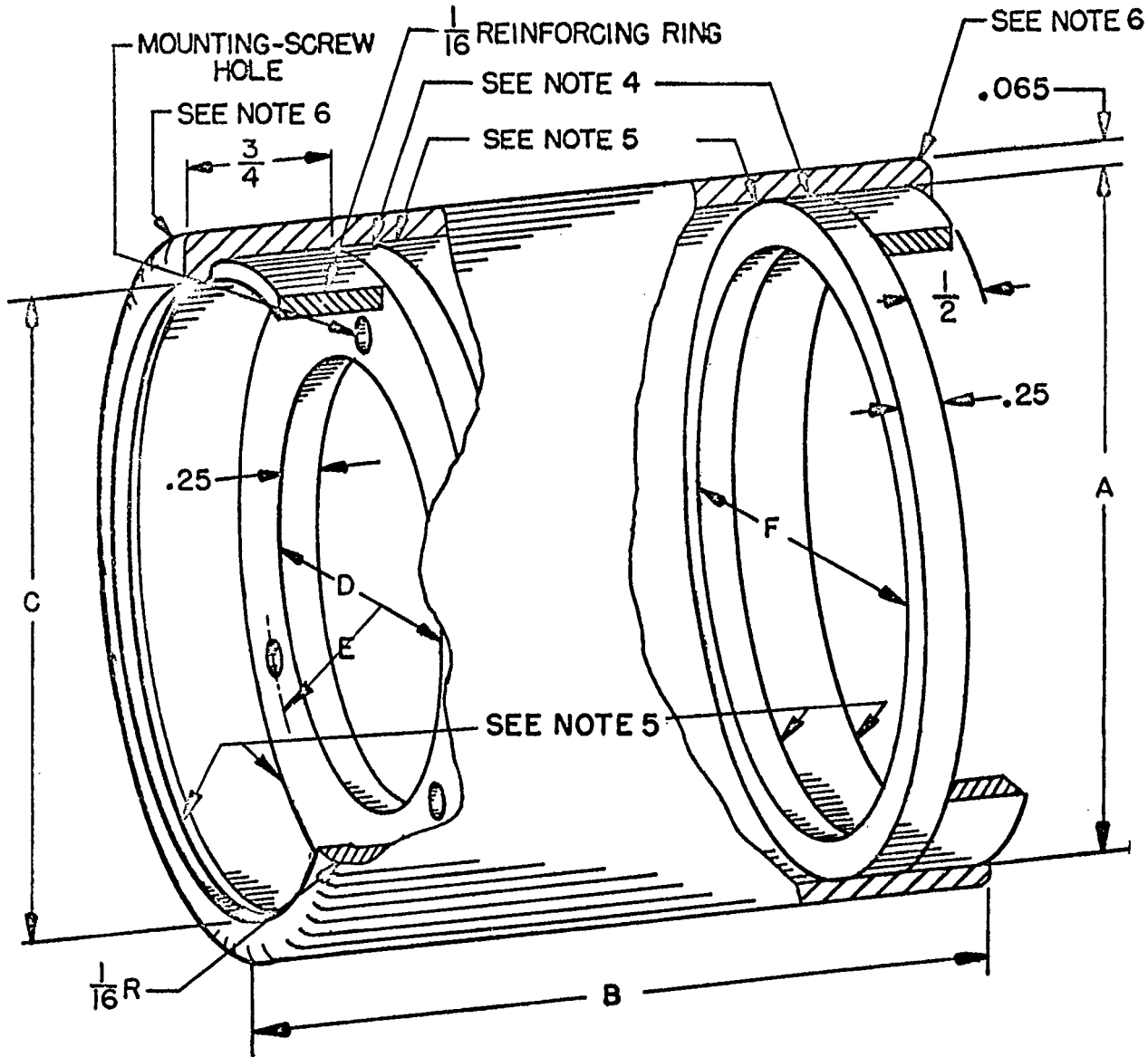
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1. All dimensions in inches.
2. Unless otherwise specified, tolerances are  $\pm \frac{1}{16}$  on fractions and  $\pm \frac{1}{2}$  on angles.
3. Material for end and side panels shall be steel .0747 nominal thickness.
4. Material for shelves and deflectors shall be steel .088 nominal thickness.

FIGURE 203-3. Cage (interior).

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Dimensions					
A	B ± 1/16	C ± 1/16	D	E (R)	F ± 1/16
3.870	4 1/32	3 3/4	1.510	.928	3.370
3.870	4 1/32	3 3/4	2.220	1.220	3.370
3.870	4 1/32	3 3/4	2.820	1.580	3.370
4.870	5 1/32	4 3/4	3.820	2.062	4.370

1. All dimensions in inches.
2. Unless otherwise specified, tolerances are  $\pm .005$  on decimals and  $\pm 1/64$  on fractions.
3. Material for sleeve and reinforcing rings shall be carbon steel, type I, condition CD&R, FS 1000, conforming to Specification QQ-S-00648.
4. Material shall be hot-rolled steel strip, annealed condition, annealed finish, conforming to Specification QQ-S-636.
5. Silver solder all around. Silver solder shall conform to class 1 of Specification QQ-S-561.
6. End of cylinder to be spun-over after insertion of reinforcing ring.

FIGURE 203-4. Sleeve.

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## METHOD 204A

### VIBRATION, HIGH FREQUENCY

**1. Purpose.** The high-frequency vibration test is performed for the purpose of determining the effect on component parts of vibration in the frequency ranges of 10 to 500 cycles per second (cps) or 10 to 2,000 cps, as may be encountered in aircraft, missiles, and tanks. The choice of test condition A, B, C, or D should be based on the frequency range and the vibration amplitude dictated by the applications of the component under consideration, and the state of the component art in relation to resistance-to-vibration damage.

#### 2. Procedure.

**2.1 Mounting.** The specimens shall be mounted as specified. For specimens with attached brackets, one of the vibration-test directions shall be parallel to the mounting surface of the bracket. Vibration input shall be monitored on the mounting fixture in the proximity of the support points of the specimen.

**2.2 Test condition A.** The specimens, while deenergized or operating under the load conditions specified, shall be subjected to the vibration amplitude, frequency range, and duration specified in 2.2.1, 2.2.2, and 2.2.3, respectively (see fig. 204-1).

**2.2.1 Amplitude.** The specimens shall be subjected to a simple harmonic motion having an amplitude of either 0.06-inch double amplitude (maximum total excursion) or 10 gravity units (G), whichever is less. The

tolerance on vibration amplitude shall be  $\pm 10$  percent.

**2.2.2 Frequency range.** The vibration frequency shall be varied logarithmically between the approximate limits of 10 and 500 cps (see 2.6), except that the procedure of method 201 of this standard may be applied during the 10 to 55 cps band of the vibration frequency range.

**2.2.3 Sweep time and duration.** The entire frequency range of 10 to 500 cps and return to 10 cps shall be traversed in 15 minutes. This cycle shall be performed 12 times in each of 3 mutually perpendicular directions (total of 36 times), so that the motion shall be applied for a total period of approximately 9 hours. Interruptions are permitted provided the requirements for rate of change and test duration are met. Completion of cycling within any separate band is permissible before going to the next band. When the procedure of method 201 of this standard is used for the 10 to 55 cps band, the duration of this portion shall be the same as the duration for this band using logarithmic cycling (approximately  $1\frac{1}{2}$  hours in each of 3 mutually perpendicular directions).

**2.3 Test condition B.** The specimens, while deenergized or operating under the load conditions specified, shall be subjected to the vibration amplitude, frequency range, and duration specified in 2.3.1, and 2.3.2, and 2.3.3, respectively (see fig. 204-1).

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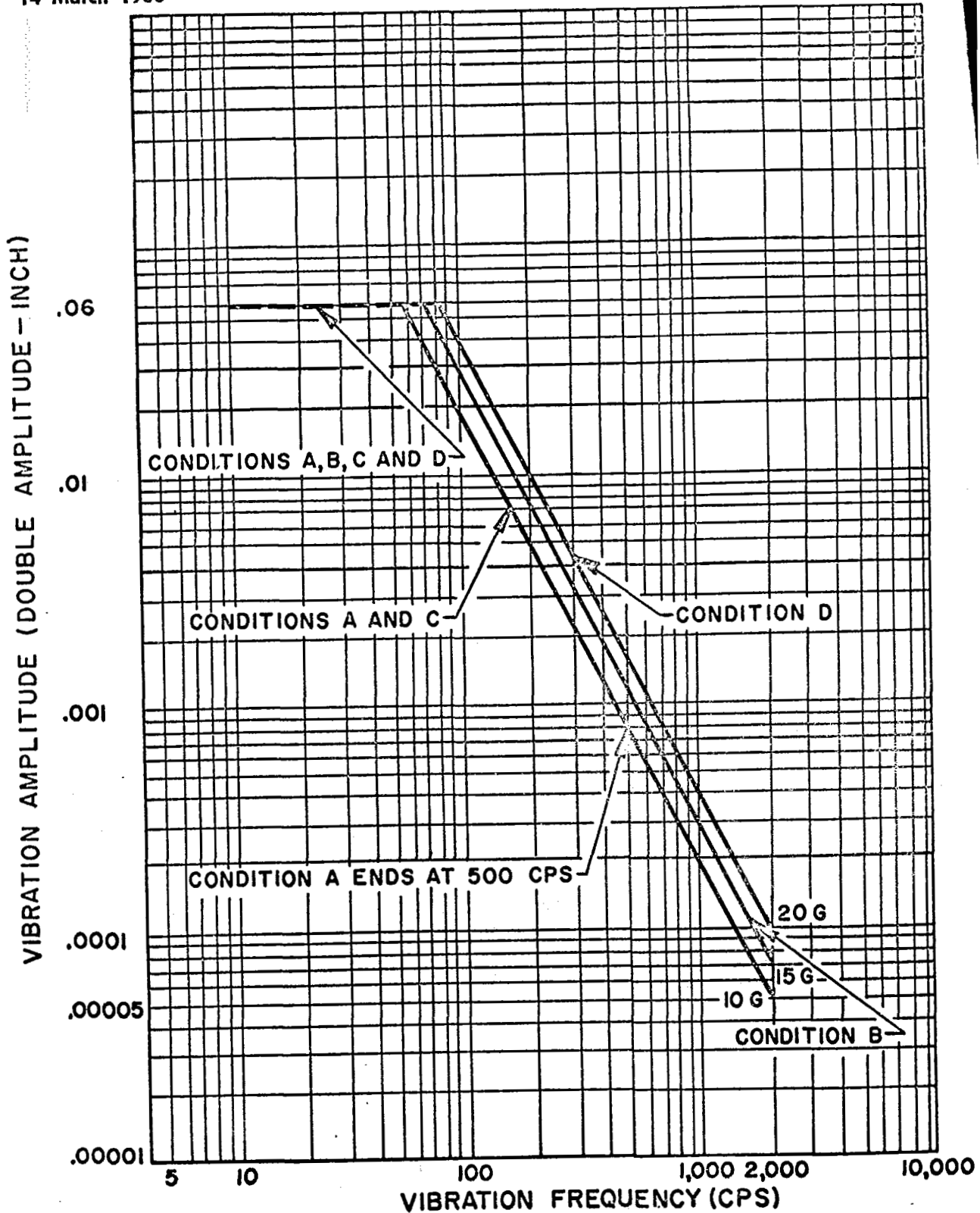


FIGURE 204-1. Vibration-test curves.

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**2.3.1 Amplitude.** The specimens shall be subjected to a single harmonic motion having an amplitude of either 0.06-inch double amplitude (maximum total excursion) or 15 G, whichever is less. The tolerance on vibration amplitude shall be  $\pm 10$  percent.

**2.3.2 Frequency range.** The vibration frequency shall be varied logarithmically between the approximate limits of 10 and 2,000 cps (see 2.6), except that the procedure of method 201 of this standard may be applied during the 10 to 55 cps band of the vibration frequency range.

**2.3.3 Sweep time and duration.** The entire frequency range of 10 to 2,000 cps and return to 10 cps shall be traversed in 20 minutes. This cycle shall be performed 12 times in each of 3 mutually perpendicular directions (total of 36 times), so that the motion shall be applied for a total period of approximately 12 hours. Interruptions are permitted provided the requirements for rate of change and test duration are met. Completion of cycling within any separate band is permissible before going to the next band. When the procedure of method 201 of this standard is used for the 10 to 55 cps band, the duration of this portion shall be the same as the duration for this band using logarithmic cycling (approximately  $1\frac{1}{8}$  hours in each of 3 mutually perpendicular directions).

**2.4 Test condition C.** The specimens, while deenergized or operating under the load conditions specified, shall be subjected to the vibration amplitude and frequency range shown on figure 204-1. The tolerance on vibration amplitude shall be  $\pm 10$  percent.

**2.4.1 Part 1.** The specimens shall be tested in accordance with method 201 of this standard for 6 hours, 2 hours in each of 3 mutually perpendicular directions.

**2.4.2 Part 2.** The specimens shall be sub-

jected to a simple harmonic motion having an amplitude varied to maintain a constant peak acceleration of 10 G, the frequency being varied logarithmically between the approximate limits of 55 and 2,000 cps (see 2.6). The entire frequency range of 55 to 2,000 cps (no return sweep) shall be traversed in  $35 \pm 5$  minutes, except that in the vicinity of what appears to be resonance, and in order to facilitate the establishment of a resonant frequency, the above rate may be decreased. If resonance is detected, specimens shall be vibrated for 5 minutes at each critical resonant frequency observed. This procedure shall be performed in each of three mutually perpendicular directions. Interruptions are permitted provided the requirements for rate of change and test duration are met.

**2.4.3 Resonance.** A critical resonant frequency is that frequency at which any point on the specimen is observed to have a maximum amplitude more than twice that of the support points. When specified, resonant frequencies shall be determined either by monitoring parameters such as contact opening, or by use of resonance-detecting instrumentation.

**2.5 Test condition D.** The specimens, while deenergized or operating under the load conditions specified, shall be subjected to the vibration amplitude, frequency range, and duration specified in 2.5.1, 2.5.2, and 2.5.3, respectively (see fig. 204-1).

**2.5.1 Amplitude.** The specimens shall be subjected to a single harmonic motion having an amplitude of either 0.06-inch double amplitude (maximum total excursion) or 20 G, whichever is less. The tolerance on vibration amplitude shall be  $\pm 10$  percent.

**2.5.2 Frequency range.** The vibration frequency shall be varied logarithmically between the approximate limits of 10 and 2,000 cps (see 2.6), except that the procedure of

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method 201 of this standard may be applied during the 10 to 55 cps band of the vibration frequency range.

**2.5.3 Sweep time and duration.** The entire frequency range of 10 to 2,000 cps and return to 10 cps shall be traversed in 20 minutes. This cycle shall be performed 12 times in each of 3 mutually perpendicular directions (total of 36 times), so that the motion shall be applied for a total period of approximately 12 hours. Interruptions are permitted provided the requirements for rate of change and test duration are met. Completion of cycling within any separate band is permissible before going to the next band. When the procedure of method 201 of this standard is used for the 10 to 55 cps band, the duration of this portion shall be the same as the duration for this band using logarithmic cycling (approximately  $1\frac{1}{3}$  hours in each of 3 mutually perpendicular directions).

**2.6 Alternate procedure for use of linear in place of logarithmic change of frequency.** Linear rate of change of frequency is permissible under the following conditions:

- (a) The frequency range above 55 cps shall be subdivided into not less than three bands. The ratio of the maximum frequency to the minimum frequency in each band shall be not less than two.
- (b) The rate of change of frequency in cycles per second per minute (cps/min) shall be constant for any one band.
- (c) The ratio of the rate of change of frequency of each band to the maximum frequency of that band shall be approximately equal.

**2.6.1 Example of alternate procedure.** As

an example of the computation of rates of change, assume that the frequency spectrum has been divided into three bands, 55 to 125 cps, 125 to 500 cps, and 500 to 2,000 cps, in accordance with 2.6(a). Let the (constant) ratio of rate of frequency change in cps/min, to maximum frequency in cps be  $k$  for each band. Then the rates of change for the three bands will be  $125k$ ,  $500k$ , and  $2,000k$ , respectively. The times, in minutes, to traverse the three frequency bands will therefore be respectively:

$$\begin{array}{ccc} \underline{125-55}, & \underline{500-125}, & \underline{2,000-500} \\ \underline{125k} & \underline{500k} & \underline{2,000k} \end{array}$$

Since the minimum total sweep time is 30 minutes.

$$30 = \frac{70}{125k} + \frac{375}{500k} + \frac{1,500}{2,000k}$$

$$\text{from which: } k = 0.0685$$

The required maximum constant rates of frequency change for the three bands are therefore 8.55, 34.2, and 137 cps/min, respectively. The minimum times of traverse of the bands are 8.2, 10.9, and 10.9 minutes, respectively.

**3. Measurements.** Measurements shall be made as specified.

**4. Summary.** The following details must be specified in the individual specification:

- (a) Mounting of specimens (see 2.1).
- (b) Electrical-load conditions, if applicable (see 2.2, 2.3, 2.4, and 2.5).
- (c) Test-condition letter (see fig. 204-1).
- (d) Method of determining resonance, if applicable (see 2.4.3).
- (e) Measurements (see 3).

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## METHOD 205B

### SHOCK, MEDIUM IMPACT

**1. Purpose.** The primary purpose of this test method is to standardize the procedures used in performing medium-impact shock tests on parts weighing up to 300 pounds so that comparable test results will be obtained by all users of the shock-testing apparatus specified herein. This apparatus was developed specifically for evaluating the ability of parts to withstand some of the rigors of military service and other conditions of rough handling.

**1.1 Comparison values for test conditions.** Because of the complex nature of the shock motions in this apparatus, and the dependence of the magnitude of acceleration measurements on the frequency response range of the instrumentation used for detecting the shock pulse, it is impractical to specify shock tests performed with this apparatus in terms of simple functions, eg, acceleration and duration. For correlation of this test method with existing specifications which call for shock in terms of specific conditions of acceleration and duration, nominally the shocks corresponding to test condition A are of the 15-gravity unit (G), 11-millisecond type; test condition B, the 30 G, 11-millisecond type; test condition C, the 50 G, 11-millisecond type (see 4.5).

**2. Precautions.** The uprights shall be checked for vertical alinement after each 500 drops, so that binding or excessive looseness of the elevator and track shall not occur. All hardware of the elevator assembly shall be checked for tightness after each 100 drops. All other hardware of the shock apparatus shall be checked for tightness after each 500 drops. The arresting material must be maintained at the proper level (see 3.3) to assure satisfactory sand preparation (see 4.1 to 4.1.5, incl).

**3. Apparatus.** The shock testing apparatus specified herein and shown on figures 205-1 and 205-2 shall be used, as applicable. Detail drawings for the apparatus shall be as shown on Drawings 205-1 and 205-2 (see 3.5). The two shock apparatus are similar in construction and method of operation, the chief difference being in the capacity of the test load. The smaller apparatus (see fig. 205-1) tests a minimum load of 20 pounds and a maximum load of 50 pounds; the larger apparatus (see fig. 205-2) tests a minimum load of 150 pounds and a maximum load of 400 pounds. Further reference in this test method to the apparatus will be "20-50 pound" for the smaller and "150-400 pound" for the larger. The test apparatus consists of an elevator with impact blocks attached. The elevator is raised to a specified height and dropped on an arresting material. The shock pulse is produced by allowing the loaded elevator table to fall freely into a sandbox which forms the base of this apparatus.

**3.1 Elevator assembly.** The assembly shall have a flat surface or table to allow placement of the parts and necessary weights. Mounting holes, used for clamping of parts, shall be placed in the table where needed.

**3.2 Impact blocks.** The impact blocks shall be constructed of hard maple or kiln-dried oak, and shall be of the dimensions specified on figures 205-1 and 205-2, as applicable. The blocks shall be faced with metal, as specified on figures 205-1 and 205-2, as applicable, to prevent wear.

**3.3 Arresting material.** The arresting material shall be sand contained in a box-like enclosure. The sand shall be Ottawa River kiln-dried sand, screened to 30-40 grit size,

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and filled to a depth of approximately 14 inches in the sandbox (see 4.1.4).

**3.4 Rakes.** The rake used with the 20-50 and 150-400 pound apparatus shall be as shown on figures 205-1 and 205-2, respectively.

**3.5 Detail drawings (see 3).** Copies of detail drawings may be obtained from the Armed Services Electro-Standards Agency, Fort Monmouth, N. J. When requesting copies of these drawings, both the identifying symbol number and title should be stipulated, as follows:

Drawing 205-1 — Medium Impact Shock Apparatus (20-50 Pound).

Drawing 205-2 — Medium Impact Shock Apparatus (150-400 Pound).

**4. Procedure.** The specimen shall be rigidly mounted on the elevator table by its normal mounting means. Special mounting means, when required, shall be as specified. When necessary, small bags of either lead shot or sand shall be added so that the total load on the elevator table of the 20-50 pound apparatus is at least 20 pounds, and that on the 150-400 pound apparatus is at least 150 pounds. The elevator shall then be raised to the height required by the specified condition (see 4.5).

#### 4.1 Sand raking procedure.

**4.1.1 Compacting of sand.** If the sand has just been placed in the sandbox or if it has been raked deeply, the elevator shall be dropped 10 times to insure that the sand is properly compacted.

**4.1.2 Displaced sand.** The sand which has been displaced to the sides of the sandbox by a previous drop shall be raked back toward the center of the sandbox by stroking the rake approximately one-third stroke from

opposite sides toward the center. At all times the rake shall be stroked in a direction perpendicular to the impact blocks.

**4.1.3 Leveling and conditioning of sand.** The sand shall then be leveled and conditioned by stroking the rake several times across the full length of the sandbox, except for the 20-50 pound apparatus. For the 20-50 pound apparatus, the sand shall be raked from the center pedestal. At the conclusion of each stroke, the rake shall be lifted from the sand and then replaced immediately behind the accumulated sand. A stroke shall then be made in the opposite direction. This procedure eliminates buildup of sand at the edges of the sandbox, and shall be continued until an even furrowed surface results.

**4.1.4 Rake alinement and sand quantity.** Care shall be taken to keep the teeth of the rake substantially vertical. Sufficient downward force shall be applied to the rake to keep the guide angles in flat contact with the flanges of the sandbox on which they ride. The proper volume of sand (see 3.3) must be present in the sandbox to achieve satisfactory raking. (If there is too little sand, sand voids will appear on the top of the furrows; the presence of too much sand will cause the excess sand to build-up at the edges of the sandbox.)

**4.1.5 Subsequent sand treatment.** Subsequent sand treatment shall involve only shallow raking and surface preparations.

**4.2 Level check.** Prior to each drop the loaded elevator shall be suspended freely from the hoist cable and the elevator table shall be leveled to insure that it is balanced and that it will fall squarely on the arresting material.

**4.3 Height indication.** The zero level of the height indicator shall be determined by bringing the loaded elevator down until the

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impact blocks just rest on the sand. Care shall be taken that the elevator be lowered gently on the sand.

4.4 Number and direction of applied shocks. Three shocks, with the specimen oriented in each of the six directions stated below, shall be applied (a total of 18 shocks). The specimen shall be rotated in the following directions:

1. Bottom down.
2. Front down.
3. Right side down.
4. Back down.
5. Left side down.
6. Top down.

If the starting point is important, it shall be specified; if not, the testing laboratory will arbitrarily assign a bottom and a front.

4.5 Height of drop. The specimen shall be subjected to one of the following conditions, as specified:

<i>Test condition</i>	<i>Height of drop<sup>1</sup> (inches)</i>
A .....	4
B .....	13
C .....	30

<sup>1</sup> The 20-50 pound apparatus shall have a minimum balance load of 20 pounds; the 150-400 pound apparatus shall have a minimum balance load of 150 pounds.

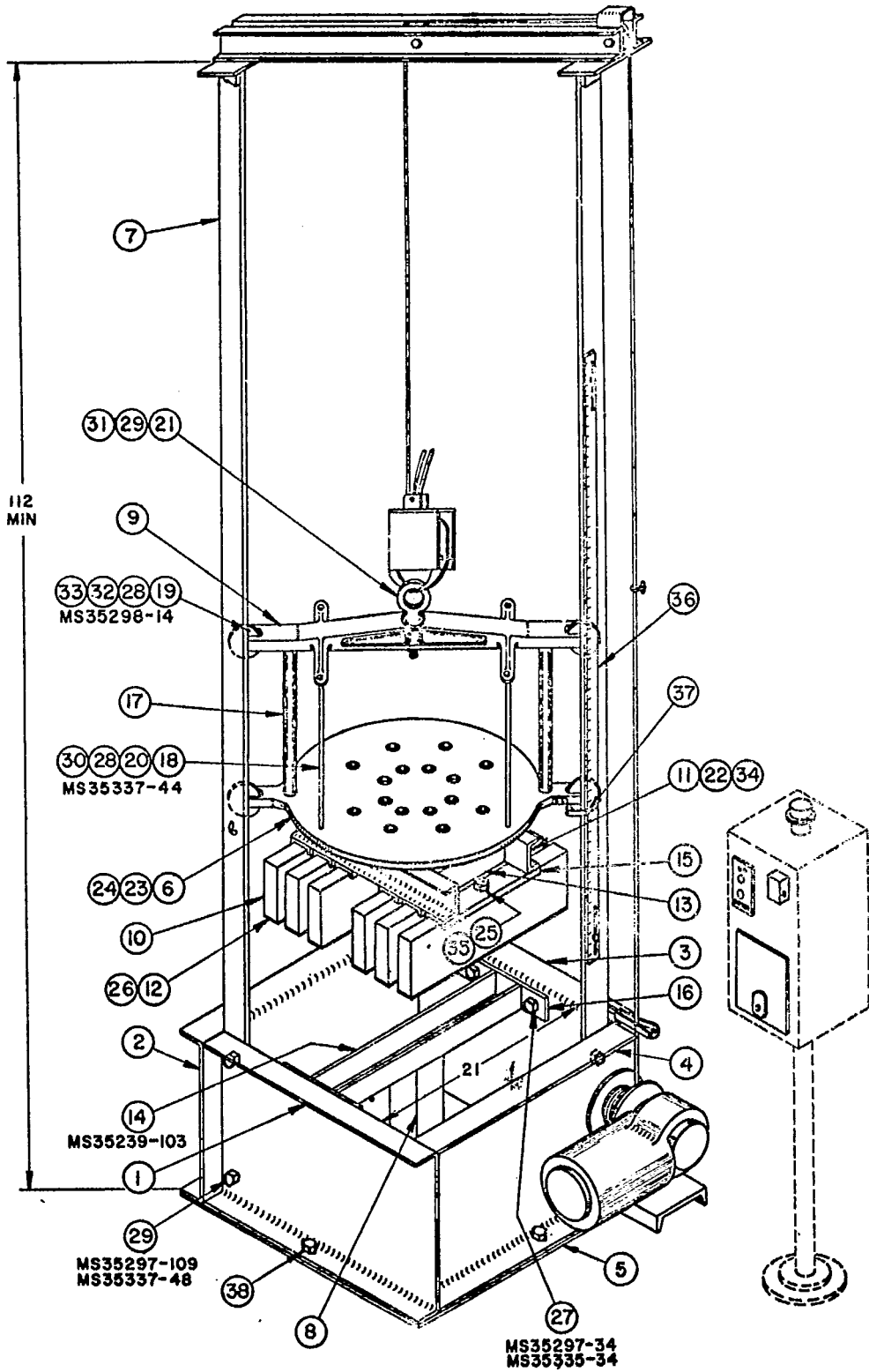
5. Measurements and electrical loading. Measurements and electrical loading shall be as specified.

6. Summary. The following details must be specified in the individual specification:

- (a) Special mounting means, if applicable (see 4).
- (b) Reference surfaces, if applicable (see 4.4).
- (c) Test-condition letter (see 4.5).
- (d) Measurements and electrical loading before, during, and after shock, if applicable (see 5).

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**FIGURE 205-1. 20-50 pound medium-impact shock apparatus.**

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## Bill of materials for 20-50 lb medium-impact shock apparatus

Item No. or MS part No.	Description	Quantity	Remarks
1	Front base channel	1	} Steel (hot-rolled).
2	Left-side base channel	1	
3	Back base channel	1	
4	Right-side base channel	1	
5	Bottom plate	1	
6	Elevator table	1	Aluminum sand-cast alloy.
7	Track (uprights)	2	Structural steel (see notes 3 and 4).
8	Sandbox center pedestal	1	Steel (hot-rolled).
9	Crossbeam	1	Aluminum sand-cast alloy.
10	Impact block	6	Wood (hard maple or kiln-dried oak), 17 x 5½ x 1½.
11	Channel	2	Steel (hot-rolled), 3 in. x 4.1 lb.
12	Impact plate	6	Steel (hot-rolled), 17 x 1½ x ½.
13	Channel	2	Steel (hot-rolled), 3 in. x 4.1 lb.
14	Cradle channel	1	} Steel (hot-rolled).
15	Strip	6	
16	Cradle plate	2	
17	Support post	2	Aluminum alloy.
18	Spacer tube	4	Aluminum.
19	Tire	4	Rubber (for NICE-400-23, Cat. No. 55, Boston Gear Works, or equal).
20	Tie rod	4	Steel (cold-rolled).
21	Shoulder eyebolt	1	Steel (hot-forged).
22	Bevel washer	4	Rolled steel (without hole), 1¼ x 1¼ x ⅝.
23	Insert	16	⅝ <sub>16</sub> -18 UNC-2B x 1⅝ <sub>32</sub> lg (Helicoil, or equal).
24	Insert	4	½-13 UNC-2B x 1 lg.
25	Screw	6	Sq hd, ⅝-16 UNC-2A, 6½ lg.
26	Screw	48	Wood, rh # 10 x ¾ lg.
27	Hex nut	4	⅝ <sub>16</sub> -18 UNC-2B.
28	Hex nut	12	¼-28 UNF-2B.
29	Hex nut	9	½-13 UNC-2B.
30	Washer	8	½ OD x .265 ID x .046 thk.
31	Washer	1	Plain, 2 OD x .515 ID x .093 thk.
32	Washer	8	Plain, ½ OD x .265 ID x .031 thk.
33	Lockwasher	4	Split, ¼ x ⅜ thk.
34	Screw	4	½-13 UNC-2A, 1⅝ lg, (hd, 1 in. across flats).
35	Nut	6	⅝-16 UNC-2B.
36	Scale	1	Height of drop (inches).
37	Height indicator	1	
38	Lag bolt	4	½ dia, steel.

FIGURE 205-1. 20-50 pound medium-impact shock apparatus—Continued

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*Bill of materials for 20-50 lb medium-impact shock apparatus—Continued*

Item No. or MS part No.	Description	Quantity	Remarks
MS35239-103	Machine screw	2	...
MS35297-34	Capscrew	4	...
MS35297-109	Capscrew	8	...
MS35298-14	Capscrew	4	...
MS35335-34	Lockwasher	4	...
MS35337-44	Lockwasher	8	...
MS35337-48	Lockwasher	8	...

<sup>1</sup> All dimensions in inches.

<sup>2</sup> Unless otherwise specified, tolerances are  $\pm 1/64$  on fractions,  $\pm .005$  on decimals, and  $\pm 1/2^\circ$  on angles

<sup>3</sup> The uprights shall be absolutely vertical.

<sup>4</sup> Height of uprights is adequate for a 58-inch drop.

<sup>5</sup> Wheels of the elevator assembly shall be adjusted so that a guided free fall will occur.

<sup>6</sup> This apparatus is to be mounted on a standard reinforced concrete pad of at least 9 square feet in area and 6 inches thick.

**FIGURE 205-1.—Continued**

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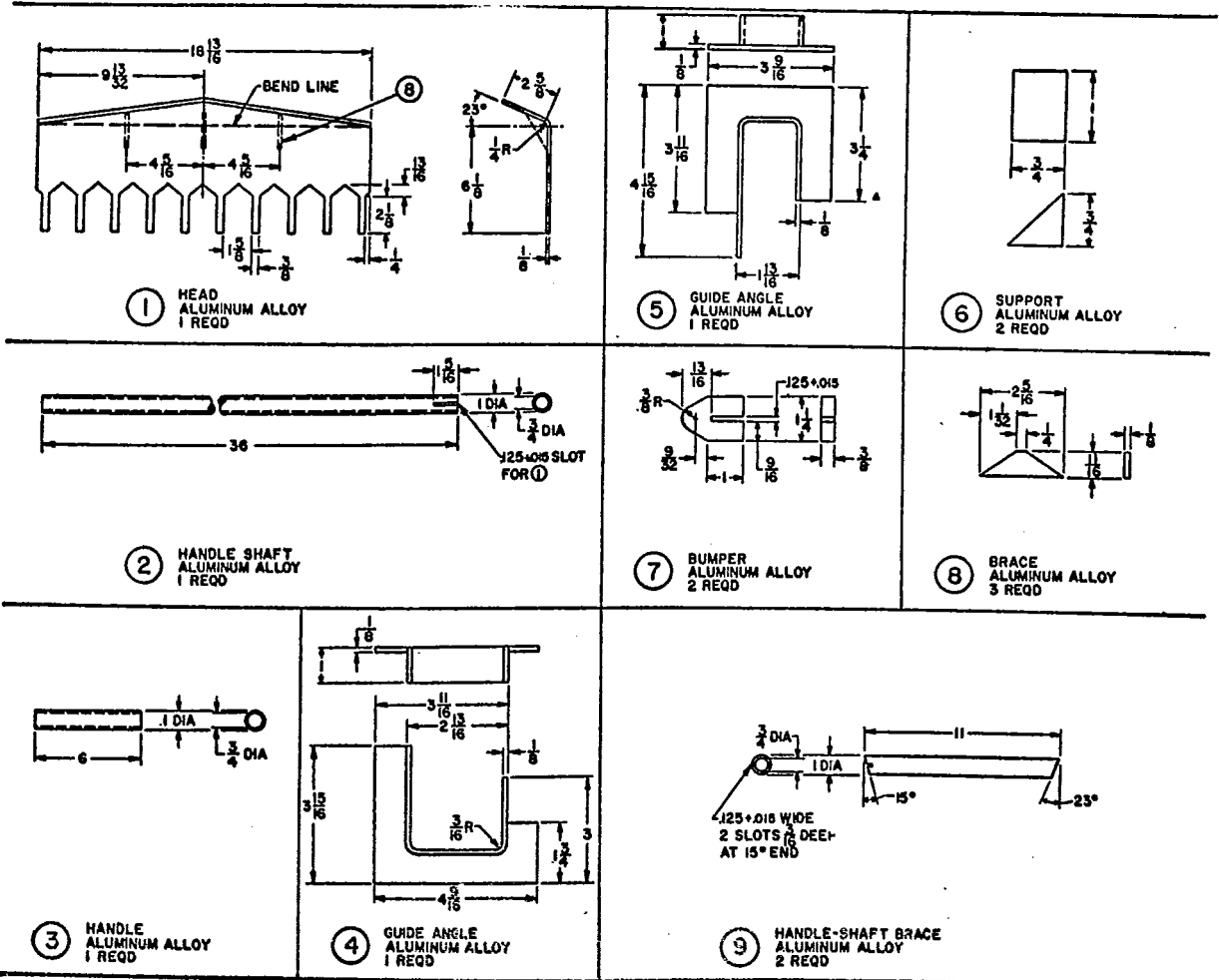
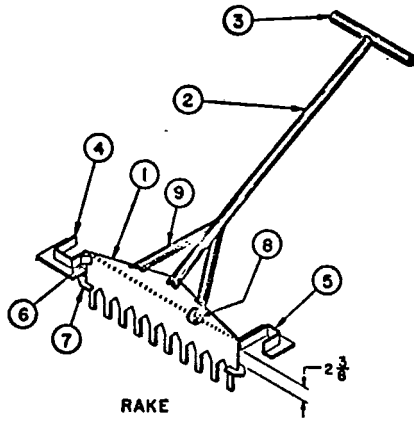


FIGURE 205-1.—Continued

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*Bill of materials for rake (U/W 20-50 lb medium-impact shock apparatus)*

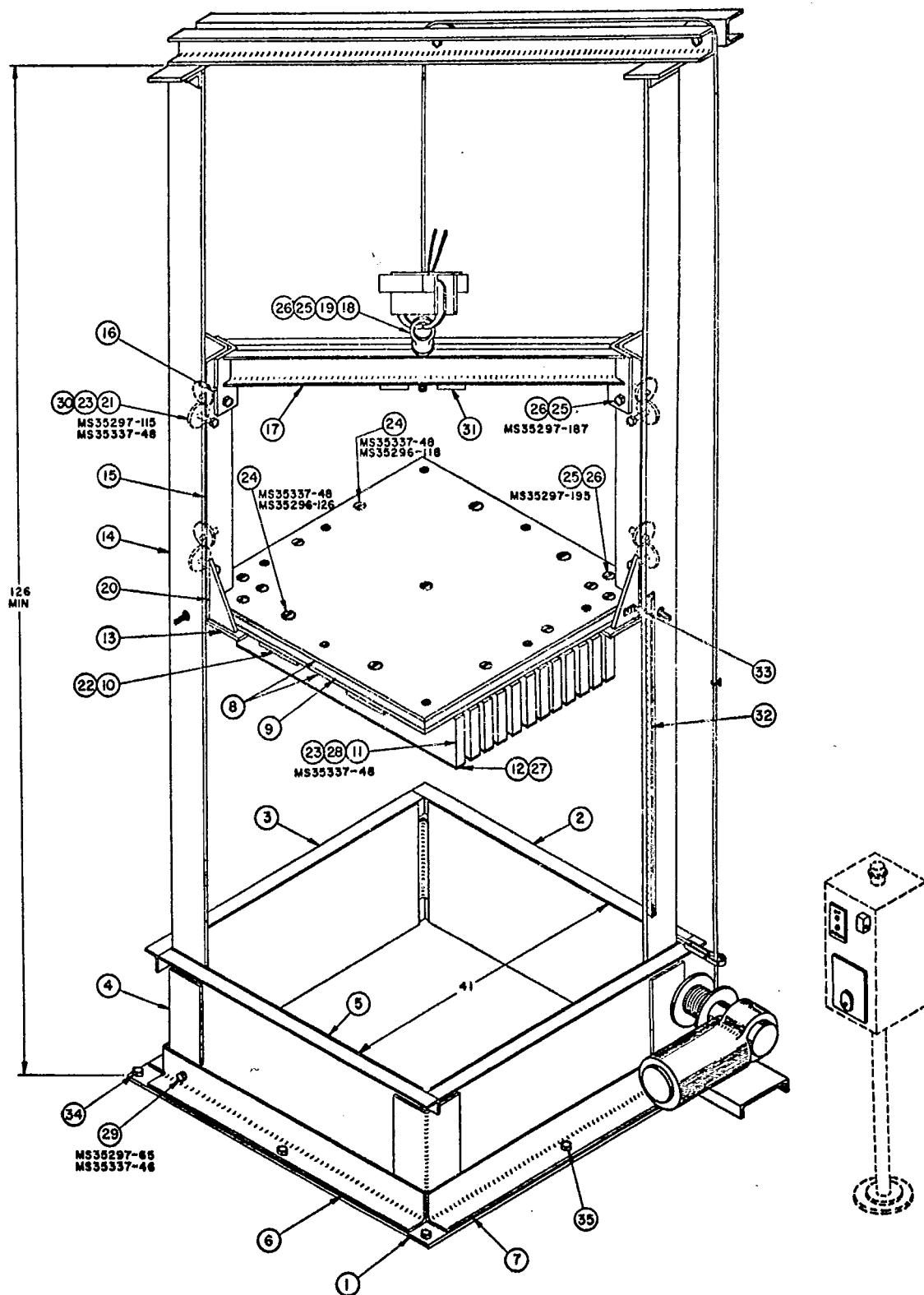
Item No.	Description	Quantity	Material
1	Head	1	Aluminum alloy, temper T3, per Specification QQ-A-362.
2	Handle shaft	1	} Aluminum alloy, temper O, per Specification WW-T-785.
3	Handle	1	
4	Guide angle	1	} Aluminum alloy, temper T4, per Specification QQ-A-267.
5	Guide angle	1	
6	Support	2	
7	Bumper	2	
8	Brace	3	Aluminum alloy, temper T3, per Specification QQ-A-362.
9	Handle-shaft brace	2	Aluminum alloy, temper O, per Specification WW-T-785.

1. All dimensions in inches.
2. Unless otherwise specified, tolerances are  $\pm 1/64$  on fractions,  $\pm .005$  on decimals, and  $\pm 1^\circ$  on angles.
3. Sharp edges shall be broken to .010 maximum.
4. Rigidly weld item ② and items ④ to ⑨, inclusive, to item ①.
5. Rigidly weld items ③ and ⑧ to item ②.

**FIGURE 205-1.—Continued**

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X



ASSEMBLY  
FIGURE 205-2. 150-400 pound medium-impact shock apparatus.

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*Bill of materials for 150-400 lb medium-impact shock apparatus—Continued*

Item No. or MS part No.	Description	Quantity	Remarks
1	Bottom plate	1	Steel.
2	Top angle	2	} Structural
3	Top angle	2	
4	Corner angle	4	} Steel.
5	Plate	4	
6	Base channel	2	} Structural steel.
7	Base channel	2	
8	Elevator table	2	Aluminum.
9	Elevator table	1	Plywood.
10	Elevator table channel	2	Structural steel, 6 in. x 8.2 lb.
11	Impact block	12	Wood (hard maple or kiln-dried oak), 35 x 5½ x 1½.
12	Impact plate	12	Steel (cold-rolled), 35 x 1½ x ½.
13	Elevator table plate	2	Steel.
14	Track (uprights)	2	Structural steel (see notes 3 and 4).
15	Elevator angle	2	} Steel.
16	Angle	2	
17	Elevator channel		Structural steel, 4 in. x 5.4 lb.
18	Shoulder eyebolt	1	Steel (hot-forged), standard ¾-10 UNC-2A, 6 lg shank.
19	Washer	1	} Steel.
20	Gusset	6	
21	Tire	8	Rubber (for NICE-400-32, Cat. No. 55, Boston Gear Works, or equal).
22	Spacer	4	½ std pipe x 1 23/32 lg.
23	Hex nut	32	½-13 UNC-2B, regular.
24	Hex nut	9	½-20 UNF-2B (cad pl stl).
25	Hex nut	11	¾-10 UNC-2B (sst).
26	Lockwasher	11	¾ dia (sst).
27	Screw	108	Wood, rh #10 x 1 lg.
28	Screw	24	Hex hd, ½-13 UNC-2A, 7 lg (cad pl stl).
29	Hex nut	4	¾-16UNC-2B (cad pl stl).
30	Spacer	8	100 x 9/16 ID x ½ thk, stl.
31	Plate	2	3¾ x 3¾ x ½, stl (weld to item②).
32	Scale	1	Height of drop (inches).
33	Height indicator	1	...
34	Lag bolt	4	½ dia, steel.
35	Lag bolt	4	¾ dia, steel.

**FIGURE 205-2.—Continued**

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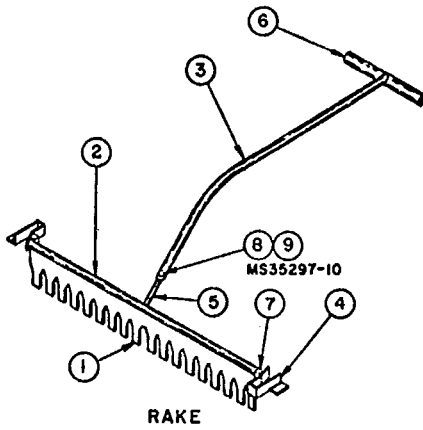
Item No. or MS part No.	Description	Quantity	Remarks
MS35296-118	Capscrew	5	...
MS35296-126	Capscrew	4	...
MS35297-65	Capscrew	4	...
MS35297-115	Capscrew	8	...
MS35297-187	Capscrew	4	...
MS35297-195	Capscrew	6	...
MS35337-46	Lockwasher	4	...
MS35337-48	Lockwasher	41	...

1. All dimensions in inches.
2. Unless otherwise specified, tolerances are  $\pm 1/64$  on fractions,  $\pm .005$  on decimals, and  $\pm 1/2^\circ$  on angles.
3. The uprights shall be absolutely vertical.
4. Height of uprights is adequate for a 36-inch drop.
5. Wheels of the elevator assembly shall be adjusted so that a guided free fall will occur.
6. This apparatus is to be mounted on a standard 6-inch reinforced concrete floor supported by earth. However, if a pad unsupported by earth is used, it should be reinforced concrete at least 36 square feet in area and 12 inches thick.

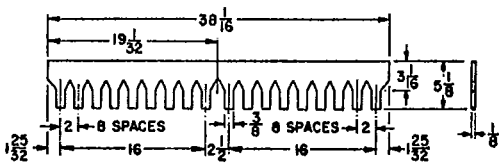
FIGURE 205-2—Continued

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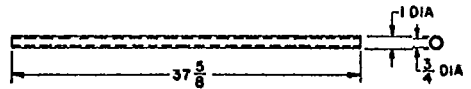
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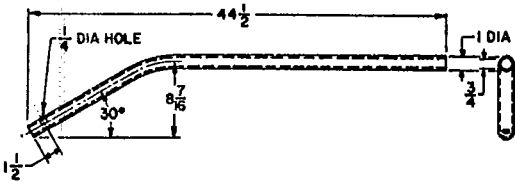
**RAKE**



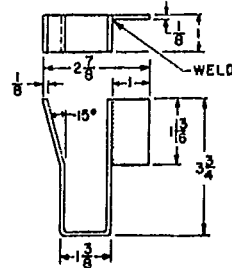
**1** HEAD  
 STEEL (COLD ROLLED)  
 1 REQ



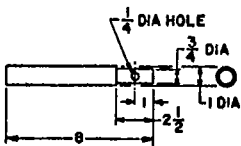
**2** TUBING  
 STEEL (COLD ROLLED)  
 1 REQ



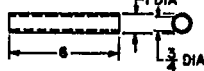
**3** HANDLE SHAFT  
 STEEL (COLD ROLLED)  
 1 REQ



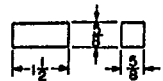
**4** GUIDE ANGLE  
 STEEL (COLD ROLLED)  
 2 REQ



**5** ROD  
 STEEL (COLD ROLLED)  
 1 REQ



**6** HANDLE  
 STEEL (COLD ROLLED)  
 1 REQ



**7** BLOCK  
 STEEL (COLD ROLLED)  
 2 REQ

**FIGURE 205-2—Continued**

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Item No. or MS part No.	Description	Quantity	Remarks
1	Head	1	Steel (cold-rolled).
2	Tubing	1	
3	Handle shaft	1	
4	Guide angle	2	
5	Rod	1	
6	Handle	1	
7	Block	2	
8	Hex nut	1	¼-20 UNC-2B (cad pl stl).
9	Lockwasher	1	¼ dia (sst).
MS35297-10	Capscrew	1	

- All dimensions in inches.
- Unless otherwise specified, tolerances are  $\pm 1/64$  on fractions,  $\pm .005$  on decimals, and  $\pm 1/2^\circ$  on angles.
- Rigidly weld item ② to item ①.
- Rigidly weld item ⑤ to item ②.
- Rigidly weld item ⑥ to item ③.
- Rigidly weld item ⑦ to items ①, ②, and ④.

FIGURE 205-2.—Continued

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## METHOD 206 LIFE (ROTATIONAL)

**1. Purpose.** This test is performed for the purpose of determining the effects of subjecting electronic and electrical parts, which are actuated by rotational motion, to a number of operations approximating the life of the part. Total resistance, contact resistance, and dielectric strength are examples of measurements which may be made prior to, during, or after test, and which would show the effects of rotational actuation. Measurements prior to and after test are generally made for comparison purposes and would indicate the amount of change that results from this test. Parts with sealed shafts and bushings might have the effectiveness of the seal disturbed by rotation; a sealing test performed after this test would disclose this inadequacy. A switch-life test may be performed in conjunction with this test method.

### 2. Procedure

**2.1 Mounting.** Specimens shall be mounted in their normal operating position by the intended mounting means. Normal care shall be taken in the mounting procedure to prevent the binding of shafts during rotation. Figure 206-1 shows a suggested means of preventing this condition, when applicable. Mechanisms such as slip clutches may be used to prevent damage from the application

of excessive torque to the specimens. When this test is conducted at an elevated temperature (see 2.6), the spacing between a group of like specimens shall be as specified.

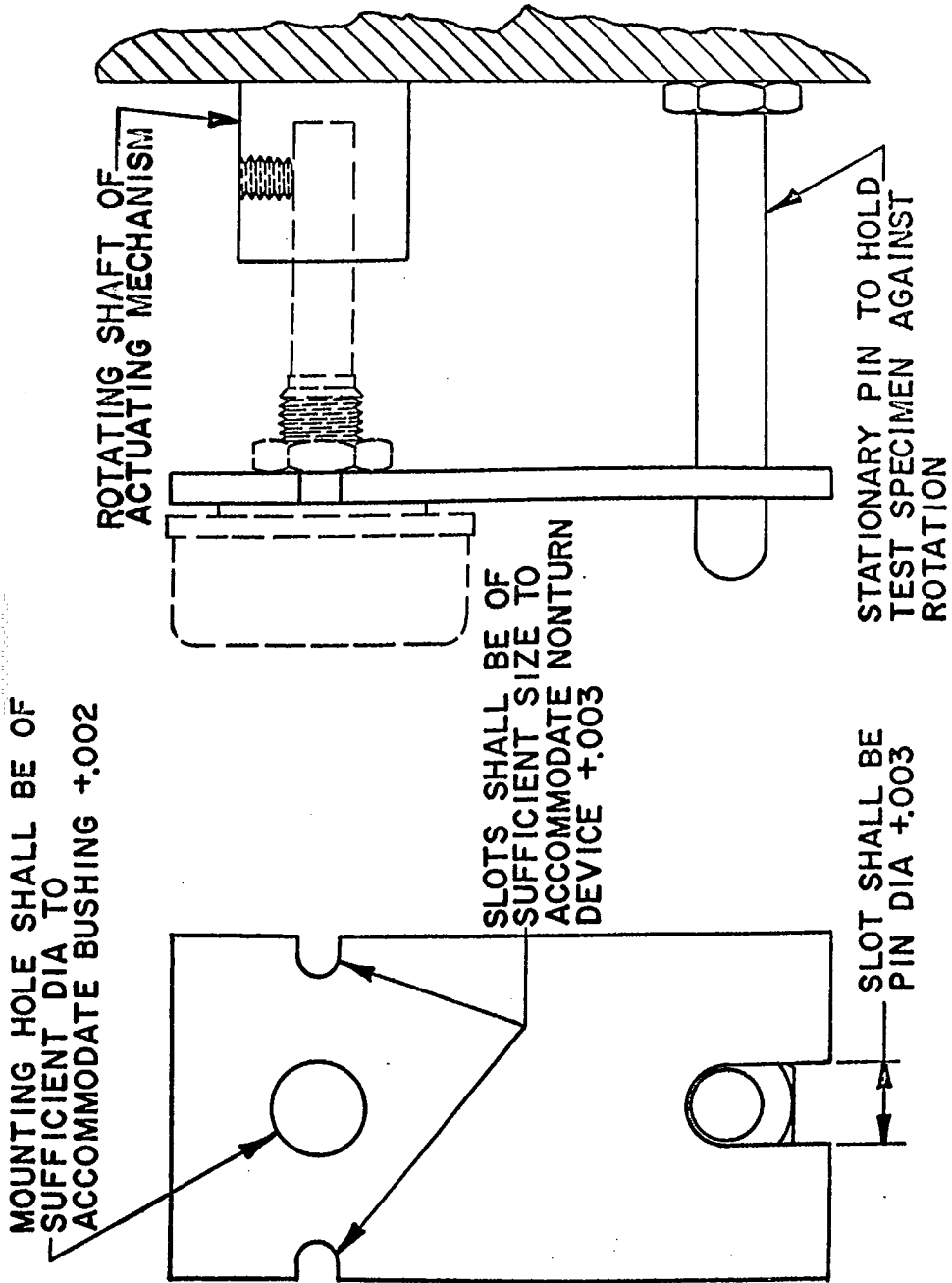
**2.2 Test potential and load.** The test potential and load applied to the specimens during rotation shall be as specified.

**2.3 Cycle.** A cycle shall consist of a rotation of the shaft from one stop position to the other stop position (passing through detent positions, if any), and return to the original position. For specimens not having stops, a cycle shall consist of a rotation of the shaft 360° and return, unless otherwise specified. Specimens with adjustable stops shall have the stops so placed as to permit maximum rotation. Specimens that are rotated by means other than a shaft shall meet the requirements of this paragraph by rotation 360° and return, unless otherwise specified, or from stop to stop.

**2.4 Cycle rate.** The cycle rate shall be expressed in cycles per minute (cpm), and shall be as specified.

**2.5 Number of cycles.** Specimens shall be subjected to one of the following test conditions, as specified:

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 Figure 206-1. Suggested mounting feature for rotational-life test.

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<i>Test condition</i>	<i>Number of cycles</i>
A .....	500
B .....	2,000
C .....	5,000
D .....	10,000
E .....	15,000
F .....	25,000
G .....	50,000
H .....	100,000
J .....	200,000
K .....	300,000
L .....	500,000
M .....	1,000,000
N .....	2,000,000

**2.6 Temperature and atmospheric pressure.** When specified, this test shall be performed at elevated or reduced temperature and at other than room ambient atmospheric pressure.

**3. Measurements.** Specified measurements or tests shall be made prior to, during or

after rotations, as specified.

**4. Summary.** The following details must be specified in the individual specification:

- (a) Spacing of specimens for elevated-temperature testing, when applicable (see 2.1).
- (b) Test potential and load (see 2.2).
- (c) Cycle, if other than specified (see 2.3).
- (d) Cycle rate in cpm (see 2.4).
- (e) Test-condition letter (see 2.5).
- (f) Temperature and atmospheric conditions, when applicable (see 2.6).
- (g) Measurements or tests prior to, during or after rotations, as applicable (see 3).

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## METHOD 207

### HIGH-IMPACT SHOCK

**1. Purpose.** This test is performed for the purpose of determining the ability of various parts to withstand shock of the same severity as that produced by underwater explosions, collision impacts, near-miss gunfire, blasts caused by air explosions, and field conditions. Exact simulation of some of the severe shock motions experienced in the field is difficult to reproduce; however, parts that successfully complete the test of this method have been found to possess the necessary ruggedness for this use. The test apparatus utilized in this method is the same as that designated as Shock Testing Machine for Lightweight Equipment in Specification MIL-S-901, Shockproof Equipment, Class HI (High-Impact), Shipboard Application, Tests for. The purpose of this apparatus is to determine the ability of equipment installed aboard naval ships to withstand shock and still continue to perform its operational function. This test method is limited to testing of parts weighing not more than 300 pounds.

**2. Precautions.** The apparatus shall be examined periodically for damage. Any hardware which has become defective by being deformed or cracked shall be replaced. Particular attention shall be given to the anvil plate which shall not be bowed more than 1 inch at the center. Proper safeguards shall be taken to protect personnel from objects that may become loosened and act as projectiles as a result of this test. A sound-warning arrangement shall be made, for use in alerting personnel in the vicinity of the test of the impending drop of the hammer.

**3. Apparatus.** The apparatus used in this test method shall be as shown on figure 207-1 and the associated detail drawings (see 3.4). The parts shall be installed on a mounting fixture which is attached to the

anvil plate of the shock-testing apparatus. A 400-pound hammer shall be dropped from a specified height (see 4.4) onto a shock pad located on the anvil plate. The shock motion is then transmitted by the anvil plate to the parts attached to the mounting fixture.

**3.1 Anvil plate.** The test apparatus of this method is so constructed that the anvil plate (see fig. 207-3) can be installed, in sequence, in two positions. By utilizing these two installation positions and separately employing both hammers of the apparatus, shock is applied through the three principal mutually perpendicular axes of the part being subjected to test. One position is to locate the anvil in such a manner that it will receive blows through the back of the anvil plate by contact from the horizontal hammer, and blows on the top shock pad of the anvil plate by a drop of the vertical hammer as shown on figure 207-2. The other position is as shown on figure 207-1, whereby the end shock pad is contacted by the horizontal hammer.

**3.2 Hammers.** The test apparatus is equipped with two 400-pound hammers. One hammer renders a blow by a vertical drop. The other hammer applies a force in a horizontal direction. In this manner, and by changing the orientation of the anvil plate, blows may be delivered to the anvil and the parts in three directions.

**3.3 Mounting fixtures.** Figures 207-4A, 207-4B, 207-5, and 207-6 show standard mounting fixtures that shall be used when testing parts with this test apparatus. These mounting fixtures simulate platform and panel mountings. The applicable mounting fixture shall be as specified. When one of the standard mounting fixtures shown on figures 207-4A, 207-4B, 207-5, and 207-6

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cannot be used, the individual specification shall specify a mounting fixture or adapter which approximates the actual rigidity encountered in service.

**3.4 Detail drawings.** Copies of detail drawings may be obtained from the Armed Services Electro-Standards Agency, Fort Monmouth, N. J., by those who require this information. When requesting copies of these drawings, both the identifying symbol number and the title should be stipulated, as follows:

Drawing 207. Class HI (High-Impact)  
Shock Testing Machine  
for Lightweight Equip-  
ment, Department of  
the Navy (BuShips)  
10-T-2415-L.

#### 4. Procedure

**4.1 Mounting method.** The specimens shall be installed by their normal mounting means on the mounting fixture in their normal operating position. Bolts for mounting the parts shall conform to type I, II, or III, grade 2, of Specification MIL-B-857, Bolts, Nuts, and Studs. Mounting bolts shall be checked for tightness before each blow. Care shall be taken in the mounting procedure to prevent initial stresses being applied to the specimens prior to shock.

**4.2 Anvil-plate bolts and positioning springs.** Due to the severity of the shock applied to the anvil plate by a series of three blows, the anvil-plate bolts shall be checked for tightness before each series of blows. The spacing between stops of the positioning springs (1.5 inches) shall also be corrected before each succession of blows.

**4.3 Direction of shock.** A total of nine blows, three through each of the three principal mutually perpendicular axes for the

heights indicated in 4.4, shall be delivered to the anvil plate supporting the specimens under test. Direction of shock shall be, in order, to the back, top, and side. Back and top blows shall be applied with the anvil plate located to receive blows from the horizontal and vertical hammers. Side blows are delivered by the horizontal hammer contacting the end shock pad of the anvil plate (see 3.1).

**4.4 Height of hammer drops.** The hammer shall strike the shock pad on the anvil plate, in sequence, from heights of 1 foot, 3 feet, and 5 feet.

**4.5 Hammer supports.** During the test, the hammer not in use shall be disengaged from the lifting cable and supported so that the hammer and its support are not in contact with the anvil plate.

**4.6 Electrical load and operating conditions.** The electrical load and operating conditions applied to the specimens shall be as specified.

**4.7 External resilient mountings.** Unless otherwise specified, no external resilient mountings associated with the specimen being tested shall be used. Integral mounting devices and external resilient mountings (if specified) associated with the specimen shall remain unblocked during tests.

**5. Measurements.** Monitoring of the specimens during test (e.g., delayed contact opening of relays, momentary stopping of dynamometers, calibration errors in meters) shall be as specified. Upon completion of the required number of blows, electrical and physical measurements shall be made as specified. Allowable tolerances shall be as specified.

**6. Summary.** The following details must be specified in the individual specification:

(a) Mounting fixtures (see 3.3).

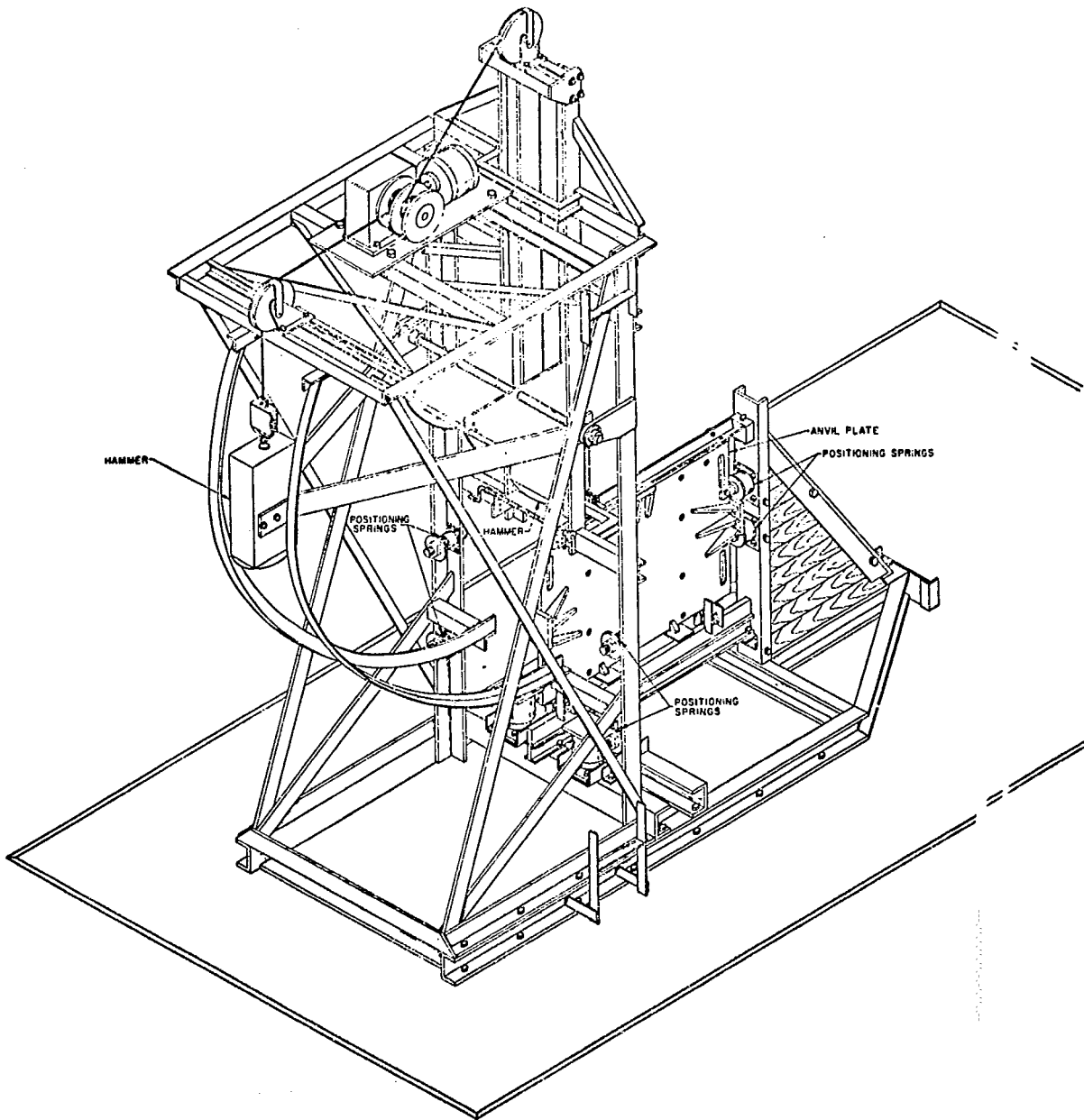
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- (b) Electrical load and operating conditions, if applicable (see 4.6).
- (c) External resilient mountings, if required (see 4.7).
- (d) Monitoring during test, measurements after test, and allowable tolerances, as applicable (see 5).

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**FIGURE 207-1. High-impact shock-testing apparatus.**

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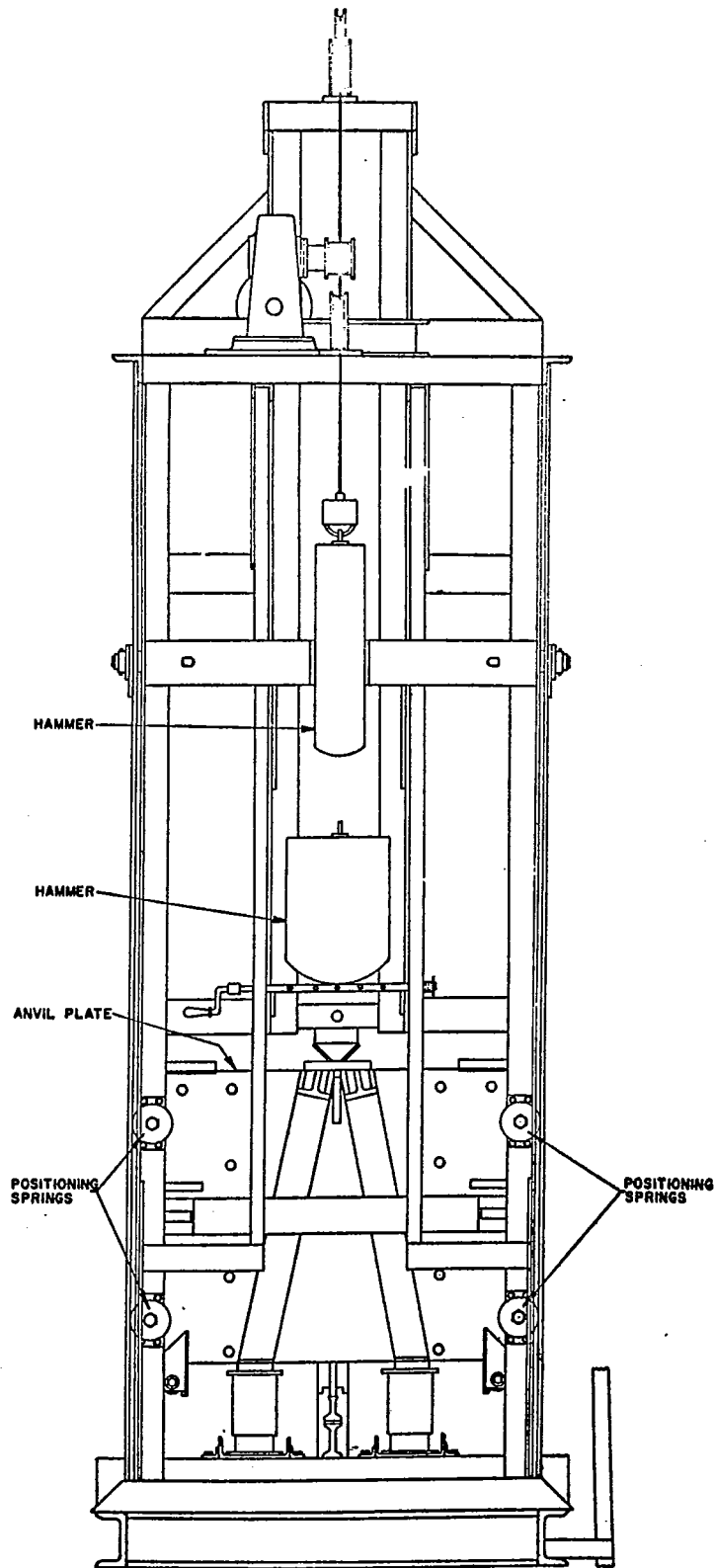
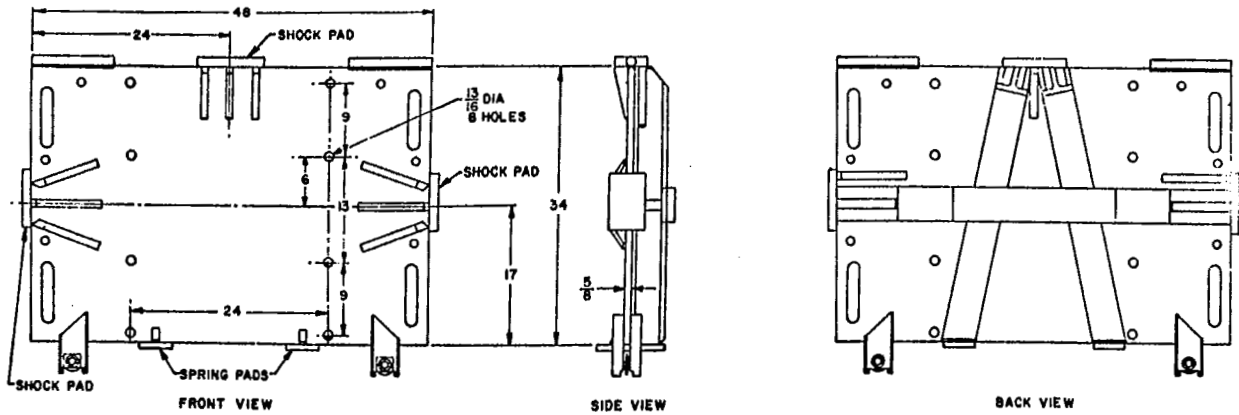


FIGURE 207-2. High-impact shock-testing apparatus (back view) with anvil plate located for back and top blows.

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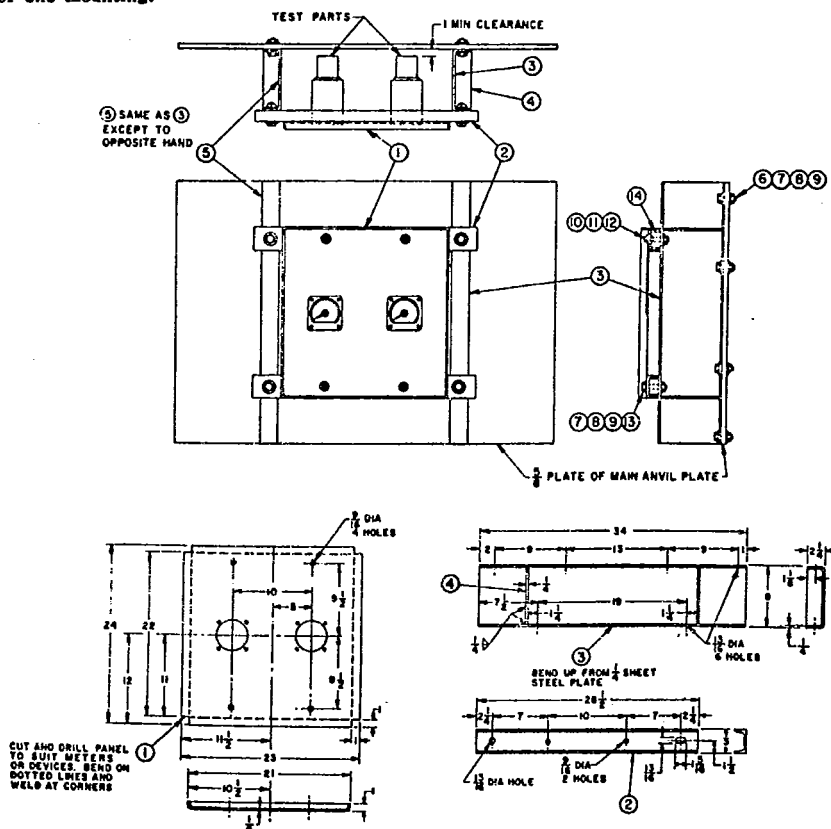
1. All dimensions in inches.
2. Tolerances are  $\pm 1/16$ .

FIGURE 207-8. Anvil plate of shock-testing apparatus.

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Item	Description	Material	Qty <sup>1</sup>
1	Panel	Steel	1
2	Standard channel, 3 x 5.0 lb.	Steel	2
3	Fabricated spacer	Steel	1
4	Spacer stiffener	Steel	4
5	Fabricated spacer	Steel	1
6	Hex hd bolt, $\frac{3}{4}$ -10 x 1 $\frac{3}{4}$ lg	Steel	1
7	Hex hd nut, $\frac{3}{4}$ -10	Steel	12
8	Washer, 2 OD x 1 $\frac{3}{16}$ ID	Steel	12
9	Washer, 1 $\frac{3}{8}$ OD x 1 $\frac{3}{16}$ ID	Steel	12
10	Hex hd bolt, $\frac{1}{2}$ -13 x 1 lg	Steel	4
11	Hex hd nut, $\frac{1}{2}$ -13	Steel	4
12	Washer, 1 $\frac{3}{8}$ OD x $\frac{9}{16}$ ID	Steel	4
13	Hex hd bolt, $\frac{3}{4}$ -10 x 2 $\frac{1}{2}$ lg	Steel	4
14	Block, 2 $\frac{1}{4}$ x 2 x 1 $\frac{1}{4}$	Steel	4

<sup>1</sup> Quantities are for one mounting.

- All dimensions in inches.
- Tolerances are  $\pm \frac{1}{16}$ , unless otherwise specified.
- Two identical specimens shall be mounted on the panel provided there is a minimum separation of 3 inches when the indicated 10-inch centers are used (total weight not to exceed 40 pounds).
- In the event that the requirement of note 3 can be met, but it is desired to test only one specimen, a counterbalance of approximately the same weight shall be mounted in a corresponding position on the opposite side of the panel. Mounting dimensions for the counterbalance shall be the same as for the specimen.
- In the event that the requirement of note 3 cannot be met, the specimen shall be mounted centrally on the panel; if the individual-specimen weight is in excess of 20 pounds, the panel shall be reinforced as indicated on figure 207-4B.
- Specimens too large to be tested on this panel shall utilize the panel indicated on figure 207-4B.
- If the depth of the specimen is such that the minimum clearance of 1 inch cannot be maintained, the specimen shall be turned around so that the front faces the anvil plate.

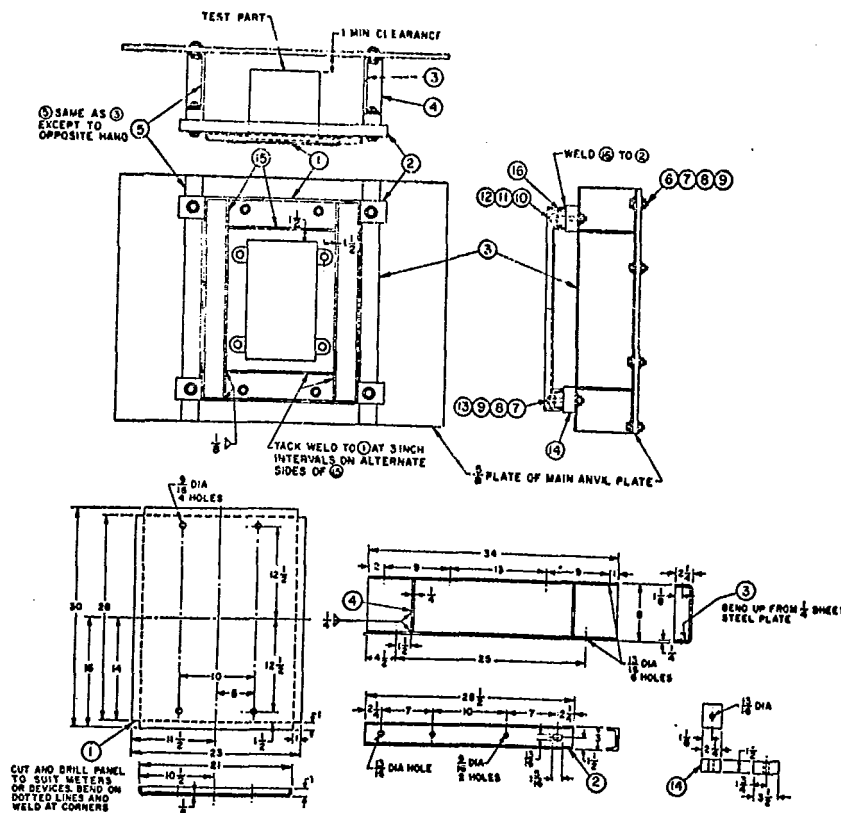
FIGURE 207-4A. Standard mounting fixtures for electrical-indicating switchboard meters and other panel-mounted parts.

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Item	Description	Material	Qty <sup>1</sup>
1	Panel	Steel	1
2	Standard channel, 3 x 5.0 lb	Steel	2
3	Fabricated spacer	Steel	1
4	Spacer stiffener	Steel	4
5	Fabricated spacer	Steel	1
6	Hex hd bolt, $\frac{3}{4}$ -10 x 1 $\frac{1}{2}$ lg	Steel	8
7	Hex hd nut, $\frac{3}{4}$ -10	Steel	12
8	Washer, 2 OD x $1\frac{3}{16}$ ID	Steel	12
9	Washer, 1 $\frac{3}{8}$ OD x $1\frac{3}{16}$ ID	Steel	12
10	Hex hd bolt, $\frac{1}{2}$ -13 x 1 lg	Steel	4
11	Hex hd nut, $\frac{1}{2}$ -13	Steel	4
12	Washer, 1 $\frac{3}{8}$ OD x $\frac{9}{16}$ ID	Steel	4
13	Hex hd bolt, $\frac{3}{4}$ -10 x 4 lg	Steel	4
14	Spacer block	Steel	4
15	Strap, $\frac{1}{8}$ x 1	Steel	4
16	Block, 2 $\frac{1}{4}$ x 2 $\frac{1}{4}$	Steel	4

<sup>1</sup> Quantities are for one mounting.



1. All dimensions in inches.
2. Tolerances are  $\pm \frac{1}{16}$ , unless otherwise specified.
3. This panel shall not be used if the panel indicated on figure 207-4A is applicable.
4. The spacer blocks, item 14, shall be used only when necessary to maintain a minimum clearance of 1 inch between the specimen and the anvil plate.
5. In the event that the depth of the specimen is such that the minimum clearance of 1 inch cannot be maintained, the spacer blocks shall be removed and the specimen mounted with the front surface toward the anvil plate.

FIGURE 207-4B. Standard mounting fixtures for electrical-indicating switchboard meters and other panel-mounted parts.

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Item	Description	Material	Qty <sup>1</sup>
1	Car building channel, 4 x 13.8 lb	Steel	1
2	Car building channel, 4 x 13.8 lb	Steel	1
3	Auxiliary mounting plate, 1/2 x 27 x 34	Steel	1
4	Spacer (see table 1)	Steel	...
5	Plastic mounting panel (see table 2)	Plastic, laminated, type FBG, per MIL-P-15035.	...
6	Hex hd bolt, 3/4-10 x 7 lg	Steel (heat-treated)	8
7	Hex hd nut, 3/4-10	Steel	8
8	Washer, 2 OD x 1 3/16 ID	Steel	16
9	Pipe spacer, 1 standard, 2 15/16 lg	Steel	8

<sup>1</sup> Quantities are for one mounting.

<sup>2</sup> The size of the auxiliary mounting plate shall be increased to 1/2 x 36 x 34 for panels No. 5 and No. 6 listed in table 2.

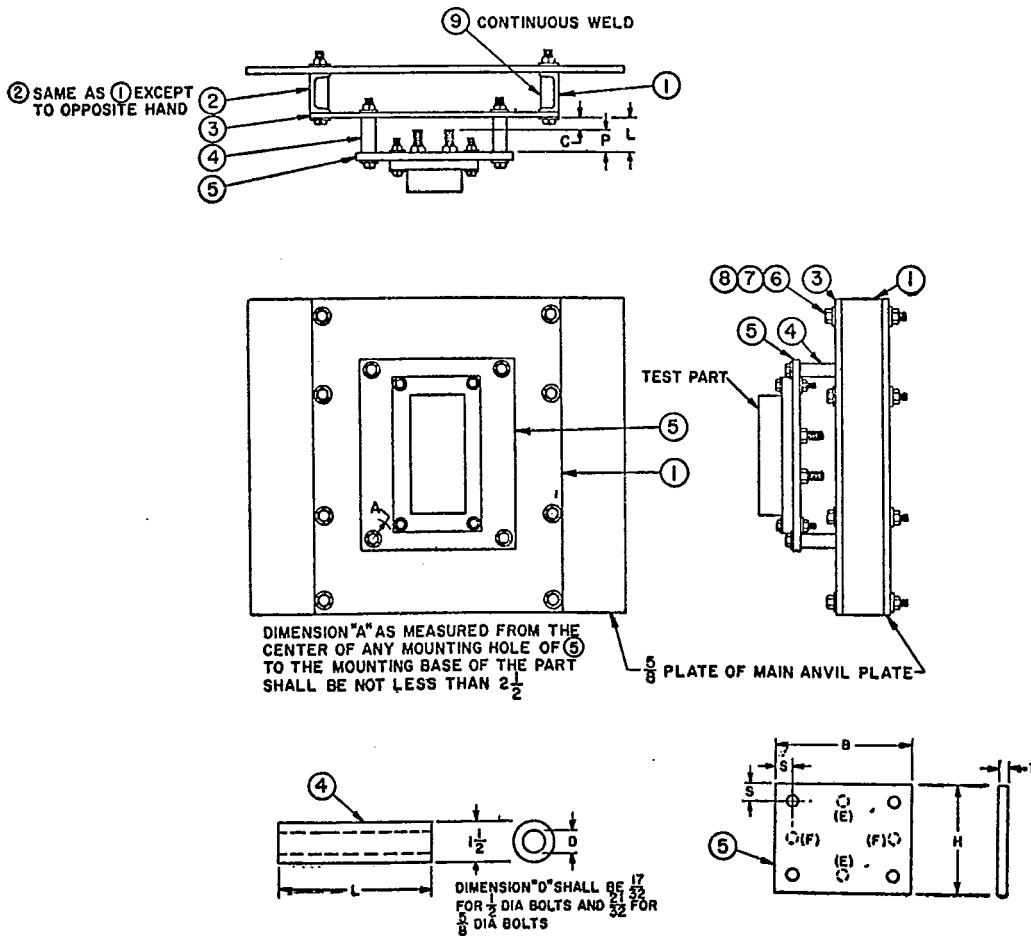


FIGURE 207-5. Standard mounting fixtures for electrical controller parts (contractors, relays, resistors, etc.)

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HOLES (E) ARE DRILLED EQUIDISTANT FROM CORNER HOLES ON SAME CENTER LINE — PANELS NO. 5 AND NO. 6 ONLY. HOLES (F) ARE DRILLED EQUIDISTANT FROM CORNER HOLES ON SAME CENTER LINE — PANELS NO. 4 AND NO. 6 ONLY.

TABLE 2. *Mounting panels*

Panel No.	B	H	T	S	No. and size of bolts	Bolt-hole dia
1	9	12	$\frac{3}{8}$	1	$4\frac{1}{2} \times 13$	$\frac{9}{16}$
2	12	16	1	1	$4\frac{1}{2} \times 13$	$\frac{9}{16}$
3	16	20	1	1	$4\frac{1}{2} \times 13$	$\frac{9}{16}$
4	20	24	1	1	$6\frac{1}{2} \times 13$	$\frac{9}{16}$
5	32	24	1	$1\frac{1}{4}$	$6\frac{5}{8} \times 11$	$1\frac{1}{16}$
6	36	34	1	$1\frac{1}{4}$	$8\frac{5}{8} \times 11$	$1\frac{1}{16}$

SELECTION OF PANEL SIZE: THE PANEL EMPLOYED SHALL BE THE SMALLEST SIZE SHOWN IN THE ABOVE TABLE THAT WILL RESULT IN A CLEARANCE, "A" (NOTE ASSEMBLY FRONT ELEVATION VIEW), OF AT LEAST  $2\frac{1}{2}$ .

TABLE 1. *Spacers*

When P (note assembly plan view) is:		L	Remarks
Less than	Greater than		
$\frac{3}{4}$	...	$1\frac{1}{2}$	....
$3\frac{1}{4}$	$\frac{3}{4}$	$P + \frac{3}{4}$	....
	$3\frac{1}{4}$	4	Cut out $\frac{1}{2}$ thick auxiliary mounting plate, item 3, to give $\frac{3}{4}$ clearance around rear projections.

- All dimensions in inches.
- Tolerances are  $\pm \frac{1}{16}$ , unless otherwise specified.

FIGURE 207-5—Continued

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## METHOD 208

### SOLDERABILITY

**1. PURPOSE.** The purpose of this test method is to determine solderability of solid wire leads of 0.045-inch diameter (AWG size 17) or smaller, which are normally joined by a soft-solder operation. This determination is made on the basis of the ability of the terminations, attached to a part, to be wetted by a new coat of solder, to verify that the treatment used in the manufacturing process to facilitate soldering is satisfactory, and that this treatment has been applied to the required portion of the part designed to accommodate a solder connection.

#### 1.1 Application in the individual specification.

(a) The validity of the test results will be affected if the following parameters are changed; therefore, they must not be modified:

- (1) Temperature of solder bath ( $450^{\circ} \pm 10^{\circ}$  F.).
- (2) Composition of the test solder.
- (3) Dwell time in solder bath.
- (4) Composition of solder flux.
- (5) Minimum of 23-power magnification.
- (6) Use of mechanical dipping device.

(b) To aid in assuring that electronic component parts will meet the solderability test method, the test must be required on a lot-by-lot basis during acceptance inspection, since solderability will be affected by at least the following:

- (1) Size of the wire lead.
- (2) Base material of the wire lead (copper, iron, nickel, etc.).

- (3) Plating on base material.
- (4) Composition and thickness of original solder coating.
- (5) Contaminates from molding processes and handling.
- (6) Different basic manufacturing processes.
- (7) Storage conditions prior to shipment by manufacturer.

(c) Sample units which have been tested may be allowed to be shipped on contract or order if they pass the test method, provided that—

- (1) No electrical or mechanical damage has resulted from the test.
- (2) Change in wire-size diameter is tolerable.

## 2. APPARATUS

**2.1 Solder pot.** A solder pot, of sufficient size to contain at least 2 pounds of solder, shall be used. This apparatus shall be capable of maintaining the solder at the temperature specified in 4.3.

**2.2 Dipping device.** A mechanical dipping device, capable of controlling the rates of immersion and emersion of the terminations and providing a dwell time in the solder bath as specified in 4.3, shall be used. A suggested dipping device is shown on figure 208-1.

**2.3 Optical equipment.** A projection system, capable of magnifying a minimum of 23 diameters, shall be used. A viewer for reading microfilmed cards, with the card-holder replaced with a chucking arrangement, is preferred for examining the wire-lead terminations.

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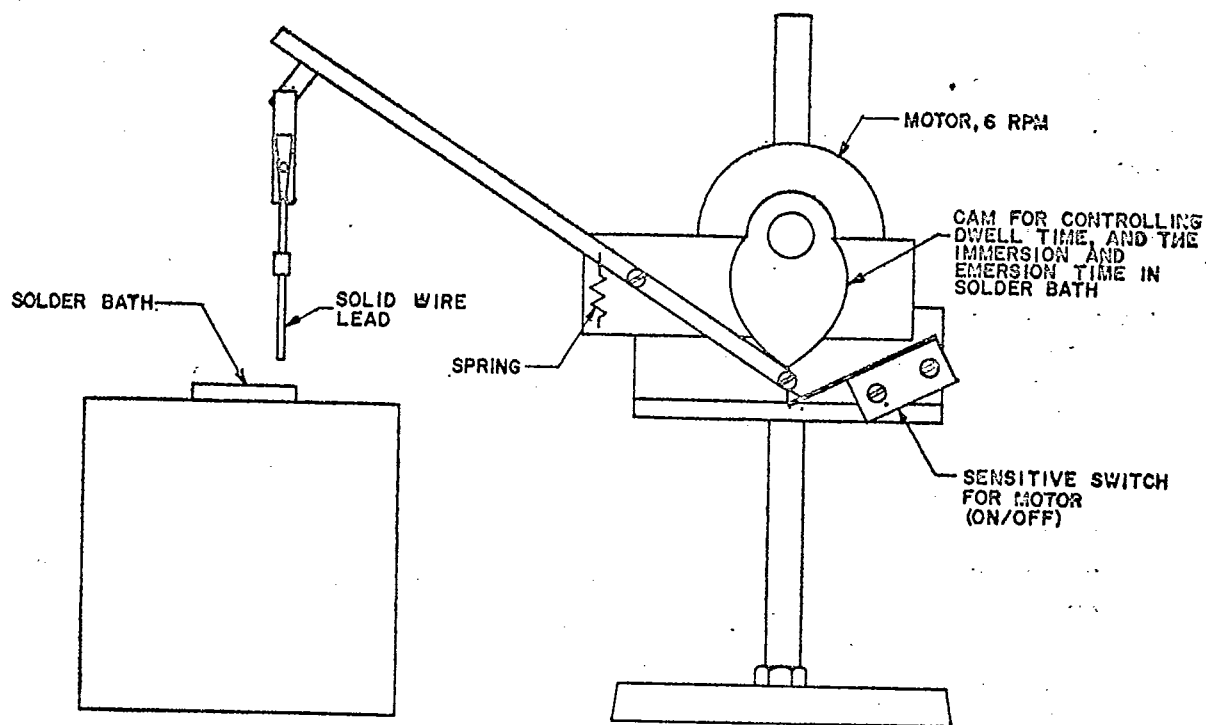


FIGURE 208-1. Suggested dipping device.

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### 3. MATERIALS

3.1 Flux. The flux shall conform to type W of Specification MIL-F-14256, "Flux, Soldering, Liquid (Rosin Base)."

3.2 Solder. The solder shall conform to type S, composition Sn60, of Specification QQ-S-571, "Solder: Lead Alloy, Tin Lead Alloy, and Tin Alloy; Flux Cored Ribbon and Wire, and Solid Form."

4. PROCEDURE. The test procedure shall be performed on a specified number of terminations, attached to each part (resistor, capacitor, transistor, etc). The test procedure consists of two operations—first, the application of flux and immersion in the solder dip of the terminations; second, the examination and evaluation of the surfaces of the terminations upon completion of the solder-dip process. The criteria for solderability during the evaluation of the terminations are that at least 95 percent of the dipped area shall be covered by a new solder surface that is —

- (a) Smooth
- (b) Clean
- (c) Shiny
- (d) Continuous
- (e) Free of pinholes

Additional criteria for solderability are:

- (a) That in the remaining 5 percent of

the dipped area, small pinholes, voids, or rough spots may show, providing they are not concentrated in one area. (Pinholes are defined as holes in the solder coating not exceeding 0.005 inch in actual diameter.)

- (b) That the total coverage of pinholes, voids, or rough spots in the dipped area shall not exceed 5 percent.
- (c) That there is no evidence of bare base metal in the dipped area, or of areas where the solder dip failed to cover the solderable portion of the part.

An example of what constitutes 5 percent of the dipped area is — six voids of 0.032-inch diameter in a 1-inch length on a 0.032-inch diameter (AWG size 20) wire. Figure 208-2 is included as an aid in the evaluation of the 5-percent allowable area. Photographs of the solderability of acceptable and non-acceptable wire leads may be obtained on a loan basis from the Armed Services Electro-Standards Agency, Fort Monmouth, N. J., by those who require this information. When requesting evaluation photographs, both the identifying-symbol number and the title should be indicated, as follows:

PHOTOGRAPHS 208. *Solderability evaluation.*

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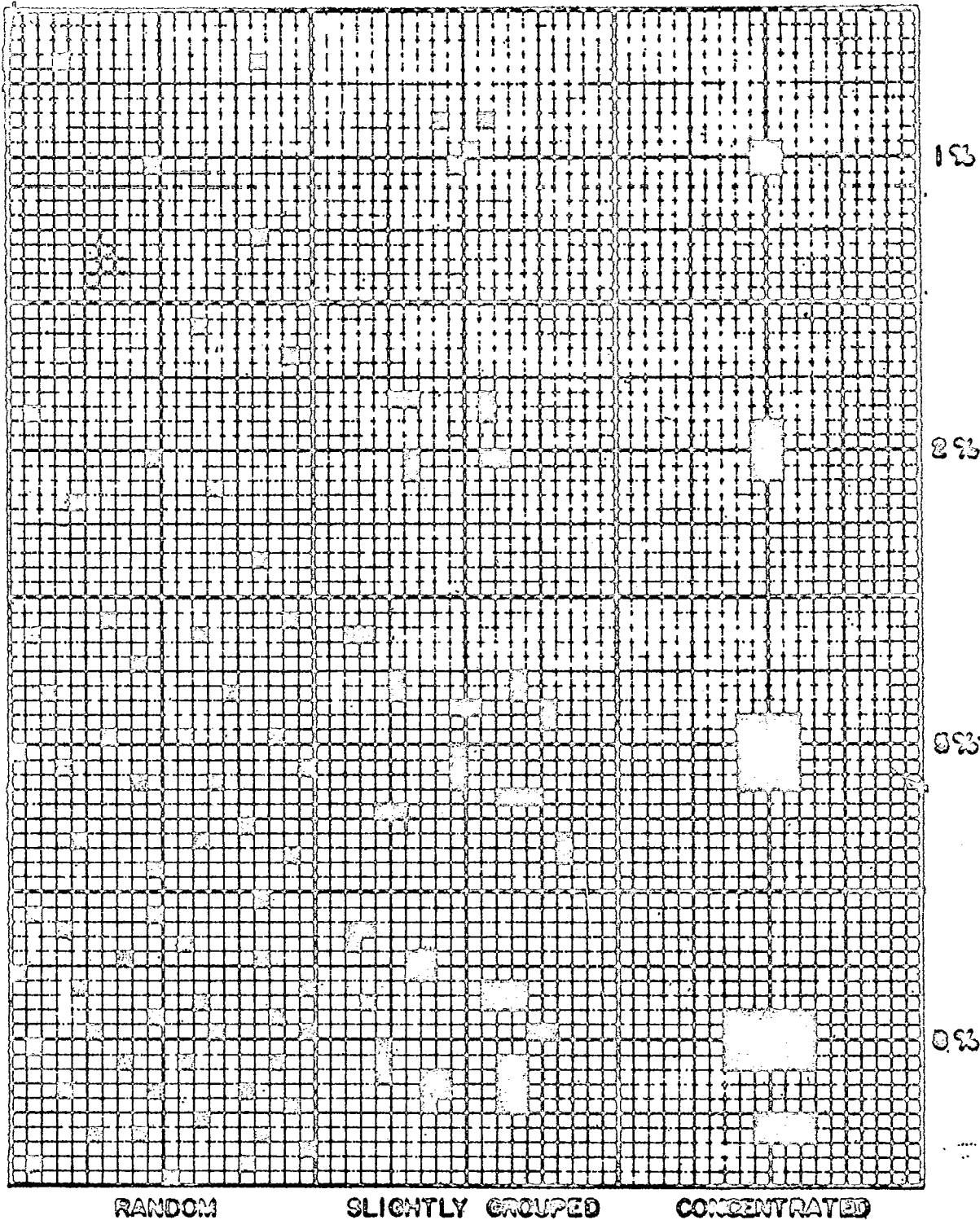
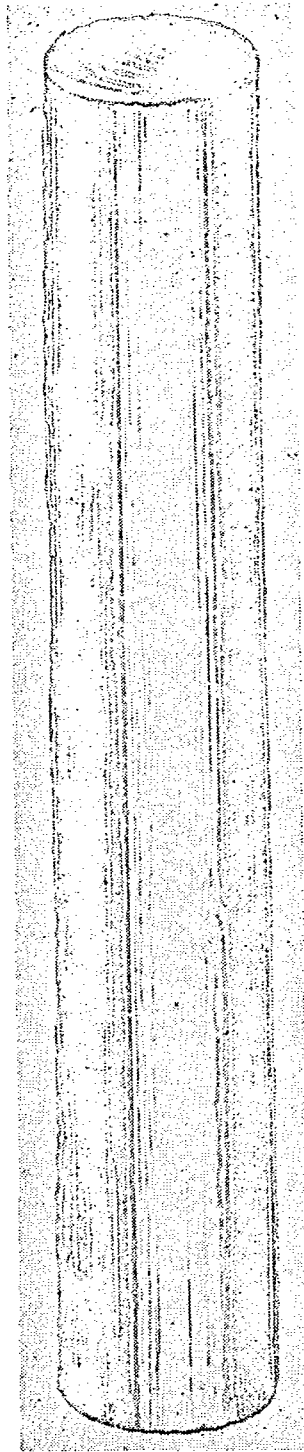


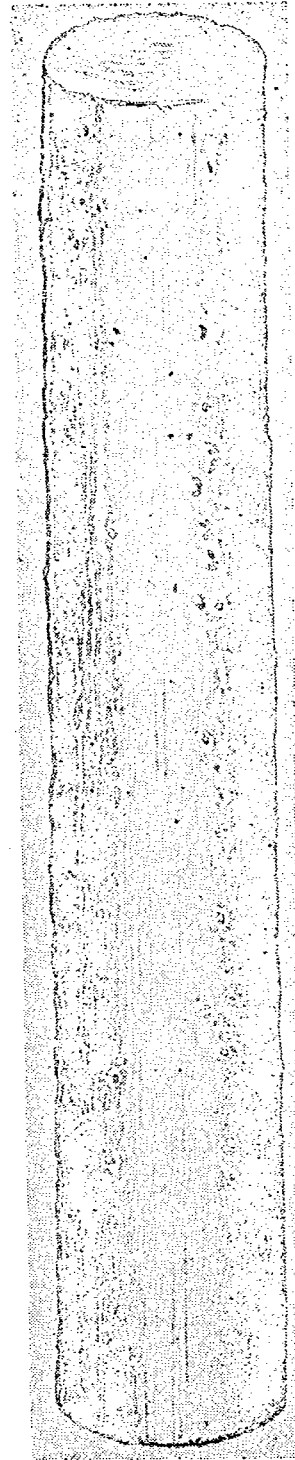
FIGURE 208-2. Aids in evaluation of 5-percent allowable area of pinholes, voids, or rough spots.

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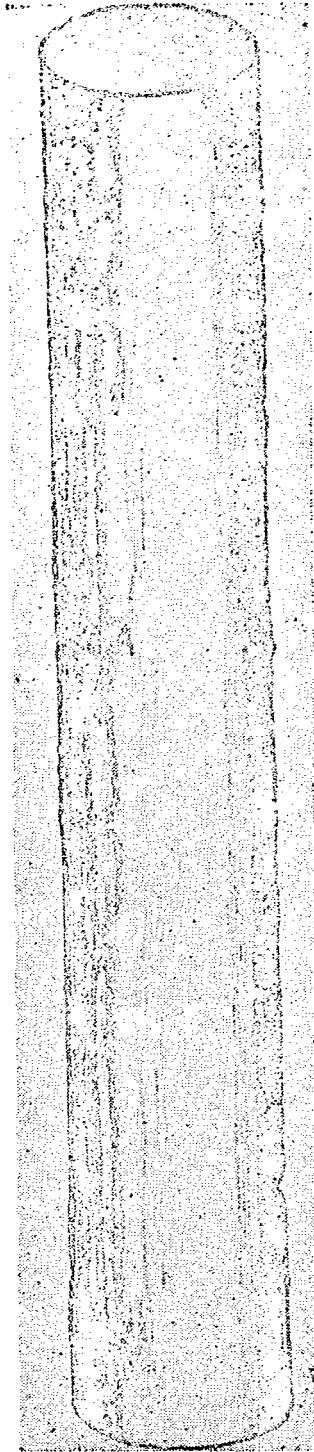
Greater than 99 percent coverage.



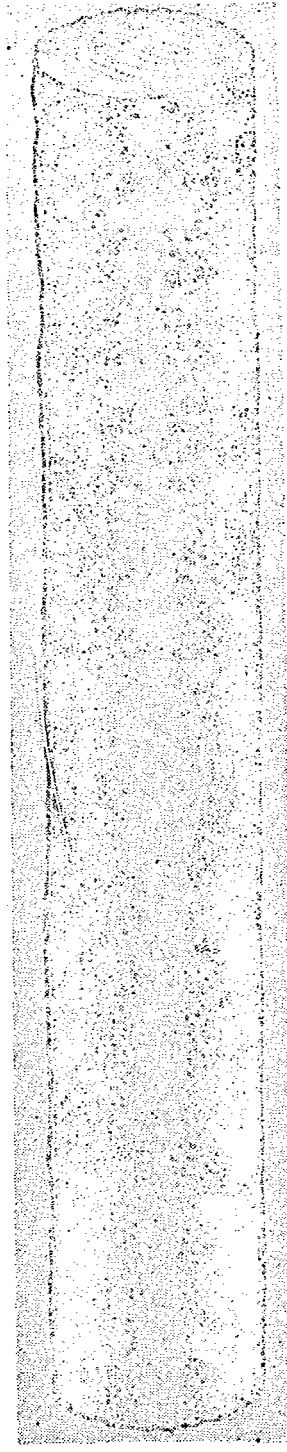
Less than 94 percent coverage.

FIGURE 208-2.—Continued

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Greater than 88 percent coverage.



Less than 75 percent coverage.

FIGURE 208-2.—Continued

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4.1 Preparation of terminations. Solderable surfaces of the terminations shall be tested in the "as received" condition. No wiping, cleaning, scraping, or abrasive cleaning of the terminations shall be performed. During handling, care shall be exercised to prevent solderable surfaces from being abraded or contaminated by grease, perspirants, etc. Any special preparation of the terminations prior to the test shall be as specified in the individual specification.

4.2 Application of flux. Terminations shall be immersed in the flux (see 3.1) which is at room ambient temperature, to the minimum depth necessary to cover the solderable surfaces. Unless otherwise specified in the individual specification, terminations shall be immersed to within 0.05 inch of the body of the part. Solderable surfaces shall be immersed in the flux for a period of from 5 to 10 seconds.

4.3 Solder dip. The dross and burned flux shall be skimmed from the surface of the molten solder specified in 3.2. The molten solder shall then be stirred with a clean stainless-steel paddle to assure that it is at a uniform temperature of  $450^{\circ}\pm 10^{\circ}$  F. ( $232.2^{\circ}\pm 5.5^{\circ}$  C.). The surface of the molten solder shall be skimmed again just prior to immersing the terminations in the solder. The part shall be attached to a dipping device (see 2.2) and the flux-covered terminations immersed once in the molten solder to the same depth specified in 4.2. The immersion and emersion rates shall be  $1\pm\frac{1}{4}$  inch per second and the dwell time (time of total immersion to the required depth) in the solder bath shall be  $5\pm\frac{1}{2}$  seconds. After the dip-

ping process, the part shall be allowed to cool in air. Residue flux shall be removed from the terminations by dipping in clean isopropyl alcohol. If necessary, a soft cloth shall be used to remove all remaining flux.

4.4 Examination of terminations. After each dip-coated termination has been thoroughly cleaned of flux, its surface shall be examined, using the equipment specified in 2.3, to determine—

- (a) That the termination is 95-percent covered by a new, smooth, clean, shiny, continuous surface, free of pinholes.
- (b) That pinholes, voids, or rough spots are not concentrated in one area and do not exceed 5 percent of the total area.
- (c) If any individual voids in the solder coating exceed the diameter of the wire.

In case of dispute, the percent of coverage with pinholes, voids, or rough spots shall be determined by actual measurement of these areas, as compared to the total area.

5. SUMMARY. The information in 1.1 should be observed, and the following details must be specified in the individual specification.

- (a) The number of terminations of each part to be tested (see 4).
- (b) Special preparation of the terminations, if applicable (see 4.1).
- (c) Depth of immersion in flux and solder, if other than within 0.05 inch of the body of the part (see 4.2 and 4.3).

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## METHOD 209

### RADIOGRAPHIC INSPECTION

**1. PURPOSE.** Radiographic inspection is generally a nondestructive (see 1.1) method for detecting internal physical defects in small component parts which are not otherwise visible. Radiographic techniques are intended to reveal such flaws as improper positioning of elements, voids in encapsulating or potting compounds, inhomogeneities in materials, presence of foreign materials, broken elements, etc.

**1.1 Precautions.** Radiographic inspection may be performed on most parts; however, radiation may cause changes in electrical behavior of some materials.

#### 2. APPARATUS AND MATERIALS

**2.1 Radiographic equipment.** The radiographic equipment used shall be capable of producing the required radiographic quality as specified in the individual specification. When using X-ray equipment, X-ray tubes with small effective focal-spot sizes and low inherent filtration are recommended.

**2.2 Film holder.** A lightproof film holder of low inherent filtration to radiation is recommended when using voltages of 50 kilovolts. A lead backing plate should be used behind the film holder to minimize fogging due to secondary back-scatter.

**2.3 Image-quality indicator.** The image-quality indicators used to indicate radiographic sensitivity shall be as specified in the individual specification. The sensitivity is the combined measure of the definition and contrast of the radiograph and should be such that the maximum allowable defect shall be shown. The image-quality indicator may be made from a sample part of the same type as the part being radiographed and should contain either an actual or simulated defect which is at least 10 percent smaller than the smallest defect to be detected.

**2.4 Film.** The film shall be compatible with the sensitivity required in 2.1. In general, finer detail is achieved by the use of finer grain films with lower exposure indexes. If extreme magnification techniques are required, the use of single emulsion films is recommended.

**2.5 Nonfilm techniques.** Nonfilm techniques may be used if required sensitivity levels, and records (when specified) can be obtained. (See 2.1.)

**2.6 Personnel safety precautions.** The safety precautions described in National Bureau of Standards (NBS) Handbook 76 — "X-Ray protection;" NBS Handbook 73 — "Protection Against Radiations From Sealed Gamma Sources;" Atomic Energy Commission Book Title 10, Part 20 — "Standard for Protection Against Radiation," Part 30 — "Licensing of By-product Material," Part 31 — "Radiation Safety Requirements for Radiographic Operations," shall be complied with when applicable.

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**3. PROCEDURE**

**3.1 Positioning of specimen.** The leaded film holder is backed up by the lead plate (see 2.2) and the specimen to be radiographed shall be placed in the position or positions specified in the individual specification.

**3.2 Exposure parameters.** The following exposure parameters may be varied to obtain the radiographic quality specified in 2.1:

- (a) Source—film distance.
- (b) Kilovoltage or type of isotope.
- (c) Milliamperage or source strength of isotope.
- (d) Exposure time.
- (e) Film speed.
- (f) Intensifying screen.

The detail sensitivity is affected by the following:

- (a) Focal spot size.
- (b) Film grain size.
- (c) Nature of the specimen.
- (d) Placement of specimen.

The above factors should be taken into consideration when determining the exposure parameters.

**3.3 Intensifying screens.** In general, metallic intensifying screens should be used at X-ray tube voltages above 125 kilovolts to minimize fogging and for intensifying effects.

**3.4 Identification of radiographs.** Suitable means shall be employed to identify individual specimens on the radiographic record.

**3.5 Marking of radiographed specimens.** If required, suitable marking shall be specified in the individual specification indicating that specimens have been inspected radiographically.

**4. EVALUATIONS.** The final image shall be examined with suitable viewing equipment, which may include magnification, to determine such defects as improper positioning of elements, voids in encapsulating or potting compounds; inhomogeneities in materials; presence of foreign materials; broken elements; and other defects as specified in the individual specification.

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5. **SUMMARY.** The following details shall be specified in the individual specification:

- (a) Required radiographic quality. (See 2.1 and 4.)
- (b) Image-quality indicator to be used. (See 2.3.)
- (c) Records, if required for nonfilm techniques. (See 2.5.)
- (d) Position or positions of specimen. (See 3.1.)
- (e) Marking indicating that specimens have been radiographed, if required. (See 3.5.)
- (f) Evaluation of images. (See 4.)
  1. Specific kind of viewing equipment, if required.
  2. Magnification, if required.
  3. Defects to be sought in the specimen.

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## Method 210

### RESISTANCE TO SOLDERING HEAT

**1. PURPOSE.** This test is performed for the purpose of determining whether component parts can withstand the effects of the heat to which they will be subjected during the soldering of their terminations. The heat can be either conducted heat through the termination into the component part, or radiant heat emanating from the solder dip or soldering iron when in close proximity to the body of the component part, or both. In order to establish a standard test procedure for the most nearly reproducible method, the use of soldering irons (with their necessary broad tolerances on temperatures and other variables in the soldering-iron procedure) is not covered by this method; however, the solder-dip method is used because of its more controllable conditions. The heat of soldering can affect the electrical characteristics of the component part and cause mechanical damage to the materials making up the part, such as: Electrical characteristics of resistive elements, semiconductor devices, soldered connections, plastics, and insulation materials are affected in varying degrees by heat; mechanical damage, such as loosening of terminations or windings, softening of insulation, opening of solder seals, and weakening of mechanical joints, can occur. For this test, some specifications which cover component parts that are fabricated of heat-susceptible materials permit the use of attached heat sinks to reduce conducted heat, or specify some form of shielding to reduce exposure to radiant heat. When allowed or required by the component-part specification, the heat sinks should simulate actual precautions which must be taken during soldering, and the shielding should afford the protection such as would be present when soldering terminations which protrude through a panel or printed-circuit board.

#### 2. APPARATUS

**2.1 Solder pot.** A solder pot, of sufficient size to contain at least 2 pounds of solder and to immerse the terminations to the depth specified for the solder dip without touching the bottom of the pot, shall be used. This apparatus shall be capable of maintaining the solder at the temperature specified in 4.4. The solder bath shall be calibrated at a depth not exceeding 1 inch below the center of the surface.

**2.2 Heat sinks or shielding.** If applicable, heat sinks or shielding shall be made part of the test, and shall be as specified in the individual specification, including all of the details, such as materials, dimensions, method of attachment, and location of the necessary protection.

#### 3. MATERIALS

**3.1 Solder.** The solder shall be lead-tin alloy with a nominal tin content of 50 to 70 percent.

**3.2 Flux.** When the use of flux is specified, it shall conform to type W of Specification MIL-F-14256, "Flux, Soldering, Liquid (Rosin Base)".

**4. PROCEDURE.** The test shall be performed on all solder terminations, attached to the component part, not specifically excepted in the individual specification.

**4.1 Special preparation of specimens.** Any special preparation of the specimens, prior to testing, shall be as specified in the individual specification. This could include specific instructions, such as bending or any other relocation of terminations, cleaning, application of flux, pretinning, and the at-

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tachment of heat sinks or protective shielding (see 2.2), prior to the solder dip.

**4.2 Application of flux.** When specified, the terminations to be tested shall be immersed in the flux (see 3.2) which is at room ambient temperature, to the depth specified for the solder dip (see 4.4). The duration of immersion shall be from 5 to 10 seconds.

**4.3 Preparation of solder bath.** The molten solder may be agitated to assure that the temperature is uniform. The surface of the solder shall be kept clean and bright.

**4.4 Solder dip.** The specified number of terminations (see 4) with any special preparations (see 4.1) shall be immersed to the depth specified by the individual specification. Terminations shall be immersed, individually, if the geometry of the component part permits. The temperature of the solder and duration of immersion shall be selected from one of the following two test conditions:

Test condition	Temperature	Immersion duration
A	350±10° C	3 $\pm$ <sub>0</sub> <sup>1/2</sup> seconds
B	260±5° C	10±1 seconds

The test-condition letter shall be as specified in the individual specification. After the dip, the specimens shall be allowed to cool and stabilize at room ambient conditions, for the time specified in the individual specification,

before final examinations and measurements are made.

**4.4.1 Precautions.** Prior to and after the solder-dip immersion, precautionary measures shall be taken to prevent undue exposure of the part to the heat radiated by the solder.

**5. EXAMINATIONS AND MEASUREMENTS.**

Examinations and measurements to be made before and after the test, as applicable, shall be as specified in the individual specification.

**6. SUMMARY.** The following details must be specified in the individual specification:

- (a) The use of heat sinks or shielding, including all details, if applicable. (See 2.2).
- (b) Solder terminations that are not to be tested, if applicable. (See 4.)
- (c) Special preparation of specimens, if applicable, (See 4.1).
- (d) Immersion of terminations in flux, if applicable. (See 4.2).
- (e) Depth of immersion in the molten solder. (See 4.4).
- (f) Test-condition letter. (See 4.4).
- (g) Cooling time prior to final examinations and measurements. (See 4.4).
- (h) Examinations and measurements before and after test, as applicable. (See 5).

**Method 211****TERMINAL STRENGTH**

**1. PURPOSE.** This test is performed to determine whether the design of the terminals and their method of attachment can withstand one or more of the applicable mechanical stresses to which they will be subjected during installation or disassembly in equipment. These stresses must be withstood by the component part without sustaining damage which would affect either the utility of the terminals or the operation of the component part itself. Evidence of damage caused by this test may not become evident until subsequent environmental tests are performed, such as seal, moisture resistance, or life. Procedures are established in this method for testing wire-lead terminals, flexible-flat-strip or tab-lead terminals, and rigid-type terminals which are threaded or have other arrangements for attaching conductors. The forces applied consist of direct axial, radial or tension pulls, twist, bending torsion, and the torque exerted by the application of nuts or screws on threaded terminals. These applied stresses will disclose poor workmanship, faulty designs, and inadequate methods of attaching terminals to the body of the part. Other evidence of damage may be disclosed by mechanical distortion of the part, breaking of seals, cracking of materials surrounding the terminals, or changes in electrical characteristics, such as shorted or interrupted circuits and changes in resistance values.

**2. TEST CONDITIONS.**

**2.1 Selection.** There are five test conditions in this method, A, B, C, D, and E. The selection of test conditions to perform the terminal-strength test depends on the type of terminal to be tested. The individual specification shall specify the test condition required. The following is included as a guide to be used, as applicable:

**Test condition A:** Pull test—also known as a tension or tensile test for terminals. It is usually applicable to most types of terminals.

**Test condition B:** Flat-terminal bend test—also known as a bend test. It is applicable to flexible-flat-strip or tab-lead terminals which can be bent by finger pressure.

**Test condition C:** Wire-lead bend test—also known as a lead-fatigue, bend, or flexibility test. It is applicable to solid-wire-lead terminals of limited ductility, such as nickel-alloy-type leads and those used in hermetically-sealed component parts.

**Test condition D:** Twist test—also known as a torsion test. It is usually applicable to ductile, solid-wire-lead terminals intended for wraparound connections.

**Test condition E:** Torque test—It is applicable to rigid-type terminals having either external screw threads or threaded inserts which are located at the center of the terminal, or to other non-wire, rigid-type terminals which should withstand the turning moment that results

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from a force applied from an off-center point on the terminal.

**3. PROCEDURE.** One or more of the following test-condition letters shall be specified in the individual specification:

**3.1 Test condition A (pull test).**

**3.1.1 Method of holding.** If the method of holding or clamping is pertinent, it shall be specified in the individual specification.

**3.1.2 Applied force.** The force applied to the terminal shall be 1, 2, 4½, or 9 pounds, as specified in the individual specification.

**3.1.3 Direction of applied force.** The point of application of the force and the force applied shall be in the direction of the axes of the terminations, as shown on figure 211-1.

**3.1.4 Duration of applied force.** The force shall be applied gradually to the terminal and then maintained for a period of 5 to 10 seconds.

**3.2 Test condition B (flat-terminal bend test).**

**3.2.1 Starting position of terminal.** Prior to the test, the terminal shall be observed to determine if it is oriented in its normal or unbent position, or if it is permanently bent out of position, as could occur as a result of prior testing.

**3.2.2 Bending cycle.** If the method of bending is not critical, the terminals may be bent by finger pressure through a bending cycle of three bends, as shown on figure 211-2. The bending cycle shall start with a 45° bend to one side of the normal position. If the terminal is already bent to an angle between 0° and 45° to one side of the normal position prior to test, it shall be bent in the same direction until an angle of 45° is achieved. The terminal shall then be bent 90° in the opposite direction to a point 45° on the opposite side of the normal position, and then back 45° to normal. If the method of bending is critical, the individual specification shall specify the method of bending and any

fixture required to control the point of application. The rate of bending shall be approximately 3 seconds per bend in each direction.

**3.2.3 Number of bending operations.** The number of bending operations shall be two or five, as specified in the individual specification.

**3.3 Test condition C (wire-lead bend test).**

**3.3.1 Preparation of specimen.** A load of ½, 1, 2½, or 5 pounds, as specified in the individual specification, shall be suspended from the terminal. The load selected shall be that closest in value to one-half the load applied during the pull test. The body of the component part shall be held with a suitable clamping or attaching device, so that the terminal is in its normal position with respect to the component part. The load shall be suspended at a point within ¼ inch from the free end of the terminal.

**3.3.2 Bending cycle.** The body of the component part shall be slowly inclined so as to bend the terminal through 90° and then return it to normal position, as shown on figure 211-3. This entire action shall be limited to one vertical plane. A bend through 90° and return to normal position shall be defined as one bend. Consecutive bends shall be in the same direction. The load shall be restricted such that the bend 3/32 ± 1/32 inch from the body of the component part. The rate of bending shall be approximately 3 seconds per bend in each direction.

**3.3.3 Number of bending operations.** The number of bending operations shall be three.

**3.4 Test condition D (twist test).**

**3.4.1 Preparation of specimen.** The solid-wire-lead terminal shall be bent 90° at a point ¼ inch from its juncture with the body of the component part, as shown on figure 211-4. The radius of curvature at the 90° bend shall be approximately 1/32 inch. The free end of the terminal shall be clamped at a point 3/64 ± 1/64 inch away from the bend, as shown on figure 211-4.

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**3.4.2 Application of torsion.** The body of the component part or the clamped terminal shall be rotated through 360° about the original axis of the bent terminal, in alternating directions, for a total of three rotations, at the rate of approximately 3 seconds per rotation.

**3.5 Test condition E (torque test).**

**3.5.1 Direction and application of torque.** The torque shall be applied clock-wise and then counterclockwise in a plane perpendicular to the axis of the terminal, as shown on figure 211-5.

**3.5.2 Duration of applied force.** The force shall be applied gradually to the terminal and then maintained for a period of 5 to 15 seconds.

**3.5.3 Screw-thread terminals.** When testing screw-thread terminals, the torque, in accordance with the terminal size, shall be applied to the centerline of the terminal assembly, as follows:

Screw-thread terminals	Torque (pound-inches)
No. 4.....	3.0
No. 6.....	5.0
No. 8.....	11.0
No. 10.....	15.0
No. 12.....	24.0
1/4 inch.....	32.0

**3.5.4 Other nonwire, rigid-type terminals.** When testing other nonwire, rigid-type terminals, the applied torque is dependent on the equivalent diameter of the external portion of the terminal assembly. The equivalent diameter is defined as equal to twice the distance from the terminal axis to the point of normal wire connection, as shown in the examples on figure 211-6. The torque shall be applied in accordance with the equivalent diameter, as follows:

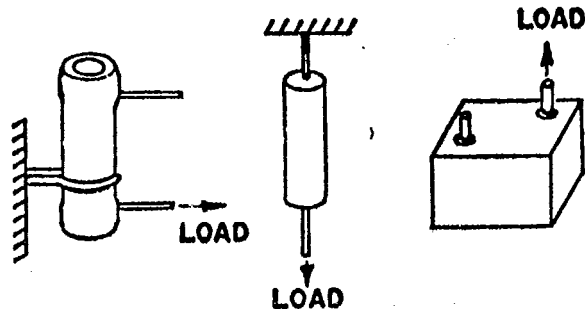
Equivalent diameter (inch)	Torque (ounce-inches)
<1/6 .....	0
>1/16 to 1/8, incl .....	8
>1/8 to 3/16, incl .....	18
>3/16 to 5/16, incl .....	40
>5/16 to 1/2, incl .....	80
> 1/2.....	As specified in the individual specification.

**4. MEASUREMENTS.** Measurements to be made before and after the test, as applicable, shall be as specified in the individual specification.

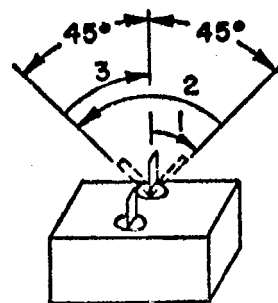
**5. SUMMARY.** The following details must be specified in the individual specification:

- (a) Test-condition letter(s). (See 3.)
- (b) If test-condition letter A is specified:
  - (1) If pertinent, the method of holding or clamping. (See 3.1.1)
  - (2) Whether applied force shall be 1, 2, 4½, or 9 pounds. (See 3.1.2.)
- (c) If test-condition letter B is specified:
  - (1) If critical, the method of bending and fixture required. (See 3.2.2.)
  - (2) Whether number of bends shall be 2 or 5. (See 3.2.3.)
- (d) If test-condition letter C is specified:
  - (1) Whether the load shall be ½, 1, 2½, or 5 pounds. (See (See 3.3.1.)
- (e) If test-condition letter E is specified:
  - (1) Torque to be applied to non-wire, rigid-type terminals when equivalent diameter is greater than ½ inch. (See 3.5.4.)
- (f) Measurements before and after test, as applicable. (See 4.)

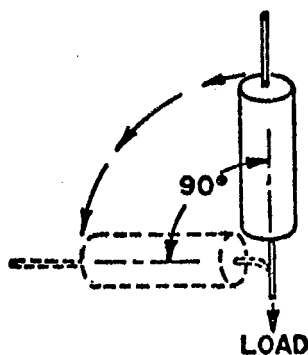
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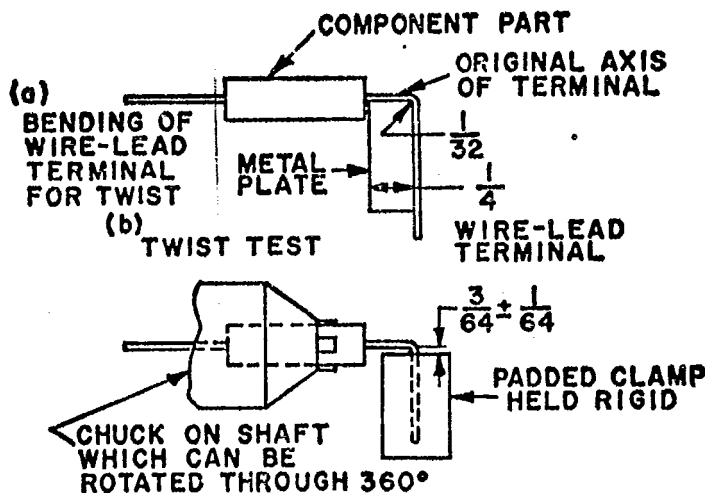
**Figure 211-1. Test condition A.**



**Figure 211-2. Test condition B.**

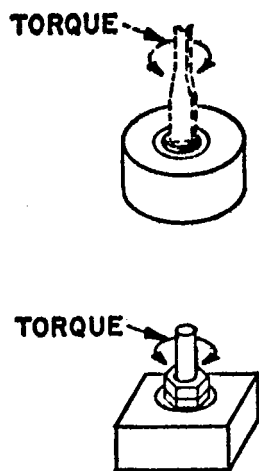


**Figure 211-3. Test condition C.**



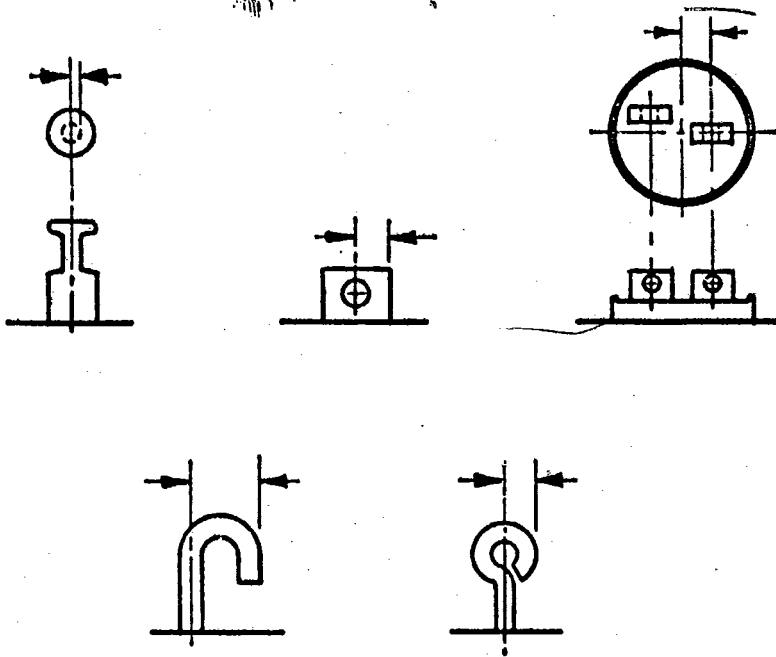
- STEP 1. BEND LEAD WITH FINGERS, OVER ROUNDED EDGE OF METAL PLATE AS SHOWN IN (a).
- STEP 2. CENTER COMPONENT PART IN CHUCK; SECURE LEAD IN CLAMP AS SHOWN IN (b).
- STEP 3. ROTATE CHUCK PART THROUGH 360° AT A RATE OF APPROXIMATELY 5 SECONDS PER 360° ROTATION. SUCCESSIVE ROTATIONS SHALL BE IN ALTERNATE DIRECTIONS. A TOTAL OF THREE SUCH 360° ROTATIONS SHALL BE PERFORMED. DURING THIS TEST, THE CHUCK SHALL ROTATE AROUND AN AXIS WHICH IS FIXED WITH RESPECT TO THE PADDED CLAMP, OR VICE VERSA. THE CHUCK SHALL HAVE NO APPRECIABLE END PLAY DURING ROTATION.

**Figure 211-4. Test condition D.**



**Figure 211-5. Test condition E.**

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**NOTE: EQUIVALENT DIAMETER IS TWICE THE DISTANCE BETWEEN THE LINES INDICATED BY THE ARROWS.**

**FIGURE 211-6. Method of determining equivalent diameter.**

## 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 spacings 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 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 acceptance 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 cycles per second in frequency and shall approximate, as closely as possible, a true sine wave in form. Other commercial power frequencies may be used for inplant acceptance testing, when specified. All alternating potentials shall be expressed as root-mean-square (rms) values, unless otherwise specified. The kilovolt-ampere rating and impedance of the source shall be such as to permit operation at all

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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 kilovolt-ampere 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 a maximum leakage current requirement is specified, a suitable ammeter 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 in-plant acceptance 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 in-plant acceptance 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 voltage surges. At the option of the manufacturer, the test voltage may be removed instantaneously during in-plant acceptance 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

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effect of the dielectric withstanding voltage test on specific operating characteristics, when specified.

**4. Summary.** The following details must 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 acceptance 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).

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## 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 resistances 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 or 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, megohmmeter, 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:

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<i>Test condition</i>	<i>Test potential</i>
A .....	100 volts $\pm$ 10%
B .....	500 volts $\pm$ 10%
C .....	1,000 volts $\pm$ 10%

For inplant acceptance 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 must be specified in the individual specification:

- (a) Test-condition letter, or other test potential, if specified (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 302**  
**6 February 1956**

## 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  $\pm 0.5$  percent if the specified tolerance on the measured resistance is  $\pm 5$  percent), unless otherwise specified. For inplant acceptance 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  $\pm 2$  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 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 must 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).

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## 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  $\pm 3^\circ\text{C}$ . 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  $\pm 0.5^\circ\text{C}$ . 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  $\pm 0.1$  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  $\pm 1$  percent of the temperature difference between the nominal test temperature and the nominal reference temperature  $+0.5^\circ\text{C}$ . 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:

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

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 centigrade.

$t_2$  = test temperature in degrees centigrade.

**4. Summary.** The following details must be specified in the individual specification:

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

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

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

**METHOD 304**  
**24 October 1956**

## 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 cycles, 120 cycles, 1 kilocycle, 100 kilocycles, and 1 megacycle.

**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  $\pm$  (0.5 percent + 0.2 micromicrofarad) unless otherwise specified. Suitable measurement techniques shall be used to minimize errors due to the connections between the measuring apparatus and the specimen. The alternating-cur-

rent (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 must 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).

**METHOD 305**  
**24 October 1956**

## 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 also 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 relation-

ships 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 must be specified in the individual specification:

(a) Test frequency (see 2).

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## 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 re-

sult 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 specimen 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 activation to be made on each contact shall be as specified.

**3. Summary.** The following details must 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 307  
24 October 1956

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 audiofrequency 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 (uv), 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 cycles per second (cps). 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

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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 a 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  $\frac{1}{2}$  to 1 second.

**2. APPARATUS.** Noise measurements shall 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 in 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.

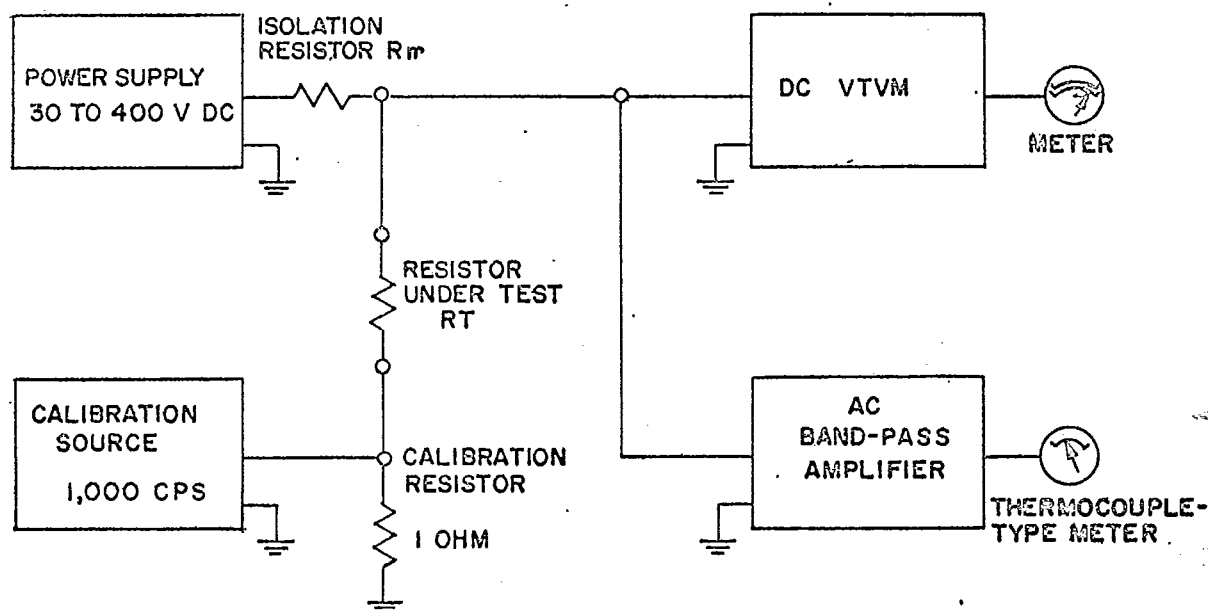


FIGURE 308-1. Block diagram of system.

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**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,  $R_m$ , (1,000 ohms, 10,000 ohms, 100,000 ohms, or 1 megohm (mego)) is selected, depending on the resistance of the resistor under test,  $R_T$ . 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 db 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-cps pass band, geometrically centered at 1,000 cps. The output-meter scale, like that of the dc VTVM, is calibrated in db to simplify calculations.

**2.1.3 Calibration technique.** The calibration technique consists of first applying a predetermined value of 1,000-cps, 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 cps 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 is equivalent to that 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 uv in a decade. Such a signal should produce a reading of 60 db when the system is properly calibrated; thus, 0 db means 1 uv 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.

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### 3. PROCEDURE

**3.1 Operating conditions.** The test shall be performed at an ambient temperature of  $25^{\circ} \pm 2^{\circ} \text{C.}$ , 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,  $R_M$ , 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 $\frac{1}{2}$ watt and higher			Resistors $\frac{1}{4}$ , $\frac{1}{8}$ , and $1/10$ watt		
Resistor under test (Rt)	Isolation resistor (Rm)	20 log V (D)	Dc voltage <sup>1</sup> (V)	Dc power dissipation (Pdc)	20 log V (D)	Dc voltage <sup>1</sup> (V)	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	9.1	250	15.1	5.7	100
390	1,000	19.9	9.9	250	15.3	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

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TABLE 308-1. Standard operating conditions—Continued

Resistance		Resistors ½ watt and higher			Resistors ¼, ⅓, and 1/10 watt		
Resistor under (Rt)	Isolation resistor (Rm)	20 log V (D)	Dc voltage <sup>1</sup> (V)	Dc power dissipation (Pdc)	20 log V (D)	Dc voltage <sup>1</sup> (V)	Dc power dissipation (Pdc)
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
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	33.4
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

<sup>1</sup> Dc voltage across the resistor under test for the measurement of total noise.

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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, ie, 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.

$$(\text{Index}), \text{ in db} = T - f(T - S) - D.$$

Where:

$$f(T - S), \text{ in db} = -10 \log [1 - 10^{-(T-S)/10}].$$

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, ie,  $T - S > 15.0$  db for which  $f(T - S) \approx 0$ , 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,

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"system noise"

T-S db	f(T-S) Correction factor	T-S db	f(T-S) Correction factor
1.0	6.9	5.4	1.4
1.1	6.8	5.5	1.4
1.2	6.2	5.6	1.4
1.3	5.9	5.7	1.3
1.4	5.6	5.8	1.3
1.5	5.3	5.9	1.3
1.6	5.1	6.0	1.2
1.7	4.9	6.1	1.2
1.8	4.7	6.2	1.2
1.9	4.5	6.3	1.1
2.0	4.3	6.4	1.1
2.1	4.1	6.5	1.0
2.2	3.9	to	
2.3	3.8	6.9	0.9
2.4	3.6	7.0	
2.5	3.5	to	0.8
2.6	3.4	7.3	
2.7	3.3	7.4	0.7
2.8	3.2	to	
2.9	3.1	7.9	0.6
3.0	3.0	8.0	
3.1	2.9	to	0.5
3.2	2.8	8.5	
3.3	2.7	8.6	0.4
3.4	2.6	to	
3.5	2.5	9.3	0.3
3.6	2.4	9.4	
3.7	2.4	to	0.2
3.8	2.3	9.9	
3.9	2.2	10.0	0.1
4.0	2.2	to	
4.1	2.1	11.5	0.0
4.2	2.0	11.6	
4.3	2.0	to	0.1
4.4	1.9	12.7	
4.5	1.9	12.8	0.2
4.6	1.8	to	
4.7	1.8	14.5	0.1
4.8	1.7	14.6	
4.9	1.7	to	0.1
5.0	1.6	15.0	
5.1	1.6		0.0
5.2	1.5	>15.0	
5.3	1.5		

whether it be bias error or random error. For the first case, the only significant quantity which varies is T, and 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," ie, 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 to small to cause an increase as much as 1.0 db, ie,  $T - S$  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

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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 measureable 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 must 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):

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