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# DEPARTMENT OF DEFENSE

## TEST METHOD STANDARD

TEST METHODS FOR  
ELECTRON TUBES



AMSC N/A

FSC 5960

MIL-STD-1311D

FOREWORD

1. This Department of Defense Standard is approved for use by all Departments and Agencies of the Department of Defense.
2. Comments, suggestions, or questions on this document should be addressed to DLA Land and Maritime – VAT, P.O. Box 3990, Columbus, OH 43218-3900, or emailed to [TubesAmps@dla.mil](mailto:TubesAmps@dla.mil). Since this contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <https://assist.daps.dla.mil>.

## MIL-STD-1311D

<u>Paragraph</u>	<u>Page</u>
1. SCOPE .....	1
1.1 Scope.....	1
2. APPLICABLE DOCUMENTS .....	1
2.1 General .....	1
2.2 Government documents .....	1
2.3 Non-Government publications .....	2
2.4 Order of precedence .....	2
3. DEFINITIONS .....	2
4. GENERAL REQUIREMENTS .....	2
4.1 Numbering system .....	2
4.2 Methods of reference .....	3
4.3 Order of precedence .....	3
4.4 Obsolescent test methods.....	3
4.5 Destructive tests.....	3
4.6 Alternate test methods .....	3
4.7 Additional testing.....	3
4.8 General test conditions.....	3
4.9 Microwave tube test setup instructions and precautions .....	5
4.10 Phototube test instructions .....	6
4.11 Life-test conditions .....	6
4.12 Definitions and instructions for pulse modulators and pulse diodes .....	7
4.13 Definitions for cathode-ray charge storage tubes.....	13
5. DETAILED REQUIREMENTS .....	14
6. NOTES .....	14
6.1 Metric equivalents.....	14
6.2 Subject term (key word) listing .....	14
6.3 Changes from previous issue.....	14

## INDEXES

Alphabetical Index.....	15
Numerical Index of Test Methods .....	22

## APPENDIX

Test methods .....	28
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## MIL-STD-1311D

## 1. SCOPE

1.1 Scope. This standard establishes uniform methods for testing the environmental, physical, and electrical characteristics of electron tubes as required by MIL-PRF-1 and the applicable tube specification sheet (TSS). Unless otherwise specified or authorized, tests are to be conducted as specified herein (see 4.6).

## 2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4 or 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of documents cited in sections 3, 4, or 5 of this standard, whether or not they are listed.

2.2 Government documents.

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

## DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-1	-	Electron Tubes, General Specification for.
MIL-DTL-75	-	Electron Tubes, Packaging of.
MIL-PRF-22684	-	Resistors, Fixed, Film (Insulated), General Specification for.

## DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-188-200	-	System Design and Engineering Standards for Tactical Communications.
MIL-STD-202	-	Test Method Standard Electronic and Electrical Component Parts.

(Copies of these documents are available online at <https://assist.daps.dla.mil> or from Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other Government documents, drawings, and publications. The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

## DEPARTMENT OF DEFENSE DRAWINGS

123-JAN	-	Bump Test Equipment.
180-JAN	-	High Impact (Fly Weight) Shock Machine for Electronic Devices Bill of Materials.
182-JAN	-	Acoustic Chamber for AF Noise and Microphonics Test.
184-JAN	-	End-Grip Retainer for Impact Testing of Miniature and Sub-Miniature Electron Tubes.
194-JAN	-	Noise and Microphonics Test Set.
200-JAN	-	Deflection Cone for Miniature Tube Base Strain Test.
216-JAN	-	Tube Clamps and Adapter Rings (for Impact Tests).
244-JAN	-	900-Megacycle and Resonant Frequency Test Equipment.
245-JAN	-	Holder for Glass Strain Testing of Miniature and Subminiature Tubes.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific acquisition functions should be obtained from the acquiring activity or as directed by the contracting officer. JAN and DLA Land and Maritime drawings are available from [TubesAmps@dlamail](mailto:TubesAmps@dlamail) or from DLA Land and Maritime -VAT, P.O. Box 3990, Columbus, Ohio 43218.)

## DEPARTMENT OF DEFENSE REPORTS

Measuring Light Output of Cathode Ray Tube Screens. (Primary Standard replica lamps; ref. Method 5221) Material Laboratory (Naval) Final Report, 5032-B15.40.

Specification Development and Technical Evaluations of Types 3ACP19 and 12SP25 Cathode Ray Tubes. (Light output measurements for P19 and P25 phosphors; ref. Method 5221) Material Laboratory (Naval) Final Report, 5032-B-15.91.

(Copies required by suppliers in connection with specific acquisitions may be obtained from SPACE AND NAVAL WARFARE SYSTEMS COMMAND, 4301 Pacific Highway, San Diego, CA 92110-3127.)

## MIL-STD-1311D

2.3 Non-Government publications. The following documents form a part of this standard to the extent specified herein. Unless otherwise indicated, the issue in effect on date of invitation for bids or request for proposal applies.

## NATIONAL CONFERENCE OF STANDARDS LABORATORIES (NCSL)

NCSL-Z540.3 - Laboratories, Calibration, and Measuring and Test Equipment (DoD adopted).

(Copies are available online at <http://www.ncsli.org> or from National Conference of Standards Laboratories [NCSL], 2995 Wilderness Place Suite 107, Boulder, Colorado 80301-5405.)

## ELECTRONIC COMPONENTS ASSOCIATION (ECA)

EIA-256-A - Deflecting Yokes for Cathode Ray Tubes.

EIA-501-A - Recommended Practice for the Measurement of X-Radiation from Raster-Scanned Direct-View Data Display Cathode-Ray Tubes.

EIA-502-A - Recommended Practice for Measurement of X-Radiation from Non-Raster-Scanned Direct-View Cathode Ray Tubes.

EIA-503-A - Recommended Practice for Measurement of X-Radiation from Direct-View Television Picture Tubes.

EIA-191-D - Measurement of Direct Interelectrode Capacitances of Electron Tubes.

EIA-209-A - Electron Tubes Supplement 1- 1965; Supplement 2 - 1968 R (1976).

(Copies of these documents are available online at <http://ec-central.org> or from Electronic Components Association, 2500 Wilson Boulevard, Suite No. 310, Arlington, VA 22201.)

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

## 3. DEFINITIONS

For the purpose of this standard, the abbreviations, symbols, and definitions are specified in appendices A and B of MIL-PRF-1.

## 4. GENERAL REQUIREMENTS

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

4.1.1 Category of tests. Each test method is designated by a four-digit number, with significance, assigned in accordance with the following criteria:

a. <u>Category of tubes</u>	<u>Numerical series (first digit)</u>
General (tests applicable to more than one tube category) .....	1000 to 1999
Receiving, transmitting, and power .....	2000 to 2999
Cold cathode, corona and glow discharge voltage regulators, graphic indicator, ignitron pulse modulators, and thyratrons.....	3000 to 3999
Crossed field, gas switching, klystrons, magnetrons, M-backward wave, O-type backward wave, and traveling-wave tubes .....	4000 to 4999
Cathode ray, cathode-ray charge storage, phototubes, image orthicons, and vidicons .....	5000 to 5999
Radiation counter .....	6000 to 6999
b. Within the above series, numbers will be assigned as follows:	
<u>Category of tests</u>	<u>Last three digits of series</u>
Environmental/Mechanical (physical).....	001 to 199
Electrical.....	200 to 499
Life .....	500 to 699

4.1.2 Revisions. Revisions to test methods will be indicated by a capital letter following the method number. For example, the first revision of method 1001 will be 1001A. Letters I and O will not be used.

## MIL-STD-1311D

4.2 Methods of reference. Applicable test methods contained herein shall be referenced on the TSS by specifying the method number of this standard and details required by the test method. Applicable methods shall be referenced without specifying a revision letter. Paragraph numbers within test methods shall not be referenced. If a particular paragraph(s) is applicable, the title shall be specified.

4.3 Order of precedence. Unless otherwise specified, in the event of conflict between this standard and the tube specification sheet (TSS), the latter shall govern (see MIL-PRF-1, paragraphs 2.4, 3.1.1 and A.2.4, Order of precedence.)

4.3.1 Quantity measurement. When it is stated in any test method that a quantity is to be measured, it is implied that the measurement, after application of any necessary correction factors or calculations, is to be within the limits specified on the TSS, or herein. Consequently, the words "... and shall be within the limits specified ..." are frequently implied but not stated, to avoid constant repetition.

4.3.2 Parameter values. Where any specific value or limit for a parameter is stated herein, the TSS may specify a different value, for good reasons; such value will automatically govern, in accordance with MIL-PRF-1 order of precedence provisions. Consequently the words "... or the specified value ..." are frequently implied but not stated, to avoid constant repetition. In the interests of standardization, TSS's should not adopt different values of such parameters without good reason.

4.4 Obsolescent test methods. Test methods labeled "OBSOLESCENT" are retained in this standard because they are specified on TSS's for a limited number of older tubes. Obsolescent methods shall not be specified on new TSS. If a similar measurement is required for new tube types, a new test method will be prepared under a different number, reflecting current practice. Obsolescent methods will be deleted from this standard when no further requirements exist.

4.5 Destructive tests. Tubes subjected to a destructive test (see MIL-PRF-1, para. 4.1) shall not be delivered on the contract or order. The manufacturer has the option of using different or the same sample tubes when more than one destructive test is required. Tubes subjected to deteriorating tests, such as environmental, physical, or life tests, which have electrical tests specified as end-point limits, shall conform to the initial limits for those electrical tests, prior to being subjected to deteriorating tests.

4.6 Alternate test methods. An alternate test method may be substituted for a method specified herein provided it is demonstrated to the qualifying Government activity that there is adequate correlation between the results of the manufacturer's test method and the test method specified herein, and provided that such substitution in no manner relaxes the requirements of MIL-PRF-1 and of this standard. The schematic diagrams and description of the test equipment to be used, shall be made available for review by the qualifying activity (DLA Land and Maritime-VQE, P.O. Box 3990, Columbus, OH 43218).

4.7 Additional testing. The manufacturer may make such additional tests as he may deem necessary to insure proper control of his product.

#### 4.8 General test conditions.

4.8.1 Order of testing. Conformance inspection tests may be conducted in any order, at the discretion of the manufacturer. For qualification testing (verification), the following tests, when specified, shall be performed after all other tests in any sequence: bump, emission, pulse cathode current, rough handling (formerly drop test), shock, and vibration.

4.8.2 Ambient conditions. Unless otherwise specified, test temperature, relative humidity, and atmospheric pressure conditions shall be in accordance with GENERAL REQUIREMENTS of MIL-STD-202.

4.8.3 Calibration of measuring and test equipment. Calibration and certification procedures for standards and instruments used to test and measure completely assembled electron tubes acquired in accordance with MIL-PRF-1, shall be as specified in NCSL-Z540.3. In addition, the following requirements shall apply:

- a. The accuracy of a calibrating instrument shall be at least four times greater than that of the item being calibrated.
- b. Calibration intervals shall be established on the basis of stability, purpose, and degree of usage for the standards and instruments and shall not exceed a 1-year interval except as indicated below. Intervals shall be shortened as required to assure continued accuracy, as evidenced by the results of preceding calibrations, and may be lengthened only when the results of previous calibrations provide definite indications that such action will not adversely effect the accuracy of the system. The individual changes shall be approved by the qualifying activity (DLA Land and Maritime-VQE, P.O. Box 3990, Columbus, OH 43218).

4.8.4 Accuracy of measurements. The specified limits are for values obtained with the specified test conditions and measuring equipment of accuracy consistent with general industry practice and calibrated in accordance with NCSL-Z540.3. Allowances are made for normal distribution and measuring instrument accuracy in establishing test specification sheet test conditions and test limits. Accuracy of measurements shall be appropriate to the test parameter(s) being measured and specific point instrument calibrations may be utilized when better accuracy than that specified and maintained for the basic measuring instrument is desired.

## MIL-STD-1311D

4.8.5 Holding periods. After completion of all manufacturing processes through final pinch-off of the vacuum envelope, the tube shall be held non-operating for minimum periods as specified in the following category listing. (NOTE: Tube categories not listed shall be held for a minimum of 24 hours.) During this holding period, external processes may be completed that do not require the application of high voltage. These processes include the completion of painting, decals, leads, magnets, mounting flanges, connectors, tuner, and other miscellaneous external hardware. Required testing performed after the holding period shall be designated on the TSS by a note. These tests shall be the first conducted after the holding period. Other required testing shall be conducted before or after the holding period, at the manufacturer's option.

<u>Category</u>	<u>HOLDING PERIODS</u>	<u>Hours held</u>
Beam switching .....		48
Cathode Ray .....		48
Cathode-Ray Charge Storage .....		48
Cold Cathode .....		96
Crossed-Field Amplifier .....		108
Electron Multiplier .....		48
Electron-Ray Indicator .....		24
Gas Switching .....		168
Graphic Indicator .....		24
Ignitron .....		96
Image Converter.....		672
Image Orthicon.....		48
Klystron .....		168
M - Backward Wave.....		168
Magnetron .....		48
Negative Grid (Microwave) .....		72
Noise Source.....		108
O - Backward Wave.....		168
Phototube.....		168
Power or Transmitting (except Hydrogen Diodes).....		72
Power Diode, Hydrogen.....		96
Pulse Modulator, Hydrogen .....		96
Pulse Modulator, Vacuum.....		72
Radiation Counter.....		720
Receiving .....		24
Thyratron.....		96
Traveling Wave.....		168
Vidicon .....		48
Voltage Regulator or Reference.....		24
Voltage Regulator, Corona .....		720

4.8.6 Preheating. Prior to testing, all tubes shall be preheated under conditions not exceeding the maximum ratings for sufficient time to obtain stabilized values of electrical characteristics. Preheating may be done in the test set if desired by the manufacturer.

4.8.6.1 Preheating cathode-ray tubes. Cathode-ray tubes shall be preheated for not less than 60 seconds under conditions of maximum rated filament voltage (no other voltages necessary).

4.8.7 Stabilization. When stabilization is specified on the TSS, all tubes shall be stabilized prior to characteristic tests for not less than the period specified. Voltages as specified on the TSS shall be applied continuously during stabilization. After all the tubes in any lot have been stabilized once, and have met the requirements of this specification, no further stabilization of these tubes will be required.

4.8.8 Electrical connections. Wiring or bus bar connections of ample size to carry the necessary currents are permitted; however, electrode connectors designed expressly for coding purposes shall not be used unless specified on the TSS.

4.8.9 Tapped filaments. Tapped filaments designed for either series or parallel operation shall be tested in a manner which will insure proper internal and external connections.

4.8.10 Metal shields and envelopes. Any shields and metal-tube envelopes, except those of external anode tubes and metal cathode-ray tubes, shall be connected to the reference point. For cathode-ray storage tubes, external shields shall be connected to ground potential of the test set.

4.8.11 Cathode resistor bias. When tests are to be made with cathode resistor bias, the resistor shall be bypassed with a capacitor of 3 ohms maximum reactance at the test frequency. For noise and vibration output, 1,000  $\mu$ F is sufficient.

## MIL-STD-1311D

4.8.12 Multiunit tubes. In multiunit tubes the unit or units not under test shall be connected to the reference point or biased to cutoff.

4.8.13 Frequency/Wavelength conversion. Conversion between frequency and wavelength shall be made using the value  $c = 2.998 \times 10^8$  m/sec.

4.8.14 Reference point. All voltages are given with respect to the reference point as defined in Appendix A of MIL-PRF-1.

4.9 Microwave tube test setup instructions and precautions. The following precautions and instructions for operating microwave tubes apply to the tests specified herein:

- a. Mount and ground the tube securely, connect (1) the high voltage, (2) the heater supply and other tube components, such as grids, focus electrodes, soles, accelerators, collectors, and repellers, (3) the rf output load system, (4) the rf drive connection, if an amplifier, to the tube under test (TUT), and (5) external magnets or solenoids when required.
- b. Provide the specified cooling through all cooling systems.
- c. Turn on pressurizing and activate arc detectors when needed.
- d. Turn on the heater supply in such a manner that the rated maximum heater current is not exceeded. (Some heater systems allow snap-on of the heater by use of inherent current limitation.)
- e. Turn on magnetic field supply and adjust as required.
- f. The electrode to be grounded may be either the cathode or the anode. (See the TSS for proper connections.) However, it is common to operate the cathode below ground with the anode and collector at ground, although some collectors may be depressed in potential toward cathode potential. The cathode is the reference point for voltages. The operating currents and voltages are indicated on each individual tube, accompanying data sheet, or TSS.
- g. Application of voltages:
  - (1) Tubes without control electrodes (magnetrons, some traveling-wave tubes, klystrons, etc): Turn on input power as stated on the TSS and adjust to operate the tube at the specified value of the indicated parameter. Unless abrupt application of voltage is specifically required, it is preferable to raise the voltage (cw or pulse) slowly, especially if the tube has been inoperative or in storage for a few months.
  - (2) Tubes with control electrodes:
    - (a) If the specified control electrode voltage is positive relative to the cathode, turn on all other voltages first in any desired sequence.
    - (b) If the control electrode is negative with respect to the cathode, the beam control electrode voltage should first be biased to cutoff beam current at the desired operating condition, then apply other voltages approximately simultaneously.
    - (c) Adjust the control electrode voltage until the required cathode current is reached.
    - (d) If required by the TSS, program the heater input downward to compensate for backheating.
    - (e) Removal of voltages may be simultaneous or in the reverse order of application. For some high-power tubes, it may be necessary to program removal of the magnetic field and cooling to follow removal of tube voltages.
    - (f) Upon completion of testing, liquid cooling (if used), shall be completely drained, and all protective covers shall be attached.
- h. Frequency meter accuracy:
  - (1) Frequency meters for measuring tunable tubes operating at frequencies less than 30 GHz shall be calibrated to an accuracy of 0.1 percent.
  - (2) Frequency meters for measuring fixed-tuned tubes operating at frequencies less than 30 GHz shall be calibrated to an accuracy of 0.05 percent.
  - (3) Frequency meters for measuring tubes operating at frequencies of 30 GHz, or higher, shall be calibrated to an accuracy of 0.2 percent.



## MIL-STD-1311D

4.10 Phototube test instructions. These tubes shall be tested in a lightproof box containing the specified light source.

- a. Test enclosures. The lightproof test enclosures shall have suitable light baffles provided to insure that only direct radiation from the light source impinges on the phototube cathode. The beam of light striking the cathode shall have approximately parallel rays which are formed by the screen apertures. An adjustable aperture shall determine the area of the cathode subjected to the light bombardment. The usable areas of phototube cathodes shall exclude support wires or parts falling behind the tube structure such as the stem, but shall not exclude that part of the cathode behind the anode, anode support wire, or activator support wire. Dimensions shall be relative to the bottom of the base shell or end cap. Cathode location shall be by projection to a plane normal to the direction of illumination.
- b. Test temperatures. The tube shall be placed in an enclosure and a thermometer shall be used to measure the ambient temperature. The temperature of the enclosure shall be controlled by means of a rheostat and adjusted to the specified ambient value. Infrared radiation from the heating element shall not strike the cathode of the phototube being tested.
- c. Standardized light sources (LS1). A coiled tungsten lamp with a lead- or lime-glass envelope operated at a color temperature of  $2,856^{\circ}\text{K} \pm 20^{\circ}\text{K}$  shall be used. Nonfiltered light flux on the phototube shall never exceed 0.1 lumen.
- d. Measurement of light intensity. The distance from the light source to the phototube shall be varied to obtain the desired intensity of illumination measured in lumens. The following method shall be used to calibrate the phototube-test set:
  - (1) A standard lamp shall be certified periodically at a recognized certification laboratory for candlepower and current requirements at a color temperature of  $2,856^{\circ}\text{K} \pm 20^{\circ}\text{K}$ .
  - (2) The phototube test lamp shall be adjusted to operate at a color temperature of  $2,856^{\circ}\text{K} \pm 20^{\circ}\text{K}$  by means of comparison with the standard lamp through the use of an optical pyrometer.
  - (3) A suitable light-sensitive device shall be calibrated against the standard lamp by calculation. A phototube-test lamp shall be substituted for the standard lamp and with the calibrated light-sensitive device in the position which the test phototube will occupy in the enclosure, the test lamp shall be moved until the proper light intensity from the lamp falls upon the light sensitive device through the aperture.

4.11 Life-test conditions. The following conditions, when applicable, supplement the conditions on the TSS.

- a. Unless otherwise specified, the manufacturer may choose intermittent or continuous operation.
- b. The mean electrode potentials (except heater or filament) may deviate from the specified values by not more than 10 percent, provided the average electrode dissipations are equal to those obtained under the specified conditions.
- c. The mean value of the filament or heater voltage shall be maintained at the specified value.
- d. If a heater cathode potential is required during the life test, the resistance applied in series with this potential shall not exceed 5,000 ohms, except for rectifier types, in which case the series resistance shall be approximately zero.
- e. When either ac or dc filament voltage is permitted, the grid bias shall be adjusted so that the average electrode dissipations are equivalent to those obtained under the specified conditions.
- f. Where a minimum envelope temperature is specified, the requirement will be satisfied if a tube having the applicable characteristic listed below, within the indicated tolerance, is determined to operate at or above the minimum specified temperature at any position in the life-test rack operating at the specified life-test conditions.
  - (1) Grid controlled vacuum tubes. Anode current, in accordance with normal test conditions, is within  $\pm 5$  percent of the bogey value.
  - (2) Rectifiers and diodes. Tube drop, in accordance with the specified conditions is within  $\pm 10$  percent of the bogey value.
  - (3) Regulators and voltage reference tubes. Tube voltage drop at the anode current specified for life test is within  $\pm 3$  percent of the bogey value.
  - (4) Other tubes. As specified on the individual TSS.
- g. Where a control grid circuit resistance is specified by a nominal value, its value shall be not less than 80 percent of this nominal value.

## MIL-STD-1311D

4.11.1 Cathode-ray tubes. In addition to the requirements of 4.11, cathode-ray tubes shall be tested with a raster covering not less than 25 percent nor more than 75 percent of the tube-screen area. The light output or beam current shall be initially adjusted to the specified value measured in accordance with the pertinent portions of method 5221. Life tests shall be interrupted at approximately 10 and 50 percent of the specified life-test duration for measurement of the pertinent characteristics and any necessary readjustment of the test conditions.

4.11.2 Gas-switching tubes. These tubes shall have the rf line power measured immediately before the last tube preceding the load. Periodically during the life test, the TUTs may be interchanged in their positions on the life-test rack. When an ignitor structure is used, the ignitor current shall not be adjusted during the life test. Life-test end points shall be measured using the voltage and resistor specified on the TSS.

#### 4.12 Definitions and instructions for pulse modulators and pulse diodes.

##### 4.12.1 Definitions.

- Charging diode (hold-off diode). A tube inserted between the supply and the pulse forming network (PFN) to prevent any power from the network flowing back into the dc supply (see figure 1).
- Clipper diode (line clipper or shunt diode). A diode in series with a resistor is placed in parallel with the modulator tube to dissipate the negative charge of the PFN after it has discharged through the thyatron (see figure 1).
- Transformer back-swing diode (clammer diode). A diode placed across the primary winding of the load transformer which dissipates the back-swing energy from the pulse transformer. (See figure 1.) This diode aids in resetting the transformer core, and changes the dc voltages. For pulse applications, the rms current  $I_p$  is calculated as  $\sqrt{I_b \times I_b}$  or  $I_b \sqrt{Du}$ .

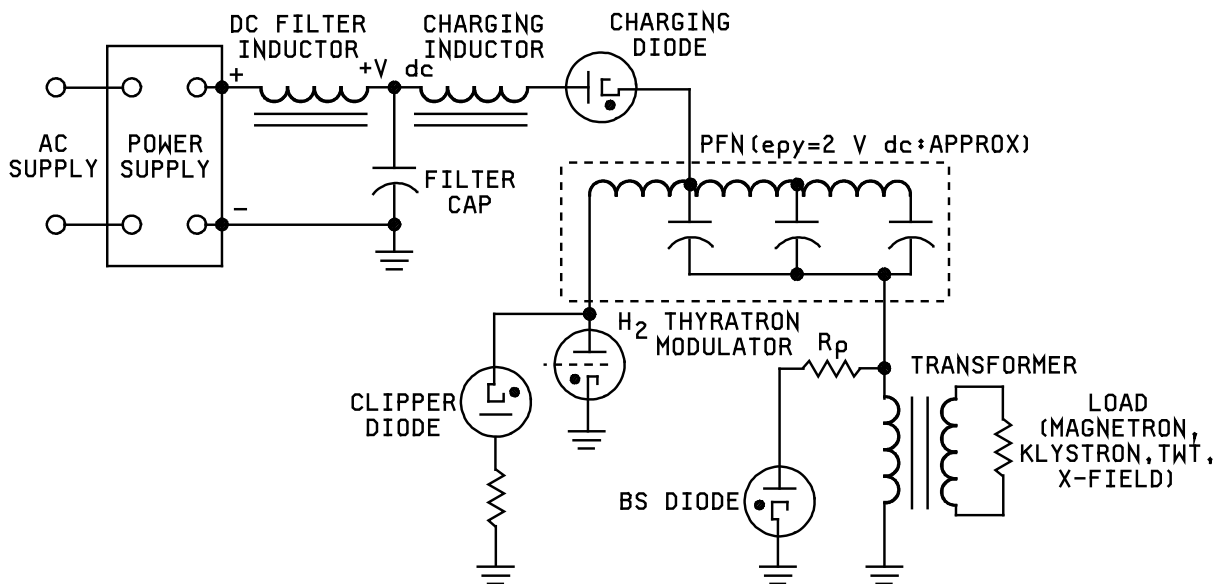


FIGURE 1. Modulator circuit showing charging diode, clipper diode, transformer BS diode and thyatron modulator.

## MIL-STD-1311D

d. Pulse characteristics. The pulse characteristics shall be as specified on the TSS. (See figure 2.)

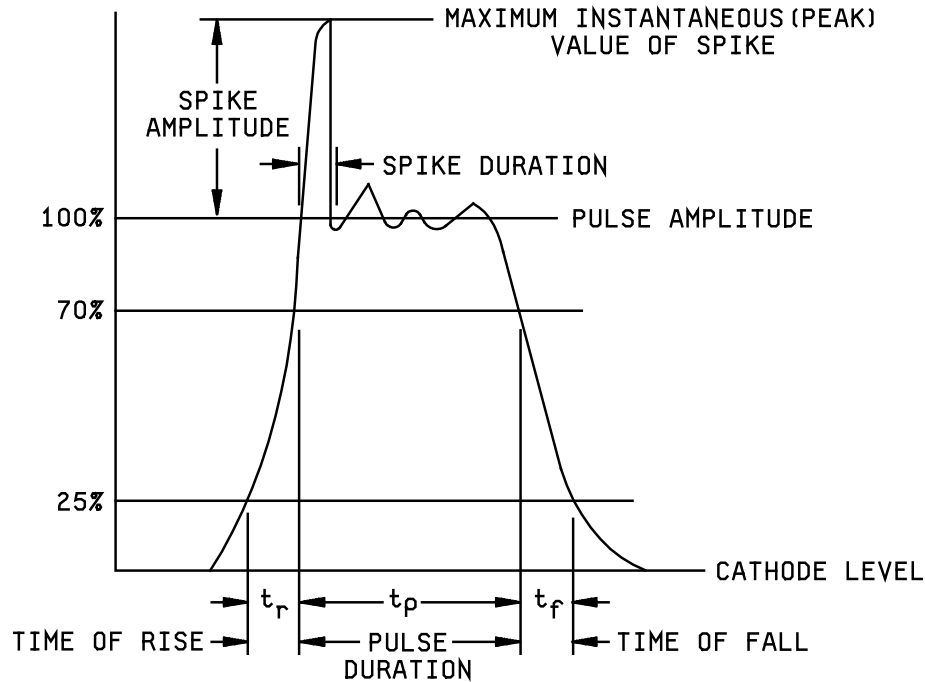
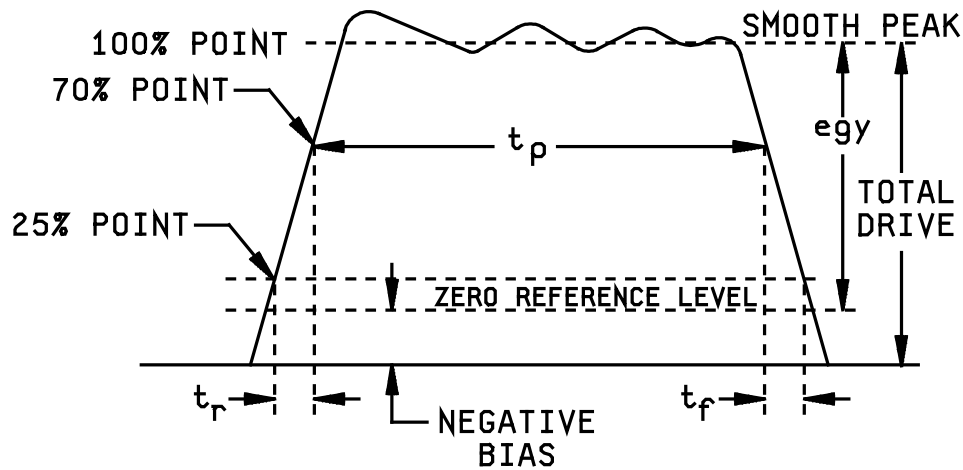


FIGURE 2. General pulse characteristics.

- e. Pulse amplitude. The pulse amplitude is the maximum value of a smooth curve through the average of the fluctuations of the top portion of the pulse, exclusive of spike. The amplitude shall be averaged over a time equal to at least 25 percent of the pulse width.
- f. Reservoir. A storage device inside the tube electrically heated for maintaining the correct gas pressure during the operating life.
- g. Spike. A spike is a transient of duration less than 10 percent of pulse width during which the amplitude appreciably exceeds the average amplitude of the pulse.
- h. Duration of spike. The time interval between the instants when the spike departs from and returns to the main-wave shape.
- i. Spike amplitude. The total excursion of the spike from the main-wave shape.
- j. Resonant charging conditions. The resonant charging rate is the rate of charging (achieved with inductive charging) such that the voltage applied to the anode reaches its peak before the pulse. This condition exists when the prr is equal to twice the natural resonant frequency of the charging-choke inductance in combination with the PFN capacity.
- k. Peak anode current ( $i_b$ ). The peak current is the amplitude of the current pulse at the 100 percent point. (See figure 2.)
- l. Rate of rise of pulse anode current ( $di_b/dt$ ). The rate of rise of pulse current is the ratio of the current change to the time of rise for that portion of the pulse.
- m. RMS anode current ( $I_p$ ). For hydrogen thyratron applications  $I_p = \sqrt{i_b \times I_b}$
- n. Time jitter ( $t_j$ ) (see method 3261). The pulse to pulse variation in anode firing time as referenced to the grid signal. (In multigrid tubes the grid shall be that which receives the last pulse.)
- o. Mean anode current ( $I_b$ ). The average value of anode current.
- p. Unloaded grid pulse. The voltage pulse applied to the grid socket terminal with the tube removed.

## MIL-STD-1311D

- q. Peak forward grid voltage ( $e_{gy}$ ). The unloaded pulse amplitude presented to the grid of the TUT. This amplitude is the algebraic sum of the total drive and the bias voltage, if any. The grid pulse characteristics shall be defined as shown on figure 3.

FIGURE 3. Grid pulse.

- r. Peak inverse grid voltage ( $e_{gx}$ ). The peak inverse grid voltage is the maximum voltage applied to the grid with respect to the cathode in the inverse direction.
- s. Unloaded grid bias voltage. The dc voltage at the grid terminal with respect to the cathode socket terminal, with the tube removed.
- t. On load grid bias voltage. The inter-pulse negative dc voltage at the grid with respect to the cathode, when the tube is operating.
- u. Forward grid impedance. The output impedance of the grid drive and bias circuit. (See trigger source impedance.)
- v. Recovery impedance. The impedance of the circuit network composed of the primary quantities, resistance, inductance, and capacitance.
- w. Grid firing time. The time interval between the instant of simultaneous application of heater, reservoir, and specified grid voltages; and the instant when the grid-cathode gap ignites.
- x. Recovery time. The time required after interruption of forward anode current for the grid to regain control, under specified operating conditions.
- y. Anode heating factor or anode breakdown factor ( $P_b$ ). The product of peak forward anode voltage, peak anode current, and pulse repetition frequency.  $P_b = e_{py} \times i_b \times \text{prf}$ . This is an indication of the energy dissipated in the tube during breakdowns.

4.12.2 Instructions for test conditions.

4.12.2.1 Grid pulse characteristics. The grid pulse characteristics are properties of the output pulse of the trigger circuit, measured at the grid input of the tube with the grid disconnected. The oscilloscope input shall be fed either directly or from a capacitance divider or compensated resistance voltage divider tap, as appropriate, and this voltage connected to the vertical input preferably by a matching coaxial cable. The voltage ratio of dividers plus associated cables shall be calibrated against a direct oscilloscope measurement. The test circuit shall be arranged to compensate for the removal of measuring equipment when the tube is operated.

$e_{gy}$ : Measured with a capacitance divider and an oscilloscope. (See figure 3.) An electrostatic peak reading voltmeter may be used as an alternative means of measurement provided no leading edge spike appears on the unloaded grid pulse.

$t_r$ ,  $t_f$ ,  $t_p$ : Measured by examining the oscilloscope presentation as shown on figure 3.

## MIL-STD-1311D

4.12.2.2 Anode pulse characteristic. With the exception of epy, the anode pulse characteristic shall be measured by examining the scope presentation of the voltage across a noninductive current viewing resistor or the output of a current viewing transformer. The anode pulse characteristic shall be measured as follows:

epy: Measured with a calibrated oscilloscope and suitable calibrated compensated voltage divider or suitable peak reading voltmeter.

ib: Measured by examining the scope presentation as shown on [figure 4](#).

$\frac{dik}{dt}$ : The  $\frac{dik}{dt}$  value is defined as the rate of rise of the current pulse. It is the ratio of the current change between the 25 percent and 70 percent points of the leading edge to the rise time for that portion of the pulse.

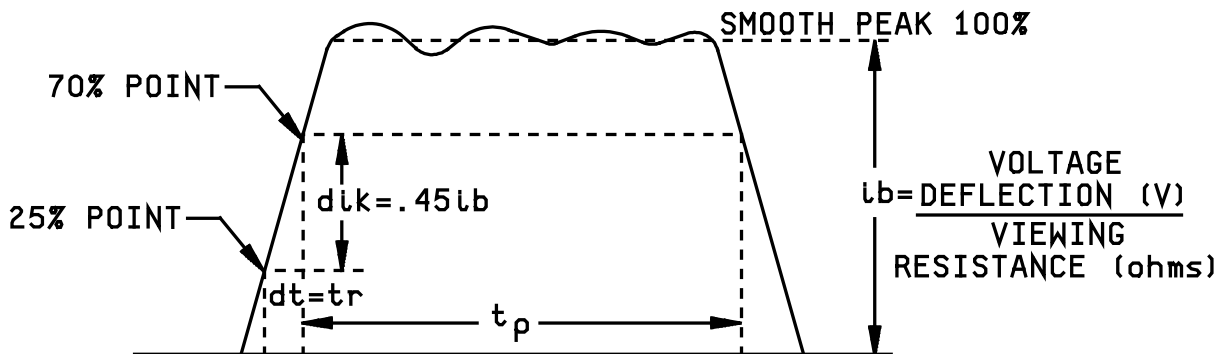


FIGURE 4. Anode pulse.

4.12.2.2.1 Resonant prr. The modulator shall be adjusted to run at the resonant prr by one of the methods given below and shall be measured with a suitable counter and timing device.

- a. With charging diode (see [figure 1](#)). The charging current waveform shall be examined on an oscilloscope, preferably as the voltage developed across a noninductive resistor inserted in series between the normally connected power supply return and ground. The charging current appears as a series of equally spaced lobes for frequencies below resonance, and as a series of lobes jointed as cusps for the resonant frequency and frequencies above (see [figure 5](#)). The resonant prr is that frequency at which the lobes just join with a sharp cusp.

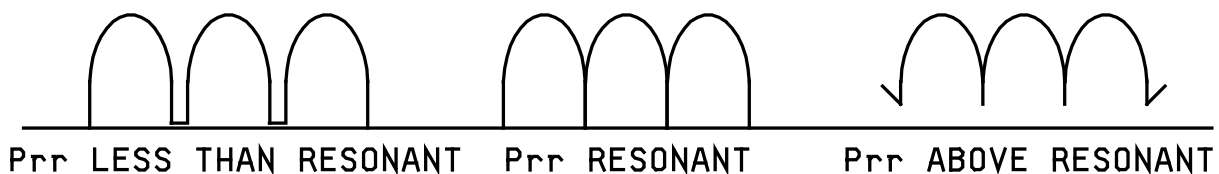


FIGURE 5. Charging current waveforms with charging diode.

## MIL-STD-1311D

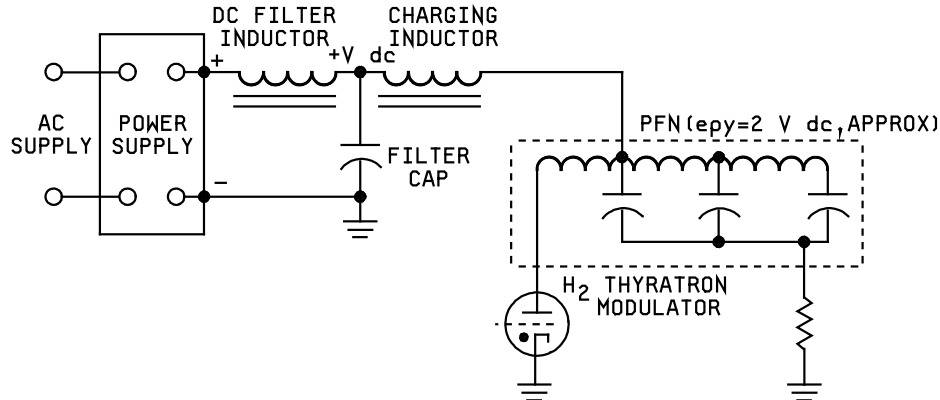


FIGURE 6. DC charging circuit without charging diode.

- b. Without charging diode (see figure 6). The charging current waveform shall be examined on a suitable oscilloscope, as the voltage developed across a noninductive resistor inserted in series between the normally connected power supply return and ground. The charging waveform for frequencies above half the resonant frequency appears as a series of lobes joined at cusps and the instantaneous value of the current at the tip of each cusp is zero when the frequency is at the resonant value (see figure 7). The approximate value of the resonant frequency for this purpose may be obtained either by calculation or by a preliminary run with low voltages.

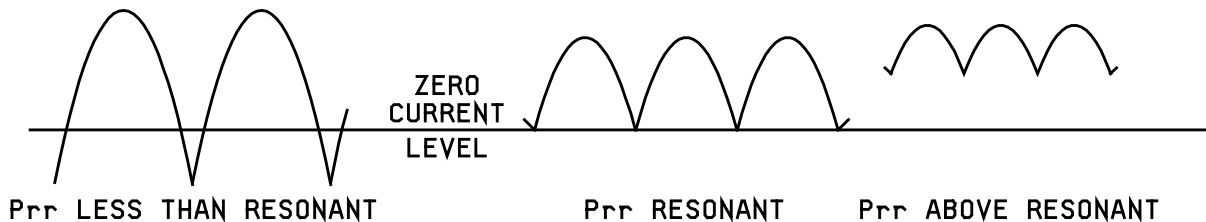


FIGURE 7. Charging current waveform without charging diode.

4.12.2.3 Trigger source impedance. The impedance of trigger sources employing a line-type modulator (gas tube circuit) shall be measured by the short-circuit current method or the matching resistor method, indicated below. The impedance of trigger sources employing a high-vacuum tube, cathode follower (or similar circuit) shall be measured by the short-circuit method only.

- a. Short-circuit current method. The equivalent trigger circuit shown on figure 8 shall be used. The voltage from B to C (eBC) shall be measured with the switches SW1 and SW2 open. Switch SW1 shall then be closed and the voltage from A to C (eAC) shall be measured. The short-circuit current shall then be determined from:

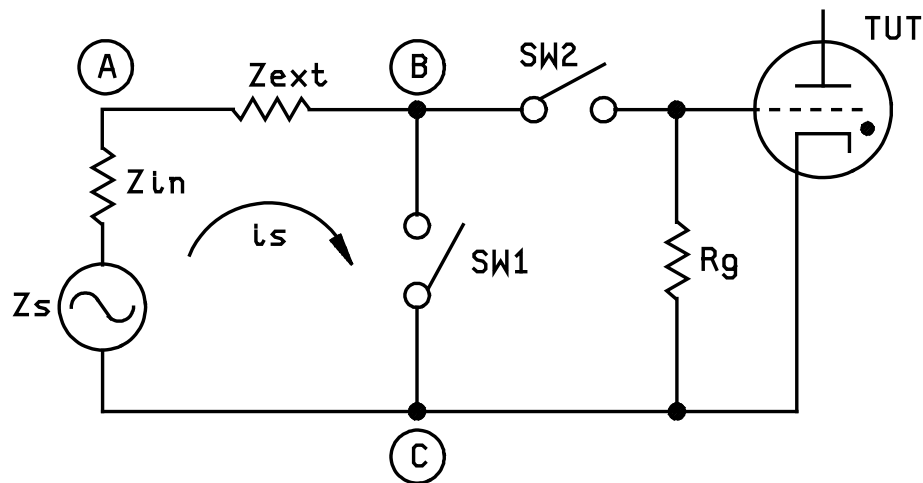
$$is = \frac{eAC}{Z_{ext}}$$

The trigger-source impedance (Zs) is then:

$$Zs = \frac{eBC}{is} = \frac{eBC}{eAC} Z_{ext}$$

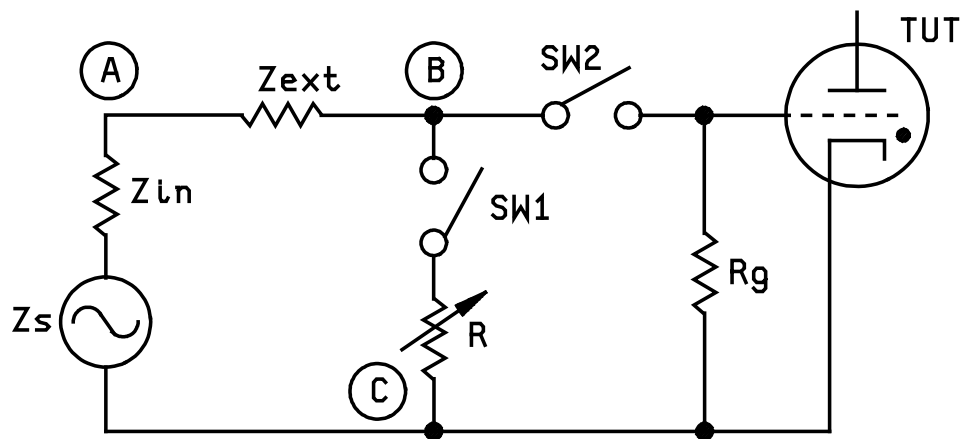
- b. Matching resistor method. The equivalent trigger circuit shown on figure 9 shall be used. With SW1 and SW2 open, measure the open-circuit voltage from B to C (eBC). A noninductive resistor shall then be inserted in series with SW1 between B and C. Close SW1. Adjust R until the measured voltage across BC equals one-half the open circuit voltage. The trigger source impedance, Zs, is then equal to the value of the resistance inserted.

MIL-STD-1311D



$Z_{in}$  - Internal impedance of trigger circuit.  
 $Z_{ext}$  - External impedance added to trigger circuit.  
 $Z_s$  -  $Z_{in} + Z_{ext}$ . This is the desired source impedance including all circuit impedance.  
 $R_g$  - Thyatron grid return.  
 $i_s$  - Short circuit current.

FIGURE 8. Trigger circuit (1).



$Z_{in}$  - Internal impedance of trigger circuit.  
 $Z_{ext}$  - External impedance added to trigger circuit.  
 $Z_s$  -  $Z_{in} + Z_{ext}$ . This is the desired source impedance including all circuit impedance.  
 $R_g$  - Thyatron grid return.

FIGURE 9. Trigger circuit (2).

## MIL-STD-1311D

4.13 Definitions for cathode-ray charge storage tubes.4.13.1 Definitions.

- a. Blemish. A blemish is a localized imperfection of the storage assembly that produces an abrupt variation in the amplitude of the output signal.
- b. Contrast ratio. The ratio of two luminances.
- c. Dark blemish. A blemish that, under specified test conditions, results in output less than that from adjacent storage surface areas.
- d. Decay time. The time interval during which the stored information decays to a stated fraction of its initial value.
- e. Destructive reading. Reading that partially or completely erases the information as it is being read.
- f. Dynamic blemish. A blemish whose presence is a function of writing or erasing rates.
- g. Dynamic range, peak-to-peak disturbance level. The number of incremental output signal levels, each equal to the peak-to-peak target disturbance at that signal level, that may be obtained between cutoff and saturation.
- h. Dynamic range, rms disturbance level. The number of incremental output signal levels, each equal to the rms target disturbance at that signal level, that may be obtained between cutoff and saturation.
- i. Erasing rate. The time rate of erasing the stored information from one specified level to another.
- j. Gray scale response. The measurable number of steps in the gray scale test pattern which are distinguishable under test.
- k. Light blemish. A blemish which, under specified test conditions, results in output greater than that from adjacent storage surface areas.
- l. Luminance. The luminous intensity per unit area on the screen.
- m. Luminance decay uniformity factor ( $DD_{WE}$ ). A time ratio under conditions of dynamic writing and erasing.
- n. Luminance uniformity factor ( $D_{WE}$ ). A ratio of luminance under conditions of dynamic writing and erasing in which the writing signal is unblanking pulse.
- o. Luminance uniformity factor ( $SE$ ). A ratio of luminances under static erasing conditions.
- p. Luminance uniformity factor ( $SW$ ). A ratio of luminances under static writing conditions.
- q. Pulse train gate time. The total time period during which the erase train is applied to the TUT.
- r. Reading time (buildup limited). The time period over which erased display rises in brightness to a specified percentage of saturation.
- s. Reading time (contrast limited). The time period required for a specified degradation in contrast ratio between a written and an unwritten area.
- t. Saturation level. That output level beyond which no further increase in output is produced by further writing.
- u. Static blemish. A blemish whose presence is not a function of writing or erasing rates.
- v. Target disturbance. The type of spurious signal, generated within a tube, which appears as abrupt variations in the amplitude of the output signal. The variations are spatially fixed with reference to the target area. A blemish, a mesh pattern, and moiré present in the output are forms of disturbance. Random noise (e.g., thermal circuit noise) is not a form of disturbance.
- w. Usable reading time. The time period over which a usable output is obtained during continuous readout.
- x. Write saturation level. The output level beyond which no further increase in output is produced by further writing.



## MIL-STD-1311D

## 5. DETAILED REQUIREMENTS

This section is not applicable to this standard.

## 6. NOTES

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

6.1 Metric equivalents. The equivalent metric dimensions provided on each drawing are for general information only. These metric dimensions are rounded off to the nearest .01 millimeter (mm) and are based upon 1 inch = 25.4 mm.

6.2 Subject term (key word) listing.

amplifier	image converter	photomultiplier	radiation counter	traveling wave
cathode ray	klystron	phototube	receiving	vacuum
Electron	magnetron	power	test	vidicon
gas switching	microwave	pulse	thyatron	voltage regulator
grid	noise source	pulse modulator	transmitting	

6.3 Changes from previous issue. The margins of this specification are marked with vertical lines to indicate where changes from the previous issue were made. This was done as a convenience only and the Government assumes no liability whatsoever for any inaccuracies in these notations. Bidders and contractors are cautioned to evaluate the requirements of this document based on the entire content irrespective of the marginal notations and relationship to the last previous issue.

MIL-STD-1311D

## ALPHABETICAL INDEX

## MIL-STD-1311D

## INDEX

<u>Title (Paragraph)</u>	<u>Paragraph</u>
Abbreviations, symbols, and definitions .....	3.
Accuracy of measurements.....	4.8.4
Additional testing .....	4.7
Alternate test methods .....	4.6
Ambient conditions.....	4.8.2
Calibration of measuring and test equipment .....	4.8.3
Category of tests.....	4.1.1
Cathode resistor bias .....	4.8.11
Definitions and instructions for pulse modulators and pulse diodes .....	4.12
Definitions for cathode-ray charge storage tubes .....	4.13
Destructive tests .....	4.5
Applicable Documents .....	2.
General.....	2.1
Government documents.....	2.2
Non-Government documents .....	2.3
Order of precedence .....	2.4
Electrical connections .....	4.8.8
Frequency/Wavelength conversion .....	4.8.13
General requirements .....	4.
General test conditions .....	4.8
Holding periods.....	4.8.5
Life-test conditions.....	4.11
Metal shields and envelopes.....	4.8.10
Methods of reference .....	4.2
Methods (of testing) .....	Appendix
Metric equivalents .....	6.1
Microwave tube test setup instructions and precautions.....	4.9
Multitube tubes.....	4.8.12
Numbering system.....	4.1
Obsolescent test methods.....	4.4
Order of precedence .....	4.3
Order of testing .....	4.8.1
Phototube test instructions.....	4.10
Preheating .....	4.8.6
Reference point .....	4.8.14
Revisions .....	4.1.2
Scope .....	1.
Stabilization .....	4.8.7
Subject term (key word) listing .....	6.2
Tapped filaments .....	4.8.9
Test methods.....	Appendix
 <u>Title (methods)</u>	 <u>Method number</u>
AC amplification.....	1321
After image (vidicons) .....	5434
Air leaks.....	1267
Alignment (cathode-ray tubes) .....	5101
Alignment (vidicons).....	5437
Amplification factor.....	1316
Amplification insertion loss (microwave amplifier tubes) .....	4257
Amplifier power bandwidth .....	4271
Amplitude modulation (TWT).....	4262
Anode delay time .....	3256
Anode resistance .....	1311
Arc loss (gas-switching tubes).....	4488
Audio frequency noise .....	1246
Audio frequency noise and microphonics .....	1251
Background, contamination, and photosensitivity(radiation counter tubes).....	6201
Barometric pressure, reduced .....	1002
Barometric pressure, reduced (simulated high altitude).....	4028
Base material insulating quality .....	1216

## MIL-STD-1311D

## INDEX - Continued

<u>Title (methods)</u>	<u>Method number</u>
Base pin solder depth .....	1111
Base strain (miniature tube) .....	1121
Beam conversion efficiency (microwave-O-type devices) .....	4221
Beam transmission .....	4222
Blemishes (electrical output) (cathode-ray charge storage tubes) .....	5408
Blemishes (visual output) (cathode-ray charge storage tubes) .....	5409
Bulb, screen, and faceplate quality (cathode-ray tubes) .....	5106
Bump (Obsolescent) .....	1036
Cathode emission .....	4214
Cathode interface life .....	1511
Cold-gas conduction (thyatron) .....	3211
Control electrode characteristics .....	4275
Conversion transconductance .....	1326
Coolant-pressure drop versus coolant flow (forced-air or fluid-cooled types) .....	1155
Cooling, forced .....	1143
Current (phototubes) .....	5301
Current division .....	1372
DC anode voltage for conduction .....	3247
Deflection (cathode-ray charge storage tubes) .....	5406
Deflection factor (cathode-ray tubes) .....	5248
Degradation due to shock (gas-switching tubes) (Obsolescent) .....	4026
Degradation due to vibration (gas-switching tubes) .....	4021
Determination of storage surface reference dimension (cathode-ray charge storage tubes - electrical output) .....	5405
Dielectric material strain (gas-switching tubes) .....	4101
Direct-interelectrode capacitance .....	1331
Direct-interelectrode capacitances (microwave tubes) .....	4266
Display persistence, visual output (cathode-ray charge storage tubes) .....	5425
Duplexer loss (dual gas-switching tubes) .....	4489
Dynamic range, electrical output (cathode-ray charge storage tubes) .....	5424
Electrode (cathode-ray charge storage tubes) .....	5401
Electrode current and voltage breakdown (cathode-ray tubes) .....	5201
Electrode current .....	1256
Electrode leakage (cathode-ray charge storage tubes) .....	5407
Electrode leakage currents (cathode-ray tubes) .....	5251
Electrode voltage .....	1261
Electronic tuning hysteresis (klystron oscillators) .....	4231
Electronic tuning range .....	4280
Emission current .....	1231
Energy diverter (crowbar) operation (Hydrogen modulators) .....	3268
Envelope strain .....	2126
Envelope temperature .....	1226
Erasing time, visual output (cathode-ray charge storage tubes) .....	5416
Filament burnout .....	1202
Firing power (gas-switching tubes) .....	4496
Firing time (ATR and pre-TR tubes) .....	4486
Flat-leakage power (gas-switching tubes) (Obsolescent) .....	4451
Focusing (cathode-ray tubes) .....	5246
Frequency change (warm-up) .....	4302
Frequency pulling figure .....	4310
Frequency pushing figure .....	4311
Frequency-temperature coefficient of (gas-switching tubes) .....	4466
Gain (microwave amplifier tubes) .....	4253
Gain linearity (microwave amplifier tubes) .....	4252
Gas (cathode-ray tubes) .....	5206
Gas amplification factor (phototubes) .....	5302
Gas ratio (vidicons) .....	5430
Glass envelope strain .....	1126
Glass-to-lead seal strain (subminiature flat-press base) .....	1119

## MIL-STD-1311D

## INDEX - Continued

<u>Title (methods)</u>	<u>Method number</u>
Gray scale response, electrical output (cathode-ray charge storage tubes).....	5420
Gray scale response, visual output (cathode-ray charge storage tubes).....	5419
Grid current (thyatron) .....	3216
Grid currents.....	1266
Grid-cutoff voltage (cathode-ray charge storage tubes).....	5402
Grid-cutoff voltage (cathode-ray tubes) .....	5241
Grid pulse (vacuum modulators) .....	3270
Grid-pulse operation .....	1356
Grid recovery .....	2210
Heater-cathode leakage.....	1336
Heater-cathode leakage (microwave tubes) .....	4270
Heater current (thyatron).....	3241
Heater-cycling life .....	1506
Heater or filament current .....	1301
Heater or filament current, nonoperating .....	4289
Heater or filament current, operating .....	4281
Heater or filament warm-up time.....	1369
High- and low-temperature performance (operating) .....	1047
High-frequency operation (thyatron).....	3214
High-level protection (gas-switching tubes) (Obsolescent) .....	4478
High-level VSWR (gas-switching tubes).....	4474
Humidity.....	1011
Hydrogen thyatron operation.....	3246
Hydrogen diode ionization voltage .....	3265
Ignitor ignition time.....	4401
Ignitor interaction (TR tubes).....	4421
Ignitor-leakage resistance (TR tubes) (Obsolescent).....	4456
Ignitor noise ratio (gas-switching tubes) .....	4460
Ignitor oscillation (TR tubes) (Obsolescent).....	4411
Ignitor voltage drop .....	4406
Incremental gain (microwave amplifier tubes) .....	4259
Input and output match (TWT) .....	4256
Insertion loss (gas-switching tubes) .....	4416
Instantaneous starting (hydrogen pulse modulators) .....	3267
Insulation of electrodes .....	1211
Interaction factor (cathode-ray multigun tubes) .....	5250
Interelement leakage resistance, cold .....	1366
Intermittent life .....	1501
Intermodulation or cross modulation (TWT) .....	4263
Intrinsic P (TR tubes) (Obsolescent) .....	4476
Intrinsic Q (TR tubes) (Obsolescent) .....	4475
Ion noise modulation (microwave tubes) .....	4264
Ion pumps.....	4268
Ionization (cold-cathode discharge types) .....	3347
Ionization characteristics (thyatron, gas).....	3201
Jitter measurements .....	4318
Lag (vidicons) .....	5432
Lead fatigue (subminiature tube).....	1116
Leakage current (radiation counter tubes).....	6205
Leakage current (voltage regulator types) .....	3305
Leakage power (gas-switching tubes) .....	4452
Leakage power (gas-switching tubes) (Obsolescent) .....	4441
Life tests (microwave tubes) .....	4551
Linear amplifier power output and distortion, two-tone method (single-sideband).....	2204
Linear amplifier power output and distortion, white noise method (single-sideband) .....	2206
Line-width (cathode-ray tubes).....	5226
Liquid cooling jacket leakage .....	4153
Loaded Q (gas-switching tubes).....	4461
Low-level VSWR (gas-switching tubes).....	4473

## MIL-STD-1311D

## INDEX - Continued

<u>Title (methods)</u>	<u>Method number</u>
Luminance (light output), visual output (cathode-ray charge storage tubes) .....	5412
Magnet polarity and strength.....	1367
Magnetization (cathode-ray tubes).....	5256
Magnetron nonoscillating impedance.....	4309
Maximum temperature coefficient of frequency.....	4029
Mean temperature coefficient of frequency .....	4004
Mechanical tuning.....	4223
Metallic base sleeve quality (acid etching test).....	1131
Microwave measurements during shock .....	4042
Modulation (cathode-ray charge storage tubes) .....	5403
Modulation (cathode-ray tubes).....	5223
Modulation transfer function, from line spread function, electrical output (cathode-ray charge storage tubes) .....	5422
Modulator test, dual control grid tetrode thyratrons.....	3273
Modulator test, shield grid negative bias tetrode thyratrons.....	3272
Moisture resistance.....	1016
Neutron irradiation .....	1046
Noise and microphonics (receiving tubes).....	2201
Noise and microphonics, peak or integrated .....	1239
Noise and oscillation (cold-cathode discharge types).....	3278
Noise figure (microwave amplifier tubes).....	4260
Noise power density (microwave tubes).....	4282
Normalized conductance (gas-switching tubes) .....	4484
Operation (thyatron).....	3206
Operation bump (klystron) (Obsolescent).....	4102
Operation, hydrogen diodes.....	3249
Operation of rectifiers.....	1353
Operation of vacuum modulators .....	3269
Operation test (vidicons) .....	5426
Oscillation test for converter tubes .....	1237
Output power and gain variation (microwave amplifier tubes).....	4251
Particles indicator .....	1206
Pattern distortion.....	5103
Permanence of marking.....	1105
Phase (microwave amplifiers) .....	4278
Plateau characteristics (radiation counter tubes).....	6216
Position of short (gas-switching tubes).....	4494
Power levels (microwave tubes).....	4250
Power oscillation and internal insulation.....	1236
Power output .....	1341
Power spectral characteristics.....	4277
Pressure (implosion) .....	1141
Pressurizing (microwave tubes) .....	4003
Pulse amplitude (radiation counter tubes) .....	6226
Pulse characteristics .....	1296
Pulse characteristics (microwave tubes) .....	4304
Pulse emission (hydrogen thyatron).....	3251
Pulse emission (transmitting tubes).....	2212
Pulse stability.....	4315
Pulse voltage (microwave tubes) .....	4306
Radio interference shielding test (microwave tubes) .....	4258
Raster burn and target quick age (vidicons) .....	5427
Raster cutoff (vidicons) .....	5431
Reading time, usable, electrical output (cathode-ray charge storage tubes).....	5421
Reading time, visual output (cathode-ray charge storage tubes) .....	5423
Recovery time (gas-switching tubes).....	4471
Reflector current (reflex klystrons).....	4229
Reflector voltage (klystrons).....	4213
Reflector voltage modulation coefficient (reflex klystrons) .....	4215

## MIL-STD-1311D

## INDEX - Continued

<u>Title (methods)</u>	<u>Method number</u>
Regulation (cold cathode discharge types).....	3335
Repetitive striking voltage (gas rectifiers).....	3202
Residual FM (reflex klystrons).....	4225
Resolution, electrical output (cathode-ray charge storage tubes) .....	5410
Resolution (vidicons).....	5429
Resolution, visual output (cathode-ray charge storage tubes) .....	5411
Resonant frequency.....	2220
Response count rate and current (radiation counter tubes) .....	6221
Reverse directed power.....	4279
RF useful power output (power and transmitting tubes).....	2214
Rough-handling test end points.....	1136
Salt spray (corrosion).....	1006
Saturated rf power output.....	4254
Screen intensity and persistence (cathode-ray tubes).....	5221
Secureness of base, cap, and insert .....	1101
Sensitivity (vidicons) .....	5436
Serrodyne operation (microwave amplifier tubes) .....	4284
Shock .....	1041
Shock (cathode-ray tubes) .....	5115
Shock, specified pulse .....	1042
Short and discontinuity detection .....	1201
Signal-to-noise ratio (phototubes) .....	5306
Signal uniformity (vidicons) .....	5428
Spectral response identification (phototubes).....	5303
Spectrum .....	4308
Spike-leakage energy (TR tubes) (Obsolescent).....	4446
Spot position (cathode-ray charge storage tubes).....	5404
Spot position (cathode-ray tubes) .....	5231
Spurious illumination (cathode-ray tubes) .....	5216
Spurious output or stability (microwave amplifier tubes) .....	4261
Spurious output ratio.....	4243
Spurious signal (vidicons) .....	5433
Stability life .....	1516
Starting voltage (radiation counter tubes).....	6211
Survival-rate life .....	1521
Target volts (vidicons).....	5435
Temperature coefficient .....	4027
Temperature/Cooling (forced-air or fluid-cooled types).....	1227
Temperature cycling, nonoperating .....	1027
Temperature range, operating.....	1026
Thermal frequency drift .....	4030
Time jitter.....	3261
Transconductance .....	1306
Transmitter-receiver isolation (dual gas-switching tubes) .....	4491
Tuning (TR tubes) (Obsolescent) .....	4431
Tuning range (TR tubes) .....	4426
Tuning susceptance (gas-switching tubes).....	4482
Turn-off control electrode voltage.....	4276
Uniformity, luminance, visual output (cathode-ray charge storage tubes).....	5414
Uniformity, output signal amplitude, electrical output (cathode-ray charge storage tubes) .....	5413
Uniformity of cathode glow (cold cathode and graphic indicator tubes) .....	3333
Vibration .....	1031
Vibration (cathode-ray tubes).....	5111
Vibration detuning (tunable gas-switching tubes) .....	4016
Vibration, mechanical.....	1032
Voltage drop (cold cathode discharge types).....	3337
Voltage drop (thyatron).....	3204
Voltage jump (voltage regulator and reference).....	3345
Voltage tuning range.....	4274

## MIL-STD-1311D

## INDEX - Continued

<u>Title (methods)</u>	<u>Method number</u>
Warm-up time .....	4303
Writing and erasing response, dynamic, electrical output (cathode-ray charge storage tubes) .....	5418
Writing and erasing response, dynamic, visual output (cathode-ray charge storage tubes) .....	5417
Writing response, static, visual output (cathode-ray charge storage tubes) .....	5415
X-radiation (microwave tubes).....	4006
X-radiation measurement (display cathode-ray tubes) .....	5001
X-radiation measurement (receiving-high voltage rectifiers and shunt regulators) .....	2202
Zero-bias anode current (magnetic deflection) (cathode-ray tubes).....	5236



MIL-STD-1311D

# NUMERICAL INDEX OF TEST METHODS

## MIL-STD-1311D

## INDEX

<u>Method No.</u>	<u>Title</u>
1002 .....	Barometric pressure, reduced
1006 .....	Salt spray (corrosion)
1011 .....	Humidity
1016 .....	Moisture resistance
1026 .....	Temperature range, operating
1027 .....	Temperature cycling, nonoperating
1031 .....	Vibration
1032 .....	Vibration, mechanical
1036 .....	Bump (obsolescent)
1041 .....	Shock
1042 .....	Shock, specified pulse
1046 .....	Neutron irradiation
1047 .....	High- and low-temperature performance (operating)
1101 .....	Secureness of base, cap, or insert
1105 .....	Permanence of marking
1111 .....	Base pin solder depth
1116 .....	Lead fatigue (subminiature tube)
1119 .....	Glass-to-lead seal strain (subminiature flat-press base)
1121 .....	Base strain (miniature tube)
1126 .....	Glass envelope strain
1131 .....	Metallic base sleeve quality (acid etching test)
1136 .....	Rough-handling test end points
1141 .....	Pressure (implosion)
1143 .....	Forced cooling
1155 .....	Coolant-pressure drop versus coolant flow (forced-air or fluid-cooled types)
1201 .....	Short and discontinuity detection
1202 .....	Filament burnout
1206 .....	Particles indicator
1211 .....	Insulation of electrodes
1216 .....	Base material insulating quality
1226 .....	Envelope temperature
1227 .....	Temperature/Cooling (forced-air or fluid-cooled types)
1231 .....	Emission current
1236 .....	Power oscillation and internal insulation
1237 .....	Oscillation test for converter tubes
1239 .....	Noise and microphonics, peak or integrated
1246 .....	Audio frequency noise
1251 .....	Audio frequency noise and microphonics
1256 .....	Electrode current
1261 .....	Electrode voltage
1266 .....	Grid currents
1267 .....	Air leaks
1296 .....	Pulse characteristics
1301 .....	Heater or filament current
1306 .....	Transconductance
1311 .....	Anode resistance
1316 .....	Amplification factor
1321 .....	AC amplification
1326 .....	Conversion transconductance
1331 .....	Direct-interelectrode capacitance
1336 .....	Heater-cathode leakage
1341 .....	Power output
1353 .....	Operation of rectifiers
1356 .....	Grid-pulse operation
1366 .....	Interelement leakage resistance, cold
1367 .....	Magnet polarity and strength
1369 .....	Heater or filament warm-up time
1372 .....	Current division

## MIL-STD-1311D

## INDEX - Continued

<u>Method No.</u>	<u>Title</u>
1501 .....	Intermittent life
1506 .....	Heater-cycling life
1511 .....	Cathode interface life
1516 .....	Stability life
1521 .....	Survival-rate life
2126 .....	Envelope strain
2201 .....	Noise and microphonics (receiving tubes)
2202 .....	X-radiation measurement (receiving-high voltage rectifiers and shunt regulators)
2204 .....	Linear amplifier power output and distortion, two-tone method (single-sideband)
2206 .....	Linear amplifier power output and distortion, white noise method (single-sideband)
2210 .....	Grid recovery
2212 .....	Pulse emission (transmitting tubes)
2214 .....	RF useful power output (power and transmitting tubes)
2220 .....	(Obsolescent) Resonant frequency
3201 .....	Ionization characteristics (thyatron, gas)
3202 .....	Repetitive striking voltage (gas rectifiers)
3204 .....	Voltage drop (thyatron)
3206 .....	Operation (thyatron)
3211 .....	Cold-gas conduction (thyatron)
3214 .....	High-frequency operation (thyatron)
3216 .....	Grid current (thyatron)
3241 .....	Heater current (thyatron)
3246 .....	Hydrogen thyatron operation
3247 .....	DC anode voltage for conduction
3249 .....	Operation, hydrogen diodes
3251 .....	Pulse emission (hydrogen thyatron)
3256 .....	Anode delay time
3261 .....	Time jitter
3265 .....	Hydrogen diode ionization voltage
3267 .....	Instantaneous starting (hydrogen pulse modulators)
3268 .....	Energy diverter (crowbar) operation (hydrogen modulators)
3269 .....	Operation of vacuum modulators
3270 .....	Grid pulse (vacuum modulators)
3272 .....	Modulator test, shield grid negative bias tetrode thyatrons
3273 .....	Modulator test, dual control grid tetrode thyatrons
3278 .....	Noise and oscillation (cold cathode discharge types)
3305 .....	Leakage current (voltage regulator types)
3333 .....	Uniformity of cathode glow (cold cathode and graphic indicator tubes)
3335 .....	Regulation (cold cathode discharge types)
3337 .....	Voltage drop (cold-cathode discharge types)
3345 .....	Voltage jump (voltage regulator and reference)
3347 .....	Ionization (cold cathode discharge types)
4003 .....	Pressurizing (microwave tubes)
4004 .....	Mean temperature coefficient of frequency
4006 .....	X-radiation (microwave tubes)
4016 .....	Vibration detuning (tunable gas-switching tubes)
4021 .....	Degradation due to vibration (gas-switching tubes)
4026 .....	(Obsolescent) - Degradation due to shock (gas-switching tubes)
4027 .....	Temperature coefficient
4028 .....	Barometric pressure, reduced (simulated high altitude)
4029 .....	Maximum temperature coefficient of frequency
4030 .....	Thermal frequency drift
4042 .....	Microwave measurements during shock
4101 .....	Dielectric material strain (gas switching tubes)
4102 .....	(Obsolescent) Operation bump (klystron)
4153 .....	Liquid cooling jacket leakage

## MIL-STD-1311D

## INDEX - Continued

<u>Method No.</u>	<u>Title</u>
4213 .....	Reflector voltage (klystrons)
4214 .....	Cathode emission
4215 .....	Reflector voltage modulation coefficient (reflex klystrons)
4221 .....	Beam conversion efficiency (microwave-O-type devices)
4222 .....	Beam transmission
4223 .....	Mechanical tuning
4225 .....	Residual FM (reflex klystrons)
4229 .....	Reflector current (reflex klystrons)
4231 .....	Electronic tuning hysteresis (klystron oscillators)
4243 .....	Spurious output ratio
4250 .....	Power levels (microwave tubes)
4251 .....	Output power and gain variation (microwave amplifier tubes)
4252 .....	Gain linearity (microwave amplifier tube)
4253 .....	Gain (microwave amplifier tubes)
4254 .....	Saturated rf power output
4256 .....	Input and output match (traveling wave tubes)
4257 .....	Amplifier insertion loss (microwave amplifier tubes)
4258 .....	Radio interference shielding (microwave tubes)
4259 .....	Incremental gain (microwave amplifier tubes)
4260 .....	Noise figure (microwave amplifier tubes)
4261 .....	Spurious output or stability (microwave amplifier tubes)
4262 .....	Amplitude modulation (traveling wave tubes)
4263 .....	Intermodulation or cross modulation (traveling wave tubes)
4264 .....	Ion noise modulation (microwave tubes)
4266 .....	Direct-interelectrode capacitance (microwave tubes)
4268 .....	Ion pumps
4270 .....	Heater-cathode leakage (microwave tubes)
4271 .....	Amplifier power bandwidth
4274 .....	Voltage tuning range
4275 .....	Control electrode characteristics
4276 .....	Turn-off control electrode voltage
4277 .....	Power spectral characteristics
4278 .....	Phase (microwave amplifiers)
4279 .....	Reverse directed power
4280 .....	Electronic tuning range
4281 .....	Heater or filament current, operating
4282 .....	Noise power density (microwave tubes)
4284 .....	Serrodyne operation (microwave amplifier tubes)
4289 .....	Heater or filament current, nonoperating
4302 .....	Frequency change (warm-up)
4303 .....	Warm-up time
4304 .....	Pulse characteristics (microwave tubes)
4306 .....	Pulse voltage (microwave tubes)
4308 .....	Spectrum
4309 .....	Magnetron nonoscillating impedance
4310 .....	Frequency pulling figure
4311 .....	Frequency pushing figure
4315 .....	Pulse stability
4318 .....	Jitter measurements
4401 .....	Ignitor ignition time
4406 .....	Ignitor voltage drop
4411 .....	(Obsolescent) Ignitor oscillation (TR tubes)
4416 .....	Insertion loss (gas-switching tubes)
4421 .....	Ignitor interaction (TR tubes)
4426 .....	Tuning range (TR tubes)
4431 .....	(Obsolescent) Tuning (TR tubes)
4441 .....	(Obsolescent) Leakage power (gas-switching tubes)
4446 .....	(Obsolescent) Spike-leakage energy (TR tubes)
4451 .....	(Obsolescent) Flat-leakage power (gas-switching tubes)

## MIL-STD-1311D

## INDEX - Continued

<u>Method No.</u>	<u>Title</u>
4452 .....	Leakage power (gas-switching tubes)
4456 .....	(Obsolescent) - Ignitor-leakage resistance (TR tubes)
4460 .....	Ignitor noise ratio (gas-switching tubes)
4461 .....	Loaded Q (gas-switching tubes)
4466 .....	Temperature coefficient of frequency (gas-switching tubes)
4471 .....	Recovery time (gas-switching tubes)
4473 .....	Low-level VSWR (gas-switching tubes)
4474 .....	High-level VSWR (gas-switching tubes)
4475 .....	(Obsolescent) Intrinsic Q (TR tubes)
4476 .....	(Obsolescent) Intrinsic P (TR tubes)
4478 .....	(Obsolescent) High level protection (gas-switching tubes)
4482 .....	Tuning susceptance (gas-switching tubes)
4484 .....	Normalized conductance (gas-switching tubes)
4486 .....	Firing time (ATR and pre-TR tubes)
4488 .....	Arc loss (gas-switching tubes)
4489 .....	Duplexer loss (dual gas-switching tubes)
4491 .....	Transmitter-receiver isolation (dual gas-switching tubes)
4494 .....	Position of short (gas-switching tubes)
4496 .....	Firing power (gas-switching tubes)
4551 .....	Life tests (microwave tubes)
5001 .....	X-radiation measurement (display cathode-ray tubes)
5101 .....	Alignment (cathode-ray tubes)
5103 .....	Pattern distortion
5106 .....	Bulb, screen, and faceplate quality (cathode-ray tubes)
5111 .....	Vibration (cathode-ray tubes)
5115 .....	Shock (cathode-ray tubes)
5201 .....	Electrode current and voltage breakdown (cathode-ray tubes)
5206 .....	Gas (cathode-ray tubes)
5216 .....	Spurious illumination (cathode-ray tubes)
5221 .....	Screen intensity and persistence (cathode-ray tubes)
5223 .....	Modulation (cathode-ray tubes)
5226 .....	Line-width (cathode-ray tubes)
5231 .....	Spot position (cathode-ray tubes)
5236 .....	Zero-bias anode current (magnetic deflection) (cathode-ray tubes)
5241 .....	Grid-cutoff voltage (cathode-ray tubes)
5246 .....	Focusing (cathode-ray tubes)
5248 .....	Deflection factor (cathode-ray tubes)
5250 .....	Interaction factor (cathode-ray multigun tubes)
5251 .....	Electrode leakage currents (cathode-ray tubes)
5256 .....	Magnetization (cathode-ray tubes)
5301 .....	Current (phototubes)
5302 .....	Gas amplification factor (phototubes)
5303 .....	Spectral response identification (phototubes)
5306 .....	Signal-to-noise ratio (phototubes)
5401 .....	Electrode (cathode-ray charge storage tubes)
5402 .....	Grid-cutoff voltage (cathode-ray charge storage tubes)
5403 .....	Modulation (cathode-ray charge storage tubes)
5404 .....	Spot position (cathode-ray charge storage tubes)
5405 .....	Determination of storage surface reference dimension (cathode-ray charge storage tubes - electrical output)
5406 .....	Deflection (cathode-ray charge storage tubes)
5407 .....	Electrode leakage (cathode-ray charge storage tubes)
5408 .....	Blemishes (electrical output) (cathode-ray charge storage tubes)
5409 .....	Blemishes (visual output) (cathode-ray charge storage tubes)
5410 .....	Resolution, electrical output (cathode-ray charge storage tubes)
5411 .....	Resolution, visual output (cathode-ray charge storage tubes)
5412 .....	Luminance (light output), visual output (cathode-ray charge storage tubes)
5413 .....	Uniformity, output signal amplitude, electrical output (cathode-ray charge storage tubes)

## MIL-STD-1311D

## INDEX - Continued

<u>Method No.</u>	<u>Title</u>
5414 .....	Uniformity, luminance, visual output (cathode-ray charge storage tubes)
5415 .....	Writing response, static, visual output (cathode-ray charge storage tubes)
5416 .....	Erasing time, visual output (cathode-ray charge storage tubes)
5417 .....	Writing and erasing response, dynamic, visual output (cathode-ray charge storage tubes)
5418 .....	Writing and erasing response, dynamic, electrical output (cathode-ray charge storage tubes)
5419 .....	Gray scale response, visual output (cathode-ray charge storage tubes)
5420 .....	Gray scale response, electrical output (cathode-ray charge storage tubes)
5421 .....	Reading time, usable, electrical output (cathode-ray charge storage tubes)
5422 .....	Modulation transfer function, from line spread function, electrical output (cathode-ray charge storage tubes)
5423 .....	Reading time, visual output (cathode-ray charge storage tubes)
5424 .....	Dynamic range, electrical output (cathode-ray charge storage tubes)
5425 .....	Display persistence, visual output (cathode-ray charge storage tubes)
5426 .....	Operation test (vidicons)
5427 .....	Raster burn and target quick age (vidicons)
5428 .....	Signal uniformity (vidicons)
5429 .....	Resolution (vidicons)
5430 .....	Gas ratio (vidicons)
5431 .....	Raster cutoff (vidicons)
5432 .....	Lag (vidicons)
5433 .....	Spurious signal (vidicons)
5434 .....	After image (vidicons)
5435 .....	Target volts (vidicons)
5436 .....	Sensitivity (vidicons)
5437 .....	Alignment (vidicons)
6201 .....	Background, contamination, and photosensitivity (radiation counter tubes)
6205 .....	Leakage current (radiation counter tubes)
6211 .....	Starting voltage (radiation counter tubes)
621 .....	6 Plateau characteristics (radiation counter tubes)
6221 .....	Response count rate and current (radiation counter tubes)
6226 .....	Pulse amplitude (radiation counter tubes)

MIL-STD-1311D

## APPENDIX

## TEST METHODS

## MIL-STD-1311D

## METHOD 1002

## BAROMETRIC PRESSURE, REDUCED

1. Purpose. The purpose of this test is to detect corona or arcing of electron tubes operated at reduced barometric pressure. Corona and arcing occurs in connection with conducting surfaces which are not enclosed within the evacuated tube envelope.
2. General. Voltage waveform and frequency shall be as specified on the individual TSS. If voltage waveform or frequency is not specified, voltage waveform shall be sinusoidal with  $F = 48$  to  $62$  Hz. Tube sockets are not required for performance of this test; however, base pin connectors shall not alter corona or arcing characteristics of the tube. Unless otherwise specified, the sequence of testing shall be as follows:
  - a. Specified voltage shall be applied to tube in test chamber.
  - b. Barometric pressure shall be reduced to the value specified and shall be maintained at that value for a period of 60 seconds.
  - c. With specified voltage maintained, barometric pressure shall be returned to normal.
3. Cathode-ray tubes. This test shall be made with the following voltages applied to all base pins, as applicable.
 

Heater voltage .....	Nominal rated values
Ehk .....	Maximum negative
Ecl .....	Maximum negative
Deflection plate voltages .....	Maximum Eb2 plus maximum ed
All other voltages .....	Maximum rated values.

During the test, each deflection plate individually and one at a time shall be switched from +ed (maximum) to -ed (maximum) to +ed (maximum). Corona proof base connectors that do not degrade the tube voltage breakdown characteristics shall be employed. With voltages applied, the pressure shall be reduced to the specified value and maintained for 60 seconds. Neon light indicators having an approximate 1.0 mA dc sensitivity shall be connected in series with each base electrode for detecting corona or voltage breakdown. The tube shall be considered satisfactory if the neon indicator light does not glow during the 60-second period.
4. Acceptance criteria. Tubes shall show no evidence of corona or arcing.



MIL-STD-1311D

METHOD 1006

SALT SPRAY (CORROSION)

Note: This test is normally performed as a "Qualification only" test.

1. Procedure. Except as specified herein, tubes shall be tested in accordance with method 101 of MIL-STD-202, test condition A, 20 percent salt solution. When the specimens are suspended from the top, suspension shall be by materials which are nonreactive to the salt solution. At the completion of the exposure, the samples shall be thoroughly dried at room temperature prior to examination.

2. Acceptance criteria. Following this test, the tubes shall be examined and shall show no conditions which may interfere with operation and shall meet all end-point test limit(s) specified.

MIL-STD-1311D

METHOD 1011

HUMIDITY

1. Procedure. The tubes shall be subjected to an atmosphere of 90 to 100 percent relative humidity at a temperature of 90°C to 100°C for a period of 96 hours. These conditions are satisfied by exposing the tubes in close proximity to a water bath heated to 95°C to 100°C.
2. Acceptance criteria. The tubes shall meet the specified end-point test(s). In the event no end-point tests are specified, those specified as conformance inspection, part 1 electrical tests shall be met.

MIL-STD-1311D

METHOD 1016

MOISTURE RESISTANCE

1. Procedure. The tubes shall be tested in accordance with method 106 of MIL-STD-202, except that step 7 shall be omitted. After the holding period of 24 hours at room ambient conditions, electrical measurements as specified on the TSS shall be made.

MIL-STD-1311D

METHOD 1026

TEMPERATURE RANGE, OPERATING

1. Purpose. To establish the ability of the tube to start up and operate after stabilization at specified temperatures.
2. Equipment. The chamber to be used for this test shall be capable of maintaining the required ambient temperatures (and fluid cooling temperatures separately when and as required) while the tube is operating.
3. Procedure. With the chamber or fluid temperature maintained and following the warm-up period, the tube shall then operate.

MIL-STD-1311D

METHOD 1027

TEMPERATURE CYCLING (NONOPERATING)

1. Purpose. To determine the ability of electron tubes to withstand ambient temperature cycling.
2. Equipment. A test chamber is required which is capable of temperature cycling the tubes over the specified temperature range. Separate hot and cold chambers may be used.
3. Procedure. The tubes shall be placed in the chamber and exposed to one temperature cycle, from room temperature, to 100°C, to -55°C, to room temperature, (or the reverse order may be used). The tubes shall be maintained at each temperature extreme long enough to stabilize, but not less than 5 minutes. Temperature changes may be gradual; or, the manufacturer may place the tubes directly in a chamber at the high or low temperature, and, after stabilization, transfer them to the other chamber, either directly, or after allowing them to stabilize at room temperature. The temperature cycle test may be performed before painting and labeling, but after all assembly operations.
4. Acceptance criteria. At the conclusion of the cycle, gas switching tubes shall pass either the ignitor ignition time test (method 4401) or the firing time test (method 4486), whichever is appropriate.

For other tubes, acceptance criteria shall be specified on the TSS.

5. Temperature cycling life test. Gas switching tubes subjected to the temperature cycling life test shall pass either the ignitor ignition time test (method 4401), or the firing time test (method 4486), as appropriate, at the conclusion of the cycling, and shall pass the same end-point test again not less than 24 hours later.

## MIL-STD-1311D

## METHOD 1031A

## VIBRATION

1. Purpose. Vibration test is performed for the purpose of determining the effect on component parts of vibration in the specified frequency range.

2. Procedure.

2.1 Fixturing and control points. For each axis of vibration, the TUT shall be rigidly mounted on a suitable fixture that is free from mechanical resonance over the test frequency. The test fixture shall not cause attenuation of the energy level exhibited at the platform using accepted standards of measurements for calibration of the shock level and time duration. The TUT may also be mounted directly on the vibration table. If a fixture is used, it shall be so designed as to transmit the acceleration along the required axis. The vibration input shall be monitored and controlled at a point on the fixture close to the attachment points of the TUT.

3. Low-frequency (25 Hz) vibration. The tube shall be rigidly mounted on a table vibrating with simple harmonic motion at a frequency of  $25 \pm 2$  Hz with a fixed amplitude of  $.040 \pm .0025$  inch (total excursion of  $.080 \pm .005$  inch). Each tube shall be vibrated in positions X and Y, except that if the cumulative result of tests on 50 or more tubes of a construction shows that more than 75 percent of the tubes have higher output voltages in one position, subsequent measurements shall be taken only in the position giving the higher readings. The voltages specified on the TSS shall be applied to the tube during vibration. The value  $E_b$  under test conditions shall be regarded as  $E_{bb}$  and shall be applied to the tube through the specified resistor ( $R_p$ ). The impedances of anode and screen voltage supplies shall not exceed that of a 40- $\mu$ F capacitor at 10 Hz. (Preheating of the tube at these voltages is permissible.) The value of the alternating voltage ( $E_p$ ) produced across the resistor ( $R_p$ ) as a result of vibration shall be measured with a suitable device. This device shall have an appropriate voltage range and shall have the ability to measure with an error of less than 10 percent, the rms value of a sine wave of voltage of all frequencies from 20 to 5,000 Hz. Thermal or VU meters may be used provided the shunting effect on the anode load does not result in error greater than the 10 percent allowed above. Unless otherwise specified, each tube shall be vibrated for a time necessary to obtain a stable reading of output voltage or for a maximum period of 30 seconds in any one position. The stable reading shall not exceed that specified on the TSS. However, if at the end of 30 seconds, the average value of the meter reading exceeds 50 percent of the maximum specified voltage and is increasing, the tube shall be vibrated for a total time of 3 minutes, and the tube rejected if the average value of the meter reading at the end of this period exceeds the maximum specified voltage. When this test is conducted and no measurement is made of output voltage, each tube shall be vibrated for 60 seconds each in positions X and Y. This test shall not result in tap or permanent shorts or defects which will cause the tube to be inoperable.

4. High-frequency (50 Hz) vibration. The test shall be conducted as specified in 3 above, except that the frequency of the vibrating table shall be  $50 \pm 2$  Hz. Upon completion of the test, the tube shall comply with the criteria specified in 3 above.

5. Operation vibration. The tube shall be vibrated in accordance with 3 above, with the specified operating conditions applied. A test load shall be arranged to pick up some power output from the tube. If the load is not vibrated with the tube, it shall be arranged so that the frequency pulling of the tube is negligible compared to the variation in frequency due to the vibration of the tube. The total radio frequency spectrum, including any permanent change in frequency, shall not exceed the limit specified on the TSS. For klystrons, the test load, as seen by the tube, shall be as specified on the TSS. Spectrum bandwidth determination shall be made during the test, with the operating conditions held unchanged.

6. Nonoperation vibration. The tube shall be vibrated at the specified frequency and acceleration in accordance with 5 above. The conditions of operation before and after vibration, including the adjustment of the tuner mechanism and reflector voltage, shall remain unchanged. The difference between the oscillation frequencies before and after vibration shall not exceed the limit specified.

7. Sweep-frequency vibration. The tubes shall be fastened rigidly to the vibration platform and vibrated with simple harmonic motion over a frequency range of 50 to 2,000 Hz at the peak acceleration value specified on the TSS. If not specified, the peak acceleration shall be 10 G. The acceleration over the frequency range shall be within  $\pm 10$  percent of the referenced acceleration at 100 Hz. At all frequencies from 50 to 2,000 Hz, the total harmonic distortion of the acceleration waveform shall be less than 10 percent. The frequency shall increase from 50 to 2,000 Hz with approximately logarithmic progression versus time and shall require 4 minutes minimum, 5 minutes maximum, to traverse the range. Each tube shall be vibrated in axes X and Y, except that if the cumulative results of tests on 50 or more tubes of a given construction show that more than 75 percent of the tubes have a higher output voltage on one axis, subsequent measurements need only be taken in the axis giving the higher readings. For special construction tubes, vibration axes shall be indicated on the TSS.

## MIL-STD-1311D

7.1 Receiving tubes. Receiving tubes shall be tested in accordance with 7 above, except the frequency range shall be traversed in 1 minute (minimum), 3 minutes (maximum). The specified voltages shall be applied to the tube during vibration. The value of Eb under test conditions shall be regarded as Ebb and shall be applied to the tube through the specified resistor Rp. The value of the alternating voltage, Ep, produced across the resistor, Rp, as a result of vibration, shall be measured with a suitable device. This device shall have an appropriate voltage range and shall have the ability to indicate with an error of less than 10 percent the rms value of a sine wave at all frequencies as specified below and shall have dynamic response characteristics equivalent to or faster than a VU meter. The voltage Ep shall be capacitance coupled to the measuring system consisting of cables, amplifier, low-pass filter, and indicator. Input impedance of the measuring system shall have a minimum value of at least 10 times the resistor, Rp, at 10,000 Hz. Combined frequency response from the capacitor input through the amplifier and filter shall be flat within  $\pm 1$  dB from 50 to 10,000 Hz, as referenced at 1,000 Hz shall be down  $10 \pm 2$  dB at 15,000 Hz, and down  $20 \pm 3$  dB at 20,000 Hz. The impedance of the anode and screen voltage supplies shall not exceed that of a 40  $\mu$ F capacitor at 10 Hz.

7.1.1 Value of Ep. The value of Ep shall not exceed the limit specified at any point in the sweep-frequency range nor shall this test result in open circuits, permanent shorts, or tap shorts.

7.2 Sweep-frequency-vibration fatigue (destructive test). The tubes shall be fastened rigidly to the vibration platform and vibrated with simple harmonic motion over a frequency range of 50 to 2,000 Hz at a peak acceleration value of 10 G. The acceleration over the frequency range shall be within  $\pm 25$  percent of the referenced acceleration at 50 Hz. The frequency of vibration shall be varied from 50 to 2,000 Hz and back to 50 Hz with the period of the sweep cycle being 10 minutes minimum to 20 minutes maximum. The tubes shall be vibrated for a total of 6 hours, that is, 2 hours in each of three axes, X, Y, and Z. For special-construction tubes, vibration position shall be specified on the TSS. Only rated filament or heater voltage shall be applied. Tubes which show one or more of the following defects shall be considered failures:

- a. Tubes which show permanent or tap shorts or open circuits following sweep-frequency-fatigue test.
- b. Tubes which do not comply with sweep-frequency-vibration-fatigue test end point limit(s) as specified on the TSS.

8. Variable-frequency vibration. The tubes shall be vibrated under the conditions specified for low-frequency vibration and axis Z shall be added. The tubes shall be vibrated at a constant amplitude in each of three axes through the frequency range from 10 to 50 Hz and back to 10 Hz. The time for gradually covering the range from 10 to 50 Hz and back to 10 Hz shall be 3 to 15 minutes. Each tube shall be vibrated for 60 seconds at the frequency which gives the maximum vibration output voltage in each of the three axes. If at the end of 60 seconds, the vibration output is increasing, the vibration shall be continued until there is no further increase. The tubes shall not show vibrational output in excess of the maximum limit specified. This test shall not result in tap or permanent interelectrode shorts or defects which cause the tube to be inoperable.

9. Vibration-fatigue test (destructive test). The tube shall be rigidly mounted on a table vibrating with simple harmonic motion at a frequency of  $25 \pm 2$  Hz with an amplitude of  $.040 \pm .005$  inch (total excursion of  $.080 \pm .005$  inch) or any equivalent combination of frequency and excursion resulting in 2.5 G applied to the TUT. The tubes shall be vibrated for a total of 96 hours, 32 hours in each of three axes, X, Y, and Z. Only rated filament or heater voltage shall be applied. Tubes which show one or more of the following defects shall be considered failures:

- a. Tubes which show permanent or tap shorts or open circuits following vibration-fatigue test.
- b. Tubes which do not comply with vibration-fatigue test end point limit(s) specified on the TSS.

10. Microwave tubes. The TSS shall specify characteristics to be measured during or after vibration.

## MIL-STD-1311D

## METHOD 1032A

## VIBRATION, MECHANICAL

(Not normally applied to receiving tubes)

1. Purpose. This method contains test procedures for verifying the ability of electron tubes to perform satisfactorily under conditions of mechanical vibration. The test conditions should be chosen to reflect the capability of the tube.

2. General considerations.

2.1 Fixturing and control points. For each axis of vibration, the TUT shall be rigidly mounted on a suitable fixture that is free from mechanical resonance over the test frequency. The test fixture shall not cause attenuation of the energy level exhibited at the platform using accepted standards of measurements for calibration of the shock level and time duration. The TUT may also be mounted directly on the vibration table. If a fixture is used, it shall be so designed as to transmit the acceleration along the required axis. The vibration input shall be monitored and controlled at a point on the fixture close to the attachment points of the TUT.

2.2 Tolerances. The following test parameters shall be maintained within the tolerance limits specified on the TSS.

Displacement	± 10 percent
Acceleration	± 15 percent
Frequency range limits	± 5 percent
Sweep rates	± 5 percent
Time durations	± 5 percent
Axes of application	± 5 percent
Electrical parameters	See TSS

2.3 Test limits. Initial readings, operating conditions, and test limit(s) during and after mechanical vibration shall be specified on the TSS.

2.4 Axes of application. The vibration procedures specified on the TSS shall be applied along the X, Y, and Z axes of the TUT in any order. A drawing or sketch of the TUT showing the X, Y, and z axes shall form a part of the TSS.

3. Test parameters for sinusoidal vibration.

3.1 Simple harmonic motion. The vibration applied to the control point shall be simple harmonic motion.

3.2 Frequency ranges. One of the following frequency ranges shall be used, as specified on the TSS:

5	to	25 Hz
10	to	60 Hz
10	to	150 Hz
10	to	500 Hz
10	to	1,000 Hz
10	to	2,000 Hz
10	to	5,000 Hz

3.3 Vibration levels. One of the following vibration levels shall be used, as specified on the TSS:

Total displacement in inches	Crossover	Acceleration	Total displacement in mm	Crossover
.006	57.0	1.0	0.15	57.5
.012	57.0	2.0	0.3	57.5
.028	59.0	5.0	0.7	59.5
.060	57.0	10.0	1.5	57.5
.080	60.5	15.0	2.0	61.0
.120	57.0	20.0	3.0	57.5
.160	60.5	30.0	4.0	61.0
.280	59.0	50.0	7.0	59.5



## MIL-STD-1311D

3.4 Frequency sweep. Logarithmic vibration frequency sweeps are recommended. Linear sweeps may be used if the sweep rates are adjusted for equal time per octave, while maintaining the desired overall rate. The units used for expressing sweep rates shall be minutes per decade. The recommended sweep rate is 2.3 minutes per decade (for example, 10 to 2,000 Hz in 5.3 minutes.)

4. Test procedures for sinusoidal vibration.

4.1 Survey. The frequency at the specified vibration level shall be cycled at a logarithmic rate from the lowest to the highest frequency specified on the TSS. The instantaneous sweep rate shall be such that one decade is swept in 2.3 minutes. If necessary, the sweep may briefly be slowed, stopped, or reversed for the proper location and identification of resonances. Record all resonances and relative magnitude.

4.2 Single sweep. With the specified vibration level applied, the vibration frequency shall be swept once from the lowest to the highest frequency. The instantaneous sweep rate shall be such that one decade is swept in 2.3 minutes. The TUT shall operate as specified on the TSS throughout the test.

4.3 Cycling. With the specified vibration level applied, cycle the vibration frequency twice from the lowest to the highest frequency and back. The instantaneous sweep rate shall be such that one decade is swept in 2.3 minutes. Before and after cycling in each axis, the TUT shall be subjected to procedure 4.1. The TUT shall operate as specified on the TSS throughout the test.

4.4 Endurance at resonance. This test shall be preceded and followed in each axis by procedure 4.1. With the vibration level applied, the TUT shall be vibrated for the time specified on the TSS at each vibration frequency at which evidence of resonance was observed during the initial survey. During the resonance period, the vibration frequency shall be adjusted as often as necessary to maintain the maximum amplitude or output. If more than four resonances were observed, the four judged most likely to cause failure shall be chosen. If no resonance was observed, endurance at resonance shall be omitted. The TUT shall operate as specified on the TSS throughout the test.

Note: This test may be destructive. If this is considered a destructive test, the TSS shall so indicate.

5, Summary of information required on TSS. For each test procedure selected, specify the following information on the TSS:

- a. Test limits and conditions (see 2.3).
- b. Axes of application (see 2.4).
- c. Frequency range (see 3.2).
- d. Vibration level (see 3.3 and note below).
- e. Time at each resonance (see 4.4).
- f. When endurance at resonance is considered constructive (see 4.4).
- g. Exceptions of modifications, if any.

NOTE: Vibrate at a constant displacement as specified in the 3.3 table, up to the listed crossover frequency and then go to constant acceleration at the specified table 3.3 acceleration value.

MIL-STD-1311D

METHOD 1036A

BUMP

(Obsolescent)

USE TEST METHOD 1042B

1. Purpose. Normally used to check the brittleness of the filaments in tubes having thoriated tungsten filaments and to check the quality of ceramic insulators.

2. Bump. Each tube shall be mounted in a vertical position in the standard bump-test equipment shown on Drawing 123-JAN. No electrical potentials shall be applied to the tube during this test. The hammer arm shall be released from the angle specified on the TSS and allowed to strike the glass envelope one blow at an angle of 45 degrees to the plane of the press seal. The hammer shall strike the tube in such position that free pendulum motion is obtained without excessive wobble. This test shall be performed three times. Subsequent to this test, the tube shall comply with all applicable mechanical requirements and meet the limit(s) of all tests specified as conformance inspection, part 1 of the TSS.

3. Bump and short. Each tube shall be tested as specified in 2 above, and in addition, suitable indicating potentials shall be applied to the various electrode combinations through a short-indicating device. There shall be no shorts, momentary or permanent, between the elements during this test.

NOTE: An alternate test may be substituted if performed on shock test equipment using a G level and pulse duration equivalent to that obtained when using this method with the hammer angle as specified on the TSS. (See 4.6.)

## MIL-STD-1311D

## METHOD 1041

## SHOCK

1. Test equipment. The shock test shall be conducted on the Navy type, high-impact (flyweight) shock machine for electronic devices, or its equivalent (see Drawing 180-JAN). The standard steel hammer shall be used. The shock machine shall be so adjusted that the hammer at rest just contacts the anvil of the shock table. Each tube shall be subjected to a total of 20 hammer blows of the specified angular displacement or G level and duration. Application shall be five blows in axes X, Y, Z plus, and Z minus, in any sequence. The tube shall be mounted for testing as follows:

<u>Size of tube</u>	<u>Clamp drawing</u>
Miniature	184-JAN
Subminiature 1/	184-JAN
T9 and larger	216-JAN or as specified

1/ The leads may be clipped.

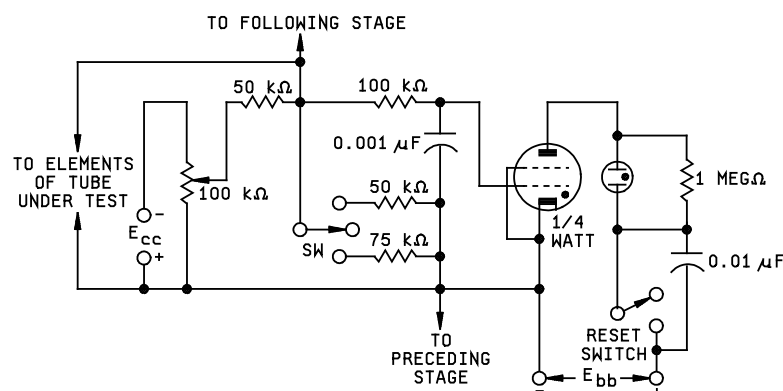
2. Test conditions. The tubes shall be tested under one of the following conditions:

- With the voltages which are specified on the TSS applied to the tube.
- With a thyatron-controlled, short-circuit indicator with the circuit constants as shown on figure 1041-1, or its equivalent, connected to indicate interelectrode shorts. Tubes shall have rated filament or heater voltage applied.
- No voltages applied.

3. Failure criteria. Tubes which show one or more of the following defects shall be considered failures:

- Tubes which show permanent shorts during the shock tests.
- Tubes which show tap or permanent shorts or open circuits following shock tests.
- Tubes which do not comply with shock test end point limit(s).

4. Test classification. This is a destructive test.



Ecc should be adjusted to indicate a short with a 50,000-ohm resistor and to give no indication with 75,000 ohms. The firing voltage Ec should not be outside the range of 1.0 to 3.0 volts.

FIGURE 1041-1. Short-circuit indicator.

MIL-STD-1311D

METHOD 1042B

SHOCK, SPECIFIED PULSE

1. Purpose. The purpose of this test is to evaluate the ability of tubes to withstand specified shock levels in accordance with MIL-STD-202, method 213.

2. Apparatus, setup, and calibration. In addition to that specified in method 213, MIL-STD-202, the following shall be applicable:

- a. The TUT shall be rigidly mounted on a suitable fixture or directly on the shock table using the normal mounting arrangement for the tube. If a fixture is used, it shall be designed so as to transmit the shock along the required axis. The shock input shall be monitored on the fixture at a point close to the attachment points of the tube.

- b. In addition to the conditions specified in method 213, MIL-STD-202, the following conditions may be applied:

Peak value ..... 15 G

Normal duration (D) ..... 11 ms

Waveform ..... Half-sine

Velocity ( $V_i$ ) ..... 3.4 feet/second

3. Procedure. The specified parameters of the tube shall be measured before and after shock. Unless otherwise stated, the tube shall be nonoperating while being shocked and tests shall be conducted only under ambient conditions.

MIL-STD-1311D

METHOD 1046A

NEUTRON IRRADIATION

1. Purpose. The purpose of this test is to determine the effect of neutron irradiation on tube characteristics.
2. Test equipment. The test equipment shall be capable of subjecting the tube to the specified intensity and dosage. These values shall be measured and recorded during test. The measurement of the neutron flux (NV) and dosage (NVT) will normally be the responsibility of the reactor personnel. The intensity, NV, or neutron flux is the number of neutrons per square centimeter per second. The dosage, NVT, is the integrated neutron flux or the number of neutrons passing through 1 sq cm in time T.
3. Procedure.
  - a. The specified end-point test(s) shall be made on the sample. The sample shall be placed in the reactor and subjected to the specified intensity and dosage rate.
  - b. After exposure, tubes are not measured until their residual radiation intensity meets acceptable personnel safety levels. The tubes shall then be retested and shall meet the end-point limit(s) specified on the TSS.
  - c. This test should normally be made only at qualification.

MIL-STD-1311D

METHOD 1047

HIGH- AND LOW-TEMPERATURE PERFORMANCE

(OPERATING)

1. Purpose. The purpose of this test is to determine the performance of electron tubes at high or at low temperature.
2. Equipment. The test chamber shall be capable of maintaining the specified ambient temperature. Facilities shall be available to measure performance of the tubes.
3. Procedure.
  - 3.1 High-temperature operation. The tube shall be introduced into the test chamber and the chamber temperature then adjusted to 100°C. The tube shall be maintained in this environment for sufficient time to reach equilibrium, but for not less than 5 minutes before the application of voltages. After reaching equilibrium and following the specified warm-up, the tube's performance shall be measured under the conditions specified.
  - 3.2 Low-temperature operation. The tube shall be introduced into the test chamber and the chamber temperature then adjusted to -55°C. The tube shall be maintained in this environment for sufficient time to reach equilibrium, but for not less than 5 minutes before the application of voltages. After reaching equilibrium and following the specified warm-up, the tube's performance shall be measured under the conditions specified.

## MIL-STD-1311D

## METHOD 1101B

## SECURENESS OF BASE, CAP, OR INSERT

1. Procedure. Unless otherwise specified on the TSS, the tubes shall be tested as indicated in table 1101-I. The immersion bath shall be clear water. After immersion (when required), the tubes shall be cooled at room temperature for at least 1 hour before torque or pull is applied.

NOTE: This method is not intended for testing glass or ceramic-to-metal vacuum seals. Methods such as 1116, 1119, 1121, 1126, or 2126 as applicable, should be selected for testing such seals.

2. Measurements. Upon completion of the required test(s), there shall be no loosening of cemented joints and not more than .031 inch movement of non-cemented mechanical joints. Caps on metal tubes shall rotate not more than 20 degrees.

TABLE 1101-I. Torque, pull, and immersion requirements.

Component sizes	Torque or pull	Component designs	Torque or pull elements	Immersion <sup>1/</sup>
<u>Bases</u>	<u>Pounds-inch</u>	<u>Bases</u>	<u>Between envelope and:</u>	
Dia. less than 0.65 inch	12	Pin mounted and integral shell	Base or pins (incl guide lug)	Required
Dia. 0.65 inch to 1.5 inch	20	Wafer insert	Insert or pins (incl guide lug)	Required
Dia. more than 1.5 inch	40	Phenolic or ceramic wafer insert on metal tubes	Pins (incl guide lug)	Not required
Wafer	60 (pound pull)	Wafer base on metal envelope	Axial pull; wafer or all pins simultaneously	Not required
<u>Caps</u>		<u>Caps</u>		
Caps with diameter of the electrical contact surface equal to .600 inch or less	1.5	Cemented	Cap	Required
Caps with diameter of the electrical contact surface greater than .600 inch.	3	Metal tubes	Cap	Not required

<sup>1/</sup> Receiving tubes: 50°C minimum, for 42 hours or boil for 6 hours.

Other than receiving tubes: 50°C for 18 hours.

MIL-STD-1311D

METHOD 1105

PERMANENCE OF MARKING

1. Purpose. These tests are designed to control the quality of marking such that a specified degree of resistance to moisture and abrasion is maintained. The tests are not required on marking made by etching or grit-blasting.
2. Sampling. Sampling shall be as specified in MIL-PRF-1, section 4.
3. Procedure.
  - a. Ink marking on glass or glazed ceramic surfaces. The tube marking to be tested shall be immersed in room temperature water for 2 minutes immediately prior to test. The tube shall be turned through 15 revolutions or submitted to 15 rubs (.500 inch minimum travel each), with the marked area in contact with No. 00 steel wool under a load of 500 grams. The active surface area of the steel wool (that area of the steel wool pad which is in direct contact with the tube and supports the 500 gram weight) shall be limited to not more than 1 square inch. The pad thickness under the load shall be approximately .500 inch. A new pad shall be used after a maximum of 15 tubes have been tested.
  - b. Marking on other than glass or glazed ceramic surfaces and other than ink marking on glass or glazed surfaces. The marking on the tube shall be rubbed 12 times with a water dampened chamois exerting a force of approximately 10 pounds.
  - c. Marking on tubes with integral permanent magnets. Steel wool shall not be used on tubes which have integral permanent magnets, because of retention of metal slivers. Follow procedure (a), but substitute a woven nylon scouring pad in place of steel wool.
4. Acceptance criteria. A defective tube shall be defined as one on which any portion of the tube number, lot identification, or service life guarantee markings are illegible following the test.
5. Disposition of samples. Those tubes which successfully complete the test may be returned to the lot. Those tubes which fail the test shall be remarked and retested prior to being returned to the lot.



## MIL-STD-1311D

## METHOD 1111A

## BASE PIN SOLDER DEPTH

1. Purpose. This test is to determine the depth of solder between the tube leads and the base pins.
2. Procedure. Determine the depth of solder contact within the base pins by either sectioning soldered joints of the tubes or by the use of X-ray techniques.

NOTE: This test is destructive if the X-ray technique is not used.

- 2.1 Minimum depth. The minimum depth of soldered contacts within the base pins shall be as follows:

<u>Pin size, inch</u>	<u>Minimum penetration, inch</u>
.093	.031
.125	.031
.156	.062
.187	.062
Larger than .187	.094

3. Specimens. Electrical rejects may be used as specimens for this test.

MIL-STD-1311D

METHOD 1116

LEAD FATIGUE

(Subminiature tube)

1. Purpose. This test is conducted in order to detect defects in the tube leads.
2. Procedure. Two leads per tube shall be tested. The leads shall be selected in a cyclical manner (regular recurring), for example, leads No. 1 and 2 on the first tube, leads No. 2 and 3 on the second tube, etc. The lead-fatigue test shall be made by subjecting each lead under test to a pull of  $16 \pm 1$  ounces. Each lead shall withstand four 90 degree arcs of the glass header. An arc is defined as the movement of the lead away from the tube through 90 degrees from normal and back, to normal. All arcs on a single lead shall be made in the same direction and in the same plane. A lead shall be considered to have failed at the time it breaks off from the tube.
3. Acceptance criteria. Upon completion of the test, acceptance or rejection of the lot shall be based on the number of tubes defective. A tube having one or more defective leads shall be considered a defective tube.

NOTE: This is a destructive test; electrical rejects may be used for this test.

MIL-STD-1311D

METHOD 1119

GLASS-T0-LEAD SEAL STRAIN

(Subminiature flat-press base)

1. Procedure.

- a. Secure the tube with its longitudinal axis in a vertical position.
- b. Attach one  $32 \pm 2$  ounce weight to the end of three adjacent leads (one shall be an outside lead).
- c. Rotate the tube in a 90 degree smooth arc of at least 2 seconds duration. (The unweighted leads shall then be at right angles to the weighted leads.)
- d. Remove the weight and examine, without magnification, for glass damage at the glass-to-lead seal areas of the base.

2. Acceptance criteria. Upon completion of this test, there shall be no evidence of fractured or chipped glass at the base.

NOTE: This is a destructive test; electrical rejects may be used for this test.

## MIL-STD-1311D

## METHOD 1121

## BASE STRAIN

(Miniature tube)

1. Preparation. Prior to testing, all tubes shall be subjected to a pin-straightening procedure. For this immersion test, the water container shall be sufficiently large so that no TUT is closer than .750 inch (19.05 mm) from the container sides. The vessel used shall have a minimum capacity of 2 liters per 15 tubes, and shall be at least 75 percent full for every strain test to insure a more uniform temperature gradient for all TUT. The holders for simultaneous testing at least fifty percent of the tubes in the sample at one time, shall provide sufficient spacing between the pins of the adjacent tubes so that the tubes do not contact each other. A minimum of six, .375 inch (9.53 mm) diameter holes shall be made in the plate of each holder. Align the axis of each tube with the axis of the deflection cone (see Drawing 200-JAN), and carefully push the small end of the cone into the circle formed by the pins until firm contact is made against the tube header.

2. Procedure. Submerge the holder with tubes in place into the container of boiling water (97°C to 100°C). The tubes attached to cones shall be completely submerged. After 10 seconds' submersion, remove from water, place on a nonmetallic support, and allow to cool at room temperature. If after removal of tubes from the cones, examination reveals some pins are bent more than others, the test has been improperly conducted.

3. Alternate test. Submerge the holder with tubes in place into a container of cool water (20°C to 30°C) for 5 seconds, followed immediately by a dip in boiling water (97°C to 100°C) for 10 seconds which is in turn followed by an immediate dip in cool water for an additional 10 seconds, then remove and allow to dry.

4. Testing shall be performed within approximately 1 hour after the exhaust operation during manufacture. Upon completion of the test, tubes shall be examined for the following defects. The class of strain-test defects shall be in accordance with the following tabulation:

<u>Defect</u>	<u>Class</u>
Envelope or tip cracks (or both)	A
Button (wafer-header) cracks	B
Seal cracks	C

MIL-STD-1311D

METHOD 1126

GLASS ENVELOPE STRAIN

1. Purpose. To check for strains which may cause breakage under severe temperature extremes.
2. Test equipment. Two water containers are required. One shall contain boiling water (97°C minimum) and the other shall contain water at melting ice temperature (5°C maximum). The volume of water shall be large enough to be appreciably unaffected in temperature by the test.
3. Procedure. The glass bulb, but not the base, of the tube shall be immersed in the hot container for a minimum period of 15 seconds and thereafter immediately immersed in the cold container for a minimum period of 5 seconds. For all glass type tubes, the entire tube shall be immersed.
4. Acceptance criteria.
  - a. The glass envelope shall not crack or break.
  - b. Electrical rejects may be used for this test.

MIL-STD-1311D

METHOD 1131A

METALLIC BASE SLEEVE QUALITY

(Acid etching test)

1. Purpose. This test is intended to reveal any evidence of subsurface hairline cracks in metallic sleeve of base with wafer insert.
2. Apparatus.
  - a. Acid bath (for brass or bronze sleeves) 1 percent aqueous solution of mercurous nitrate to which has been added 3 milliliters of nitric acid (sp gr 1.42) per liter.
  - b. Neutralizing bath.
  - c. Salt spray (for noncorrosive steel sleeves).
3. Procedure.
  - 3.1 Brass or bronze sleeves.
    - a. Immerse the degreased, unplated sleeves into the acid bath with base wafer (insert) attached. (Plated brass or bronze sleeves shall have the plating removed before starting this test.)
    - b. After 15 minutes immersion, remove from acid bath, wash in neutralizing bath, wipe dry, and examine.
  - 3.2 Noncorrosive steel sleeves. Substitute the salt-spray test method 1006 for the acid bath.
  - 3.3 Rejection criteria. Upon completion of the test, any evidence of cracks in the sleeves shall cause the sleeve to be considered a failure, and the lot shall be rejected.
4. Samples. Three samples from each lot or shipment of sleeves shall be tested.

## MIL-STD-1311D

## METHOD 1136C

## ROUGH-HANDLING TEST END POINTS

1. Purpose. The purpose of this test is to determine the ability of the shipping pack or package to safeguard the tube from damage due to rough handling.

2. Acceptance criteria. Unless specially indicated on the TSS as "Required for qualification approval", this test shall not be performed as a qualification test. Tubes prepared for shipment in accordance with MIL-DTL-75 shall have met all applicable provisions of the TSS prior to the performance of the specified rough-handling test(s). Upon completion of the MIL-DTL-75, section 4, rough-handling test(s), the tubes shall comply with the following acceptance criteria, as applicable:

NOTE: All categories of tubes, other than those listed below, shall meet the initial acceptance limits of all tests specified under conformance inspection, part 1.

- a. Beam switching. Conformance inspection, part 1: Counting voltage range and current.
- b. Cathode-ray tubes. Shall be subjected to the following tests and shall meet the requirements specified.
  - (1) The change in position of the undeflected focused spot from its position noted before the test shall not exceed the following values:

Tube diameter (inches)	Change (mm)	Tube diameter (inches)	Change (mm)
1 - - - - -	1.5	7 - - - - -	5
2 - - - - -	3	9 - - - - -	6
3 - - - - -	3	10 - - - - -	6
4 - - - - -	4	12 and over - - - -	8
5 - - - - -	4		

- (2) The change in deflection factor for electrostatic tube types shall not exceed 5 percent.
- (3) Starting with a tube with no loose particles, the maximum number of loose particles as a result of dropping shall be no more than a total of five loose particles greater than .016 inch in any one cathode-ray tube. Tubes having any loose particles greater than .016 inch shall be vibrated with the face down in a horizontal plane at 5 G for 1 minute. If the screen shows damage from such vibration, the tubes shall be rejected.
- (4) The change in grid-cutoff voltage shall not exceed 10 percent.
- (5) There shall be no damage to the external parts of the tube.
- c. Cathode ray charge storage. Spot position, deflection factor, writing gun cutoff, loose particles.
- d. Cold cathode. Conformance inspection, part 1: Electrical tests.
- e. Crossed-field amplifier. Conformance inspection, part 1: Electrical tests.
- f. Electron multiplier. Conformance inspection, part 1: Operation.
- g. Electron-ray indicator. Conformance inspection, part 1: Electrical tests.
- h. Gas-switching tubes. TR tubes shall pass the initial acceptance limits for the ignitor voltage test specified. Pre-TR and ATR tubes shall pass the initial acceptance limits for the firing time test specified.
- i. Graphic indicator Uniformity of cathode glow, conformance inspection, part 1: Ionization.
- j. Ignitron. Conformance inspection, part 1: Electrical tests.
- k. Image converter. Conversion index, cathode and screen quality.
- l. Image orthicon. Resolution, spurious signal, cutoff.

## MIL-STD-1311D

- m. Klystrons. Shall be tested for controlling-electrode voltage, power output, and tuning range.  
After rough-handling test, the controlling electrode voltage and power outputs shall not have changed from their initial values by more than the amount specified. The tubes shall pass the frequency-range test specified on the TSS. Tubes using an external cavity shall operate within the frequency specified.
- n. M-type backward wave. Power output and voltage tuning, conformance inspection, part 1.
- o. Magnetrons. Shall pass the initial test requirements for pulse voltage, stability, frequency, and bandwidth. These tests shall be performed under the oscillation conditions for those parameters specified in the life-test end points.
- p. Negative grid (microwave). Power Osc or transconductance, conformance inspection, part 1.
- q. Noise source. Conformance inspection, part 1: Excess noise ratio.
- r. Phototube. Anode sensitivity.
- s. Power or transmitting tubes (except hydrogen diodes). Shall pass the anode current, cutoff, and operation tests when these tests are specified on the TSS. Gas rectifiers shall be subjected to the operation tests, a minimum 24 hours after this rough-handling test has been made.
- t. Pulse modulator, hydrogen. Shall pass the time jitter and operation tests when these tests are specified on the TSS. These tests shall be made a minimum of 24 hours after the rough-handling test has been made.
- u. Pulse modulators, vacuum. Grid pulse operation.
- v. Radiation counter.  
6201 Background contamination.  
6211 Starting voltage.  
6216 Relative plateau slopes.
- w. Receiving tubes. Shall be within the limits of the following when specified as conformance inspection, part 1: heater-cathode leakage, anode current, cutoff, power output, transconductance, anode resistance, ac amplification, and conversion transconductance. Rectifiers shall pass the operation and heater cathode insulation test when specified on the TSS. Gas rectifiers shall be subjected to the operation test a minimum of 24 hours after the rough-handling test has been performed.
- x. Thyratrons (excluding hydrogen thyratrons). Shall pass the anode voltage, grid voltage, and operation tests when these tests are specified on the TSS. These tests shall be made a minimum of 24 hours after the rough-handling test has been made.
- y. TWT and O-type backward wave. Conformance inspection, part 1: Noise figure, gain, saturated power.
- z. Vidicon. Resolution, spurious signal, cutoff.
- aa. Voltage regulators. Shall be within the limits of the ionization-voltage test. Only those ionization tests which are conformance inspection, part 1 tests, shall be made.
- bb. Voltage regulator: Corona discharge. Conformance inspection, part 1: 3347 Ionization voltage.



MIL-STD-1311D

METHOD 1141

PRESSURE

(Implosion)

1. Purpose. A safety precaution to guard against the implosion of a glass tube with a large volume, primarily cathode-ray tubes.
2. Procedure. The tube shall be subjected to 45 pounds per square inch (3.1 kilograms per square centimeter) absolute pressure for a period of at least 60 seconds. This pressure shall be attained within 60 seconds.
3. Acceptance criteria. Upon completion of the test, there shall be no physical damage to the tube.

MIL-STD-1311D

METHOD 1143A

FORCED COOLING

1. Purpose. The purpose of this test is to demonstrate:

- a. That air or liquid passages are not obstructed.
- b. That the temperature of the tube is held at an acceptable level when operated within its ratings, with the specified coolant and flow rate.

This test is not to demonstrate satisfactory operation at the rated temperature extremes for the tube, but to determine that the design provides adequate cooling at normal ambient temperatures.

2. Test equipment. Temperature, pressure, and flow rate indicating devices are needed depending upon those characteristics to be controlled or measured, as specified on the TSS.

3. Procedure. The TSS shall specify the coolant flow rate, and necessary dimensions of the external hardware (ducting, orifice size and position, or liquid coolant pipe sizes), including flexibility requirements where necessary to avoid stressing the tube unduly. The coolant used shall be as specified, and at the temperature specified.

- a. Pressure drop. When specified on the TSS, the pressure drop across the tube is to be measured when the coolant is flowing at the specified rate (purpose 1(a)).
- b. Rate of flow. When specified on the TSS, the rate of flow through the cooling system including the specified mating fixtures is to be measured at the specified pressure drop (purpose 1(a)).
- c. Temperature. When specified on the TSS, the temperature at a point indicated on the outline drawing is to be measured. In the case of air cooling, this temperature shall not exceed the input air temperature by more than 50°C, or the value specified. In the case of liquid cooling, the TSS shall specify whether evidence of boiling is permissible or not (purpose 1(b)).

4. Precaution. In the case of liquid cooling, provision shall be made for removal of all coolant from the tube before storage or shipment, to avoid damage due to freezing.

MIL-STD-1311D

METHOD 1155

COOLANT-PRESSURE DROP VERSUS COOLANT FLOW

(Forced air or fluid-cooled types)

1. General. When applicable, the following conditions shall be specified on the TSS for each separate cooling system:

- a. Coolant type(s), flow (volume and velocity), direction of flow, area and method of application, limits of incoming temperature, system pressure (if other than atmospheric).
- b. Appropriate meters, indicators, and methods of measurement.
- c. Accessories such as air socket or distributor, water (or fluid) jacket, auxiliary radiators (terminals, etc.), and air directors or reflectors. When relevant, manufacturer's part number, catalog number, etc., for commercially available components shall be specified or complete detailed drawings shown.

2. Procedure.

- a. With conditions as specified on TSS (conditions shall include exceptional conditions or environmental requirements such as closed systems, altitude, inert gases, etc.), the pressure drop(s) shall be within limit(s) specified. Pressure measurement shall be made as close to the TUT as possible.

- b. Formula:  $P = P_{\text{inlet}} - P_{\text{outlet}}$

Fluid systems:

P is the gauge/pressure in pounds/square inch (psi).

Forced-air systems:

P is the static-head pressure in inches of water (W.G.).

## MIL-STD-1311D

## METHOD 1201C

## SHORT AND DISCONTINUITY DETECTION

**Requirements.** When this method is specified on the TSS, testing shall include the following tests: discontinuity, shorts, permanent shorts, tap shorts, and air leaks. Tubes shall be rejected as inoperative, if failing any of these tests.

1. **Discontinuity.** Tubes shall be tested for discontinuity of any possible circuit, including shell, base, base sleeve, shield, and duplicate-pin connections to the same electrode, as applicable. During the discontinuity tests, the tubes shall be tapped (except life-test samples) as specified in 2. Tubes shall give no indication of permanent or intermittent open circuits during this test.

2. **Shorts.** Tubes shall be tested for shorts between any elements, no-connection base pins, and internal shields.

The tube shall be connected to the shorts test equipment in such a manner that the minimum specified sensitivity specified herein is maintained between all elements in a single section of the tube, but like elements in the sections of a multisection tube may be paralleled, provided that the mechanical assembly of the tube structure is such that the possibility of shorts between sections is proven to be remote in that the cumulative results of tests on 1,000 or more tubes of a given construction shows that no more than 0.4 percent of the tubes show any indication of tap shorts between like elements in the sections of a multielement tube. The shorts simulator used for calibration shall be of the passive type (time-controlled-switch closure) and shall add a minimum of capacitance to the circuit under test consistent with good low-capacitance wiring technique. Except for heater-cathode, a short circuit shall be defined as an equivalent resistance between adjacent elements which persists for a period of time in excess of that determined by a limiting curve of resistance versus time duration passing through the following points:

<u>Resistance (ohms)</u>	<u>Time duration</u>
600,000 -----	Constant value (permanent short)
500,000 -----	500 $\mu$ s
100,000 -----	100 $\mu$ s
1,000 -----	60 $\mu$ s

For heater-cathode, the sensitivity need not exceed 10 percent of the above resistance value. Figure 1201-1 illustrates this curve and is marked to show the area of rejection and acceptance; for example, a short circuit of 100,000 ohms equivalent resistance shall be accepted if it persists for less than 100  $\mu$ s, etc. The voltage applied between adjacent elements of the tube shall have a value between 20 and 70 volts dc or peak ac.

2.1 **Permanent shorts.** Tubes shall be tested without mechanical excitation.

2.2 **Tap shorts.** Tapping procedure for receiving tubes.

- a. The tube shall be mounted in the test socket of the shorts test equipment and tapped three times on each of two planes 90 degrees to 120 degrees apart. During tapping, the tube shall be supported only by a socket and a light-finger pressure or soft-cushioned mechanical pressure on the dome of the bulb. The finger or mechanical pressure on the dome of the bulb shall be used only to prevent the tube from coming out of the socket. This pressure shall be so applied that it offers negligible restraint to lateral motion at the top of the bulb.
- b. The tap blows shall be delivered to the tube approximately two-thirds up on the holddown height.
- c. The tapping device shall be so designed and adjusted that it will deliver an impulse of approximately one-half sine wave of  $300 \pm 50$   $\mu$ s duration, as measured at 10 percent of the amplitude of the half wave and have a minimum average amplitude equivalent to 80 G peak acceleration for T5-1/2 and larger tubes, and 40 G peak acceleration, for directly heated filamentary T5-1/2 tubes intended for dry-battery operation, and for tubes smaller than the T5-1/2 bulb size.
- d. The tapper impulse shall be measured with a Gulton model A-305 accelerometer, or equivalent, mounted in a standard production type (replaceable cap and clips) T5-1/2 socket and having no other support. For this measurement, the TUT shall be removed from the socket and the test accelerometer shall be inserted. The tap blow shall be delivered to the accelerometer at the approximate midpoint and in a direction parallel to the plane of maximum sensitivity of the accelerometer. The output of the accelerometer shall be coupled through a cathode follower and low-pass filter-amplifier combination to a suitable calibrated oscilloscope. The low-pass filter shall have a minimum high frequency cutoff at 5,000 Hz. (The Gulton KA-1 test set on 5 kHz filter position possesses appropriate characteristics.)

2.2.1 **Reliable tube types.** If a short indication is obtained at any time during the tapping procedure, the tube shall be rejected as inoperative.

MIL-STD-1311D

2.2.2 Types other than reliable. If a short indication is obtained, the tapping cycle shall be repeated two more times. If a short indication is again obtained, the tubes shall be rejected as inoperable.

2.2.3 Filamentary types intended for dry-battery operation. The tube shall be tested for shorts between any elements, base pins having no connections and internal shields. A short circuit shall be 50,000 ohms or less regardless of duration. A minimum voltage of 20 V dc or peak ac shall be applied between adjacent elements.

2.3 Tapping procedure for other than receiving. The tubes shall be mounted in the socket of the short test equipment and tapped three times on each of two planes 90 degrees apart. Sharp blows shall be delivered with a mallet consisting of a .125 inch (3.18 mm) diameter fiber rod inserted and glued into the small end of a No. 8 high quality cork 1.062 inches (26.97 mm) long and having a large diameter of .875 inch (22.22 mm) and a small diameter of .688 inch (17.47 mm). The overall length of rod and cork shall be 6 inches (152.4 mm).

3. Air leaks. Tubes shall be tested for air leaks as specified in method 1267.

4. Short and discontinuity detection (for power and transmitting tubes). A hexaphase short and discontinuity system may be used as an alternate test.

MIL-STD-1311D

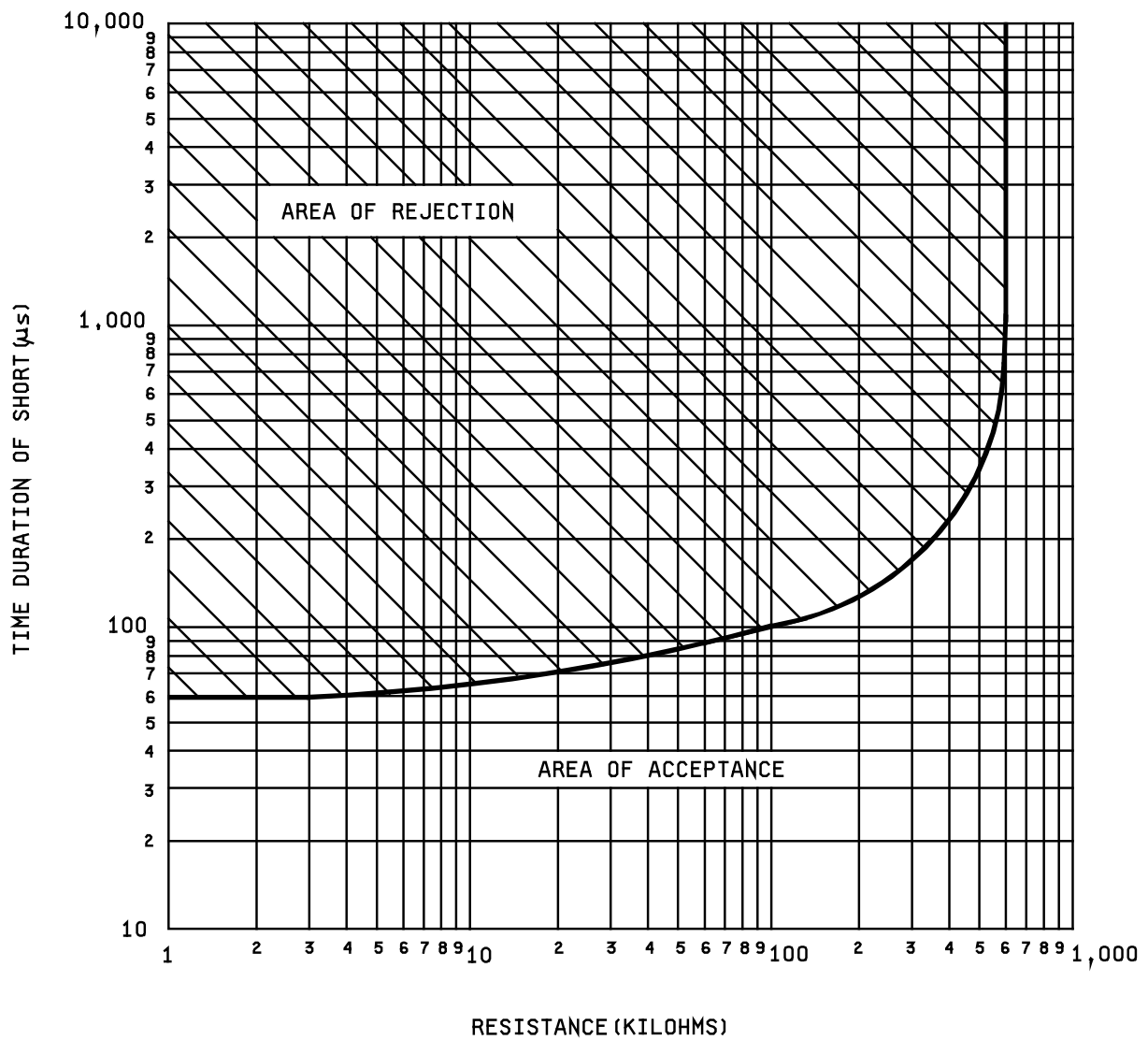


FIGURE 1201-1. Resistance versus time duration.

MIL-STD-1311D

METHOD 1202

FILAMENT BURNOUT

1. Purpose. The purpose of this test is to ensure that the filament suspension is designed such that when the filament opens, no permanent short circuit occurs between the filament and any element carrying anode voltage.
2. Procedure. Raise the Ef until the filament opens. Test for shorts from the filament to elements carrying B+ voltage.
3. Acceptance criteria. If a short circuit is indicated and passes a current in excess of five times the rated filament current without burning out the short circuit, the tube will be deemed a failure.

NOTE: This test is normally carried out during qualification approval testing only.

4. This is a destructive test.

MIL-STD-1311D

METHOD 1206

PARTICLES INDICATOR

1. Purpose. This test is conducted to detect shorts caused by loose conducting particles within the tube envelope.
2. Apparatus.
  - a. Short testing equipment with sensitivity as specified in method 1201.
  - b. Accelerometer: Gulton model A-305, or equivalent.
  - c. A device suitable for mounting and rotating the tube in the required positions.
3. Procedure. Subject each sample to one test cycle.
  - a. Preheat at rated Ef and test with the heater energized.
  - b. Throughout the following movements, tap 12 times (25 G, average blow, 300  $\mu$ s minimum time duration).
    - (1) With the tube vertical, rotate the major axis through a vertical plane to an inverted position and return.
    - (2) Rotate the tube about its major axis for a minimum of 180 degrees and return (if not simultaneous with motion (1) above, the major axis shall be horizontal.)
4. Acceptance criteria. Any indication of a short during the test cycle shall be classified a major 2 defect.



## MIL-STD-1311D

## METHOD 1211

## INSULATION OF ELECTRODES

Test each control grid to all other elements tied and test each anode to all other elements tied. In the test set, the center tap or one side of the filament transformer shall be tied to the positive bus. When testing multisection tubes, all elements of sections not under test shall be connected to the positive bus. The value of the insulation resistance, measured with the applied potential specified in 1, 2, 3, and 4 below as applicable, shall be not less than 100 megohms for reliable tubes and not less than 10 megohms for all other receiving tubes. This test shall be performed with the filament energized immediately after the other specified electrical tests are concluded or immediately following a minimum pre-heating time of 5 minutes.

1. Receiving tubes with a maximum anode potential rating greater than 330 V dc. Receiving tubes with maximum anode potential rating greater than 330 V dc, or rectifiers whose maximum rms test voltage per anode exceeds 300 V ac, shall be tested with a negative potential of at least 500 V dc when measuring insulation resistance from anode to all other elements tied. The applied potential shall be not less than -300 V dc when measuring resistance from each control grid to all other elements tied.
2. Receiving tubes with maximum anode potential rating of 330 V dc or less. Receiving tubes with a maximum anode potential rating equal to or less than 330 V dc, except those intended for dry-battery operation, or rectifiers whose maximum rms test voltage per anode is less than 300 V ac, shall be tested with a negative potential of at least 300 V dc when measuring insulation resistance from anode to all other elements tied; however, the applied potential shall be a negative voltage of at least 100 V dc when measuring insulation resistance from each control grid to all other elements tied.
3. Receiving tubes intended for dry-battery operation. Receiving tubes intended for dry-battery operation shall be tested with a negative potential of 100 V dc.
4. For tubes other than receiving, the value of insulation resistance and the applicable voltages shall be specified on the TSS.

## MIL-STD-1311D

## METHOD 1216A

## BASE MATERIAL INSULATING QUALITY

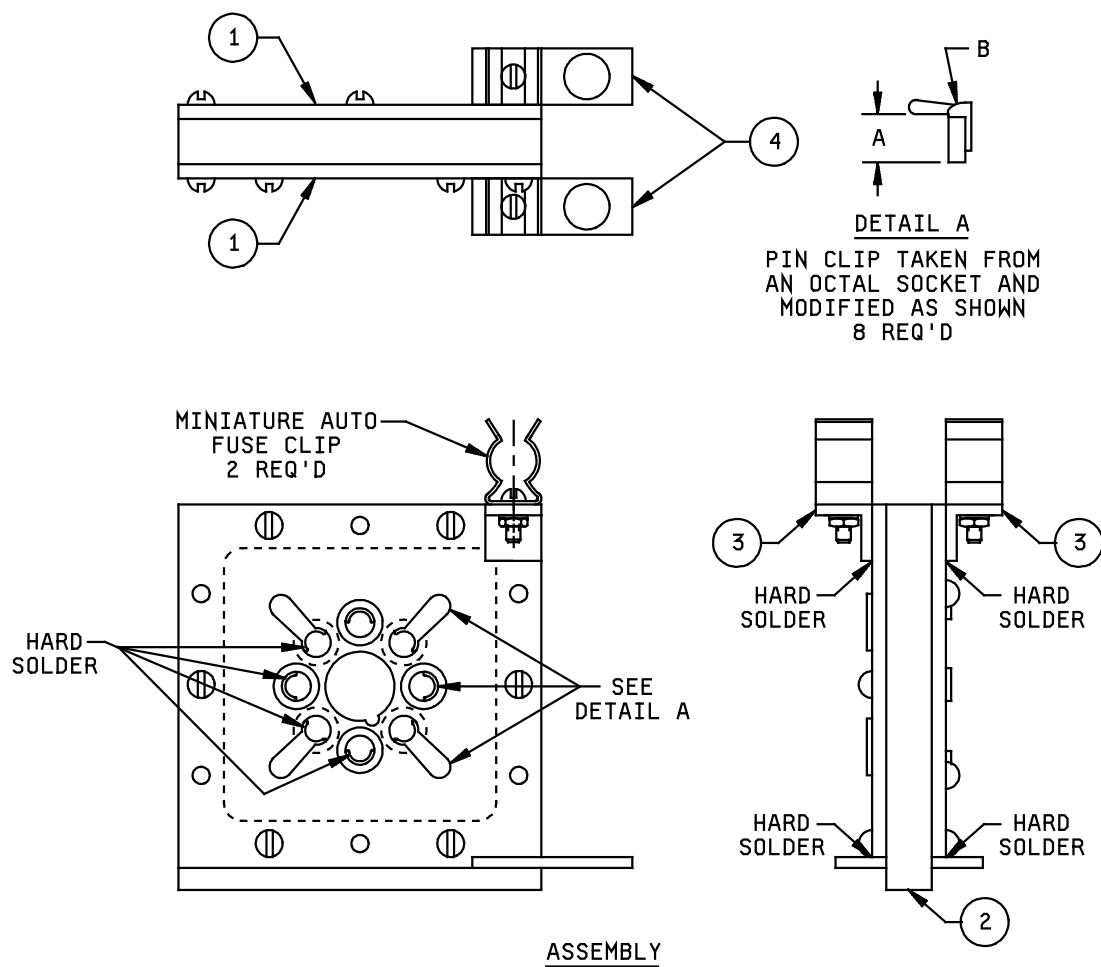
1. Purpose. This test is conducted to classify the insulating quality of base material.
2. Apparatus.
  - a. 100 MHz Q meter; Boonton 190A, or equivalent, with external coil. This coil shall be so constructed that with it and the empty adapter connected to the Q meter (see procedure) it will have a minimum Q of 250 at 100 MHz and the Q meter will have sufficient range to retune to 100 MHz with a base inserted into the adapter.
  - b. Base adapter (figure 1216-1).
  - c. Distilled water bath.
  - d. Eight pin octal bases molded from the base material being classified and with the pin and index guide dimensional limits of group 1 of EIA-209-A.
  - e. Noninductive calibrating resistors; International Resistor Company Type F metallized high frequency resistors, or equivalent.
3. Procedure.
  - a. Immerse the base in a 50°C minimum distilled water bath.
  - b. After 48 hours immersion, remove base from bath and dry with a 2 to 5-minute air blast.
  - c. Attach the base adapter to the C terminals of the Q meter by means of the terminals composed of the two parts No. 4 of figure 1216-1 and attach the external coil to the L terminals of the Q meter. Odd numbered pins of base adapter shall be connected to one C terminal, even numbered pins connected to the other C terminal.
  - d. Insert the base under test into the adapter and tune to 100 MHz noting the resulting meter reading. Next, remove the base from the adapter and insert several calibrating resistors into the fuse clips, one at a time, and note the meter reading for each when tuned to 100 MHz. From this series of readings, a curve of resistance versus Q is drawn from which the equivalent resistance of the base may be determined.
4. Resultant measurement.
  - a. The following tabulation specifies appropriate zone number for various resistance ranges:

<u>Resistance range (ohms)</u>	<u>Zone No.</u>
0 to 5,500 .....	1
Over 5,500 to 8,500 .....	2
Over 8,500 to 10,000 .....	3
Over 10,000 to 12,500 .....	4
Over 12,500 to 15,000 .....	5
Over 15,000 to 20,000 .....	6
Over 20,000 to 25,000 .....	7
Over 25,000 to 32,000 .....	8
Over 32,000 to 40,000 .....	9
Over 40,000 to 50,000 .....	10
Over 50,000 to 75,000 .....	11
Over 75,000 to 100,000 .....	12
Over 100,000 to 150,000 .....	13
Over 150,000 to 250,000 .....	14
Over 250,000 .....	15

## MIL-STD-1311D

- b. The base material shall have a zone equal to or greater than that specified on the TSS. If no zone number is specified, the following shall apply for the materials indicated:

<u>Base material</u>	<u>Zone No.</u>
Ceramic .....	13 or higher
Low-loss phenolic .....	11 or higher
Plastic or other bases.....	5 or higher

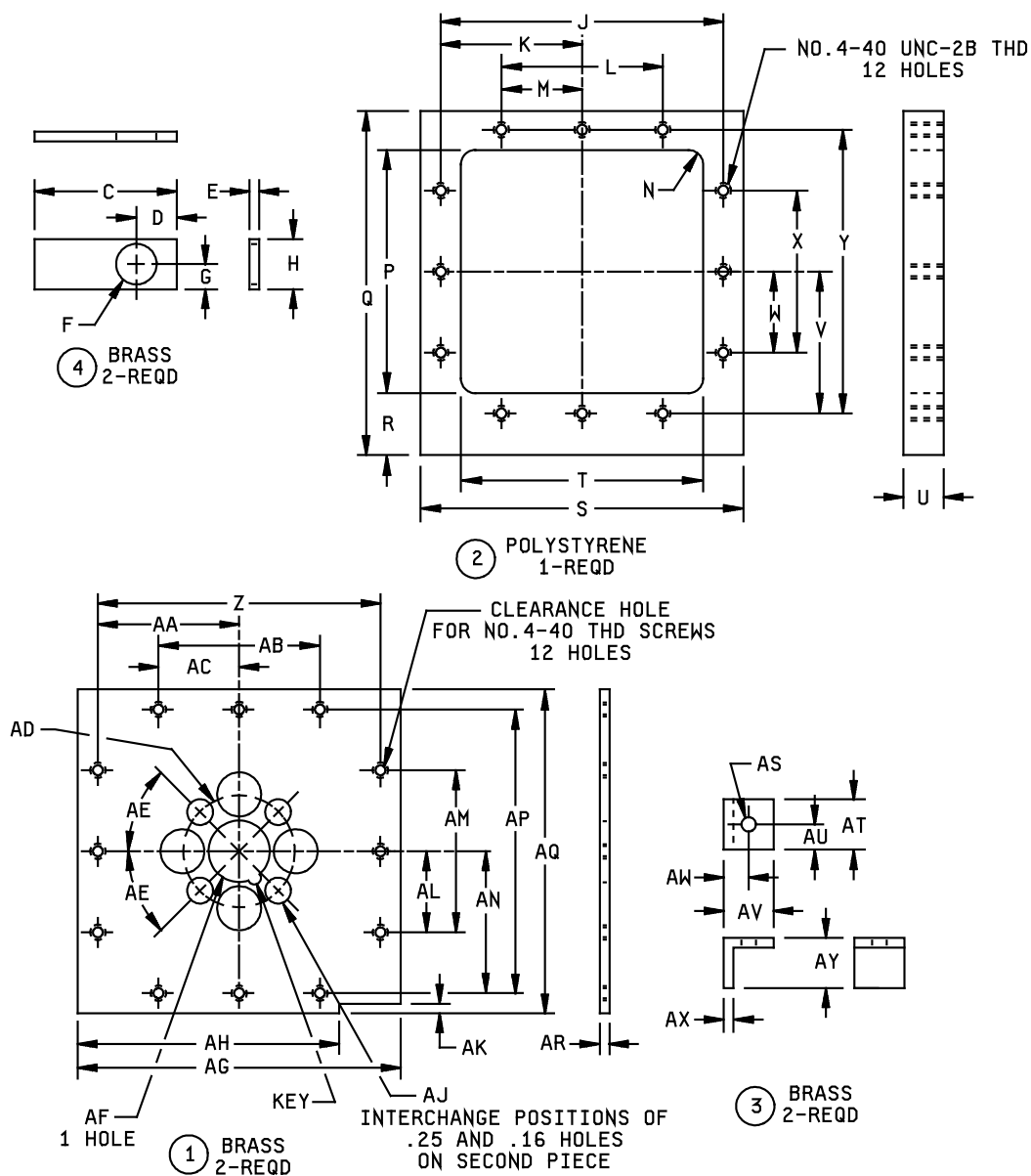


## NOTES:

1. Dimensions are in inches.
2. Unless otherwise specified, tolerances are  $\pm .02$  and  $\pm .5^\circ$  on angles.
3. Dimension B represents maximum diameter.

FIGURE 1216-1. Adapter for octal tube bases.

MIL-STD-1311D



## NOTES:

1. Dimensions are in inches.
2. Unless otherwise specified, tolerances are  $\pm .02$  and  $\pm .5^\circ$  on angles.

FIGURE 1216-1. Adapter for octal tube bases - Continued.

## MIL-STD-1311D

Ltr	Dimensions			
	Inches		Millimeters	
	Min	Max	Min	Max
A	.36	.40	9.1	10.2
B	.14	.18	3.6	4.6
C	.86	.90	21.8	22.9
D	.23	.27	5.8	6.9
E	.04	.08	1.0	2.0
F	.23 DIA	.27 DIA	5.84 DIA	6.86 DIA
G	.15	.19	3.8	4.8
H	.29	.33	7.4	8.4
J	1.73	1.77	43.9	45.0
K	.86	.90	21.8	22.9
L	.98	1.02	24.9	25.9
M	.48	.52	12.2	13.2
N	.07 R	.11 R	1.8 R	2.8 R
P	1.48	1.52	37.6	38.6
Q	2.10	2.14	53.3	54.4
R	.36	.40	9.1	10.2
S	1.98	2.02	50.3	51.3
T	1.48	1.52	37.6	38.6
U	.23	.27	5.8	6.9
V	.86	.90	21.8	22.9
W	.48	.52	12.2	13.2
X	.98	1.02	24.9	25.9
Y	1.73	1.77	43.9	45.0
Z	1.73	1.77	43.9	45.0

Ltr	Dimensions			
	Inches		Millimeters	
	Min	Max	Min	Max
AA	.86	.90	21.8	22.9
AB	.98	1.02	24.9	25.9
AC	.48	.52	12.2	13.2
AD	.67	.71	17.0	18.0
AE	44°30'	45°30'	44°30'	45°30'
AF	.36 DIA	.40 DIA	9.1 DIA	10.2 DIA
AG	1.98	2.02	50.3	51.3
AH	1.60	1.64	40.6	41.7
AJ	.14 DIA	.18 DIA	3.6 DIA	4.6 DIA
AK	.04	.08	1.0	2.0
AL	.48	.52	12.2	13.2
AM	.98	1.02	24.9	25.9
AN	.86	.90	21.8	22.9
AP	1.73	1.77	24.9	25.9
AQ	1.98	2.02	50.3	51.3
AR	.04	.08	1.0	2.0
AS	.07 DIA	.11 DIA	1.8 DIA	2.8 DIA
AT	.29	.33	7.4	8.4
AU	.14	.18	3.6	4.6
AV	.29	.33	7.4	8.4
AW	.14	.18	3.6	4.6
AX	.04	.08	1.0	2.0
AY	.29	.33	7.4	8.4

## NOTES:

1. Dimensions are in inches.
2. Unless otherwise specified, tolerances are  $\pm .02$  and  $\pm .5^\circ$  on angles.

FIGURE 1216-1. Adapter for octal tube bases - Continued.

## MIL-STD-1311D

## METHOD 1226

## ENVELOPE TEMPERATURE

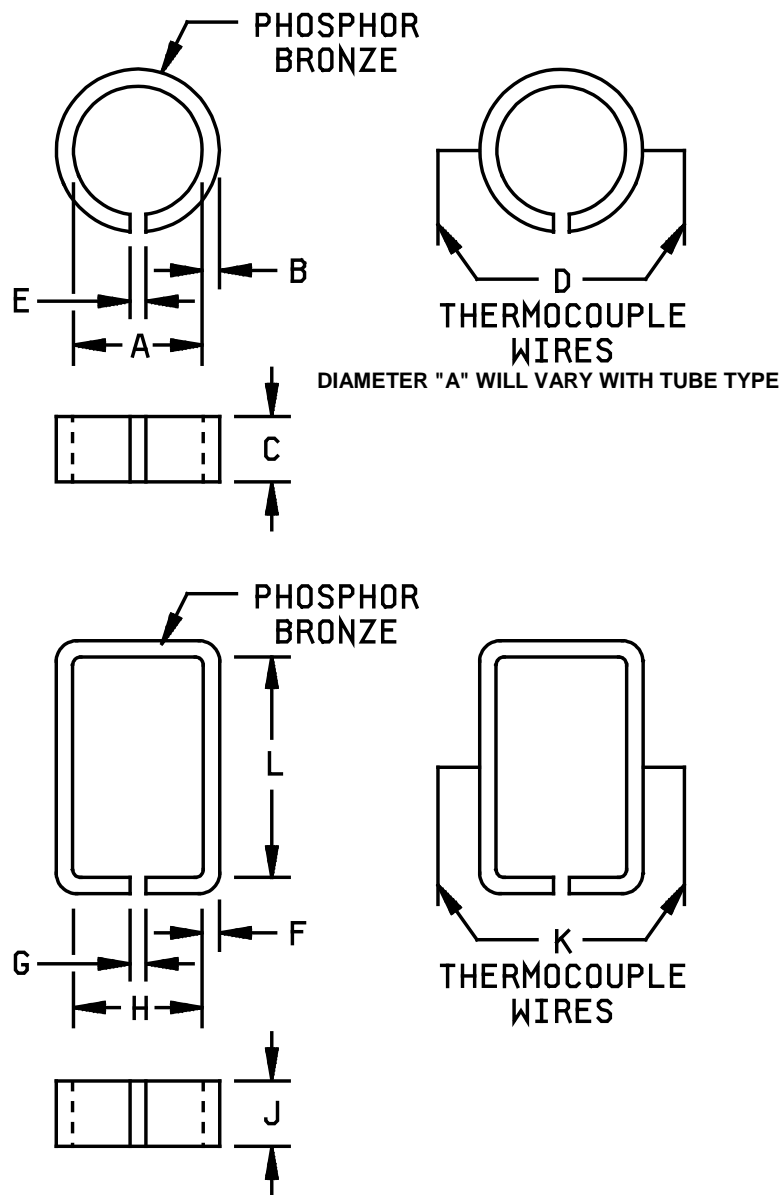
When a measurement of envelope temperature is required, the hot spot shall be located as specified in 1 below, and the temperature measured as specified in either 2 or 3 below. The method to be used shall be specified on the TSS. When the use of thermocouples is not practical because of high voltage or stray rf power, a temperature-sensitive paint or lacquer may be used.

1. Hot-spot location. For each tube type the hottest point on the tube envelope shall be determined using a temperature lacquer (Tempilaq, or equivalent) with melting point not more than 5°C less than the maximum permissible bulb temperature for the type. The tube shall be placed in an oven, and with the specified test conditions applied, the oven temperature shall be raised until the lacquer just begins to melt locally. The central point of the melted area shall be taken as the location of the hottest point.

2. Temperature by loop-thermocouple measurement. A length of wire, type 304, or 302, spring temper, corrosion-resistant steel, .004 inch diameter approximately equal to the perimeter of the tube envelope at its hottest point shall be formed into a loop by spot welding the ends together. At approximately 25 percent the length of the loop from the weld, a V-shaped kink shall be made at right angles to the plane of the loop to insure spring-tightness of the loop on the envelope at approximately 50 percent the length of the loop from the kink, the junction of a No. 40 B and S or equivalent, gauge thermocouple of chromel and alumel shall be spot-welded to the inside of the loop. The junction of the thermocouple shall be calibrated to within  $\pm 0.5^\circ\text{C}$ . The loop thermocouple shall be placed on the tube envelope so that the junction is in direct contact with the hottest point. (See 1 above.) The tube with the thermocouple in position shall be placed in the oven. The cold junctions of the oven thermocouple and the loop thermocouple shall be immersed in a melting ice bath, or a cold junction compensated potentiometer may be used provided the necessary accuracy is obtained. All voltages shall be read with a potentiometer with a sensitivity of at least 0.02 millivolt (or  $0.5^\circ\text{C}$ , if direct reading).

3. Temperature by conduction-band measurements. Envelope temperature measurements shall be made by use of thermocouple wires welded to opposite sides of a split phosphor bronze ring in good thermal contact with the envelope. The dimensions of the ring shall be as shown on figure 1226-1, or such that equivalent envelope contact is made. Unless otherwise specified, the ring shall be located at the hottest spot on the envelope (see 1 above).

MIL-STD-1311D



Ltr	Dimensions			
	Inches		Millimeters	
	Min	Max	Min	Max
B	.015	.025	0.38	0.64
C	.095	.105	2.41	2.67
E	.010	.020	0.25	0.51
F	.015	.025	0.38	0.64
G	.010	.020	0.25	0.51
H	.240	.250	6.10	6.35
J	.095	.105	2.41	2.67
L	.370	.380	9.40	9.65
Reference				
D	.002		0.05	
K	.002		0.05	

## NOTES:

1. Dimensions are in inches.
2. Unless otherwise specified, tolerance is  $\pm .005$ .

FIGURE 1226-1. Typical conduction band temperature measurement rings.

MIL-STD-1311D

METHOD 1227

TEMPERATURE/COOLING

(Forced-air or fluid-cooled types)

1. General. When applicable, the following conditions shall be as specified in the TSS:

- a. Applied electrode voltages and wattage to be dissipated by the various elements. If dc potentials are specified, the maximum rms ripple shall not exceed 5 percent unless a wattmeter is used to measure anode-input power. If ac potentials are specified, a low-power factor wattmeter shall be used. Instrument burden, transformer and circuit losses shall be compensated for if such losses exceed 3 percent of the anode power specified.
- b. Coolant type(s), flow (volume and velocity), direction(s) of flow, area and method of application, limit(s) of incoming temperature, system pressure (if other than atmospheric), supplemental cooling (if required for proper operation).
- c. Appropriate meters, indicators and methods of measurement.
- d. Accessories such as air socket or distributor, water (or fluid) jacket, auxiliary radiators (terminals, etc), and air directors or reflectors. When relevant, manufacturer's part number, catalog number, etc., for commercially available components shall be specified or complete detail drawings shown.

2. Procedure.

- a. Temperature rise. With no voltages applied and with coolant system(s) operating at TSS conditions, observe the temperature ( $T_{\text{initial}}$ ) at the specified location. Then, apply specified electrode voltages and adjust to obtain power dissipation to the electrodes. After sufficient time to establish thermal equilibrium observe the temperature ( $T_{\text{final}}$ ) at the same location as noted for  $T_{\text{initial}}$ . The temperature rise,  $\Delta T$ , shall be within TSS limit(s). Formula:  $\Delta T = T_{\text{final}} - T_{\text{initial}}$ .
- b. "Hot-Spot" temperature. With specified electron voltages applied, and with specified power dissipation to the electrodes, the "hot-spot" temperature shall be observed after thermal equilibrium has been reached and shall be less than the maximum TSS limit.



## MIL-STD-1311D

## METHOD 1231A

## EMISSION CURRENT

1. Emission. To avoid damaging the TUT, the emission voltage shall be applied only for sufficient time to permit the emission to reach the specified minimum value. The duration of the test shall not exceed 5 seconds. When only a minimum current limit is specified, a voltage less than the value specified may be applied provided the required minimum emission current is thus obtained. In qualification testing of receiving tubes, when only a minimum current limit is specified, the test shall be performed by increasing the applied voltage until the specified minimum emission current is obtained and reading the voltage drop across the TUT.

1.1 Emission at reduced filament voltage. If an emission-current test is specified at reduced filament voltage, this test shall be performed prior to the emission-current test at rated filament voltage. Operate the tube with 90 percent of rated filament voltage only applied. After allowing the cathode temperature to stabilize, apply the emission voltage in the manner specified in 1 above.

1.2 Emission at rated filament voltage. Operate the tube with rated filament voltage only applied. After allowing the cathode temperature to stabilize, apply the emission voltage in the manner specified in 1 above.

2. Peak emission by voltage drop. The tube shall be tested with the specified voltage applied to the filament or heater, with a 60 Hz anode supply sufficient to start the tube and sufficient series resistance to limit the anode current to the specified maximum current (ib) value per anode. A suitable circuit designed to permit the conduction of the specified peak current for one or two approximate half-cycles per second shall be provided. The slow pulse repetition is employed to prevent excessive reduction of the tube voltage drop due to cathode heating during conduction. The peak voltage drop, exclusive of the starting voltage measured from an anode to the reference point as shown on a cathode-ray oscilloscope, or by other suitable means, shall be within the limit(s) specified.

3. Peak emission. The filament or heater potential shall be applied and the grid or grids, if present, shall be connected to the anode. A suitable capacitor shall be discharged through the tube and a load resistor. The peak current shall be measured by an oscilloscope suitably calibrated. An equivalent method may be used. Pulses shall be applied in such a manner that the tube will not be damaged. The peak current shall be within the limit(s) specified and there shall be no evidence of sparking during the test.

4. Emission by oscillation. At the end of the power-oscillation test, the filament potential shall be reduced until the rf power output has been reduced 10 percent, at which point the filament potential shall not exceed the value specified; or the filament potential shall be adjusted to the limit value specified, at which point the power output shall be not less than 90 percent of the initial value.

5. Pulsing emission. Either of the following test methods may be used to accomplish pulsing emission testing. Previous TSS's that specify pulsing emission or pulsing emission sinusoid may now be interpreted to include either of the a and b options below:

- a. Square wave. The tube shall be operated at the electrode potentials specified. Where pulse voltages are indicated, the pulse duration shall be not less than 2 nor greater than 10  $\mu$ s. Time of rise shall be not greater than 10 percent of the pulse duration and time constant of fall not greater than 20 percent of the pulse duration. The duty shall be not less than 0.001. Variations in 80 percent of the top portion of the pulse shall not exceed  $\pm 5$  percent of the maximum amplitude and no portion shall fall below the maximum amplitude by more than 10 percent. There shall be no sign of arcing during the latter half of the test and the average peak anode current shall be within the limit(s) specified.
- b. Sinusoidal. The tube shall be operated as a diode at the electrode potentials and conditions specified on the TSS. Apply a nominal 50 percent sinusoidal pulse source which meets the following requirements: Pulse duration (tp) = 2  $\mu$ s minimum, 10  $\mu$ s maximum, at the base line of the pulse; pulse repetition rate (prf) shall be not less than 20 pulses per second. There shall be no sign of arcing during the latter half of the test. Excluding any spike, the peak diode current, or peak tube drop (whichever is specified), shall meet the specified limit(s) at the required peak pulse value, when a stabilized reading is obtained up to a maximum of 1 minute.

6. Thyratron or gas-rectifier emission. The tube shall conduct pulses at a recurrent rate of not less than 1 nor more than 60 pulses per second. The duration of the pulses shall be such that the current flows not less than 0.5 nor more than 2.0 percent of the time. The pulse width in no case shall be less than 150  $\mu$ s. The shape of these pulses shall be such that the current rises smoothly and continuously to its peak value near the middle of the pulse. The grid or grids, if any, shall be connected as specified. With the filamentary types, connection to the filament circuit shall be made to the midpoint of the filament transformer. Variations in the tube voltage drop at current values below the peak current specified shall be ignored. There shall be no evidence of sparking of the filament (or cathode) during the test, and the peak voltage drop shall be within the limit(s) specified.

## MIL-STD-1311D

7. Emission oscillation. This test shall be made with the tube operating under the oscillation-test conditions after the power-oscillation test. The filament potential shall be changed as specified and the change in power output or cathode current shall be within the limit(s) specified.

8. Pulse emission. The tube shall be tested for pulse emission in the circuit shown on figure 1231-1. A resistor shall be substituted for the TUT for calibration purposes.  $R_a$ ,  $R_p$ , and the calibrating resistor (as shown on figure 1231-1) shall be within  $\pm 5$  percent of that specified on the TSS and shall be noninductive. The control grid, and the screen grid when present, shall be tied directly to the anode. The calibrated pulse voltage amplitude shall be within the value specified over 80 percent of the top portion of the pulse and shall not vary from this value by more than 5 percent. The modulator impedance shall be as specified on the TSS. The pulse voltage characteristics shall be  $t_p = 5.0 \pm 0.25 \mu s$ ;  $t_r = 0.5 \mu s$  maximum;  $t_f = 1.0 \mu s$  maximum. The pulse emission shall be within the limit(s) specified on the TSS.

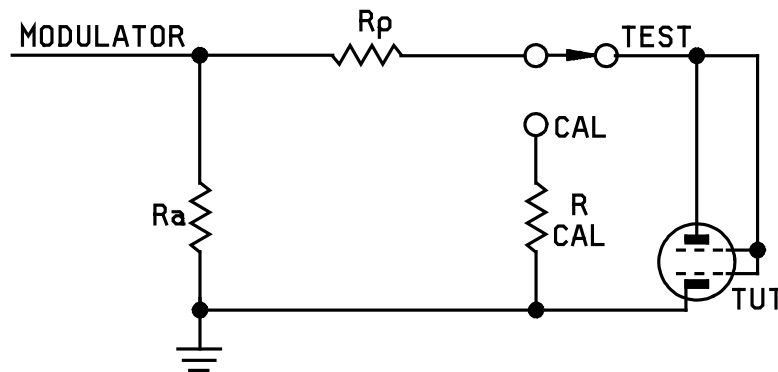


FIGURE 1231-1. Circuit for testing pulse emission.

## MIL-STD-1311D

## METHOD 1236A

## POWER OSCILLATION AND INTERNAL INSULATION

1. Power oscillation.

1.1 Purpose. To measure the radio frequency power output (whether it be useful or tube power output) flowing from the output of the tube or into a dissipative load. This method is for measurement over the frequency range up to but not including 225 MHz.

1.2 Definitions.

- a. Useful power output. Self-excited oscillator, amplifier and their push-pull equivalents; the useful power output shall be interpreted to be the power delivered to the load.
- b. Tube power output. In those cases where useful power output is not specifically defined in the test limit or a related note, then the test limit is total rf power output of the tube.
- c. Push-pull operation. The current and power requirements specified in the TSS are on a per-tube basis and the tubes should share the load equally.
- d. Each tube shall be so tested that the load circuit is adjusted for not more than the specified anode current and the grid excitation is adjusted until the dc grid current is within 20 percent of the value specified.
- e. A resistor of the specified value ( $\pm 10$  percent) shall be connected in the dc grid circuit or the specified bias voltage shall be applied or a combination.

1.3 General.

- a. When the frequency of operation is not specified, the TUT can be operated at any frequency.
- b. When the frequency is specified, the test frequency shall not be lower than that value, but may be higher.

1.4 Type of operation. Any one or more of the following procedures may be used to test the TUT(s):

- a. Procedure A: Self-excited oscillator.
- b. Procedure B: Separately excited amplifier.
- c. Procedure C: Push-pull self-excited oscillator.
- d. Procedure D: Push-pull separately excited amplifier.

1.5 Specified TSS test conditions:

- a. Electrode voltages.
- b. Electrode currents or ranges of current.
- c. Frequency of operation.
- d. Value of grid resistor.
- e. Driving power if required (if no wattmeter exists, the grid or cathode current and a specified grid or cathode resistor, respectively, can be used as the driving condition).

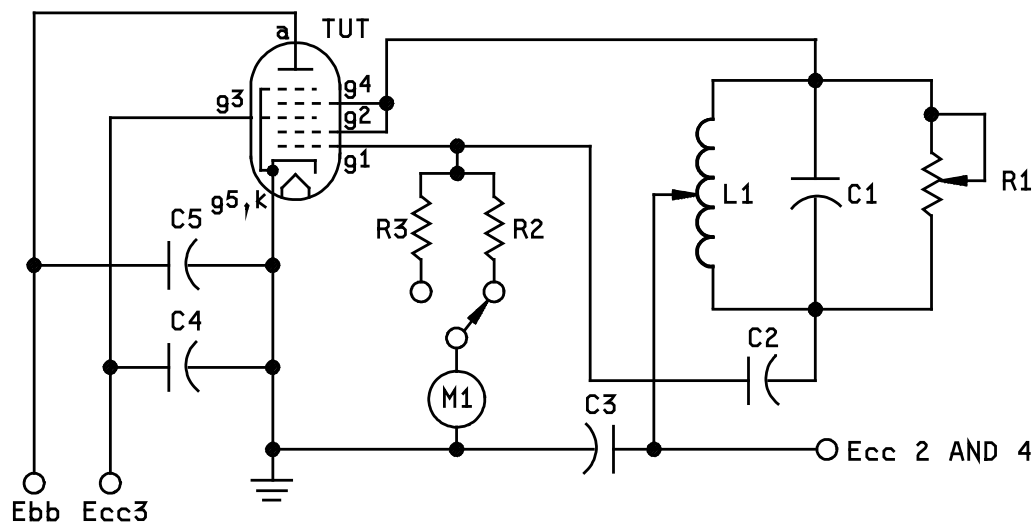
2. Internal insulation (when specified on the individual TSS). At the conclusion of the power-oscillation test of the highest frequency specified on the TSS and with operation at approximately the same frequency, the anode voltage shall be increased 10 percent and the circuit readjusted to obtain the same anode input. The grid drive may be reduced but the power output shall be not less than that specified for the referenced oscillation test. The tube shall then be operated for 1 hour under the above conditions. During this period, the insulating material used within the tube should not become overheated as indicated by reddening, nor shall any electrical breakdown occur within or upon the surface of such insulation. At the end of this test, the emission and power output shall be within the limit(s) specified for the referenced oscillation test.

## MIL-STD-1311D

## METHOD 1237A

## OSCILLATION TEST FOR CONVERTER TUBES

1. Purpose. To determine the capabilities of a converter tube to oscillate.
  2. Oscillator grid current. Oscillator performance shall be measured according to the circuit shown on figure 1237-1. The specified voltages shall be applied to all elements through the specified circuit impedances. Oscillator performance shall be determined by the value of grid current for the specified resonant tuned impedance as obtained by the adjustment of R1.
- 2.1 The oscillator grid current test described herein and with the circuit components shown on figure 1237-1 is not usable with tuned impedances below 1,000 ohms. The low impedances may result in oscillation under spurious conditions. Tube types with relatively high-transconductance levels which result in tuned impedance below 1,000 ohms should not be subjected to this test. Oscillator performance should be evaluated by another method.



C1 - 100 pF  
 C2 - 200 pF  
 C3 - 0.1  $\mu$ F  
 C4 - 0.1  $\mu$ F  
 C5 - 0.1  $\mu$ F

R1 - 50,000 ohm  
 potentiometer  
 R2 - 20,000 ohm  $\pm$  1 percent (wire  
 R2 - 50,000 ohm  $\pm$  1 percent (wire  
 M1 - Grid current meter

L1 - 23.3  $\mu$ H  
 Coil diameter - 1.25 inch  
 Winding length - 0.992 inch  
 Wire - No. 30 enamel copper  
 Turns - 83  
 Tap - 33 turns from anode end

FIGURE 1237-1. Converter tube test oscillator circuit.

## MIL-STD-1311D

## METHOD 1239

## NOISE AND MICROPHONICS, PEAK OR INTEGRATED

A TSS may specify noise and microphonics, peak, or noise and microphonics, integrated, or both tests. However, the integrated test alone gives good agreement with swept frequency vibration noise output and with the applications studied. The peak test should be an unusual requirement.

1. Mounting. The TUT shall be mounted in the test socket and tapped at least 2 times in each of two planes  $90^\circ \pm 10^\circ$  apart. During tapping, the tube shall be supported only by the socket and light finger or soft cushioned mechanical pressure on the dome of the bulb. The finger or mechanical pressure on the dome of the bulb shall be used only when necessary to prevent the tube from coming out of the socket and shall be so applied that it offers negligible restraint to lateral motion at the top of the bulb. The tap blows shall be delivered to the tube approximately two-thirds up on the holddown height.

1.1 Tapper impulse. The tapping device shall be so designed and adjusted that it will deliver an impulse of approximately one-half sine wave of  $300 \pm 50$  microseconds duration, as measured 10 percent from the base of the impulse and having an amplitude equivalent to  $45 \pm 5$  G peak acceleration as measured on a Gulton Manufacturing Company Type A-305 accelerometer, or equivalent. The tapper impulse shall be measured with the accelerometer mounted in a standard production type (replaceable cap and clips) T5-1/2 socket and having no other support. The tap blow shall be delivered to the accelerometer in the plane of its maximum sensitivity. The output of the accelerometer shall be coupled through a cathode follower and low-pass filter to an oscilloscope having amplitude and time base calibration. The frequency response of the filter shall not be down more than 3 dB at 5,000 Hz. The tapper calibration using a T5-1/2 accelerometer applies regardless of the size of the tube to be tested. On tapping devices, where the hammers are accelerating just before impact, the hammer travel distance must be the same during testing as it was during calibration. On devices where the hammers approach the tube at essentially constant linear or angular velocity, the travel distance need not be controlled.

1.2 Test limits. The test limit(s) shall apply to the response of the output indicators to the voltage developed by the TUT across a load resistor  $R_p$  in response to the mechanical excitation (see figure 1239-1). Peak and integrated audio frequency noise and microphonics tests may be performed simultaneously.

1.3 Anode voltage. The value of  $E_b$  under "test conditions" shall be regarded as  $E_{bb}$  for this test. Cathode and screen bypass capacitors, when specified, shall be regarded as minimum nominal values.

1.4 Anode circuit decoupling/screen voltage-dividing network. The anode-circuit decoupling network is permitted if its resistance is less than 10 percent of  $R_p$  and its series impedance is greater than the reactance of its bypass capacitor at 10 Hz. A screen voltage-dividing network is permitted if the bleeder current is at least 10 times the operating screen current and if the screen is bypassed by a capacitor whose reactance at 10 Hz is less than 10 percent of the effective resistance of the two sections of the divider in parallel.

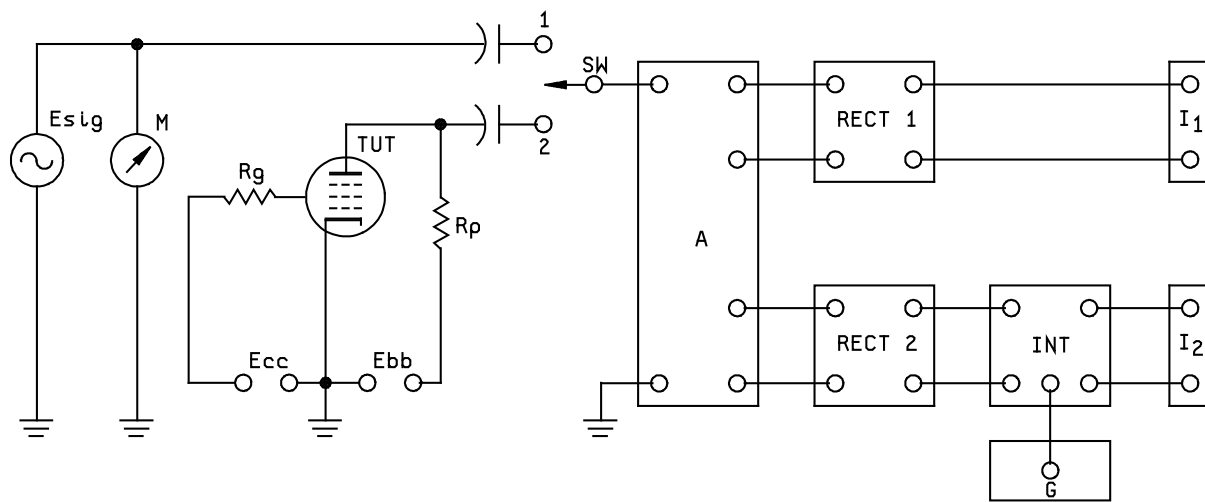
2. Noise and microphonics, peak. Test equipment and procedures specified in 1 above, shall apply. The indicating system shall respond to the absolute peak value (peak positive or negative value, whichever is larger) of noise output voltage of the TUT resulting from each tap blow. The system shall indicate, within  $\pm 20$  percent, the peak value of sinusoidal voltage of all frequencies between 100 and 15,000 Hz. It shall indicate, within  $\pm 20$  percent, the peak voltage of a single 20  $\mu$ s square pulse.

3. Noise and microphonics, integrated. Test equipment and procedures specified in 1 above, shall apply. The indicating system shall measure the integral of the absolute value of noise output voltage of the TUT during a period,  $t$ , following each tap blow. The integrating period,  $t$ , shall be a minimum value and shall be specified.

3.1 Calibrating signal. A sine wave calibrating signal,  $E$  rms volts, applied to the anode pin of the test socket for a period,  $t$  milliseconds, should read 0.9 tE millivolt seconds (mVs). The indicating system shall be capable of measuring this quantity, to an accuracy of  $\pm 10$  percent at 5,000 Hz, at each of two signal voltage amplitudes, one of which is 100 times the voltage of the other, with a single gain setting of the system. The larger voltage shall be measured for a period of 1-millisecond minimum. The smaller voltage shall be measured for a period of 100 ms minimum. An oscilloscope may be connected to the indicator to show that integration is correct for the required periods.

3.2 Frequency response. The frequency response of the amplifier and rectifier portions of the system shall be within  $\pm 3$  dB of the response at 1,000 Hz over the frequency range from 100 to 15,000 Hz.

MIL-STD-1311D



A	Audio amplifier	INT	Integrator
G	Integrator timing gate	M	Voltmeter
Esig	5,000 Hz signal source	RECT <sub>1,2</sub>	Full-wave rectifiers
I <sub>1</sub>	Indicator, peak channel	SW	Transfer switch
I <sub>2</sub>	Indicator, integrated channel		1 - Calibrate 2 - Test

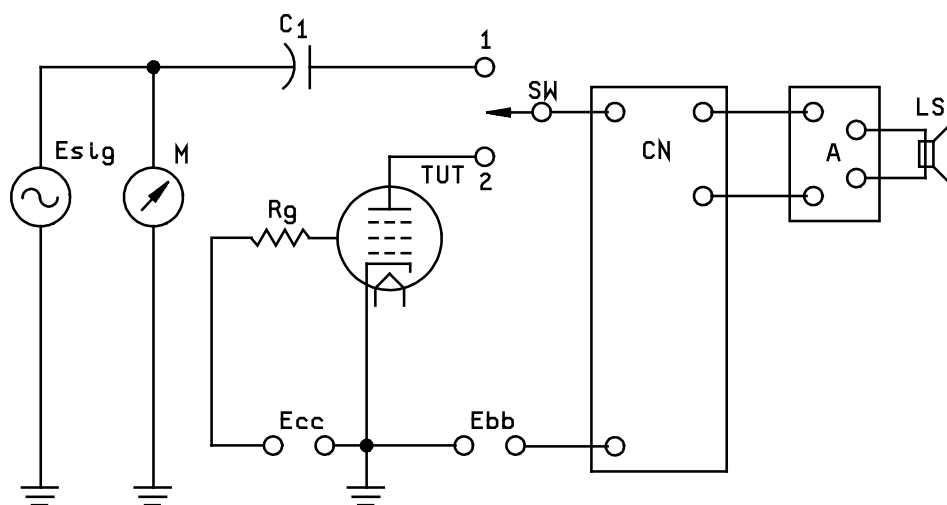
FIGURE 1239-1. Noise and microphonics, peak and integrated tests.

## MIL-STD-1311D

## METHOD 1246A

## AUDIO FREQUENCY NOISE

The anode of the TUT shall be coupled to the input of a power amplifier, the response of which shall be within  $\pm 5$  dB of the response at 400 Hz over the frequency range of 60 to 5,000 Hz. This power amplifier shall have an overload voltage characteristic of at least 10 to 1 with the specified calibrating signal used as the reference. The value of  $E_b$  under test conditions shall be regarded as  $E_{bb}$  for this test. A commercial dynamic loudspeaker (4 inch min) with a rating of at least 2.5 watts, properly coupled and excited, shall be used. The gain of the power amplifier (see figure 1246-1) shall be adjusted by removing the tube from the socket and introducing the specified calibrating voltage at 400 Hz into the anode circuit at the tube socket through a capacitor having an impedance of not more than 100 ohms at the calibrating frequency. Unless otherwise specified, the power amplifier gain shall be adjusted for 50 mW output. The signal and calibrating network shall be removed and the TUT inserted. The minimum external grid-circuit resistance for the TUT shall be 100,000 ohms and shall not be bypassed. The minimum external anode-circuit impedance shall be as specified. When operating under the above conditions, the tube shall be tapped at least three times in each of two directions which are at right angles to each other. The tube shall be tapped with a mallet or mechanical tapping device as specified in test method 1201. Tubes shall be rejected if any objectionable noise is heard in the loudspeaker that is caused by leakage, intermittent shorts, clicks, or any scratchy noise. Any electrical disturbance sufficiently large to interfere with proper operation of equipment is considered objectionable. Noise-indicating devices other than the loudspeaker and neon indicator are acceptable provided they give comparable results. When a meter deflection is specified, this reading shall be obtained by using a VU meter. Both the meter and the speaker shall be connected to the amplifier in such a manner that the meter indicates 50 mW when the speaker is receiving 50 mW of power from the amplifier. The tube shall be tapped with a mallet or mechanical tapping device as specified in test method 1201.



A - Audio amplifier	Esig - 400 Hz signal source	SW - Transfer switch
CN - Coupling network	LS - Loudspeaker	1 - Calibrate
CI - 4 $\mu$ F capacitor (min)	M - Voltmeter	2 - Test

FIGURE 1246-1. Audio frequency noise test.

## MIL-STD-1311D

## METHOD 1251A

## AUDIO FREQUENCY NOISE AND MICROPHONICS

The TUT shall have the specified operating potentials applied to all elements and shall be tested in an acoustic chamber constructed in accordance with Drawing 182-JAN, with a 7-inch or 8-inch-diameter speaker having a nominal free-air-cone-resonance of 70 Hz, or lower, and a power rating of 5 watts minimum mounted on the 11- by 18-inch closed end and facing inward, and the tube test socket mounted approximately 3 inches from the opposite open end. The top and sides of the acoustic chamber shall be free and clear of all material that might affect the acoustic characteristics. The anode of the TUT shall be coupled through a 0.1  $\mu$ F capacitor to an audio amplifier having an input resistance of approximately 100,000 ohms and a response characteristic between 60 and 5,000 Hz, flat within  $\pm 2.0$  dB of the 400-Hz response, with a resistor load substituted for the speaker. The power amplifier shall be capable of delivering 5 watts with less than 10 percent distortion. The speaker shall be coupled to the output of the amplifier so as to present rated load to the amplifier. The output indicator shall be a VU meter. The VU type meter with its attenuator shall be bridged across a suitable tap on the output of the amplifier. The VU meter may have the dial calibrated in electrical or arbitrary units, but the attenuator shall be designed to retain the ballistic characteristics specified for the VU meter. The calibrated points used for setting the amplifier gain shall be the rejection points and shall be determined for each test set on the basis of the power in the resistor load only. At 400 Hz and 50 mW, the resistor shall have been adjusted to the same impedance as the voice coil for which it is substituted. The amplifier gain shall be adjusted (without the tube in the test socket) to give the specified output with the specified calibration voltage at 400 Hz applied to the anode terminal of the tube-test socket. The calibrating voltage shall be removed and the TUT inserted (see figure 1251-1). When operating under the above conditions, no objectionable noise or microphonism shall be evident either with the tube at rest or when it is tapped at least three times in each of two directions which are at right angles to each other. The tube shall be tapped with a mallet or mechanical tapping device as specified in test method 1201. Objectionable noise or microphonism shall be defined as:

- a. Background noise, sustained microphonics, or oscillation over 2 second in duration having greater than .5 mW output power level.
- b. Clicks or scratchy noises of any sort.

NOTE: The ballistic deflection as indicated by the output meter shall not exceed the maximum output specified.

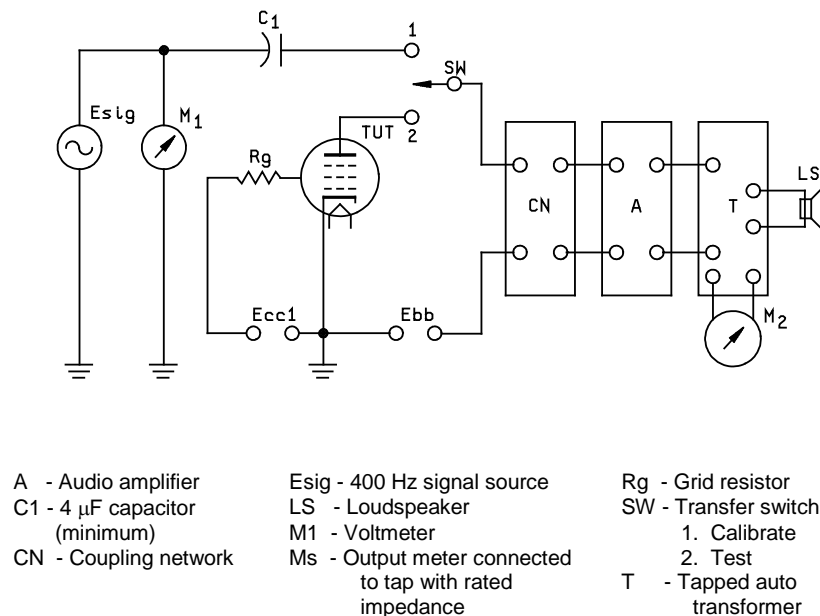


FIGURE 1251-1. Audio frequency noise and microphonics test.



MIL-STD-1311D

METHOD 1256

ELECTRODE CURRENT

1. Purpose. To measure the particular electrode current at the point in the circuit and in the manner specified.
2. Equipment. Suitable instruments as required for the measurement with precautions being observed to eliminate any pulse or rf current not intended to be included in the measurement.
3. Procedure.
  - a. Electrode current. With the specified voltages and currents applied, the current flowing to the electrode concerned shall be within the specified limit(s).
  - b. Tube operation time. Tube operation time is the time (t1) required for the anode current to reach a specified percentage of the anode current measured at the conclusion of a specified period of time (t2). The tube filament shall be energized instantaneously from a substantially zero impedance source. The tube shall have had no potentials applied for a period of at least 1 hour prior to the performance of this test. Tubes intended principally for use with zero bias or fixed bias shall be tested under anode current test conditions with zero or fixed bias. Tubes intended for use with self bias or those intended for use with self bias or those intended for use with either self bias or fixed bias shall be tested under self bias anode current conditions. The time (t1) for the anode current to reach the specified percentage of the anode current measured at the conclusion of the time (t2) specified shall not exceed the maximum specified for the individual tube type.

NOTE: When electrode-current tests are made on converter-type receiving tubes, no signal shall be applied to the signal grid.

MIL-STD-1311D

METHOD 1261

ELECTRODE VOLTAGE

1. Purpose. To measure the particular electrode voltage at the point in the circuit and in the manner specified.
2. Equipment. Instruments of proper impedance shall be used to have negligible effect on the performance of the circuit or the indicated value.
3. Procedure. With the specified voltages and currents applied and the specified currents flowing to the electrode concerned, its voltages shall be within the specified limit(s).

NOTE: When the electrode-voltage tests are performed on converter-type receiving tubes, no signal shall be applied to the signal grid.

## MIL-STD-1311D

## METHOD 1266A

## GRID CURRENTS

1. Total grid current. When the specified voltages applied to the tube, the total grid current read with a series microammeter shall be within the limit(s) specified. The total external circuit resistance shall not exceed 100,000 ohms, except that when the maximum current limit is  $-0.5 \mu\text{A}$  dc or less, the resistance may be increased to 1.0 Meg maximum. The duration of this test (including preheating time at specified test conditions, if continuous with the test) shall be 2 minutes unless a greater duration is specified, or, in the case of tubes having a specified maximum grid current of  $5 \mu\text{A}$  or less, it shall be only long enough to establish a steady value. When a greater duration is required, a test period of 3 minutes shall be permitted if the grid current at the end of this time is stable or no longer rising, and does not exceed the limit(s) specified. On those TSSs where zero is specified as the minimum value, a positive current not exceeding  $0.05 \mu\text{A}$  dc shall be acceptable.

2. Grid emission. This test applies to tubes where grid emission is high compared to grid leakage. At the conclusion of the test specified in 1 above, the tube shall be biased to cutoff and the grid current measured immediately. This current shall be considered to be due to leakage and primary emission and shall be within the limit(s) specified.

3. Grid leakage. This test applies to tubes where grid leakage is high compared to grid emission. At the conclusion of the test specified in 1 above, the filament or heater voltage shall be cut off and the grid current measured when the parts have cooled. This current shall be considered to be due to leakage and shall not exceed the limit specified.

4. Grid current (cold). The filament switch shall be opened until the elements have cooled below visible color. The filament switch shall then be closed and the value of the grid current at the first pause in its rising value shall not exceed the value specified.

5. Gas current. When specified on the TSS, the value of the current determined as specified in 2 above shall be subtracted from the value of the current determined as specified in 1 above. This difference shall be considered the gas current and shall be within the limit(s) specified.

6. Primary grid emission. By means of suitable rectifiers and a 60-Hz ac source, the grid shall be heated during the positive half cycles, and the primary emission measured during the negative half cycles. The voltage shall be adjusted for the input power or average grid current specified. The primary emission current shall be not greater than the limit(s) specified. All unused elements shall be left floating or grounded as specified on the individual TSS.

MIL-STD-1311D

METHOD 1267

AIR LEAKS

1. Tubes shall be tested for air leaks by one of the following methods:

- a. In gridded tubes, grid current is one microampere or is twice the maximum initial limit, whichever is greater. In those cases in which there is a different maximum limit after life test, twice the life-test limit shall be used in judging an air-leak defect that occurs during life test.
- b. In vacuum diodes, appearance of ionized gas in space outside the anode (not to be confused with bulb fluorescence).

NOTE: In those cases where such methods cannot be applied, air leaks shall be defined by the individual TSS.

## MIL-STD-1311D

## METHOD 1296

## PULSE CHARACTERISTICS

When pulse voltages or currents are specified on the TSS, the values of time of pulse, repetition rate, and pulse amplitude shall be specified. The pulse amplitude shall be defined as the maximum value (excluding spike) of a smooth curve through the average of the fluctuation over the top portion of the pulse (see figure 1296-1). The allowable spike width measured at the base of the spike shall not exceed 10 percent of the pulse duration ( $t_p$ ). The width of the pulse, at an amplitude of 0.9 of the pulse amplitude, shall be not less than 80 percent of the ( $t_p$ ). The time of rise ( $t_r$ ) shall not exceed 0.1 of the  $t_p$ , and the time of fall ( $t_f$ ) shall not exceed 0.2 of the ( $t_p$ ). (For magnetrons, see method 4304.)

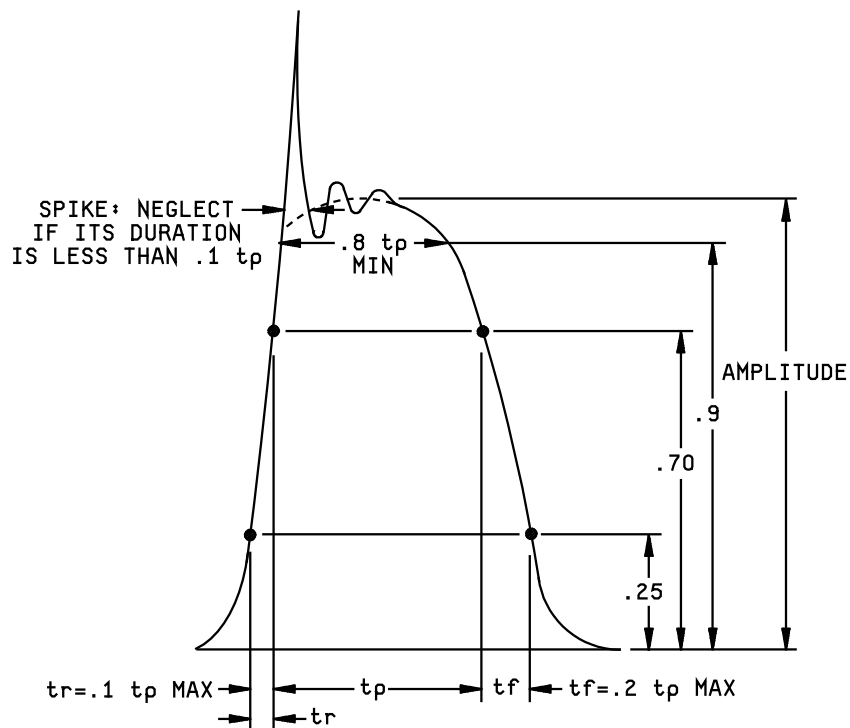


FIGURE 1296-1. Pulse voltage or current characteristics.

MIL-STD-1311D

METHOD 1301

HEATER OR FILAMENT CURRENT

When the voltage specified on the specification sheet is applied to the heater or filament, the current shall be within the limit(s) specified. During this test, no other elements shall be conducting.

## MIL-STD-1311D

## METHOD 1306B

## TRANSCONDUCTANCE

1. Methods of determination. The grid-anode transconductance shall be determined graphically from the slope of the grid-anode transfer characteristic, calculated from measurements of the amplification factor and the anode resistance, or measured directly by means of the voltage-ratio method shown in figure 1306-1 or by an equivalent method.

2. Voltage-ratio method. The voltage-ratio method utilizes a system of transformers, capacitors, and attenuators to supply three independent, properly phased, and adjusted ac voltages (normally 1,000 Hz) from a common source. The ac (rms) voltage E1, E2, and E3 must be in phase and the output resistance of the attenuators made small by proper design in order to neglect the voltage drop due to electrode currents. The voltage ratio E2/E1 must be accurately determinable. The voltage applied to the grid (whether using an alternating current signal or the incremental bias technique) shall be kept as low as practicable to obtain as true a value of transconductance as possible at the specified test point. When a null is reached,  $S_m = \frac{E_2}{E_1} \times \frac{1}{R}$ , where R is a fixed resistor of 100,000 ohms. By using the correct voltage multipliers or dividers, the reading can be obtained directly in micromhos.

3. Transconductance. The grid-anode transconductance shall be within the limits specified. For a change in the value of transconductance with reduced filament or heater voltage, the reading at the reduced voltage shall be taken when the value of transconductance is rising or stable.

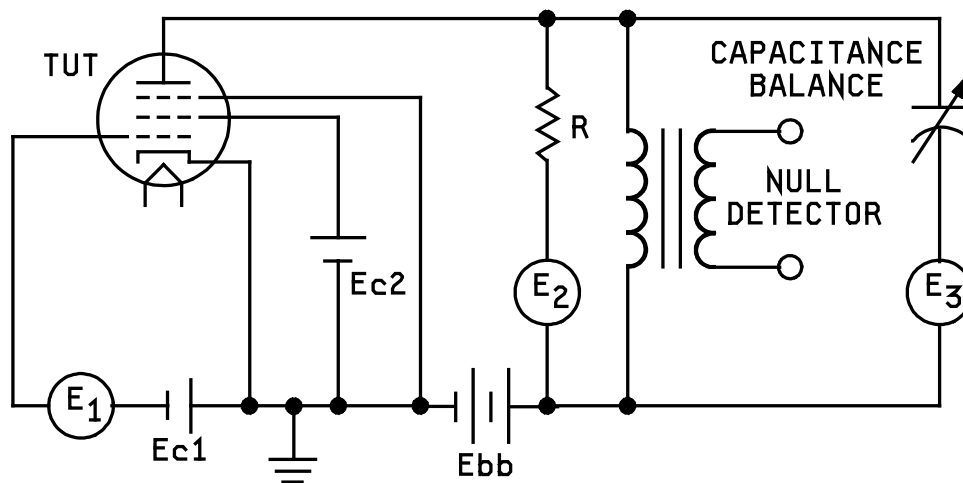


FIGURE 1306-1. Simplified circuit for measuring transconductance.

## MIL-STD-1311D

## METHOD 1311A

## ANODE RESISTANCE

1. Methods of determination. The anode resistance shall be determined graphically from the reciprocal of the slope of the graph of anode currents as ordinates against anode voltages as abscissas (other electrode voltages being maintained constant) or measured directly by means of the voltage-ratio method shown in figure 1311-1 or by an equivalent method.

2. Voltage-ratio method. The voltage-ratio method utilizes a system of transformers, capacitors, and attenuators to supply three independent, properly phased, and adjusted ac voltages (normally 1,000 Hz) from a common source. The ac (rms) voltages E1, E2, and E3 shall be in phase and the output resistance of the attenuators made small by proper design in order to neglect the voltage drop due to electrode currents. The voltage ratio E2/E1 shall be accurately determinable. When a null is reached,

$r_p = \frac{E_2}{E_1} \times R(\text{ohms})$  where R is a fixed resistor of 100,000 ohms. The anode resistance shall be within the limit(s) specified.

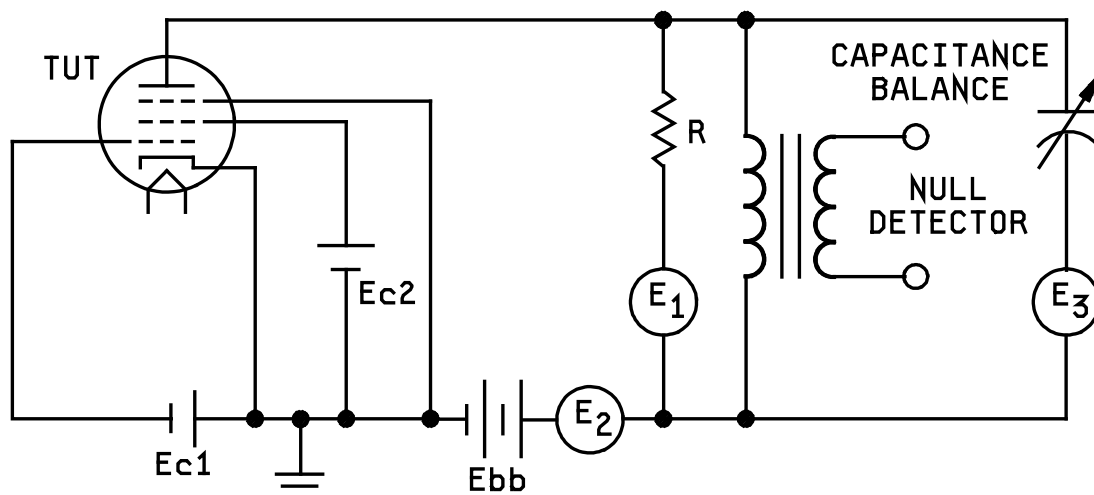


FIGURE 1311-1. Simplified circuit for measuring anode resistance.





MIL-STD-1311D

METHOD 1321

AC AMPLIFICATION

The test shall be made with the specified input signal (Esig) at a frequency of 60 to 2,000 Hz. The signal shall be coupled to the grid of the tube with no bias supply, through a 0.1- $\mu$ F capacitor. A 10-Meg resistor shall be connected from the grid to ground. The internal impedance of the signal source shall not exceed 2,500 ohms. The resistance (Rp) in series with the anode shall be 0.5 Meg, unity power factor. The circuit capacitance (including the vacuum-tube voltmeter) shall have a reactance of not less than 5 Meg at the test frequency. Qualification testing shall be made with Esig at a frequency of 400 Hz and with the output voltage measured by the Hewlett-Packard 400A vacuum-tube voltmeter, or equivalent.

## MIL-STD-1311D

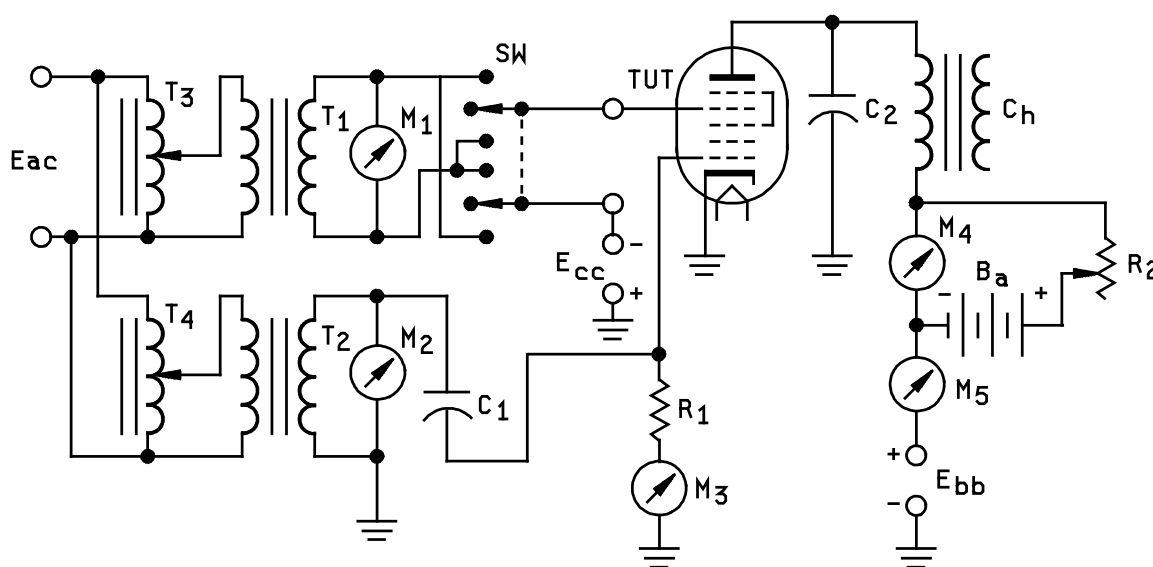
## METHOD 1326A

## CONVERSION TRANSCONDUCTANCE

Conversion transconductance shall be determined from measurements of the magnitude of a single-beat frequency component ( $F' - F''$ ) or ( $F' + F''$ ), of the output current, and of the magnitude of the input voltage of frequency  $F'$ , and shall be within the limits specified. The standard method of measurement of conversion transconductance shall be by application of 60-Hz voltages of identical phase and frequency from a source of less than 100 ohms impedance, to the specified electrodes, such as the signal and oscillator grids, with provisions for a phase reversal of  $180^\circ$  of one with respect to the other (see figure 1326-1). The time constant of the grid-coupling capacitor (C1) and grid-resistor (R1) at the oscillator grid-signal frequency ( $F_o$ ) shall satisfy the equation

$$\frac{1}{F_o R_1 C_1} \leq 0.16. \quad \text{The change in dc anode current due to the phase reversal represents the difference frequency anode current}$$

component. The rms value of the signal frequency voltage shall be 0.354 volt. The quotient of the change in anode current and twice the peak value of the sinusoidal voltage applied to the signal input electrode shall be the conversion transconductance. Specified operating potentials shall be applied to the tube, and the oscillator injection voltage shall be adjusted to the specified oscillator grid current.



- |  |                                       |
|--|---------------------------------------|
| Ba - Bucking battery                           | M4 - dc microammeter (low resistance) |
| Ch - Choke (filter)                            | incremental anode current             |
| C1 - Coupling capacitor                        | M5 - dc milliammeter (anode current)  |
| C2 - Capacitor (filter)                        | R1 - oscillator grid resistor         |
| Eac - 60 Hz supply (sinusoidal)                | R2 - Rheostat (bucking current)       |
| M1 - Voltmeter (signal)                        | SW - Reversing switch                 |
| M2 - Voltmeter (Oscillator injection)          | T1, T2 - Isolation transformers       |
| M3 - dc microammeter (oscillator grid current) | T3, T4 - Variable auto transformers   |

FIGURE 1326-1. Conversion transconductance test.

MIL-STD-1311D

METHOD 1331

DIRECT-INTERELECTRODE CAPACITANCE

The capacitance between the designated combination of elements shall be measured in accordance with EIA-191-D, and shall be within the limit(s) specified on the TSS.

MIL-STD-1311D

METHOD 1336

HEATER-CATHODE LEAKAGE

1. Rated heater voltage. The rated heater voltage shall be applied. For heaters having a rating of less than 35 volts, either ac or dc voltage shall be used; for heaters having a rating of 35 volts or greater, only ac heater voltage shall be used. One hundred volts dc in series with a microammeter shall be applied between the highest numbered heater pin and the cathode. If ac heater-cathode potential is specified, the heater voltage shall be phased to subtract from this heater-cathode potential. The current shall be determined for both negative and positive polarities between heater and cathode, except for rectifier sections of multiunit tubes, in which the measurements shall be made with the heater at a negative potential with respect to the cathode. The absolute values of the leakage current measured shall not exceed the limit specified. All other tube elements, except those internally connected, shall be electrically isolated from the heater during this test. A resistor, in series with the current meter, of not more than 1,000 ohms per volt of heater-cathode potential, shall be used in this measurement.

2. Voltage drop. The voltage drop which is developed across a protective resistor is considered in setting up the limit. The stable value of heater-cathode leakage current, when measured under both negative and positive voltage conditions, shall not exceed the limit(s) specified.

## MIL-STD-1311D

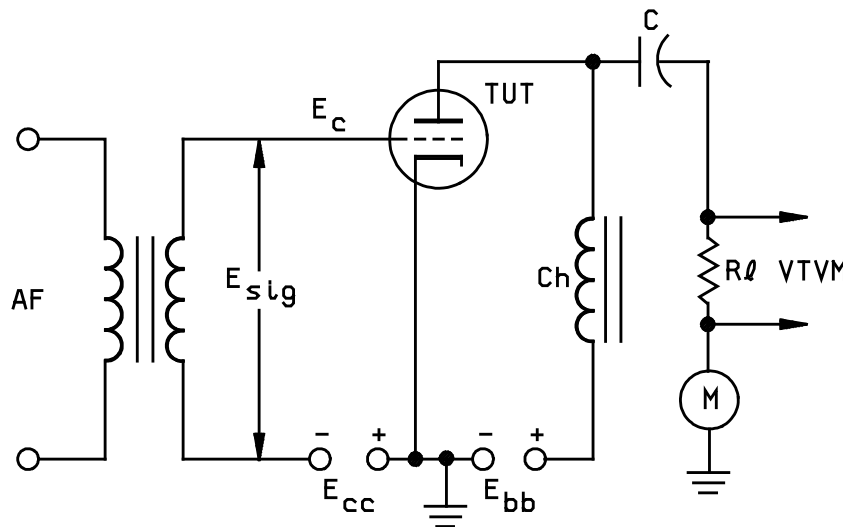
## METHOD 1341

## POWER OUTPUT

1. **Class A amplifier.** Power output shall be measured with specified potentials applied to the tube. The specified signal shall be applied to the control grid and measurement made of the total power output delivered from the anode of the tube into the specified resistive load. Unless otherwise specified, the impedance of the signal source shall be very low as compared with the minimum peak grid impedance. For a change in power output with reduced filament or heater voltage, the reading at the reduced voltage shall be taken when the value of the power output is rising or stable.

**Precaution:** The impedance of all voltage supplies shall be limited to 1 percent of the load resistance. Where an anode coupling transformer or choke is used, the loss should be added to the power measured in the load resistance.

1.1 This test shall be made with the circuit shown on figure 1341-1. The specified load shall be inserted in the anode circuit, the specified potentials shall be applied to the tube elements, and an audio frequency sinusoidal voltage of specified value shall be applied directly to the control grid. The internal impedance of the signal source shall not exceed 2,500 ohms. The rms alternating voltage across the load shall be measured with an rms measuring vacuum-tube voltmeter whose input impedance is at least 1 Meg, or with a current meter in series with the load, and the ac power in the load calculated.



Meter: RMS values;  
Ch: Negligible dc resistance.  
C: Negligible reactance at the signal frequency.

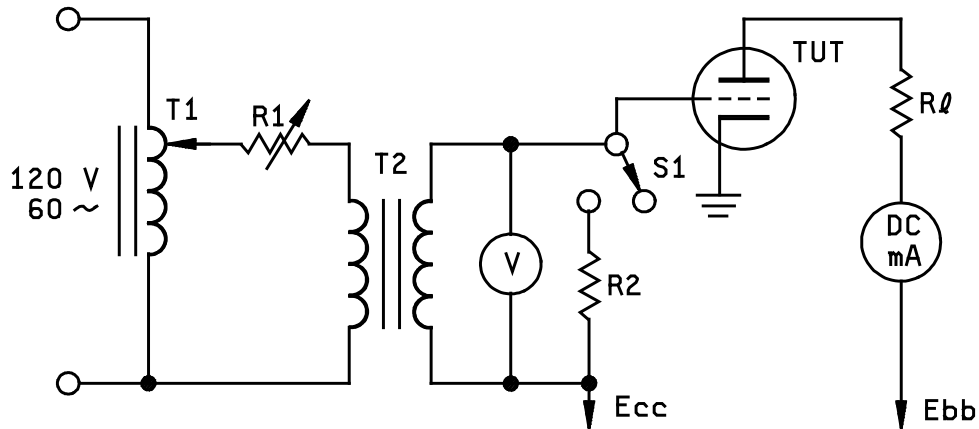
FIGURE 1341-1. Circuit for measuring class A power output.

2. **Class B amplifier.** This test shall be made on a tube or on each separate unit of multiunit tubes, in the circuit shown on figure 1341-2. The grid circuit shall have the specified impedance at the signal frequency and negligible dc resistance. The grid signal shall be adjusted to the specified voltage without a tube in the socket. The impedance of the signal source shall be adjusted without a tube in the socket so that a resistor load of the same value as the specified impedance decreases the signal voltage 50 percent when connected across the grid circuit. The total harmonic distortion of the signal shall not exceed 5 percent excluding distortion introduced by the source impedance. A noninductive resistance load ( $R_l$ ) shall be inserted in the anode circuit of the tube without the use of shunting choke or transformer. The specified anode voltage ( $E_b$ ) shall be regarded as supply voltage ( $E_{bb}$ ) for this test. The dc anode current shall be measured with no signal ( $I_{bo}$ ) and with the specified signal ( $I_{bs}$ ) and the power output calculated as follows:

$$P_o = \frac{\pi^2}{4} \left( I_{bs} - \frac{I_{bo}}{4} \right)^2 R_l$$

## MIL-STD-1311D

2.1 Idling anode current. For production purposes, the manufacturer may use a fixed value of  $I_{bo}$  provided the value chosen is representative of the current product. For a change in power output with reduced filament or heater voltage, the reading at the reduced voltage shall be taken when the value of the power output is rising or stable.



- T1 - 5-A variac.
- T2 - Low-impedance transformer.
- R1 - 10,000-ohm noninductive 8-watt rheostat.
- R2 - 500-ohm  $\pm 5$  percent noninductive 4-watt resistor.
- V - ac voltmeter.
- S1 - Microswitch normally open.

FIGURE 1341-2. Circuit for measuring class B power output.

## MIL-STD-1311D

## METHOD 1353A

## OPERATION OF RECTIFIERS

Each tube shall operate satisfactorily and without rejectable arc-backs in a rectifier circuit under the conditions specified. The criteria for rejectable arc-back and their detection shall be as specified in 1 to 3, inclusive, as applicable, or as specified. When the test conditions specify circuit constants, the dc current in the load resistor shall be within the limits specified. The duration of test shall be sufficient to obtain indication of satisfactory operation. For mercury-vapor rectifiers, the cathode shall be allowed to heat for a period of time sufficient to distribute the mercury properly in the bulb. Inductive loading shall not be used. Unless otherwise specified, rejectable arc-backs do not apply to life tests.

1. Receiving-type rectifiers. In the operation of receiving-type rectifiers, a rejectable arc-back is one which has a peak reverse current at least 3.5 times the rated peak steady-state anode current per anode and which occurs after a delay of at least 5 input frequency cycles from the time of application of anode voltage. (This delay distinguishes arcs attributable to the tube from those which result from transient instability of the test equipment.) The arc-back detector shall have a maximum charging time constant of 0.5 millisecond and shall be capable of detecting a single rectangular peak of 0.5 millisecond duration with an amplitude of 3.5 times the rated peak steady-state anode current per anode. The minimum test time shall be the time required for the TUT to reach the minimum operation current,  $I_o$ , specified on the TSS. The tube may be preheated at rated heater or filament voltage at the option of the manufacturer. This is not a destructive test.

2. Gas rectifiers. In the operation of gas rectifiers, a rejectable arc-back is one which has a current in the reverse direction whose peak value is not less than five times the peak forward anode current obtained during this test. In the test circuit, the source impedance shall be such that the peak value of the steady-state current in the shorting circuit, when all tubes are short circuited, shall not be less than 7.5 times the peak forward anode current obtained during this test. The arc-back detector shall be capable of detecting a rejectable arc current whose duration is equal to or greater than  $\frac{1}{4}$  cycle of the frequency of the applied voltage. Unless otherwise specified, the frequency of operations shall be 50 to 60 Hz. Qualification samples shall be operated for 1 hour.

3. Power-vacuum rectifiers. In the operation of power rectifiers, a rejectable arc-back is one which has a peak reverse current at least 3.5 times the rated peak steady-state anode current. In the test circuit, the source impedance shall be such that the peak value of the steady-state current in the shorting circuit, when all tubes are short circuited, shall be at least four times the peak forward anode current obtained during this test. The arc-back detector shall be capable of detecting a rejectable arc current whose duration is equal to or greater than  $\frac{1}{4}$  cycle of a cycle of the frequency of the applied voltage. The frequency of the applied voltage shall be 50 to 60 Hz. Qualification samples shall be operated for 1 hour.



MIL-STD-1311D

METHOD 1356

#### GRID-PULSE OPERATION

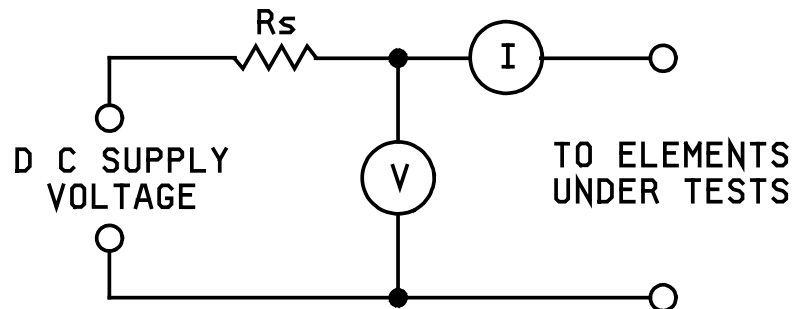
The electrical potentials specified on the TSS shall be applied to the tube. Sufficient negative grid voltage shall be applied to cut off the anode current. The cathode shall be preheated for a minimum of 30 seconds before grid pulse is applied. The duration of the test, excluding preheating, shall be as specified. The grid pulse (in time duration, excluding time of rise and time of fall) shall be as specified. Instantaneous anode, screen, and negative grid voltages shall not exceed 1.5 times their specified dc values due to transients. There shall be no evidence of arcing during the last half of this test.

MIL-STD-1311D

METHOD 1366A

## INTERELEMENT LEAKAGE RESISTANCE, COLD

1. Purpose. The purpose of this test is to measure interelement leakage resistance.
2. Procedure. When using the circuitry shown on figure 1366-1, the resistance (for example,  $R = V/I$ ) between the specified elements should be greater than the limit specified. All other unused elements shall be disconnected. Voltage (V, and its polarity) on the elements under test shall be as specified on the TSS.



NOTE: Other instrumentation producing equipment results may be used.

FIGURE 1366-1. Test circuit for interelement leakage resistance cold.

## MIL-STD-1311D

## METHOD 1367A

## MAGNET POLARITY AND STRENGTH

1. Purpose. The purpose of this method is to avoid confusion in determining the strength and polarity of magnets and solenoids or magnet coils. Some tubes are sensitive to polarity, while others require only the correct shape and intensity of magnetic field. When correct polarity is required, an incorrect determination may cause immediate destruction of the tube.

2. Definitions on polarity.

2.1 The north (N) pole of a magnet is that pole which points toward the geographic north of the earth, when the magnet is freely suspended. No distinction is made between "north" and "north-seeking". The implication that the earth's pole in the north of Canada is a magnetic south (S) pole is an accepted paradox.

2.2 The direction of a magnetic field at any point, whether due to a permanent magnet or to a solenoid, is the direction of the force on the north pole of a small magnet at that point. Hence, it is the direction in which the N end of a compass needle points when placed in the field.

2.3 The direction of the external field of a permanent magnet is away from the north pole, toward the south pole. However, the ends of a solenoid should not be marked N or S, because both the internal and external fields are accessible, and run in opposite directions, so that any such marking is ambiguous. Coil markings, if used, should relate the direction of the internal field directly to the polarity of the current supply, without reference to N or S poles. For example,

"Internal field direction



when black lead is positive."

3. Method for polarity.

3.1 Permanent magnet: Bring a compass or suspended test magnet near to one end of the permanent magnet. This end is north (N) if the compass points away from it.

3.2 Solenoid or coil: With a current of known polarity flowing in the solenoid or coil, bring a compass into the region of interest (normally inside the coil\*); the field direction is the direction in which the compass points, assuming that the current is sufficient for the solenoid field to mask the earth's field.

\* Even when the region of interest is inside, it may be more convenient to check the polarity externally (provided there is no iron return path), to avoid removal of a tube or other component within the coil. In this case, the polarity should be checked close to the coil and in any plane, perpendicular to the axis, which passes through the working region (near the ends the field has strong radial components). The internal field direction is then the opposite of that observed externally.

3.3 If the winding direction of a coil is known or can be seen, the magnetic field direction can be determined by the right-hand rule: With the right thumb along a wire, pointing in the direction of current flow, the fingers curl around the wire in the direction of the magnetic field. Alternatively, to an observer looking along the coil axis, a clockwise flow of current produces a magnetic field directed along the coil axis and away from the observer.

4. Precautions. A compass or small test magnet can be remagnetized in the reverse direction if it is suddenly exposed to a large field from a permanent magnet or solenoid. Therefore, the compass or test magnet should be checked before and after a measurement by taking it a short distance away from local magnetic influences, and making sure that the N or marked end points toward geographic north.

5. Convention for magnetrons. Non-packaged magnetrons (for example, magnetrons operated in a permanent magnet which is separate from the tube) should be mounted with the cathode terminal of the tube adjacent to the north pole of the magnet.

MIL-STD-1311D

6. Strength. Measurements of strength of magnetic fields shall be made by an instrument calibrated against a standard magnet. The following information shall be available:

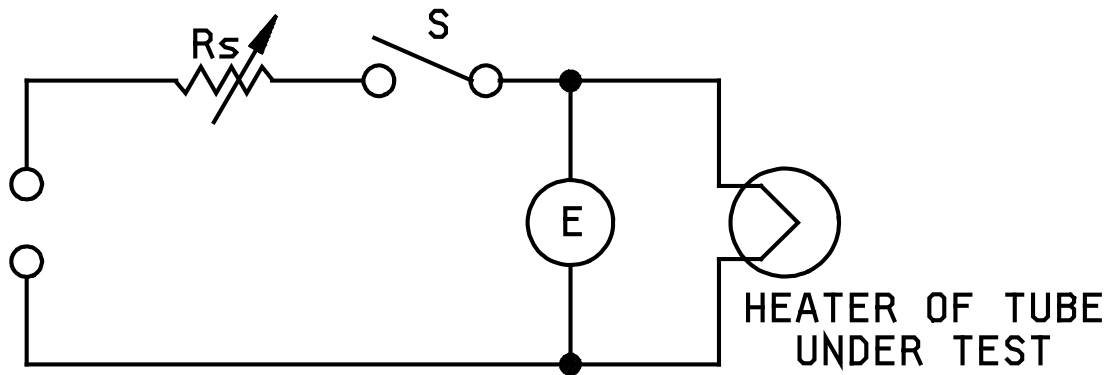
- a. Field strength.
- b. Cross-sectional area.
- c. Volume.
- d. Position of sensing element.

## MIL-STD-1311D

## METHOD 1369

## HEATER OR FILAMENT WARMUP TIME

1. Test circuit. The heater or filament warm-up time test shall be made in the circuit shown (see figure 1369-1). Before the test is made, the electrodes of the TUT shall be at or near room temperature.
2. Rs adjustment. The series resistor ( $R_s$ ) shall be adjusted before the warm-up time as follows: Set open-circuit voltage at 4 times the rated heater voltage ( $E_f$ ). Insert a resistance equal to  $E_f/I_f$  (bogey) in place of TUT. Adjust  $R_s$  such that voltage shown on a high-impedance voltmeter ( $E$ ) is equal to rated (bogey) heater voltage ( $E_f$ ).  $R_s$  should not vary more than 5 percent during the following test.
3. Test procedure. With the switch open, insert the TUT into the socket. Adjust supply voltage to the proper value, close the switch and simultaneously start a timing device, accurate to 0.1 second. When the voltage reading of the voltmeter ( $E$ ) reaches 0.8  $E_f$ , stop the timer and record time. This time should be within the limit(s) specified on the TSS.

FIGURE 1369-1. Test circuit for heater of filament warm-up time.

MIL-STD-1311D  
METHOD 1372A  
CURRENT DIVISION

1. Long pulse (Method A):

1.1 General. Unless otherwise specified, the following conditions apply (see figures 1372-1 and 1372-2):

- a. DC voltages to electrodes ..... As specified.
- b. Pulse duration (tp) ..... 1,000  $\mu$ s to 4,500  $\mu$ s.
- c. Pulse recurrence rate (prf) .....  $11 \pm 2$  pps.
- d. Grid voltage pulse (egk) ..... Square wave (adjust for procedure (a) or (b)).
- e. Input wave shape (tr), (tf) ..... 25  $\mu$ s, max, each.  
     Top slope ( $\Delta$ ic) ..... 0.5 percent, max.  
     Ripple ..... 0.1 percent, max.

1.2 Procedure.

- a. The magnitude of the grid-voltage pulse shall be adjusted to produce the specified anode current at the leading edge of the pulse, excluding any spike. The magnitude of the grid-voltage pulse (egk) relative to zero level shall be within the limit(s) specified. When indicated, the magnitudes of the grid current(s) ic1, ic2, ic3, etc., shall be within the limit(s) specified.
- b. The magnitude of the grid-voltage pulse shall be adjusted to bring the grid to zero voltage level during the pulse. The magnitude of the pulse anode current (ib) and, when indicated, the grid current(s) ic1, ic2, ic3, etc., shall be read at the leading edge, excluding spike, and shall be within the limit(s) specified.
- c. Pulse duration (tp) should be adjusted to a maximum value between the specified values stated commensurate with practical limitations of the tubes element dissipations.

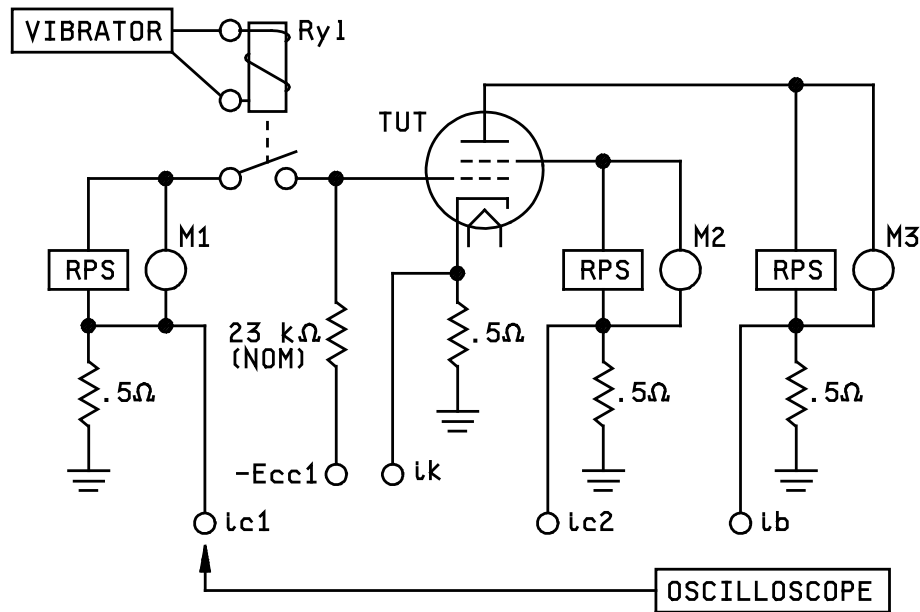
2. Short pulse (Method B):

2.1 General. The dc voltages applied to the tube electrodes shall be as specified. The pulse duration (tp), pulse recurrence rate (prf), and type of pulse used shall be appropriate for the TUT. The magnitude of the grid-voltage pulse shall be adjusted as required for either procedure a or procedure b.

2.2 Procedure.

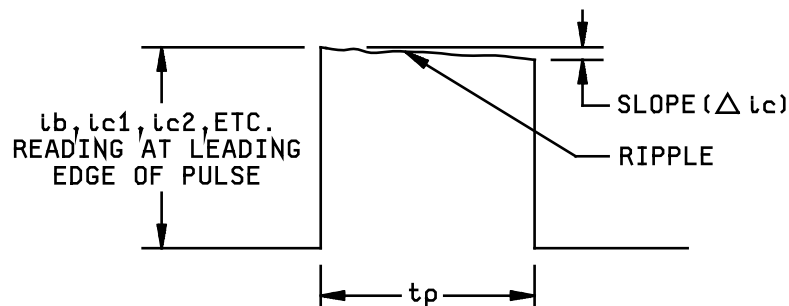
- a. The magnitude of the grid-voltage pulse shall be adjusted to produce the specified peak anode current (ib). The magnitude of the grid-voltage pulse above zero level (egk) shall be within the limit(s) specified. When indicated, the magnitude of the grid current(s) ic1, ic2, ic3, etc., shall be within the limit(s) specified.
- b. The magnitude of the grid-voltage pulse shall be adjusted to bring the grid to zero voltage level at the peak of the pulse. The magnitude of the peak pulse anode current (ib), and when indicated, the magnitude of the peak grid current(s) ic1, ic2, ic3, etc., shall be within the limit(s) specified.

MIL-STD-1311D



## NOTES:

1. Regulated power supplies (RPS) shall be capable of maintaining the voltage steady over the duration of the pulse.
2. The magnitude of the grid voltage pulse (egk) shall be as read on meter M1 which reads V dc.
3. Meters shall be accurate to within 1.0 percent.
4. Ry1 shall be a mercury wetted contact type relay or equivalent.
5. Current monitoring resistors may be shorted out.
6. Peak reading devices which measure pulse amplitude may be used in place of the oscilloscope. The amplitude of the pulse leading edge shall be measured within 30 microseconds.

FIGURE 1372-1. Basic test circuit.FIGURE 1372-2. Pulse.

## MIL-STD-1311D

## METHOD 1501A

## INTERMITTENT LIFE

1. Test conditions. When intermittent life-test is performed, the tubes shall be operated under the specified test conditions with the filament or heater supply interrupted periodically. There shall be 12 to 25 uniform cycles, totaling approximately 20 hours of "on" operation each 24 hours. The filament or heater supply shall be applied and removed instantaneously. Other potentials may be applied continuously, at the option of the manufacturer. The accumulation of the "on" time shall be the time considered in determining compliance with the minimum specified time value. The filament or heater-supply impedance shall not exceed 10 percent of the hot filament-load impedance. Warm-up time,  $t_k$ , when specified on the TSS as a test condition for intermittent life test, shall be adhered to at the beginning of each "on" period. This is a destructive test.

2. Tube intermittent life-test procedure. Regular life test shall be in effect initially and shall continue in effect until the eligibility criteria for the reduced-hours life test have been met. Sampling shall be as specified in MIL-PRF-1, section 4. This is a destructive test.

2.1 Regular life test.

- a. Regular life test shall be conducted for 500 hours.
- b. Regular life-test acceptance shall be on the basis of the specified 200- and 500-hour life-test end-point limits.

2.2 Reduced-hours life test.

- a. Eligibility for reduced-hours life test is established when no first sample failure due to the regular 500-hour life test has occurred in the preceding 3 consecutive lots.
- b. Reduced hours life test shall be conducted for 200 hours and acceptance shall be based on the 500-hour life-test end-point limits. Two 200-hour life-test lot failures occurring in the last 3 consecutive lots shall result in loss of eligibility for reduced-hours life testing.
- c. The life-test sample from the first lot accepted each quarter shall continue on life test for an additional 300 hours (500 hours total life-test time). Failure of this sample to meet the 500-hour life-test end-point limits shall result in loss of eligibility for reduced-hours testing.

2.3 Readings: The life-test sample shall be read at the following times:

0	hours
+24	
200	hours
-0	
+24	
500	hours
-0	

Additional reading periods may be used at the discretion of the tube manufacturer.

2.4 Acceptance criteria. The lot shall be considered satisfactory for acceptance if the specified allowable defects are not exceeded and the change in average of any characteristic in the life-test sample specified for life-test control of averages is not exceeded. The average percentage change shall be obtained from the determination of the individual changes for each tube in the life test sample from the zero-hour value for the specified characteristics. For purposes of computation of this average percentage change, the absolute values of the individual changes for each tube in the life test sample may be used. Any tube found inoperable during life testing shall not be considered in the calculation of this average.



MIL-STD-1311D

2.5 Resubmitted lots: A resubmitted lot shall be subjected to all conformance inspection, part 1 and part 2 tests, except the following:

- Vibration tests
- Shock tests
- Physical (including dimensions)
- Secureness of base, cap, or insert
- Lead fatigue
- Barometric pressure, reduced
- Base strain (miniature)
- Glass strain

2.6 Accidental breakage: Not more than one accidental breakage shall be allowed in the life-test sample. In the event that one life-test tube is accidentally broken, acceptability of the life-test sample shall be based upon the remaining tubes in the sample, provided the broken tube was not known to be defective.

MIL-STD-1311D

METHOD 1506

HEATER-CYCLING LIFE

1. Cycling. A complete cycle is made in a 2-minute period as follows: 1 minute "on", 1 minute "off". Duration of the cycling test shall be 2,000 cycles. The heater-voltage supply shall have a regulation of not more than 3.0 percent (no-load to steady-state load). Heater-cathode voltage shall remain on continuously. Any tube which shows an open heater, open-cathode circuit, heater-cathode short, or fails to meet any specified life-test end-point limit(s) for this test prior to the completion of the cycling test shall be considered a defective tube. A leakage current in excess of 500  $\mu$ A dc between the heater and cathode shall be considered a heater-cathode short. Sampling shall be as specified in MIL-PRF-1, section 4. This is a destructive test.

2. Use of defectives. Electrical or mechanical defectives may be used for this test except for the following:

- a. Tubes shall be within initial limits for heater or filament current.
- b. Tubes shall meet the post-heater cycling acceptance criteria.

## MIL-STD-1311D

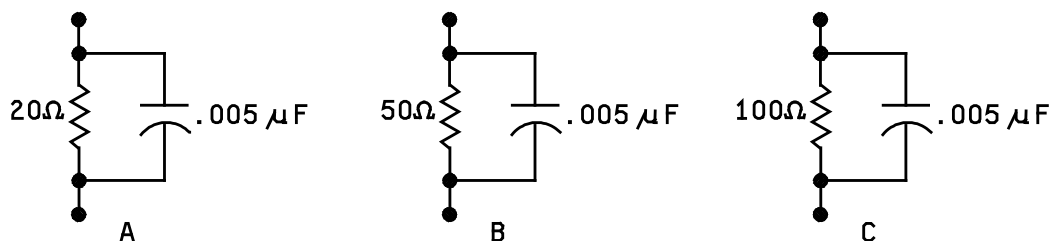
## METHOD 1511

## CATHODE INTERFACE LIFE

1. Test conditions. The tubes shall be operated for 500 hours with 110 percent of normal heater voltage applied and with other electrodes disconnected. The tubes shall then be measured for cathode interface impedance. The readings of cathode interface resistance shall not exceed the life-test end point limit(s) specified. This is a destructive test.

2. Impedance test.

- a. Equipment. Interface impedance may be measured by any equipment capable of meeting the calibration requirements specified below. The equipment shall be capable of measuring the calibration network to within  $\pm 15$  percent of the  $R_i$  value given in the calibration networks of figure 1511-1.
- b. Calibration. Calibration shall be performed by connecting the calibration networks in series with the cathode of an interface-free tube operated at a maximum of 2,500 micromhos transconductance. Any tube type, capable of the specified transconductance, is satisfactory for this calibration. The calibration procedure need be performed using only one tube type.



(Resistors shall be noninductive deposited carbon film type of 1.0 percent accuracy)

FIGURE 1511-1. Interface networks.

- c. Interface-free determination. To determine whether the calibration tube is interface-free, use is made of the temperature sensitive characteristics of the interface resistance. With the calibration network in series with the cathode of the tube, interface resistance is measured at 20 percent lower than rated heater voltage and at 20 percent higher than rated heater voltage. If the difference between the two readings is less than 10 percent, the tube shall be accepted for use as an interface-free tube.
3. Conditions.
- a. The tube measured shall be operated under the conditions specified on the TSS.
  - b. Heater voltage shall be controlled to within 1.0 percent of the value specified.
  - c. Preheat by applying the specified heater voltage used for the measurement for not less than 5 minutes.
  - d. Life-tested tubes shall not be subjected to any other electrical measurements between the end of the life test and the interface test.
  - e. When testing multisection tubes, the opposite sections may be grounded, cutoff, or floating.
  - f. If the anode current specified on the TSS cannot be obtained on an individual tube, the interface measurement shall be made at zero bias.

## MIL-STD-1311D

## METHOD 1516

## STABILITY LIFE

1. Purpose. The purpose of this test is to determine the stability of specified characteristics during early life.
2. General. This is a test of 2 to 20 hour duration, under specified conditions, preceded and followed by measurements of one or more specified characteristics, and with maximum percentage characteristic change specified for individual tubes. The sampling plan and sample size will be stated on the individual TSS or as specified in MIL-PRF-1, section 4.
3. Procedure.
  - a. Serially number all the tubes of the sample.
  - b. Record the specified characteristic measurements on the entire sample after maximum operation of 15 minutes under specified voltage and current conditions.
  - c. The regular stability-life-test sample shall be operated at the specified stability-life-test conditions or equivalent, for  $20 \pm 4$  hours with an intermediate down-period reading point at  $2 \text{ hours} \pm 30 \text{ minutes}$ . (Intermittent or continuous operation may be employed.) The regular stability life-test shall be in effect initially and shall continue in effect until the eligibility criteria for the reduced-hours stability life test have been met.
  - d. Reduced-hour stability-life-test.
    - (1) Eligibility for reduced-hours stability-life test shall be as follows: No lot failure due to the regular stability-life has occurred in the preceding 5 consecutive lots.
    - (2) Reduced-hours stability-life test shall be conducted for  $2 \text{ hours} \pm 30 \text{ minutes}$ . Acceptance shall be based on the stability-life test endpoint limit. One lot failing the reduced-hours stability-life test shall result in loss of eligibility for the reduced hours stability-life test.
    - (3) The stability-life-test sample from the first lot accepted each month shall continue on stability-life test to the  $20 \pm 4$  hours duration. Failure of this sample to meet the regular stability-life test endpoint limit shall result in loss of eligibility for the reduced hours stability-life test.
  - e. Life-test conditions shall be conducted as specified in 4.11 (General requirements), except that the mean electrode potentials (except heater or filament) may be established at values differing by not more than 5 percent from the specified values, provided the same average electrode dissipations are obtained that occur with the specified voltages. Fluctuations of all voltages, including heater or filament voltage, shall be as small as practicable.
  - f. Record measurements of the specified characteristics at the specified reading periods. The measurements shall be taken immediately following the specified reading periods, or the tubes shall be preheated a maximum of 15 minutes under specified voltage and current conditions, and the characteristics immediately measured following the specified reading periods.
  - g. A defective shall be defined as a tube having a change in the specified characteristic greater than that specified.
  - h. A resubmitted lot shall be subjected to all conformance inspection part 1 and part 2 tests, except the following:
    - Vibration tests
    - Shock tests
    - Physical (including dimensions)
    - Secureness of base, cap, or insert
    - Lead fatigue
    - Barometric pressure, reduced
    - Base strain (miniature)
    - Glass strain

MIL-STD-1311D

METHOD 1521

SURVIVAL-RATE LIFE

1. Purpose. This test is designated to maintain quality level in terms of early life survival.

2. Procedures.

- a. Select samples in accordance with MIL-PRF-1, section 4.
- b. Test tubes at 100 hours as specified in method 1201. When any tap-short indication is obtained, the test shall be repeated. When any tap shorts are again obtained, the tube shall be rejected as inoperable.
- c. Determine the number of tubes defective at the 100-hour period.
- d. If more than the allowable number of defectives occur, declare the lot nonconforming.
- e. A resubmitted lot shall be subjected to all conformance inspection, part 1 and part 2 tests, except the following:

- Vibration tests
- Shock tests
- Physical (including dimensions)
- Secureness of base, cap, or insert
- Lead fatigue
- Barometric pressure, reduced
- Base strain (miniature)
- Glass strain

3. Equivalent conditions. For survival-rate life test, the equivalent stability-life-test conditions shall be interpreted as having the same heater voltage ( $E_f$ ) and heater-cathode voltage ( $E_{hk}$ ) as the stability life test; and the same interruption rate as the intermittent life test. The electrode voltages shall be such that the element dissipations are not less than 80 percent nor more than 100 percent of stability-life-test anode dissipation. These voltages shall be maintained within the limits of 50 percent minimum and 200 percent maximum of specified voltage.

MIL-STD-1311D

METHOD 2126A

ENVELOPE STRAIN

1. Envelope strain (miniature and subminiature receiving tubes). All tubes subjected to this test shall have been sealed a minimum of 48 hours prior to conducting this test. All tubes shall be at room temperature. The tube holder shall be in accordance with Drawing 245-JAN. The entire tube shall be immersed in water at not less than 97°C for 15 seconds, and immediately thereafter immersed in water at not more than 5°C for 5 seconds. The volume of water shall be large enough so that the water temperature will not be appreciably affected by the test. The tubes shall be placed in the water so that no contact is made with the containing vessel, nor shall the tubes contact each other. After the 5-second submersion period, the tubes shall be removed and allowed to return to room temperature on a wooden surface. After drying at room temperature for a period of 48 hours, the tubes shall be inspected for evidence of air leaks (see method 1267).

2. Use of rejects. Electrical rejects may be used for this test.

## MIL-STD-1311D

## METHOD 2201

## NOISE AND MICROPHONICS

(Receiving tubes)

1. Test circuit. The basic circuit for the noise and microphonics test is shown on figure 1 of Drawing 194-JAN. In this circuit, the TUT is connected in a resistance coupled amplifier circuit. The circuit constants  $R_k$ ,  $R_{g1}$ ,  $R_{g2}$ , and  $R_p$ , and applied electrode voltages shall be those values as specified by tube type on the specification sheet. The value of  $E_b$  under test conditions shall be regarded as  $E_{bb}$  for this test.

2. Equipment components. The principal components of this equipment, as shown on Drawing 194-JAN, are described as follows:

- a. Calibration circuit. The calibration circuit (Ecal) is provided for selecting the specified signal voltages on each specification sheet. The calibration circuit used for this purpose shall have a range of 0 to 1,000 mV and shall be capable of supplying any calibrating voltage in this range with an accuracy of  $\pm 2.0$  percent (see figure 2201-1).
- b. Cathode follower and noise and microphonics amplifier. The anode of the TUT shall be coupled to the input of the cathode follower which may be located either in the test chassis as shown on the drawings or in the noise and microphonics amplifier. The response of the cathode follower and amplifier shall be within  $\pm 0.5$  dB of the response at 400 Hz over the frequency range of 50 to 5,000 Hz and have a 6 dB per octave maximum cutoff rate in the ranges 20 to 50 Hz and 5 to 20 kHz. The response shall be measured at the anode terminal of the test socket with a generator having an output impedance of 10,000 ohms, or less. The actual input resistance of the cathode follower shall be 1 Meg in parallel with a distributed circuit capacity of  $80 \pm 10$  pF. The power amplifier shall have a power capability of 3 watts minimum at a point of 3 percent harmonic distortion. The hum and noise level shall be at least 30 dB below rejection level. Below the 3-watt level, the output voltage shall not fall more than 3 dB when going from no load to full load over the frequency range of 50 to 5,000 Hz. The output to input voltage ratio of the cathode follower and amplifier shall be linear within  $\pm 5.0$  percent over the output power range of 0 to 3 watts.
- c. Speaker. The speaker shall be an 8-inch commercial dynamic type with a rating of at least 2.5 watts. The speaker shall be coupled to the output of the amplifier so as to present rated load to the amplifier. The speaker may be mounted in accordance with figure 2 of Drawing 194-JAN and shall be positioned in such a manner that acoustic and mechanical feedback to the TUT is at a minimum.
- d. Output meter. The output indicator shall be a VU meter with the rejection level set at the meter reading obtained during calibration.
- e. Mechanical tapping device. A mechanical tapping device shall be used for mechanically exciting the TUT during noise and microphonics testing. This tapper consists of a motor driven cam actuating an overbalanced lever which delivers an impact to a suspended platform upon which an adapter and the TUT are mounted. The platform shall be tapped at the rate of 120 taps per minute. The details of the mechanical parts of the tapper and of the adapter box for mounting the TUT are as shown on figure 3 of Drawing 194-JAN and must be standardized so that good correlation will exist between data taken on different equipment.
- f. Mallet. (Not shown on drawing.) The mallet used for manual tapping shall be as specified in method 1201 (tapping). The mallet may be equipped with a conductive coating.

MIL-STD-1311D

3. The operation of the equipment shall be as follows:

- a. Calibration. The gain shall be adjusted for 50 mW output by removing the tube from the socket and introducing the specified calibrating voltage, at a frequency between 50 and 5,000 Hz into the anode circuit at the tube socket. During calibration, the output of the amplifier shall be terminated in a load resistor having the same impedance as the speaker. The signal and calibrating network shall be removed.
  - b. Test procedure. The TUT shall be inserted. The tube shall be operated under conditions as specified on the specification sheet in an adapter in accordance with figure 4 of Drawing 194-JAN. When operating under the above conditions, the automatic tapper shall be energized and the average maximum output as observed during approximately six taps noted. If the output reading is rising, continue only until the reading is stabilized. Then, the tube shall be tapped sharply two times with a mallet, using a 2-inch stroke, and the output re-read under automatic-tapping conditions.
4. Rejection. Tubes shall be rejected for microphonics if the average maximum VU meter readings exceed the limit(s) specified on the TSS either before or after the manual tapping when the output load switch is in the microphonics position. Tubes shall be rejected for noise if any objectionable noise is heard in the speaker such as that caused by leakage, intermittent shorts, etc., when the output load switch is in noise position. Objectionable noise shall be defined as clicks or scratchy noises.



MIL-STD-1311D

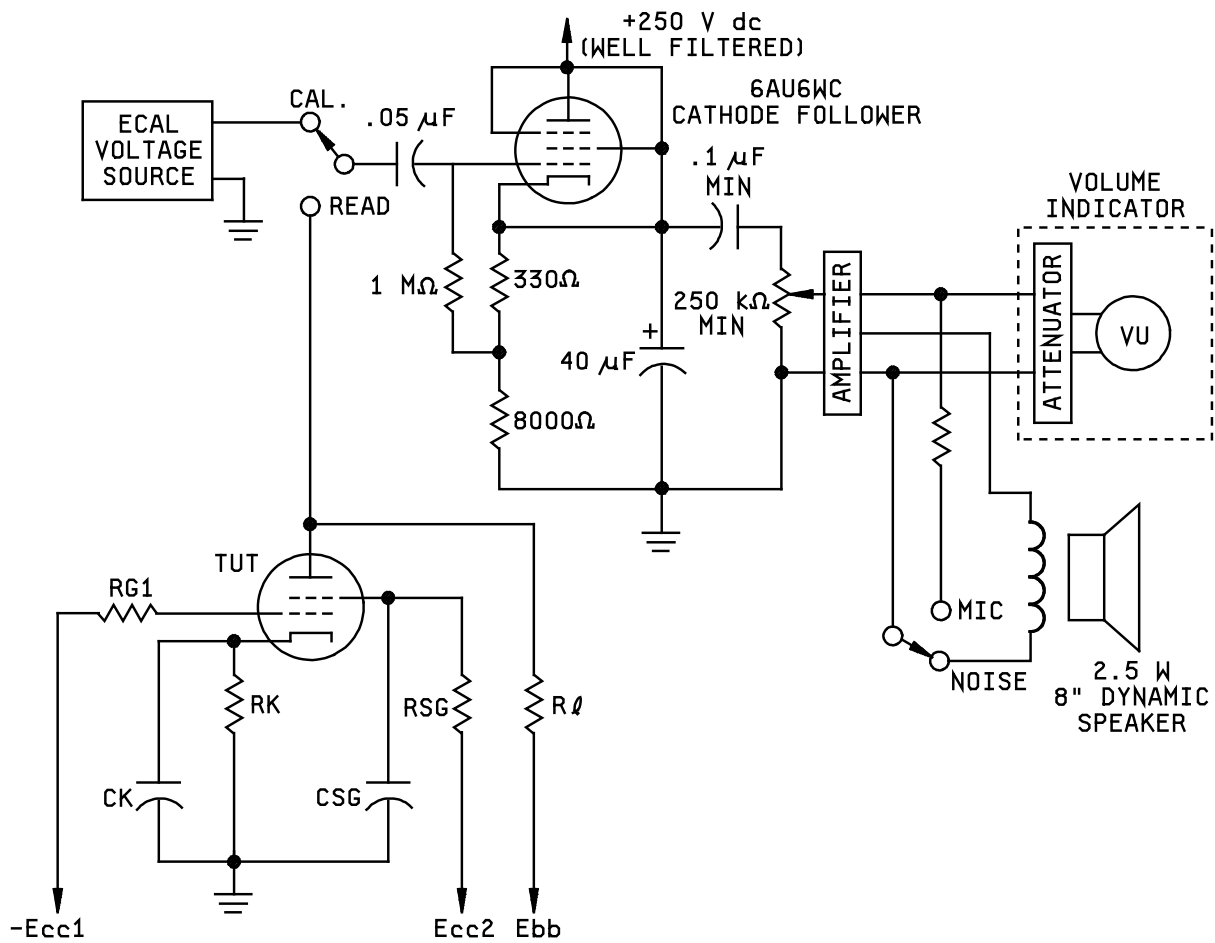


FIGURE 2201-1. Calibration circuit.

MIL-STD-1311D

METHOD 2202

X-RADIATION MEASUREMENT

(Receiving - high voltage rectifiers and shunt regulators)

1. Purpose. To obtain the x-radiation intensity of high-voltage rectifier and shunt regulator tubes to determine the levels emitted by the tubes when operated at high voltages without external shielding.

2. Equipment.

2.1 Survey meter. A dose-rate meter (electrostatically shielded) for probing or rapid surveying of a radiation field (Victoreen Model 440 RF/C, or equivalent). This meter, with a chamber of 10 cm<sup>2</sup> cross-sectional area, is intended to be the principal measuring instrument.

NOTE: Other detectors of low-energy x-radiation may also be used; such as Geiger-Mueller counters, proportional counters, scintillation counters, or solid-state counters, provided that the calibration is known over the energy ranges being measured and differences in cross-sectional areas of the detectors are considered.

2.2 Test equipment. To provide stable electronic conditions for operation of the TUT and to measure anode voltage and current.

NOTE: Test equipment shall be so designed as to shield operators to below acceptable personnel safety level.

2.2.1 High-voltage meter. A meter for measurement of the high voltage during test, with an accuracy of at least  $\pm 0.5$  percent. Calibrate using a high-voltage divider with suitable accuracy and stability.

2.2.2 Current meter. A meter for measurement of the current during test, with an accuracy of at least  $\pm 2.0$  percent.

2.3 Survey-meter support. A holder for supporting the survey meter during exposure in the recommended positions. It shall be constructed of wood or plastic and shall not lie between the meter and the tube.

3. Calibration.

3.1 The survey meter shall be calibrated by exposure to an x-ray field of such an energy that half-value layer of aluminum is 1.1 mm. This results in an effective energy of about 23 kiloelectron volts (keV). The calibrating dose rate shall be representative of the intensities to be measured. This calibration shall be made traceable to the National Institute of Standards and Technology.

NOTE: To insure accurate instrumentation, consideration should be given to correction factors for extreme variations in temperature and barometric pressure.

3.2 Stability of the calibration may be checked periodically by using an appropriate radioactive source.

4. Test conditions.

4.1 The TUT shall be positioned relative to the test equipment so that measurements will be made at the point where maximum radiation is observed.

4.2 Shunt regulators. The TUT shall be operated at the maximum rated high dc anode (not supply) voltage and current, which shall not vary or drift, including ripple, more than  $\pm 0.5$  percent during the entire test period. If the combination of maximum rated high dc anode voltage and current produces a dissipation value in excess of the tube type's maximum anode dissipation rating, the current shall be reduced by an amount such that the maximum rated anode dissipation value is acquired without reduction of the rated dc anode voltage.

4.3 High-voltage rectifiers. These tubes shall be tested under dc conditions. A dc potential, corresponding to the maximum rated peak inverse voltage (total dc and peak), will be applied to the cathode or filament. This voltage shall not vary or drift, including ripple, more than  $\pm 0.5$  percent during the entire test period. It is not necessary to energize the heater or filament during this test. The power supply impedance should be a minimum of 3 megohms to prevent arcing which can influence the radiation reading.

## MIL-STD-1311D

4.4 A warm-up period shall be provided for both the tube (excluding rectifiers) and test equipment in order to obtain stable operating conditions before proceeding with measurements.

5. Procedures.

5.1 Survey-meter method.

5.1.1 The background radiation shall be verified at the test position for the test exposure period and corrections to the observed data shall be applied as required.

5.1.2 The specified voltage of 4.2 and 4.3 shall be applied and the specified current of 4.2 shall be adjusted on the TUT. (Rectifiers are generally not tested with forward current.)

5.1.3 The detectors specified for this measurement are normally calibrated to read the radiation level at the center of the detecting chamber. Therefore, the distance from the TUT to the center of the chamber shall be 6 inches. This corresponds to the 4 inches from the external surface of the TUT, to the plastic spacer of the 440 RF/C survey meter. For equivalent equipment with different dimensions, the tube-to-window distance will change. The tube-to-center-of-chamber distance remains constant. The detection device should not be closer than 4 inches at up to 40 kv because of the high-voltage hazard. Appropriate precautions should be taken to prevent corona which could result in spurious readings.

5.1.4 Radiation measurements shall be made at the location of maximum intensity. This point may be found by rotating the tube or the survey meter.

5.1.5 Readings. At the point of maximum radiation, record the maximum stable radiation observed in mR/hr. During any exposure period the voltage and current shall be constantly monitored to insure conformance with 4.2 and 4.3. The maximum allowable radiation limit in mR/hr shall be specified on the TSS.

NOTE: Transient deflections of the survey needle due to unrelated environmental radiation may occur randomly and vary in magnitude. Before a reading is recorded, precaution should be taken to assure that the indication is a steady one due only to the tube being measured.

6. Precautions.

6.1 X-radiation of the soft x-ray category may constitute a health hazard on a prolonged exposure at close range. Therefore, equipment design shall provide for adequate shielding. Adequate precautions shall be taken to protect personnel from this hazard and film badges or other monitoring devices shall be assigned to all personnel involved in performing x-radiation measurements.

6.2 A warning label informing of these precautions shall be placed in an appropriate position on the equipment.

MIL-STD-1311D

METHOD 2204B

## LINEAR AMPLIFIER POWER OUTPUT AND DISTORTION, TWO-TONE METHOD

(Single-Sideband)

1. Purpose. To measure the power output (normally up to 32 MHz) of a linear amplifier with one or two-tone input signals and to measure the intermodulation distortion with two-tone input signals.

1.1 General.

1.2 Procedure 2.1 shall be used for 1-tone power output measurement and 2-tone IM distortion measurement. Procedure 2.2 shall be used for 2-tone power output measurement and 2-tone IM distortion measurement. Procedure 2.1 or 2.2 may be specified. These are grounded cathode tests.

1.3 The following shall be specified on the TSS:

- a. DC voltages applied to the tube elements.
- b. Maximum value for  $R_g$ .
- c. Value for  $R_L$ , with tolerance.
- d. Value for anode loaded tank Q, with tolerance.
- e. Idling anode current ( $I_{bo}$ ) with no rf drive applied.
- f. One tone and/or two tone rf drive level to be applied (in terms of setting for specified grid current, peak grid/cathode voltage (egk), power output, or other as applicable).
- g. Minimum or maximum time to be held under the specified test conditions, if applicable.
- h. Which odd-order IM distortion products are to be measured (3rd, 5th, etc.).

1.4 The test shall be performed using the basic circuit shown on figure 2204-1.

- a. All circuit components, circuitry, layout, construction, and metering shall be in accordance with good engineering practice.
- b. The filament voltage meter and the dc meters used for measuring current and voltage in the grid circuits and the anode circuit, shall be calibrated for 1.0 percent accuracy or better. All calibrations shall be referred to the TUT socket.
- c. The rf test frequency range used shall be specified on the TSS.
- d. The IM distortion of the (two-tone) SSB signal source shall be at least 10 dB better than the corresponding IM limit on the TSS, but never worse than -55 dB. The two tones shall be equal in amplitude, with a tone separation of 1,000 to 2,000 Hz. If audio tones are used to initiate the signal, they shall not be harmonically related.
- e. All power supplies except the anode shall be electronically regulated to 1.0 percent or better for line/load variations.
- f. IM distortion shall be measured with a high-quality spectrum analyzer, or equivalent, referencing only one tone of the two equal-amplitude signals making up the (two-tone) composite signal. The TSS limit(s) shall be interpreted to mean that the maximum amplitude of the IM products shall be the specified number of dB or more below the reference tone.
- g. Power output shall be considered as useful, delivered to the load, and shall be read with 5 percent accuracy or better. If power is computed from  $E_2/R$ , the VTVM used should be a true rms responding and reading instrument or equivalent.
- h. No negative feedback is to be used in the test circuit in figure 2204-1 except the stage may be neutralized if required for stable operation. If neutralization is necessary, it should be adjusted with no anode current flowing and no further adjustment should be made thereafter.

MIL-STD-1311D

2. Procedures.

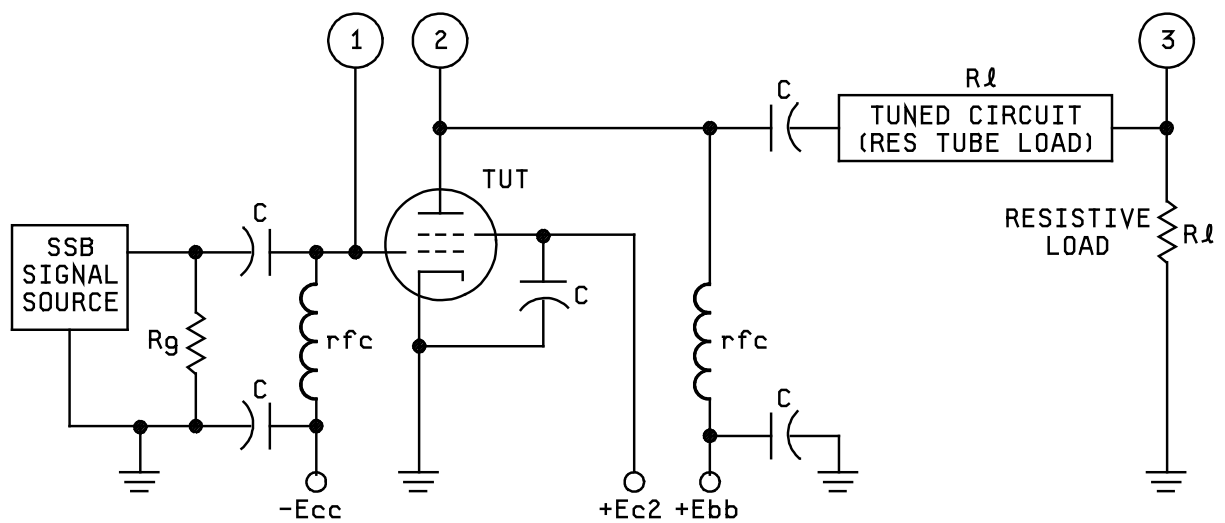
2.1 1-tone power output measurement.  
2-tone IM distortion measurement.

- a. The TUT shall be set to operate under the specified idling conditions. Ibo must be stable before proceeding with the remainder of the tests.
- b. The rf drive applied shall be single tone.
- c. The drive shall be set to the specified level, and a notation made of this level (in terms of egk or other appropriate terms.)
- d. Useful power output shall be read or held for the specified time and read.
- e. The rf drive shall be switched to two-tone, and set to the same peak envelope level as noted in 2.1(c).
- f. The IM distortion products of the amplifier shall be read.

2.2 2-tone power output measurement.  
2-tone IM distortion measurement.

- a. The TUT shall be set to operate under the specified idling conditions. Ibo must be stable before proceeding with the remainder of the test.
- b. The rf drive applied shall be two tone.
- c. The drive shall be set to the specified level.
- d. Useful peak envelope power (PEP) output shall be read or held for the specified time and read. If a power meter which measures average power, for example, a calorimeter or true rms voltmeter is used, PEP is equal to two times the average power output.
- e. The IM distortion products of the amplifier shall be read.

MIL-STD-1311D



## NOTES:

1. IM distortion and drive voltage monitor point.
2. Measure anode load resistance ( $R_l$ ). Remove all voltages on TUT. Use Rx bridge or equivalent.
3. IM distortion and rf power output monitor point.

FIGURE 2204-1. Basic circuit for IM distortion and power output test.

## MIL-STD-1311D

## METHOD 2206

## LINEAR AMPLIFIER POWER OUTPUT AND DISTORTION, WHITE NOISE METHOD

(Single-Sideband)

1. Purpose. To determine the intermodulation (IM) distortion and power output (normally up to 32 MHz) with a white, Gaussian noise signal, that simulates multitone modulation in grounded-cathode linear amplifier service.

1.1 General. A white noise signal of Gaussian amplitude distribution having an insertable narrow notch, located near the center of the channel passband, is applied to the TUT. The level of the applied notched noise signal is set to drive the TUT to the minimum power output level specified on the individual TSS. The noise power output shall be measured in the notch filter bandwidth for both the notch-in and the notch-out conditions. The relative power may be established by switching the notch-out and readjusting the signal for the minimum power output level specified on the individual TSS. Other means that provide an accurate measure of the signal noise power (notch filter out) to IM noise power (notch-in) can be used if equivalent accuracy is shown. The test signal at the TUT shall meet the requirements shown on figure 2206-1 for the notch-in case and the following:

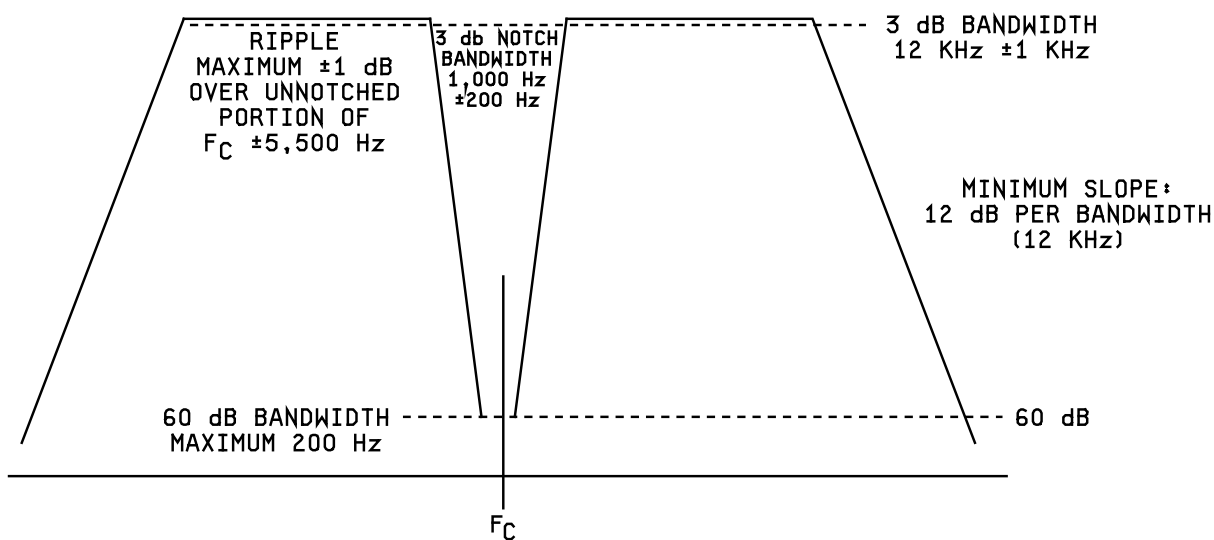
- a. Noise spectrum. The noise generator output shall be flat (constant power per hertz of bandwidth)  $\pm 1$  dB over 100 Hz to 12,000 Hz passband of the test signal.
- b. Noise amplitude distribution. The noise signal amplitude density distribution shall be as indicated below when measured in a narrow window (for example, 0.2 (sigma) where sigma is the standard deviation or rms value of the noise voltage).

<u>Voltage (in sigma)</u>	<u>Amplitude density distribution</u>
0	$0.0796 \pm 0.005$
$\pm 1$	$0.0484 \pm 0.005$
$\pm 2$	$0.0108 \pm 0.003$
$\pm 3$	$0.000898 \pm 0.0002$

- c. The notch-out case is just removal of slot from figure 2206-1. The TUT circuit shall be in general accordance with the provisions of figure 2206-2 and figure 2206-3.
  - d. Signal to IM distortion ratio (S/IMD) is defined as: The ratio of the test signal noise power to that of the IM distortion noise power in the notch, expressed in dB. It should be noted that this number (in dB) may not be identical with that number provided by the NPR-(SSB) test of MIL-STD-188. Noise from causes other than noise intermodulation distortion products also contributes to the spectral content within the cleared portion of a notched noise signal in single sideband or independent sideband equipment output.
  - e. The noise test signal may be initiated at an rf level or an audio level. If an audio noise generator and filters are used, the dynamic range of the frequency translator shall be wide (90 dB) and the phase noise associated with the conversion injection signal shall be sufficiently small so as to not affect the S/IMD measurement.
2. The following shall be specified on the TSS:
- a. DC voltages applied to the tube elements.
  - b. The drive source impedance ( $Z_s$ ) shall be resistive and 1,000 ohms maximum.
  - c. Load resistance ( $R_l$ ) with tolerance.
  - d. Anode tank loaded Q, with tolerance.
  - e. Idling anode current ( $I_{bo}$ ) with no rf drive applied.

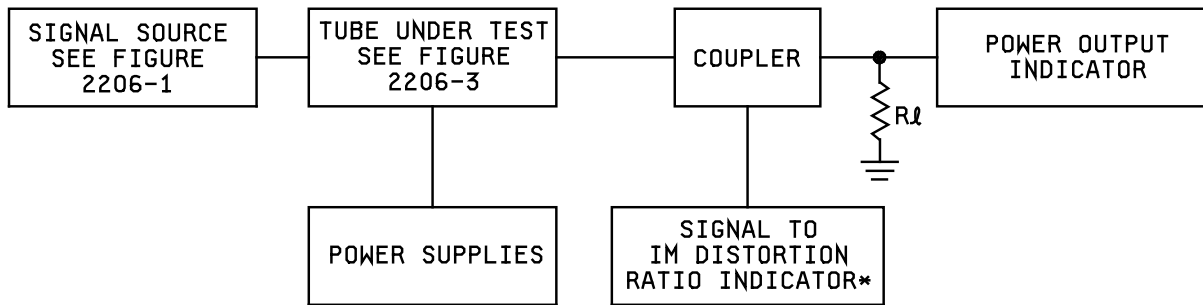
## MIL-STD-1311D

- f. RF drive level to be applied, in terms of anode current, power output, or other as applicable.
  - g. The rf test frequency range used shall be specified on the TSS.
  - h. Minimum or maximum time to be held under the specified test conditions, if applicable.
  - i. Test limit(s) for power output, and if applicable, the signal to IM distortion ratio.
  - j. No negative feedback shall be used except the stage may be neutralized if required for stable operation. If neutralized, it shall be adjusted with no anode current flowing and no adjustments are permitted thereafter.
3. Procedures.
- a. The TUT shall be set to operate under the specified idling conditions. Ibo shall be stable before proceeding with further testing.
  - b. The noise rf drive signal, which meets the requirements detailed in 1.1 and figure 2206-1, is applied and set as specified with the notch-out.
  - c. Power output (useful) is measured in accordance with figure 2206-3, note 6.
  - d. Insert notch-in signal source and readjust drive level for power output measured in c above.
  - e. Signal to IM distortion ratio is determined by comparing the relative noise power with the notch into the signal with the notch-out (at same power output). This may be done with a selective voltmeter (see figure 2206-2) or by any other means which provides an accurate measurement of the ratio.

FIGURE 2206-1. Characteristics of signal source (notch in case).



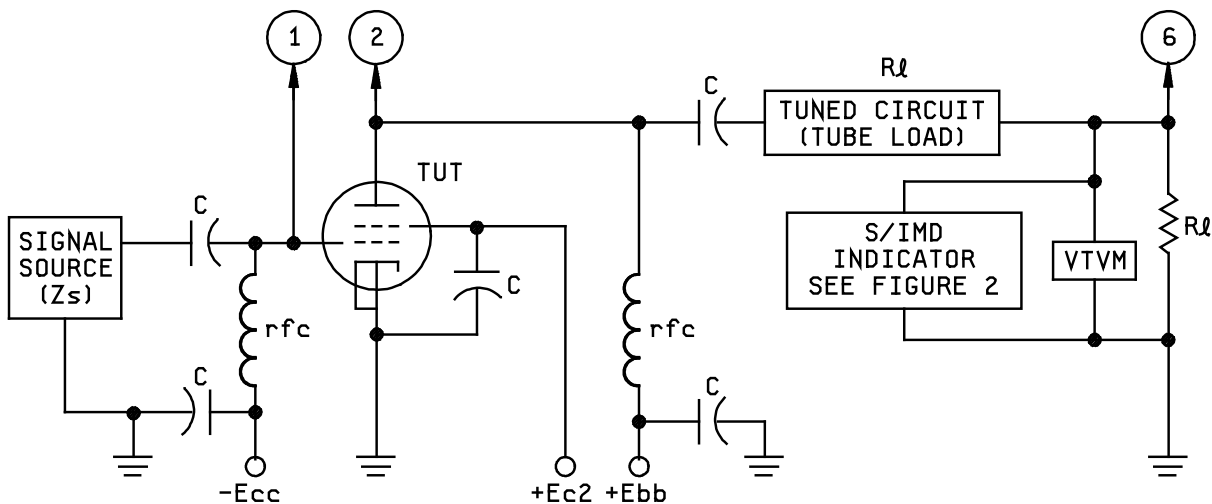
## MIL-STD-1311D



\* Bandwidth requirements: Such that when used in conjunction with the notch or stopband filter in the signal source, the noise signal energy passed is low enough for a dynamic measurement range capability of 50 dB minimum.

\* Bandpass filter: The 3 dB bandwidth of the bandpass filter should be sufficiently wide ( $50 \text{ Hz} \pm 5 \text{ Hz}$ ) to minimize integration time required for a reasonably steady ( $\pm 0.5 \text{ dB}$  typical) meter indication. The 60 dB bandwidth shall be sufficiently narrow ( $100 \text{ Hz} \pm 10 \text{ Hz}$ ) to allow, when used in conjunction with the notch filter, for the measurement dynamic range desired (50 dB minimum). NOTE: A 100 kHz crystal filter design can meet these typical characteristics.

\* Frequency translator: The dynamic range of the frequency translator shall be wide (90 dB typical). NOTE: The phase noise associated with the conversion injection signal shall be sufficiently small so as to not affect the S/IMD measurement.

FIGURE 2206-2. S/IMD measurement.

## NOTES:

1. Signal source monitor point (see figure 2206-1).
2. Measure anode  $R_l$ . Remove all voltages on TUT. Use Rx bridge, vector, voltmeter, or equivalent.
3. All circuit components, circuitry, layout, construction and metering in accordance with good engineering practice.
4. Filament or heater voltage meter, and meters for measuring current and voltage in the anode and grid circuits shall be calibrated for one percent accuracy or better as installed in the equipment.
5. All power supplies except anode electronically regulated one percent or better for line/load variations.
6. VTVM used should be a true rms responding or average, or equivalent, with power output (useful) computed from  $P = E^2/R$ . An equivalent method for measuring power may be used, such as calorimetric methods, provided it is capable of  $\pm 5$  percent accuracy, or better.

FIGURE 2206-3. Basic circuit for signal to IM distortion (S/IMD) and power output test.

## MIL-STD-1311D

## METHOD 2210

## GRID RECOVERY

1. Purpose. To measure the ability of the front-end tube in a receiver to recover after an exceptionally large input signal.
2. Equipment.
  - a. A pulse generator capable of applying a specified pulse to the grid of the TUT.
  - b. An oscilloscope capable of measuring the current undershoot  $\Delta I_b$  compared to the average current that exists between pulses.
  - c. A meter for measuring the average anode current.

NOTE: The average current during pulsing and the steady state between pulses can be considered equal owing to the low-duty factor of the pulse.

3. Procedure. The tube shall operate at the test voltage given under conditions with 10,000 ohms in the anode supply and with grid voltage adjusted for the initial quiescent level of anode current prior to pulsing as specified on the TSS. Apply to the grid, pulses of 20  $\mu$ s duration at a prr of 60 with pulse amplitude as specified on the TSS. Pulsing at this frequency may continue until a stabilized reading is obtained. The  $\Delta I_b$  is a measure of the peak undershoot and  $\Delta I_b$  is defined as the change in average current during pulsing as compared to the initial quiescent level.

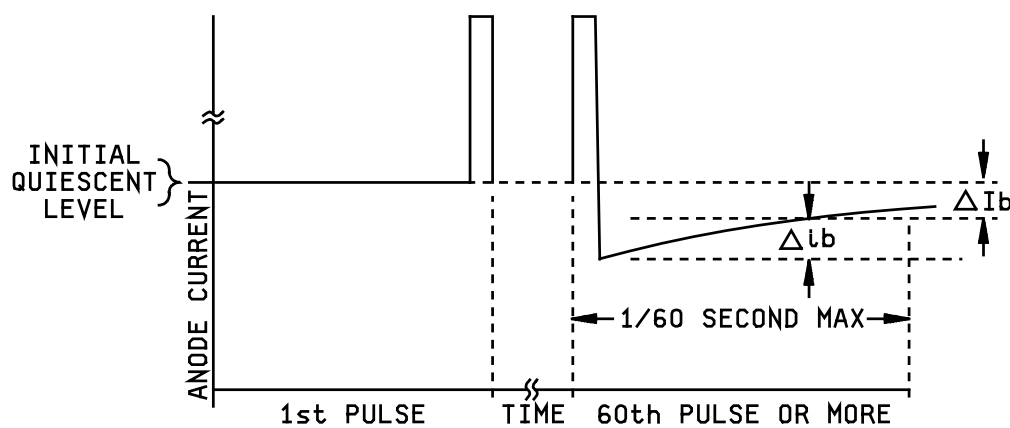


FIGURE 2210-1. Grid pulse characteristics-recovery.

MIL-STD-1311D

METHOD 2212A

PULSE EMISSION

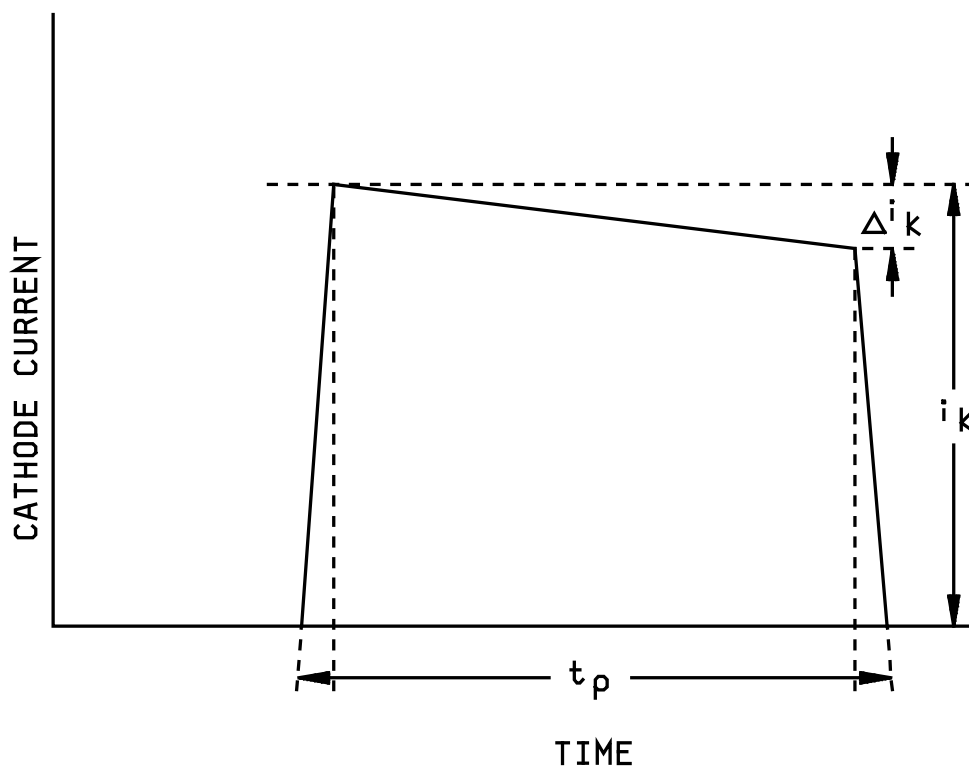
(Transmitting tubes)

1. Procedure. The specified voltages shall be applied to the TUT. An essentially rectangular pulse voltage shall then be applied to the grid. Limits for the following shall be indicated on the TSS:

- a. Duration ( $t_p$ ); maximum.
- b. Time of rise and fall ( $t_r$ ), ( $t_f$ ); maximum.
- c. Slope at top of pulse; maximum.
- d. Ripple; maximum.
- e. Pulse repetition rate (pps).

2. Conditions. The voltage of the applied pulse shall be adjusted to give the specified cathode current,  $i_k$ , at the leading edge of the pulse. The  $\Delta i_k$  from leading to falling edge shall not exceed the value specified (see 2212-1).

3. Equipment. The basic test circuit shown on figure 1372-1 shall be used.



NOTE:  $t_r$  and  $t_f$  cannot be shown on the cathode current/time graph as these values refer only to grid voltage times.

FIGURE 2212-1. Cathode pulse characteristics emission.

## MIL-STD-1311D

## METHOD 2214B

RF USEFUL POWER OUTPUT <sup>1/</sup>

(Power and transmitting tubes)

1. Purpose. To measure that part of the radio frequency output power flowing from the tube output terminals into a dissipative load. Most accurate monitoring can be achieved when the dissipative load is matched to the transmission line in which the power measurements are made. This method is for higher frequency measurements over a frequency range from 225 to 1,250 MHz.

2. Procedure A (for power amplifier).

- a. For circuit, see figure 2214-2.
- b. Neutralization of inherent feedback may be accomplished by known techniques to maintain stable tube operation.
- c. Dotted blocks are optional devices which may be used to initially establish appropriate circuit performance and frequency.
- d. The frequency meter setup shown can be located in either of the two indicated positions in the driver or output side.
- e. The rf input or rf output circuits can be either distributed line such as strip-line, coaxial cavity, lumped parameter amplifiers, etc., as defined in the TSS.
- f. Power measurements should be accomplished by either calorimetric or other suitable power techniques to an accuracy of  $\pm 5$  percent.

2.1 Test procedure.

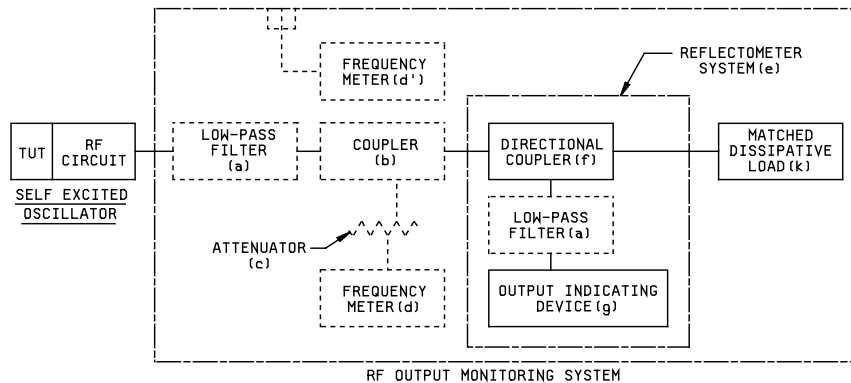
- a. The grid bias is set to the specified value or adjusted for maximum output. If power gain is to be determined, grid bias shall be set to specified value.
- b. The anode and screen supplies are applied and adjusted to the specified values.
- c. The tuning and output coupling are adjusted to obtain the highest possible output power.
- d. If specified, the driving power, or input rf power is given by the difference between the forward and reflected values measured by the reflectometer (see figure 2214-2 test circuit notes).

2.2 Specified TSS test conditions.

- a. Electrode voltages. However, when the TSS does not specify grid bias, the tube may be operated class C, since the cutoff would vary from tube to tube.
- b. Electrode currents or ranges of current.
- c. Frequency of the rf output.
- d. Maximum allowable driving power.
- e. Type of input/output circuit (see 2e above).

<sup>1/</sup> Where the measurement of useful output power is of a linear amplifier, single sideband, HF (normally up to 32 MHz) and precedes an intermodulation distortion (IM) measurement, this method does not apply.

## MIL-STD-1311D

3. Procedure B (for self-excited oscillator).3.1 Circuit schematic.FIGURE 2214-1. Schematic for self-excited oscillator.

NOTE: Above measurement system for an oscillator is similar to the right hand output half of the circuit block diagram shown for the power amplifier (procedure A). Comparable devices are used here for identical reasons defined in the amplifier circuit and test circuit diagram data. Oscillator frequency has to be measured, however, on the output side as there is no driver and oscillation is accomplished by coupling output energy into the input side of the TUT to sustain oscillation.

- a. Dotted blocks are optional devices which may be used to initially establish appropriate circuit performance and frequency.
- b. Power measurements should be accomplished by either calorimetric or other suitable power techniques to an accuracy of  $\pm 5$  percent.

3.2 Test procedure.

- a. The electrode voltages are adjusted to the specified values and the grid current is observed to ensure that it does not exceed the specified value.
- b. The anode-to-grid feedback, and the output coupling are adjusted to obtain the highest possible output at the specified values of anode and grid currents.

3.3 Specified TSS test conditions.

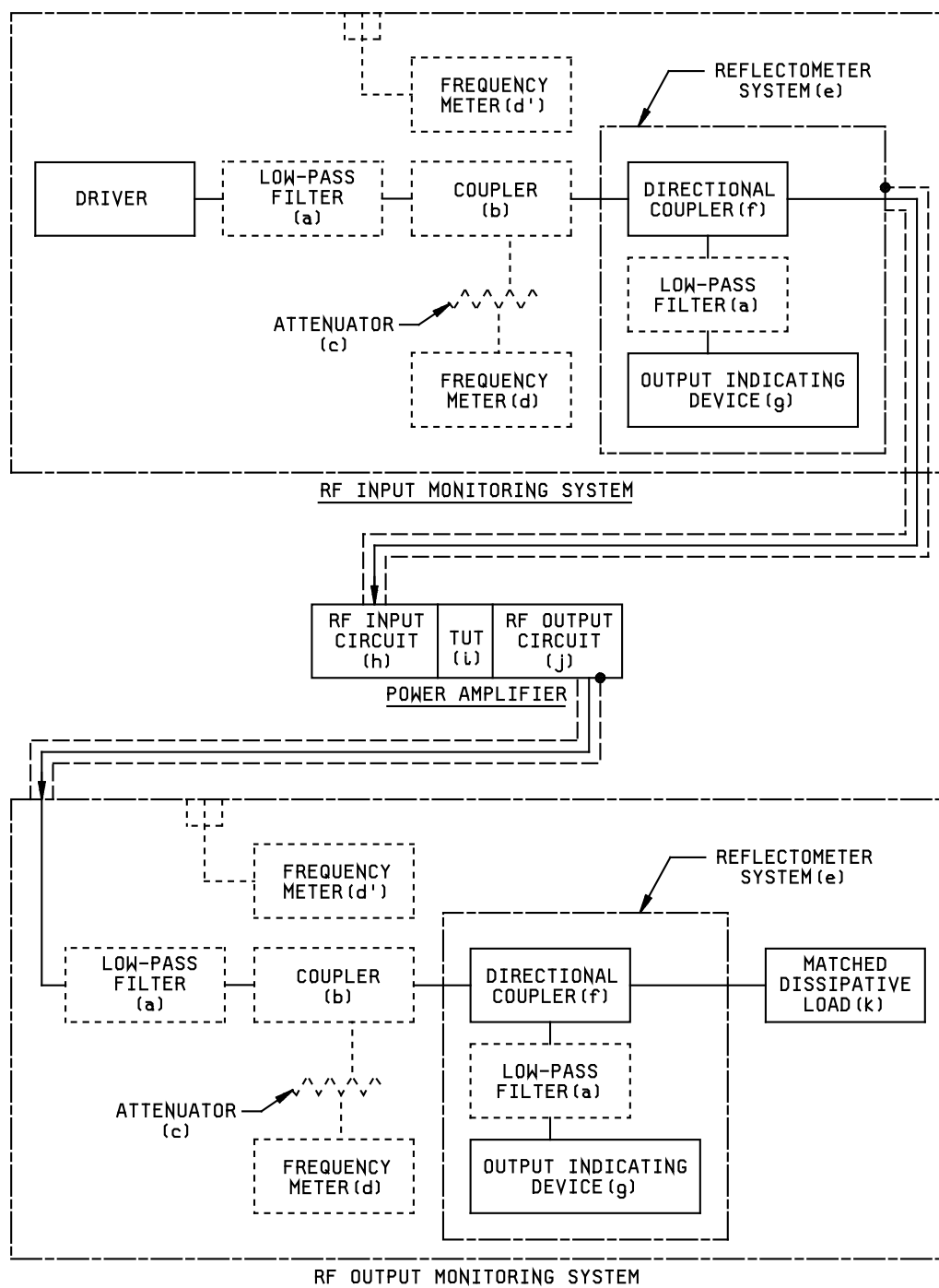
- a. Value of grid bias resistor.
- b. Electrode voltages.
- c. Anode current and range of grid currents.
- d. Frequency of oscillation (may be specified, or higher).

4. Alternative procedures. Procedures alternative to those of procedure A and procedure B are similar except the adjustments are made in order to obtain at least the specified value of output power, the electrode currents being within specified values.

4.1 Alternate specified TSS test conditions.

- a. Electrode voltages and value of grid resistor for oscillator.
- b. Frequency of rf output.
- c. Required level of output power.
- d. Maximum value of anode current.
- e. Range limits for grid (and screen grid) currents.

MIL-STD-1311D



NOTE: Many types of auxiliary instrumentation are used in the measurement of rf drive or output power at the higher rf frequencies. The key circuit devices used in rf power measurements are briefly described and their intended purposes defined for clarity (see figure notes).

FIGURE 2214-2 Schematic for power amplifier.

NOTES:

## MIL-STD-1311D

1. Low-pass filter (a) is an optional device which is suggested for initial evaluation to determine whether the attenuation of spurious or harmonic signals is required. If it is determined that these unwanted signals are negligible, then the low-pass filter can be considered as an optional device and its use can be omitted. If it is determined that these unwanted signals have an effect on the overall tube performance, then the low-pass filter shall be used. In general, the harmonic energy is negligible compared to the fundamental and, thus, low-pass filters are normally not required. Occasionally, couplers or voltage probes will couple more tightly to harmonic signals than the fundamental and, in these instances, a low-pass filter is recommended.

Where it may not be practical to obtain a high-power low-pass filter for some high-power applications. It is then permissible to insert a lower-power filter (in the energy sampling region) between the directional coupler and the output indicating device as shown in the reflectometer system (e).

In some high-power equipment, the detector is built into the directional coupler loop, providing no access for a low-pass filter. In such a case, a spectrum analyzer in conjunction with calorimetric techniques can be used.

2. The frequency can be measured either in the driver or preferably in the output side as indicated in the circuit block diagram. To measure the frequency either of the following devices and methods may be used:

A coupler (b) with a suitable resistance attenuator (c) are necessary to prevent burn-out of the frequency meter (d) due to excessive power coupling. Only the coupler needs to be in series with the driver system.

A portable frequency instrument (d') may be periodically coupled to the rf system through the sensing of radiated energy.

After the frequency has been established, the frequency measuring instrument and/or attenuators may be removed to avoid tying up of an expensive frequency instrument on a permanent basis. A portable frequency instrument, however, should be made readily available to periodically check and verify the frequency specified. The instrument used for measuring the frequency should either have an accuracy of  $\pm 1.0$  percent or meet the frequency tolerances specified in the TSS.

3. A reflectometer system (e) consisting of a one-port forward directional coupler and a one-port reverse directional coupler, its counterpart, a two-port directional coupler, or a one-port directional coupler with a bi-directional rotating plug-in element, any of which are connected to associated readout instrumentation calibrated for either power output or VSWR. These directional couplers are usually connected to an output indicating device or readout device such as a crystal detector or a bolometer detector. In the case where the sampling power level is excessive for crystal or bolometer detectors, the directional coupler can be directly coupled to a calorimetric load and its associated power meter.

The directional coupler (f) and output indicating device are necessary units for measuring the true power (forward minus reverse power) of driver input or output. In the instance where the load matches the transmission line, the net power is equal to the forward power since the reverse power is negligible or zero.

The reflectometer system (e), depending upon the output readout indicating device, can be used to measure either true power output (forward minus reverse power) or voltage standing wave ratio (VSWR). Where the true power of the transmission system is measured, the VSWR can be calculated by using the relationship:

$$\frac{P_r}{P_i} = \left( \frac{r-1}{r+1} \right)^2$$

where  $r = \text{VSWR}$   
 $P_r = \text{reflected power}$   
 $P_i = \text{incident or forward power}$   
 $P_t = \text{true power} = P_i - P_r$

The converse is equally true if VSWR is measured. The true power ( $P_t$ ) can then be calculated by using the same equation and the  $P_t = P_i - P_r$  relationship.

4. The components (h), (i), and (j) represent the input, TUT and output circuits of the power amplifier system.
5. A load (k) providing for a matched dissipative termination absorbs the rf output power of the amplifier system. The correct power dissipated in the load can also be measured calorimetrically. When power is measured calorimetrically, the use of the reflectometer system (directional coupler and output indicating device) is optional.

FIGURE 2214-2. Schematic for power amplifier - Continued.

MIL-STD-1311D  
METHOD 2220  
RESONANT FREQUENCY  
(Obsolescent)

NOTE: This test is normally performed as a "Qualification only" test.

1. Purpose. The purpose of this test is to determine the tube's ability to resonate at a specified frequency.

2. Equipment.

- a. Lecher frame.
- b. Oscillator (or signal generator) loosely coupled to the Lecher frame.
- c. Grid current meter (or auxiliary Lecher line with voltage detector).

NOTE: Drawing 244-JAN indicates 900-MHz resonant frequency test equipment for subminiature tubes.

3. Procedure.

- a. Connect the nonoperating tube to the open end of the Lecher frame. The specified pins shall be attached to the Lecher wires (lines) or rods. The diameter and spacing of the Lecher wires (lines) or rods shall be as specified on the TSS.
- b. The oscillator shall be tuned to the frequency specified.

4. Measurements. At resonance, the distance between the base of the TUT and the Lecher frame shunt shall be not less than the specified minimum limit.



MIL-STD-1311D

METHOD 3201

IONIZATION CHARACTERISTICS

(Thyratron, Gas)

Limits specified for grid voltage shall apply when the common point of the anode and grid circuits is the cathode, or, in filamentary types, is the midtap of the filament transformer or the midpoint of the filament, if present.

1. Critical grid voltage for conduction. Under the conditions specified, the control-grid voltage shall be changed in a positive direction until the tube starts to conduct current. The grid voltage measured at the grid-voltage supply required to cause conduction shall be within the limit(s) specified.

2. Critical anode voltage for conduction. Under the conditions specified on the TSS, the anode voltage shall be increased until the tube starts to conduct current. The anode voltage required shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 3202

REPETITIVE STRIKING VOLTAGE

(Gas rectifiers)

The tube shall conduct the specified anode current,  $I_o$ , for at least 1 minute after which the striking voltage shall be measured.

MIL-STD-1311D

METHOD 3204

VOLTAGE DROP

(Thyratron)

This test shall be performed under the conditions specified. The anode voltage shall be applied for a minimum of 1.0 second. The potential drop between anode and cathode shall be within the limit(s) specified. For filamentary types, the measurement shall be made between the anode and electrical center of the filament circuit.

MIL-STD-1311D

METHOD 3206

OPERATION

(Thyratron)

The tube shall be operated under the specified conditions for which the anode supply shall be a reversing voltage. The tube shall be in a state of conduction at the specified minimum grid supply voltage (positive going direction) and conduction shall cease to reoccur before the specified maximum grid supply voltage (negative going direction) is reached.

MIL-STD-1311D

METHOD 3211

COLD-GAS CONDUCTION

(Thyratron)

The anode voltage shall be applied between anode and grid with the grid approximately at ground potential. The anode resistor shall be adjacent to the anode and no connection shall be made to the filament (or cathode). The temperature of all parts of the tube shall be between 15°C and 50°C. The frequency of the anode supply voltage shall not exceed 150 Hz. At the minimum limit specified for the anode-supply voltage, or less, not more than two flash discharges of any nature shall occur. Between the minimum and maximum limits specified for the anode-supply voltage, the tube shall conduct the specified current for at least 1 second, or shall conduct three or more flashes of current.

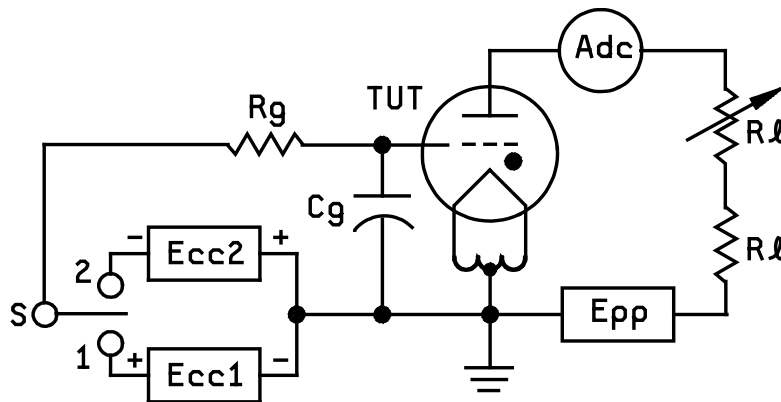
## MIL-STD-1311D

## METHOD 3214

## HIGH FREQUENCY OPERATION

(Thyratron)

1. Purpose. The purpose of this test is to determine:
  - a. Whether the tube would have full grid control up to the specified minimum frequency (maximum deionization time) rating.
  - b. Whether the tube has the proper gas pressure as evidenced by the maximum cutoff frequency.
2. Equipment. The basic test circuit shown on figure 3214-1 shall be used. The circuit parameters shall be as specified on the individual TSS.

FIGURE 3214-1. High-frequency operation.

3. Procedure. The frequency of the anode voltage supply (Epp) shall be set well above the maximum limit specified on the TSS with the specified positive bias on the tube. Switch (S) is in position 1.
  - a. The value of the anode voltage supply and series anode resistor shall then be adjusted for the specified operating conditions while the tube is conducting.
  - b. Switch the position 2 and reduce the frequency of the anode supply voltage until the tube cuts off.
4. Acceptance criteria. The frequency at the cutoff point shall be within the limit(s) specified on the TSS.

MIL-STD-1311D

METHOD 3216

GRID CURRENT

(Thyratron)

1. With the tube operating under the specified conditions, for which the anode supply shall be a reversing voltage, the grid bias shall be increased in a negative direction to a value, Ecco (1), at which the tube just cuts off. The negative grid bias shall then be made zero, and the specified grid resistance shall be reduced to 10,000 ohms, and the anode current readjusted to the value specified. The grid bias shall again be increased in a negative direction to cutoff, Ecco (2). The grid current shall be computed from the following formula:

$$I_c \text{ (in } \mu A \text{ dc)} = \frac{Ecco(1) - Ecco(2) \text{ (in volts)}}{\Delta R_g \text{ (in Meg)}}$$

2. The grid current as determined in accordance with 1 above, shall not exceed the maximum limit specified.

MIL-STD-1311D

METHOD 3241

HEATER CURRENT

(Thyratron)

1. Heater current (cathode).

1.1 Nonreservoir type. With the specified voltage applied to the heater, the resulting current, after equilibrium temperature is reached, shall be within the limit(s) specified. During this test, no other element shall be conducting.

1.2 Reservoir type. With the specified voltage applied to the heater terminals of a tube having an internally connected reservoir, the resulting current after equilibrium temperature is reached, shall be within the limit(s) specified. If the tube has an adjustable reservoir, the test shall be performed with the reservoir voltage set as specified under the particular or general test conditions. During this test no other element shall be conducting.

2. Heater current (reservoir). With the cathode-heater voltage set as specified and the specified voltage applied to the reservoir heater, the resulting reservoir-heater current, after equilibrium temperature is reached, shall be within the limit(s) specified. During this test no other element shall be conducting.



## MIL-STD-1311D

## METHOD 3246A

## HYDROGEN THYRATRON OPERATION

1. Test procedures. Hydrogen thyratrons shall be tested in the basic circuit shown on figure 3246-1. The tube shall be tested in a circuit constructed to produce the conditions specified on the TSS. The conditions specified in 4.12 (Definitions and instructions for pulse modulators and pulse diodes) are only for the purpose of determining circuit constants. The actual operating voltages and repetition rates for each test are specified under the particular conditions or under general test conditions. Tests performed at repetition rates less than the resonant charging rate shall be made with a charging diode. The anode power supply shall be capable of being varied from zero to the maximum voltage required and the grid drive shall be adjustable as required. The tube shall operate as specified.

During operation tests, the specified number of kick-outs as a result of continuous conduction shall not be exceeded and there shall be no evidence of detrimental anode heating.

1.1 Tubes with hydrogen reservoirs having adjustable reservoir heater voltage shall be operated at the specified reservoir heater voltage marked on the tube.

1.2 Tubes with hydrogen reservoirs connected internally to the heater shall be operated at the specified heater voltage.

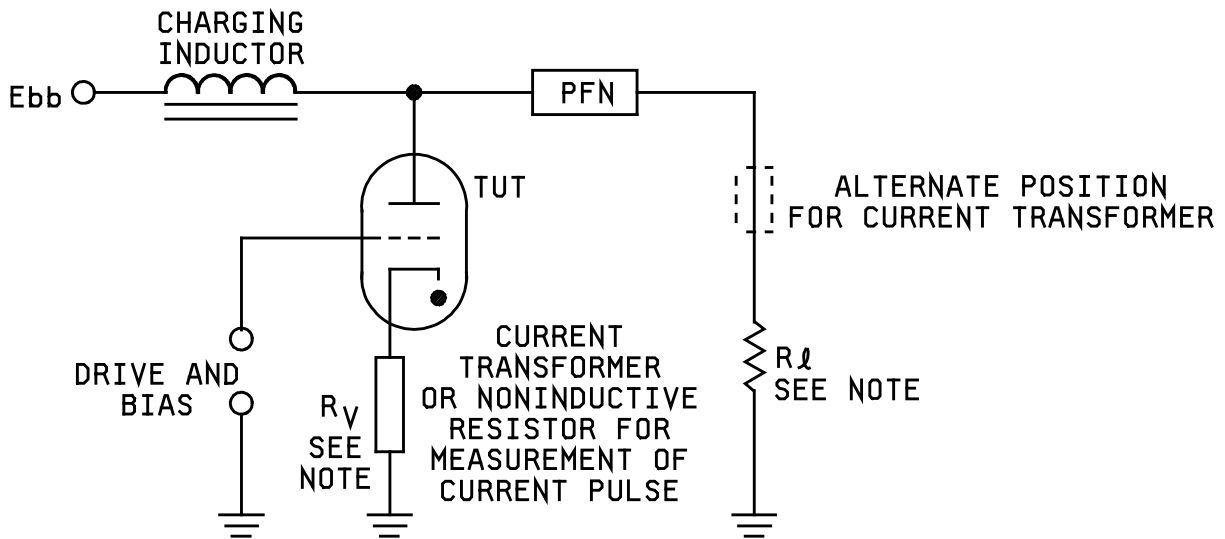
2. Operation at elevated ambient temperature. Elevated ambient temperature tests shall be made at the operating conditions and ambient temperatures specified on the TSS. Not more than three breakdowns shall be permitted during the entire operating period.

- a. Tubes without reservoirs shall be operated at the bogey-filament voltage for the entire operating period.
- b. Tubes with reservoirs tied directly across the heater shall be operated at the upper limit for heater voltage for the entire operating period.
- c. Tubes with a separate reservoir lead shall be operated at the high end of the reservoir range.

3. Operation of optimum reservoir voltage. This test is performed to determine compliance with the reservoir voltage when marked. The procedure for the test shall be as follows:

- a. Set up the trigger and anode circuits for operation under operation test conditions.
- b. Set the reservoir voltage at the value specified on the TSS.
- c. After the specified warm-up period, apply the trigger voltage to the grid of the tube. Start the anode voltage at the minimum position of the voltage control and raise the voltage until the specified epy has been reached.
- d. The tube shall operate continuously for the time specified without evidence of arc-back or anode heating.
- e. The value marked on the base shall be within the limit(s) specified on the TSS.

MIL-STD-1311D



NOTE: Include  $R_v$  as part of  $R_l$ .

FIGURE 3246-1. Basic modulator test circuit for hydrogen thyratrons.

MIL-STD-1311D

METHOD 3247

DC ANODE VOLTAGE FOR CONDUCTION

1. Procedure. The dc anode voltage test shall be performed in the same circuit as the operation test of method 3246 and within 60 seconds following the conclusion of the operation test. Under the conditions specified, the anode voltage shall be increased until the tube starts to conduct current. The dc anode voltage required shall be within the limit(s) specified on the TSS.

## MIL-STD-1311D

## METHOD 3249

## OPERATION, HYDROGEN DIODES

Cathode and reservoir heaters shall be operated at the voltages specified. During operation, the specified number of rejectable arc-backs (for rectifiers) and arc-backs due to voltage hold-off deficiency (for other diodes) shall not be exceeded and there shall be no evidence of detrimental anode heating.

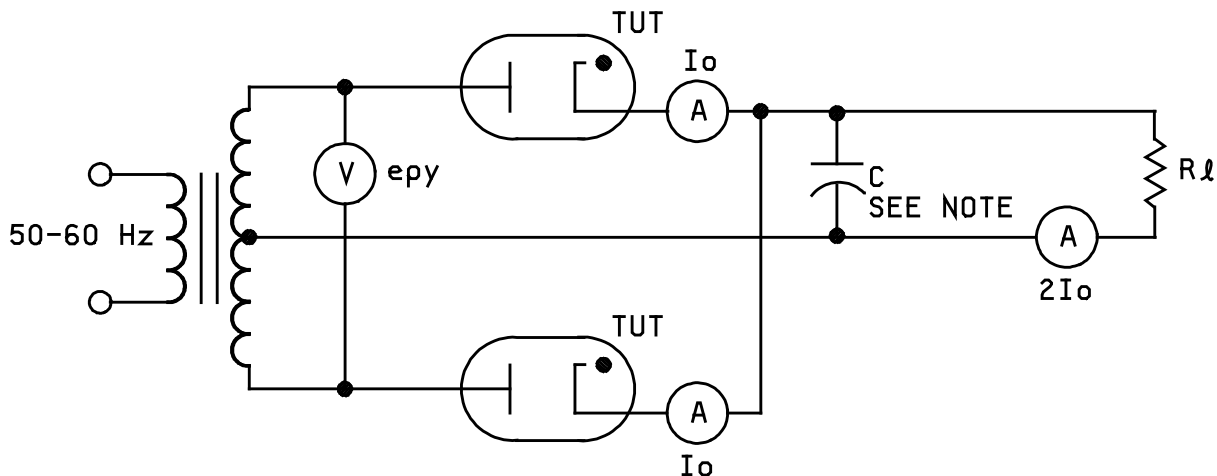
1. Rectifier operation. Each tube shall operate satisfactorily and without rejectable arc-backs in the full-wave rectifier circuit shown on figure 3249-1 under the conditions specified. A rejectable arc-back is one which has a current in the reverse direction whose peak value is not less than five times the peak forward anode current obtained during this test. In the test circuit, the source impedance shall be such that the peak value of the steady-state current in the shorting circuit, when all tubes are short circuited, shall not be less than 7.5 times the peak forward anode current obtained during this test. The arc-back detector shall be capable of detecting a rejectable arc current whose duration is equal to or greater than one-quarter cycle of the frequency of the applied voltage. Unless otherwise specified, the frequency of operation shall be 50 to 60 Hz.

2. Clipper diode operation. Clipper diodes shall be tested in a thyatron modulator circuit shown on figure 3249-2 under the conditions specified for epy, ib, tp, prr, and the resonant prr (resonant charging frequency).

3. Pulse transformer backswing diode operation. Pulse transformer backswing diode shall be operated in the thyatron pulse modulator circuit shown on figure 3249-3 to give the conditions specified for ep<sub>x</sub>, ib, tp, and prr.

4. Charging diode operation. Charging diodes shall be operated on a thyatron pulse modulator circuit as shown on figure 3249-4 under the specified conditions of epy, ib, ip, pulse repetition rate, and resonant prr (resonant charging frequency).

5. Hydrogen diodes may be operated simultaneously provided all electrical conditions are met for the individual operation and life-test requirements, for example, tubes may be operated in a pulse modular circuit; one as a charging diode, one as a clipper diode, one as a clipper, and one as a backswing pulse transformer diode, or any combination.



NOTE: Value of capacitor adjusted to yield ib as specified.

FIGURE 3249-1 Circuit for operation of rectifiers.

MIL-STD-1311D

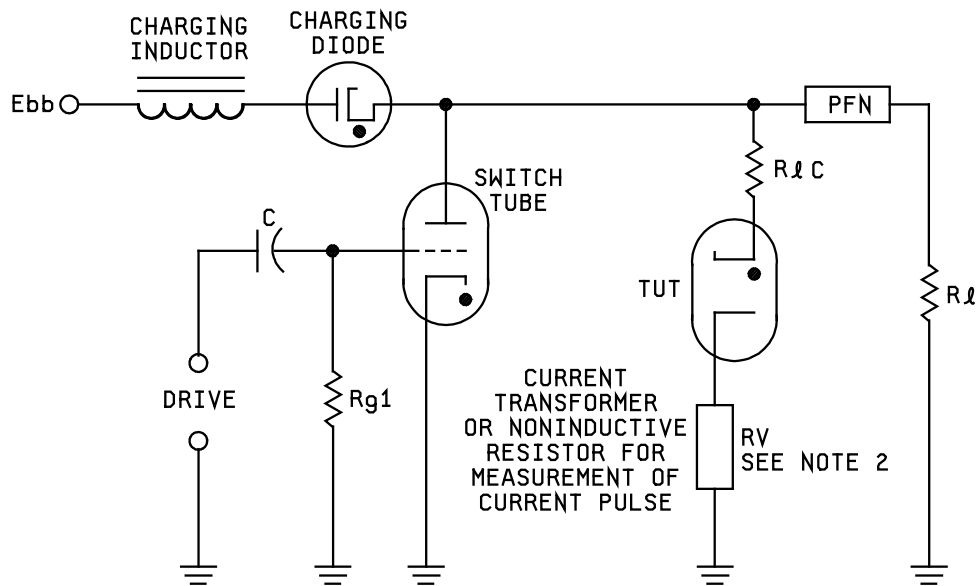
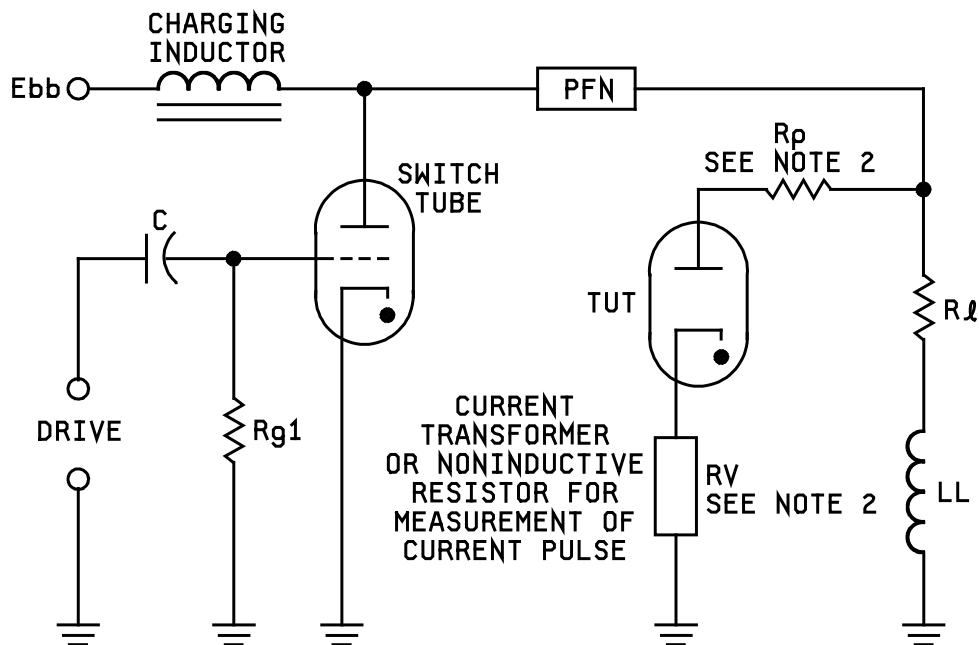


FIGURE 3249-2. Circuit for operation of line clipper diodes.

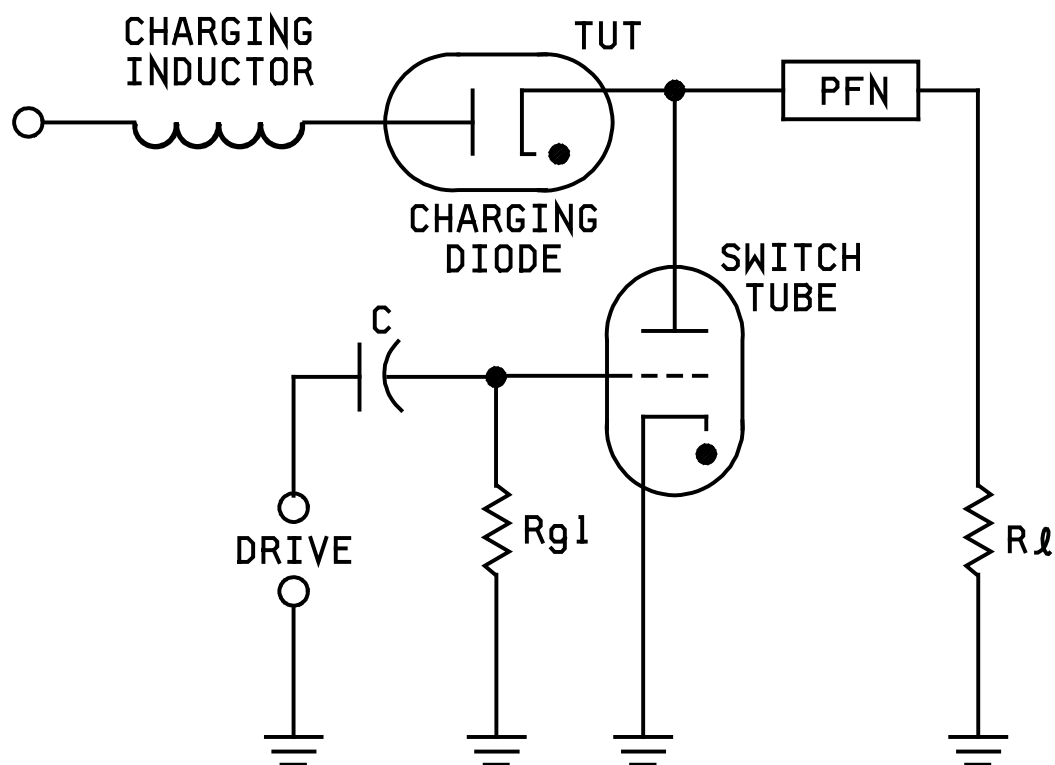


NOTES:

1. Use of charging diode between charging choke and switch tube is optional.
2. Include  $RV$  as part of  $R/C$  (figure 3249-2) or  $R_p$  (figure 3249-3).

FIGURE 3249-3 Circuit for operation of pulse transformer backswing diode current.

MIL-STD-1311D

FIGURE 3249-4. Circuit for operation of charging diode.

MIL-STD-1311D

METHOD 3251A

PULSE EMISSION

(Hydrogen thyatron)

1. Pulse emission (method A). This test is performed in circuit on figure 3251-1. The emission quality is determined by measuring the grid-cathode voltage during a pulse of current discharged from the pulse forming network. Test conditions shall be as specified on the TSS.

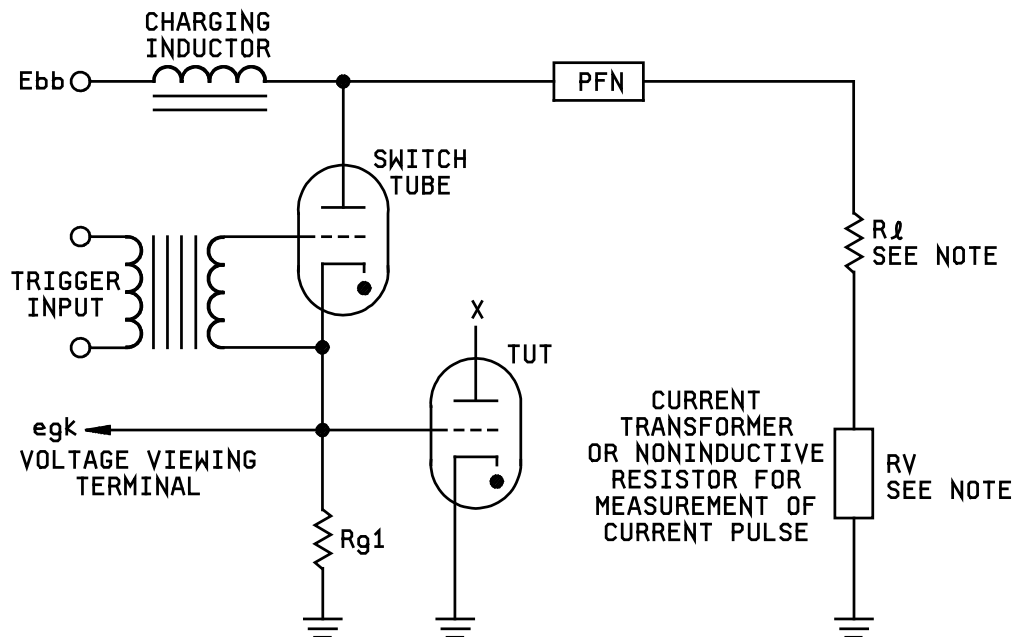
1.1 With the anode floating, a positive pulse shall be applied to the grid of the TUT or the pulse shall be applied to the anode with a 1-ohm resistance between grid and anode. Voltage (egk) shall be measured as shown on figure 3251-2 between the grid and cathode (anode and cathode in case of the alternate connection) at a point in time not later than the value specified on the TSS after beginning of current pulse. The voltage shall be within the limit(s) for egk specified on the TSS whether the anode or grid voltage is measured and the voltage shall not rise during the conduction time following the point of measurement.

2. Pulse emission (method B). The tube shall be tested for pulse emission in the circuit shown on figure 3251-3. The emission quality is determined by measuring the grid cathode voltage during a pulse of current discharged from an appropriate pulse generator. Test conditions shall be as specified on the TSS.

2.1 If positive "keep-alive" current is specified on the TSS, it shall be drawn to the grid, with the isolating diode connected to the grid as shown on figure 3251-3. In tubes equipped with an additional or "keep-alive" electrode, the isolating diode shall be connected directly to that electrode.

2.2 A positive pulse shall be applied to the grid of the TUT. Voltage (egk) shall be measured as shown on figure 3251-2 between the grid and cathode at a point in time not later than the value specified on the TSS after the beginning of the current pulse. The voltage shall be within the limit(s) specified on the TSS and the voltage shall not rise during the conduction time following the point of measurement.

NOTE: The TSS shall specify either method A or B.



NOTE: Include RV as part of  $R_l$ .

FIGURE 3251-1. Pulse emission test circuit.

MIL-STD-1311D

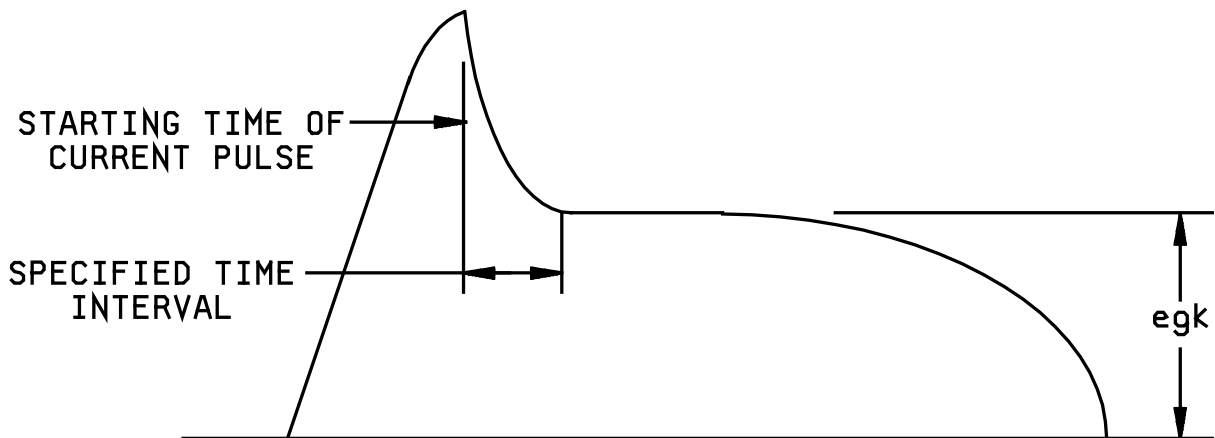


FIGURE 3251-2. Positive grid pulse (emission test).

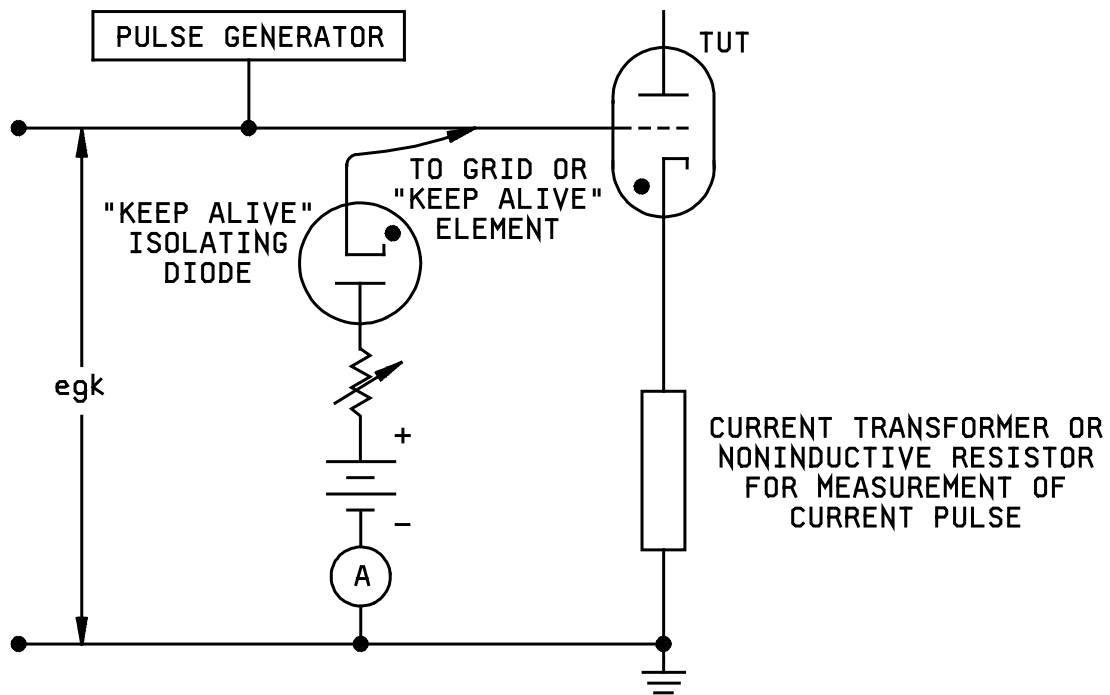


FIGURE 3251-3. Pulse emission for TUT with "Keep alive" or ignitor current.



## MIL-STD-1311D

## METHOD 3256

## ANODE DELAY TIME

These tests are measurements of the time interval anode delay time (tad) between the 25-percent point on the rising portion of the unloaded grid pulse and the point where anode conduction takes place as shown on figure 3256-1. In multigrid tubes, the reference grid shall be that which receives the last pulse.

1. Anode delay time. The tad measurement shall be made at the end of the specified period of operation. If a measurement of anode delay time drift is also required, operation of TUT shall be continued.
  - a. After completion of the initial tad reading, continue the tube in operation under the same conditions.
  - b. After a specified time duration (measured from beginning of the tad measurement), make another measurement of the tad.
  - c. The difference between the initial and second tad readings is the  $\Delta t_{ad}$  and shall not exceed the specified maximum value.
2. Anode delay time drift. This test is a measurement of the change in anode delay time caused by continued operation of the tube.

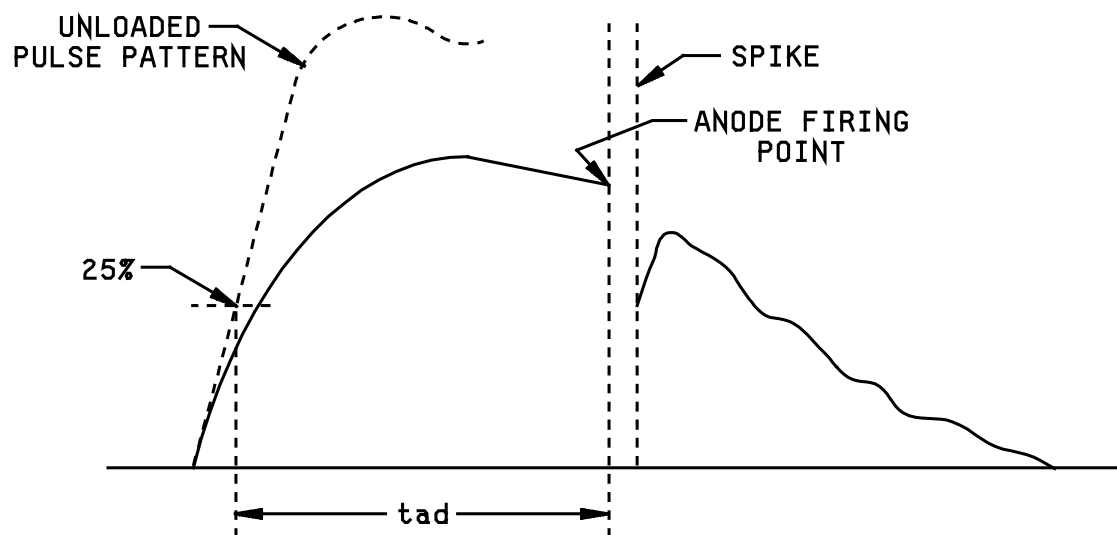


FIGURE 3256-1. Grid pulse (anode conducting).

MIL-STD-1311D

METHOD 3261

TIME JITTER

This test is a measurement of the variation in anode firing time. Time jitter shall be determined by examining the scope presentation of the cathode current pulse as shown on figure 3261-1 and shall be measured at 50 percent of the pulse amplitude and shall not exceed the specified limit. In multigrid tubes, the time jitter shall be measured with respect to the trigger on the grid that receives the last pulse.

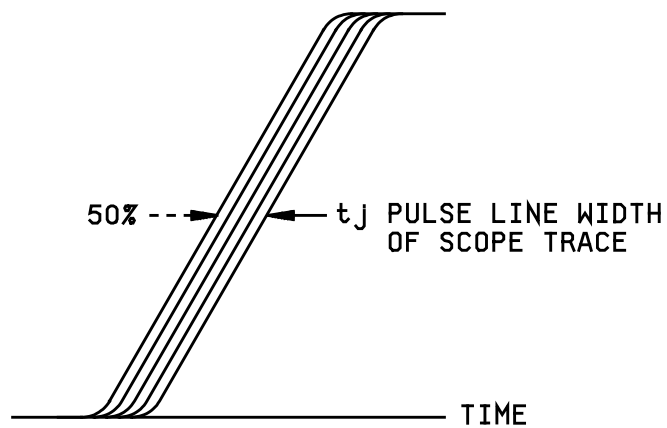


FIGURE 3261-1. Cathode current pulse (leading edge) - time jitter.

MIL-STD-1311D

METHOD 3265

HYDROGEN DIODE IONIZATION VOLTAGE

1. Operation. The tube shall be operated in the circuit as specified on the TSS. Raise the voltage applied to the tube until the tube goes into conduction. EZ shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 3267A

INSTANTANEOUS STARTING

(Hydrogen pulse modulators)

NOTE: This test shall be the first high-voltage test to be conducted after the specified holding period.

1. No voltages shall be applied prior to the start of this test. Filament and reservoir voltages shall be applied for the specified warm-up time, and grid drive voltage shall be applied not more than 10 seconds in advance of the application of anode voltage. The filter in the anode power supply shall be such that epy rises from zero to the specified value within .03 seconds. Intervals between successive attempts shall be not less than 10 seconds nor more than 30 seconds.
2. The tube shall operate satisfactorily with the anode voltage applied. Any tube failing to start or continue to operate for at least 10 seconds within the maximum number of trials specified shall be considered a failure.
3. The circuit indicated in figure 3246-1 shall be used when conducting this test.

MIL-STD-1311D

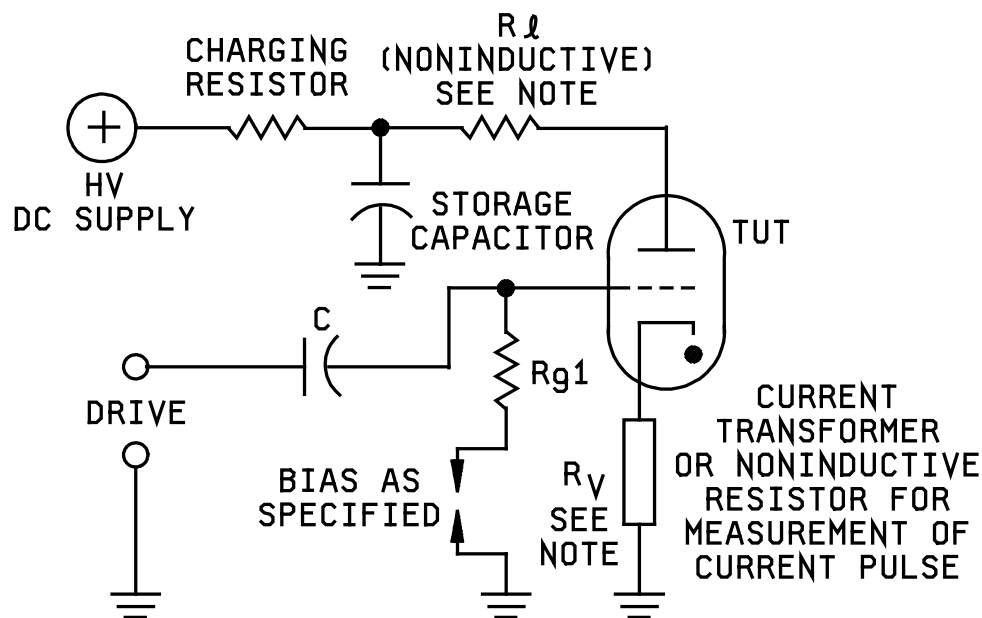
METHOD 3268B

## ENERGY DIVERTER (CROWBAR) OPERATION

(Hydrogen modulators)

1. Energy diverter operation. In the test circuit as shown on figure 3268-1 the anode voltage shall be maintained and the tube triggered as specified. A tube which fires without being triggered is a failure. A tube which does not fire when triggered is also a failure.

2. Energy diverter anode delay time. Under the operation test conditions, the energy diverter anode delay time shall not exceed the specified value. The anode delay time shall be measured from the 25 percent point of the unloaded single pulse trigger to the start of the anode current pulse.



NOTE: : Include  $R_v$  as part of  $R_l$ .

FIGURE 3268-1. Basic energy diverter thyatron operation test circuit.

MIL-STD-1311D

METHOD 3269

OPERATION OF VACUUM MODULATORS

The electrical potentials specified on the TSS shall be applied to the tube. Negative-grid voltage shall be applied to cut off the anode current. The cathode shall be preheated for the specified warm-up time before grid pulse is applied. The duration of the test, excluding preheating, shall be as specified. The grid pulse (in time duration, excluding time of rise and time of fall) shall be as specified. There shall be no evidence of arcing during the last half of this test.

MIL-STD-1311D

METHOD 3270

GRID PULSE

(Vacuum modulators)

Vacuum modulator tubes shall be tested as shown on figure 3270-1.

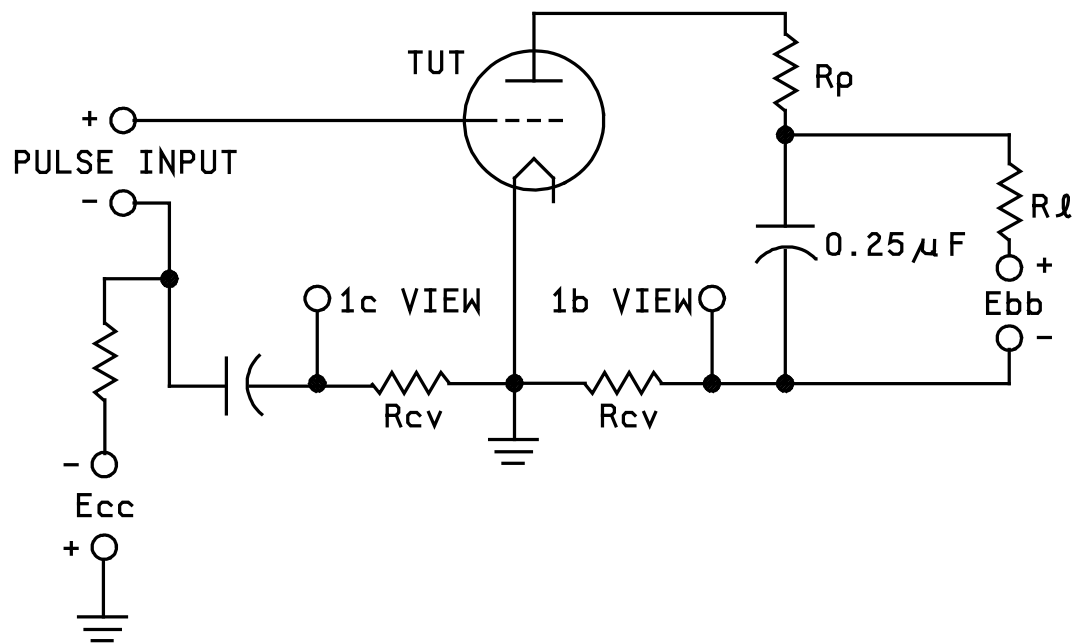


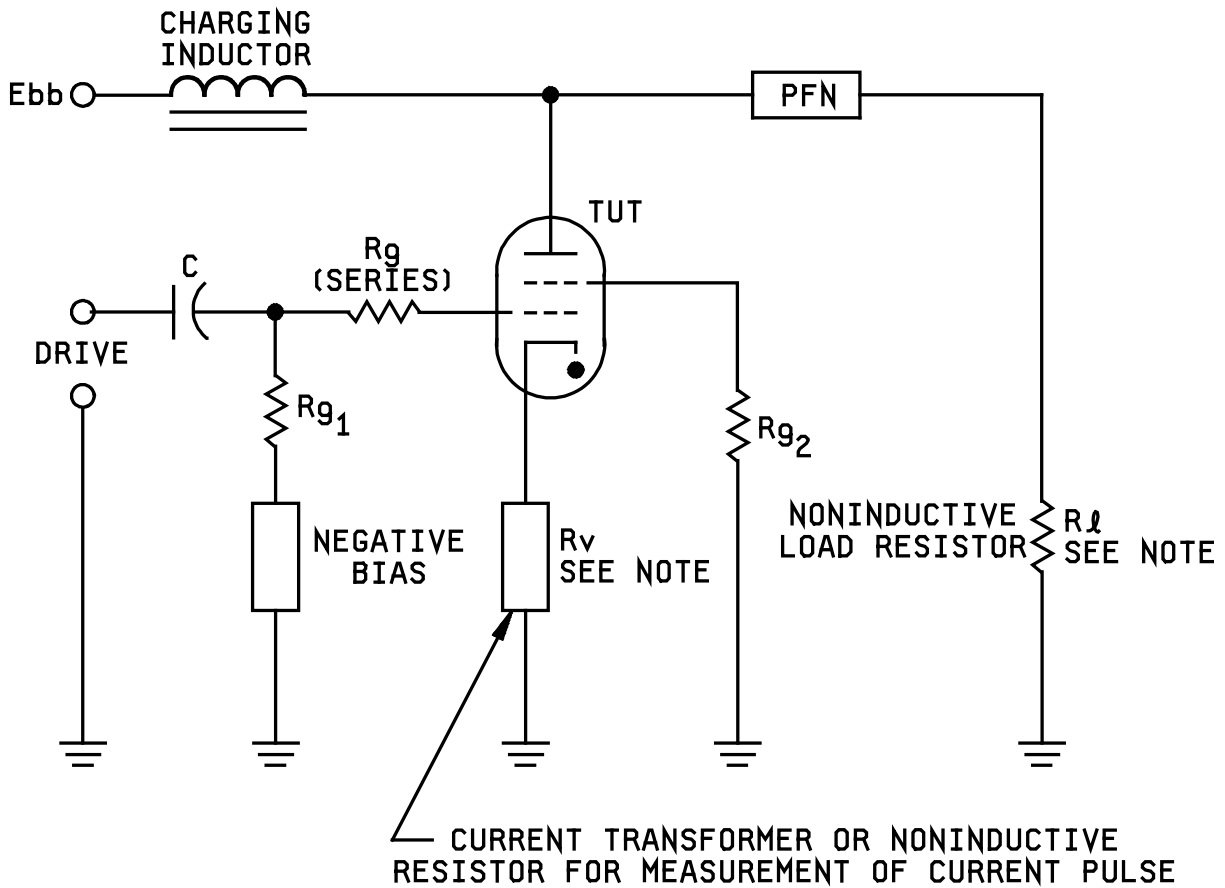
FIGURE 3270-1. Grid pulse test, modulator tubes, vacuum.

MIL-STD-1311D

METHOD 3272

## MODULATOR TEST, SHIELD GRID NEGATIVE BIAS TETRODE THYRATRONS

Shield grid negative bias tetrodes. Shield grid negative bias tetrode thyratrons shall be tested in the basic circuit shown on figure 3272-1.



NOTE: Include  $R_v$  as part of  $R_l$ .

FIGURE 3272-1. Basic modulator circuit for shield grid negative bias tetrode thyratrons.

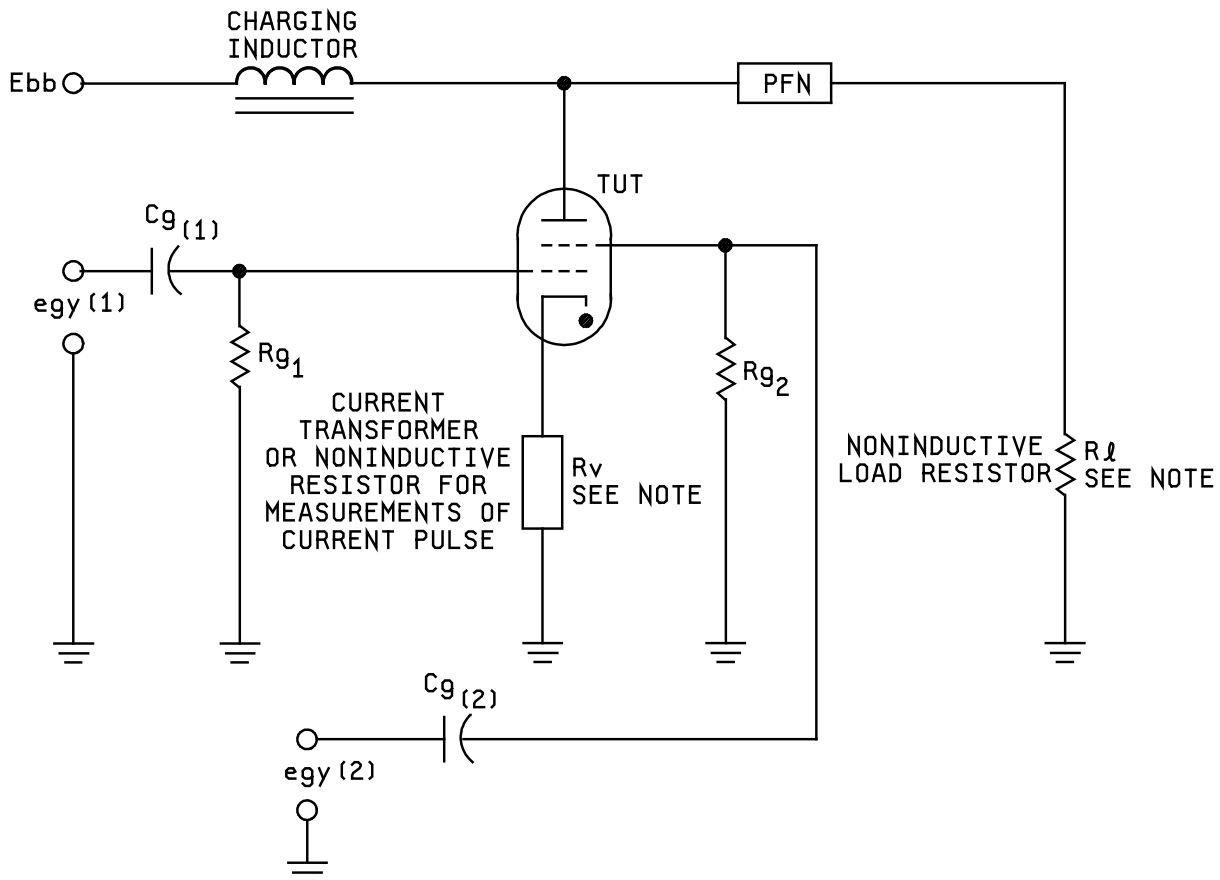


MIL-STD-1311D

METHOD 3273

## MODULATOR TEST, DUAL CONTROL GRID TETRODE THYRATRONS

Dual control grid tetrodes. Dual control grid tetrode thyratrons shall be tested in the basic circuit shown on figure 3273-1. The respective grid drive amplitude and phasing shall be as specified on the TSS.



NOTE: Include  $R_v$  as part of  $R_L$ .

FIGURE 3273-1. Basic modulator circuit for dual control grid switch tubes.

MIL-STD-1311D

METHOD 3278A

NOISE AND OSCILLATION

(Cold cathode discharge types)

Test equipment. The tube shall be operated from a well-filtered variable dc supply, the output capacitance of which shall be at least 16  $\mu$ F. The voltage from the filter output shall be supplied to the tube through a series resistance R1 of 500 ohms. The internal connection between the base pins shall be connected in series with one of the tube electrodes. The test circuit is shown on figure 3278-1. The tube shall be coupled through a series capacitance of 0.1  $\mu$ F to the amplifier. The amplifier shall have an output within  $\pm 5$  dB of its 400 Hz response, over the frequency range of 60 to 5,000 Hz, and shall be capable of producing undistorted output when an input signal is 10 times the calibrating rms voltage. A commercial dynamic loudspeaker, with a rating of at least 2.5 watts and of low impedance, shall be matched to the amplifier and properly excited.

1. Oscillation test. The amplifier gain shall be adjusted for 50 mW output when the specified calibrating signal voltage at 400 Hz is applied to the amplifier input. The current through the tube shall be varied in each direction between the minimum and the maximum specified values, using either voltage or load variation, and taking not less than 2 seconds to traverse the range. No oscillation persisting over a current range of more than 2 mA dc shall be generated as evidenced by aural observations.

2. Noise test. With the conduction current reduced to the value specified, the tube shall be tapped as specified in method 1201 for tap shorts; tapping procedure for receiving tubes, or the tapping procedure for other than receiving tubes. The amplifier gain shall be adjusted for 50-mW output when the maximum voltage limit specified is applied at 400 Hz to the amplifier input. Tubes producing a voltage disturbance to the amplifier which exceeds the specified limit shall be rejected.

MIL-STD-1311D

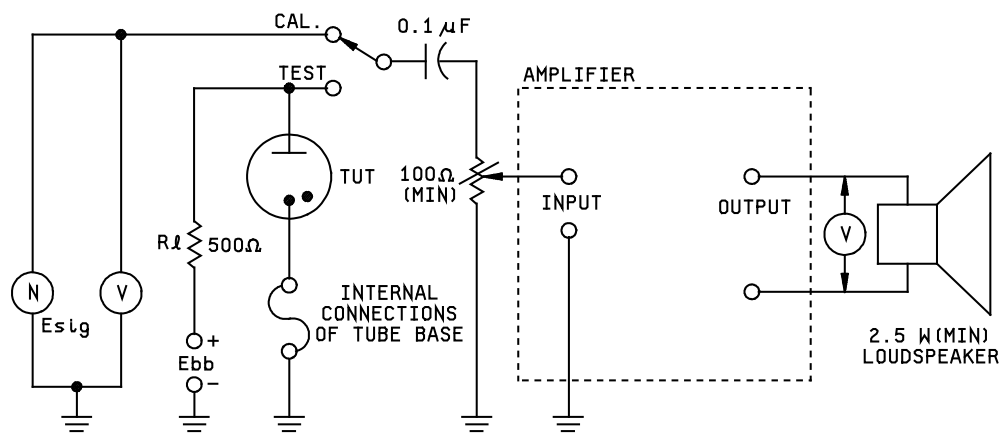


FIGURE 3278-1. Noise and oscillation test.

MIL-STD-1311D

METHOD 3305

LEAKAGE CURRENT

(Voltage regulator types)

The tube shall be tested for leakage current by applying the specified anode potential which is below the ionization potential. The total external circuit resistance shall not exceed 100,000 ohms. The anode current shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 3333

UNIFORMITY OF CATHODE GLOW

(Cold cathode and graphic indicator tubes)

Under the conditions specified on the TSS, the cathode glow shall be substantially uniform over the cathode surface.

MIL-STD-1311D

METHOD 3335

REGULATION

(Cold cathode discharge types)

The voltage drop across the tube shall be measured under two different conditions. First, while conducting a specified minimum current; and second, while conducting a specified maximum current. The difference between the two voltages shall be within the limit(s) specified for regulation.

MIL-STD-1311D

METHOD 3337

VOLTAGE DROP

(Cold cathode discharge types)

Under the specified conditions and with the tube conducting current for at least 0.1 second, the tube voltage drop shall be within the limit(s) specified.

## MIL-STD-1311D

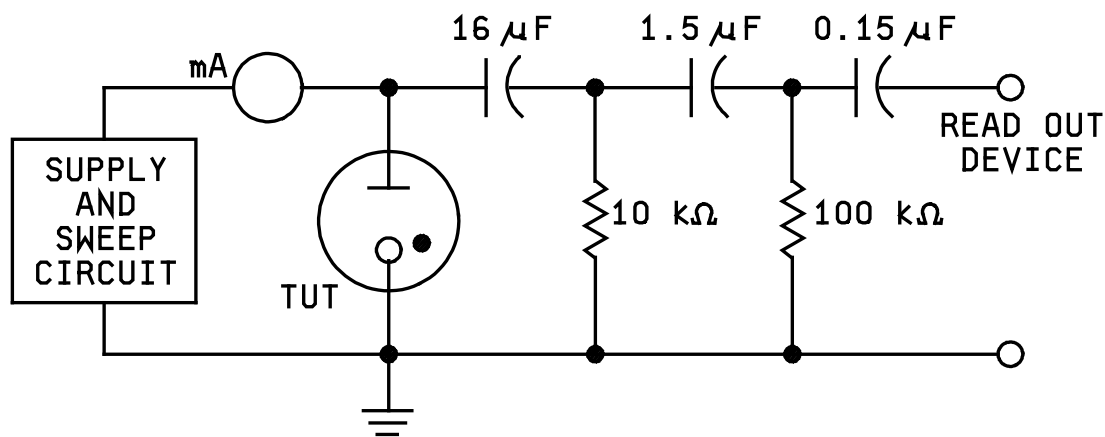
## METHOD 3345A

## VOLTAGE JUMP

(Voltage regulator and reference)

1. Purpose. Tube voltage jump is defined as an abrupt change or discontinuity in tube voltage drop when the tube current is varied.

2. Procedure. Voltage regulator and reference tubes shall be tested for voltage jump by cycling the tube current between the specified minimum and maximum values for a minimum of one complete cycle. One complete cycle consists of varying the tube current between the minimum and maximum values in both the current increasing and current decreasing direction. The total ambient noise level of the supply voltage and test equipment shall be not greater than 20 percent of the maximum allowable voltage jump. The variation of the tube current in any one direction shall be accomplished in not less than 3 seconds, nor more than 30 seconds. The current sweep may be linear, exponential, or sinusoidal. Unless a specific filter is specified, the TUT shall be coupled to the readout device by the filter shown on figure 3345-1.



NOTE: Use nonelectrolytic capacitors.

FIGURE 3345-1. Test circuit.

The filter shall be terminated with a resistance of 1 megohm including the input resistance of the following stage or read-out device. The read-out device shall be an oscilloscope, or an equivalent device, capable of measuring a voltage change having a 10-microsecond rise time. Unless otherwise specified, tubes shall be operated at the maximum rated test current value for a period of not less than 15 seconds, and the test shall be continued for the specified number of cycles to determine whether the voltage jump is reproducible.

NOTE: (a) A voltage jump may not necessarily recur at a constant current value.

(b) Switching transients may occur at each end of the sweep and should not be confused with a voltage jump.



MIL-STD-1311D

METHOD 3347A

IONIZATION

(Cold cathode discharge types)

Ionization voltage. When a holding period is specified for the test specified in 1 or 2 below, each test shall be immediately preceded by its own holding period. A test shall not be repeated until this holding period has again elapsed.

1. Ionization voltage (1) (with illumination). Under the conditions specified on the TSS, the voltage required to start conduction shall be within the limit(s) specified. Unless some specific value of illumination is given, the tube shall be subjected to normal room illumination, either natural or artificial. When a conditioning current is specified, this current shall be conducted between the elements to be tested not more than 30 seconds prior to making this test. This conditioning current shall be conducted for a period of not less than 0.1 second nor greater than 5 seconds.

2. Ionization voltage (2) (total darkness). The tube shall be held inoperative in total darkness for a holding period of not less than 24 hours prior to performance of the test and until completion of the test. The cover used to obtain a state of total darkness shall be fabricated from an opaque, non-metallic material. Under the conditions specified on the TSS, the voltage required to start conduction in total darkness shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 4003A

PRESSURIZING

(Microwave tubes)

1. Purpose. The purpose of this test is to determine:
  - a. Whether the input or output seals of the tube are capable of forming a leak-tight seal to their connectors, when the operating voltage or power level of the tube is such as to require operation with pressurized input or output.
  - b. Whether the tube is physically damaged under the specified pressure.
2. Equipment. Use a suitable pressure chamber with appropriate flanging and pressure gauge. When waveguide connections are to be tested, the waveguide itself shall be the test chamber. Potential leakage areas shall be painted with a soap solution.
3. Procedure. Pressurizing shall be performed by one of the following specified methods:
  - 3.1 Method A, leakage.
    - a. The chamber, together with the appropriate flanging and pressure gauge, shall be such that a specified differential air pressure shall be maintained for the specified duration, normally 2 minutes. (See note.)
    - b. Leaks may be detected by painting potential leakage areas with a soap solution.
  - 3.2 Method B, rate of leakage. The chamber shall be such as to maintain, as a minimum, the rate of leakage specified on the TSS (see note).
4. Acceptance criteria. The leakage rate, when specified, shall not be exceeded and on completion of the test, the tube shall show no signs of physical damage and shall pass the specified tests.
5. Precautions.
  - a. Care should be taken to ensure that the tube body temperature does not significantly affect the differential air pressure.
  - b. Care shall be taken to ensure that no corrosive residue is left on the tube.

NOTE: Where the waveguide connections are to be tested, the waveguide itself shall be the test chamber.

MIL-STD-1311D

METHOD 4004

MEAN TEMPERATURE COEFFICIENT OF FREQUENCY

1. Purpose. To determine the mean value of the temperature coefficient of frequency over a stated range.
2. Equipment. A test chamber capable of maintaining its environmental temperature (and its cooling fluid temperature, if required) at either of the two stated values. It shall be capable of tube operation.

If actual tube temperature is to be varied, alternate methods may be used, such as changes in either the flow rate or temperature of the cooling air or fluid. These methods shall be capable of maintaining the temperature at the designated values.
3. Procedure. Temperature specified will be ambient temperatures unless (a) spot(s) on the tube surface is (are) designated as reference(s) for temperature measurements.
  - 3.1 The test shall be started with the tube stabilized at ambient temperature and the frequency and operating conditions recorded. The temperature shall then be raised, (normally 30°C) at any desired rate to the stated value. After stability is achieved at the applicable operating conditions, the frequency is again recorded.
  - 3.2 The temperature and operating conditions are returned at any desired rate to the first values and frequency again recorded after stability is reached.
4. Definition. The greater difference between the frequency measured at the upper temperature and the lower temperature divided by the corresponding temperature change is the mean temperature coefficient of frequency.

At his option, the manufacturer may average the values obtained from three thermal cycles.

MIL-STD-1311D

METHOD 4006

X-RADIATION

(Microwave tubes)

1. Purpose. To obtain the x-radiation intensity of microwave tubes in order to determine the levels emitted by the tubes when they are operated at high voltages with integral tube shielding in place but without external shielding.

2. Equipment.

2.1 Survey meter. A dose-rate survey meter (electrostatically shielded) for probing or rapid surveying of radiation field. The aperture for entrance of ionizing radiation shall have an area no larger than  $10 \text{ cm}^2$ . The sensitivity of the detector at the wavelength (hardness) to be measured shall be known. The time constant shall be long enough to smooth out fluctuations in readings at low levels (usually 15 seconds).

2.2 Film holder. A holder for x-ray sensitive film which has been designed to shield the film from exposure to light (and heat, if necessary).

2.3 Test equipment. To provide normal operation of the tube.

3. Procedure.

3.1 Method A (survey meter). A warm-up period shall be provided for both the tube and test equipment in order to obtain stable operating conditions before proceeding with measurements.

3.1.1 The background radiation shall be noted at the test position and corrections to the observed data shall be applied as required.

3.1.2 The TUT shall be in a position relative to the test equipment so that measurements will be made at the points where maximum radiation is observed. The tube shall be operated as specified in the TSS.

3.1.3 The detectors specified for this measurement are to be calibrated to read radiation level at the center of the detecting chamber. The distance from any readily accessible surface of the TUT to the center of the chamber shall be 12 inches or as specified in the TSS.

3.1.4 Readings. At the point of maximum radiation, record the maximum stable radiation observed in mR/hr. The maximum allowable radiation limit in mR/hr shall be specified on the TSS.

3.1.5 Calibration.

3.1.5.1 The survey meter shall be calibrated by exposure to sources which bracket the intensity and energy to be measured. The standard source(s) shall be traceable to the National Bureau of Standards.

3.1.5.2 Calibration shall be made using a minimum of three readings, which shall be averaged, for each point of calibration.

3.1.5.3 To insure accurate instrumentation, consideration shall be given to correction factors for extreme variations in temperature and barometric pressure.

3.1.5.4 Stability of the calibration shall be checked periodically by using an appropriate radioactive source.

3.2 Method B (film survey).

3.2.1 The film shall be positioned at a distance of 12 inches, or as specified, from readily accessible surfaces of the TUT.

3.2.2 The tube shall be operated in accordance with the TSS. Operation used is continued for the length of time specified for the film being used.

MIL-STD-1311D

3.2.3 Calibration.

3.2.3.1 The film mount, including a series of thicknesses of aluminum, is usually read by a film reader service using densitometer to determine energy and intensity. The densitometer calibration shall be traceable to the National Institute of Standards and Technology.

4. Precautions.

4.1 WHEN OPERATING A TUBE WITH INTEGRAL TUBE SHIELDING, AS DEFINED BY THE TUBE MANUFACTURER, IN PLACE BUT WITHOUT EXTERNAL SHIELDING, THE X-RADIATION MAY BE VERY GREAT AND HAZARDOUS.

INTEGRAL TUBE SHIELDING NOT ONLY INCLUDES PERMANENT TYPE SHIELDING BUT ALSO INCLUDES THOSE SPECIFIC SHIELDS RECOMMENDED AND/OR SUPPLIED BY THE TUBE MANUFACTURER FOR OPERATION OF THE TUBE.

ADEQUATE PRECAUTIONS SHALL BE TAKEN TO PROTECT PERSONNEL FROM THESE HAZARDS. WHEN THESE CONDITIONS OCCUR, FILM SURVEY TECHNIQUES ARE RECOMMENDED IN PLACE OF THE SURVEY METER.

4.2 Film badges should be assigned to all personnel involved in making x-radiation measurements.

4.3 Before a reading is recorded, precautions should be taken to assure that the indication on the survey meter is a steady one, due only to the tube being measured.

4.4 Survey instrument calibration shall be obtained against known radiation of the same spectral quality as that being measured, or errors as large as 10:1 from the true energy level can be introduced.

MIL-STD-1311D

METHOD 4016

VIBRATION DETUNING

(Tunable gas-switching tubes)

1. Purpose. To check the stability of the tuning mechanism of a tunable frequency tube under specified vibration conditions.
2. Equipment. The tube shall be vibrated in accordance with method 1031, high-frequency (50 Hz) vibration, using a suitable short circuit indicator (method 1041 or equivalent).
3. Procedure. The tube shall be tuned to resonance at the microwave frequency specified and then vibrated in the direction of the tuner axis. After vibration, the tuning shall not have changed by more than the specified amount, and the tube shall not have been physically damaged.

MIL-STD-1311D

METHOD 4021

DEGRADATION DUE TO VIBRATION

(Gas-switching tubes)

1. Purpose. The purpose of this test is to determine whether the ignitor electrode will short circuit during the vibration cycle, whether the tube will detune, and whether the tube will remain vacuum tight after the vibration cycle.
2. Equipment. The tube shall be vibrated in accordance with method 1031, high-frequency (50 Hz) vibration, using a suitable short circuit indicator (method 1041 or equivalent).
3. Procedures.
  - a. TR tubes shall be vibrated in a plane perpendicular to the ignitor axis under the conditions specified. During this interval there shall be no evidence of shorting between the ignitor electrode and the adjacent cone. After this test, the tube shall satisfy the VSWR (method 4473) and the ignitor voltage drop tests (method 4406).
  - b. ATR tubes shall be vibrated in a plane perpendicular to the tuning diaphragm under the conditions specified. After this test, the tube shall satisfy the tuning susceptance (method 4482) and firing time test (method 4486).
  - c. Pre-TR tubes shall be vibrated in a plane perpendicular to the input plane of the tube under the conditions specified. After this test, the tube shall satisfy the arc loss test (method 4488).

MIL-STD-1311D

METHOD 4026

(OBSOLESCENT)

DEGRADATION DUE TO SHOCK

(Gas-switching tubes)

1. Purpose. The purpose of this test is to determine whether the ignitor electrode will short circuit during the shock test, whether the tube has been detuned by the shock, and whether the tube remained vacuum tight after the shock.

2. Equipment. Suitable shock machine capable of meeting the conditions specified with a short-circuit indicator and fixture.

3. Procedure.

3.1 Method of mounting. The tube shall be mounted to a fixture that utilizes all the tube mounting flanges.

3.2 Shock. The tube shall be subjected to the specified number of shocks of 50 G acceleration and  $11 \pm 1$  millisecond duration in each of the three mutually perpendicular planes. In the case of tubes containing ignitor electrodes, there shall be no evidence of shorts during this test.

4. Acceptance criteria. After procedure 3.2, TR tubes shall satisfy the VSWR (method 4473) and ignitor voltage drop tests (method 4406), ATR tubes shall satisfy the tuning susceptance (method 4482) and firing time tests (method 4486) and, pre-TR tubes shall satisfy the arc loss test (method 4488).



MIL-STD-1311D

METHOD 4027

TEMPERATURE COEFFICIENT

The temperature coefficient is defined as the ratio of the change in the specified parameter to the change in temperature at the points specified on the TSS. The temperature coefficient shall be measured over the temperature ranges and under the conditions specified in the TSS. It is permissible to average the results of up to three temperature cycles. Unless otherwise specified,  $\Delta F/^{\circ}\text{C}$  shall be determined from the average of three tests over any 30°C temperature range.

MIL-STD-1311D

METHOD 4028

BAROMETRIC PRESSURE, REDUCED

(Simulated high altitude)

1. Purpose. The purpose of this test is to determine that microwave tubes will perform suitably and are not subject to electrical breakdown in air insulated portions of input or output system, as specified, when operating at reduced barometric pressure.

2. Equipment. In addition to the normal operating equipment (as used in method 4250), the following equipment shall be needed:

- a. A vacuum chamber with input and output feed-throughs capable of carrying the test voltages without arcing or corona from atmosphere down to the required pressure, or fixtures for specified input or output systems (see TSS) which permit continuous reduction of barometric pressure while operating.

NOTE: The position of the ground plane relative to the tube must be specified if the test pressure is low enough to permit long path discharges.

- b. Mechanical pumps as required.
- c. Pressure gauges or manometers as required.

3. Procedure.

3.1 The tube shall be operated in the manner specified at normal ambient conditions. If a variation of a parameter such as frequency is to be measured, an initial measurement shall be made after the temperature of the operating tube has stabilized.

3.2 While operation continues, the barometric pressure shall be reduced at the specified rate for:

- a. The whole tube in the chamber, or
- b. The specified input and output systems.

3.3 The tube is then allowed to stabilize at the final value and operate for 60 seconds. If required, a load VSWR of 1.5:1 shall be continuously varied through all its phases for the final 60 seconds.

4. Acceptance criteria.

- a. When the variation of a parameter such as frequency is to be measured, both the maximum deviation and the final value of the specified parameter shall be within the limit(s) specified.
- b. There shall be no visible or audible corona or arcing at either the input or output.

5. Precautions. Because breakdown may occur at a pressure other than the final value due to long path discharges, observations should be conducted throughout the pressure cycle. Thus, if rate of change of pressure is non-linear, it shall be a continuous function from ambient to final value.

MIL-STD-1311D

METHOD 4029

MAXIMUM TEMPERATURE COEFFICIENT OF FREQUENCY

1. Purpose. The purpose of this test is to determine the maximum value of the temperature coefficient ( $\Delta F/^{\circ}\text{C}$ ) of the tube over a given temperature range.

2. Equipment. If ambient environmental temperature is to be varied, a chamber shall be used for this test that shall be capable of maintaining the specified temperature. If actual tube temperature is to be varied, a chamber may be used for this test that is capable of maintaining the specified temperature, or alternate methods may be used such as changes in either temperature or flow rate of the cooling air or cooling liquid. These alternate methods shall be capable of maintaining the specified temperatures.

3. Procedure. The temperature may be that of a specified element or a specified point on the tube surface on which frequency depends. The temperature alternate may be specified as ambient environment. If ambient temperature is the variable, the rate of change of ambient shall not be greater than  $2^{\circ}\text{C}$  per minute.

3.1 The test shall start with the tube operating and stabilized at normal room temperature operating conditions. This shall be the starting temperature. The temperature and frequency shall be recorded. The temperature shall then be raised to a value  $30^{\circ}\text{C}$  above the starting temperature and frequency recorded at intermediate values and end point of temperature. The temperature shall then be returned to the starting temperature and frequency recorded at intermediate values and end point of temperature. Measurements of temperature and frequency shall be made after conditions of thermal equilibrium have been reached.

3.2 A smooth curve of frequency versus temperature shall be drawn through the data points. The temperature coefficient ( $\Delta F/^{\circ}\text{C}$ ) shall be the greatest slope of this curve.

MIL-STD-1311D

METHOD 4030

THERMAL FREQUENCY DRIFT

1. Purpose. The purpose of this test is to determine the extremes of operating frequency which result from operation of the tube under a variety of ambient conditions, and when there is a severe requirement for frequency stability.
2. Equipment. The test chamber shall be capable of the independent maintenance of the specified ambient temperature and the temperature of the input cooling fluid. Facilities shall be available to operate the tube.
3. Procedure. The thermal frequency of drift specified shall not be exceeded for any combination of anode inlet cooling temperature and ambient temperature between the values specified. The frequency difference between the maximum and minimum frequencies observed as F1 through F5 shall not exceed the value specified. The conditions are as follows.
  - 3.1 With chamber temperature and anode inlet coolant temperature at  $30^{\circ}\text{C} \pm 10^{\circ}\text{C}$ , the stated conditions for operation shall be applied, and the frequency is measured and noted as F1 after stability has been reached. The tube is stabilized when the frequency difference between the maximum and minimum frequency measured over a period of 1 hour at 5-minute intervals shall not exceed 0.05 percent of the operating frequency.
  - 3.2 Adjust chamber temperature to the stated upper limit and the anode inlet coolant temperature to its stated upper limit. After the frequency has stabilized, measure the frequency and note as F2.
  - 3.3 Repeat 3.2 except maintain tube chamber temperature at the upper limit and adjust anode inlet coolant temperature to the lower limit and note stabilized frequency as F3.
  - 3.4 Repeat 3.2 except adjust chamber temperature to the lower limit and the anode inlet coolant temperature to its lower limit and note the stabilized frequency as F4.
  - 3.5 Repeat 3.2 except maintain chamber temperature at the lower limit and adjust anode inlet coolant temperature to the upper limit and note stabilized frequency as F5.
  - 3.6 If an unintentional interruption of the test occurs in the first 10 minutes of the test, discontinue further testing and start over. If an unintentional interruption occurs after the first 10 minutes of the test, it is permissible to normalize the data and continue the test.

MIL-STD-1311D

METHOD 4042

MICROWAVE MEASUREMENTS DURING SHOCK

1. Purpose. This test is designed to observe the effect of a physical shock on the performance characteristics of a microwave tube, while the tube is operating.

2. Equipment. The TUT shall be rigidly mounted on a suitable fixture or directly on the shock table using the normal mounting arrangement for the tube. If a fixture is used, it shall be designed so as to transmit the shock along the required axis. The shock input shall be monitored on the fixture at a point close to the attachment points of the tube.

Suitable equipment must be used to observe desired performance characteristics before, during, and after the shock impulse. In addition, the equipment must include a storage device which observes the selected operating characteristic during the shock impulse and holds it for subsequent reference.

3. Procedure. Testing shall be conducted in accordance with method 213 of MIL-STD-202 except that the tube will be subjected to one shock in each direction along three mutually perpendicular axes, for a total of six shocks in all. The operating characteristics are to be observed during each separate shock impulse. The individual TSS must specify the following.

- a. The operating characteristic(s) which is to be observed during shock testing. Usually this will be power output. In addition, observations such as operating frequency, momentary electrical shorts, may be required.
- b. The operating voltages to be applied to the tube during testing.
- c. The shock pulse (shape, peak acceleration, and duration) selected from test condition in method 213 in MIL-STD-202.
- d. The failure criteria for each characteristic in a. above.

4. Precautions. Prior to subjecting the tube to shock testing, the test instrumentation should be set up and checked under shock conditions in order to determine that the test instrumentation and connecting cable itself is unaffected by the shock impulses. This can best be accomplished by connecting the cabling to a nonoperating or dummy sample.

5. This is a nondestructive test.

MIL-STD-1311D

METHOD 4101A

DIELECTRIC MATERIAL STRAIN

(Gas switching tubes)

1. Purpose. The purpose of this test is to determine whether the tube will withstand the thermal shock of the test without breakage or loss of vacuum.
2. Equipment. The volume of water shall be great enough to be unappreciably affected in temperature by this test.
3. Procedure. The rf window sections of the tube shall be immersed in water at not less than 97°C for 15 seconds and immediately thereafter immersed in water at not more than 5°C for 5 seconds. In the case of tubes with more than one rf window, each section may be tested separately. After this test, the following requirements shall be met:
  - a. TR tubes: Ignitor voltage drop test (method 4406), or recovery time (method 4471), as specified.
  - b. ATR tubes: Firing-time test (method 4486).
  - c. Pre-TR tubes: Arc loss test (method 4488).

MIL-STD-1311D

METHOD 4102

(OBSOLESCENT)

OPERATION BUMP

(Klystron)

1. Purpose. The purpose of this test is to insure that minor transient shocks do not permanently impair tube performance.

2. Procedure.

2.1. Method of mounting. The tubes shall be mounted as shown on the TSS, under specified test conditions.

2.2 Operation bump. This test shall be made with a pendulum consisting of a steel ball .625 inch (15.88 mm) in diameter suspended by a wire .02-inch (0.5 mm) in diameter, with the distance between the point of suspension and the center of the ball 4.250 inch (107.95 mm), or with an equivalent pendulum. The ball shall be suspended so that when at rest it touches the tube at approximately one-half the distance between the extreme limits of the tube projecting above the socket. In this position, the point of suspension of the ball shall be directly above the center of the ball. The ball shall be permitted to swing freely through an arc of 60° in a plane through the axis of the tube and from such an angle that the ball strikes only the tube envelope.

3. Acceptance criteria. After striking the tube with the ball, the power output or the frequency, or both if specified, shall not change by more than the amount indicated. The tube shall be considered to have met the test satisfactorily if, after testing in this manner three times, the tube does not fail on any test and if, during this test, the quantity measured does not at any time show a nontransient change of more than the specified amount from the original value.

MIL-STD-1311D

METHOD 4153

LIQUID COOLING JACKET LEAKAGE

1. Purpose. To establish the integrity of the liquid-cooling system so that high-voltage insulation will not deteriorate due to the presence of cooling liquid as well as to eliminate any need to dispose of leaked liquid.
2. Equipment. A source of air or nitrogen at the required pressure and a supply of liquid soap or detergent for leak checking.
3. Procedure. The cooling system shall be emptied and dried. The liquid cooling connections shall be completed, without coolant, and the pressure system and the tube shall be coated with liquid soap or detergent. Gas at the required pressure shall be applied to the liquid cooling jacket for 1 minute minimum. Leaks are indicated by the formation of bubbles in the liquid soap.



MIL-STD-1311D

METHOD 4213

REFLECTOR VOLTAGE

(Klystrons)

With the specified potentials applied and the tube adjusted for the frequency specified, the reflector voltage necessary for maximum obtainable power output shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 4214

CATHODE EMISSION

1. Purpose. The purpose of this measurement is to determine the degree of cathode activity measured under controlled conditions.
2. Procedure. The cathode current shall be measured with the tube operating as specified. The filament or heater voltage shall be changed to the lower value specified. The cathode current shall be remeasured after the specified time. If the TSS does not specify a time, the stabilized cathode current shall be measured. The change in cathode current shall be divided by the initial value and expressed as a percentage.
3. Precaution. The current indicating device shall measure the current in the cathode lead of the tube.

MIL-STD-1311D

METHOD 4215

REFLECTOR VOLTAGE MODULATOR COEFFICIENT

(Reflex klystrons)

1. Purpose. To determine the frequency change caused by variations in reflector voltage.
2. Definition. The reflector voltage modulation coefficient is the ratio of (1) the change in output frequency, caused by (2) an incremental change in reflector voltage.
3. Equipment.
  - 3.1 Power supplies to provide normal operating voltage and currents.
  - 3.2 A means of observing and measuring the changes in output frequency caused by changes in the applied reflector voltage.
  - 3.3 A means for varying and measuring the changes in reflector voltage.
4. Procedure.
  - 4.1 Method A (dynamic).
    - 4.1.1 The tube shall be operating under test conditions as specified in the TSS.
    - 4.1.2 The reflector voltage shall be adjusted to the maximum output power point, or any other measurement point(s) specified in the TSS.
    - 4.1.3 Raise and lower the reflector voltage a known amount by superimposing on the dc reflector voltage a 60 Hz voltage of the specified value (usually a few volts peak-to-peak) and record the lowest and highest output frequencies generated by the tube.
    - 4.1.4 The reflector voltage modulation coefficient is the difference in output frequencies, recorded in 4.1.3 divided by the absolute change in reflector voltage and shall be within the limit specified.
  - 4.2 Method B (static).
    - 4.2.1 The tube shall be operating under test conditions as specified in the TSS.
    - 4.2.2 The reflector voltage shall be adjusted to the maximum output power point, or any other measurement point(s) specified in the TSS.
    - 4.2.3 The reflector voltage shall be reduced a small known amount (usually a few volts) and after 60 seconds, record the reflector voltage and output frequency.
    - 4.2.4 The reflector voltage shall be increased a similar known amount above the initial value, and after 60 seconds, record the reflector voltage and output frequency.
    - 4.2.5 The reflector voltage modulation coefficient is the difference in output frequency, recorded in 4.2.3 and 4.2.4, divided by the difference in reflector voltage, recorded in 4.2.3 and 4.2.4 and shall be within the limit(s) specified.
5. Precautions. The reflector voltage modulation coefficient reaches a minimum near the maximum output power point of the reflector voltage mode, and increases rapidly on both sides of this minimum point. Theoretically, the modulation coefficient data should be taken with an infinitely small value of modulation voltage, sweeping equally on either side of the specified measurement point. In practice, the smallest modulation voltage that will give reliable data should be used.

## MIL-STD-1311D

## METHOD 4221

## BEAM CONVERSION EFFICIENCY

(Microwave - O-type devices)

1. Purpose. To measure the beam conversion efficiency of O-type devices with or without depressed collector.
2. Definition. The beam conversion efficiency of a microwave O-type device is defined as follows:

$$\text{Beam conversion efficiency} = \frac{P_o}{[(Eb1)(Ib1)] + [(Eb2)(Ib2)] + [(Ebn)(Ibn)]}$$

Where: Ebn and Ibn are the nth electrode voltage and current (includes all electrodes, grids, anodes, body, helix, collector, etc.) where all voltages are referenced to the cathode.

3. Procedure.

- 3.1 Use circuit in method 4250 for measurement of power output.
- 3.2 The tube is operated as specified in the TSS to obtain measurements for calculation of beam conversion efficiency.
- 3.3 The beam conversion efficiency shall be within the limit as specified in the TSS.

4. Precautions.

- 4.1 Beam conversion efficiency as defined here is valid for saturated or unsaturated power levels.
- 4.2 Beam conversion efficiency as defined here is not to be confused with total efficiency which would take into account additional input powers such as rf drive power, heater power, etc., but excluding solenoid power.

MIL-STD-1311D

METHOD 4222

BEAM TRANSMISSION

When the beam transmission test is performed, the tube shall be operated as specified. The current intercepted or collected, or the power dissipated by the part of the tube specified, expressed as a percentage of either the total beam (cathode) current or total beam power, shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 4223

MECHANICAL TUNING

1. Purpose. The purpose of this method is to test the mechanical characteristics of the tuning mechanism.

2. Definitions.

2.1 Mechanical tuning of microwave tubes is accomplished by changing the physical configuration of the resonant circuit(s) in a manner that changes the resonant frequency independently of any electrical or electronically induced frequency changes.

2.2 A tuning cycle is a complete excursion through the full tuning range and back to the starting point.

2.3 Tuning rate is the rate of change of frequency with respect to tuner position. It may be specified in terms of the total tuner motion required to cover the specified frequency range.

2.4 Tuning speed is the number of complete tuning cycles which can be accomplished per second.

3. Equipment. Figure 4223-1 is a block diagram of the equipment required for these measurements.

4. Mechanical tuning range. The tube shall be capable of continuous operation over the specified frequency range. All other parameters shall remain within the specified limit(s).

5. Mechanical tuning rate. The tuning rate, and any discontinuity in tuning rate, shall be within the limit(s) specified.

6. Tuner torque or force.

a. Starting torque or force. The torque or force required to produce an initial frequency shift shall be within the limit(s) specified, over the tuning range.

b. Operating torque or force. The torque or force required to maintain tuner motion shall be within the limit(s) specified, over the tuning range.

c. Tuner stop endurance. The tuning mechanism shall withstand the specified torque (including impact values) at the limits of mechanical motion, without evidence of physical damage to the tuner drive mechanism, and shall meet the requirements of starting and operating torques.

7. Mechanical tuning fatigue. The tube shall withstand the specified number of coarse or vernier tuning cycles without the tuning mechanism becoming inoperable. Unless otherwise specified, this test may be made on an inoperative or on a nonoperating tube.

7.1 This is a destructive test.

8. Resetability. The tuning dial shall be adjusted in one direction to a given setting, and the frequency measured. The tuner shall then be taken through the specified number of tuning cycles and returned to the given setting.

a. From the same direction, and

b. From the opposite direction.

The frequency shall be reproduced within the specified limit(s) This test shall be performed in a manner which excludes thermal effects.

MIL-STD-1311D

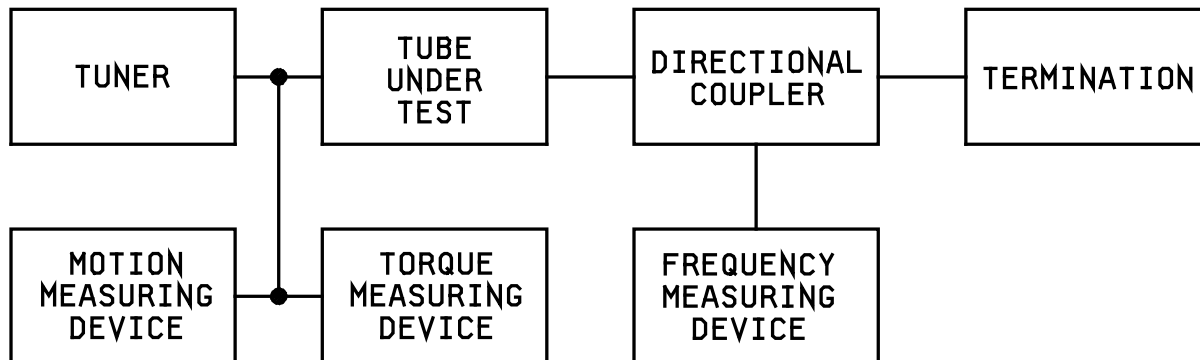


FIGURE 4223-1. Equipment layout for mechanical tuning test equipment.

MIL-STD-1311D  
 METHOD 4225  
 RESIDUAL FM  
 (Reflex klystrons)

1. Purpose. To describe a method for determining the magnitude of the residual FM deviations in the rf output frequency.
2. Definition. Residual FM is the background frequency modulation of the rf output which is contributed by the TUT and is not due to intentional modulation from an applied signal, or unwanted modulation contributed by the power supplies.
3. Equipment.
  - 3.1 Power supplies to provide normal operating voltages and currents.
  - 3.2 AC heater supply as specified on the TSS.
  - 3.3 Equipment to monitor the rf output, as shown in figure 4225-1.

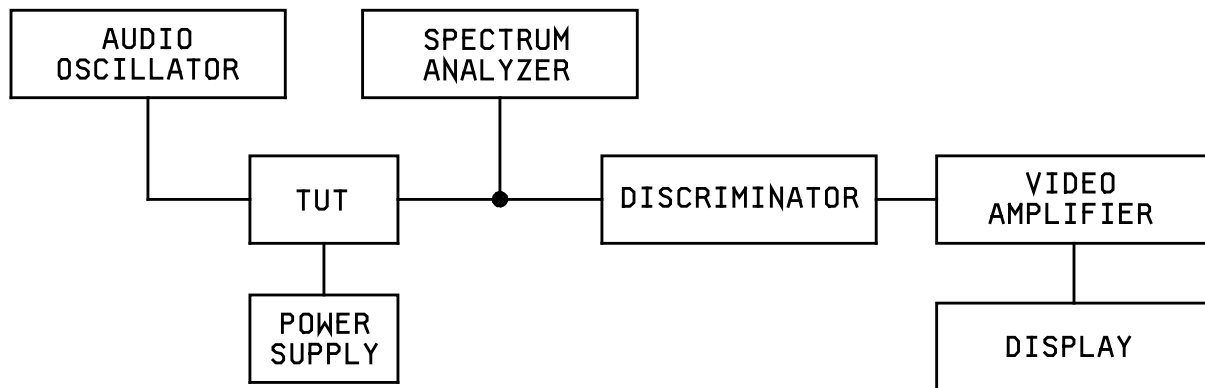


FIGURE 4225-1. Equipment for measuring residual FM.

4. Procedure. The residual FM due to the tube alone, is usually so small that conventional display devices, such as video spectrum analyzers, wave analyzers, microwave oscilloscopes, etc., are not calibrated accurately enough to measure the FM deviation values of interest. This method uses the TUT, along with the other equipment shown in figure 4225-1, to calibrate the output display device prior to reading the total residual FM level.

4.1 Calibration.

4.1.1 Use the audio oscillator to modulate the reflector electrode voltage of the TUT, and use the spectrum analyzer to observe the production of sidebands in the rf output.



## MIL-STD-1311D

4.1.2 Vary the frequency and/or the output voltage of the audio oscillator until the spectrum analyzer display shows that the fundamental (carrier) frequency has been reduced to its minimum value. (Theoretically, the output power at the fundamental frequency of a frequency modulated source, follows the form of a Bessel function of the first order and the first kind. Such a Bessel function has its first zero (minimum) at 2.405. From this the modulation sensitivity ( $M_s$ ) of the TUT in kilohertz per volt is given by:

$$M_s = \frac{2.405 F_m}{V_s(\text{peak})} = \frac{2.405 F_m}{1.414 V_s(\text{rms})} = \frac{1.7 F_m}{V_s(\text{rms})}$$

Where:  $F_m$  = frequency of the modulating signal  
(audio oscillator) in kilohertz.

$V_s$  = voltage of the modulating signal  
from the audio oscillator.

4.1.3 Calibrate the video amplifier display device, using the known modulating signal frequency and amplitude, along with the measured modulation sensitivity of the TUT.

4.2 Measurement. Remove the reflector electrode modulation and record the maximum deflection of the display device. Convert the maximum deflection to residual FM using the calibrations previously derived, this shall not exceed the maximum limit as specified in the TSS.

## 5. Precautions.

5.1 The output frequency and modulating voltage supplied by the audio oscillator shall be known with whatever accuracy is required of the measurements.

5.2 The calibration level shall be sufficiently larger (at least four times larger) than the FM being measured to avoid erroneous calibrations.

5.3 The video bandwidth shall be wide enough to include all components of interest, or as specified on the TSS. (100 kHz is a typical video bandwidth.)

5.4 The beam and reflector power supplies shall be relatively free from hum and noise, or any inherent modulation from the TUT will be hidden.

MIL-STD-1311D

METHOD 4229

REFLECTOR CURRENT

(Reflex klystrons)

1. Purpose. The purpose of this test is to determine leakage and gas ion currents to the reflector electrode of a reflex klystron.

2. Definitions.

2.1 Total reflector current is the gas ion plus leakage current to the reflector electrode when the reflector electrode is operated as the ion collector of an ionization gauge.

2.2 Reflector-leakage current is the current to the reflector electrode when the tube is operated as in 2.1 except, that the beam current is interrupted by opening the cathode circuit.

2.3 Reflector-gas current is the remainder when 2.2 is subtracted from 2.1.

3. Equipment.

3.1 Power supplies are required to provide heater voltage, an accelerating voltage, and a retarding voltage as specified on the TSS.

3.2 A direct current meter is required which has sufficient sensitivity to measure the currents, which are normally less than 5  $\mu$ A dc. (A push-to-read circuit and a multiple range meter are recommended.)

4. Procedures.

4.1 Total reflector current. When specified voltages are applied to the tube, the total reflector current shall be within the limit(s) specified. The duration of this test, including preheating time at specified test conditions if continuous with the test, shall be as specified. Unless otherwise specified, the tube should not be oscillating during this test.

4.2 Reflector-leakage current. At the conclusion of the test specified in 4.1, the cathode connection shall be opened and the reflector current shall be measured.

4.3 Reflector-gas current. When specified on the TSS, the value of current as determined in 4.2, shall be subtracted from the value of current as determined in 4.1.

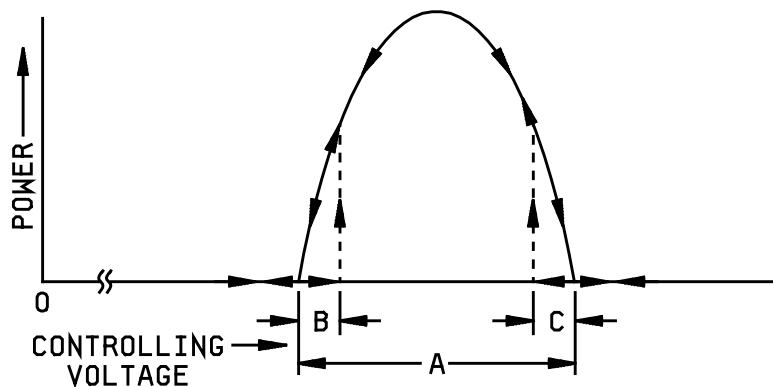
## MIL-STD-1311D

## METHOD 4231A

## ELECTRONIC TUNING HYSTERESIS

(Klystron oscillators)

1. Purpose. This test is a measurement of electronic tuning hysteresis in klystron oscillators.
2. Definition. Electronic tuning hysteresis is present in a klystron oscillator when, with the same set of operating conditions, the output power and operating frequency can have more than one value (including zero) for the same electronic controlling voltage.
3. Equipment.
  - a. Power supplies to provide normal operating voltages and currents.
  - b. Means to vary the controlling voltage, dynamically and statically.
  - c. Means to observe the output power as the controlling voltage is varied; such as a microwave diode (crystal rectifier) and a cathode-ray oscilloscope.
  - d. Means to observe or check the output frequency, such as a tunable frequency meter.
4. Procedure.
  - a. The measurement of electrical-tuning hysteresis shall be made with test condition voltages applied and the frequency of oscillation adjusted to the value specified.
  - b. In addition to the direct voltage required for the mode specified, a low-frequency sweep voltage of essentially sinusoidal shape, sufficiently large to suppress oscillations on the two ends of the sweep, shall be applied between the controlling electrode and the cathode.
  - c. A loosely coupled portion of the klystron output shall be detected by a suitable microwave diode (crystal rectifier).
  - d. The crystal-rectifier current shall be examined as a function of the sweep voltage with a cathode-ray oscilloscope, and any interval over which oscillation is observed for one direction of sweep only is said to exhibit hysteresis.
5. Acceptance criteria.
  - 5.1 Hysteresis (1). The ratio of the voltage interval or intervals in which hysteresis is present to the voltage interval in which oscillation is observed shall not exceed the amount specified.

FIGURE 4231-1. Hysteresis (1).

## MIL-STD-1311D

On figure 4231-1, controlling voltage intervals B and C show regions where hysteresis exists and A represents the voltage required to sweep through the full oscillating mode. The ratio of  $\frac{B+C}{A}$  represents the percentage of the mode where hysteresis exists. (Some tubes may show hysteresis at only one side of the mode.)

5.2 Hysteresis (2). The ratio of the highest power level at which hysteresis occurs to the maximum power level shall be within the limit(s) specified. Suitable methods shall be used to calibrate the crystal response in terms of relative power level.

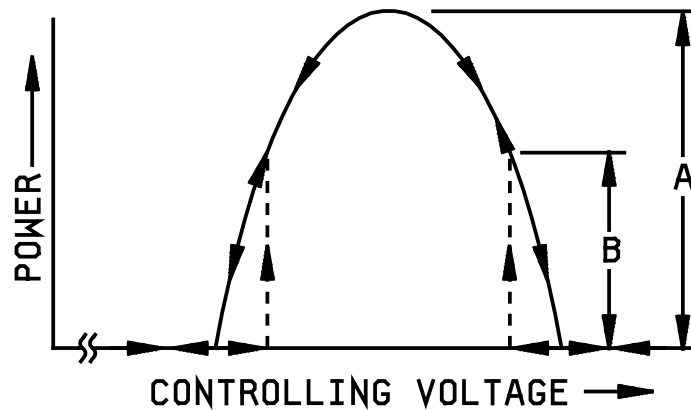


FIGURE 4231-2. Hysteresis (2).

On figure 4321-2, the maximum output power for the mode is represented by A, and B represents the highest output power level at which hysteresis is observed. A maximum limit on the ratio  $\frac{B}{A}$  is normally specified as a percentage.

## MIL-STD-1311D

## METHOD 4243A

## SPURIOUS OUTPUT RATIO

1. Purpose. To determine the amplitudes of spurious output signals.

2. Definitions. Spurious output signals are undesired outputs having a degree of coherence sufficient to distinguish them from white noise. Harmonics of the fundamental desired signal are normally considered separately. The spurious output ratio is the value of the ratio expressed in dB between (1) the fundamental frequency output power and (2) the largest co-existing spurious output signal within the band specified for spurious search.

3. Equipment.

3.1 Equipment to operate the tube as on figure 4243-1.

3.2 Means for changing the frequency of the tube or tunable filter, manually or dynamically, over the specified portion of the tuning range.

3.3 Means for measuring spurious output: Either of

a. Spectrum Analyzer with the following characteristics:

- (1) Tunable frequency range as required.
- (2) Display bandwidth as needed to simultaneously display both power output and spurious signal outputs.
- (3) Sweep speeds which are so low compared to the dynamic tuning rate (see precautions) used in the measurement that the indicator shall produce a true response to all spectral components present.
- (4) Dynamic range of the indicator system shall exceed the range encompassing power output and spurious output power.

b. Oscilloscope, tunable filter and microwave detector:

- (1) The rise time of the oscilloscope, the rate of tuning of the filter, and the Q of the wavemeter should be mutually compatible so that all spurious responses are fully indicated.
- (2) It is often convenient to mark the face of the oscilloscope with the locus of one or more levels of calorimetrically measured power versus frequency, as a means of calibrating sensitivity versus frequency.

NOTE: The frequency calibration which is derived from the tuning voltage is only correct for the main output signal. System sensitivity to other modes whose frequency is measured by the tunable filter can be determined by the locus value at the corresponding horizontal deflection calibration.

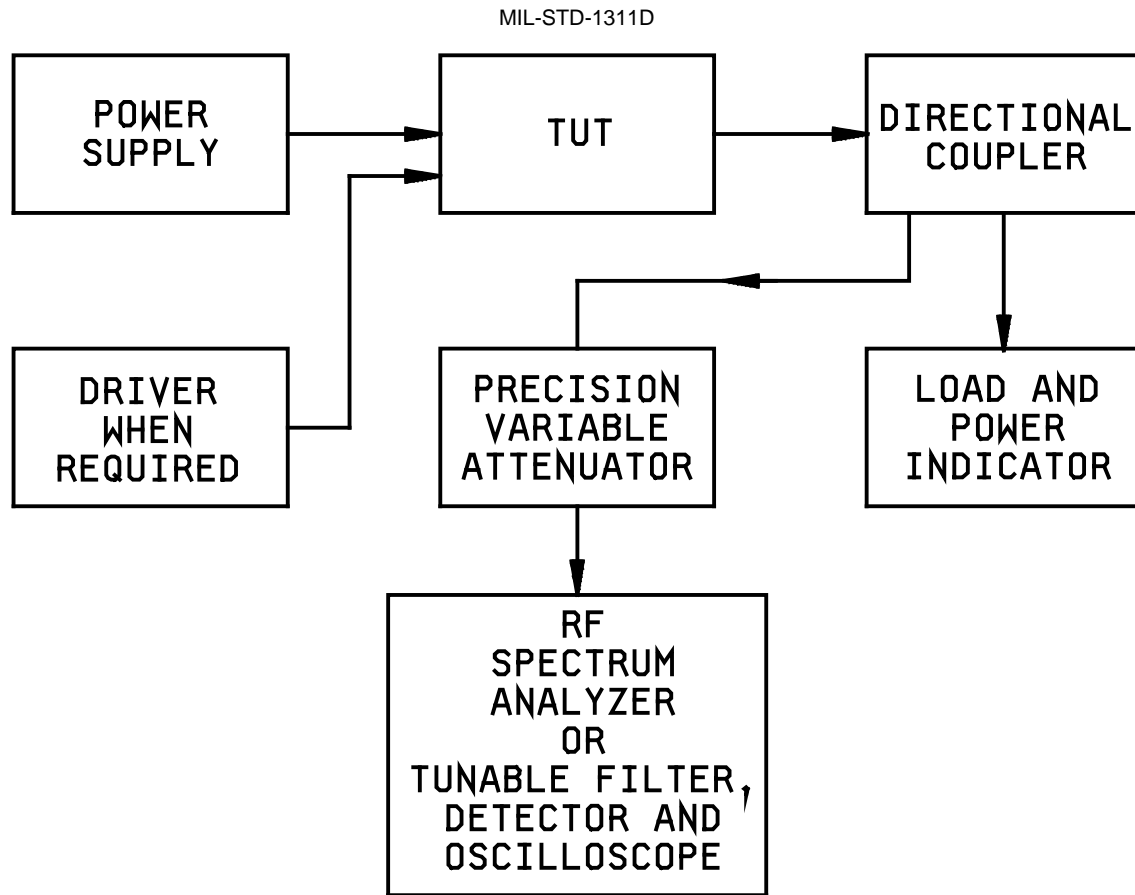


FIGURE 4243-1. Spurious output ratio setup.

4. Procedure. The tube shall be tested for spurious output power using either method below.

4.1 Method A (Spectrum analyzer method). With the tube operating under the specified conditions, the frequency is manually or dynamically swept over the specified band. The dispersion of the spectrum analyzer should be set to encompass this band of frequencies. Using the precision attenuator, the ratio of (1) the peak of the power output indication to (2) the peak indication of the simultaneously existing spurious signal output shall be measured directly in dB and shall exceed the specified value.

4.2 Method B (Oscilloscope method). With the tube operating at one end of the band under the specified conditions the tunable filter is swept manually or dynamically throughout the required frequency region. If signals other than the main output signal are indicated, retune the filter to the power output signal and adjust the precision attenuator to the reference level for that frequency on the oscilloscope. The filter is then manually tuned to the spurious output signal, its frequency is measured and the attenuator is readjusted to the reference level which corresponds to that frequency. The difference between the attenuator reading now obtained and the earlier value expressed in dB is the required measurement and must be greater than the specified value. This process is repeated at as many frequencies throughout the required band as is required to demonstrate that proper performance is everywhere observed. Sometimes the tracking of the spurious signal while tuning the tube will permit a single measurement at the conditions for maximum spurious output, thus simplifying the procedure.

NOTE: The frequency range on either side of the main power component may be excluded from this test, as shown on the TSS.

MIL-STD-1311D

5. Precautions.

5.1 The dynamic tuning rates used in the measurement shall be low enough that the time traversing any signal component shall exceed the response time of the measuring system.

5.2 When tuning dynamically and sweeping dynamically, the two rates shall be asynchronous so that all possible combinations of variables are encountered.

MIL-STD-1311D  
 METHOD 4250A  
 POWER LEVELS  
 (Microwave tubes)

1. Purpose. The purpose of these tests is to determine power level at specified frequencies.

1.1 Input power measurement (amplifiers only).

1.2 Test circuit.

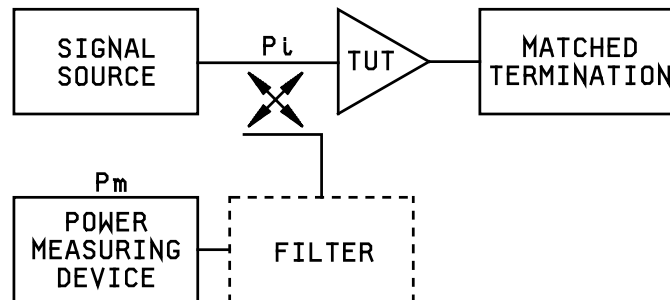


FIGURE 4250-1. Input power measurement.

1.3 Procedure. With the TUT inserted in the circuit shown on figure 4250-1, part of the power from the signal source is fed by directional coupler to a power measuring device. The power ( $P_m$ ) is then measured by either test A, B, or C as appropriate. The input power to the TUT is then determined from the following relationship:

$$P_i = P_m + 10 \log [(\text{antilog } k/10) - 1] + L_f$$

Where:  $P_i$  = input power in dBm to the TUT (the power level to be determined).

$P_m$  = power level actually measured in dBm.

$k$  = coupling coefficient of the directional coupler in dB.

$L_f$  = attenuation in dB of filter at measurement frequency.

NOTE: If the coupling coefficient  $k$  is 20 dB or higher, the following simplified expression may be used with negligible error:

$$P_i = P_m + k$$

2. Output power measurement.

2.1 Test circuit.

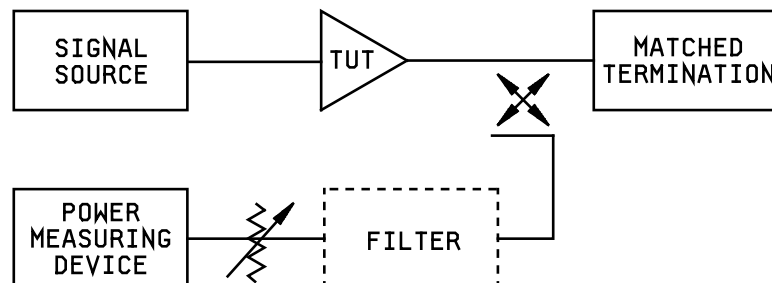


FIGURE 4250-2. Output power measurement.



## MIL-STD-1311D

2.2 Procedure. With the TUT inserted in the circuit shown on figure 4250-2, the output of the TUT is dissipated in a broadband load. A portion of the TUT output is fed by directional coupler to an attenuator, then to a power measuring device, and then measured by either test A, B, or C as appropriate. The combination of coupling and attenuation shall be such that the power measuring device is operating in its proper range. The output power of the TUT is then determined from the following relationship:

$$P_o = k + A + P_m + L_f$$

Where:  $P_o$  = output power in dBm.

$k$  = coupling coefficient of directional coupler in dB.

$A$  = attenuation in dB of attenuator.

$P_m$  = power level actually measured in dBm.

$L_f$  = attenuation in dB of filter at measurement frequency.

### 3. Test A (calorimeter method of average power measurement).

#### 3.1 Test circuit.

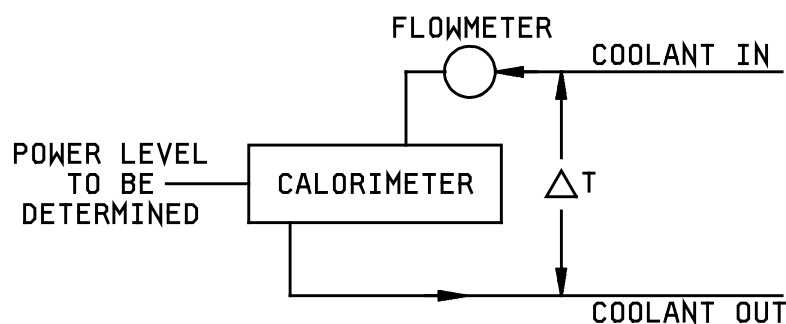


FIGURE 4250-3. Calorimeter method.

3.2 Procedure. Using the circuit shown on figure 4250-3, the power to be measured is dissipated in the calorimeter. The power is then determined from the following relationship:

$$(1) \quad P_o = 4.187 \times m \times S_p \times \Delta T$$

Where:  $P_o$  = dissipated power in watts.

$m$  = coolant flow in grams per second.

$S_p$  = specific heat of coolant in calories per gram per °C.

$\Delta T$  = temperature rise of coolant in °C.

## MIL-STD-1311D

When heat losses from the load and from the cooling liquid are not negligible, the calibration of the calorimeter shall take these losses into account by the following method:

Set a liquid flow rate  $m_1$  grams/sec, and determine apparent power  $P_1$  from equation (1) above. Adjust the flow to a different rate  $m_2$  (about half or twice  $m_1$  is convenient) and determine apparent power  $P_2$ . If  $P_1 = P_2$ , there is no significant cooling error. If  $P_1 \neq P_2$ , the true power  $P$  is given by:

$$P = \frac{P_1^{\frac{m_1}{m_1-m_2}}}{P_2^{\frac{m_2}{m_1-m_2}}}$$

or:  $(m_1-m_2) \log P = m_1 \log P_1 - m_2 \log P_2$ .

From a pair of readings, a general correction factor  $K(m)$  for any flow rate can be plotted using the equation:

$$K(m) = \frac{P}{P(m)} = \left( \frac{P_1}{P_2} \right)^{\frac{m_1 m_2}{m(m_1-m_2)}}$$

Where:  $P(m)$  is the apparent power at flow  $m$ .

Alternatively, the relationship between temperature rise and power dissipated can be determined experimentally by substituting known values of dc or 60 Hz power in the calorimeter system.

4. Test B (bolometer method of average power measurement). The bolometer is a power detecting device whose operating resistance changes as a function of rf power dissipated across it. The barretter is a bolometer using a noble metal which exhibits a positive temperature coefficient and the thermistor is a bolometer using a semiconductor which exhibits a negative temperature coefficient.

#### 4.1 Test circuit.



FIGURE 4250-4. Bolometer method.

4.2 Procedure. Using the circuit shown on figure 4250-4, the bolometer and bridge circuits are energized and the power to be measured is fed to the input of the bolometer mount. Care shall be taken to insure the time constant of the bolometer will not introduce error when making measurements of low-duty pulsed rf power. The thermistor with a time constant of 1 second is ideal for measurement of low-duty cycle rf power. Also, when self-balancing bridges are used, care shall be taken to insure the pulse repetition rate does not adversely affect the automatic balancing.

#### 5. Test C (comparison method of average power measurement).

##### 5.1 Test circuit.

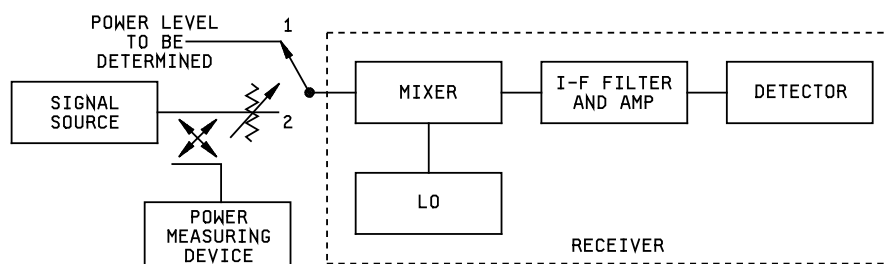


FIGURE 4250-5. Comparison method.

## MIL-STD-1311D

5.2 Procedure. Using the circuit shown on figure 4250-5, the attenuator is adjusted such that the same indication is obtained at the receiver with the switch in either of positions 1 or 2. The power from the signal generator ( $P_m$ ), which is at the same frequency as that of the unknown, is then measured. The unknown power level is then determined from the following relationship:

$$P = P_m - A + 10 \log \left[ \left( \frac{\text{anti log } k}{10} \right) - 1 \right]$$

Where:  $P$  = unknown power level to be determined in dBm.

$P_m$  = power actually measured in dBm.

$A$  = amount of attenuation in dB.

$k$  = coupling coefficient of couple in dB.

NOTE: If the coupling coefficient  $k$  is 20 dB or higher, the following simplified expression may be used with negligible error:

$$P = P_m - A + k$$

#### 6. Pulse duty factor method of peak power measurement.

6.1 Procedure. The average power is measured by either test A, B, or C as appropriate. The peak power is then determined from the following relationship:

$$P_k = \frac{P_a}{D_u}$$

Where:  $P_k$  = peak power in watts.

$P_a$  = average power in watts.

$D_u$  = duty cycle (pulse width times repetition rate, pulse width to be taken at 50 percent power points of the rf pulse.)

7. Notch wattmeter method. The notch wattmeter method is suited only for pulse power measurements. In this method, power from a signal generator shall be combined in a directional coupler with power from the device under test. The signal generator shall be pulsed off for the pulse length of the device under test. It is important that the blank out time be negligibly small. Using the oscilloscope display the power level from the signal generator shall be adjusted to that of the device under test, as shown on 4250-6. The combined output shall be fed to a bolometer and the power shall be measured with a power bridge.

The power thus determined is the peak power of the device under test.

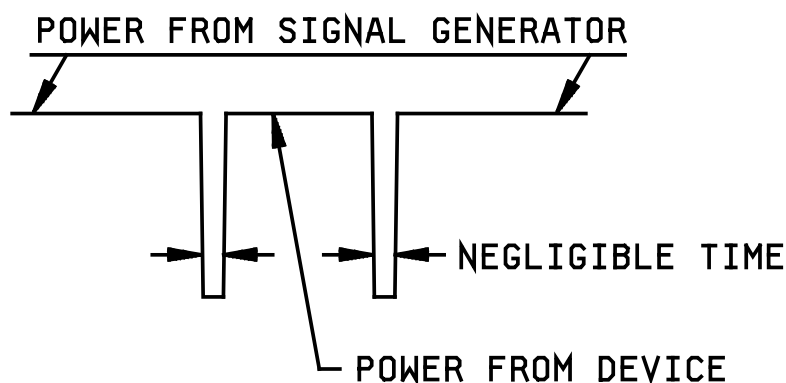


FIGURE 4250-6 Notch wattmeter oscilloscope display.

MIL-STD-1311D

8. Conditions of test. The operating parameters for power measurements of the TUT and the type of power measurement (peak pulse, average pulse, CW) shall be as specified on the individual TSS. These parameters shall include the following where applicable:

Operating voltages.  
Operating currents.  
RF input and output match specifications. <sup>1/</sup>  
RF input drive power specifications.  
Tuning procedures.  
Other special test conditions.

In addition, for tests of power as a function of some variable, for example,  $f$ ,  $E_r$ , temperature, etc., the test shall be conducted either with all parameters constant except the specified variable or with allowable parameter adjustments for maximum power after each change in the variable, as specified on the TSS.

9. Precautions.

9.1 Appropriate filters may be used to isolate the frequency of interest or to eliminate harmonic powers and spurious responses in broadband or synchrodyne tubes.

9.2 Care shall be taken to insure that minimum mismatches exist in the circuitry between the TUT and the specified load.

---

<sup>1/</sup> For magnetrons in which the specified coupling includes an impedance transformation section, the load VSWR measured shall not include the VSWR of this section. For tubes in which the specified coupling does not impose any such section, the VSWR shall be measured adjacent to the output coupling of the tube.

## MIL-STD-1311D

## METHOD 4251

## OUTPUT POWER AND GAIN VARIATION

(Microwave amplifier tubes)

1. Purpose. This test is designed to measure the variation in the output power and gain of a microwave amplifier tube as a result of a change in frequency, operating voltages, input power, magnetic field, or other operating conditions of the tube as specified.

2. Test circuit.

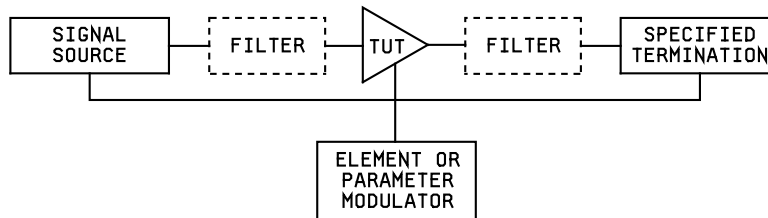


FIGURE 4251-1. Output power variation.

3. Procedure. With the TUT inserted in the circuit shown on figure 4251-1, the output power is measured in accordance with method 4250 as the specified parameter(s) is varied. The gain is measured in accordance with method 4253 as the specified parameter(s) is varied.

4. Precautions.

4.1 Appropriate filters shall be used for measurement of power output in accordance with method 4250.

4.2 Unless otherwise specified, under conditions wherein power output is to be measured into a load which is other than a matched load, the power output is defined as that power accepted by the load rather than that power incident upon the load.

4.2.1 In this case, the specified termination shall be as shown on figure 4251-2.

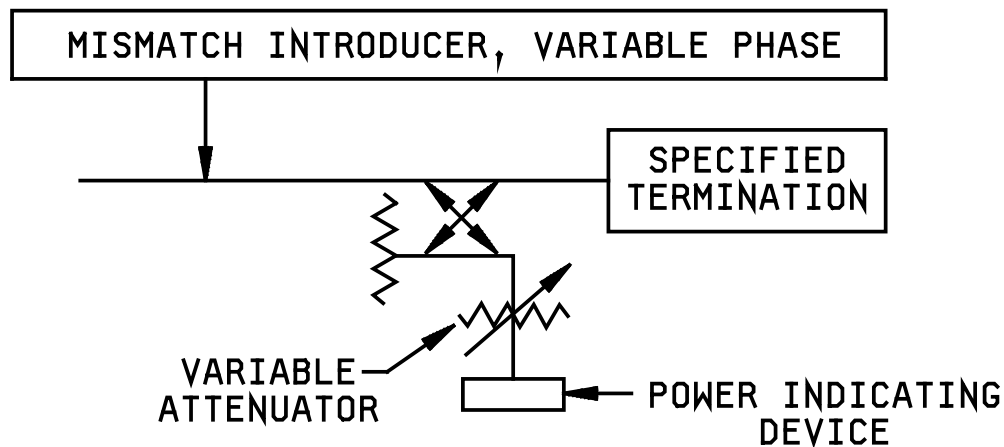


FIGURE 4251-2. Alternate termination.

MIL-STD-1311D

METHOD 4252

GAIN LINEARITY

(Microwave amplifier tubes)

1. Purpose. To measure gain linearity in microwave amplifier tubes.
2. Definition. Gain linearity is the ratio of the numerical value of (1) the minimum incremental gain to (2) the maximum incremental gain within a given range of input or output power.
3. Equipment. Use method 4259 for measuring incremental gain.
4. Procedure.
  - 4.1 Measure the incremental gain at numerous points within the given range of input or output power.
  - 4.2  $\text{Gain linearity} = \frac{\text{Minimum incremental gain}}{\text{Maximum incremental gain}}$
  - 4.3 The gain linearity shall be within the limit(s) as specified in the TSS.
5. Precautions.
  - 5.1 Operating voltage fluctuations should be minimized so their effect on the measured results are negligible.
  - 5.2 Measuring systems should contain harmonic filters.

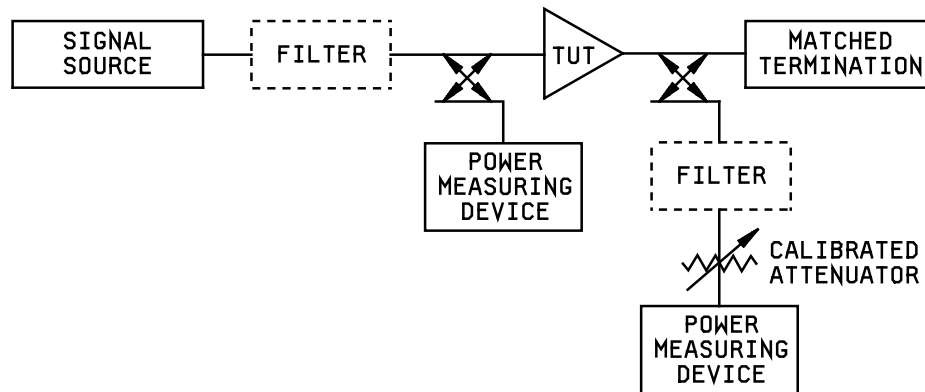
## MIL-STD-1311D

## METHOD 4253

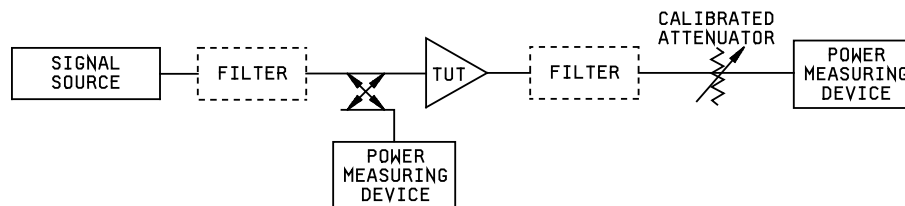
## GAIN

(Microwave amplifier tubes)

1. Purpose. To determine the power gain of a microwave amplifier tube.
  2. Test methods. The TSS shall specify whether the gain is to be measured under small signal, saturated, or other conditions.
- 2.1 Method A (directional coupler method).
- 2.1.1 Test circuit.

FIGURE 4253-1. Directional coupler method.

- 2.1.2 Test circuit.

FIGURE 4253-2 Attenuator method

2.1.3 Procedure. With the TUT inserted in the circuit shown on figure 4253-1 (or 4253-2) the input power to the TUT and the output power from the TUT are measured. The gain of the TUT in dB is the output power in dBm minus the input power in dBm.

- 2.1.4 Precautions.

2.1.4.1 Appropriate filters will be used if required by TSS for measurement of power output.

2.1.4.2 In the case of high-gain broadband amplifiers, the broadband noise power output of the TUT may be of sufficient magnitude to affect significantly the results obtained with these methods. Spurious output signals can also be of significant magnitude. Simple subtraction of the noise or spurious contributions can give an incorrect answer. In these cases band limiting filters should be used ahead of power indicating devices.

## MIL-STD-1311D

## 2.2 Method B.

## 2.2.1 Test circuit.

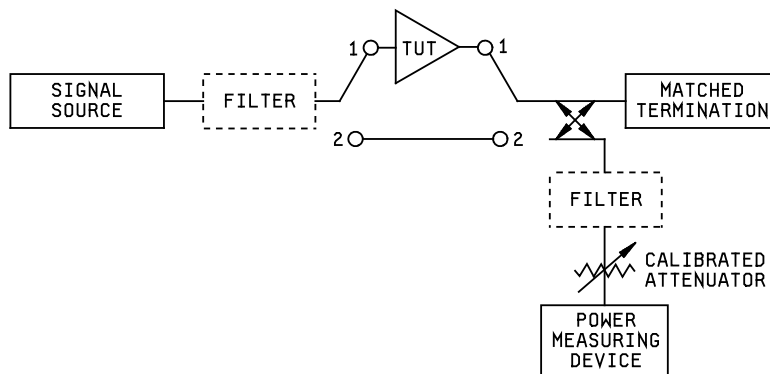


FIGURE 4253-3. Substitution method (high power).

## 2.2.2 Test circuit.

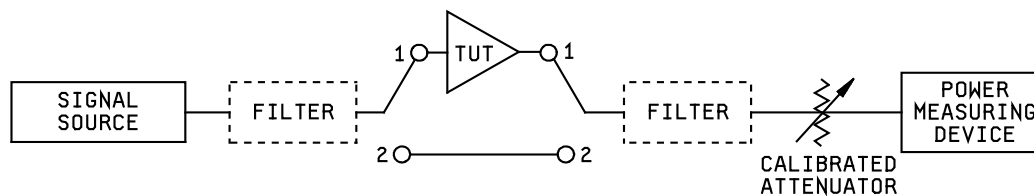


FIGURE 4253-4. Substitution method (lower power).

2.2.3 Procedure. With the TUT inserted in the circuit shown on figure 4253-3 or 4253-4, the attenuator is adjusted to give a convenient power measurement with the switches in position 1. The switches are then changed to position 2, and the attenuator is readjusted to give the same power measurement as obtained with the switches in position 1. The gain of the TUT is the difference between the two attenuator readings.

2.2.4 Precautions.

2.2.4.1 In some cases the VSWR presented to the source by the TUT and by the by-pass circuit may be different. The source shall be sufficiently well decoupled to prevent changes in incident power in the two cases.

2.2.4.2 The loss in the by-pass circuit including mismatch at either end shall be included in the gain calculation.

2.2.4.3 In the case of high-gain broadband amplifiers, the broadband noise power output of the TUT may be of sufficient magnitude to affect significantly the results obtained with these test methods. Spurious output signals can also be of significant magnitude. Simple subtractions of the noise or spurious contributions can give an incorrect answer. In these cases band limiting filters should be used ahead of power indicating devices.



## MIL-STD-1311D

## 2.3 Method C (ratio method).

## 2.3.1 Test circuit.

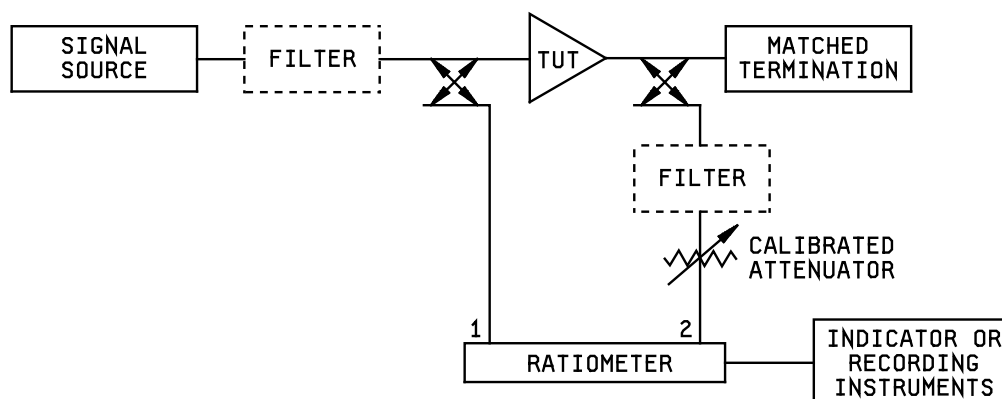


FIGURE 4253-5. Ratio method.

2.3.2 Procedure. With the TUT inserted in the circuit shown on figure 4253-5, portions of the input power to the TUT and of the output power from the TUT are fed to a ratio meter. The attenuator is set at a proper level. The ratio of the power to input (2) to the power at input (1) to the ratio meter is determined. The gain of the TUT is given by the formula below:

$$\text{Gain} = \text{dBR} - \text{dBi} + \text{dBo}$$

The ratio meter reads the ratio of the input power (2) to input power (1).

Where:

Gain = Gain of TUT in dB.

dBR = Ratio in dB determined by the ratio meter.

dBi = Ratio in dB of the TUT input power to that portion of the TUT input power fed to the ratio meter.

dBo = Ratio in dB of the TUT output power to that portion of the TUT output power fed to the ratio meter. (Sum in dB of directional coupler decoupling, attenuator, and filter (if required) losses.)

2.3.3 Precaution.

2.3.3.1 This method usually requires a square-wave modulated source for use with the ratio meter. This may produce erroneous results when used with certain kinds of pulse tubes. In the case of medium or high-power CW tubes erroneous performance measurements can result because of the reduced rf duty factor.

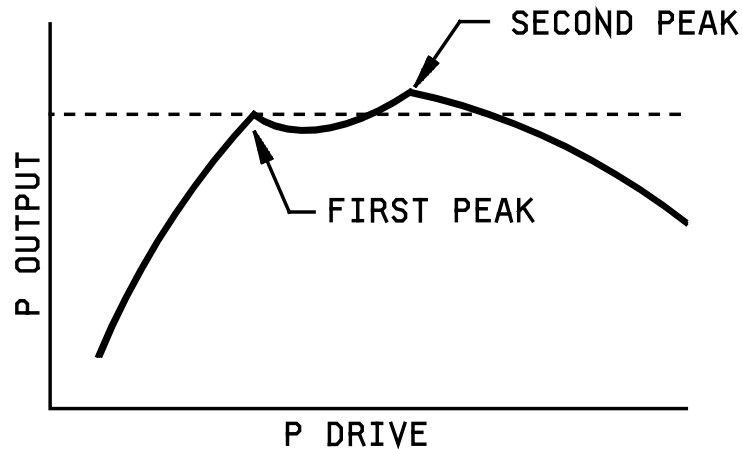
2.3.3.2 Serious errors can occur with this method unless matched detectors are used. Care shall be taken to scan parameters at a speed suitable for the response speed of test instruments.

## MIL-STD-1311D

## METHOD 4254

## SATURATED RF POWER OUTPUT

1. Purpose. To measure saturated rf power output. (Saturated rf power output is defined as the maximum fundamental rf power output obtained when the only variable is the rf drive power.)
2. Equipment. The output power measurement test circuit indicated in method 4250 shall be used.
3. Procedure. The tube shall be operated at the voltages, frequencies, and conditions specified on the TSS. The rf drive power shall be increased until maximum power output is obtained. As the rf drive is increased, it is possible that a second peak of output power will be observed. Only the first peak shall be used (see figure 4254-1), however. The second peak may be either lower or higher than the first.
4. Precautions.
  - a. Harmonic filtering should be used.
  - b. Rf drive power should not be applied in excess of that specified by the manufacturer.



NOTE: Use first peak only.

FIGURE 4254-1. Power output peaks.

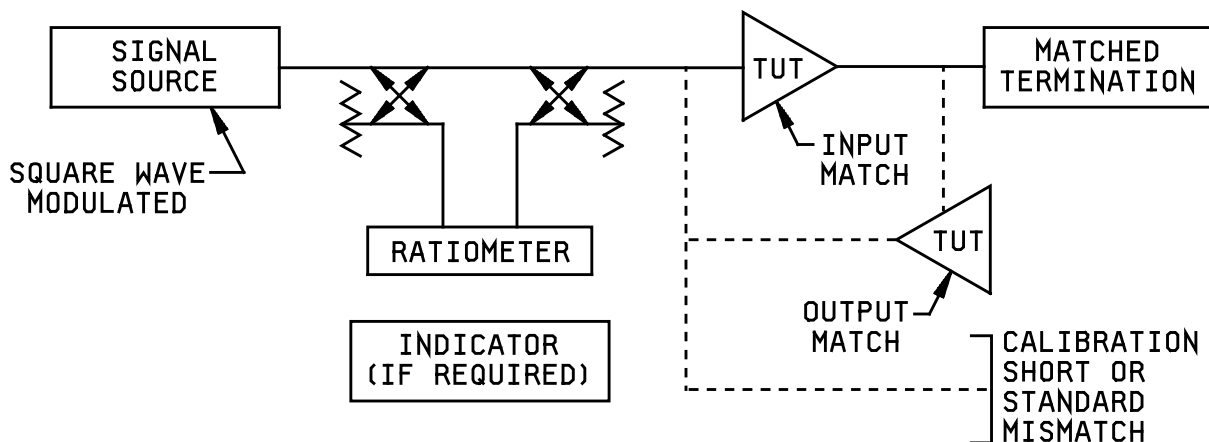
## MIL-STD-1311D

## METHOD 4256

## INPUT AND OUTPUT MATCH

(Traveling-wave tubes)

1. Purpose. To define methods of measuring input and output hot and cold match.
2. Definitions.
  - 2.1 Cold input (or output) match. The match of the input (or output) in the absence of operating voltages.
  - 2.2 Hot input (or output) match. The match of the input (or output) with operating voltages and drive applied as specified on the TSS.
3. Introduction. Hot and cold input and output match shall be measured using a continuous frequency variation or a series of discrete frequencies between frequency limits specified under test conditions. Slotted line techniques may be substituted for the other techniques when greater measurement accuracy of VSWR at discrete frequencies is required. Peak power ratios shall be used to establish hot-input match and hot-output match where the duty factor is other than continuous in the tube. In no case shall specified operating conditions be such as to require match measurements in non-linear regions.
4. Test methods.
  - 4.1 Method A (reflectometer method).
    - 4.1.1 Test circuit.

FIGURE 4256-1. Reflectometer method.

## MIL-STD-1311D

4.1.2 Procedure. The measuring circuit (see figure 4256-1) shall consist of a reference directional coupler and a measuring directional coupler connected to a device which indicates the ratio of the reflector signal power to the incident signal power. Directional couplers shall be chosen such that at the power level used square law operation of the detectors is assured. Calibration shall be accomplished by means of a short circuit or a standard mismatch replacing the TUT. The unmeasured rf connector shall be terminated in a resistive impedance which matches the nominal impedance of the tube as specified on the TSS.

4.1.3 Precautions.

4.1.3.1 This method usually required a square-wave modulated source for use with a ratiometer. When measuring hot match on a pulse tube, certain errors may result when using the conventional ratiometer technique.

4.1.3.2 The signal source shall be sufficiently decoupled from its load.

4.1.3.3 Hot input and output matches may depend upon signal level because of tube non-linearity.

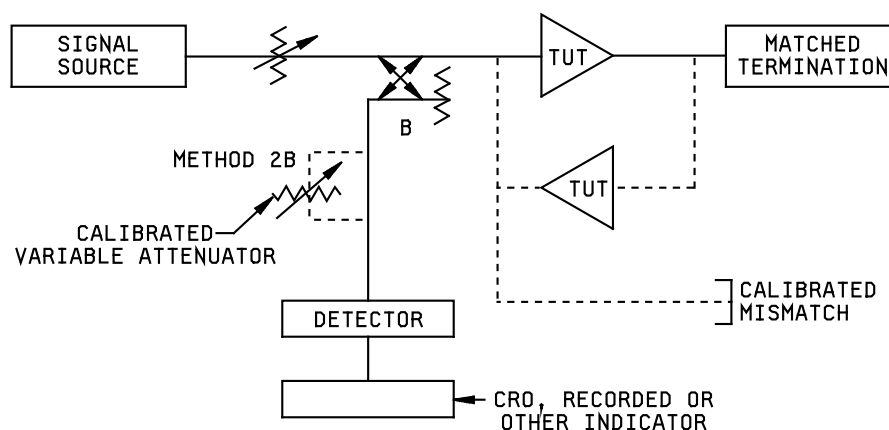
5. Method 2A (comparison to a calibrated mismatch).5.1 Test circuit.

FIGURE 4256-2. Comparison to calibrated mismatch.

5.2 Procedure. With the calibrated mismatch substituted for the TUT, and with a fixed output from the signal source, a baseline and a calibration line are established on the CRO or on the recorder. Several values of calibrated mismatch may be used if necessary.

A calibrated mismatch may be fabricated by using a calibrated attenuator in series with a short circuit. The VSWR is related to the setting of the calibrated attenuator (including line loss) by the following formula (if the measurement to be taken is a power measurement):

$$\text{Attenuator setting in dB} = 10 \log \frac{\text{VSWR} + 1}{\text{VSWR} - 1}$$

Replace the calibrated mismatch with the TUT and display or record the reflected power from the TUT. The VSWR may be read directly from the display or recording.

## MIL-STD-1311D

5.3 Precautions.

5.3.1 A level signal source is recommended where possible.

5.3.2 The calibration line will not be linear with VSWR. It is desirable to use calibrated mismatches of the same order of magnitude as the mismatch of the TUT.

5.3.3 Errors may be introduced because of inadequate directivity in the directional couplers. This is particularly important in measuring low VSWR's. The directivity of the coupler shall be at least 20 dB better than the return loss from the TUT to avoid errors due to phase effects on the mismatch.

5.3.4 The signal source shall be sufficiently decoupled from its load.

5.3.5 Hot input and output matches may depend upon signal level because of tube non-linearity.

6. Method 2B (comparison to calibration short circuit). Refer to figure 4256-2 in which a calibrated variable attenuator is inserted in the directional coupler leg at B at a fixed output from the signal source. With the TUT replaced by the calibration short, a baseline and calibration lines are established on the face of the CRO or recorder. The VSWR calibration lines are related to the attenuator setting by the following formula (if the measurement to be taken is a power measurement):

$$\text{Attenuator setting in dB} = 10 \log \frac{\text{VSWR} + 1}{\text{VSWR} - 1}$$

Test procedure and precautions remain the same as 5.2 and 5.3.

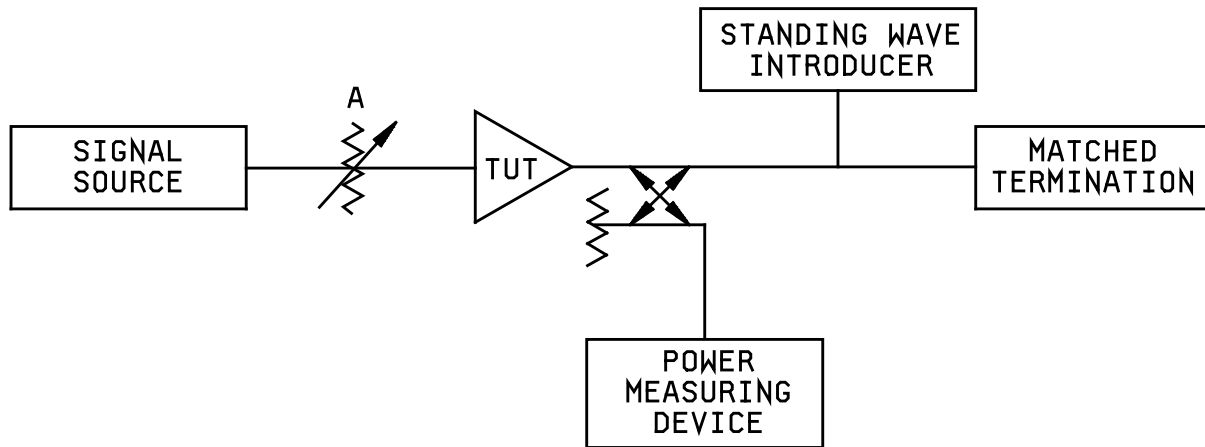
7. Method 3 (manual hot output match with applied input signal).7.1 Test circuit.

FIGURE 4256-3. Manual hot output match.

## MIL-STD-1311D

7.2 Procedure. Measurements shall be made on a single frequency point by point basis. Attenuator A sets the operating rf level. The standing wave introducer is adjusted to produce a known reflection coefficient  $K_T$ . A maximum power reading,  $R_{\max}$ , and a minimum power reading  $R_{\min}$ , are obtained by movement of the standing wave introducer. The square root of  $\frac{R_{\max}}{R_{\min}}$ , called "S", is used to compute the reflection coefficient of the output of the TUT,  $k_A$ , as follows:

$$k_A = \frac{(S-1)}{K_T(S+1)}$$

To express the match in VSWR, the following equation shall be used:

$$VSWR = \frac{1+k_A}{1-k_A}$$

7.3 Precautions.

7.3.1 The VSWR of the standing-wave introducer shall not be greater than the maximum rated operating mismatch of the tube in order to prevent damage to the TUT.

7.3.2 In some cases the VSWR of the matched termination may be comparable with standing-wave introducer resulting in a variation of VSWR as the phase is changed. This error may be corrected by making the measurement twice, with the load shifted by a quarter wavelength, and taking the geometric mean of the two values.

7.3.3 The signal source shall be sufficiently decoupled from its load.

7.3.4 Hot input and output match may depend upon signal level because of tube non-linearity.

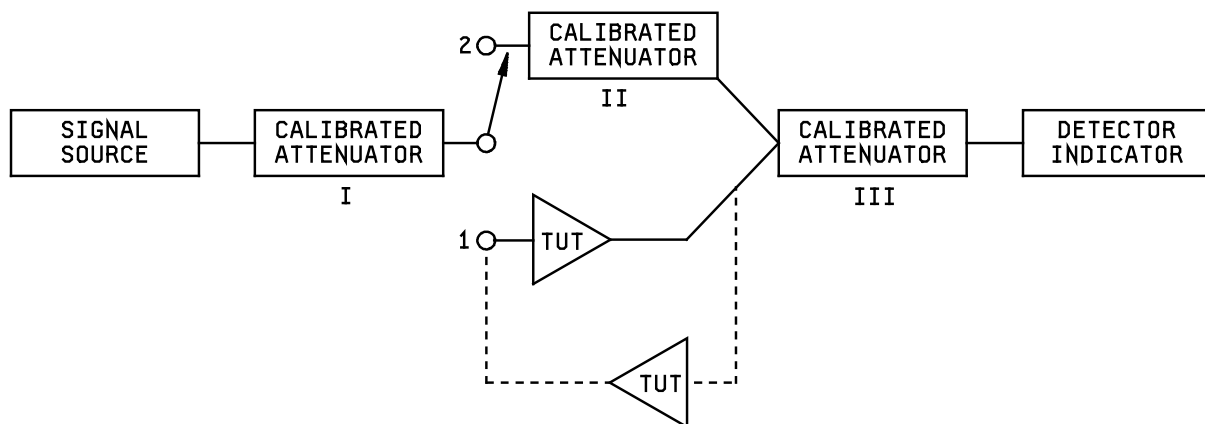
## MIL-STD-1311D

## METHOD 4257

## AMPLIFIER INSERTION LOSS

(Microwave amplifier tubes)

1. Purpose. This test is designed to determine the loss a microwave amplifier tube introduces when inserted into a circuit.
2. Definitions.
  - 2.1 Cold-insertion loss (backward and forward). This is performed with no voltages applied to the tube.
  - 2.2 Hot-insertion loss (forward). This is performed with the tube operating, except that the control electrode or anode is set at the specified voltage condition for cutoff.
  - 2.3 Hot-insertion loss (backward). This test is performed with normal operating voltages applied. The signal source is connected to the output of the tube.
3. Introduction. Cold and hot loss shall be measured by substitution method as shown on figure 4257-1 at the frequencies specified in the test conditions using a suitably isolated signal source and a detector at the input and the output of the tube, respectively. Any one, or combination, of the attenuators shown in the diagram may be used.
4. Test circuit.

FIGURE 4257-1. Substitution method.

5. Procedure. With the switch in position 1, set the signal output such that there is a convenient level displayed on the indicator. Note the value of the attenuators.

With the switch in position 2, the calibrated attenuators are adjusted to reproduce the same level on the indicator. Note the value of the attenuators. The amplifier loss is the difference between the sum of the attenuators in position 1 and the sum of the attenuators in position 2.

MIL-STD-1311D

6. Precautions.

- 6.1 The signal source shall be of high enough level and the attenuators shall be of sufficient value to cover the range of the tube.
- 6.2 Care shall be taken to prevent leakage from all rf cables and switches and connectors, including all video, dc, and collector leads.
- 6.3 Care shall be taken to set the indicated signal level sufficiently above the noise level in order to reduce errors.
- 6.4 In the case of hot-backward loss; if the TUT is operating in an unstable or nearly unstable condition, erroneous results may be obtained. This shall be taken into account to obtain meaningful results.



MIL-STD-1311D

METHOD 4258

## RADIO INTERFERENCE SHIELDING

(Microwave tubes)

1. Purpose. The purpose of this test is to determine the amount of rf radiation from the TUT and the susceptibility of a TUT to external rf fields. This test will normally be conducted in a system in its final configuration and not on a tube alone.

2. Method A (shielding to prevent radiation).

2.1 Test circuit.

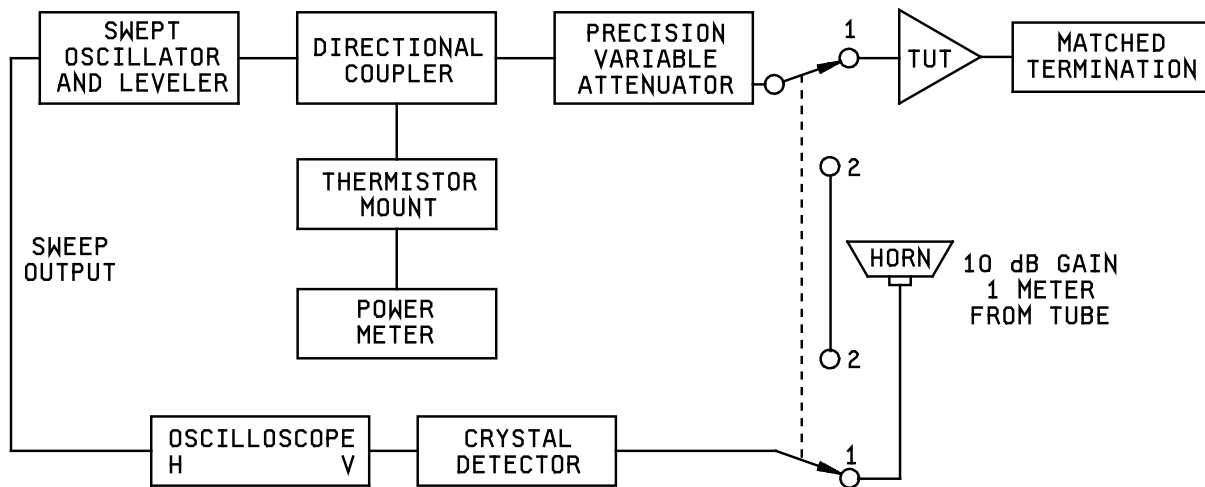


FIGURE 4258-1. Shielding to prevent radiation.

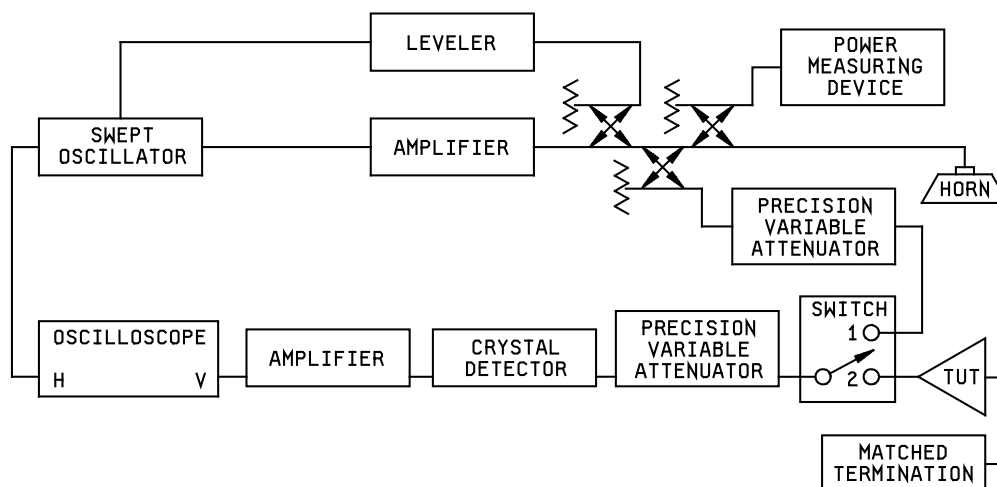
2.2 Procedure. With the switch in position 1, operate the tube with an input signal level of the specified value over the specified bandwidth, and with the output terminated into a matched load, the leakage power density at a distance of 1 meter from the tube shall be less than the specified value for all tube orientations. Switch position 2 is used for calibration of the system.

2.3 Precautions.

2.3.1 It is recommended the tube be measured in its specified operating environment, or equivalent, since the presence of surrounding material can affect the rf pattern of the horn.

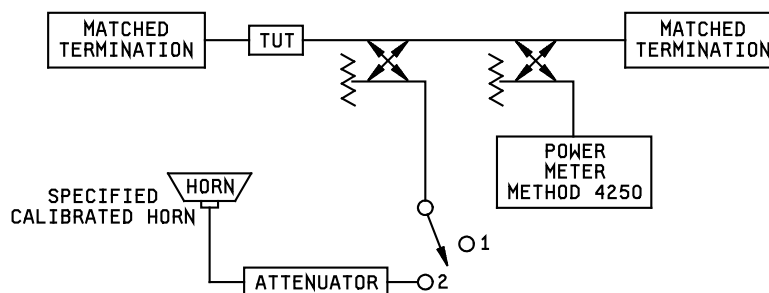
3. Method B (shielding against rf pickup).

## MIL-STD-1311D

3.1 Test circuit.FIGURE 4258-2. Shielding against rf pickup.

3.2 Procedure. With the tube immersed in a uniform field of the specified watts per square meter of arbitrary polarization and with the input terminated into a matched load, the signal appearing at the output of the test set shown on figure 4258-2 shall not exceed the value specified. The test shall be performed at the given frequencies or over the specified frequency band.

The output of the swept oscillator is amplified and the power supplied to the radiating horn is measured. By use of the directional coupler and precision variable attenuator, the power supplied to the vertical plates of the oscilloscope can be adjusted for a certain deflection at a calibrated power level when the switch is in position 1. When the switch is in position 2, the output of the tube can be measured as a result of the rf field from the horn.

4. Method C (shielding to prevent feedback).4.1 Test circuit.FIGURE 4258-3. Shielding to prevent feedback.

4.2 Procedure. Connect the TWT as shown on figure 4258-2 with normal voltages applied. Unless otherwise specified, the position of the horn is 1 meter from the tube.

With the switch in position 1, note the relative power output. With the switch in position 2, note the change in relative power output. The change shall not be greater than the specified value.

MIL-STD-1311D

4.3. Precautions.

4.3.1 Since noise is used as an indicator from the TUT, a band frequency limiter may be required to exclude signals of no interest.

4.3.2 Changes of power indication are a function of orientation of the horn. Unless otherwise specified, find the orientation which produces the maximum change.

MIL-STD-1311D

METHOD 4259

INCREMENTAL GAIN

(Microwave amplifier tubes)

1. Purpose. To measure incremental gain in microwave amplifier tubes.
2. Definition. Incremental gain is the ratio of (1) the change in rf output power, to (2) a specified small change in rf drive power at a stated driving or output power level.
3. Equipment. Use circuit in method 4253 for measurement of gain.
4. Procedure.
  - 4.1 The tube is operated in accordance with the voltages, stated driving or output power, and conditions specified in the TSS. The rf drive power is changed by the amount specified in the TSS, and the corresponding change in rf output power is recorded. The ratio of change in rf output power to the change of rf drive power is incremental gain expressed in dB.

$$\text{Incremental gain (dB)} = 10 \log \frac{\Delta P_{out}}{\Delta P_{in}}$$

- 4.2 The incremental gain shall be within the limit(s) as specified in the TSS.

5. Precautions.

- 5.1 Operating voltage fluctuations should be minimized so their effect on the measured results are negligible.
  - 5.2 It is important that the measuring systems contain harmonic filters.

## MIL-STD-1311D

## METHOD 4260

## NOISE FIGURE

(Microwave amplifier tubes)

1. Purpose. The purpose of this test is to measure thermal noise figure.

2. Method A (signal source method).

2.1 Test circuit.

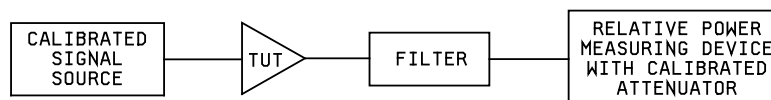


FIGURE 4260-1. Signal source method.

2.2 Procedure. Normal operating voltages are applied to the tube. With the input terminated, note the power output and attenuator setting. Increase the output attenuator 3 dB. Apply rf drive necessary to restore output power to previous indication.

$$NF_{dB} = 114 - S - B$$

Where:

NF = Noise figure in dB

B = 10 log (BW in MHz of filter or measuring device, whichever is narrower)

S = the power input from the calibrated signal source in dBm

2.3 Precautions.

2.3.1 The noise power from the TUT at the detector input should be much greater than the intrinsic detected noise. This can be ascertained by observing the noise power with the tube turned off and on. If there is not at least a 10 dB difference, the measured noise figure must be corrected by measuring the noise figure of the detector in the same way. Then the noise figure of the tube is given by:

$$(NF)_{tube} = (NF)_{measured} - \frac{(NF)_{receiver} - 1}{G_{tube}}$$

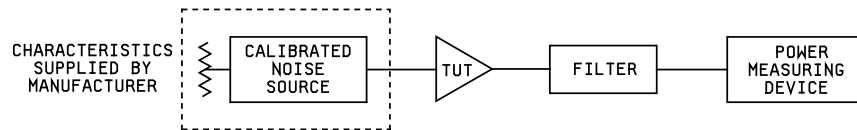
The noise figures and gain of the tube ( $G_{tube}$ ) are in numerics; not dB.

2.3.2 The signal source shall present the source impedance for which the amplifier is designed.

2.3.3 The signal source shall be matched when it is on and when it is off.

2.3.4 Insure that spurious oscillations are not included in the measurement.

## MIL-STD-1311D

3. Method B (broadband noise source method).3.1 Test circuit.FIGURE 4260-2 Broadband noise source method.

3.2 Procedure. Tube is operating with all normally specified voltages applied. With the noise source turned off, record the power output -  $N_1$ . With the noise source turned on, record the power output -  $N_2$ .

$$(NF)_{dB} = 10 \log \left[ \frac{F_s - 1}{\left( \frac{N_2}{N_1} - 1 \right)} \right]$$

Where:  $F_s$  is the ratio of (available power per cycle from noise source) to  $K_T$ .

3.3 Precautions.

3.3.1 The VSWR looking back into the noise source should be 1.5 maximum.

3.3.2 If it is necessary to change the power level from the noise source, a directional coupler or precision attenuator can be used between noise source and TUT. This will change  $F_s$  by the coupler or attenuator ratio.

3.3.3 Insure that spurious oscillations are not included in the measurement.

4. Automatic noise figure measurements. It is possible to make method B automatic by pulsing the noise source on and off at an audio rate and reading the noise figure directly on commercially available equipment.

## MIL-STD-1311D

## METHOD 4261

## SPURIOUS OUTPUT OR STABILITY

(Microwave amplifier tubes)

1. Purpose. The purpose of this test is to measure the stability of a microwave amplifier by varying the load conditions without rf drive and measuring power output variations.

2. Method A (broadband spurious). This is used to measure the broadband power emanating from the rf terminals of the TUT.

2.1 Test circuit.

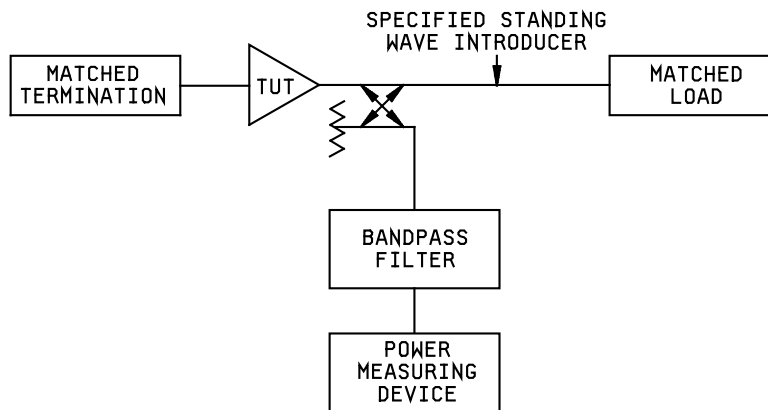


FIGURE 4261-1. Spurious output or stability method.

2.2 Procedure. With the TUT inserted in the circuit on figure 4261-1, with VSWR as specified, the phase of the standing-wave introducer is adjusted until a maximum power indication is obtained. The power is then measured. The bandpass filter shall have a specified bandwidth.

2.3 Precautions.

2.3.1 Under some conditions, tubes operating into a mismatch may produce out-of-band oscillations resulting in lower than normal spurious power output readings.

3. Method B (narrow-band). This is used to measure the narrow-band power emanating from the rf terminals of the TUT.

3.1 Test circuit. Replace the bandpass filter of figure 4261-1 with a tunable narrow-band filter of specified bandwidth.

3.2 Procedure. With the TUT inserted in the circuit shown on figure 4261-1, the frequency band of the TUT shall be searched by tuning the narrow-band filter to each peak of power. The phase of the standing-wave introducer is adjusted for maximum power indication. The power is then measured.

3.3 Precautions.

3.3.1 The combination of tunable narrow-band filter and power measuring device shall have adequate sensitivity.

3.3.2 A sufficient number of standing-wave introducer positions shall be used to insure that no peaks are missed.

MIL-STD-1311D

METHOD 4262A

AMPLITUDE MODULATION

(Traveling-wave tubes)

1. Purpose. The purpose of this test is to measure quantitatively the AM appearing on an rf signal as a result of electrical, mechanical, or accoustical stimuli applied to the TUT.

2. Method A (amplitude modulation).

2.1 Test circuit.

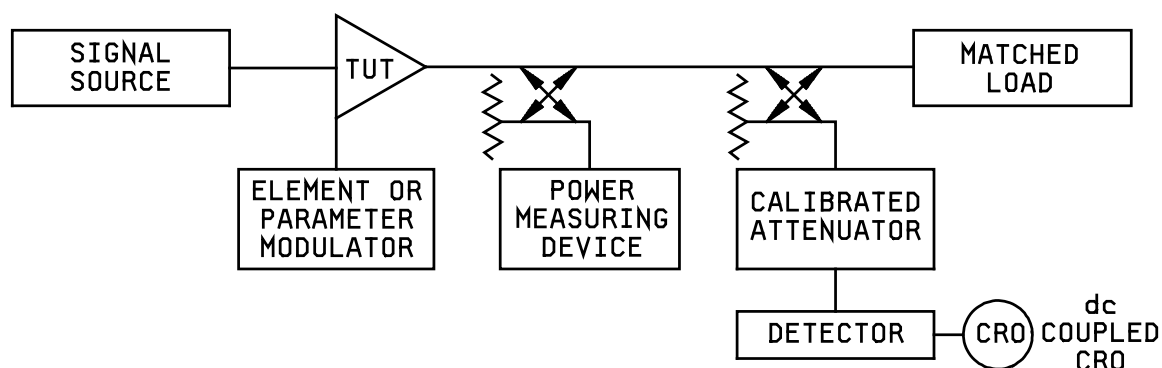


FIGURE 4262-1 Amplitude modulation method A.

2.2 Procedure. With the TUT operating with specified voltages and stimuli applied, adjust the attenuator to display the rf on the scope. Observe and note the positions of the maximum and minimum. Adjust the attenuator to measure the dB difference between the maximums and minimums, refer to figure 4262-2.

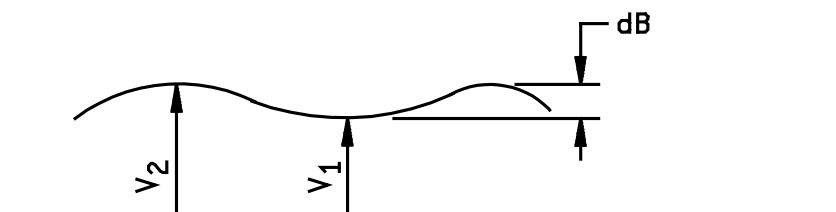


FIGURE 4262-2. Enlarged scope display.

$$\frac{V_2}{V_1} = \text{anti log} \left( \frac{dB}{20} \right)$$

This can be expressed in percent by  $\frac{V_2 - V_1}{V_2 + V_1} \times 100$

$$= \frac{\frac{V_2}{V_1} - 1}{\frac{V_2}{V_1} + 1} \times 100$$



## MIL-STD-1311D

If a power detector is used, then

$$\frac{P_2}{P_1} = \text{anti log} \left( \frac{dB}{10} \right)$$

which expressed in percent modulation becomes,  $\frac{\sqrt{\frac{P_2}{P_1} - 1}}{\sqrt{\frac{P_2}{P_1} + 1}} \times 100$

In cases where the AM, as displayed on the scope, is too small to be conveniently displayed, the scope should be calibrated on a less sensitive range with the attenuator, and the scope's sensitivity should then be increased by a known amount.

In cases where the AM is very large, the detector may be operating over a non-linear part of its range. The peak-to-peak readings are correct, but further manipulations of the data can lead to errors unless intermediate calibration points are used.

### 3. Method B (amplitude modulation based on two $\Delta$ -power measurements.

#### 3.1 Test circuit.

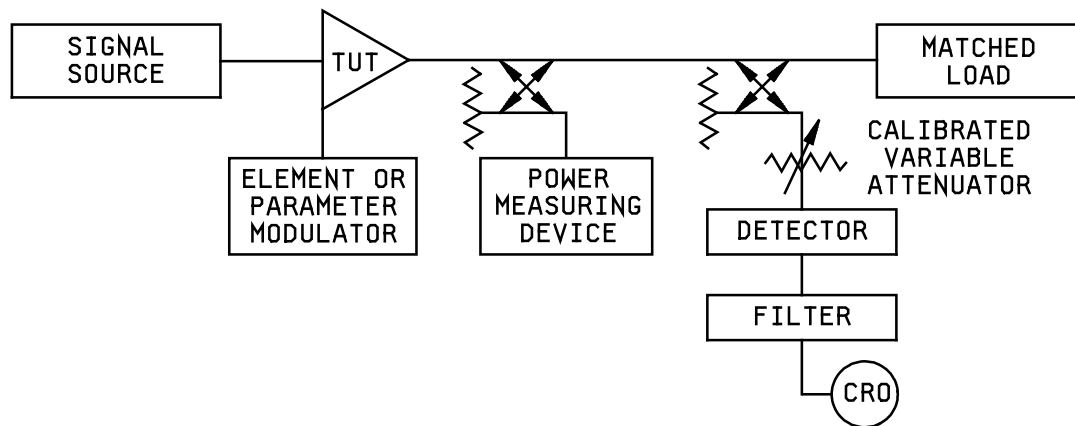
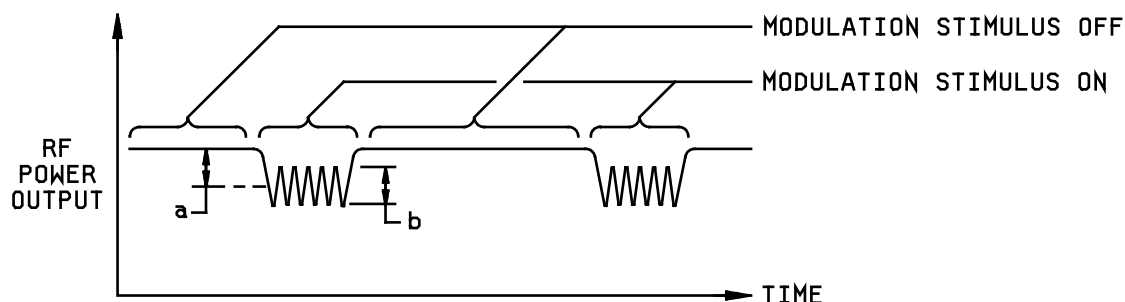


FIGURE 4262-3. Amplitude modulation based on two  $\Delta$ -power measurements.

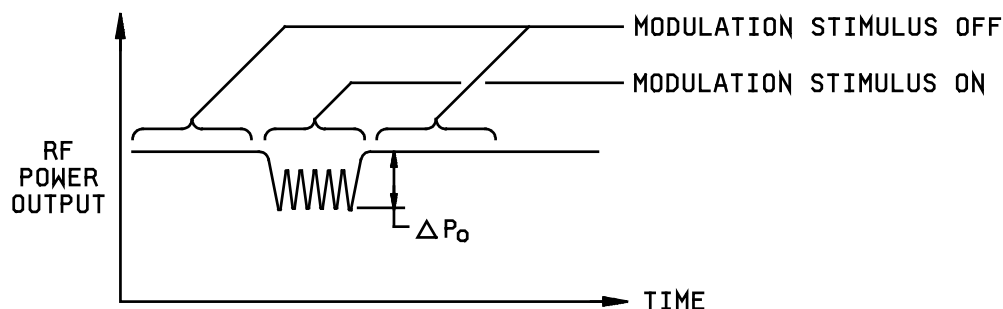
## MIL-STD-1311D

3.2 Procedure. Amplitude modulation is defined on the basis of two powers: (a) and (b) illustrated on figure 4262-4. Power output (a) is defined as the maximum deviation of average tube-power output from that observed when the modulation stimulus is momentarily removed. Momentary removals of the stimulus shall be frequent enough to eliminate from the measurements the effects of long-term or permanent degradations or increases in power output. Power output (b) is defined as the maximum peak-to-peak modulation of the tube-power output during the time the modulation stimulus is applied. During the test, two-power measurements are made, one for  $\Delta$ -power output (a) and one for  $\Delta$ -power output (b). The devices used shall be such that the readout information is directly proportional to tube-power output. The frequency response of the readout for  $\Delta$ -power (a) shall be restricted such that the effective response of the circuit items and readout device taken in combination is equal to that of a one-section low-pass RC filter with a time constant of 2 seconds. The frequency response of the readout for  $\Delta$ -power (b) shall be such that tube output fluctuations from zero up to a frequency equal to three times the maximum modulation stimulus input frequency shall be presented without appreciable attenuation.

FIGURE 4262-4. AM based on two  $\Delta$ -power measurements.4. Method C (amplitude modulation based on one  $\Delta$ -power measurement.

4.1 Test circuit. Same as 4262-3.

4.2 Procedure. Illustrated on figure 4262-5, amplitude modulation is defined as the maximum instantaneous deviation of tube power output (due to modulation) from the tube output when the modulation stimulus is momentarily removed. Momentary removals of modulation stimulus shall be frequent enough to eliminate from the measurements the effects of long-term or permanent degradations or increases in power output.

FIGURE 4262-5. AM based on one  $\Delta$ -power measurement.

MIL-STD-1311D

5. Precautions.

5.1 In case the power output or drive frequency of the TUT varies as other parameters are varied, it must be recognized that calibration may change and these shall be taken into account in the results.

5.2 The signal source contribution to AM shall be taken into account in the results.

5.3 Total viewing bandwidth shall be great enough to reproduce the expected AM. It is recommended the bandwidth be specified on the TSS.

5.4 This method is a basic AM measurement method. If complex displays on the scope are expected, the TSS shall define how to manipulate the data to make it compatible with system needs.

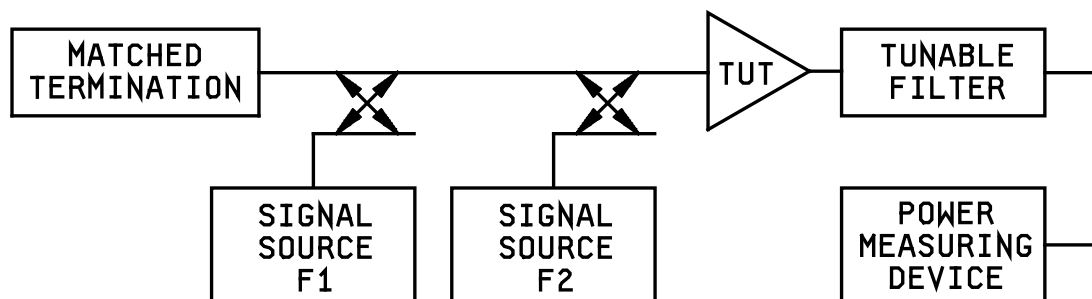
## MIL-STD-1311D

## METHOD 4263

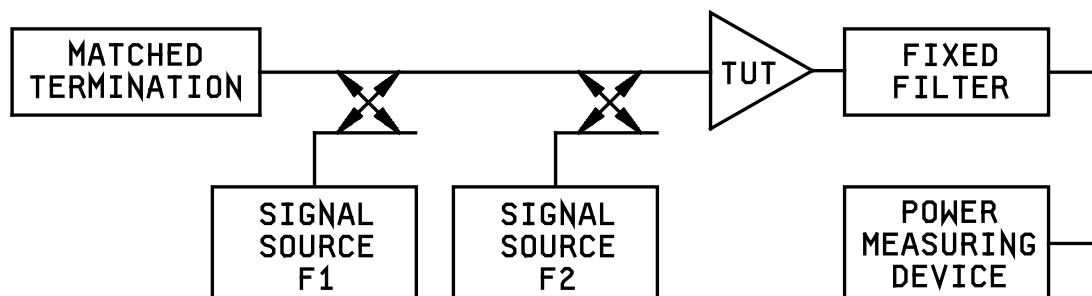
## INTERMODULATION OR CROSS MODULATION

(Traveling-wave tubes)

1. Purpose. This test is designed to measure the degree of intermodulation or cross modulation present when two or more signals are passed through a traveling-wave tube. Intermodulation is defined as that phenomenon of non-linear effects producing new frequencies of  $mF1 \pm nF2$  (m and n are integers) when two unmodulated signals of frequencies F1 and F2 are passed through a microwave amplifier. Cross modulation is defined as that phenomenon which results in changes of the output level of one unmodulated signal when other unmodulated signals are simultaneously applied to the input.

2. Intermodulation.2.1 Test circuit.FIGURE 4263-1. Intermodulation.

2.2 Procedure. With the TUT inserted in the circuit shown on figure 4263-1, signals of specified power and frequency at F1 and F2 are simultaneously applied to the TUT input. The power output of each frequency component is measured in accordance with method 4250. The filter shall reject all signals except those at the desired frequency.

3. Cross modulation.3.1 Test circuit.FIGURE 4263-2. Cross modulation.

MIL-STD-1311D

3.2 Procedure. With the TUT inserted in the circuit shown on figure 4263-2, a signal of specified power and frequency of F1 is fed to the TUT input. The power output at F1 is measured. A signal of specified power and frequency of F2 is then added to the input of the TUT, and the output power at frequency F1 is again measured. The change in output power  $P_o$  at frequency F1 is then calculated. The filter shall reject all signals except those at frequency F1.

MIL-STD-1311D  
METHOD 4264A  
ION NOISE MODULATION  
(Microwave tubes)

1. Purpose. The purpose of this test is to measure ion noise modulation of a microwave tube.
2. Test circuit.

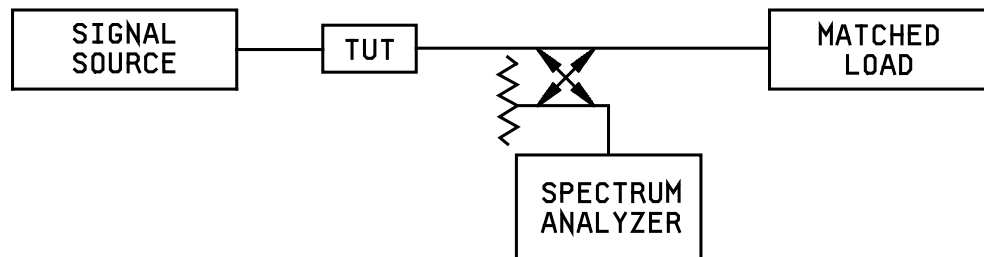


FIGURE 4264-1. Ion noise modulation.

3. Procedure. The TUT is operated as specified on the TSS in the circuit shown on figure 4264-1. Observe the rf output of the TUT on a spectrum analyzer and measure the amplitude modulation side bands which are typically within 50 kHz to 10 MHz either side of the carrier.
4. Precautions.
  - 4.1 The sweep speed of the spectrum analyzer shall be slow enough to achieve adequate dynamic range and resolution.
  - 4.2 Spectrum analyzers have finite resolution. Therefore, it may not be possible to make measurements as close to the carrier as may be required by some TSS's. In these cases, more elaborate angular phase measurement equipment is required and it shall be specified on the TSS.

MIL-STD-1311D

METHOD 4266A

DIRECT INTERELECTRODE CAPACITANCES

(Microwave tubes)

1. Purpose. The purpose of this test is to measure the effective capacitances of electrodes relative to each other on and within the TUT.

2. Procedure. The capacitance shall be measured with cathode cold and no direct voltages applied. All elements, except the one under test, shall be connected to ground. If flying leads are part of the tube, lead and sleeve lengths shall be specified.

3. Precautions.

3.1 When measuring the capacitance of any lead with respect to ground, the effect of by-pass capacitors, if any, in any lead shall be taken into account. Unless otherwise specified, they shall be included in the measurements.

MIL-STD-1311D

METHOD 4268

ION PUMPS

When an ion pump is an integral portion of the tube, serving either as a vacuum pumping device or as a sensitive ion gauge and has a measurement specified on the TSS, the ion pump current shall be within the limit(s) specified. The power supply for an ion pump shall be a high impedance device, so only the power supply specified on the TSS or exact equivalent may be used. The test measurement shall be made at a point in time as specified on the TSS after application of all element potentials.



MIL-STD-1311D

METHOD 4270

HEATER-CATHODE LEAKAGE

(Microwave tubes)

1. Purpose. The purpose of this test is to measure the leakage current across the insulation used to isolate the heater from the cathode. This test is not applicable for tubes where the heater is tied internally to the cathode lead of the tube.

2. Procedure. Ground one of the heater leads. All other tube leads except the cathode lead shall be tied together and connected to a separate ground. Apply rated heater voltage only. Apply the TSS dc test voltage between the grounded heater lead and the cathode lead. A protective resistor, whose value in ohms is not more than 1,000 times the H-K voltage, shall be used in series with the current meter. Measure the dc current from cathode to ground for the TSS polarities of the cathode to heater voltage.

3. Precaution. The measurement circuit shall be metered so that the only leakage current measured is that from heater to cathode.

MIL-STD-1311D

METHOD 4271A

AMPLIFIER POWER BANDWIDTH

1. Purpose. To determine the frequency range between points of specified output power level of an amplifier as the frequency of the driving source is varied. The level may be specified absolutely or relative to the maximum power.
2. Definition. Power bandwidth is defined as the total frequency range over which the output power of a microwave tube exceeds a specified value of output power. Two varieties of bandwidth measurements can be defined as follows:
  - a. Dynamic power bandwidth is measured with a swept-frequency drive source of constant output power level.
  - b. Static power bandwidth is measured point-by-point at a series of spot frequencies of a constant drive power level.
  - c. Amplifier power bandwidth is frequently specified between the half-power (-3 dB) points, but measurements between other output levels are valid for other applications. The TSS shall show the power level at the band limits when a level other than -3 dB is required.
3. Equipment. Appropriate output power and frequency measuring equipment shall be used for the power levels and frequencies of interest. Output power shall be measured as in method 4250.
4. Procedure.
  - a. The tube shall be operated under the specified conditions, adjusted as for the power output test and the frequency of the driving power varied through the required excursion by a dynamic (swept) or a static (point by point) technique, as specified, and the output power measured or displayed. When necessary, the sweep rate and other conditions will be specified.
  - b. The driving power frequency shall be varied to change the output of the TUT between the specified output power values and the frequencies at these values shall be measured. Requirements or limits on loading, discontinuities, and hysteresis shall be as specified.
5. Precautions.
  - a. When the swept technique is used, care shall be taken to insure that the sweep rate is low enough to avoid high frequency instrumentation problems and high enough to avoid any thermal tuning effects.
  - b. In multiple resonator and high-beam current tube types, thermal detuning and beam loading can cause wide differences in the results obtained by the dynamic and the static methods.

## MIL-STD-1311D

## METHOD 4274A

## VOLTAGE TUNING RANGE

1. Purpose. The purpose of this test is to measure the voltage(s) required at the tuning element (electrode) to obtain an indicated frequency (or frequency range).

2. Definitions.

- a. Hole. A break in the voltage-frequency characteristic which, in effect, makes certain frequencies inaccessible. This break is the result of electronic tuning hysteresis and is measured in terms of the width of the inaccessible frequency band,  $\Delta F$ .
- b. Power drop-outs. A power drop-out is a discontinuity in the power-frequency characteristic which exceeds a specified change in power,  $\Delta P$ , or which results in a reduction of power to a level which is less than specified minimum,  $P_{min}$ .

3. Equipment.

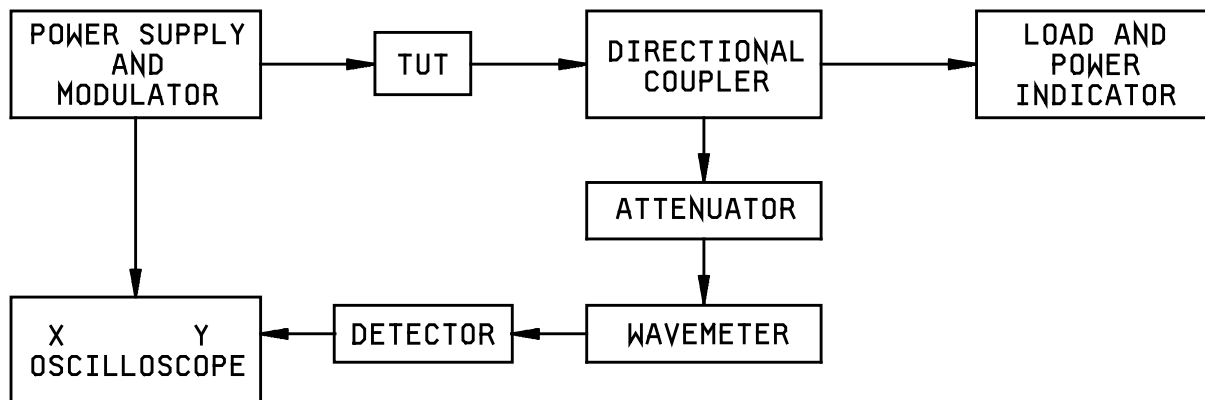


FIGURE 4274-1. Equipment layout for voltage tuning measurements.

An oscilloscope with a fast enough response to observe power versus frequency, including any frequency discontinuity while sweeping the tube is required. Any frequency of operation can be found by observing the wavemeter pip on the oscilloscope. The regulation of the supplies shall be sufficient to stay within specified tolerances of the voltages and currents.

4. Procedure.

- a. Anode tuning (VTM). With the specified conditions applied to all other electrodes, the anode voltage shall be adjusted to sweep the required frequency range.
- b. Delay line tuning (MBWO). With the specified conditions applied to all other electrodes, the delay line voltage shall be adjusted to sweep the required frequency range.
- c. Sole tuning (MBWO). With the specified conditions applied to all other electrodes, the sole voltage shall be adjusted to sweep the required frequency range.
- d. Ratio (slope) tuning (MBWO). With the specified conditions applied to all other electrodes, both the delay line voltage and sole voltage shall be adjusted to sweep the required frequency range. The ratio of delay line voltage to sole voltage shall be maintained at the specified value.

5. Acceptance criteria. The tube shall tune the specified frequency range as a consequence of the specified voltage variations. The TSS shall specify the maximum value of  $\Delta F$  for holes, and  $\Delta P$  or  $P_{min}$  for power drop-outs, or may require no detectable holes using a specified wavemeter.

## MIL-STD-1311D

## METHOD 4275

## CONTROL ELECTRODE CHARACTERISTICS

1. Purpose. The purpose of this test is to measure the change in output resulting from the application of specified voltages to the control electrode.

2. Equipment.

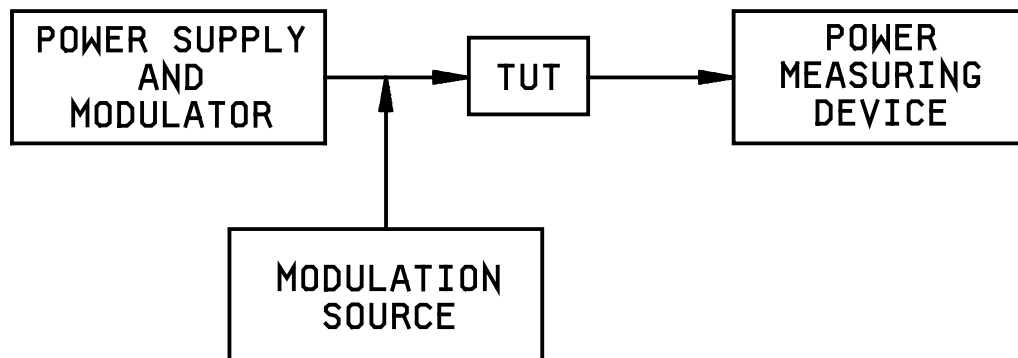


FIGURE 4275-1. Equipment layout for control electrode characteristics measurements.

3. Procedure.

a. Cutoff power ratio.

- (1) With voltages adjusted to the specified values, measure the power output.
- (2) Change the control electrode voltage to the indicated value for cut-off, and again measure the power output. The power level under these conditions may be quite low, so it may be necessary to change power measuring devices to make this power measurement.  
Cutoff power ratio is the ratio of the two measured powers expressed in dB.

b. Cutoff current ratio.

- (1) With voltages adjusted to the specified values, measure the current to the specified electrode.
- (2) Change the control electrode voltage to the indicated value for cutoff, and again measure the current.  
Cutoff current ratio is the ratio of the two measured currents, expressed in dB.

c. Modulation. With the specified conditions applied to all other electrodes, the control electrode voltage shall be varied as specified, and the variation of power output shall be measured. The ratio of the highest and lowest values, expressed in dB, shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 4276A

## TURN-OFF CONTROL ELECTRODE VOLTAGE

1. Purpose. To determine the change in control electrode voltage needed to reduce the flow of power from normal to a specified low level.
2. Definition. Turn-off control electrode voltage is the change in control electrode voltage required to reduce the normal power to a specified low level of power or dB above  $KT\Delta F$ .
3. Equipment.

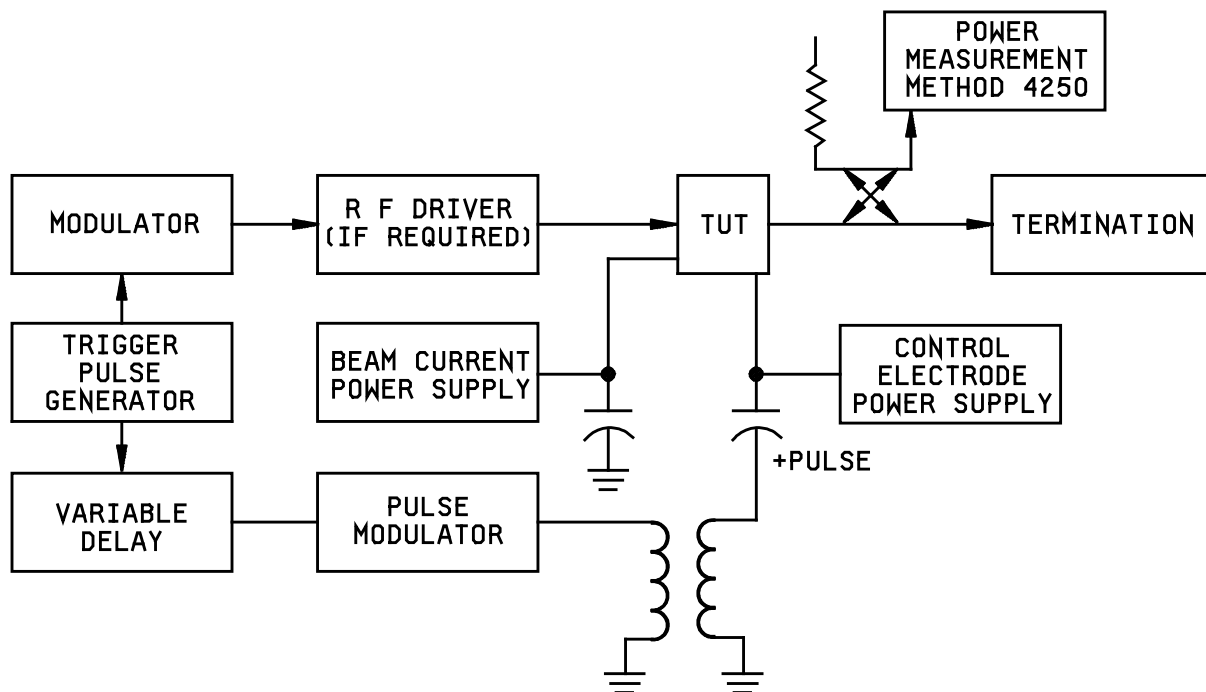


FIGURE 4276-1. Equipment layout for control electrode voltage measurements.

4. Procedure. With the tube operating in the circuit of figure 4276-1 for power output, the peak control electrode voltage (using a measuring circuit of method 4306) required to effect turn-off shall be within the limits specified.

## MIL-STD-1311D

## METHOD 4277A

## POWER SPECTRAL CHARACTERISTICS

1. Purpose. The purpose of this test is to measure two characteristics of the rf output spectra from self modulated or externally modulated cross field devices. These two characteristics, with freedom from harmonic content, are (a) the total average power (P) within a specified spectral bandwidth (BW), and (b) the bandwidth (BW) at a specified power density level (pdl).

2. Method A (integrator).

2.1 Equipment.

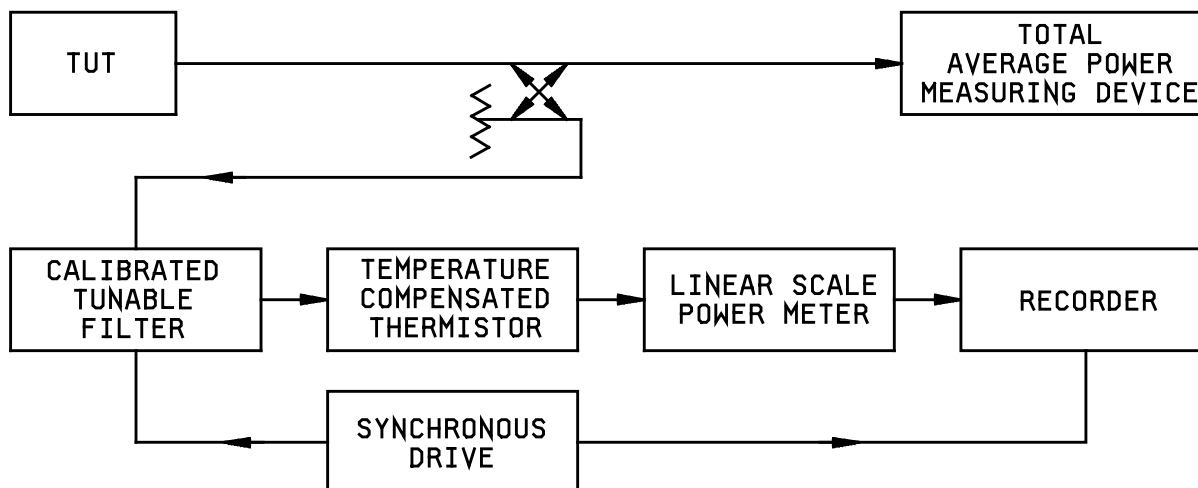


FIGURE 4277-1. Equipment layout for power spectral characteristics measurements.

2.2 Procedure. Using the test circuit shown on figure 4277-1, a relative plot of power versus frequency is obtained on the recorder. A typical plot is shown on figure 4277-2. The horizontal frequency scale is determined by the synchronous drive relation between the calibrated tunable filter and the recorder. The vertical scale Y is arbitrary and is determined by the following calculations:

$$Y = \frac{X \times (pdl) \times At}{Po}$$

Where:

Y = Vertical scale value (expressed in dimensional units, for example, inches) for specified power density level, pdl.

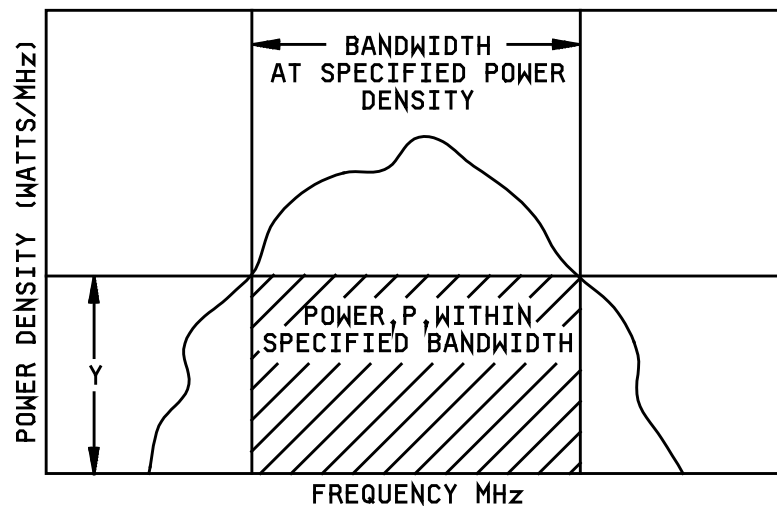
pdl = Specified power density level, W/MHz.

X = Horizontal scale calibration (expressed in MHz/dimensional units, for example, MHz/inch).

At = Total area under plot (expressed in dimensional units, for example, inch<sup>2</sup>) and may be measured by a planimeter or any equivalent integration technique.

Po = Total average fundamental power output from the TUT.

MIL-STD-1311D

FIGURE 4277-2. Typical plot of power versus frequency.

2.3 The average power,  $P$ , within the specified bandwidth is determined by the relationship,

$$P = \frac{A \times P_o}{A_t}$$

Where:

$A$  = Total area within bandwidth specified.

$A_t$  = Total area under plot.

$P_o$  = Total average power output from TUT.

2.4 The bandwidth (BW) at a specified power density level (pdl) is obtained directly from the calibrated recorder plot as illustrated on figure 4277-2. Calibrating in this fashion the power meter reading corresponding to  $Y$  can be used without the recorder to determine the two frequencies at which  $Y$  is first reached.

### 2.5 Precautions.

- a. The tunable filter shall have a 3 dB bandwidth that is less than 10 percent of the bandwidth being examined.
- b. The directional coupler shall have a relatively flat response or known calibration over the frequency range of interest and harmonics should be excluded from the thermistor.

### 3. Method B. Average tuning sensitivity/spot tuning sensitivity method.

3.1 In method B, power density is defined as the power per unit bandwidth delivered when the tube is tuned across the specified frequency band by a linear voltage sweep. It is, therefore, affected by both power output and tuning sensitivity variations across the band, which are allowed for in the following method.

## MIL-STD-1311D

The following definitions are required:

$\Delta F$  = Specified frequency band.

$\Delta V$  = Tuning voltage swing required to cover  $\Delta F$ .

$\Delta V$  (max) = Maximum permissible value of  $\Delta V$ .

ATS = Average tuning sensitivity, where  $ATS = \frac{\Delta F}{\Delta V}$  MHz/volt.

N = Number of equal segments into which  $\Delta F$  is divided for measurement purposes; measurements are made at the N + 1 spot frequencies separating the segments, including the end points.

$\delta F$  = Width of one frequency segment.

$\delta V$  = Voltage swing required to tune over one segment ( $\delta V$  may be distinguished by subscripts, for different segments).

STS = Spot tuning sensitivity, where  $STS = \frac{\delta F}{\delta V}$ .

Po = Power output at the center of a segment, taken as the average of the values at the two measurement points defining the segment.

P/TSP = Power/tuning sensitivity parameter, where

$$\frac{P}{TSP} = \frac{P_o \times ATS}{STS} \geq (\text{minimum power density}) \times \Delta F.$$

The TSS shall specify a minimum value of ATS, which will ensure that the tube can be tuned across the band with a swing no greater than  $\Delta V$  max, and a minimum value of P/TSP which will ensure the required power density in each segment, without placing unnecessary restrictions on Po and STS separately. The values of N and  $\delta F$  should be chosen so that the variations of power and tuning sensitivity are not large within one segment, for a typical tube of the type being tested, while N is no larger than necessary.

### 3.2 Test circuit.

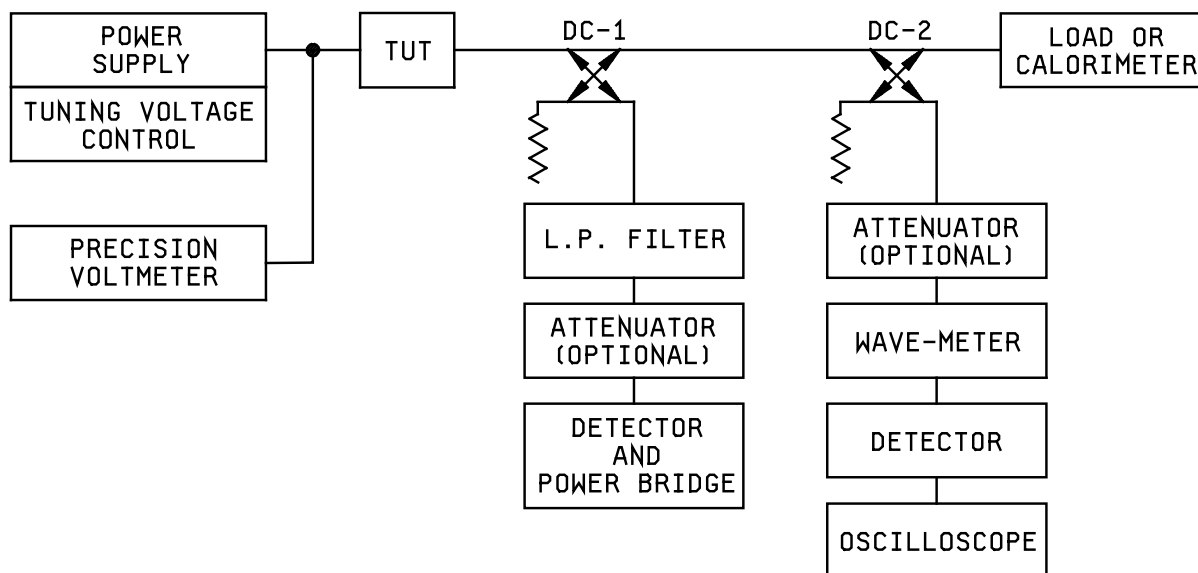


FIGURE 4277-3. Test circuit for power spectral characteristics.



## MIL-STD-1311D

3.3 Procedure. The equipment is set up as on figure 4277-3. Directional coupler No. 1 (DC-1) and its associated components form the power measuring circuit. They are calibrated as a unit at each of the  $N + 1$  measurement frequencies, by connecting a calorimeter on the end of the line and manually tuning the tube to each frequency, as indicated by the components attached to directional coupler No. 2 (DC-2). It is permissible to use the calorimeter for all power measurements, and eliminate DC-1 and associated components, but this procedure is normally too slow for production testing.

The tube is oscillated at each of the  $N + 1$  frequencies in turn, under the conditions specified on the TSS, and the CW power output and tuning voltage are measured at each point (other required electrode voltages and currents may be integrated with these measurements, but do not form part of this method). The differences of tuning voltage give the values of  $P_o$ , for each segment. The difference of the first and last voltages give  $\Delta V$ .

From these measurements, calculate ATS, STS, and P/TSP in accordance with the definitions given in 3.1. ATS shall not be less than the specified value. P/TSP shall not be less than the specified value, in each segment individually. The measurements are illustrated on figure 4277-4.

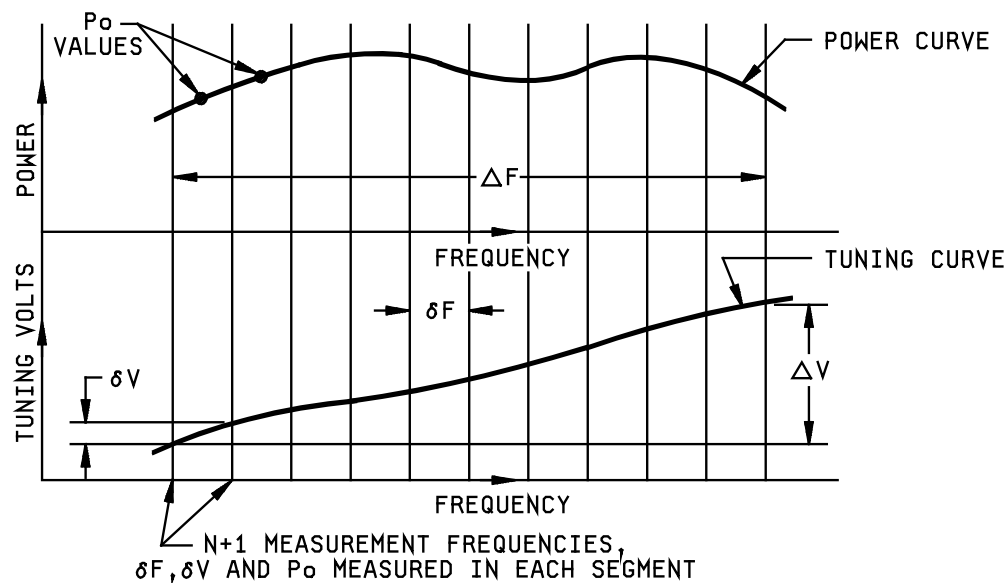


FIGURE 4277-4. Graph-tuning volts versus power output.

3.4 Dynamic presentation. A dynamic presentation can be obtained by inserting a wavemeter or tunable bandpass filter in the No. 1 directional coupler circuit, sweeping the tube with a linear (sawtooth) tuning voltage, and displaying the detected output on an oscilloscope. Since the attenuation and bandwidth of a tunable filter are not generally constant across a wide tuning range, the system shall be calibrated by the static measurements described under 3.2; if the tube output is adjusted at each frequency segment so that the P/TSP is just equal to the specified minimum, and the corresponding oscilloscope deflection recorded under the dynamic conditions, a curve representing minimum acceptable response at each frequency is obtained which allows for the varying filter response and detector sensitivity. Note that the oscilloscope horizontal sweep is tied to the sweep of the tunable filter, not to the modulating voltage. The frequency of the latter shall be much higher than the sweep frequency of the filter (which may be a manual sweep).

In place of the tunable filter, a heterodyne system with a separate swept oscillator and fixed (IF) filter may be used. In this case the sweep frequency of the swept oscillator must be either much higher or much lower than the sweep frequency of the TUT, and the oscilloscope is locked to the slower one. The method of calibration is by reference to the static measurements as before.

## MIL-STD-1311D

3.5 Precautions. The low-pass filter is required in the circuit of directional coupler No. 1 to eliminate errors due to harmonic power passing through the directional coupler to the side arm with less than the correct attenuation. The filter should cut off above the highest frequency to be measured, but if possible below the second harmonic of the lowest frequency.

Since comparatively small differences of frequency and voltages are to be measured, the instruments used to measure these two should be capable of a resolution of 1 part in  $10^4$ , though the absolute accuracy of the voltage measurement need not normally be better than 1 percent. The voltage measurements are subject to error due to rectification of rf pickup, since the voltage of an electrode close to, or part of, the rf circuit must be measured. This effect tends to be more serious with high impedance instruments, which are usually the most precise. The errors can be reduced by the use of shielded leads and low-impedance circuits. It may be necessary to use a digital voltmeter to obtain the required resolution, and to shunt the input with both capacity and resistance, to by-pass both rf and rectified currents. The shunting resistor will not affect the dc measurements as long as it is high compared to the lead resistance, and does not put a significant drain on the power supplied.

This method may be used over any bandwidth, with appropriate choice of N, but is slower than method A in narrow-band cases.

3.6 Calibration. The system calibration is referred to the appropriate calibrations for power, frequency, and voltage, made by standard methods with the precautions indicated.

MIL-STD-1311D

METHOD 4278A

PHASE

(Microwave amplifiers)

1. Purpose. The purpose of this test is to measure the several phase parameters of microwave amplifiers.
2. Equipment. The block diagram (figure 4278-1) describes the relationships of the system components while the diagrams on figure 4278-2 and figure 4278-3 show optional equipment which might be utilized in a laboratory phase measuring system. When power and frequency measuring devices are used, they shall be located external to the phase sampling arms leading to the comparator.

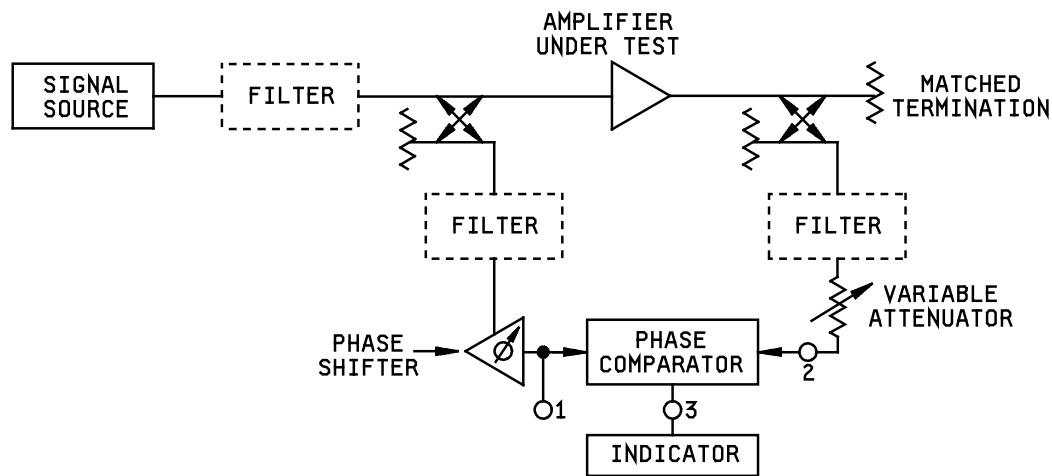


FIGURE 4278-1 Basic phase shift measuring circuit.

3. Theory. Phase measurements in microwaves are usually derived from substitution methods. However, microwave devices which incorporate velocity modulation principles or slow-wave circuits cannot be replaced by an equal length of transmission line because the physical length of the device bears no relationship to its electrical length. Furthermore, the position of the electron beam near the circuit participates in the determination of that electrical length and thus may cause the phase length to vary with input conditions and driving power as well as driving frequency. This method describes the means for making phase measurements.

A long length of transmission line has a phase frequency characteristic which is a direct function of its electrical length, as given by:

$$\phi_{\text{degrees}} = \frac{360\ell f}{c} \quad (1)$$

Where:

c = velocity of light

 $\ell$  = length in electrical wavelengths

f = frequency

The insertion of this line produces a shift in phase of which any fractional part of  $360^\circ$  is capable of measurement but any integral multiples of  $360^\circ$  will be lost.

However, the slope of the phase-frequency curve measured when the line is inserted at a point in a phase measuring circuit is:

$$\frac{\partial \phi}{\partial f} = \frac{360\ell}{c} \quad (2)$$

The slope of the frequency-phase characteristic at a given frequency can then be inserted into equation (1) to determine the electrical phase length.

## MIL-STD-1311D

4. Test circuit. Using the basic circuit given in figure 4278-1, the required phase tests shall be measured using either method A or B as appropriate.

#### 4.1 Method A.

4.1.1 The phase comparator configuration on figure 4278-2 is inserted in 4278-1 as indicated by numbers 1, 2, and 3. It consists of a standing-wave indicator fed from both ends and a probe, terminated in a voltage indicator. The phase shifter is used to compensate for any existing phase shift which is not attributable to the amplifier under test.

The incident power sampled by the directional couplers is applied to the two ends of the standing-wave detector. For maximum measurement accuracy, the sampled powers arriving at the voltage indicator should be of nearly equal magnitude, and is achieved by using the variable attenuator.

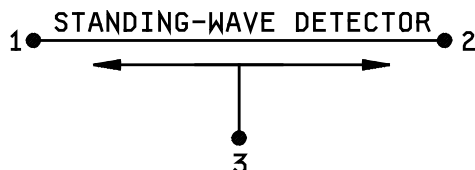


FIGURE 4278-2. Phase comparator configuration (method A).

4.1.2 Procedure. A reference position of the travel probe is established by adjusting the position of the probe for a minimum reading of the voltage indicator.

The shift of the probe position in electrical degrees from the reference position to a position where the voltage indicator again shows a minimum is measured as a function of the change in operating conditions under consideration, for example: electrode potentials, electron current, or input rf drive.

The phase shift of the output signal in electrical degrees is twice the shift of the probe positions.

#### 4.2 Method B.

4.2.1 An alternative method of measuring the phase shift of the output signal is shown on figure 4278-3 inserted in 4278-1 as indicated by numbers 1, 2, and 3. With this technique, the output signal sampled by the directional coupler goes to the probe of the standing-wave detector, and the voltage indicator is connected to one end of the standing-wave detector.

In all other respects, the measuring setup is identical with figure 4278-2. The measurement procedure is as before except that the phase shift of the output signal in electrical degrees will be equal to the shift of the probe position.

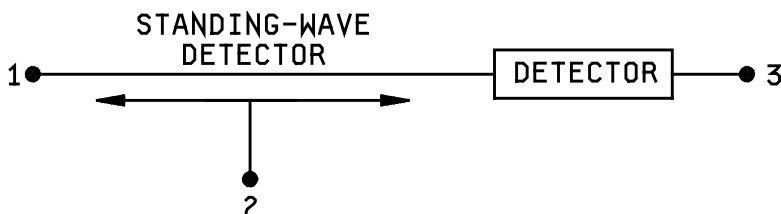


FIGURE 4278-3. Phase shift measuring circuit (method B).

## MIL-STD-1311D

5. Phase measurements.

5.1 Phase shift. The purpose of this measurement is to determine the phase shift of the rf signal introduced by the insertion of the amplifier in the circuit.

5.1.1 Procedure. With the amplifier out of the circuit and the mainline of the directional couplers joined together by a section of transmission line of the same electrical length as the amplifier, the phase shift versus frequency is recorded. The phase can be balanced to zero at some convenient frequency by the phase shifter in order to simplify the computations.

With the amplifier inserted in the circuit and operating under its specified conditions, the phase shift versus frequency is again recorded with the phase shifter remaining at its previously calibrated position. Measurements shall be taken at each specified frequency.

The phase shift of the amplifier is the difference between the two measurements at corresponding frequencies.

5.2 Phase linearity. The purpose of this measurement is to determine the linearity of the amplifier phase shift as a function of the rf frequency.

5.2.1 Procedure. With the amplifier inserted in the circuit and operating under its specified conditions, the phase shift is measured over the specified frequency range.

The frequency band shall be swept with a well leveled or programmed drive signal or enough measurements are taken at different frequencies to obtain a curve of the phase shift versus frequency. Phase linearity is the deviation in degrees of this curve from a straight line or specified curve, in a specified frequency interval giving minimum degradation after subtracting residual phase error introduced by the phase bridge components.

5.3 Phase sensitivity. The purpose of this measurement is to determine the sensitivity of phase shift with respect to amplifier applied voltage, current, and applied rf drive power, with the frequency held constant.

5.3.1 Procedure. Measure the change in phase as the specified parameter is varied over the required range of values. All other operating conditions are to remain constant during this measurement. The change of phase is expressed in terms of degrees per units of the parameter varied (usually a 1.0 percent variation).

5.4 Phase stability. The purpose of this measurement is to determine the dependency of phase shift upon the passage of time.

5.4.1 Procedure. Phase measurements are taken at specific intervals while the amplifier is operating for the required number of hours. The slope of the phase shift versus time or the total phase shift over a certain time interval can be computed.

6. Precautions.

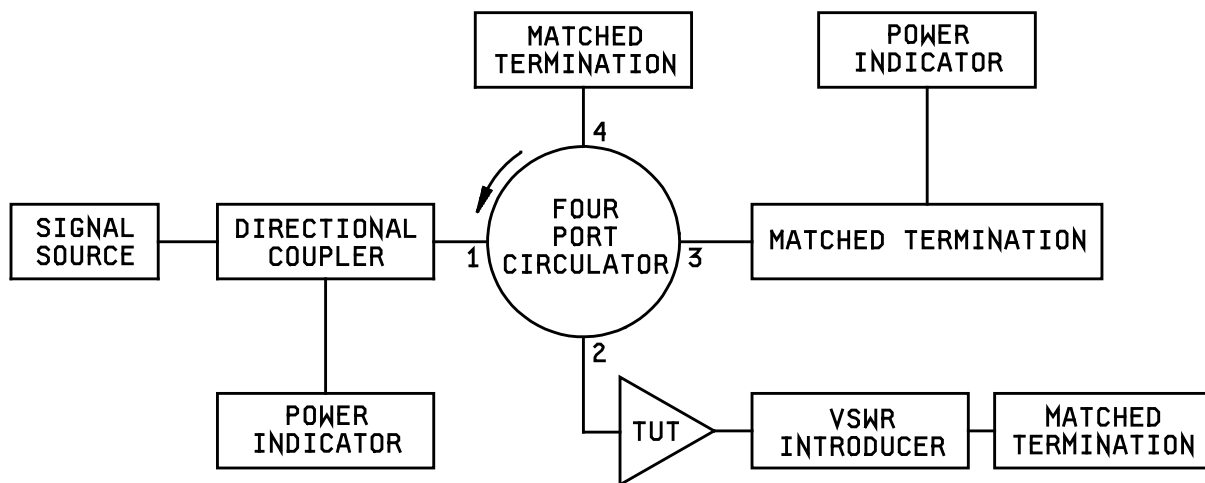
- a. Variable attenuator shall be carefully selected to insure a linear phase response.
- b. Directivity of directional couplers shall be sufficient to make insignificant any error in phase due to input reflections or frequency changes.
- c. Mismatches at connection points shall be minimized. It may be advantageous to use lossy cable to minimize phase errors caused by multiple reflections.
- d. It may be necessary to use harmonic rejection filters. These filters shall have a good match and identical phase characteristics.

MIL-STD-1311D

METHOD 4279

## REVERSE DIRECTED POWER

1. Purpose. To determine the amount of reverse directed power appearing at the driving terminals of an amplifier when a specified mismatch is placed at the output.
2. Equipment. As required to measure power and gain, but in addition a four port circulator to separate the reverse directed power. See figure 4279-1.
3. Procedure. With the tube operating under the specified conditions, and using the circuit shown on figure 4279-1, or equivalent, the phase of the specified VSWR shall be adjusted for maximum power on the power indicator in branch 3. The reverse directed power is the sum of the power measured in branch 3 and the calculated power lost due to the circulator insertion loss between 2 and 3.

FIGURE 4279-1. Reverse directed power measuring circuit.

MIL-STD-1311D

METHOD 4280A

## ELECTRONIC TUNING RANGE

1. Purpose. The purpose of this test is to measure electronic tuning range.

2. Definitions.

- a. Electronic tuning range is defined as the frequency range over which the TUT can be varied by adjusting specified electrical parameters after all other parameters have been optimized and then held constant. Simultaneously, the power output of the TUT shall not fall below the value specified on the TSS.
- b. Multiresonator-oscillator electronic tuning range is defined as the frequency difference between the two points where the power first falls to the specified level as the controlling voltage is varied (usually dynamically) about the specified operating point. (In general, the maximum power point will not occur at mode center nor will the two peaks have equal amplitudes. Unless otherwise specified on the TSS, if external adjustment of resonator tuning(s) and feedback are inherent in the design, the operating voltage, resonator tuning(s), and feedback shall be mutually adjusted to produce a symmetrical continuous mode).

3. Equipment. Use the circuitry of method 4250 and appropriate frequency measuring equipment.

4. Procedure. Measure and record frequency and output power versus the adjustable parameter(s). The test may be made on a static (point by point) or dynamic (swept) basis. If not specified, the test method is optional.

The load and coupling shall be specified. Requirements or limits for tuning voltage, mode asymmetries and discontinuities, and hysteresis shall be specified.

5. Precautions. In many tube types, particularly those with multiple resonators, thermal tuning effects can cause wide variations in the data obtained, so that dynamic (swept) techniques are more useful than static test methods. The sweep frequency should be chosen high enough to avoid these thermal tuning effects, but not so high as to cause high frequency instrumentation problems.

MIL-STD-1311D

METHOD 4281A

HEATER OR FILAMENT CURRENT, OPERATING

1. Purpose. To measure heater or filament current on an operating tube.
2. Introduction. Microwave tubes may require measurement of operating heater/filament current while one or more of the following occurs:
  - a. Pulse or radio frequency currents are flowing in the heater circuit.
  - b. Back-bombardment of the emitter by rejected electrons causes overheating, therefore requiring that heater/filament power be reduced (triodes, magnetrons, crossed field amplifiers).
  - c. Heater/filament current is non-sinusoidal due to the action of a back-heat compensator control as in (b) or because of the non-linear action of a low capacitance (high-leakage reactance) supply transformer.
  - d. Because the anode or collector is often grounded in microwave tubes, the cathode may have high voltage applied to it, relative to ground.
3. Equipment.
  - 3.1 The meter shall measure true rms values of heater current, including harmonics as present.
  - 3.2 The meter shall be by-passed with a capacitance of such a value to prevent the pulse or rf current components from passing through the meter.
  - 3.3 When the cathode is at high voltage with respect to the ground, the meter shall be enclosed in a metal box or cage at cathode potential so that:
    - a. The meter reading is not affected by attraction of the pointer due to the high electric fields, and
    - b. the meter is not damaged by corona currents passing through it.
  - 3.4 Magnetic shielding between meters, or sufficient distance between meters and magnetic fields or materials, shall be such that the accuracy of the meter readings are not affected.
4. Procedure. When the heater/filament input is adjusted to be within the given limits under operating conditions, the stabilized voltage or current shall be measured.
5. Precautions.
  - 5.1 Personnel should take adequate precautions to protect themselves when there is high voltage on the meter or hv cage.
  - 5.2 When a low-capacitance transformer is used, or when an automatic back-heating compensator is used, the meter should measure true total rms values of heater supply fundamental component and all appropriate harmonics content.
  - 5.3 Measurements should be made using the back-heat schedule, if specified.
  - 5.4 Voltage and current measurements shall be corrected for incidental voltage drops and shunt currents due to the meters, in accordance with standard practice.



MIL-STD-1311D  
METHOD 4282  
NOISE POWER DENSITY  
(Microwave tubes)

1. Purpose. The purpose of this method is the measurement of noise power density, as a function of frequency, for traveling-wave tubes (or other broadband power tubes).

2. Definitions and discussion. Noise power density is the ratio of (1) total noise power emitted within a defined narrow measurement bandwidth, to (2) the width of this band. It is normally expressed in watts/MHz or dBm/MHz.

2.1 The measurement bandwidth should be narrow compared both to its own center frequency and to the working bandwidth of the TUT. The center frequency of the measurement bandwidth can then be swept across the working band of the TUT, to obtain the frequency dependence of the noise power density.

2.2 Even though the internally-generated component of the noise power density may be low, the large bandwidth of a microwave tube can result in a considerable total of internally-generated noise, which may extend to frequencies well outside the nominal bandwidth. Care shall be taken that this out-of-band noise power does not vitiate the measurement.

3. Equipment (method A). The equipment required is shown on figure 4282-1. The If amplifier bandwidth is the measurement bandwidth. The bandwidth of the tunable bandpass filter must be wide enough to have no effect on the measurement bandwidth, but must also have adequate rejection at the image frequency (normally 60 MHz away), and its stop bands must extend beyond the frequency range over which the TUT emits significant noise power. Isolators or attenuators may be required on either side of the tunable filter to improve the matching.

The circuit is shown for the normal condition in which the expected noise power from the TUT in the measurement bandwidth is greater than, or not much smaller than, the maximum signal generator power. If the noise power is much less than the signal generator power, the output connections from the directional coupler C must be interchanged.

3.1 Procedure (method A). The input of the TUT is connected to a noise source or to a termination, as specified. The tunable bandpass filter is tuned to the frequency at which the noise power density is to be measured. The local oscillator is offset from this frequency by the amount of the If (normally 30 MHz). The signal generator is tuned to the center frequency of the bandpass filter, and its output is attenuated to the point where it has no effect on the output power meter. The system is calibrated for dynamic range by plotting the power output from the If amplifier as a function of signal-generator power.

3.1.1 The gain of the If amplifier is adjusted so that the noise from the TUT gives a convenient deflection on the output meter. This reading is noted. The output of the signal generator is then increased until the output meter reading increases by 3 dB.

3.1.2 The signal generator is then switched to the power meter, and its power output is measured as  $P_1$ .

3.1.3 The procedure is repeated with the tunable bandpass cavity, and the signal generator both retuned to the next frequency, continuing until the required band has been covered.

3.2 Calculation (method A). The noise power density  $N_0$  at each frequency is then calculated as follows:

a. If  $P_1$  is measured in mW (or watts):

$$N_0 = \frac{P_1 \left[ \text{anti log} \left( \frac{C}{10} \right) - 1 \right]}{\Delta F} \quad \frac{\text{mW (or watts)}}{\text{MHz}}$$

Where C = coupling factor, dB, of directional coupler labeled C in figure 4282-1;

$\Delta F$  = bandwidth of If amplifier in MHz.

## MIL-STD-1311D

If C = 20 dB (nominal value) or greater, this simplifies to:

$$N_o = \frac{P_1 \operatorname{anti} \log \left( \frac{C}{10} \right)}{\Delta F} \frac{mW \text{ (or watts)}}{MHz} \text{ with negligible error}$$

b. If  $P_1$  is measured in dBm:

$$N_o = P_1 + C - 10 \log(\Delta F) - 10 \log \left[ 1 - \frac{1}{\operatorname{anti} \log \left( \frac{C}{10} \right)} \right] \frac{dBm}{MHz}$$

If C = 20 dB(nominal) or greater, this simplifies to:

$$N_o = P_1 + C - 10 \log(\Delta F) \frac{dBm}{MHz} \text{ with negligible error}$$

c. If the output connections of coupler C have been interchanged because  $N_o$  is small, then measure  $P_1$  in dBm and use

$$N_o = P_1 - C - 10 \log(\Delta F) + 10 \log \left[ 1 - \frac{1}{\operatorname{anti} \log \left( \frac{C}{10} \right)} \right] \frac{dBm}{MHz}$$

As before, the last term can be omitted if  $C \geq 20$  dB.

4. Equipment (method B). This method may be used when the noise power in the measurement bandwidth is relatively large.

The equipment required is shown on figure 4282-2. The bandwidth of the tunable bandpass filter is now the measurement bandwidth. Its stop bands must extend beyond the frequency range over which the TUT emits significant noise power. Isolators or attenuators may be required on either side of the tunable filter to improve the matching.

4.1 Procedure (method B). The procedure is simply to tune the bandpass filter to each measurement frequency in turn, and read the power meter  $P_1$ . The power meter may be a commercial bolometer bridge, or any method from method 4250 may be used as appropriate.

4.2 Calculation (method B). If  $P_1$  is measured in mW (or watts):

$$N_o = \frac{P_1 \operatorname{anti} \log \left( \frac{L}{10} \right)}{\Delta F} \frac{mW \text{ (or watts)}}{MHz}$$

Where L is the insertion loss (dB) of the tunable filter, averaged over the measurement bandwidth, plus the insertion loss of any isolators or attenuators in the line.  $\Delta F$  is the bandwidth of the tunable filter at the center frequency being used.

If  $P_1$  is measured in dBm (or dBW):

$$N_o = P_1 + L - 10 \log(\Delta F) \frac{dBm \text{ (or dBW)}}{MHz}$$

## MIL-STD-1311D

5. Precautions.

5.1 Method A. The insertion loss of the tunable filter need not be considered, since it affects both signals equally, but any attenuator in one arm only must be taken into account.

5.2 Method B. The bandwidth and insertion loss of the tunable filter are likely to vary across the tuning range, and both should therefore be calibrated at each measurement frequency.

5.3 High- and low-pass filters may be necessary to remove out-of-band noise.

5.4 The output of the IF amplifier, displayed on an oscilloscope shall be observed and discrete noise components shall be noted.

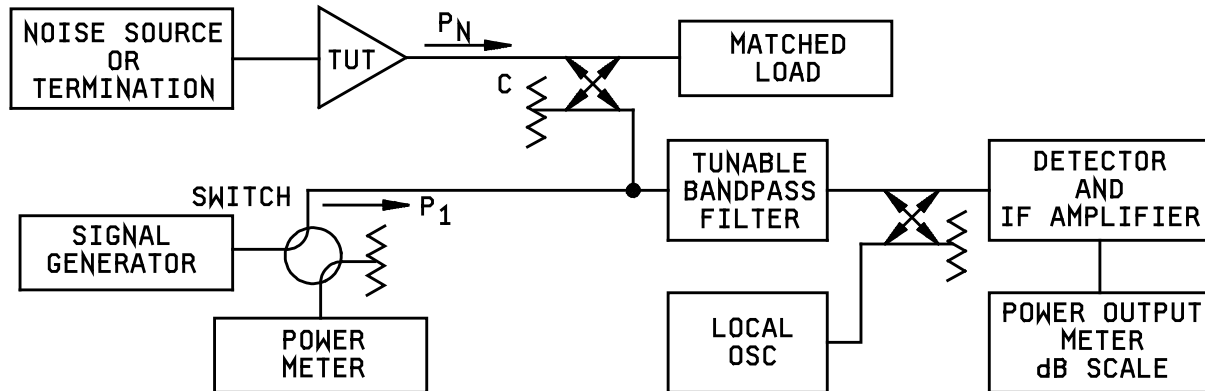


FIGURE 4282-1. Test setup for noise power density (method A).

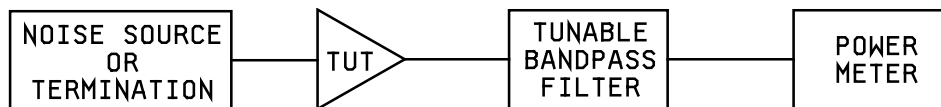


FIGURE 4282-2. Test setup for noise power density (method B).

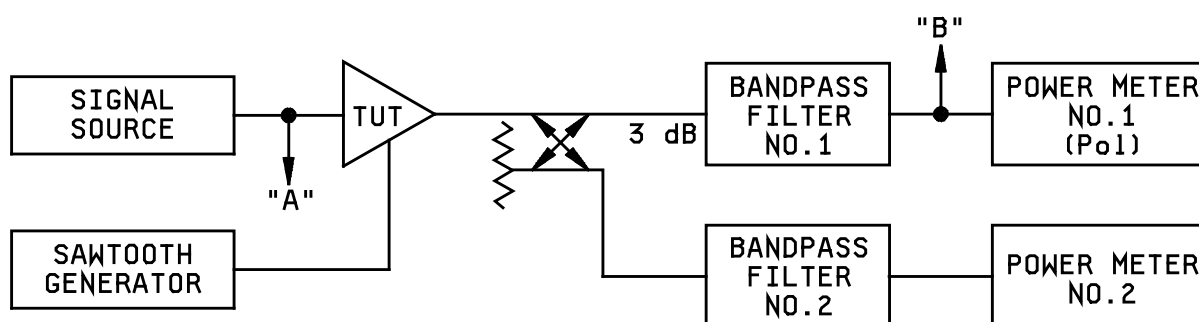
## MIL-STD-1311D

## METHOD 4284

## SERRODYNE OPERATION

(Microwave amplifier tubes)

1. Purpose. The purpose of this method is to measure the spectral purity of a tube operated in the serrodyne mode.
2. Definition. Serrodyne operation is the method of frequency conversion by application of a sawtooth voltage to a transit-time device; e.g., a sawtooth helix voltage applied to a traveling-wave tube.
3. Test circuit.

FIGURE 4284-1. Test circuit for serrodyne operation.

4. Procedure. An input signal and sawtooth wave, as specified by the TSS are applied. Power meter No. 1 is used to monitor the desired output  $P_{01}$ . The level of  $P_{01}$  is to be set to the value specified by the TSS with bandpass filter No. 1 set to the desired frequency.

The amount of frequency translation is equal to the difference between the input frequency  $F_i$  and the output frequency  $F_o$  at which the power  $P_{01}$  is measured. For reference,  $\Delta F = (F_i - F_o)$ .

The gain of the serrodyne device is measured between points A and B using method 4253, with  $P_{01}$  set to the specified level. The gain shall be within the limits specified on the TSS but corrected for the loss of 3 dB through the directional coupler.

Under the same conditions, bandpass filter No. 2 is set to  $F_o \pm \Delta F$ ,  $F_o \pm 2 \Delta F$  (and as specified on the TSS) and power measurements taken at each of these frequencies. The maximum of these shall be less than the limit specified on the TSS as "suppressed power,  $P_s$ ". The amount of amplitude modulation (AM) introduced by the serrodyne operation at  $F_o$  shall be measured using method 4262, and shall be less than the limit specified on the TSS.

MIL-STD-1311D

METHOD 4289

HEATER OR FILAMENT CURRENT, NONOPERATING

1. Purpose. The purpose of this method is to specify the procedures for measuring heater or filament current.
2. Procedure. When the voltage specified on the TSS is applied to the heater or filament, the stabilized value of current shall be within the limit(s) specified. During this test no other elements shall be conducting.
3. Precautions.
  - a. Apply the heater voltage in such a manner that the maximum surge current, if specified on the TSS, is not exceeded.
  - b. If a warm-up time is specified, at least this amount of time shall be allowed for the heater current to stabilize.
  - c. Voltage and current measurements shall be corrected for incidental voltage drops and shunt currents due to the meters, in accordance with standard practice.
  - d. When heaters or filaments are operated with low-capacitance (high-leakage reactance) transformers, or other non-sinusoidal sources, all measurements shall be made using instruments which will indicate true rms values including the harmonic power.
  - e. Magnetic shielding between meters, or sufficient distance between magnetic fields or magnetic materials, is required so that accuracy of the meter readings is not affected.

## MIL-STD-1311D

## METHOD 4302A

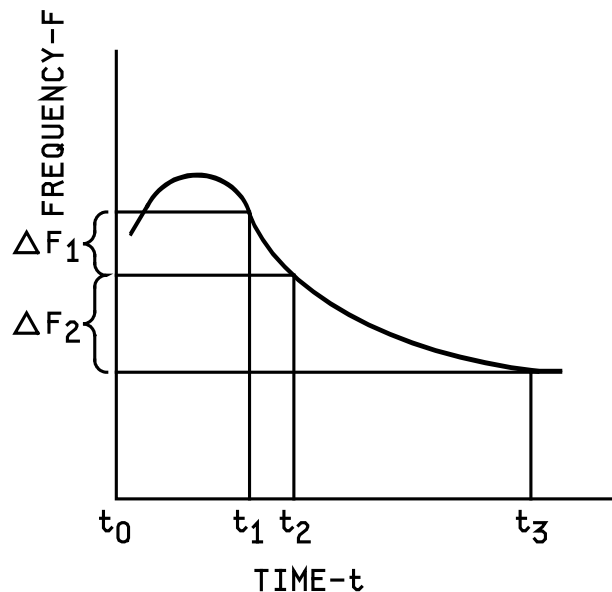
## FREQUENCY CHANGE (WARMUP)

1. Purpose. The purpose of this test is to measure the short-term frequency variation which occurs when an oscillator is switched on. This method is not to be used for long-term frequency changes due to erosion or similar irreversible effects, nor the frequency changes due to changes in ambient conditions (see method 1023).

2. Frequency change. Initially the tube shall be under normal ambient conditions, with no voltages applied, and shall be connected to the specified load, with frequency-measuring equipment of adequate sensitivity to measure the small changes involved. Heater power shall be applied for the specified time, followed by operating voltages in correct sequence. Time shall be measured from the moment ( $t_0$ ) when these voltages are all fully applied.

The frequency shall be measured at times  $t_1$  and  $t_2$  specified on the TSS; the absolute value of frequency difference  $\Delta F_1$  shall be within the limit(s) specified on the TSS; if longer term thermal transients are also expected, a third time  $t_3$  and frequency change  $\Delta F_2$  may be specified. If no values are specified for times  $t_1$ ,  $t_2$ , and  $t_3$ , the following shall be used:

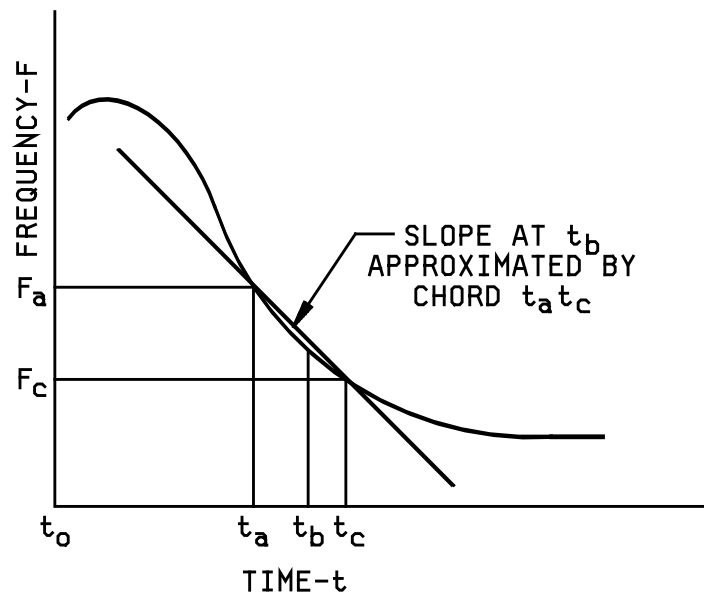
$t_1 = 1$  minute  
 $t_2 = 3$  minutes  
 $t_3 = 15$  minutes

FIGURE 4302-1. Frequency change.

3. Drift rate. When the drift rate is significant to the application, the TSS will specify a maximum slope (MHz/minute) and a time  $t_b$ ; the slope may be measured as the difference of the frequencies measured at times  $t_a$ ,  $t_c$ , bracketing  $t_b$ , and differing by a small fraction of  $t_b$ .

The absolute value of the slope shall be within the limit(s) specified.

MIL-STD-1311D

FIGURE 4302-2 Drift rate.

## MIL-STD-1311D

## METHOD 4303

## WARMUP TIME

1. Purpose. To describe techniques for the measurement of various warm-up times.
2. Equipment. Timing device, voltmeters, ammeters, power meters, frequency meters, and other equipment normally associated with testing a microwave tube.
3. Definition. Warm-up time is the time required for an observed characteristic to reach a specified value, or a specified percentage of the normal stabilized value, after the application of operating voltage(s). Typically these characteristics may be heater current, cathode current, output power, and frequency.
4. Measurements. These measurements are normally made on a tube which has stabilized at room temperature in a nonoperating condition. The application of the heater voltage is normally the reference point for all time measurements.
  - a. Heater warm-up time. The time interval ( $t_0$  to  $t_1$ ) between the application of heater voltage at time ( $t_0$ ) and the time ( $t_1$ ) when the heater current has decreased to within a specified percentage (usually 10 percent) of its normal stabilized value. In some cases a particular value of heater current is specified, so that in these cases the time ( $t_1$ ) is read when the heater current has decreased to this value, after the initial heater surge.
  - b. Cathode warm-up time. The time interval ( $t_0$  to  $t_2$ ) between the application of the heater and anode voltage at time ( $t_0$ ) and the time ( $t_2$ ) when the cathode current at a particular anode voltage has increased to within a specified percentage (usually 90 percent) of its normal stabilized value. In some cases a particular minimum value of cathode current is specified, so that in these cases, the time ( $t_2$ ) is read when the cathode current has reached this value.

Precaution. It is normal to specify a minimum cathode preheating time ( $t_3$ ) before the application of the anode voltage. In these cases, the heater voltage is applied for the specified time interval before the anode voltage is applied, with the application of heater voltage as the time reference.
  - c. Output power warm-up time. The time interval between the application of heater voltage ( $t_0$ ) or anode voltage ( $t_3$ ) and the time ( $t_4$ ) when the rf output power has reached either a particular minimum, or a specified percentage (usually 90 to 95 percent) of its final stabilized value. Heater voltage and anode voltage may be applied simultaneously if cathode preheating is not required. Output power warm-up time shall be designated as either ( $t_0$  to  $t_4$ ) or ( $t_3$  to  $t_4$ ) as defined in the TSS.
  - d. Frequency warm-up time. See method 4302.



## MIL-STD-1311D

## METHOD 4304

## PULSE CHARACTERISTICS

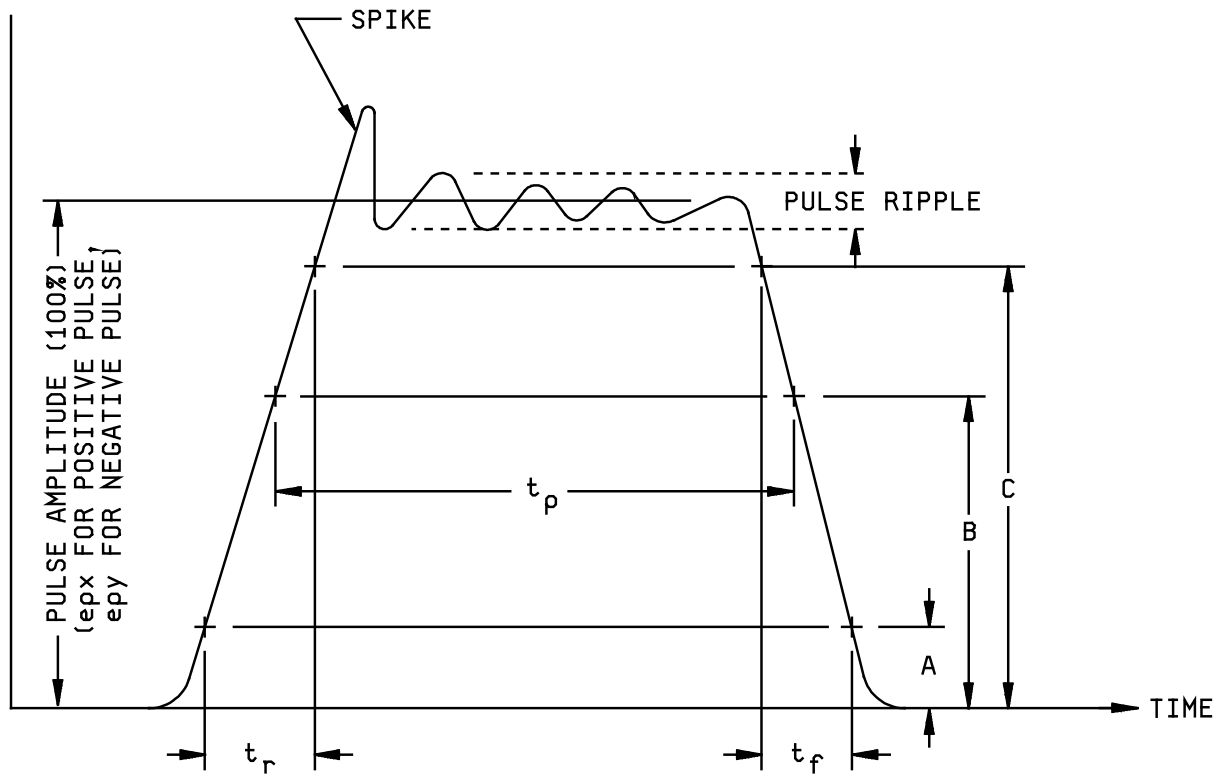
(Microwave tubes)

1. Purpose. To define the characteristics of pulses; voltage, current, or microwave output, in a self-consistent fashion.
2. Equipment. An oscilloscope with a linear sweep and resolution better than 5 percent of  $t_p$  having time jitter in a sweep circuit less than 5 percent of  $t_p$ . If a crystal is used on measurement of an rf pulse, it shall be calibrated at the operating level.
3. Definitions. Pulse definitions described on figure 4304-1 or figure 4304-2, in conjunction with table 4304-I, are self consistent in that pulse length, duty or power measurements made in accordance with them will have reasonable correlation among any two or three parameters.

TABLE 4304-I. Levels A, B, and C as percentage of pulse amplitude (see figure 4304-1).

Quantity:		Power			Voltage			Current		
Nature of tube	Value:	A	B	C	A	B	C	A	B	C
Space charge control tubes:		10	50	90	33	70	95	33	70	95
Beam tubes ( $I = KV^{3/2}$ ):		10	50	90	10	70	90	10	70	90
Crossed field (M-type):		10	50	90	See figure 4304-2			10	50	90

## MIL-STD-1311D

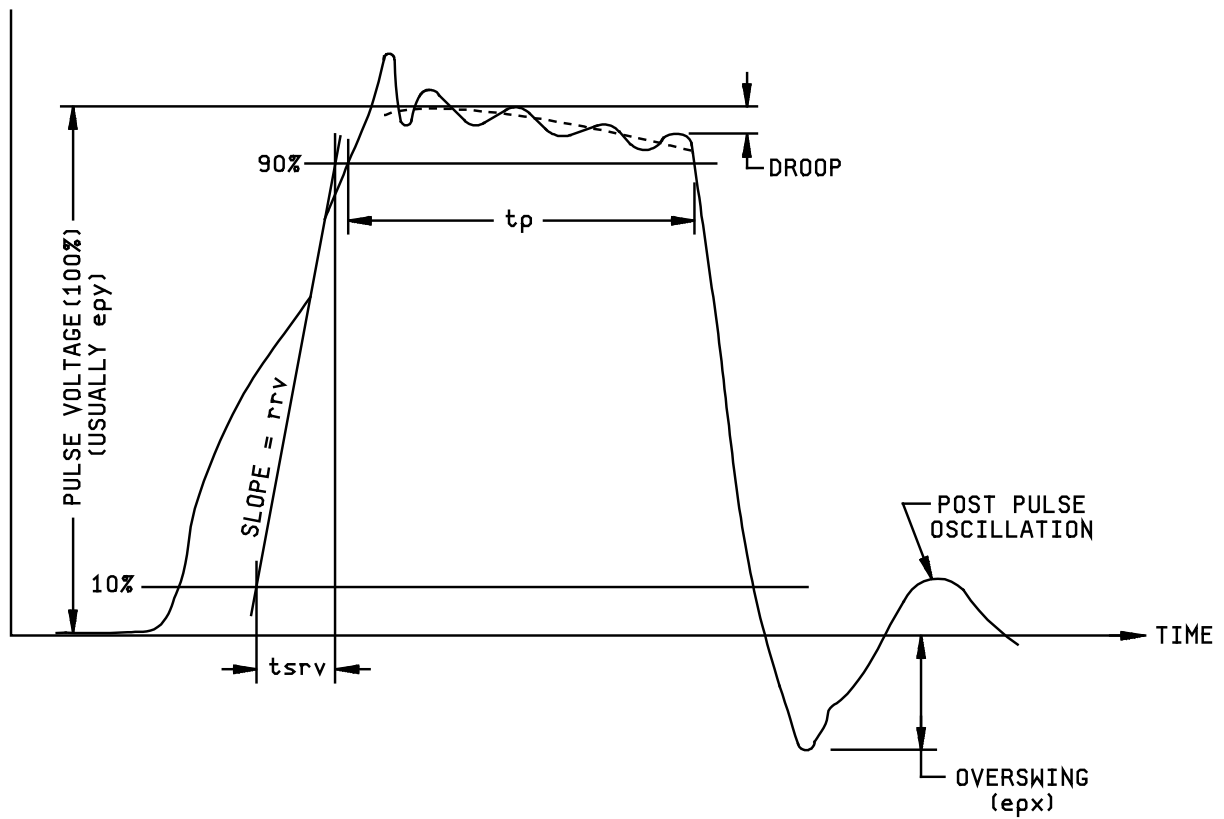


## NOTES:

1. Value of the spike is generally neglected if duration  $< 0.1 t_p$ .
2. If there is overswing on the trailing edge, see figure 4304-2 for definitions.
3.  $t_r < 0.1 t_p$ ,  $t_f < 0.2 t_p$  generally.
4. When measuring average anode current, usually in the anode supply return, a suitable pulse by-pass should shunt the meter.

FIGURE 4304-1. Pulse characteristics (see table 4304-I for values A, B, and C.

## MIL-STD-1311D



## NOTES:

1.  $rrv$  is the slope of the steepest tangent above the 50 percent amplitude point.
2.  $tsrv$  is the time interval between the intersection of this tangent with the 10 percent and 90 percent levels.

FIGURE 4304-2. Voltage pulse definitions for magnetrons and crossed-field or M-type tubes.

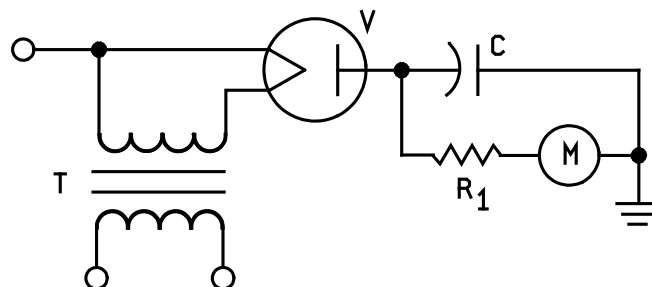
MIL-STD-1311D

METHOD 4306A

PULSE VOLTAGE

(Microwave tubes)

1. Purpose. The measurement of pulse voltages, exclusive of spikes, under a variety of conditions.
2. Equipment. A peak reading voltmeter is required, as indicated on the figures referenced to each method, including despiking circuitry.
3. If an oscilloscopic method is to be used, the oscilloscope should have Z axis capability so that measurement accuracy is not limited by the resolution of beam size relative to image size.
4. General. Errors in the measurement of peak voltage can arise from a number of factors including:
  - a. In the peak diode method, a high dynamic impedance of the diode may prevent full charging of the capacitors before the end of the pulse.
  - b. Corona from capacitors or resistors which renders the low-level calibration inadequate and variable.
  - c. Stray inductance and capacitance effects.
- 4.1 Careful design of the circuits can minimize these errors. Diodes should be selected to provide a minimum of shunt capacitive loading on the system whose pulse voltage is to be measured while at the same time offering an equivalent series impedance such that its product with C (figure 4306A-1) in the circuit is less than 25 percent of the length of the voltage pulse to be measured. In some cases, it may be necessary to add series/resistance to low-impedance diodes so that this time constant acts as a despiker.
- 4.2 Similarly, corona and leakage can be controlled by careful electrode design or immersion of the system in oil, each of which adds to C (see figure 4306-1).
- 4.3 The impedance of the tube mount or its connection lead-ins may distort pulse shape of very fast pulses unless suitable distributive line techniques are used.
5. Method I (peak diode voltmeter).
  - a. The following method is limited to applications at pulse voltages less than 35 kilovolts by diode and corona problems. Within the range 0 to 35 kv, the accuracy may be improved if the components V, C, R, T, and shunt, if used, are enclosed in a dust free, temperature regulated compartment. Diode losses may be affected by filament voltage variations. The proper filament voltage will be that value from which a  $\pm 10$  percent change will not affect the meter reading.



V = Suitable diode  
 C = Energy storage capacitor, 40 kv rating  
 M = Microammeter (suitable range)

T = Filament transformer, 20 pF (max)  
 capacitance  
 R<sub>1</sub> = Noninductive resistor  
 t = Inter-pulse period

NOTE: The product  $tCR_1$  shall exceed 6.0

FIGURE 4306-1. Voltmeter circuit.

## MIL-STD-1311D

- b. The standard voltmeter circuit shall be used with a resistive divider as shown on figure 4306-2 calibrated on the test modulator with a laboratory standard capacity divider. The resistors, Ra and Rb, are not critical and should be chosen to operate the standard circuit within its voltage rating, but because of stray capacitance and inductance, the applicable range of pulse lengths may be limited.

## 6. Method II (cathode-ray display).

6.1 Resistive divider method. The following method may be used at all voltages above or below 35 kv, for pulse lengths between 0.5 and 10 microseconds and duty cycles on the order of 0.001; additional capacitive compensation may be required if the rise time is less than 0.25  $\mu$ s. This method is applicable if no diode is available or if errors from spike or pickup of cathode lead radiation are suspected. It is not suitable for testing low-power pulse tubes (for example, beacon magnetrons), because the additional loading on the modulators is then excessive. The method uses a resistive voltage divider to reduce the pulse voltage by a factor of the order of 1,000. The divided pulse is measured on a calibrated oscilloscope. The circuit is shown on figure 4306-3 and the physical layout of the resistive divider on figure 4306-4.

- a. The total resistance shall be kept low enough to swamp capacitive errors; the value depends on the environment, and on the division ratio desired, but in general should be not higher than 40,000 ohms. A range of 10,000 to 25,000 ohms is preferred.
- b. The wattage rating of the resistors shall be not less than 2.5 times the expected average dissipation, which is:

$$\frac{(\text{peak voltage})^2 \times \text{duty cycle}}{\text{divider resistance}}$$

This dissipation is higher than in conventional dividers, but is still not a significant load on a high-power modulator. For example: 70 kv, with 0.001 duty cycle, ten 90 watt 2,500-ohm resistors may be used.

- c. To minimize inductive effects, composition film (VHF) resistors (MIL-PRF-22684), or equivalent, must be used. Noninductive wire-wound resistors are not satisfactory in this application. The resistors should be arranged in a planar zig-zag array on an insulating baseboard. The clips at the high-voltage end may require rounding to prevent corona. At very high voltages the whole assembly may be immersed in an oil bath.
- d. To minimize the effect of voltage coefficient of resistance, the same type of resistor should be used throughout.
- e. Effects of the connecting cable are eliminated by matching it at both ends. The effective low-end resistance is then half the cable characteristic impedance. Preferred values are 50-ohm cable, terminated in 50 ohms at each end to give 25 ohms resistance. Overall divider resistances of 10,000 to 25,000 ohms then give ratios in the range 400 to 1,000 to yield convenient oscilloscope inputs.
- f. The exact ratio is determined by measuring the high and low resistances with a precision dc bridge. Owing to the use of thin film resistors, the ratio remains constant to very high frequencies.
- g. The pulse height on the oscilloscope may be measured by conventional use of the y-deflection calibration. The method of use, and of calibration against a standard voltmeter or a standard voltage source, will depend on the type of oscilloscope used. A square wave voltage calibrator may be used provided it can in turn be referred to a standard instrument.

MIL-STD-1311D

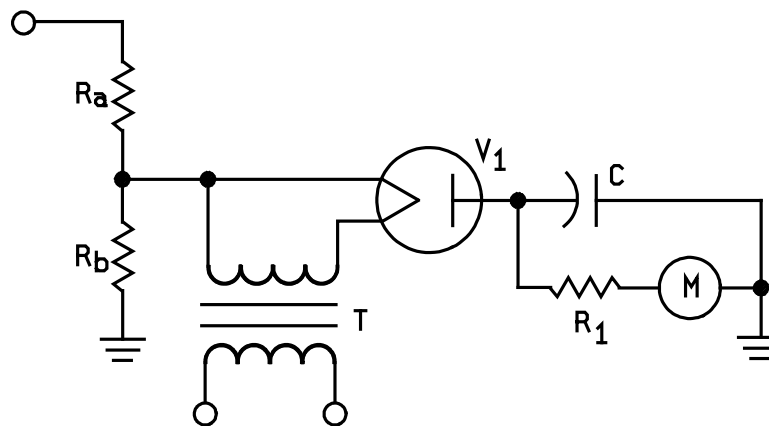
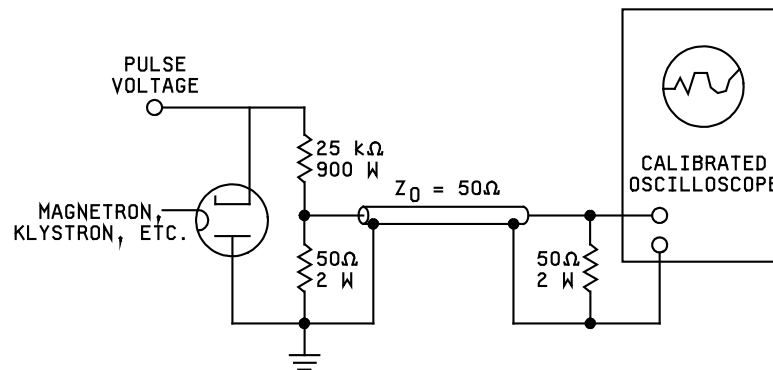


FIGURE 4306-2 Voltmeter circuit.



NOTE: Numerical values shown are illustrative only.

FIGURE 4306-3. Pulse voltage measurement circuit.

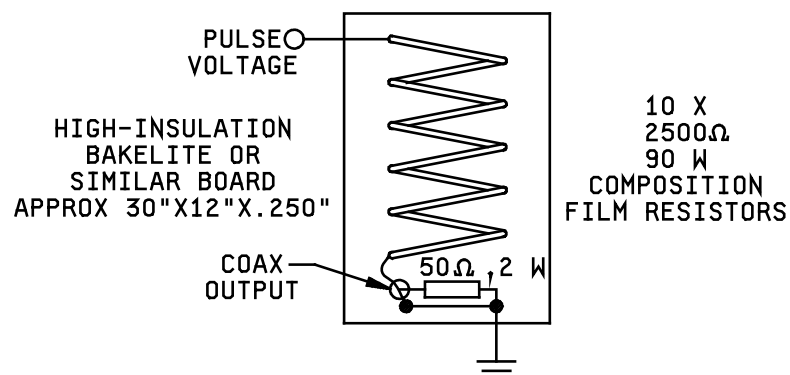


FIGURE 4306-4. Resistive divider.

## MIL-STD-1311D

6.2 Capacitive divider circuit. The capacitive divider circuit is particularly useful at very short pulse durations. Its use for longer pulse durations is restricted by the amount of pulse droop which can be tolerated.

- a. The divider is made up of a capacitor  $C_1$  developing a high voltage in series with a capacitor  $C_2$  developing a low voltage; the divider ratio being approximately inversely proportional to the ratio of these values. The divider network is connected to the CRO through a series matching resistor  $R$ , a coaxial cable and if necessary a blocking capacitor  $C_3$ . The input resistance of the CRO should be two or three orders larger than  $R$ . The capacitor  $C_1$  has a value usually in the range of 1 to 10 pF and should be shielded to avoid stray pickup. The dielectric may be ceramic, resin, oil, or vacuum as required by the working voltage. The capacitor  $C_2$  should have very low inductance and a safety spark gap should be connected across this capacitor.
- b. The divider circuit may be calibrated using other methods described (for example, resistive divider and peak voltmeter within its range) using a suitable pulse duration and where the errors due to the known characteristics of the methods are minimized.
- c. For pulse durations down to about 0.05 microsecond, the length of the coaxial cable should not exceed that which has a two-way transit time of about 10 percent of the pulse duration. For pulse durations below about 0.05 microsecond the cable length becomes impractically short and the divider may be mounted directly on the CRO.

6.3 Balanced divider circuit. The balanced divider circuit is particularly useful when the pulse waveform is to be faithfully reproduced in detail.

- a. The divider consists of a high-voltage section  $R_1$  and  $C_1$ , and a low-voltage section  $R_2$  and  $C_2$ , and the CRO matching components. The time constants of each section, including the effects of strays, shall be equal. Usually, the value of  $R_2$  is made equal to the characteristic impedance of the coupling line between the divider network and the CRO. In this case, the resistance  $R_3$  in figure 4306-6 is zero, and  $R_4 = R_2$ . This gives a division ratio  $\frac{2R_1}{R_2} = \frac{C_2}{C_1}$ . The time constants of the two circuits are  $R_1C_1$  and  $\frac{R_2C_2}{2}$ , respectively. When the required division ratio is greater than  $\frac{2R_1}{R_2}$ , a smaller value of  $R_2$  may be used, and the match condition for the cable restored by inserting a nonreactive series resistor  $R_3$ , where  $R_3 = Z_0 - R_2$ . In this case,  $R_4$  shall be made equal to  $Z_0$ , and the division ratio is:

$$\frac{R_2 R_4}{R_1 (R_2 + R_3 + R_4) + R_2 (R_3 + R_4)}$$

The time constants are then given by  $R_1C_1$  and  $R_2C_2$  where  $R_2 = \frac{R_2 (R_3 + R_4)}{(R_2 + R_3 + R_4)}$

It is difficult to use this circuit when  $R_2$  exceeds  $Z_0$  of the cable.

- b. When assembled, the divider shall be checked for division ratio and pulse distortion due to possibly overlooked stray effects. This may be done using a calibrated square-wave generator whose rise and fall time characteristics are similar to the pulse to be measured. Alternatively, calibrated signal sources in the frequency range dc up to twice the reciprocal of the pulse duration may be used.

NOTE: In practice, it may be useful to isolate the divider network from the cable and the CRO by using a value of  $R_3$  several times greater than  $Z_0$ , but the cable is then not matched at the sending end.

MIL-STD-1311D

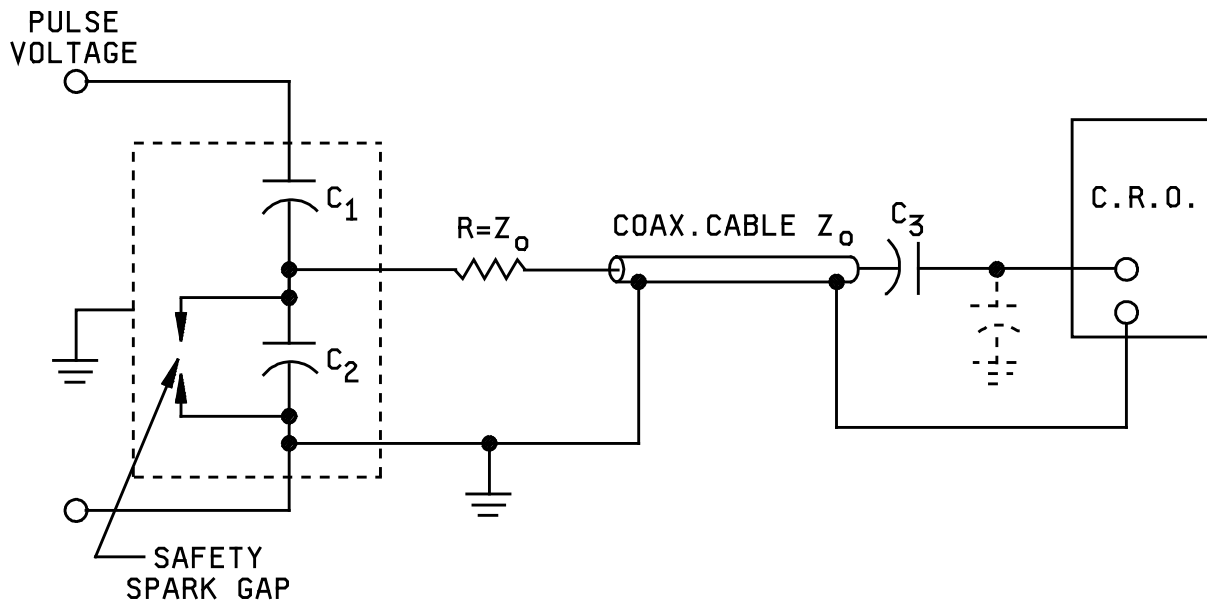


FIGURE 4306-5. Capacitive divider circuit.

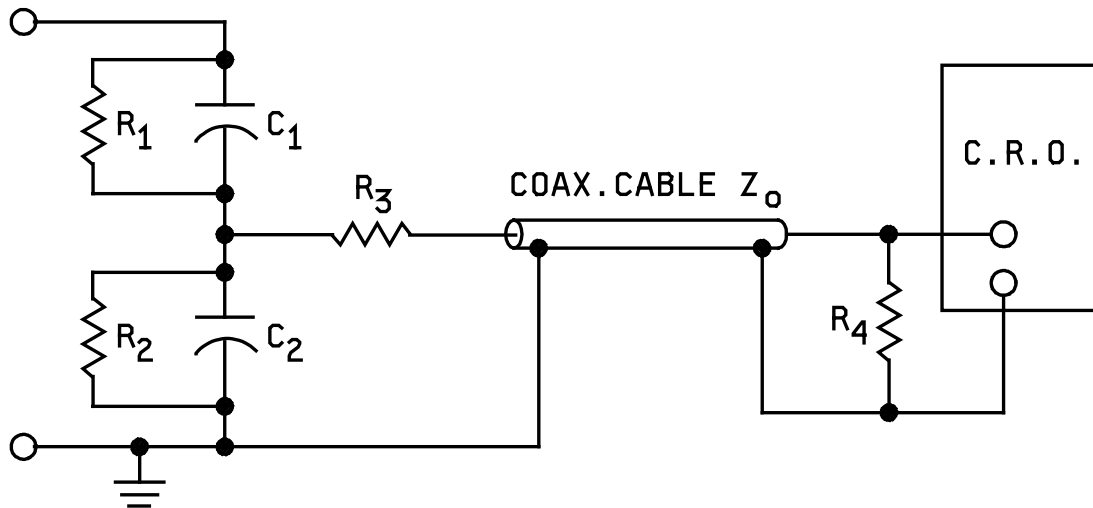


FIGURE 4306-6. Balanced divider circuit.

METHOD 4306A



## MIL-STD-1311D

4306-5

25 March 1970

## METHOD 4308A

## SPECTRUM

1. Purpose. The purpose of this test is to verify that the output of the tube is sufficiently well concentrated within a desired range of frequencies. The spectrum of a pulsed or modulated tube has the general appearance shown on figure 4308-1. For the purposes of this method, two parameters are defined:

- RF bandwidth. The width, in frequency units, of the spectrum at a level 6 dB below the peak; this includes any minor lobes which exceed the -6 dB level.
- Minor lobe ratio. The ratio of the major lobe amplitude to the highest minor lobe, normally expressed in dB.

NOTE: Measurement of either or both of these parameters may be specified.

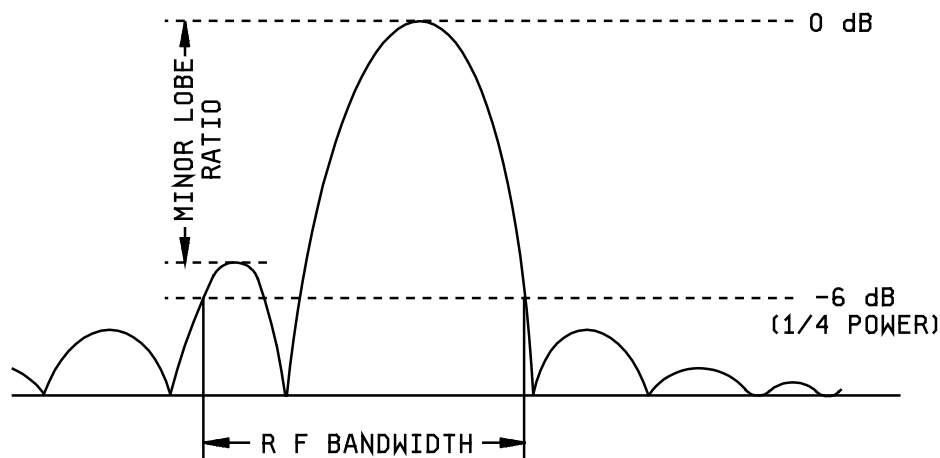


FIGURE 4308-1. RF spectrum, illustrating definitions of RF bandwidth and minor lobe ratio.

2. Test setup. The tube shall be operated in a mismatch unit and specified load; the VSWR of the unit shall be 1.5:1 (defined as in method 4310, pulling figure), variable over all phases (half wavelength motion of the mismatch). The TSS may specify the distance from the tube to the mismatch unit; if not, the unit shall be as close to the tube as is practicable. The output is sampled and fed to a spectrum analyzer, which will display a spectrum similar to figure 4308-1. The mismatch phase is adjusted to the worst position for the parameter being measured (for example, either widest spectrum or highest side lobes).

If the spectrum analyzer does not have adequate internal calibrators for frequency and amplitude, a marker generator may be used to provide frequency calibration points, and a calibrated attenuator may be inserted in the analyzer input line to measure minor lobe ratio as the difference in readings when the main lobe and highest minor lobe are brought in turn to a common reference level.

3. Calibration procedures for the load VSWR, spectrum analyzer, (and marker generator and attenuator if used) are standard, or as given by the manufacturers.

4. Precautions. Since the spectrum of a tube is a sensitive function of the pulse shape or modulation delivered by the supply, as well as of the performance of the tube, care shall be taken to insure that the measurement of either RF bandwidth or minor lobe ratio is not degraded by poor performance of the modulator.

NOTE: For short pulse measurements, the spectrum analyzer linearity shall be adequate to ensure that it does not degrade the bandwidth. This may be checked by varying the analyzer center frequency so as to shift the portion of the sweep used in the display, and observing that the spectrum shape does not change.

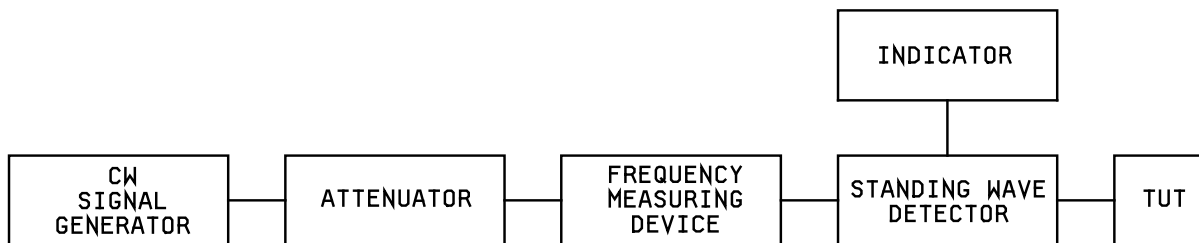
5. Formulas. Since the theoretical minimum bandwidth is a function of the pulse duration, the TSS may specify the permissible bandwidth in terms of duration (for example,  $BW = 2.5/t_p$  where BW is in MHz and  $t_p$  in ms). In this case, the value to be used for  $t_p$  is the measured value of the current pulse duration,  $t_{pc}$ .

MIL-STD-1311D

METHOD 4309A

## MAGNETRON NONOSCILLATING IMPEDANCE

1. Purpose. To measure the impedance of a nonoscillating magnetron.
2. Definitions.
  - a. Phase of sink. The phase of the sink is the position of a standing wave minimum (expressed in fractions of a guide wavelength), measured from the reference plane specified on the outline drawing, where the rate of change of oscillating frequency versus phase of the reflection coefficient is a maximum. It is measured positively in the direction away from the tube, toward the load. With this phase of the reflection coefficient, power is generally maximum as well as instability and starting time jitter.
  - b. Q<sub>o</sub>. The unloaded Q of the magnetron cavity system.
3. Measurement apparatus required. A microwave measurements system shall be assembled as indicated in the block diagram:

FIGURE 4309-1. Magnetron nonoscillating impedance circuit.

- a. The signal generator shall be capable of smooth adjustment of the CW signal frequency as fine as 10 percent of the pulling figure of the magnetron.
  - b. The attenuator may be internal to the signal generator, or external.
  - c. The frequency measuring device shall be capable of resolution to better than 10 percent of the TUT's pulling figure.
  - d. The standing-wave detector shall be capable of indicating the minimum position with suitable accuracy and shall form a part of the uniform transmission system as specified on the outline drawing or by designation of the output coupler.
  - e. The standing-wave indicator shall be suitably calibrated for use at the anticipated signal levels.
4. Measurements. The following tests shall be performed as specified.
    - 4.1 Determination of VSWR and position of minimum. With TUT nonoperative at room temperature, adjust the signal generator frequency to the value obtained previously with the tube operating under normal conditions. Measure VSWR and the position of the minimum which is nearest the reference plane, relative to the reference plane. Divide this distance by the guide wavelength, as measured or calculated in the same units. The value of VSWR and the fraction of the distance smaller than a half-guide wavelength shall be within the limit(s) specified.

## MIL-STD-1311D

4.2 Phase of sink. With the tube nonoperating and at room temperature, the standing-wave detector is used to determine the distance,  $d$ , of the nearest minimum in the standing-wave pattern to the reference plane of the tube with respect to which it is desired to determine the phase of sink. This position is expressed in terms of the guide-wave length  $\lambda_g$  as a function of frequency where measurements are made at frequencies below and above the cold resonant frequency of the TUT. Plots similar to those shown on figure 4309-2 (overcoupled case) and figure 4309-3 (undercoupled case) are obtained. (It is noted that measurements are not performed in the immediate vicinity of the tube resonant frequency owing to a rapid change of phase in this region and consequent difficulties in obtaining accurate measurements.) A sufficient number of points should be taken to insure that they are falling on the linear portion of the phase characteristic. The phase of sink is the phase at the point of cold resonant frequency of the straight line drawn through the points of measurement.

- In the case of a tunable tube, the measurement may be simplified as follows: The signal generator is tuned to the frequency,  $f_0$ , at which it is desired to determine the phase of frequency sink. The tube is tuned to a frequency far away from  $f_0$ . The position of the nearest minimum in the standing-wave pattern,  $d$ , as explained above, defines the phase of frequency sink at  $f_0$ .
- The procedure is the same in both the undercoupled and overcoupled cases.

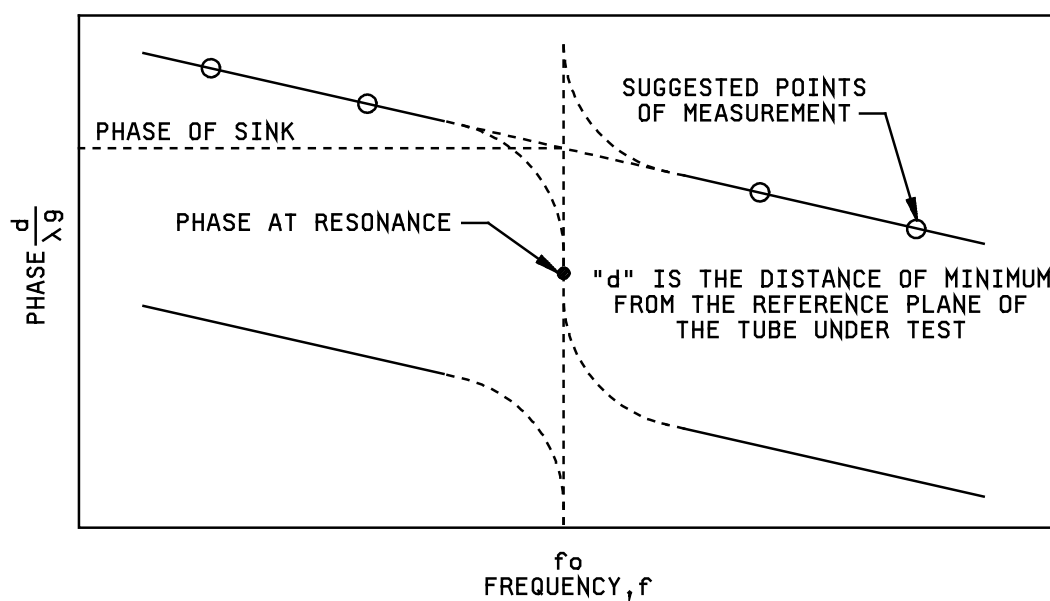
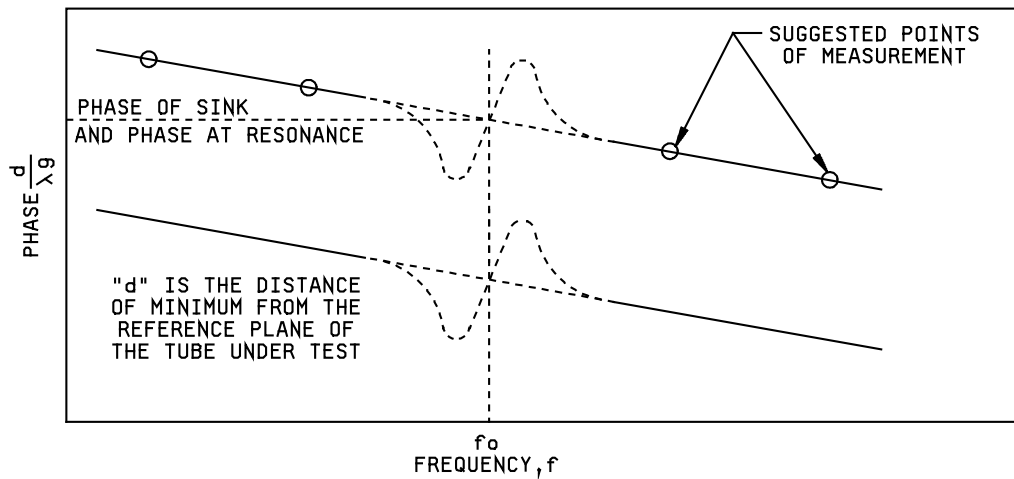


FIGURE 4309-2. Phase of standing-wave minimum as a function of frequency (overcoupled case).

MIL-STD-1311D

FIGURE 4309-3. Phase of standing-wave minimum as a function of frequency (undercoupled case).5. Precautions.

- a. The rapid changes in phase of the reflection coefficient with frequency render measurements inaccurate unless suitable isolation has been provided between the signal generator and the measurements system (enough to eliminate changes in the signal generator tuning curve derived from the magnetron or wavemeter resonances). After measuring frequency, the wavemeter should be completely detuned.
- b. A CW signal generator has been specified because the transient response of the resonant system will cause errors unless pulse lengths at least a magnitude longer than  $2Q_0/F$  are used. If this condition can be realized in a pulsed system, greater ease and accuracy of measurement of VSWR will result but it will be necessary to make certain that the output frequency does not change during the pulse.

## MIL-STD-1311D

## METHOD 4310A

## FREQUENCY PULLING FIGURE

1. Purpose. To determine the susceptibility of a tube to change its oscillating frequency as a result of changes in load. In actual practice a change in reflection coefficient may result from the motion of an antenna system with near field variations, or from the motion of the microwave plumbing elements themselves.

2. Definition. The pulling factor is the maximum oscillating frequency excursion obtained when a tube is exposed to its specified load VSWR being dynamically varied through all phase angles. The rate of this variation shall be rapid enough to minimize thermal effects, and gradual enough to permit observation of instability, if present, at each phase position.

3. Equipment. See figures 4310-1 and 4310-2.

4. Test circuits. Either method A or B shall be performed. The choice will be the manufacturer's option.

4.1 Method A.

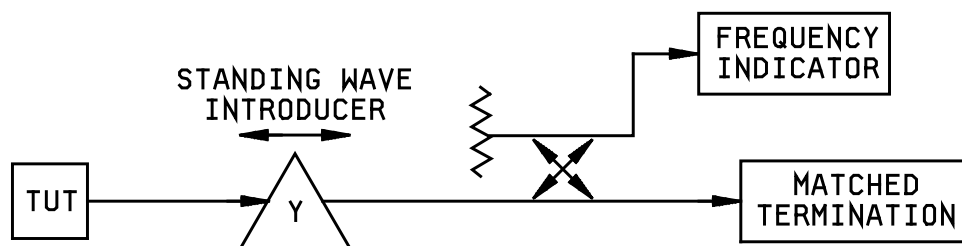


FIGURE 4310-1. Pulling factor test circuit method A.

4.1.1 Procedure. The standing-wave introducer is adjusted such that at any phase position the tube is exposed to a minimum VSWR of 1.5:1. The total frequency excursion is measured by the frequency indicator when the standing-wave introducer traverses all phase positions as previously defined.

4.2 Method B.

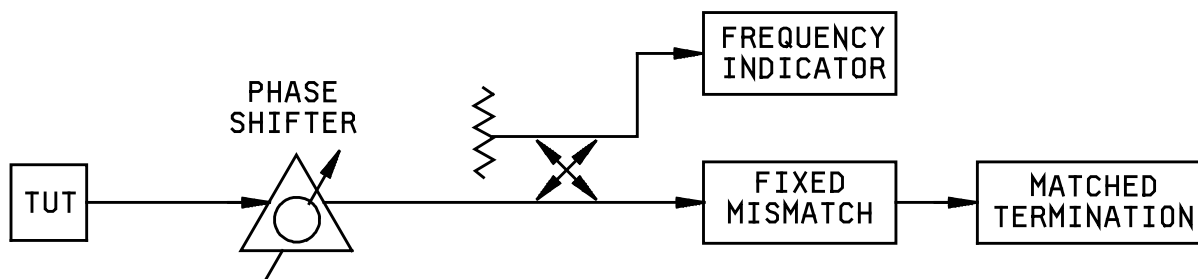


FIGURE 4310-2. Pulling factor test circuit method B.

MIL-STD-1311D

4.2.1 Procedure. The fixed mismatch and phase shifter are chosen such that in any phase position the tube is exposed to a minimum VSWR of 1.5:1. The total frequency excursion is measured by the frequency indicator when the phase shifter traverses all phase positions as previously defined.

5. Precautions.

5.1 The elements producing the 1.5:1 VSWR shall be close to the tube in order to eliminate any "long-line effects."

5.2 When the tube is retested at other than the manufacturing location, the tube shall not be exposed to a VSWR greater than 1.5:1 at any phase position.

5.3 The specified tube operating conditions are not readjusted during the pulling factor measurement.

5.4 The frequency indicator shall be capable of measuring instantaneous frequency values with the required accuracy. Commonly accepted frequency indicators are the spectrum analyzer, the electronic frequency counter, and the cavity wavemeter.

5.5 In calibration of the standing-wave introducer it is desirable that harmonics of the signal be of negligible proportion, and that a significant number of phase positions of the introducer be measured and plotted to show that the VSWR/phase plot is circular. A non-circular plot is an indication of unwanted resonances.

MIL-STD-1311D

METHOD 4311A

FREQUENCY PUSHING FIGURE

1. Purpose. This test is performed to determine the change in frequency of oscillation resulting from a change in electrode current.

2. Equipment.

- a. Power sources required for operation of the tube and a specified matched load capable of absorbing the output power.
- b. Either spectrum analyzer or wavemeter to measure the oscillation frequencies.
- c. Modulation equipment capable of varying the current over the specified range, either sinusoidally or by switching between two levels at a frequency not less than 45 Hz or as specified.

3. Procedure. The frequency pushing figure shall be measured by varying the electrode current periodically about the operating point under the specified operating conditions. The difference between the extremes of frequency of oscillation throughout the specified current variation shall be measured and the frequency pushing figure computed as the ratio of (1) this difference in frequency, to (2) the magnitude of the current variation. One of the following methods shall be used as specified.

3.1 Method A (pulse operation).

- a. The amplitude of the electrode current pulse shall be periodically modulated, usually sinusoidally, at such a rate that thermal effects may be neglected, with provision being made to measure the peak difference in the changing current. The frequency change may be measured by a spectrum analyzer or by a receiver.
- b. The result is to be expressed as the ratio of (1) the change in frequency, to (2) the difference between current peaks during a modulation cycle.

3.2 Method B (CW operation).

- a. The electrode current shall be modulated smoothly over, at least the specified range, at such a rate that thermal effects may be neglected.
- b. The output of a suitable frequency discriminator shall be connected to one axis of the oscilloscope and the electrode current signal applied to the other axis which shall be calibrated in order that the instantaneous frequency at all values of current can be observed.

4. Precaution. The frequency discriminator shall be of sufficiently high resolution to resolve the expected frequency difference.

## MIL-STD-1311D

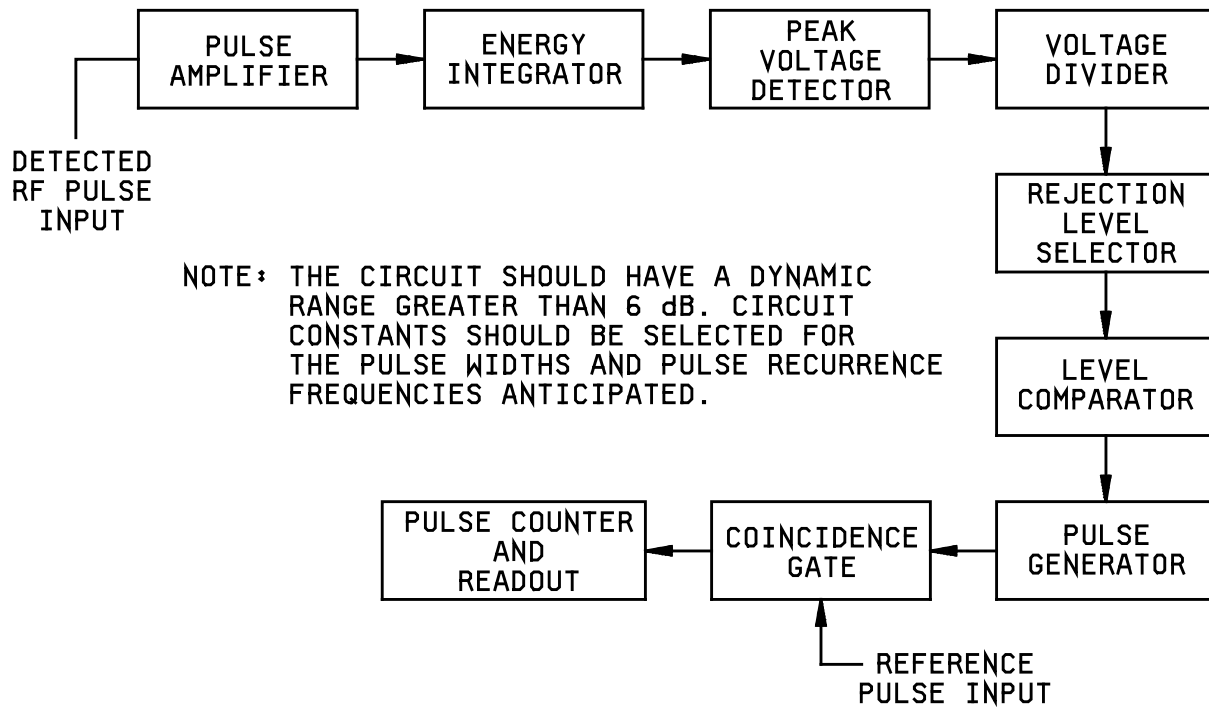
## METHOD 4315A

## PULSE STABILITY

1. Purpose. To evaluate the pulse output power stability of microwave tubes.
2. General. Microwave tubes are generally quite stable so that it is generally expedient to measure instead the occasional instabilities which arise because of internal or external effects. Pulses may be deficient in power output when an arc occurs in the cathode circuit or in the microwave resonant circuits when the tube operates wholly or in part in the wrong mode. Since stability is often a function of time elapsed since turn-on (cathode activity or gas clean-up) it is expected only one of the following tests will be specified on any tube type. Stability of a microwave tube shall be expressed in terms of the percent of all pulses which are missing or deficient. A missing or deficient pulse is one whose total energy content within a specified bandwidth is less than the minimum value specified. The minimum value is 70 percent of the average total energy content of each of a series of complete pulses, or may be expressed as 1.5 dB down from that energy level.
3. Equipment. In addition to the equipment required for the power levels test (method 4250), the following additional equipment is required:
  - a. Means of introducing a standing wave in the output system and varying its phase through all possible values while at the same time maintaining VSWR in excess of the specified value.
  - b. Power divider (directional coupler) to obtain a sample of RF output.
  - c. A frequency selective crystal detector system of specified RF bandpass.
  - d. Reference input pulse from the modulator which is time coincident with the pulse applied to the tube.
  - e. Missing pulse detector as shown on figure 4315-1 capable of recording random missing pulses or clusters of missing pulses.
4. Procedure. The tube shall be operated into the stated load whose phase is adjusted to that which produces the greatest number of deficient pulses. The level of the rf power applied to the input of the bandpass filter and detector is adjusted so that all pulses are just counted. The level is then increased by the specified amount and the number of missing pulses are counted over a specified period.
  - 4.1 Stability. The missing pulses observed according to the above procedure over the specified time base interval expressed in percent of the total pulses applied during the interval shall not exceed the value specified.
  - 4.2 Starting stability. This test shall be performed as the first test following the holding period. Since the time required to set up the measuring conditions may vary, the maximum allowed time for setting up shall not be included in the measuring period. Stability as in 4.1 shall be measured in the first time base interval which begins no later than the end of the allowed setup time.
  - 4.3 Snap-on stability. This test shall be the first test following a specified period of inactivity, using the specified load. Prior to starting the test period it is generally found convenient to adjust input to the tube and output VSWR approximately to the specified values using another tube. Then the "snap-on" tube is inserted in the socket and heater power is applied. After the specified warm-up period full pulse voltage is suddenly applied. Missing pulses, observed as in 4.1, shall be measured with the time base interval starting at the instant of application of the first pulse.
  - 4.4 Runup stability. This test shall be performed as the first test following the holding period. Upon completion of the heater warm-up time, apply  $e_b = 0$  and runup at the specified rate to  $P_o$  test conditions. Stability as in 4.1 shall be measured using a time base which begins immediately after reaching  $P_o$  test conditions.



MIL-STD-1311D

FIGURE 4315-1. Typical energy type missing pulse detector.

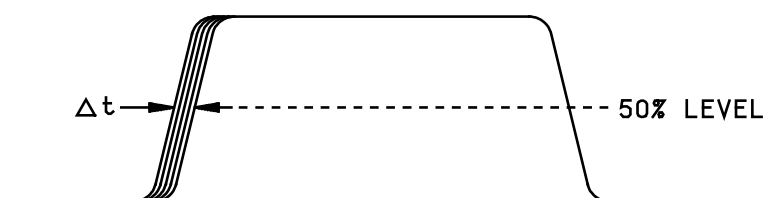
## MIL-STD-1311D

## METHOD 4318

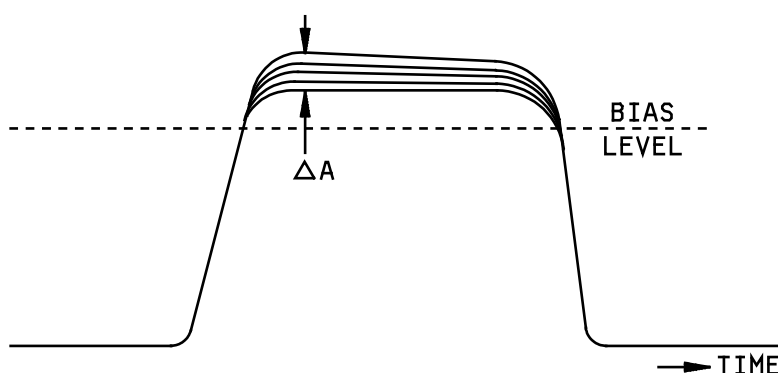
## JITTER MEASUREMENTS

1. Pulse-to-pulse jitter. The values of time, frequency, and amplitude for a series of power pulses generated by a microwave oscillator are not exactly identical but rather are distributed about a mean value. The pulse-to-pulse jitter shall be defined as the width of such a distribution of time, frequency, or amplitude and shall be expressed as an rms quantity. The rms pulse-to-pulse value may be computed from cumulative distribution data or by individual analysis of successive pulse pairs providing a sufficient quantity of data is taken to satisfy statistical computations.

1.1 Time jitter. Time jitter shall be measured at approximately the 3 dB power point (50 percent voltage point) shown on figure 4318-1 of the detected rf pulse. It shall represent that relative variation in starting time referenced from the leading edge of the voltage pulse as specified on the TSS or equivalent.

FIGURE 4318-1. Detected rf pulse.

1.2 Amplitude jitter. Amplitude jitter shall be measured at the top of the detected rf pulse at the point in time of maximum jitter within the usable portion of the pulse or as specified on the TSS (see figure 4318-2). In cases where amplitude jitter in the test modulator causes an increase in oscillator jitter, that amount of jitter which is over and above the true amplitude jitter of the TUT may be deducted.

FIGURE 4318-2. Detected rf pulse amplitude jitter.

## MIL-STD-1311D

1.3 Frequency jitter. Frequency jitter shall be measured using a suitable microwave interferometer or frequency discriminator (see figure 4318-3). The measurement shall be taken at the point in time of maximum jitter within the usable portion of the discriminated pulse waveform or as specified on the TSS. Means shall be taken to minimize the effect of frequency drift which might occur during this measurement.

In cases where amplitude jitter in the test modulator causes an increase in jitter due to frequency pushing, that amount of jitter which is over and above the tube frequency jitter of the TUT may be deducted.

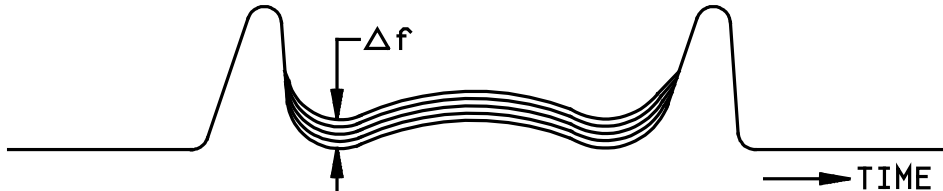


FIGURE 4318-3. Frequency jitter output of interferometer or frequency discriminator.

2. The method of obtaining cumulative distribution data and calculating the rms value of pulse-to-pulse jitter shall generally be as follows:

- Step 1: Using suitable associated test equipment (see 3 below), sample the jitter trace in discrete progressive cumulative levels and determine the percent of pulses exceeding a particular level during a fixed time interval. The time interval shall be  $\frac{1,000 \text{ seconds}}{\text{prf}}$  minimum or sufficiently long to satisfy statistical computations.
- Step 2: Continue sampling the jitter trace in progressive cumulative steps to enable a probability curve to be constructed.
- Step 3: Plot an arithmetic probability curve of cumulative percent of pulses versus the particular increment of jitter. Figure 4318-4 illustrates such a Gaussian distribution of time jitter of the leading edge of the RF envelope with respect to the voltage pulse and also the resultant probability curve that is obtained as the jitter trace is sampled at the 50-percent level in a cumulative incremental manner.
- Step 4: The rms value of jitter,  $\sigma_m(1)$ , shall represent that jitter increment between the 50 percent and 84.13 percent points on this curve, see  $\sigma_m(1)$  on figure 4318-5.
- Step 5: If the distribution is Gaussian, the pulse-to-pulse rms value of jitter may be computed from the following formula, using time jitter as the example.

$$J_r = \sqrt{2} \sigma_m(1)$$

If the cumulative distribution of jitter is not Gaussian, due to periodic or cyclic contributions from either the tube or associated test equipment, statistical methods may be employed to deduct that portion of the jitter measurements resulting from periodic variations (see 5 below).

3. Test equipment for obtaining measurement of cumulative distribution data. Figure 4318-6 is a simplified block diagram of one possible arrangement for obtaining cumulative distribution data in the measurement of time, amplitude, and frequency jitter. This method employs an electronic detector circuit. However, other methods such as photomultiplier detector circuits are equally satisfactory and may also be used.

## MIL-STD-1311D

Briefly, the operation of the circuit for the three types of jitter is as follows,

3.1 Time jitter. A sample of energy is detected, amplified, fed through a precision variable delay line into a special coincidence circuit where it is delayed. The oscillator voltage pulse to which the rf output pulse must be compared, triggers a pulse generator which produces an output pulse that has negligible relative time jitter and adjustable pulse width. The two pulses are added together in the coincidence circuit and the trailing edge of the generated pulse adjusted to align with the leading edge of the rf pulse as shown on figure 4318-7. This produces a triangular waveform whose output is proportional to time variations in the leading edge of the rf pulse. This signal is then fed into a gate generator, the triggering level of which is approximately equal to a 50-percent level on the leading edge of the rf envelope. Each time a triangular-wave pulse exceeds this level, a pulse is generated in the gate generator and fed into a decimal counter. Also, a similar pulse is generated for each group of successive triangular pulses that exceed this triggering level. These pulses or "runs" count are also fed into a decimal counter. The decimal counter has a time base established by the preset counter driven by the voltage pulse applied to the oscillator under test. The time base is set for a minimum of  $\frac{1,000}{prf}$  seconds. The precision delay time is then varied in discrete steps such that the amplitude of the triangular pulse varies from a point where 0 percent of the pulses are counted until 100 percent are counted.

This procedure is used to obtain the cumulative distribution data.

3.2 Frequency jitter. The microwave interferometer is used as the sensing element. It has a detected output signal as shown on figure 4318-8a which is amplified and then fed into the coincidence circuit where it is added to a pulse from the pulse generator, see figure 4318-8b. The resultant signal will contain amplitude variations which are proportional to frequency changes in the output pulse of the oscillator under test. This signal containing amplitude variations is fed into the coincidence circuit much in the same manner as that for time jitter.

In this case, cumulative distribution data is obtained by varying the frequency of the interferometer in discrete steps until 0 to 100 percent of the pulses are counted for a given preset time interval.

3.3 Amplitude jitter. For amplitude jitter measurements, the sampled energy is fed through a precision adjustable attenuator to a detector biasing circuit where the top of the pulse is detected and bottom clipped as shown on figure 4318-9a. The top of the envelope is then fed through the video amplifier and into the coincidence circuit where it is combined with the output of the pulse generator shown on figure 4318-9b. This results in a pulse having amplitude variations which are representative of amplitude variations in the pulse generated by the oscillator under test, see figure 4318-9c. This signal is then fed into the gate generator and handled in the same manner as time and frequency jitter. Cumulative distribution data is obtained by varying the precision attenuator in discrete steps in the same manner as previous jitter measurements.

4. Correlation of peak-peak jitter (jt for peak-peak time jitter) measurements with the pulse-pulse rms value. Where sufficient data has been taken to show that peak-peak measurements of jitter are correlatable, with the pulse-pulse rms value of jitter as measured by these statistical techniques, it may be used as the basis for acceptance. Some of the factors to be considered are the effects of different test modulators, tubes, interpretations of test operators, as well as any other factors which could affect the relationship of peak-peak jitter with the pulse-pulse rms jitter.

5. Measurement of jitter which includes some periodic-ripple contribution. In addition to the cumulative incremental distribution data, simultaneous data shall be taken to determine the number of "runs" that occur during each fixed time interval. A "run" is defined as any group of successive pulses that exceeds a particular level of jitter during a fixed time interval. If amplitude jitter is being measured and a group of 15 pulses vary in amplitude in the following manner, the total of individual pulse "counts" and "runs" would be as shown on figure 4318-10.

## MIL-STD-1311D

5.1 To further illustrate, the following represents typical "runs" and "counts" information that might be obtained when jitter is sampled in an incremental cumulative distributional manner. In this example, the following assumptions are made:

- a. A total of 1,000 pulses are sampled during each jitter increment.
- b. The pulse repetition frequency equals 1,000 pps.
- c. The ripple frequency is 120 Hz.

<u>Increment</u>	<u>Runs</u>	<u>Count</u>	
1	0	0	(0% counts)
2	80		
3	170		
4	176	500	(50% counts)
5	172		
6	85		
7	0	1,000	(100% counts)

5.2 With cumulative "runs" and "counts" information available, the random pulse-pulse rms jitter may be computed in the following manner:

Step 1: In the region of 50 percent counts, determine the average value of the number of runs. This includes ripple count. (In the example, average number of runs - 176.)

Step 2: Divide this number of step 1 by a number which is 25 percent of the total number sampled during a count interval, to determine a ratio of

$$\frac{\text{runs with ripple}}{.25 \times \text{number of pulses sampled}}$$

(In the example, this ratio is  $176 \div (.25 \times 1,000)$  or  $176 \div 250 = 0.7$ )

Step 3: Establish the ratio of ripple frequency to the pulse repetition frequency of the TUT. (In the example, this is  $120 \div 1,000$  or 0.12) Then determine on figure 4318-11 the point of intersection with the ratio obtained in step 2. This will enable a value of N, the ratio of  $\frac{\text{peak value of ripple}}{\text{random jitter}}$  to be determined by the example  $N = 1.6$ .

Step 4: Using this value of N, determine a new upper limit for statistical  $\sigma$  on the probability versus N graph. (See figure 4318-12.) (In the example, new limit of  $\sigma = 82.5$ .)

Step 5: Determine the value of  $\sigma_m$ , ( $\sigma$  measured), by measuring the jitter between 50 percent and the upper limit obtained from step 4 on a curve of percent counts versus jitter such as is illustrated on figure 4318-5 by  $\sigma_m(2)$ .

## MIL-STD-1311D

Step 6: Compute the value of random rms pulse-pulse jitter from the following formula, using time jitter as the example.

$$J_t = \sigma_m(2) \frac{\sqrt{4 + 2N^2 (1 - \cos 2\pi r)}}{2 + N^2}$$

Where:

$$N = \frac{\text{Peak value of ripple}}{\text{Random jitter}} \quad (\text{Step 3})$$

$$\sigma_m(2) = \sigma \text{ measured} \quad (\text{Step 5})$$

$$R = \frac{\text{Ripple frequency}}{\text{Pulse repetition frequency}} \quad (\text{Step 3})$$

$J_t$  = Random rms pulse-pulse time jitter.

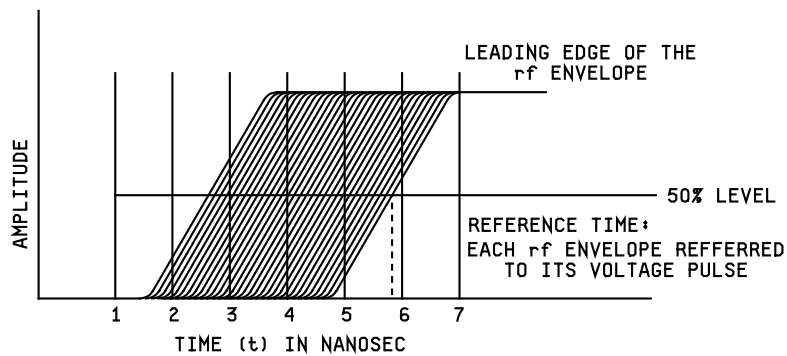


FIGURE 4318-4. Time jitter of the leading edge of the rf envelope with respect to voltage pulse.

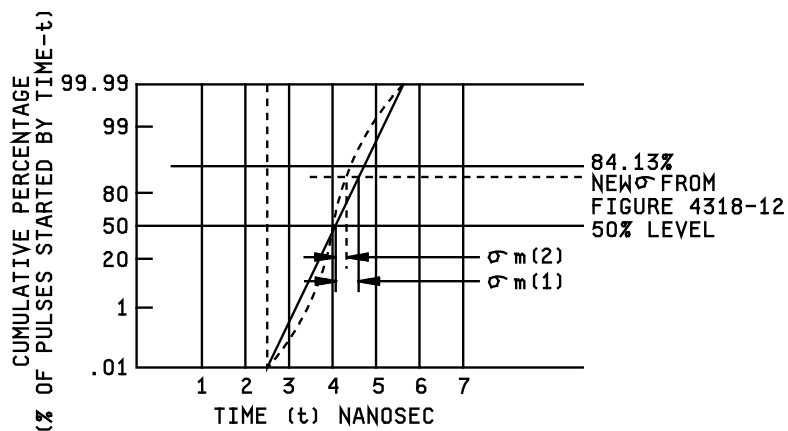


FIGURE 4318-5 Cumulative percent versus time as a jitter variable.

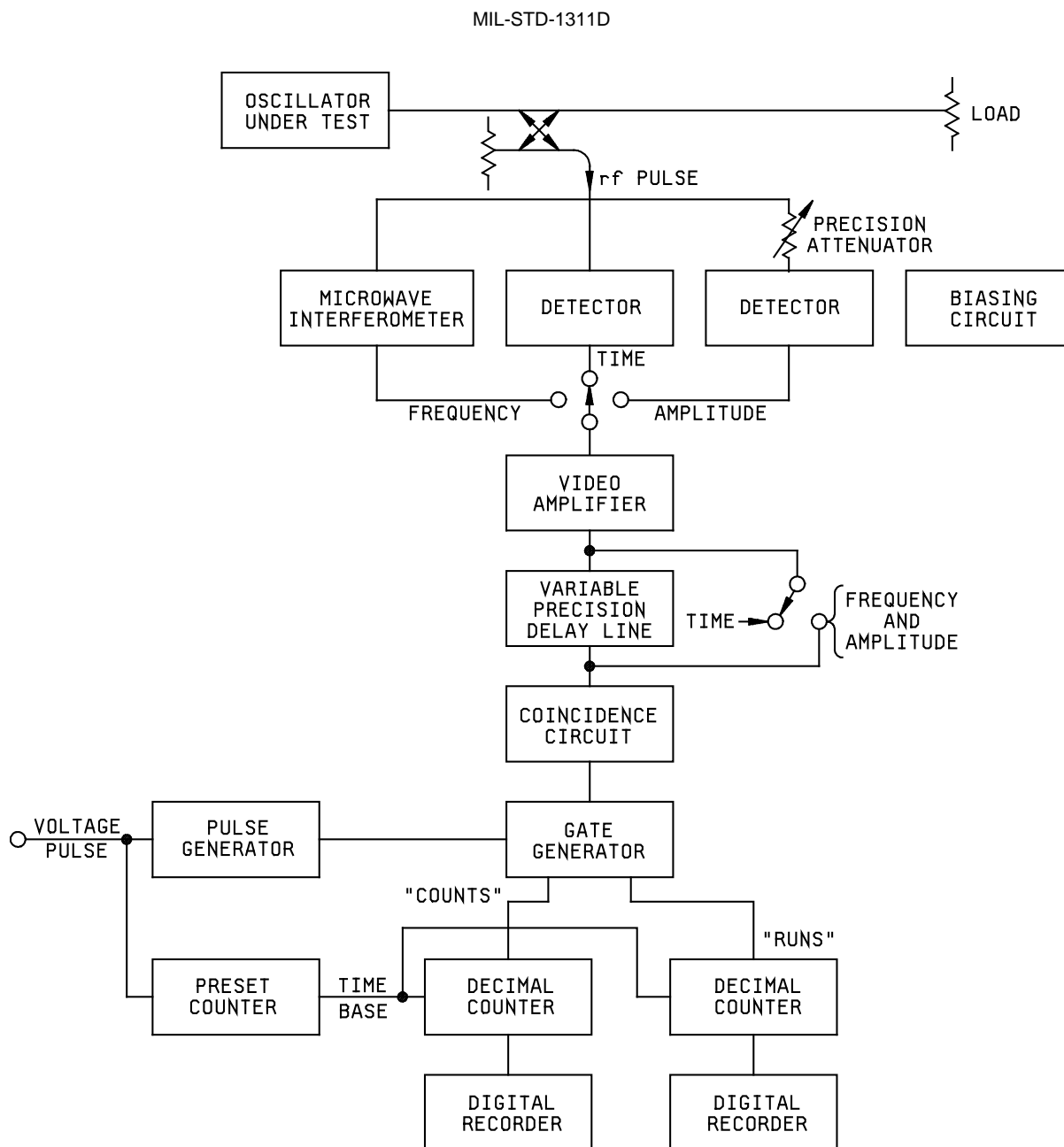


FIGURE 4318-6. Arrangement for measuring time, frequency, and amplitude jitter.

MIL-STD-1311D

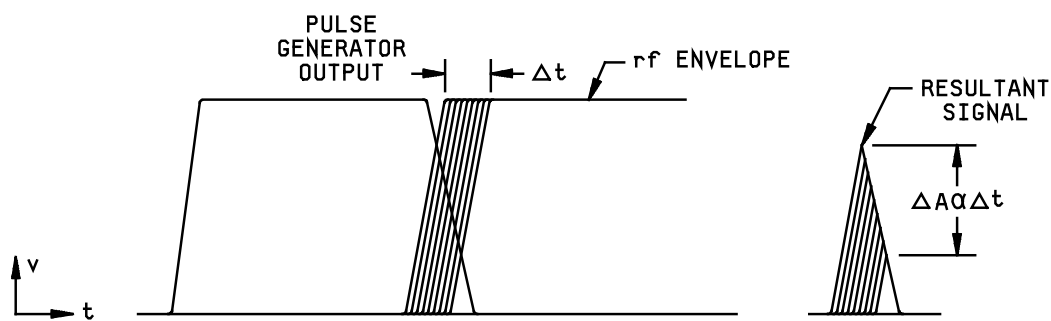


FIGURE 4318-7. Time jitter.

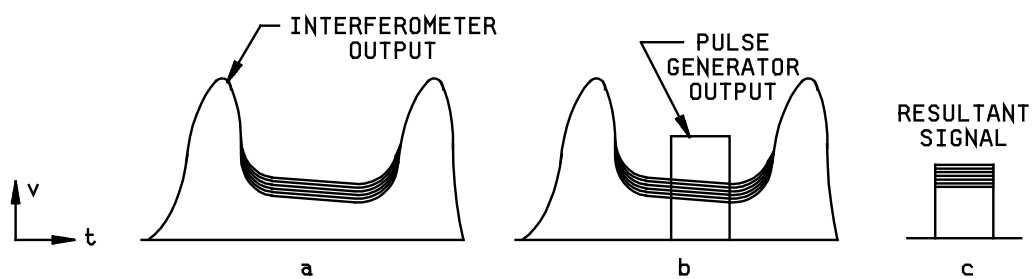


FIGURE 4318-8. Frequency jitter.

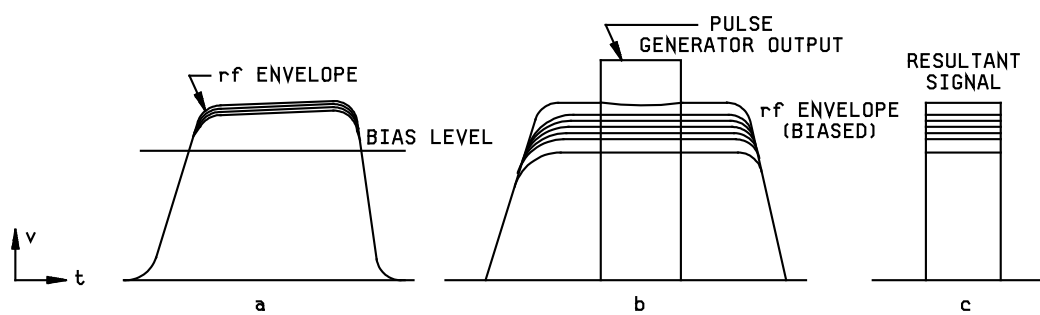


FIGURE 4318-9. Amplitude jitter.



MIL-STD-1311D

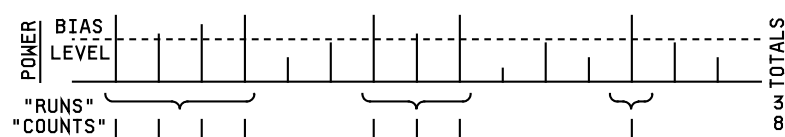


FIGURE 4318-10. Typical "runs" and "counts" chart.

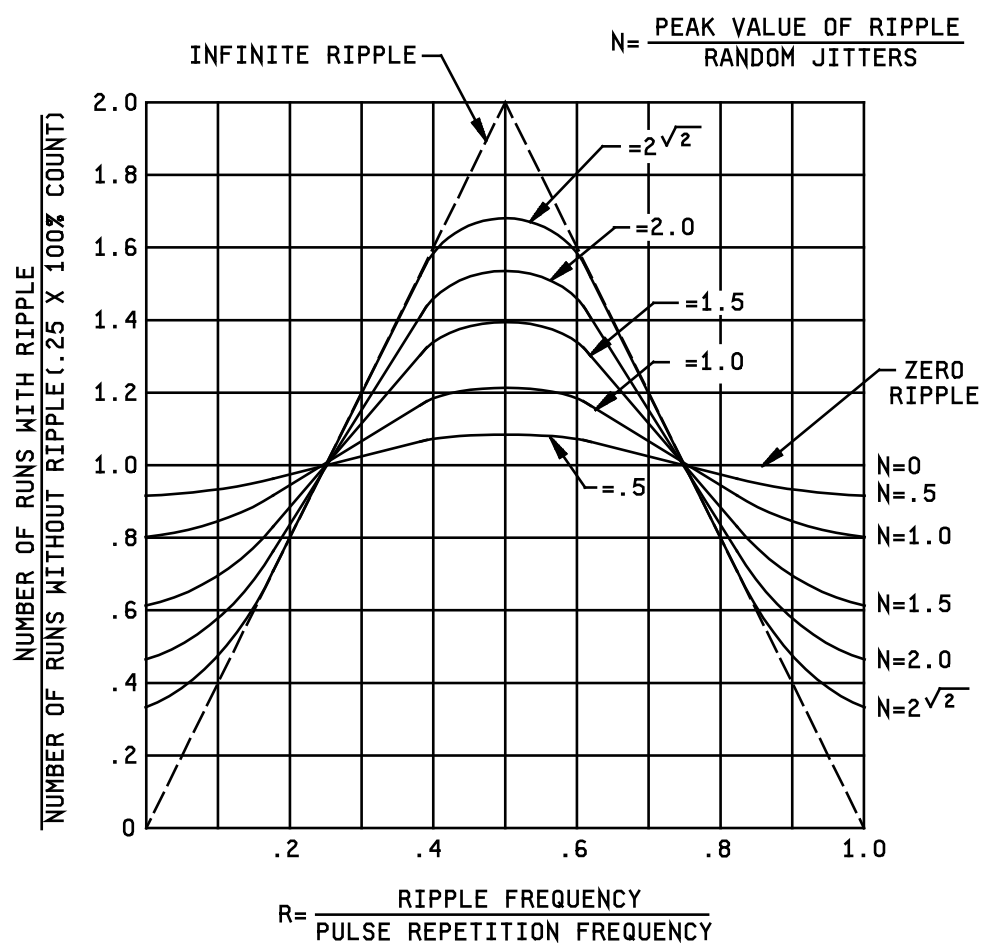
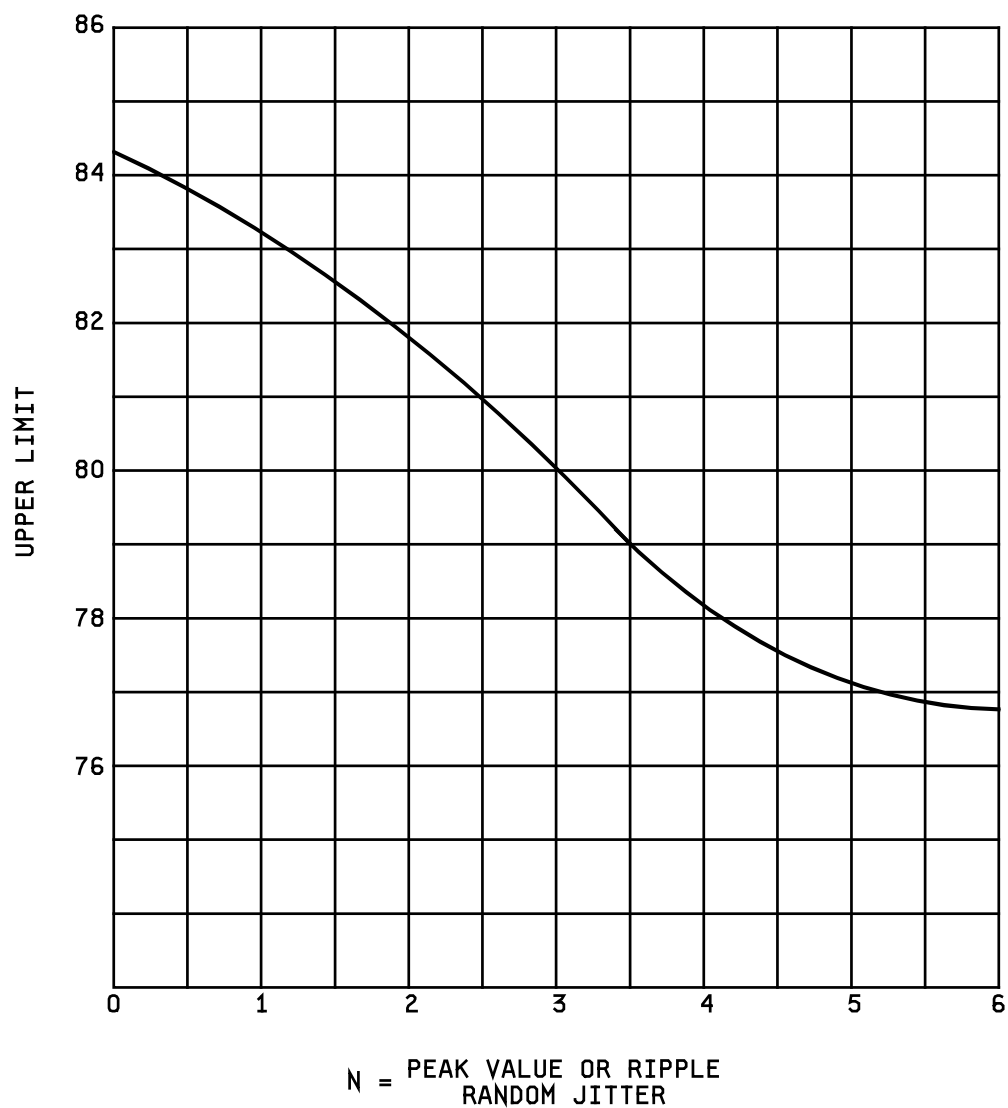


FIGURE 4318-11. Ripple frequency ratio chart.

MIL-STD-1311D

FIGURE 4318-12. Determination of upper limit to compute measured.

MIL-STD-1311D

METHOD 4401B

## IGNITOR IGNITION TIME

1. Purpose. To measure the period of time taken for the tube to ignite after application of ignitor voltage.
2. Equipment. The test circuit shown on figure 4401-1, or an equivalent circuit, shall be used for making this test. The counting circuit, which consists of a neon bulb, a  $2\ \mu\text{F}$  capacitor, two fixed resistors (3 Meg and 5 Meg), and a 5 Meg potentiometer, may be omitted if an equally accurate alternate method of measuring time is used. The TSS shall specify the open circuit voltage, and the total series resistance ( $R_1$ ).

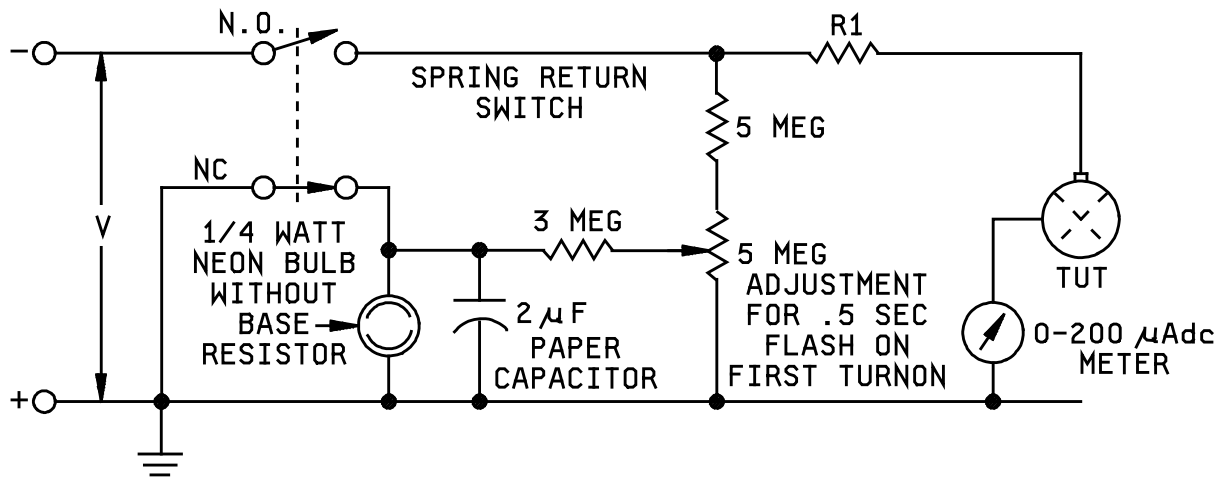


FIGURE 4401-1. Ignitor igniting-time circuit.

3. Procedure. The tube shall be tested in the specified circuit and the time between voltage application and ignition shall be measured.

MIL-STD-1311D

METHOD 4406

IGNITOR VOLTAGE DROP

1. Purpose. The purpose of this test is to determine the voltage drop of the ignitor under specified operating conditions.
2. Equipment. The test circuit shall consist of a variable voltage supply, a series resistor, a microammeter, and a high-impedance voltmeter. (This test may be made in conjunction with the ignitor ignition time test, method 4401, using the circuit shown on figure 4401-1.)
3. Procedure. With the ignitor current adjusted to the value specified, the voltage drop across the tube shall be measured.

MIL-STD-1311D

METHOD 4411

(OBSOLESCENT)

IGNITOR OSCILLATION

(TR tubes)

The tube shall be placed in the circuit as shown on figure 4411-1, or equivalent circuit. With the supply voltage adjusted to 800 V dc, the ignitor current shall be set by means of the variable resistor in series with the ignitor electrode. The minimum current that will prevent low-frequency relaxation oscillations shall be within the limit(s) specified on the TSS. The high-frequency oscillations cause no difficulties. Relaxation oscillations are indicated on the oscilloscope trace when the current drops below the level of the high-frequency relaxation oscillations.

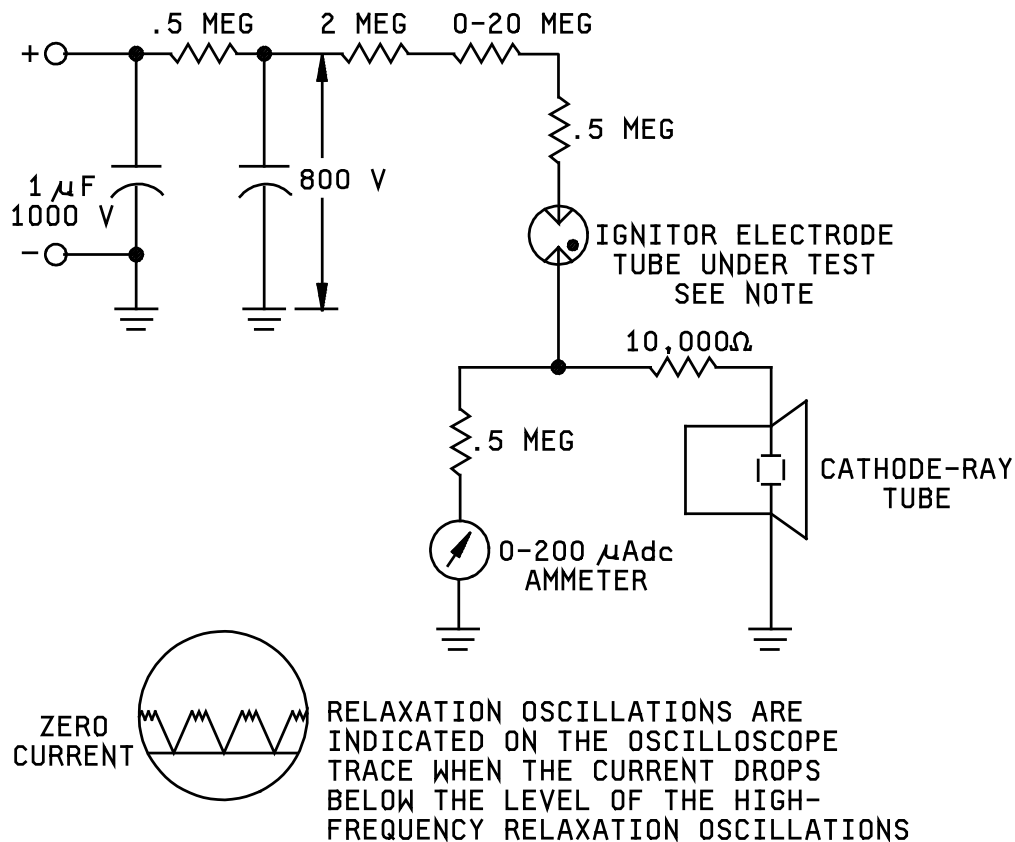


FIGURE 4411-1. Ignitor oscillation circuit.

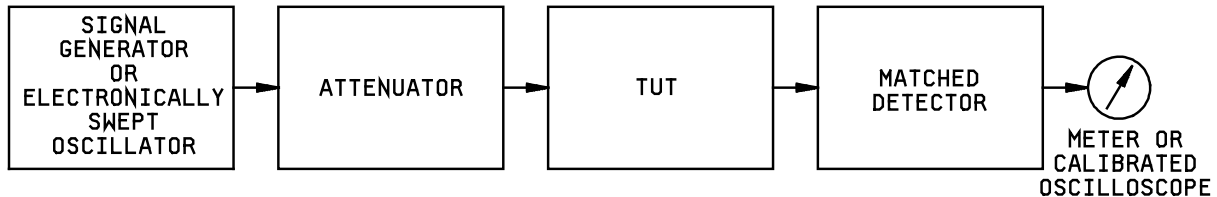
## MIL-STD-1311D

## METHOD 4416

## INSERTION LOSS

(Gas-switching tubes)

1. Purpose. The purpose of this test is to determine the loss of power incurred in a transmission line due to the insertion of the tube in the line.
2. Equipment. The equipment for making this measurement shall consist of a signal generator or sweep oscillator, an attenuator, a matched detector, and a meter or calibrated scope. The equipment layout is shown on figure 4416-1.

FIGURE 4416-1. Equipment layout for insertion-loss measurements.3. Procedure.

3.1 Integral cavity. The insertion loss shall be measured by a transmission method, as shown on figure 4416-1, in which the tube is placed between a matched generator and detector. With the signal generator set at the reference frequency, the tube shall be tuned to resonance as evidenced by a pronounced peak of the output indicator. The dB loss of power at the detector, due to the insertion of the tube in the transmission line, shall be within the limits specified.

3.2 Fixed tuned. With the signal generator set at the reference frequency, the dB loss of power at the detector, due to the insertion of the tube in the transmission line, shall be within the limit(s) specified. See figure 4416-1 for test circuit.

3.3 External cavity. The tube shall be mounted in the specified cavity and placed in the circuit specified on figure 4416-1. With the signal generator set at the reference frequency, a relative power reading at the output detector shall be noted. The tube shall then be replaced by the specified cavity calibrator (dummy tube), and the new output reading recorded. The dB ratio of power at the detector with the calibrator in the cavity, to the power at the detector with the tube in place, shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 4421

IGNITOR INTERACTION

(TR tubes)

1. Purpose. To measure the increase in insertion loss or change in intrinsic Q of a TR tube resulting from the ignitor electrode discharge.
2. Equipment. See method 4416 and figure 4416-1, or method 4475. An adjustable ignitor supply shall be added.
3. Procedure.
  - 3.1 Insertion loss. The tube shall be placed in the circuit specified in method 4416. With the ignitor current set to the value specified, the increase in insertion loss over the quiescent insertion loss shall not be greater than the amount specified on the TSS.
  - 3.2 Intrinsic Q change. The tubes shall be placed in the circuit specified in method 4475. With the ignitor current adjusted to the given value, the change in intrinsic Q shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 4426

TUNING RANGE

(TR tubes)

1. **Purpose.** To determine if a tunable tube covers the specified tuning range in no less than the specified minimum number of turns of the tuning screw and to check for irregularities in the tuning mechanism within the tuning range.
2. **Equipment.** The equipment for making this measurement shall consist of a signal generator or sweep oscillator, a frequency meter, an attenuator, a matched detector, and a meter or calibrated oscilloscope. See figure 4426-1 for equipment layout.

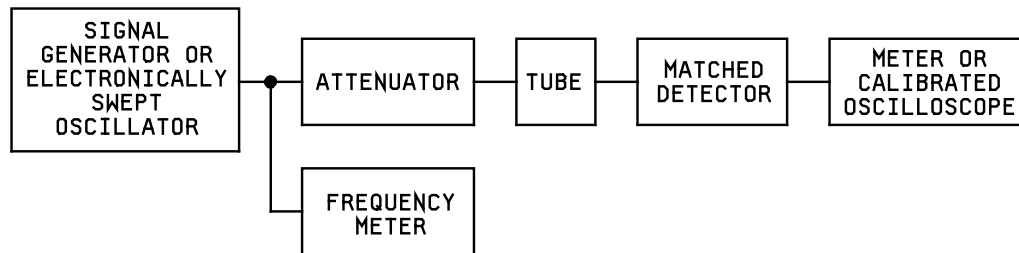


FIGURE 4426-1. Equipment layout for tuning range measurements.

3. **Procedure.** The tube shall be connected between a matched generator and a matched load and the tuner adjusted to one end of the specified frequency range. The tuning mechanism shall be varied around this point to observe any irregularities in the tuning characteristic as illustrated on figure 4426-2. This procedure shall be repeated at the other end of the tuning range. No tube shall require less than the specified number of complete turns of the tuning screw to cover the tuning range. The tuning screw shall be cycled from stop to stop before electrical tests are performed.

3.1 When the tuning control is cycled through its entire range, the cones of the tunes shall not touch as shown by an electrical continuity test when the two cones can be electrically isolated or by visual means when they cannot be electrically isolated.

3.2 With reference to figure 4426-2, the tube shall be rejected if, in addition to the main peak, one or more peaks of the output are present for which A is greater than a 20 degree movement of the tuning knob, or B is greater than 10 percent of the amplitude of the main peak.



MIL-STD-1311D

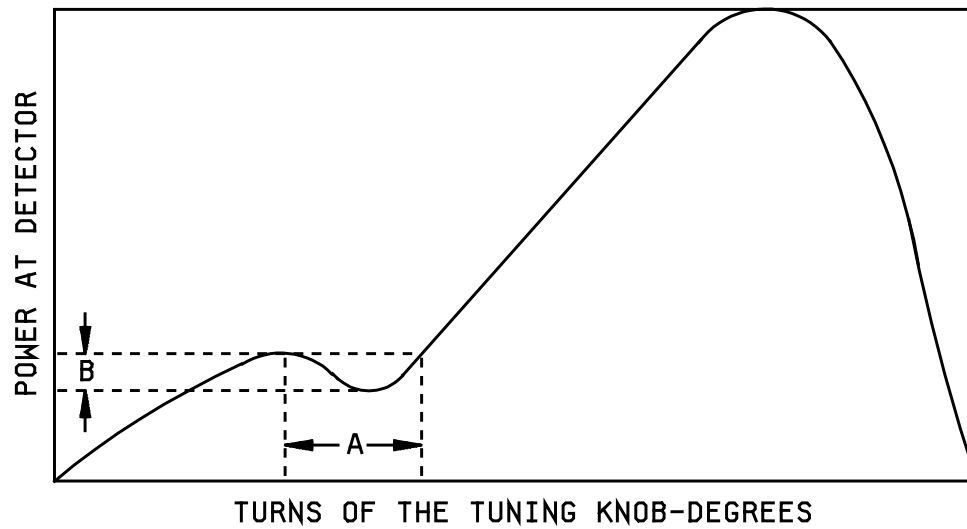


FIGURE 4426-2. Tuning characteristics.

MIL-STD-1311D

METHOD 4431

(OBSOLESCENT)

TUNING (TR TUBES)

1. Purpose. This test applies to fixed tuned tubes used in conjunction with an external cavity to function as a TR tube. Its purpose is to determine whether the fixed tuned tube meets the specified frequency limits when tested in a specified cavity. The resonant frequency of the combination is largely dependent upon the cavity internal dimensions so these shall be specified in detail on the TSS.

2. Equipment. The equipment layout as shown on figure 4431-1 may be used for this test. More than one cavity (different internal dimensions) may be specified to check the tube at different frequencies.

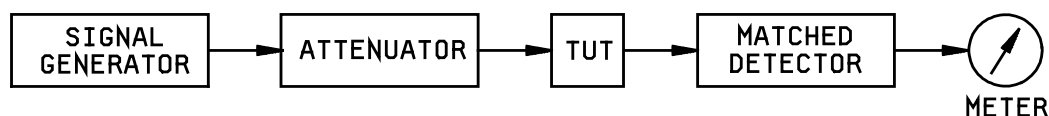


FIGURE 4431-1. Equipment layout for tuning (TR tubes) measurements.

3. Procedure. The tube shall be mounted in the specified external cavity and placed between a matched generator and detector. The signal generator frequency shall be varied to obtain the resonant frequency of the tube and cavity as evidenced by a pronounced peak at the output indicator. The value of this resonant frequency shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 4441

(OBSOLESCENT)

LEAKAGE POWER

(Gas-switching tubes)

1. TR tubes. The leakage power shall be measured after a shelf life of 7 days. The tube shall be mounted as a series tee with the rf power in the main line set for the conditions specified on the TSS. The tube shall be tuned to the reference frequency, and the ignitor current set to the given value. The peak leakage power can be obtained from the following equation:

$$\text{Peak leakage power} = \frac{\text{Average power}}{\text{prf} \times \text{width of leakage pulse}}$$

1.1 A functional block diagram of the system is shown on figure 4441-1.

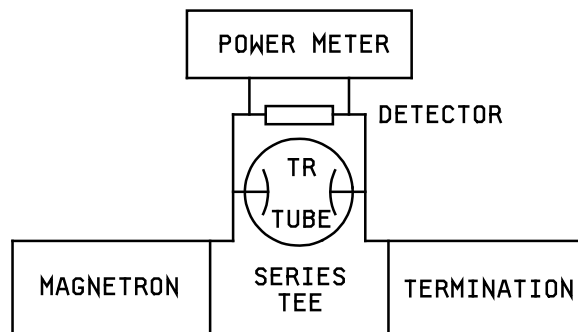


FIGURE 4441-1. Equipment layout for leakage-power measurements for TR tubes.

2. Dual TR tubes. Couplers (3-dB hybrid) are used having a maximum terminated VSWR of 1.10 over the specified frequency range. Each coupler shall split the power evenly to within 0.25 dB and shall have a minimum isolation of 25 dB.

2.1 Leakage power shall be measured using the circuit shown on figure 4441-2. The leakage power shall be within the limits specified when measured in accordance with methods 4446 and 4451.

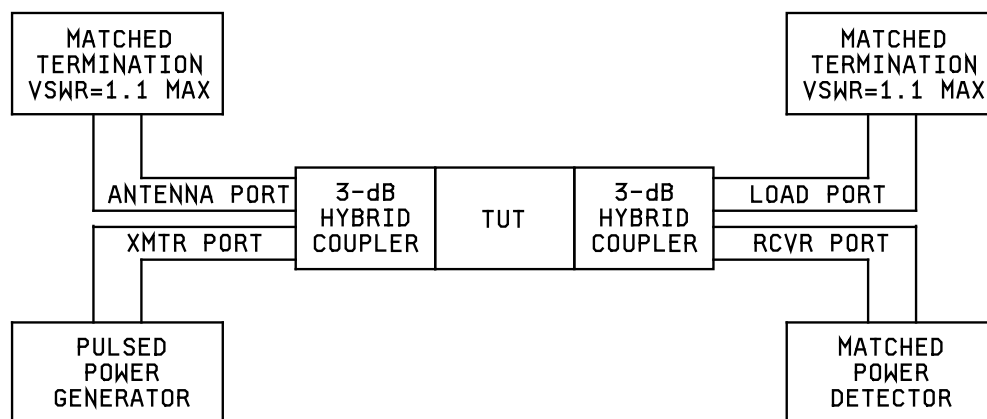


FIGURE 4441-2. Equipment layout for leakage-power measurement for dual TR tubes.

MIL-STD-1311D

METHOD 4446

(OBSOLESCENT)

SPIKE-LEAKAGE ENERGY

(TR tubes)

The leakage energy shall be measured after a shelf life of 7 days. The tube shall be mounted as a series tee with the rf power in the main line set for the conditions specified. With the ignitor current adjusted to the given value, the average leakage power through the tube shall be measured at each of the two designated pulse durations tp1 and tp2. The spike-leakage energy (Ws) shall be within the limits specified when determined as follows:

$$W_s = \frac{10^7}{prf} \left[ P_1 - \left( \frac{(P_1 - P_2)tp_1}{(tp_1 - tp_2)} \right) \right]$$

Where:

P1 = Average leakage power at tp1, in watts.

P2 = Average leakage power at tp2, in watts.

MIL-STD-1311D  
METHOD 4451A  
(OBSOLESCENT)  
FLAT-LEAKAGE POWER  
(Gas-switching tubes)

The flat-leakage power (pf) shall be within the limits specified when calculated as follows:

$$pf = \frac{(P1 - P2)}{pr r (tp1 - tp2)}$$

Where:

P1 = Average leakage power at tp1, in watts.

P2 = Average leakage power at tp2, in watts.

MIL-STD-1311D

METHOD 4452A

LEAKAGE POWER

(Gas-switching tubes)

1. Purpose. The purpose of this test is to measure the amount of energy contained in the spike portion, and the peak power level of the flat portion of the leakage pulse through a gas-switching tube during high level operation.

2. Test circuits.

2.1 Basic circuits. The basic test circuits for measuring spike-leakage energy and flat-leakage power are shown on figure 4452-1.

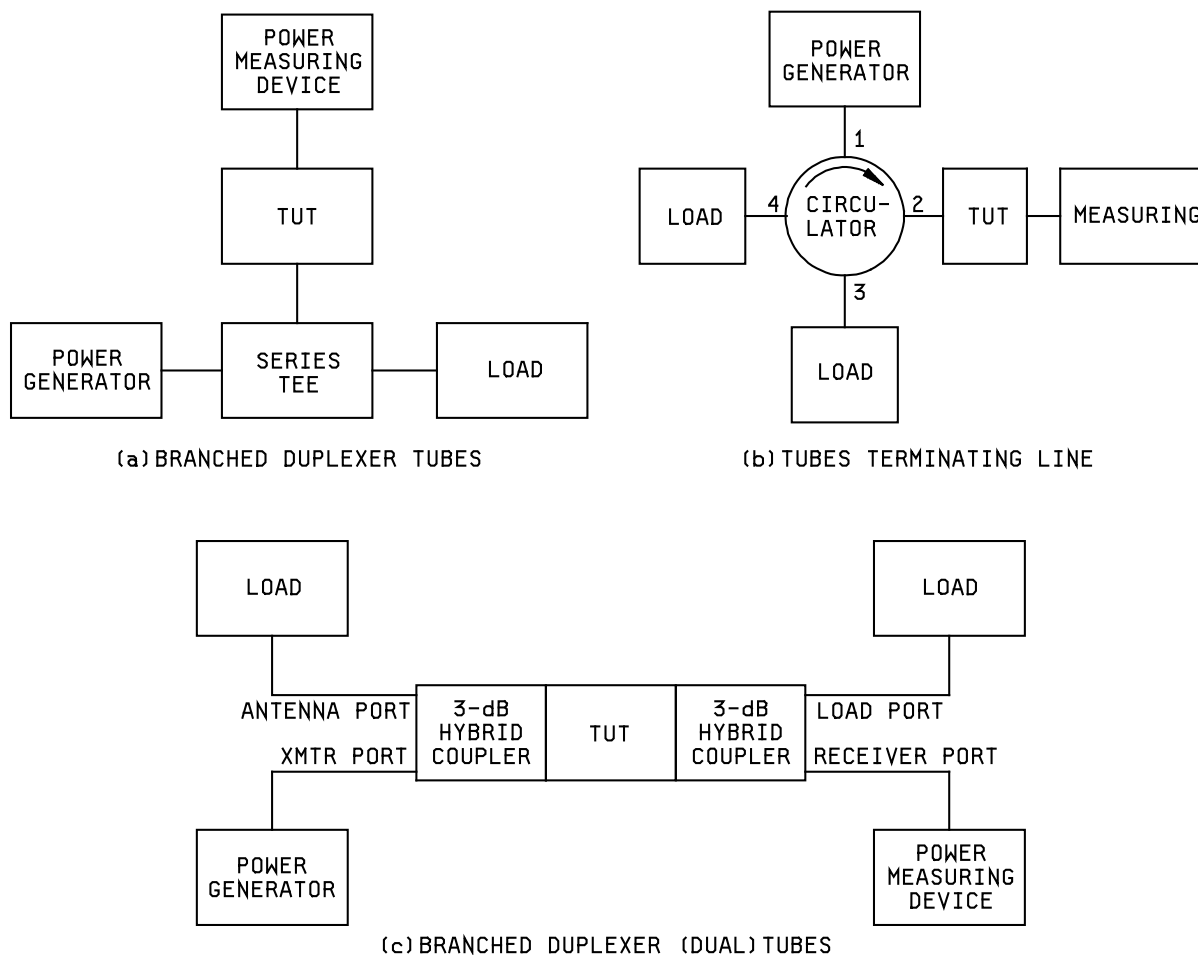
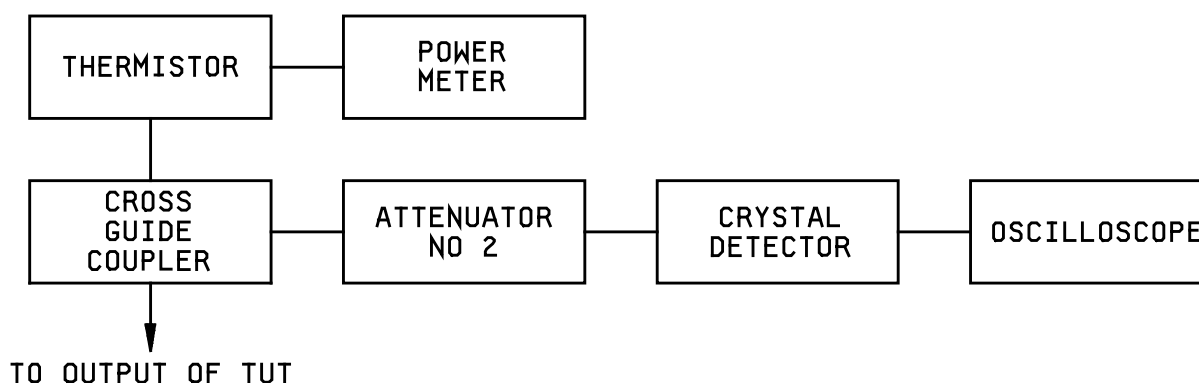


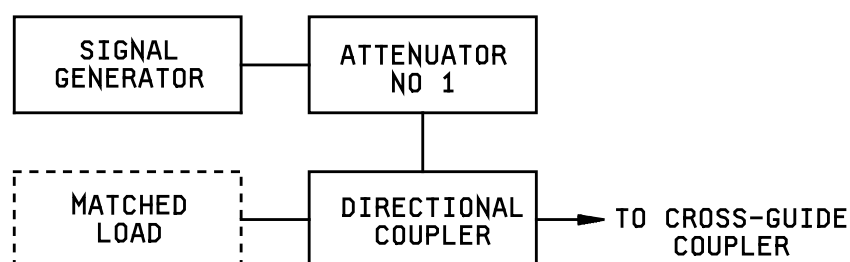
FIGURE 4452-1. Basic circuits for leakage power measurements.

2.2 Power measuring devices. The power measuring device in each of the basic circuits (figure 4452-1) may be simply a power meter with a thermistor, or it may be an oscilloscope with auxiliary equipment. A typical arrangement of equipment using an oscilloscope is shown on figure 4452-2.

MIL-STD-1311D

FIGURE 4452-2. Typical power measuring circuit.

2.2.1 When using an oscilloscope with auxiliary equipment for measuring peak power levels, it is necessary to calibrate the oscilloscope by comparison with some other power measuring device. This may be done by connecting a signal generator klystron circuit like the one shown on figure 4452-3 to the crossguide coupler of figure 4452-2.

FIGURE 4452-3. Typical calibration circuit.

2.2.2 The calibration of the oscilloscope may be performed separately or the calibration circuit may be connected into the leakage power measuring circuit permanently.

### 2.3 Detailed test circuits.

2.3.1 The foregoing sections show the important basic and branch circuits for measuring leakage power, and it is possible to combine these circuits in several different ways. The following circuits show typical arrangements of equipment for making leakage power measurements on different classes of tubes.

#### 2.3.2 Branched duplexer tubes.

2.3.2.1 A circuit in which the basic circuit of figure 4452-1(a) is combined with a thermistor and a power meter (No. 1) is shown on figure 4452-4. A directional coupler in the main line with another thermistor and power meter (No. 2) makes provision for monitoring the input power to the TUT. The addition of the monitoring circuit is optional.

## MIL-STD-1311D

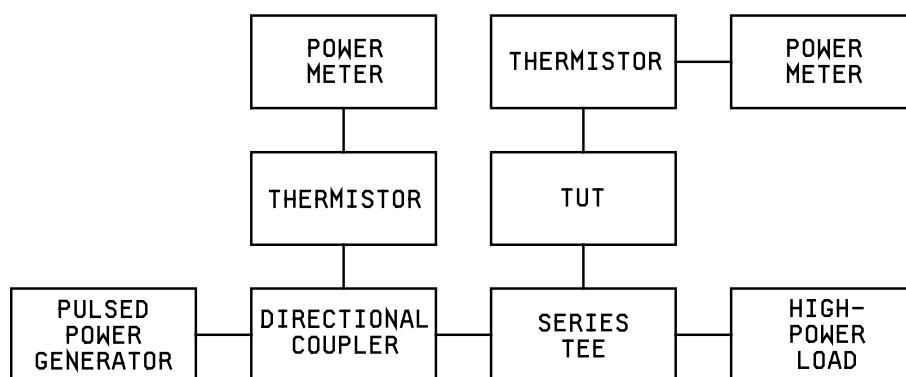


FIGURE 4452-4. Equipment layout No. 1 for leakage power measurements on tubes for branched duplexer applications.

2.3.2.2 A circuit in which the basic circuit of figure 4452-1(a) is combined with a branch circuit containing an oscilloscope, and another branch circuit containing a signal generator which is used for calibrating the oscilloscope, is how on figure 4452-5. An optional power monitoring circuit is included. The signal generator branch may be removed once the oscilloscope has been calibrated in terms of power level.

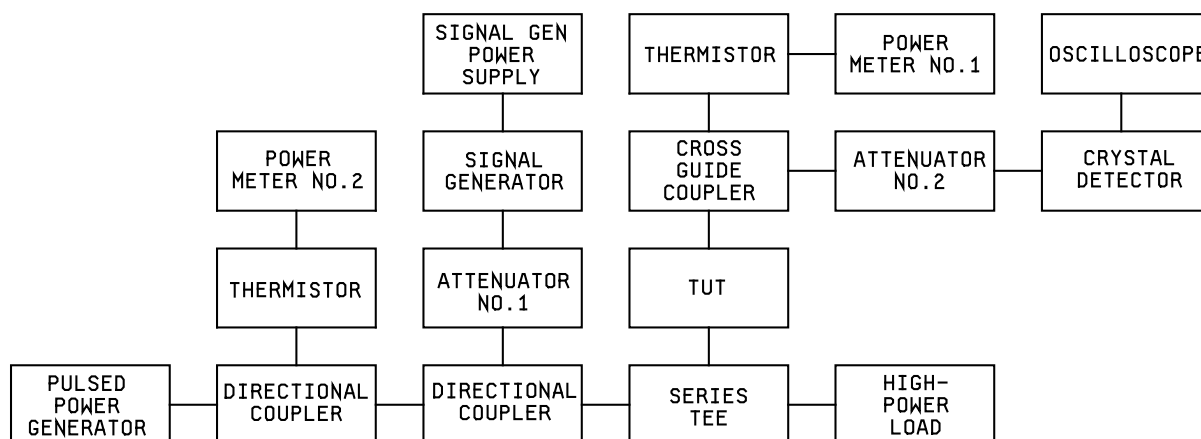


FIGURE 4452-5. Equipment layout No. 2 for leakage power measurements on tubes for branched duplexer applications.

### 2.3.3 Tubes terminating the line.

2.3.3.1 A circuit in which the basic circuit of figure 4452-1(b) is combined with a thermistor and a power meter is shown on figure 4452-6. A power monitoring circuit containing power meter No. 2 is included.



MIL-STD-1311D

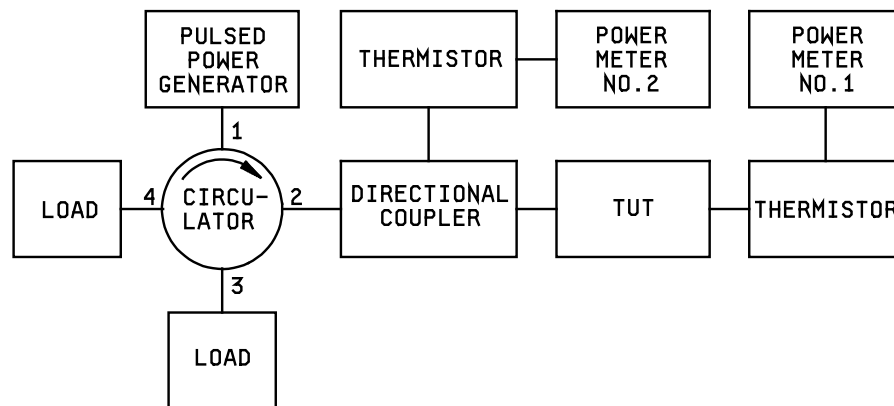


FIGURE 4452-6. Equipment layout No. 1 for leakage power measurements on tubes terminating the line.

2.3.3.2 A circuit in which the basic circuit of figure 4452-1 (b) is combined with a branch circuit containing a signal generator which is used in calibrating the oscilloscope, is shown on figure 4452-7. An optional power monitoring circuit is included. The signal generator branch may be removed once the oscilloscope has been calibrated in terms of power level.

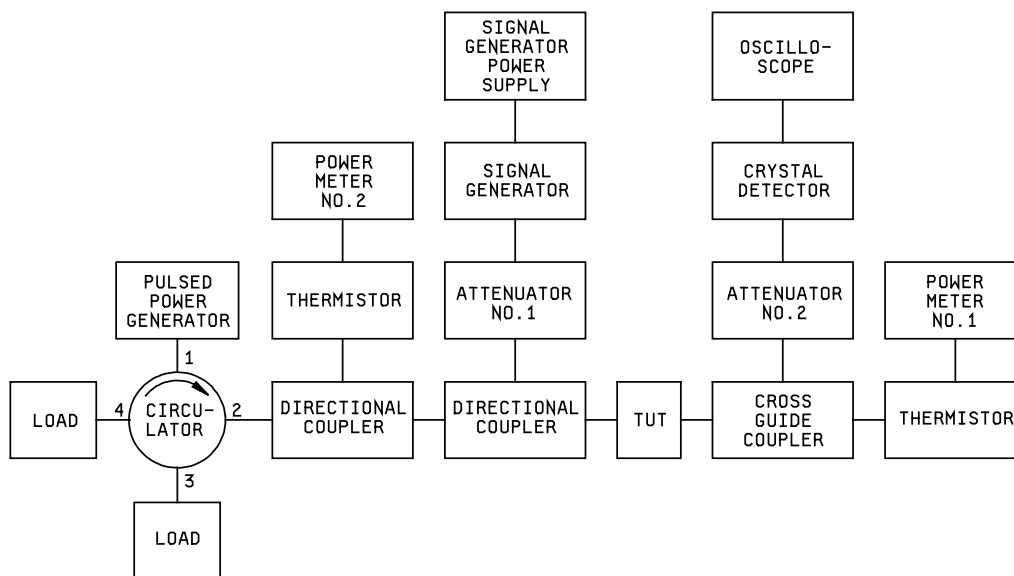


FIGURE 4452-7. Equipment layout No. 2 for leakage power measurements on tubes terminating the line.

#### 2.3.4 Dual tubes.

2.3.4.1 The basic circuit shown on figure 4452-1(c) is used in making leakage power measurements on dual tubes. This circuit, as shown, uses a power meter for measuring the leakage power. An oscilloscope circuit could be used in place of the power meter as already described for branched duplex tubes and tubes terminating the line.

## MIL-STD-1311D

3. Procedure.3.1 Power meter measuring circuits

3.1.1 With the tube in the test circuit, the ignitor current or voltage and the rf power in the main line shall be adjusted to the specified values. The average leakage power shall be measured at each of two pulse durations, tp1 and tp2. These are the durations of the power generator pulses measured as in method 4304, while tp3 and tp4 are the corresponding leakage pulse durations measured at the base line of the leakage pulses passing through the TUT.

3.1.2 The peak flat-leakage power (pf), in milliwatts, shall be computed by using the following formula:

$$pf = \frac{(P1 - P2) \times 10^3}{prr (tp3 - tp4)}$$

Where:

tp3 = Leakage pulse width of longer pulse, in seconds, measured at the baseline.

tp4 = Leakage pulse width of shorter pulse, in seconds, measured at the baseline.

P1 = Average leakage power at tp1, in watts.

P2 = Average leakage power at tp2, in watts.

3.1.3 The spike-leakage energy, in ergs, shall be computed by using the following formula:

$$Ws = \frac{10^7}{prr} \left[ P1 - \frac{(P1 - P2) tp3}{tp3 - tp4} \right]$$

Where the terms are defined in 3.1.2.

3.1.4 If it is possible to adjust the pulse width, tp2, to a very small value so that the leakage pulse consists mainly of the spike and essentially no flat, the spike-leakage energy may be computed using the following formula:

$$Ws = \left( \frac{10^7}{prr} \right) P2$$

Where:

P2 = Average leakage power, in watts, at the shorter pulse width.

3.2 Oscilloscope measuring circuits.

3.2.1 To calibrate the oscilloscope, connect the two circuits, figures 4452-2 and 4452-3 together, or if they are branch circuits of a complete leakage power test setup, use the following procedure.

With the power from the signal generator, calibrate the oscilloscope to some selected value of peak power using attenuator No. 1 with no tube in the circuit. Knowing the duty cycle at which the signal generator is operating, the peak power indicated on the oscilloscope can be calculated by dividing the average power measured with the power meter by the duty cycle.

3.2.2 With the signal generator turned off or disconnected, insert the TUT into the circuit, adjust the ignitor to its specified current or voltage, and set the rf power conditions in the main line to those specified on the TSS. With no change in the oscilloscope controls, attenuator No. 2 is adjusted to bring the peak of the spike or the flat to the calibrated reference level set on the oscilloscope. The peak power value of the spike, ps, or the flat, pf, obtained by multiplying the reference level peak power by the power ratio obtained from the attenuator. The width of the spike, ts, is measured in nanoseconds at the 3 dB level on the spike portion of leakage pulse and is used in calculating the spike-leakage energy.

## MIL-STD-1311D

3.2.3 The spike-leakage energy, in ergs, is calculated using the following formula:

$$Ws = ps \times ts \times 10^{-2}$$

Where:

ps = Peak power of the spike (in watts).

ts = Width of the spike portion (in nanoseconds).

3.2.4 The peak value of the flat portion of the leakage pulse, pf, is obtained as explained in 3.2.2.

#### 4. Recommended usage and precautions.

4.1 When using the procedure given in 3.1.1 through 3.1.3, it is assumed that the spike and flat portions of the leakage pulse are approximately rectangular and the calculations involving the two-pulse method are based on this assumption. Because broadband (low Q) gas-switching tubes generally have a leakage pulse with a considerable trough following the spike portion, the results obtained by calculation show lower than the true value of spike-leakage energy, and sometimes higher than the true value of flat-leakage power. This procedure is recommended when equipment is not readily available to make the measurements in accordance with the procedures given in 3.2.1 through 3.2.4.

4.2 The procedure given in 3.1.4 is recommended for broadband, waveguide type gas-switching tubes. The present restrictions on using this method of measurement of spike leakage is the availability of test equipment, particularly pulsed power generators, which will operate with narrow pulses.

4.3 The procedures given in 3.2.1 through 3.2.4 are recommended where small values of spike are encountered with tubes such as TR limiters and crystal protectors. Increased accuracy is obtained when the oscilloscope known as a "sampling scope" is used.

4.4 When testing dual tubes as described in 2.3.4, it is important to use a well-balanced circuit. The 3 dB hybrid couplers used should have a VSWR of less than 1.10, should split the power evenly to within 0.25 dB, and should have a minimum isolation of 25 dB.

MIL-STD-1311D

METHOD 4456

(OBSOLESCE)

IGNITOR-LEAKAGE RESISTANCE

(TR tubes)

Ignitor-leakage resistance is the dc resistance between the ignitor electrode and the tube body when the tube is in the deionized state. This resistance shall be within the limit(s) specified. The measurement shall be made after the completion of the leakage power and ignitor tests.

MIL-STD-1311D  
 METHOD 4460A  
 IGNITOR NOISE RATIO  
 (Gas-switching tubes)

1. Purpose. The purpose of this test is to measure the ratio of noise power output of the gas-switching tube with ignitor operating, to that of the tube without ignitor operating.
2. Equipment. The basic circuit shown on figure 4460-1, or its equivalent, may be used for this test.

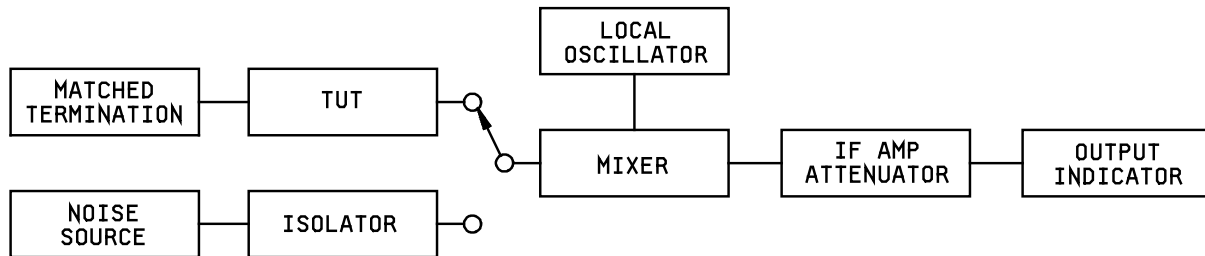


FIGURE 4460-1. Equipment layout for noise ratio measurement.

3. Procedure. With the noise source and the isolator in the circuit, the noise figure of the receiver is measured and recorded. With the gas-switching tube and matched termination in the circuit and using the same convenient level of receiver output (as in step 1 on the output indicator), the ignitor is energized and the ignitor current is set to the magnitude stated in the TSS. The increase in noise level is nullified by increasing attenuation to yield the previous level at the output indicator, and the increase in attenuation is measured.

4. Formula. The noise ratio is computed from the pertinent formula as shown:

- a. Single-sideband receiver:

$$NR = 1 + F(y-1)$$

- b. Double-sideband receiver:

$$NR = 1 + \frac{F(y-1)}{2}$$

Where F = Receiver noise figure (power ratio)

y = IF attenuation (power ratio) required to counteract the ignitor noise power.

MIL-STD-1311D

METHOD 4461A

LOADED Q

(Gas-switching tubes)

1. Purpose. To determine an important characteristic of high-Q tunable TR tubes which directly affects the sharpness of tuning, and is an indication of the operational bandwidth. For ATR tubes, the loaded Q serves to specify the band of frequencies over which the ATR can be utilized.

2. Equipment. The equipment for making this measurement shall consist of a signal generator or sweep oscillator, a frequency meter, an attenuator, a matched detector, and a meter or calibrated oscilloscope. The equipment layout is shown on figure 4461-1.

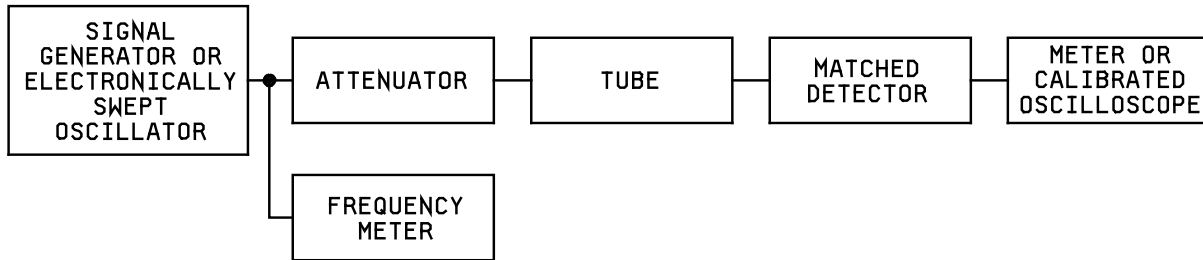


FIGURE 4461-1. Equipment for loaded Q measurements.

### 3. Procedure.

3.1 TR tubes. The tube shall be placed in a transmission circuit between a matched signal generator and a matched detector, with sufficient attenuation between the generator and tube to prevent frequency or power changes in the signal source due to tuning of the tube. With the signal source at the reference frequency, the tube shall be tuned to resonance ( $F_o$ ), as indicated by a pronounced peak of the output indicator, and the output power shall be measured. The frequency of the signal generator shall then be increased until the power at the termination falls to one-half of the value at resonance. The frequency at this point shall be recorded as  $F_1$ . The procedure shall then be repeated in the direction of decreasing frequency, the resulting half-power point being noted as  $F_2$ . The loaded Q shall be within the limits specified when determined as follows:

$$QL = \frac{F_o}{F_1 - F_2}$$

As the signal generator is tuned from  $F_1$  to  $F_2$ , its output power shall be stable in amplitude to better than 1 percent to insure accurate determination of the half-power frequencies. If this condition can not be satisfied, the frequency versus power-output characteristic of the signal generator shall be determined and taken into account in locating  $F_1$  and  $F_2$ .

3.2 ATR tubes. The tube shall be inserted as a series tee in the specified mount between a matched generator and termination. The loaded Q is then defined in terms of the rate of change of susceptance with frequency, and may be expressed as:

$$QL = \frac{F_o \frac{dB}{df}}{2(1 + g)}$$

## MIL-STD-1311D

Where:

Fo = Resonant frequency.

df = F1-F2.

b = B/Yo = Normalized susceptance of the tube.

g = G/Yo = Normalized conductance of the tube.

Since Fo is always close to Fr, (the specified reference frequency for the tube), this latter quantity shall always be used in place of Fo in the above equation. The quantity  $\frac{dB}{df}$ , which is the rate of change of susceptance with frequency, in the vicinity of Fo, can be

determined by the measurement of b at two frequencies near Fo and assuming a linear relationship between b and f. The linear relationship may be assumed for any frequencies within 1 percent of Fo. An alternative technique for the determination of  $\frac{dB}{df}$

involves the measurement in front of the tube of the rate of change of the phase of the standing wave minimum with frequency, then:

$$\frac{dB}{df} = \frac{2\pi}{\lambda g} (1 + 2g) \frac{d1}{df}$$

Where:

$\lambda g$  = Guide wavelength at the reference frequency.

g = Normalized conductance of the tube.

$\frac{d1}{df}$  = Rate of change of the phase of the voltage standing wave before the tube with respect to frequency.  $\frac{d1}{df}$

shall be determined at the voltage maximum close to the plane of symmetry of the tube. Since it is not usually possible to take measurements at this position, impedance shall be measured at a remote point and a correction for the length of line shall be made.

This is:  $\frac{d1}{df} = \frac{d1'}{df} - \frac{m}{4} \frac{d\lambda}{df} g$

Where:

$\frac{d1'}{df}$  = Measured slope of the line obtained by plotting the observed position of a voltage minimum as a function of frequency.

m = Odd number of quarter wavelengths measured, at resonance, from the reference minimum to the plane of symmetry of the tube.

Frequencies within 1 percent of Fo should be used in the measurement of  $\frac{d1}{df}$ .

MIL-STD-1311D

METHOD 4466

TEMPERATURE COEFFICIENT OF FREQUENCY

(Gas-switching tubes)

1. Purpose. To determine the shift in resonant frequency of a tube over a specified range of temperature.
2. Equipment. A test chamber capable of maintaining temperature at the specified values. A signal source and means of measuring frequency and indicating power are required.
3. Procedure.

3.1 Method A (for tunable tubes). The tube shall be placed in a temperature-controlled chamber at room temperature and connected in a transmission circuit between a matched signal generator and detector. With the signal source set at the reference frequency, the tube shall be tuned to resonance as indicated by a pronounced peak of the output indicator. The temperature in the chamber shall then be reduced to 0°C and the tube body allowed to come to thermal equilibrium. The resonant frequency of the tube at 0°C shall be determined by retuning the signal source for a peak of the output; the procedure shall then be repeated at +100°C. The frequency change of the tube over the temperature range shall be within the limit(s) specified.

3.2 Method B (fixed tuned tubes). The tube shall be mounted in the specified external cavity and placed in a circuit as specified in method A above. The signal source shall be tuned to the resonant frequency of the tube and cavity as indicated by a pronounced peak of the output indicator. The frequency shall be recorded and the procedure of method A shall then be followed. The frequency change over the temperature range shall be within the limit(s) specified.



MIL-STD-1311D

METHOD 4471B

RECOVERY TIME

(Gas-switching tubes)

1. Purpose. The purpose of this test is to measure the time after the removal of rf power from a TR tube, or a Pre-TR tube, at which the low-level attenuation of the tube is 3 dB above its attenuation in the unexcited state. Also to measure the shift in position of the VSW minimum of an ATR tube at a specified time after the removal of rf.

2. Procedure. To establish the basic circuits and procedures.

2.1 Method A (TR tubes, pulsed signal).

2.1.1 Equipment. The circuit for measuring the recovery time of a TR tube using a pulsed signal to simulate the return signal is given on figure 4471-1.

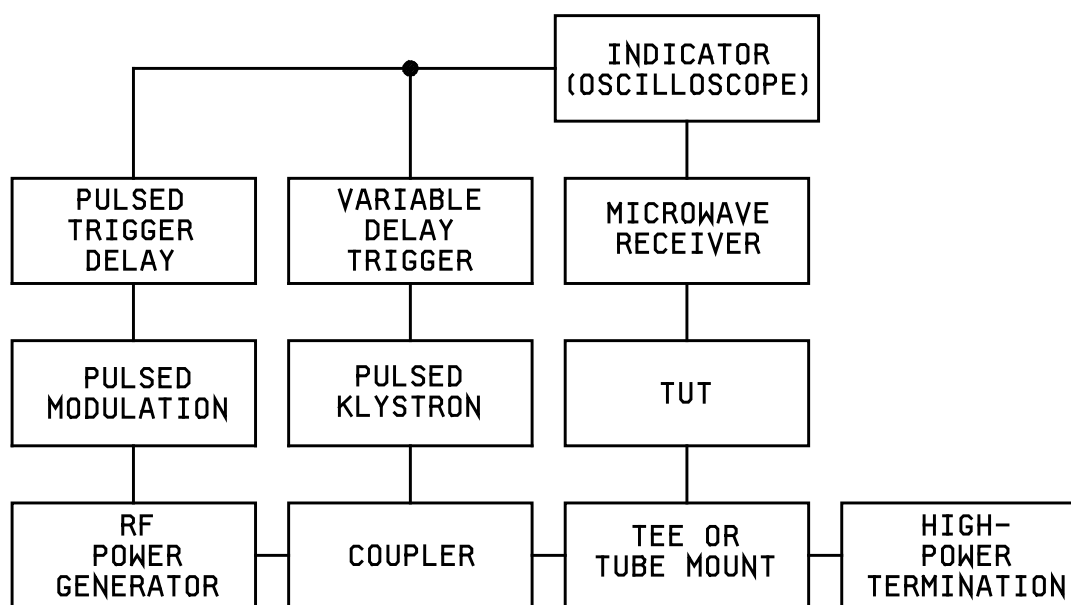


FIGURE 4471-1. Equipment layout for recovery time measurements (TR and Pre-TR) method A.

2.1.2 Procedure. The tube shall be mounted as a series tee with the rf power in the main line set for the specified conditions. A low-level pulse modulated signal (simulated received echo) at the reference frequency, which is synchronized with the high-powered transmitter rf pulse through a trigger variable delay unit, shall be introduced into the main line through a coupling device. The power transmitted through the TR tube shall be viewed on the oscilloscope. As the low-level signal is varied in time with respect to the transmitter pulse, its amplitude will vary due to the attenuation characteristic of the TR tube, which is deionizing. Attenuated amplitude measurements of the received signal are made with respect to the amplitude of received signal received when the TR tube has completely recovered. The recovery time, measured from the trailing edge of the transmitted pulse to the leading edge of the received signal at the specified attenuation level, shall be within the limits specified. This measurement can conveniently be made using the leading edge of the transmitted pulse as a reference and subtracting the pulse duration from the time readings.

## MIL-STD-1311D

## 2.2 Method B (TR tubes, CW signal).

## 2.2.1 Equipment.

2.2.1.1 Tube series-mounted as in method A. The circuit for measuring the recovery time of a series mounted TR tube using a CW signal is shown on figure 4471-2.

2.2.1.2 Tube terminating the line. The circuit for measuring the recovery time of a TR tube shunting the line using a CW signal is shown on figure 4471-3.

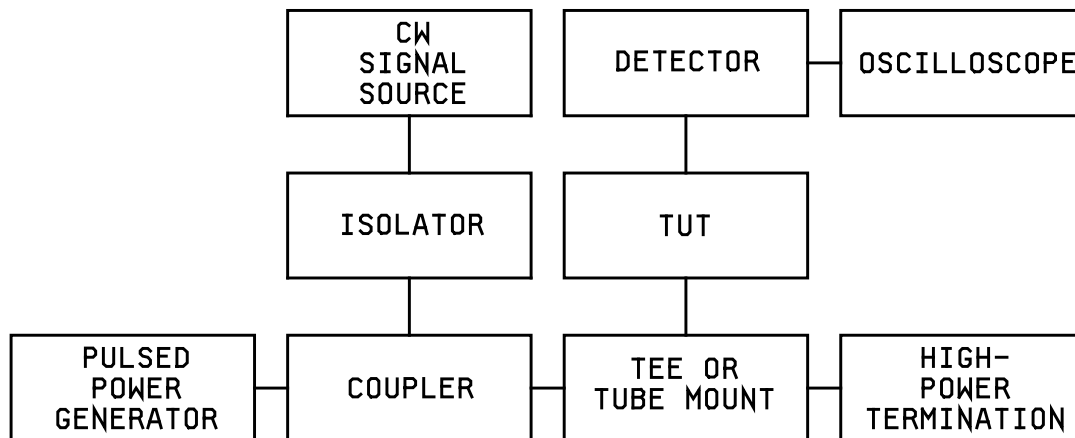


FIGURE 4471-2. Equipment layout for recovery time measurements (TR and Pre-TR) method B (see 2.2.1.1).

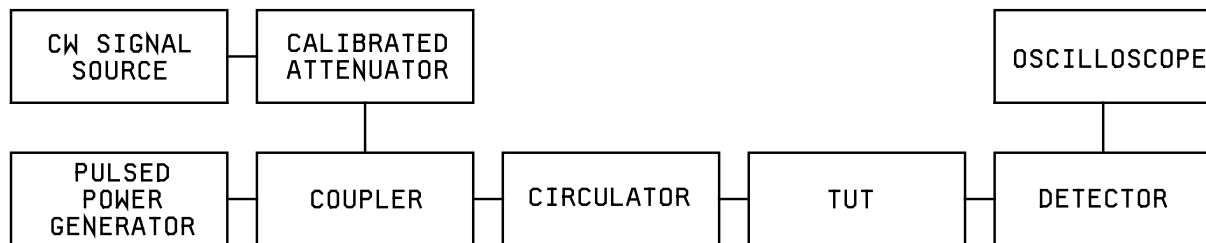
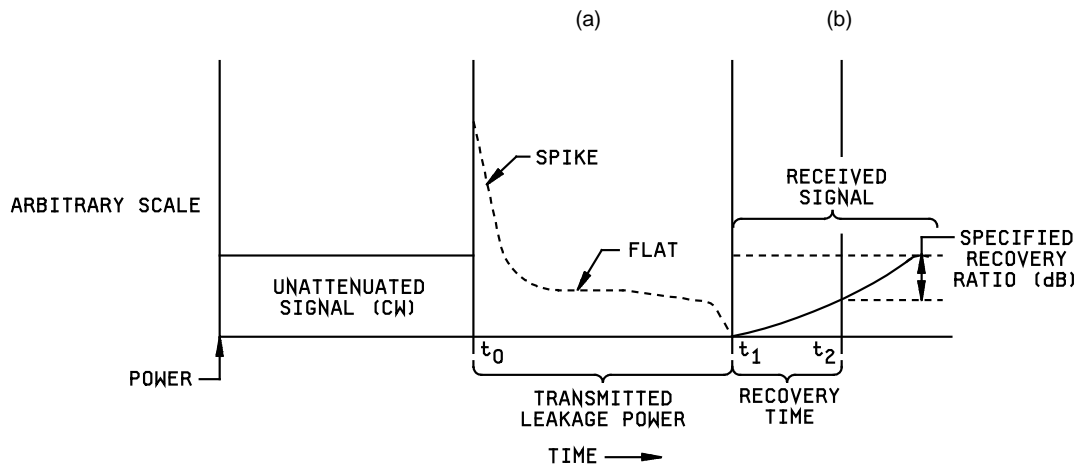


FIGURE 4471-3. Equipment layout for recovery time measurements (TR and Pre-TR) method B (see 2.2.1.2).

2.2.2 Procedure. The tube shall be mounted as shown either on figure 4471-2 or 4471-3. A low-level CW signal adjusted to the specified frequency is coupled into the main line through an appropriate coupling device. Pulsed rf power at the specified peak power level is now turned on in the main line. The resulting pattern is ideally represented as shown on figure 4471-4. The pulse shown represents the transmitted pulse through the TR tube, being essentially the leakage power pulse.

## MIL-STD-1311D



$t_0$  = time at start of pulse

$t_1$  = time at end of pulse

$t_2$  = time when loss through TR tube = specified recovery ratio (3dB)

$t_2 - t_1$  = recovery time

FIGURE 4471-4. Oscilloscope pattern using CW method of measuring recovery time.

The leakage power pulse is shown on figure 4471-4 under three different conditions. Curve (a) is the pattern used in measuring the recovery time after the -3 dB level has been established by attenuating the signal to obtain the resultant pattern shown by the dotted line. Curve (b) is drawn only to show that the conventional leakage power will be seen if the CW signal is removed. A time reference,  $t_1$ , is established at the trailing edge of the leakage pulse. Time  $t_2$  is found by observing the point at which the curve (a) crosses the -3 dB reference line. The difference between  $t_1$  and  $t_2$  is the recovery time of the tube.

**2.2.3 Precautions.** To obtain a suitable pattern for making measurements, it may be necessary to use enough amplification so that the spike and the flat portions of the leakage pulse are greatly amplified. This results in two separate lines on the oscilloscope screen which are used in the measurement of points  $t_1$  and  $t_2$  as referenced in 2.2.2. The power from the CW source should be kept as low as possible so as not to saturate the crystal used for viewing.

### 2.3 Method C (pre-TR tubes).

**2.3.1 Equipment.** The test circuits shown on figures 4471-2 or 4471-3 may be used in measuring the recovery time of a pre-TR tube.

**2.3.2 Procedure.** The procedure for measuring recovery time of a pre-TR is the same as for a TR tube, as outlined in methods A or B. If a TR tube is used following the pre-TR tube, the received signal must see a match, looking into the TR cavity, for example, tuned to resonance and properly loaded. If loading cannot be adjusted, resistive padding can be used between the pre-TR and the TR tube. Precautions shall also be taken to insure that the recovery characteristic of the TR tube will not affect the measurement of the recovery time of the pre-TR tube.

### 2.4 Method D (dual TR tubes or dual pre-TR tubes).

**2.4.1 Equipment.** The circuit shown on 44471-5 is used for measuring the recovery time of dual TR or pre-TR tubes.

## MIL-STD-1311D

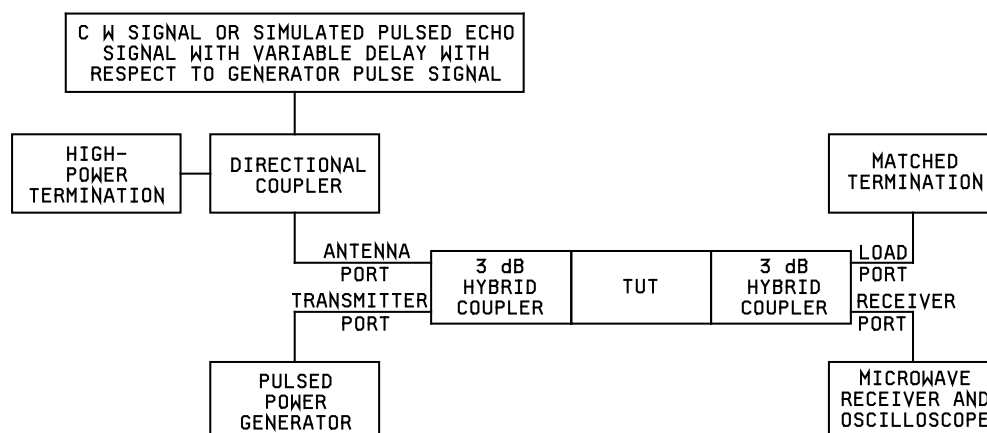


FIGURE 4471-5. Equipment layout for recovery time measurements (Dual TR or Pre-TR) method D.

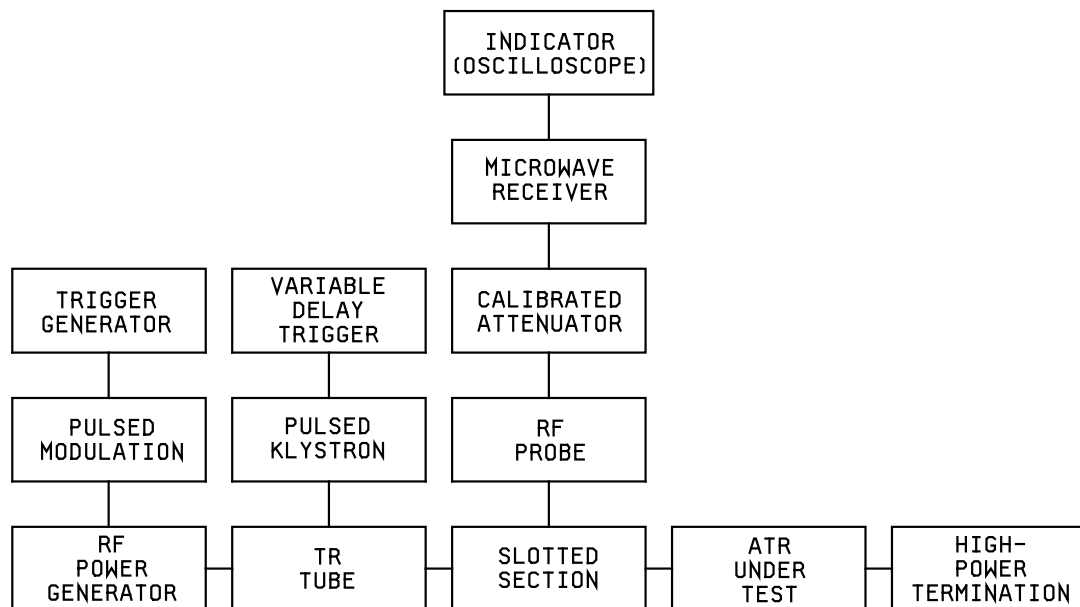
2.4.2 Procedure. The procedure for testing is the same as those given in either method A or method B for TR tubes. Either the pulsed signal method or the CW signal method may be used.

2.4.3 Precautions. The 3 dB couplers shall have a VSWR less than 1.10, shall split the power evenly to within 0.25 dB, and shall have a minimum isolation of 25 dB.

## 2.5 Method E (ATR tubes).

2.5.1 Equipment. The circuit shown on figure 4471-6 is used in measuring recovery time of ATR tubes.

## MIL-STD-1311D

FIGURE 4471-6. Equipment layout for ATR tube recovery time measurements.

2.5.2 Procedure. The ATR tube shall be mounted as specified on the TSS. The probing signal frequency shall be within 0.1 percent of the resonant frequency of the ATR under test. The distance between the position of the minimum in the unfired condition and the position of the minimum at the specified time interval for the transmitter pulse, shall be less than 0.042 guide wavelengths.

MIL-STD-1311D

METHOD 4473

LOW-LEVEL VSWR

(Gas-switching tubes)

1. Purpose. To measure the voltage standing-wave ratio as a function of frequency for the TUT when not ionized.
2. Equipment. The tube shall be mounted in a low-level transmission circuit between a matched generator and matched termination. Figure 4473-1 shows the basic circuit for single tubes, and figure 4473-2 shows the circuit for dual tubes.

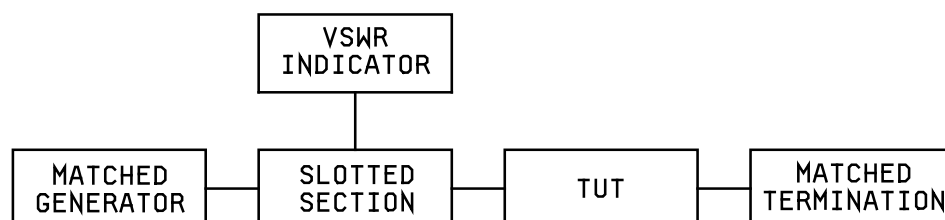


FIGURE 4473-1. Equipment layout for single tube low-level VSWR measurement.

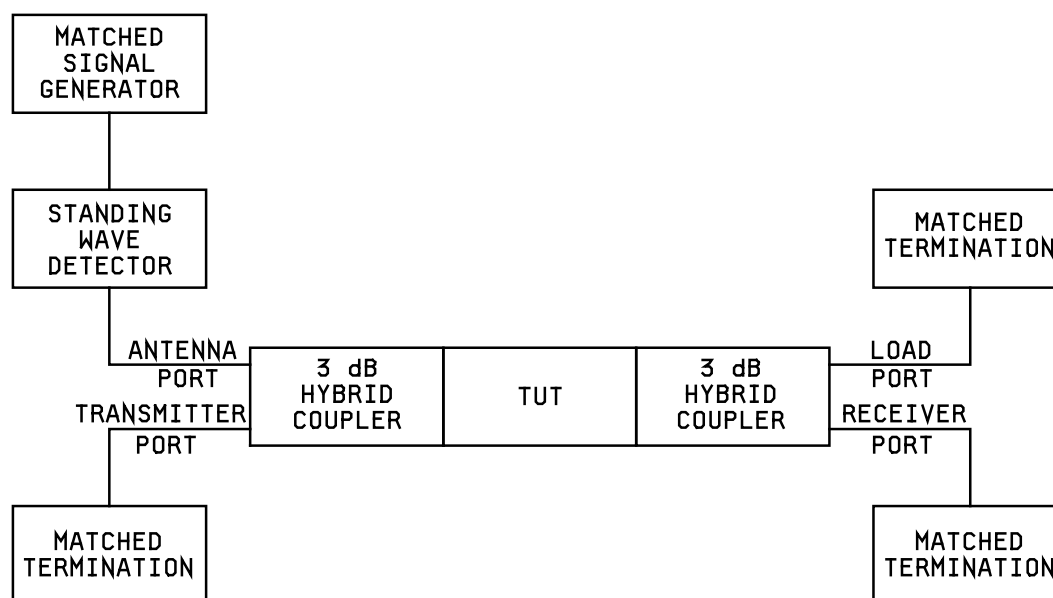


FIGURE 4473-2. Equipment layout for dual tube low-level VSWR measurement.

MIL-STD-1311D

3. Procedure. The tube shall be mounted as shown in the appropriate circuit. With the generator set to the reference frequency, the VSWR immediately before the single tube, or the VSWR in the antenna port in the dual tube circuit, shall be measured.

4. Precautions. The matched terminations used in the test circuits shall have a VSWR of less than 1.05 so as not to affect the measured VSWR value.

The 3 dB hybrid couplers used shall have a VSWR of less than 1.10, shall split the power evenly to within 0.25 dB, and shall have a minimum isolation of 25 dB.

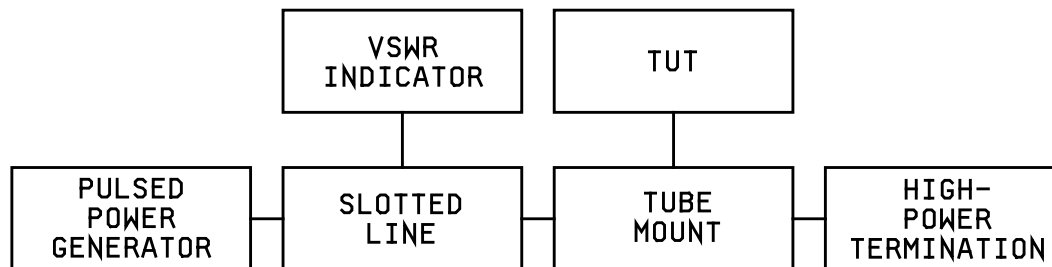
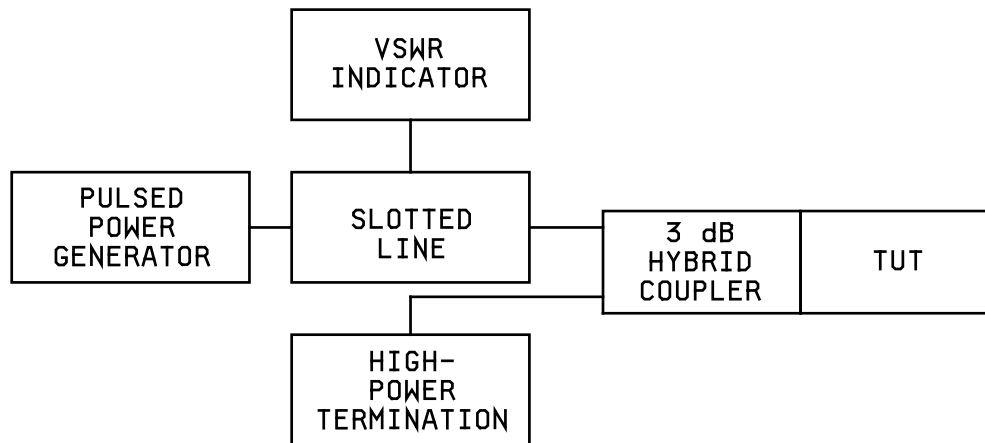
MIL-STD-1311D

METHOD 4474

HIGH-LEVEL VSWR

(Gas-switching tubes)

1. Purpose. To measure the magnitude of the discontinuity in the main transmission line, when the switching tube is ionized.
2. Equipment. The tube shall be mounted as a series tee in the main line using the specified mount. Figure 4474-1 shows the basic circuit for single tubes, and figure 4474-2 shows the circuit for dual tubes.

FIGURE 4474-1. Equipment layout for single tube high-level VSWR measurement.FIGURE 4474-2. Equipment layout for dual tube high-level VSWR measurement.

3. Procedure. With the power in the line set to the specified conditions, the VSWR in the line shall be measured.
  4. Precautions. The high-power termination used shall have a VSWR which is well below the limit specified for the TUT.
- The 3 dB hybrid coupler used shall have a VSWR of less than 1.10, shall split the power evenly to within 0.25 dB, and shall have a minimum isolation of 25 dB.



MIL-STD-1311D

METHOD 4475

(OBSOLESCENT)

INTRINSIC Q

(TR tubes)

1. High-Q external cavity. The tube shall be mounted in the specified cavity and placed in a circuit between a matched generator and detector. The signal generator shall be tuned to resonance, as indicated by a pronounced peak of the output indicator, and the resonant wavelength ( $\lambda_0$ ) and relative value of the power transmitted to the detector ( $P_d$ ) shall be recorded. The frequency of the signal generator shall then be decreased from resonance until the transmitted power falls to one-half its original value, and the corresponding wavelength shall be measured and recorded as 1. The frequency shall then be increased above the resonant value to the half-power point and this wavelength recorded as 2. The power available at the detector ( $P_a$ ) is determined by removing the tube and associated cavity from the circuit. The intrinsic Q of the tube and cavity shall be computed from the following equation:

$$Q_o = \frac{\lambda_0}{(\lambda_1 - \lambda_2)(1 - \sqrt{T})}$$

Where:

$$T = \frac{P_d}{P_a}$$

 $\lambda_0$  = Wavelength at resonance. $\lambda_1$  = Wavelength at lower half-power point. $\lambda_2$  = Wavelength at higher half-power point.

This equation assumes that the input- and output-coupling devices are identical. The coupling devices may be checked for equality by measuring the VSWR with the cavity reversed so that the former output coupling device is used as the input. If the VSWR measured with the cavity in its initial position is denoted as  $r_1$ , and the VSWR with the cavity reversed is  $r_2$ ,  $r_1$  and  $r_2$  will be equal if the coupling devices are identical. If  $r_1$  and  $r_2$  are not equal, the expression for  $Q_o$  becomes:

$$Q_o = \frac{\lambda_0}{\lambda_1 - \lambda_2} \frac{1 + r_1 r_2 + r_1 + r_2}{r_1 r_2 - 1}$$

2. Intrinsic Q (relative). The tube shall be tested on a relative basis under the conditions specified in 1 above, by comparing the reading of the output indicator at resonance with the reading for a tube whose intrinsic Q is known. The test cavity shall be isolated from the oscillator by at least 10-dB attenuation. The test equipment shall be calibrated at intervals, not to exceed 30 days, by means of tubes that have passed the intrinsic Q measurement specified in 1 above.

MIL-STD-1311D

METHOD 4476

(OBSOLESCENT)

INTRINSIC P

(TR tubes)

1. Intrinsic P (P'). The tube shall be mounted in the specific cavity and placed in a circuit between a matched generator and detector. The resonant cavity and its associated tube shall be excited from the signal generator through a matched attenuator and standing-wave detector, and the input power adjusted to a level that is insufficient to fire the tube. The frequency of the signal generator shall be tuned to the resonant wavelength of the cavity as indicated by a pronounced peak in the power observed in the output circuit. The output and input coupling mechanisms (either loops or rises) shall be adjusted until the input to the cavity is matched to the transmission line as measured by the standing-wave detector, and until the low-level transmission T is between 0.1 and 0.01. The transmission T is defined as the ratio of the power transmitted through the cavity at resonance, to the power available at the input to the cavity when measured by removing the cavity and connecting the power-measuring device to the input transmission line. With each change in the coupling, the signal generator shall be retuned to resonance. After final adjustment, the resonant wavelength  $\lambda_o$  and low-level transmission T shall be measured and recorded. The frequency of the signal generator shall then be decreased until the power transmitted through the cavity has dropped to one-half its value at resonance. The wavelength corresponding to this point shall be measured and recorded as  $\lambda_1$ . The frequency shall then be increased above resonance to the half-power point and this wavelength measured and recorded as  $\lambda_2$ . The signal generator shall be retuned to resonance and the input power level increased to the amount stated on the specification sheet, which should be sufficient to fire the tube gap. No change should be made in the adjustments of the coupling mechanisms. The power in watts measured in the output circuit under these conditions shall be recorded as Pr. The value of P'o shall be computed from the following equation:

$$P'o = \frac{2Pr \lambda_o}{T(\lambda_1 - \lambda_2)} \text{ volt - amperes}$$

It should be noted that  $\lambda_o$ ,  $\lambda_1$ ,  $\lambda_2$ , and T are all measured at low levels with the tube unfired, and that Pr is the only quantity measured when the tube is fired. When the required input power is specified in terms of the power into the gas discharge, this is computed from the following equation:

$$Pg = \left[ \frac{P P'o (\lambda_1 - \lambda_2)}{2\lambda_o} \right]^{1/2} - \left[ \frac{P'o (\lambda_1 - \lambda_2)}{2\lambda_o} \right]$$

Where Pg is the power in the gas discharge, P is the available power at the input to the cavity, and the other symbols are already defined. In the event that it is impossible or inconvenient to adjust the coupling mechanisms to the cavity to the matched input conditions, the intrinsic P can be expressed as:

$$P'o = \left[ \frac{4Pr \lambda_o}{T(\lambda_1 - \lambda_2)} \right] \left[ \frac{1}{1 + g} \right]$$

Where:

g = Normalized input admittance to the cavity.

$$Pg = \left[ \frac{P P'o (\lambda_1 - \lambda_2)}{\lambda_o} \cdot \frac{1}{(1 + g)} \right]^{1/2} - \left[ \frac{P'o (\lambda_1 - \lambda_2)}{\lambda_o} \cdot \frac{g}{(1 + g)} \right]$$

## MIL-STD-1311D

Defining the VSWR before the tube as  $r$ , where  $r > 1$ ,  $g$  is equal to  $r$  or  $\frac{1}{r}$  depending upon whether  $g$  is greater or less than unity.

The ambiguity can be resolved as follows: The position of a minimum in the standing wave-pattern is measured along the standing wave-detector from an arbitrary origin. If  $g < 1$ , there will be a quarter-wavelength shift from the position of the minimum at resonance to the position of the minimum at frequencies far off resonance. If  $g > 1$ , the position of the minimum will be the same at resonance as for frequencies far off resonance.

2. Intrinsic P (relative). The tube shall be tested on a relative basis, under the conditions specified in 1, by comparing the reading of the output indicator when the tube gap is fired with tubes having known intrinsic P values within the specified limits. The readings of the output indicator are assumed to be proportional to the value of intrinsic P. The cavity temperature shall be  $47^{\circ}\text{C} \pm 3^{\circ}\text{C}$  and the tube temperature shall be  $45^{\circ}\text{C}$  or higher, when inserted in the cavity.

MIL-STD-1311D

METHOD 4478

(OBSOLESCENT)

HIGH-LEVEL PROTECTION

(Gas-switching tubes)

The tube shall be mounted in the cavity specified on the TSS and placed in a transmission circuit between a matched generator and detector. The power level at the input shall be sufficient to fire the rf gap of the tube, and to insure that the measurement is being made on the flat part of the power in the gap versus leakage-power curve. If the main discharge gap does not fire, it shall be caused to fire by a short application of the ignitor voltage. The tube shall be tested on a relative basis by comparing the reading of the output meter when the gap is fired, to the reading of a standard tube when its gap is fired. The output indication of the tube shall be less than that of a standard tube.

MIL-STD-1311D

METHOD 4482A

## TUNING SUSCEPTANCE

(Gas-switching tubes)

1. Purpose. The measurement of susceptance at the specified frequency indicates the degree of accuracy with which the ATR tube is tuned to resonance.

2. Equipment. The tube shall be inserted as a series tee in the specified mount between a matched generator and a matched termination.

3. Procedure. Either method A or B may be used to measure and compute susceptance.

3.1 Method A. The susceptance shall be measured by comparing the phase of the standing wave before the tube with that of a reference tube that is known to be resonant at the specified frequency. The susceptance shall be computed as follows:

$$b = \frac{(1 + 2g)}{2} \tan \frac{4\pi\Delta\ell}{\lambda_{go}}$$

Where:

$b = B/Y_o$  = Normalized susceptance of the tube.

$g = G/Y_o$  = Normalized conductance of the tube.

$\Delta\ell$  = Shift of standing wave minimum position from sample to reference tube.

$\lambda_{go}$  = Guide wavelength (same units as for  $\ell$  at reference frequency).

For small values of susceptance  $\Delta\ell$ , can be expressed approximately as:

$$b = (1 + 2g) \frac{2\pi\Delta\ell}{\lambda_{go}}$$

3.2 Method B. An alternative technique involves the determination of the ratio of  $P_i$ , the power incident upon the tube, and  $P_1$ , the power transmitted to the matched termination, with the signal source set at the specified frequency. The susceptance of the tube is then computed as follows:

$$b^2 = \frac{(1 + 2g)^2 - 4g^2 K^2}{4(K^2 - 1)}$$

Where:

$g$  = Normalized conductance of the tube.

$P_i$  = The power incident upon the tube.

$P_1$  = The power transmitted through the tube to the matched load at the reference frequency.

$$K = \sqrt{\frac{P_i}{P_1}}$$

4. Precautions. Care shall be exercised if a directional coupler is used for a measurement of  $P_i$ . The power reflected by the tube is comparable in magnitude to the incident power, and the directivity of the coupler may not be great enough to prevent this reflected power from affecting the measurement of  $P_i$ .

MIL-STD-1311D

METHOD 4484

## NORMALIZED CONDUCTANCE

(Gas-switching tubes)

1. Purpose. To determine the value of a parameter in an ATR tube which is a measure of its impedance at resonance. When this value is below a specified maximum, it assures that there will not be any appreciable loss of received signal energy to the transmitter during the reception period.

2. Test equipment. The tube shall be inserted as a series tee in the specified mount between a matched generator and a matched termination.

3. Test procedure.

3.1 Method A. The maximum value of VSWR,  $r_o$ , occurs at the resonant frequency of the tube, at which the susceptance,  $b$ , is equal to zero. To determine the maximum value, the VSWR,  $r$ , is measured over a narrowband of frequencies around this resonant frequency, and a VSWR/frequency curve obtained.

The normalized conductance is then computed as follows:

$$\text{Normalized conductance, } g = \frac{1}{r_o - 1}$$

3.2 Method B. An alternative method for determining the normalized conductance consists of measuring the power incident upon the tube and the power transmitted to the termination with the signal source set at the resonant frequency  $F_o$ . The normalized conductance is then computed as follows:

$$g = \frac{1}{2(K - 1)}$$

Where:

$P_i$  = The power incident upon the tube.

$P_1$  = The power transmitted to the termination.

$$K = \sqrt{\frac{P_i}{P_1}}$$

4. Precautions. Care shall be exercised if a directional coupler is used for a measurement of  $P_i$ . The power reflected by the tube is comparable in magnitude to the incident power, and the directivity of the coupler may not be great enough to prevent this reflected power from affecting the measurement of  $P_i$ .

## MIL-STD-1311D

## METHOD 4486

## FIRING TIME

(ATR and pre-TR tubes)

1. Purpose. The purpose of this test is to determine whether the tube fires within the time limit specified, under the specified operation conditions.

2. Equipment.

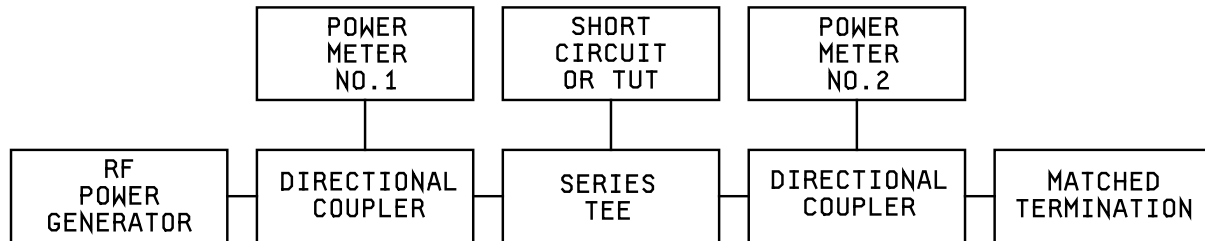


FIGURE 4486-1. Equipment layout for firing time test.

3. Procedure.

3.1 ATR tubes and single pre-TR tubes. Set the equipment up as indicated on figure 4486-1, or an equivalent circuit, at the required power level, with the short circuit in place of the TUT. With the tube inserted in the test equipment, the time for the tube to fire, after the application of power, as indicated by an abrupt change on meter No. 2, shall be within the limit(s) specified.

3.2 Dual pre-TR tubes. The same procedure shall be used to test dual tubes in the equipment shown on figure 4486-2.

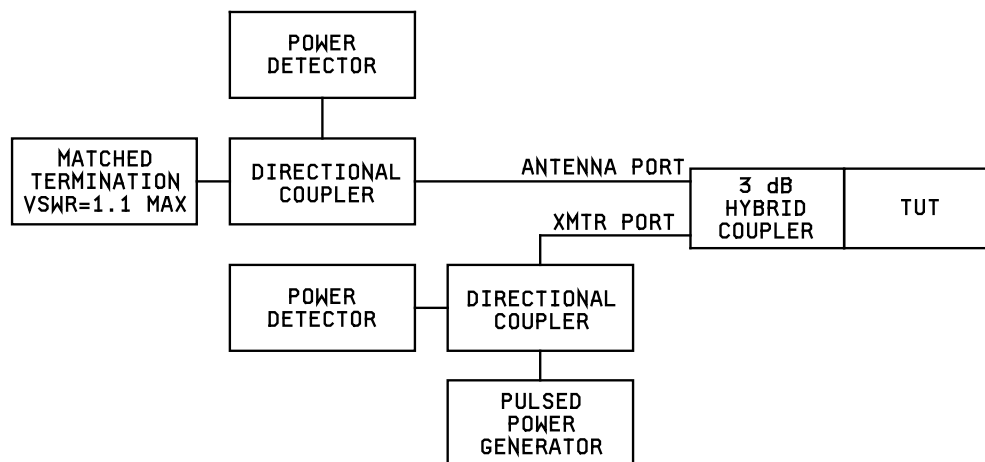


FIGURE 4486-2. Equipment layout for firing time measurements.

MIL-STD-1311D

METHOD 4488A

ARC LOSS

(Gas-switching tubes)

1. Purpose. The purpose of this test is to measure the power loss due to the arc discharge of the switching tube.

2. Equipment.

2.1 TR, pre-TR, and ATR, use the layout on figure 4488-1 or equivalent.

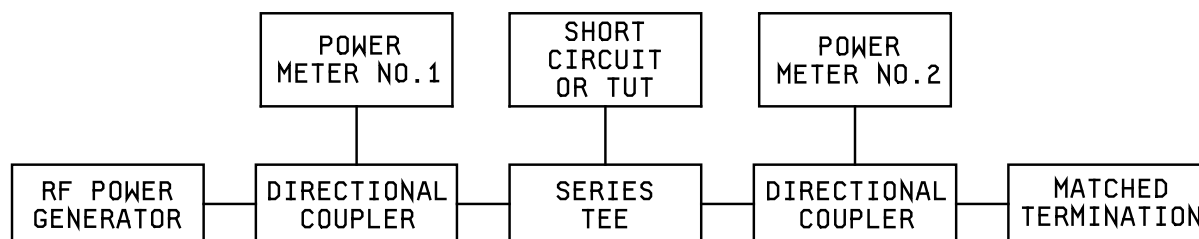


FIGURE 4488-1. Equipment layout for arc loss test.

2.2 Dual tubes use the layout on figure 4488-2.

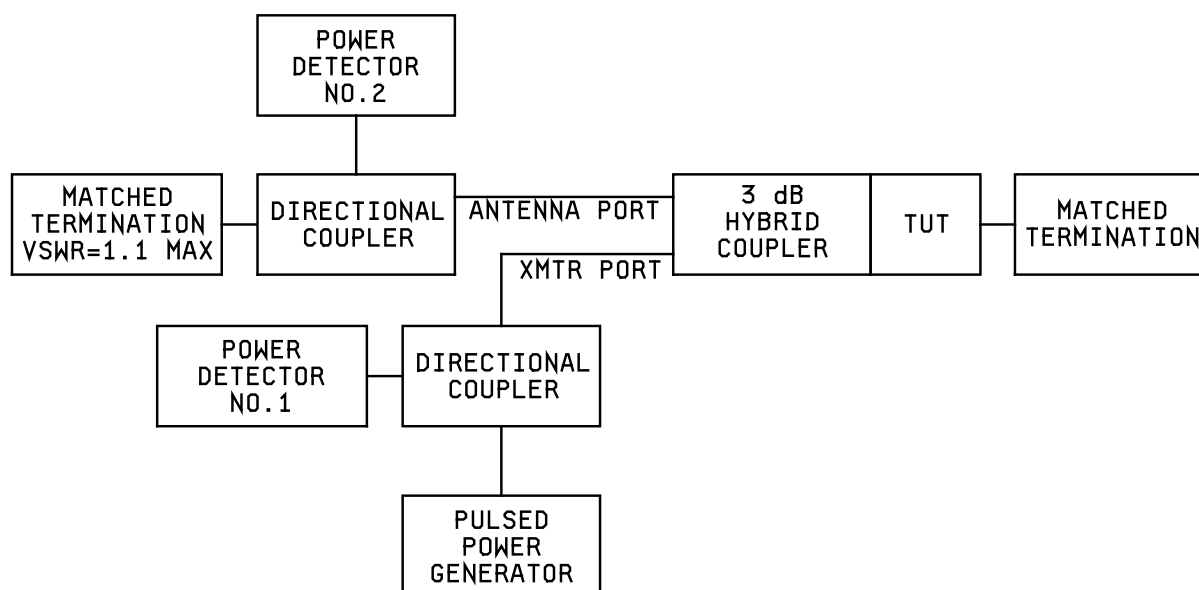


FIGURE 4488-2. Equipment layout for arc-loss measurement.



## MIL-STD-1311D

3. Procedure. With the tube installed in the appropriate circuit, the line power is set at the specified level as observed on power detector No. 1. The arc loss,  $L_a$ , shall be taken as the dB change in power at the termination, when the tube is replaced by a metallic short circuit.

4. Equipment. The 3 dB hybrid couplers used shall have a maximum terminated VSWR of 1.10 over the specified frequency range. Each coupler shall split the power evenly to within 0.25 dB and shall have a minimum isolation of 25 dB.

5. Formula. Although the loss may be read directly from the power meter, it may be also computed from:

$$L_a = 10 \log \frac{P_s}{P_t}$$

Where

$P_s$  = Power reading with short circuits in watts,

$P_t$  = Power reading with tube in watts.

## MIL-STD-1311D

## METHOD 4489

## DUPLEXER LOSS

(Dual gas-switching tubes)

1. Purpose. The purpose of this test is to determine the loss of power incurred in a transmission line due to the insertion of the tube in the transmission line.

2. Equipment. The following basic equipment layout, or its equivalent using an electronically swept generator, may be used for this test.

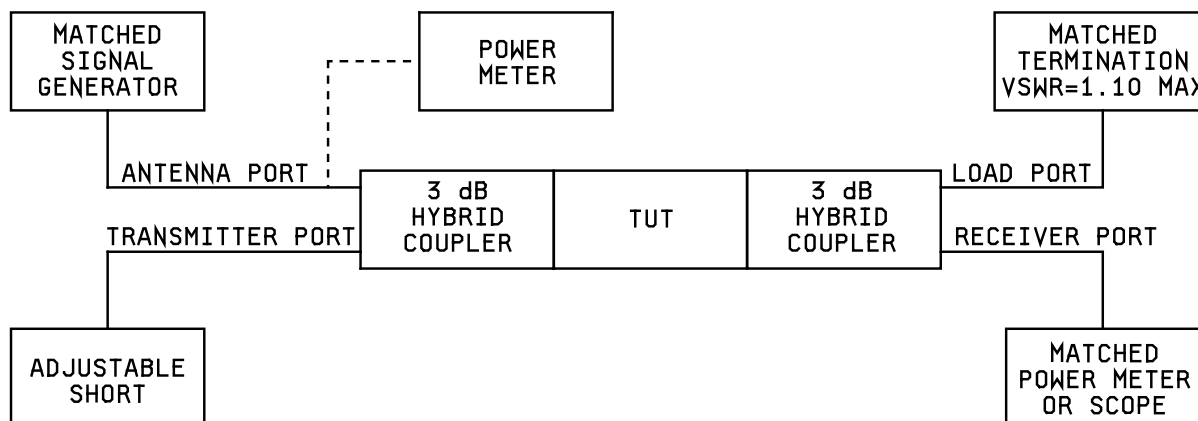


FIGURE 4489-1. Equipment layout for duplexer loss measurements.

3. Procedure.

3.1 Non-isolated transmitter. Using a no-loss simulated tube, the transmitted power is measured in the receiver port. With the TUT in the circuit, the adjustable short is adjusted for minimum power (maximum duplexer loss) at the reference frequencies. The duplexer loss shall be within the limits specified as read on the power meter or viewed on the oscilloscope at the receiver port.

3.2 Isolated transmitter. Using a matched load on the transmitter arm, the difference in power loss measurements of the simulated no-loss tube and the TUT shall be within the limits specified.

4. Equipment. The 3 dB hybrid couplers used shall have a maximum terminated VSWR of 1.10 over the specified frequency range; split the power evenly to within 0.25 dB; and shall have a minimum isolation of 25 dB.

5. Formula. Although the loss may be read directly from a power meter or calibrated oscilloscope, the duplexer loss may be computed as follows:

$$L_d = 10 \log \frac{P_a}{P_r}$$

Where:

$P_a$  = Power at the antenna port.

$P_r$  = Power at the receiver port.

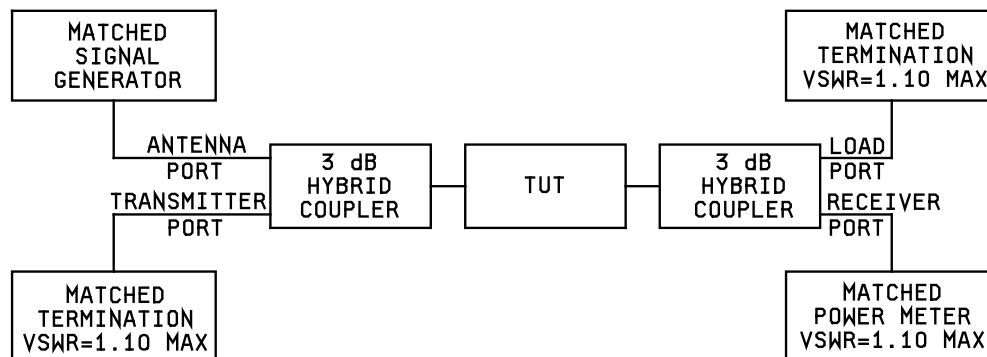
## MIL-STD-1311D

## METHOD 4491

## TRANSMITTER-RECEIVER ISOLATION

(Dual gas-switching tubes)

1. Purpose. The purpose of this test is to determine how effectively the transmitter is decoupled from the receiver during the reception of a low-power signal at the antenna port.
2. Equipment. The following basic equipment layout, or its equivalent using an electronically swept generator, may be used for this test.

FIGURE 4491-1. Equipment layout for transmitter-receiver isolation measurements.

3. Procedure. With the TUT in the circuit, as shown on figure 4491-1, the power in the receiver port,  $P_r$ , is measured. The matched termination at the transmitter port, and the power meter at the receiver port are then interchanged, and the power at the transmitter port,  $P_t$ , is measured.

The test may also be performed with two matched power meters, one at the transmitter port, and one at the receiver port, allowing  $P_t$  and  $P_r$  to be read at the same time.

4. Formula.

The isolation is then calculated as:

$$\text{Isolation} = 10 \log \frac{P_r}{P_t}$$

Alternatively, if  $P_r$  and  $P_t$  are measured in dB,

$$\text{Isolation} = P_r \text{ (dB)} - P_t \text{ (dB)}.$$

5. Precautions. The 3 dB hybrid couplers used shall have a maximum terminated VSWR of 1.10 over the specified frequency range; split the power evenly to within 0.25 dB; and shall have a minimum isolation of 25 dB.

MIL-STD-1311D

METHOD 4494

## POSITION OF SHORT

(Gas-switching tubes)

1. Purpose. To measure the position of the gas discharge sheath behind the window of the tube with respect to a given reference plane. This is of importance in the design of the waveguide mounting of the tube in a system to minimize the magnitude of the discontinuity that the fired tube introduces into the line.

2. Equipment.

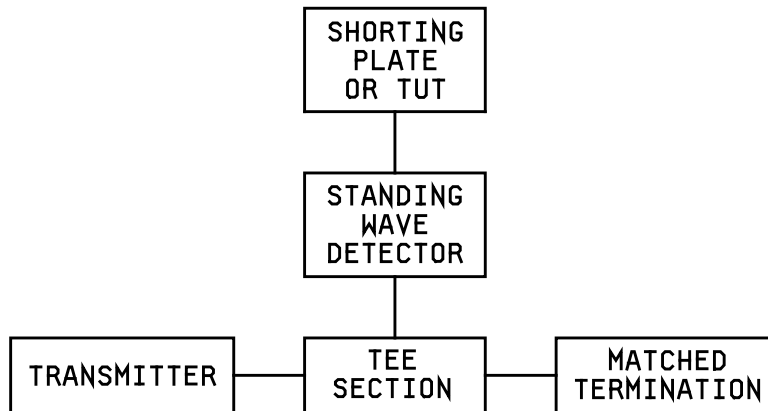


FIGURE 4494-1. Equipment layout for position of short measurements.

3. Procedure. With the equipment shown on figure 4494-1, the rf power in the mainline shall be set for the conditions specified, and the position of the voltage standing wave minimum before the shorting plate shall be determined. The metal shorting plate shall then be replaced by the tube, and the shift in the position of the voltage standing wave minimum shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 4496

FIRING POWER

(Gas-switching tubes)

1. Purpose. The purpose of this test is to determine the maximum peak power level transmitted through the TR or crystal protector tube before gas switching occurs.

2. Equipment.

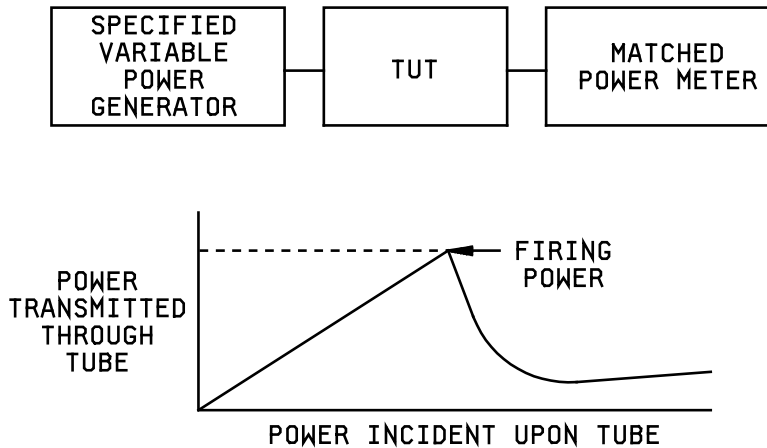


FIGURE 4496-1. Equipment layout for firing power measurements.

3. Procedure. With the tube in the circuit and with the ignitor current adjusted to the specified value, the incident power level is increased until a sharp reduction in power transmitted through the tube is noted (see figure 4496-1). The firing power is defined as  $\frac{P_o}{D_u}$ , where  $P_o$  is the maximum average power transmitted through the tube and  $D_u$  is the duty cycle of the incident power.

## MIL-STD-1311D

## METHOD 4551A

## LIFE TESTS

## (Microwave tubes)

1. Purpose. The purposes of a life test are:

- a. To give a degree of statistical assurance that the failure rate or average life of each tube lot is acceptable.
- b. To provide information on the average life capability of the tube type.
- c. To provide information on the physical causes of failure, so that engineering effort can be directed to these areas.

The relative importance of these purposes depends on the tube application, and should be considered in selecting the statistical group (A, B, C, D, S, or other) to be specified. In general, groups A, B, C, and D give greater weight to a. above, and are more appropriate for receiving tubes (including microwave tubes such as reflex klystrons and low-noise low-level TWT's); group S, or other tests involving test durations comparable to the average tube life, give more weight to b. and c. above and are appropriate for power tubes.

2. Definitions.

2.1 Continuous life test. A life test in which all inputs to the tube are applied continuously, except for occasional shutdowns for testing or plant closing.

2.2 Intermittent or cycled life test. A life test in which the inputs to the tube are switched on and off on a regular schedule (to simulate equipment switching) except for occasional shutdowns for testing or plant closing.

2.3 Load-cycled life test. A life test in which the output load (VSWR or phase or both) is varied cyclically, to simulate the effect of a moving antenna. This may be used in combination with either 2.1 or 2.2. When it is used in combination with 2.2, the load cycling should not be synchronized with the high voltage switching, so that the tube is required, over a period of time, to start against every load condition. If "load cycling" is specified without further qualification, the following shall be used: Load VSWR 1.5:1 minimum, varied through all phases at a rate of not less than 4 cycles per hour.

If manually moved, the standing wave introducer shall be cycled through the four phase positions corresponding to maximum power, minimum power, maximum frequency, and minimum frequency, at least once during the specified life of the tube, spending approximately equal periods of time in each phase position.

3. Procedure.

3.1 The TSS shall specify the life test group, the cycling, if any, the operating level ("oscillation (1)," etc.) and the life test end points. The latter are usually slightly relaxed limits on a few key parameters. For power tubes, it is usual to specify a power output end point equal to 80 percent of the conformance inspection, part 1, power output limit.

3.2 Intermittent life test. The TSS will specify the schedule in the following form:

- a. Preheat (heater power) (TBS) 1/ minutes
- b. Operation (1) (TBS) minutes
- c. No voltages (TBS) minutes.

Operation 3.2 b. may consist of more than one operation condition, in sequence, with a specified time for each.

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1/ TBS = to be specified.

## MIL-STD-1311D

3.3 The tube shall be operated under the specified conditions until either:

- a. The end of the specified life-test period, or
- b. There is an evident catastrophic failure, or
- c. It fails to meet one or more of the life-test end points.

When load cycling (see 2.3) is specified, it is permissible to disconnect the variable load, and substitute a matched load, in order to test for the power output end point, or other end points normally measured under matched load conditions.

3.4 Time measurement. The life-test time is the cumulative time during which full inputs are applied (for example, the sum of periods 3.2b for intermittent life test) up to the time determined by either 3.3a, 3.3b, or 3.3c, as appropriate.

When the time of failure is known exactly, this time, in completed hours, shall be the life-test time. When the time of failure is not known exactly, the life-test time shall be the lesser of,

- a. The time up to the midpoint between the last successful reading and the first unsuccessful reading, or
- b. The time at the last successful reading plus 10 percent of the specified life.

4. Precautions. Care must be taken, particularly on intermittent life tests, that operating voltages are applied in the correct sequence, and in such manner that no absolute rating of the tube is exceeded even transiently.

On intermittent life test, tube cooling means are to be switched with the tube voltages. If the TSS requires that cooling be continued for a specified time after removal of voltages, then delayed shutdown of the cooling means shall be used.

MIL-STD-1311D

METHOD 5001

X-RADIATION MEASUREMENT

(Display cathode-ray tubes)

1. Purpose. To obtain the X-radiation intensity of display cathode-ray tubes in order to determine the levels emitted by the tubes when operated at high voltages.

2. Procedure. Tubes shall be tested in accordance with EIA-501-A, "Recommended Practice for the Measurement of X-Radiation from Raster-Scanned Direct-View Data Display Cathode-Ray Tubes," EIA-502-A, "Recommended Practice for Measurement of X-Radiation from Non-Raster-Scanned Direct-View Cathode-Ray Tubes," and/or EIA-503-A "Recommended Practice for the Measurement of X-Radiation from Direct-View Television Picture Tubes." The tube shall be operated as specified in the TSS.

3. Acceptance criteria. At the point of maximum radiation, record the maximum stable radiation observed in mR/hr. The maximum allowable radiation limit in mR/hr shall be specified on the TSS.

4. Precautions.

4.1 X-radiation of the soft x-ray category may constitute a health hazard on prolonged exposure at close range. Therefore, equipment design shall provide for adequate shielding. Adequate precautions shall be taken to protect personnel from this hazard and film badges or other monitoring devices shall be assigned to all personnel involved in performing X-Radiation measurements.

4.2 A warning label informing of these precautions shall be placed in an appropriate position on the equipment.



## MIL-STD-1311D

## METHOD 5101A

## ALIGNMENT

(Cathode-ray tubes)

1. Base alignment (electronic types). The angle between the trace produced by the designated deflecting plates and the plane passing through both the center of the designated base pin and the axis of the tube shall not exceed 10 degrees.
2. Side terminal alignment (electrostatic types). The angle between a designated trace and a plane through the center of the side terminal and the axis of the tube shall not exceed 10 degrees.
3. Side terminal and base alignment. The angle between the plane passing through both the center of the designated base pin and the axis of the tube, and the plane passing through the center of the side terminal and the axis of the tube shall not exceed 10 degrees. The designated base pin shall be on the same side of the tube as the side terminal.
4. Neck and bulb alignment (electrostatic types). This test should normally be performed during qualification inspection only. The alignment of the neck with the body of the tube shall be measured by rotating the tube about an axis through the center of the pin circle (in the plane of the bottom of the base) and the center of the face of the bulb. The diameter of the circular area swept through by transverse section of the neck at a point .250 inch (6.35 mm) nearer the base than the CD line (the horizontal line at the junction of the bulb body and neck) shall not exceed the value specified.
5. Neck and base alignment (electrostatic types). The angle between the longitudinal axis of the base and the longitudinal axis of the neck shall not exceed 2 degrees.
6. Neck and bulb alignment (magnetic types). This test should normally be performed during qualification inspection only. The tube shall be rotated about the axis of the neck, and measurement shall be made of the variation in distance from the axis of rotation to the periphery of the bulb in a plane normal to the axis of rotation and nearer the base than the point where the axis of rotation intersects the face of the tube by the following distances: .3125 inch (7.938 mm) for 3- and 5-inch tubes, .75 inch (19.1 mm) for 7-inch tubes, 1.25 inches (31.8 mm) for 9-inch tubes, 1.5 inches (38.1 mm) for 10-inch tubes, and 1.75 inches (44.5 mm) for 12-inch tubes. The axis of the neck is defined as the axis of rotation when the neck is supported on two sets of "V" wheels, 3-wheel checks or equivalent, placed .75 inches (19.1 mm) and 4.25 inches (107.9 mm) below the reference plane. The variation shall be not more than .125 inches (3.18 mm) for 3- and 5-inches, .225 inches (5.72 mm) for 7-inch tubes, and .400 inch (10.16 mm) for 9-, 10-, and 12-inch tubes.
7. Angle between traces. When measured with a device having an accuracy of at least  $\pm 0.2$  degree, the angle between horizontal and vertical traces shall be  $90 \pm 3$  degrees. The angle shall be measured counterclockwise from the horizontal traces. The angle between corresponding traces of multigun tubes shall be not greater than 1 degree. This test shall be performed using traces at the center of the useful scan area. The length of traces shall be 75 percent of the useful scan dimensions. The beam current shall be adjusted to a level just below that which would cause screen damage.
8. Face tilt. This test should normally be performed during qualification inspection only. When the tube is rotated about the axis of the neck (see 6. above), the total variation in the distance from the faceplate to a plane perpendicular to the axis of rotation shall be not greater than .080 inch (2.03 mm) for 3- and 5-inch tubes, .150 inch (3.81 mm) for 7-inch tubes, and .225 inch (5.72 mm) for 9-, 10-, and 12-inch tubes. This variation shall be measured on the face at a distance from the axis of rotation equal to the minimum useful screen radius for the tube.
9. Neck straightness. The neck and base straightness shall be determined by the insertion of the tube neck in a cylinder 5.00 inches (127 mm) long and 1.4375 inches (36.513 mm) maximum inside diameter. This cylinder shall move freely between the reference line and the base of the assembled tube.
10. Trace and bulb alignment (rectangular electrostatic types). When measured with a device having an accuracy of at least  $\pm 0.2$  degree, the angle between the specified trace and the specified bulb wall shall not exceed 2 degrees. The trace shall be located at a scan area center and have a length equal to 75 percent of the useful scan dimensions.
11. Spot deflection. With a positive potential applied on the deflection plate specified on the TSS, the spot shall be deflected in the direction of the designated pin.

## MIL-STD-1311D

## METHOD 5103

## PATTERN DISTORTION

1. Pattern distortion shall be specified in percent at a given percentage of the minimum useful scan of the tube. It shall include the total errors of the deflection defects of trace angle, keystone, pin cushion, and barreling. The method for testing for pattern distortion shall be as follows.

2. The test shall be made by means of a transparent overlay (such as a photographic film) on which are two concentric rectangles and two cross lines bisecting the rectangles and mutually perpendicular to their sides. The sizes of the two rectangles shall be computed as follows:

- a. The size of the scan at which the determination of pattern distortion is to be made shall be computed by multiplying the dimension of the minimum useful scan of each axis by the percentage of scan at which the pattern distortion test is to be made. These shall be the dimensions of the inner rectangle.
- b. The dimensions of the inner rectangle shall be multiplied by the maximum allowable percentage of pattern distortion. Each side of the outer rectangle shall be displaced from the edge of the inner rectangle by this computed amount.

Example: A cathode-ray tube has a minimum useful scan of 4.000 inches (101.6 mm) on 1D2 and 3.000 inches (76.2 mm) on 3D4. Pattern distortion shall be less than 2 percent at 75 percent of useful scan.

75 percent x 4.00 inches = 3.00 inches, 75 percent x 3.00 inches = 2.25 inches  
Inner rectangle dimensions, therefore, are 3.00 inches x 2.25 inches.

2 percent x 3.00 inches = .060 inch, 2 percent x 2.25 inches = .045 inch  
Outer rectangle dimension are  $3 + 2(.060) = 3.12$  inches by  $2.25 + 2(.045) = 2.34$  inches.

3. The overlay shall be fixed in position with respect to the tube face with the center of the rectangles at the center of the tube face and with a trace produced by the 1D2 deflection plates aligned with the cross line parallel with the 1D2 scan dimension of the overlay, and equal to it in length. With balanced dc voltages on the 3D4 deflection plates, the trace shall be moved out alternately to both edges of the overlay pattern. At some given trace position, its entire length shall fall within the boundaries of the two rectangles. After the trace has been repositioned to the center of the tube, and without repositioning the overlay, a trace shall then be produced by the 3D4 deflection plates, and the above procedure repeated. If the trace fails to fall within the area between the inner and outer rectangles on any of the four sides of the overlay, the tube shall be rejected.

MIL-STD-1311D

METHOD 5106

BULB, SCREEN, AND FACEPLATE QUALITY

(Cathode-ray tubes)

1. The tube shall be viewed while operating at the normal test voltage conditions specified on the TSS with the screen fluorescing uniformly under a defocused scan. Long persistence screens shall be viewed under phosphorescence. In either case, the ambient illumination shall be well below the luminescent level.

1.1 Screen and faceplate blemishes. Inspection shall be made for spots, holes, and blemishes on the screen and faceplate of the tube. The number and size of, and the intensity variations due to, spots, holes, and blemishes shall not exceed those specified in Appendix D of MIL-PRF-1.

2. Bulb defects (see Appendix D of MIL-PRF-1).

MIL-STD-1311D

METHOD 5111

VIBRATION

(Cathode-ray tubes)

Vibration (cathode-ray tubes). Each tube shall be vibrated along X and Y axes and shall withstand, without damage, simple harmonic vibration, at an amplitude of  $.040 \pm .0025$  inch ( $0.10 \pm 0.063$  mm), ( $.080 \pm .005$  inch ( $2.03 \pm 0.13$  mm) total excursion), at a frequency of  $25 \pm 2$  Hz for 60 seconds and at a frequency of  $50 \pm 2$  Hz for 300 seconds, in each direction. The increase in line width or displacement of the spot or trace due to the relative motion of the tube parts shall not exceed the limit(s) specified. Electrostatic-deflection tubes shall be vibrated with a circular trace adjusted for optimum focus. Magnetic deflection, electrostatic-focus tubes, shall be vibrated with a low-intensity optimum-focus spot. Magnetic deflection, magnetic-focus tubes, shall be vibrated with a low-intensity spot corresponding to the image of the final aperture.

## MIL-STD-1311D

## METHOD 5115

## SHOCK

(Cathode-ray tubes)

1. The test shall be performed in accordance with MIL-STD-202, method 213, table 213-1, test condition A. The following conditions apply:

- a. The tube shall be mounted to the elevator table by a suitable rigid assembly. Hardwood clamps shall be used at the face plate and near the neck to secure glass tubes (having no integral metal shields) to the assembly. Hardwood or metal clamps may be used at similarly appropriate points on tubes having integral shields.
- b. The assembly shall be such as to permit changes in tube orientation. A total of 10 shocks shall be applied to the tube in the order, number, and directions as follows:

<u>Order</u>	<u>Number of drops</u>	<u>Direction</u>
1	2	Base to face
2	2	X+
3	2	X-
4	2	Y+
5	2	Y-

- c. No potentials shall be applied during shock.
2. After shock test, cathode-ray tubes shall be subjected to the following tests and shall meet the requirements specified.
- a. The change in position of the undeflected focused spot from its position noted before the test (see method 5231) shall not exceed the following values:

<u>Tube face diameter or diagonal (in.)</u>	<u>Change mm</u>
1	1.5
2	3
3	3
4	4
5 and 6	4
7 and 8	5
9	6
10 and 11	6
12 and over	8

- b. The change in deflection factor for electrostatic tube types shall not exceed 5 percent (see method 5248).
- c. Starting with a tube with no loose particles, the maximum number of loose particles as a result of shocking shall be not more than a total of five loose particles greater than .016 inch (0.41 mm) in any one cathode-ray tube. Tubes having loose particles greater than .016 inch (0.41 mm) shall be vibrated with the face down in a horizontal plane at 5 G's for 1 minute. If the screen shows damage from such vibration, the tube shall be rejected.
- d. The change in grid cutoff voltage shall not exceed 10 percent (see method 5241).
- e. There shall be no damage to the external parts of the tubes.

MIL-STD-1311D

METHOD 5201

ELECTRODE CURRENT AND VOLTAGE BREAKDOWN

(Cathode-ray tubes)

1. Electrode current. Under the specified test conditions, the electrode current shall be within the limit(s) specified. The light output shall be measured as specified in method 5221.
2. Voltage breakdown. The maximum rated heater or filament voltage shall be applied with the potential of the control grid at maximum rating with respect to the cathode, and with the instantaneous potential of any part of the heater at its maximum rating with respect to the cathode (when unipotential cathode not internally connected to the heater is used) and with all other voltages equal to zero. Maximum rated heater or filament voltage shall be 7.0 volts for tubes with heater or filament voltage rating of  $6.3 \pm 10$  percent and 2.75 volts for tubes with maximum heater or filament voltage of  $2.5 \pm 10$  percent. There shall be no recurrent breakdown between elements.
3. Voltage breakdown (electrostatic types). The control grid shall be adjusted for cutoff, and the first and second anodes (and the third anode, when present) set at their maximum rated voltages. There shall be no breakdown between elements.
4. Voltage breakdown (magnetic types). The control grid shall be adjusted for cutoff, and grid No. 2 focusing electrode and anode set at their maximum rated voltages. There shall be no breakdown between elements.

MIL-STD-1311D

METHOD 5206

GAS

(Cathode-ray tubes)

1. Gas "cross" (electrostatic deflection). Test voltage, as specified, shall be applied and the trace adjusted to focus. The screen of the tube shall be scanned to yield a square pattern having an area equal to approximately 2 by 2 inches (50.8 mm by 50.8 mm). Linear saw-tooth scanning as follows shall be used:

Horizontal - - - - - 2,100 to 6,300 Hz

Vertical - - - - - 60 Hz

When the light output or screen current is set at the value specified on the TSS, the appearance on the screen of a "cross" is indicative of excessive gas. All tubes upon which crosses appear shall be rejected.

2. Gas ratio (magnetic deflection). With voltage as specified in conditions A and B and with focus, scanners, and ion trap magnets off,  $I_k$  (mA dc) and  $I_b$  ( $\mu$ A dc) shall be determined.

Condition A

$E_b = -25$  V  
 $E_{c2} = +300$  V  
 $E_{c1}/I_k = 500$   $\mu$ A dc

Condition B

$E_b = -25$  V  
 $E_{c2} = +300$  V  
 $E_{c1} = -90$  V

For types with cutoff voltage greater than 90, use sufficient bias to insure cutoff. The value of gas ratio (Gr) shall be computed from the following equation and shall not exceed the limits specified on the TSS.

$$Gr = \frac{I_b(\text{condition A}) - I_b(\text{condition B})}{0.500}$$

MIL-STD-1311D

METHOD 5216

SPURIOUS ILLUMINATION

(Cathode-ray tubes)

1. Cathode illumination. This test should normally be performed during qualification inspection only. With the tube enclosed in a lightproof container and with the specified heater potential applied for a minimum of 60 seconds, the light output at the face of the tube shall be not more than 0.154 mfl in any 2-inch (50.8 mm) diameter area.
2. Stray light emission (conventional types). There shall be no visible stray emission when viewed at a distance of 2 or 3 times the screen height and with 0.4 foot candle (ftC) diffused ambient illumination measured at the tube face.
3. Effects of grid emission. The following test is applicable only to tube types used in low-ambient light conditions. Each gun shall be operated for a minimum of 5 minutes with maximum potentials applied to heater and accelerating anodes. Ec1 shall be maximum negative; positioning and deflection voltages shall be zero. Viewed under dark conditions with the eye dark-adapted for 5 minutes, there shall be no visible evidence of fluorescent light when Eb1 is varied from minimum to maximum.



## MIL-STD-1311D

## METHOD 5221

## SCREEN INTENSITY AND PERSISTENCE

(Cathode-ray tubes)

1. Light output. The light output of the screen shall be measured under the specified conditions and the following general conditions: A 35- to 105-line pattern shall be provided on the cathode-ray tube screen, using a 60 Hz saw-tooth scanning on one axis and a 2,100 to 6,300 Hz saw-tooth scanning on the other axis. In the case of electrostatic deflection types, the mean potential of free deflecting plates shall be that of anode No. 2. The pattern size shall be adjusted to 2 by 2 inches (50.8 mm by 50.8 mm), and the light output shall be read. A foot-candle (ftC) meter or foot lambert (fL) meter, corrected for the spectral response of the eye, shall be used to measure the light output. The light output so determined shall be not less than the value specified on the TSS. When these conditions are satisfied, and the light meter is placed so that the sensitized surface of the photocell is against the tube face, the meter may be used to read fL directly.

2. Screens. The phosphorescent light intensity "D" observed "t" seconds after completion of the application of the "Nth" raster to the tube is Dt(N), for example, D1(5) is the phosphorescent light intensity 1 second after the fifth excitation raster. Dt(E) shall denote that raster's are applied until equilibrium is reached. The cbf shall be fluorescent light output under continuous raster excitation. Buildup factor is described as G5:1 and is defined as the ratio of the light intensity obtained 1 second after the fifth raster to the light intensity obtained 1 second after the first raster. Unless otherwise specified, the screen characteristics shall be measured under the following conditions:

- a. Raster size (focused beam). Where tube size or useful scan permits 7.1 cm by 7.1 cm giving a total area of 50 cm<sup>2</sup>.

Smaller tubes. 4.1 cm by 4.1 cm giving a total area of 16.7 cm<sup>2</sup> (48 cB shall be added to cB readings to correct for smaller raster size).

The tube shall then be defocused to a spot approximately 0.25 cm in diameter.

- b. Beam current. Tubes shall be operated at a current to produce the power shown below when operated at the specified test voltage:

Screen	Power in watts for raster size	
	50 sq. cm.	16.7 sq. cm.
P2	0.24	0.08
P7	0.24	0.08
P12	0.02	0.007
P14	0.24	0.08
P19	0.02	0.007
P25	0.05	0.017

- c. Duration of raster = 0.0167 second. The raster is formed by means of linear scanning with the horizontal scanning frequency 12 kHz and the vertical scanning frequency 60 Hz. The raster is repeated at 1-second intervals.
- d. Distance of raster from axis of calibrated 931 VA multiplier phototube = 30 cm.
- e. Red or white light. Sufficient to de-excite the phosphor before buildup measurements so that the results are within 3 cB of those that would have been obtained after total de-excitation.

3. Deviations from the conditions listed above in regard to test voltages, currents, and pattern size, required to test a number of different tube types will be permissible if such deviations are approved by the service concerned.

**NOTE:** Descriptions of primary standard replica lamps for various screen types are specified in Naval Material Laboratory Final Report Number 5032-B15.40. Data on phosphors P19 and P25 are included in Naval Material Laboratory Final Report Number 5032-B15.91. These reports may be obtained in accordance with section 2.1 of this standard.

## MIL-STD-1311D

4. Centibels (CB) may be converted to millifoot-Lamberts (mfL) by use of the following equations:

<u>Screen type</u>	<u>Conversion equation</u> <sup>1/</sup>
P2	$\text{mfL} = 2.70 \times 10^{-3} \times 1K$
P7 with Wratten 15 filter, or equivalent	$\text{mfL} = 2.45 \times 10^{-3} \times 1K$
P12	$\text{mfL} = 1.82 \times 10^{-3} \times 1K$
P14 with Wratten 15 filter, or equivalent	$\text{mfL} = 3.09 \times 10^{-3} \times 1K$
P19	$\text{mfL} = 1.77 \times 10^{-3} \times 1K$
P25	$\text{mfL} = 3.88 \times 10^{-3} \times 1K$

<sup>1/</sup> K = 10 raised to the  $\frac{cB}{100}$  power.

4.1 Using the symbols defined above, the light output measurements presently specified for the various types of phosphors are as follows:

P2	D1(1)
P7	D1(5), G5:1
P12	cBf, DO.1(E)-DO.3(E)
P14	D1(E), cBf, DO.1(E)-D1(E), D1(E)-D10(E)
P19	cBf, DO.1(10), D1(10), D1(10)-D10(10)
P25	cBf, DO.1(10), D1(10), D1(10)-D10(10)

4.2 The values for the measurements are as follows:

P2	D1(1) = 360 cB (minimum)
P7	D1(5) = 400 cB (minimum) G5:1 = 4
P12	cBf = 550 cB (minimum) DO.1(E) - DO.3(E) = 80 to 100 cB
P14 (Non-aluminized)	D1(E) = 410 to 450 cB cBf = 640 cB (minimum) DO.1(E) - D1(E) = 60 to 90 cB D1(E) - D10(E) > DO.1(E) - D1(E)
P14 (Aluminized)	D1(E) = 430 to 470 cB cBf = 680 cB (minimum) DO.1(E) - D1(E) = 60 to 90 cB D1(E) - D10(E) > DO.1(E) - D1(E)
P19	cBf = 575 cB (minimum) DO.1(10) = 410 cB (minimum) D1(10) = 335 cB (minimum) D1(10) - D10(10) = 75 to 120 cB
P25	cBf = 600 cB (minimum) DO.1(10) = 400 cB (minimum) D1(10) = 325 cB (minimum) D1(10) - D10(10) = 50 to 80 cB

MIL-STD-1311D

5. Screen brightness I. Screen brightness I shall be measured under the same conditions as those specified in 2, except that no pulsing shall be used on the grid, and the screen current shall be 60  $\mu$ A dc. The steady-state light output shall be 640 cB minimum.

MIL-STD-1311D

METHOD 5223

MODULATION

(Cathode-ray tubes)

The grid drive (grid voltage above spot-cutoff) required for the specified minimum light output or screen current shall be not greater than the value specified on the TSS.

## MIL-STD-1311D

## METHOD 5226

## LINE-WIDTH

(Cathode-ray tubes)

Two line-width determinations shall be made; one determination at the center of the screen (position A in both electrostatic- and magnetic-deflection types) and another determination at a point along the direction of high-frequency scanning, distant from the center of the screen by .375 inch (9.53 mm) of the maximum bulb diameter. For electrostatic types, this second position is referred to as position B; and magnetic types, as position C.

1. Line width (electrostatic deflection). The scanning pattern specified in method 5221 (light output), shall be set at the light output or screen current specified. The high-frequency scanning shall be applied to the deflecting plates nearest the screen and the amplitude shall be adjusted to give a line length of approximately 90 percent of the maximum tube diameter. The low-frequency scanning amplitude shall be expanded to make the line structure clearly visible and adjustment shall be made for best focus in the center of the pattern. Unless otherwise specified, each pair of deflection plates shall have the same potential which may be varied to obtain the best compromise between vertical and horizontal line width, and which shall not exceed  $\pm 100$  volts difference from the adjacent anode or shield voltage. The pattern shall be compressed until the line structure first disappears or begins to overlap or shows reverse line structure at the center of the screen. The line width at position A is then given by the quotient of the width of the compressed-pattern transverse to the line structure divided by the number of lines which are being scanned, and shall be within the values specified. The connection of deflection elements to the low- and high-frequency scanning supplies shall then be interchanged and line-width determination repeated without adjustment of focus or astigmatism voltages. Without changing the focus or astigmatism voltages, the line structure shall be determined at the less favorable of the two alternate B positions. Again, the line width is given by the transverse width of the pattern divided by the number of lines. The line width so determined shall be within the values specified.

2. Line width (magnetic deflection). The procedure specified in 1 above for electrostatic types shall be followed in the case of line-width determination at position A. Without interchange of connections to the deflecting elements, line-width determination shall then be made at the less favorable of the two alternate C positions. Unless otherwise specified, standard focusing coil JEDEC No. 106 and deflection yoke (cf. EIA-256-A, "Deflecting Yokes for Cathode Ray Tubes"), or equivalent, shall be used. The distance (D) from center of focus coil air gap to reference line shall be as specified. The line width so determined shall be within the values specified.

MIL-STD-1311D

METHOD 5231

SPOT POSITION

(Cathode-ray tubes)

The tube shall be operated at the test conditions specified. The tube shall be shielded against external magnetic and electrical influences and the control-grid voltage shall be set at a value which will avoid damage for the screen.

1. Spot position (magnetic deflection). With the tube operated as specified above, the distance between the center of the undeflected spot and the center of the screen shall be within the limit(s) specified. In the case of magnetic-focus types, the focusing current shall be zero. In the case of electrostatic-focus types, the spot shall be adjusted for focus.

2. Spot position (electrostatic deflection). The tube shall be operated as specified above, and adjusted for focus with each of the free deflecting electrodes connected to anode No. 2. The spot shall be within a square, the dimensions of which are within the limit(s) specified on the TSS, the center of which coincides with the geometric center of the tube face, and one side of which is parallel to a trace produced by one set of deflecting electrodes.

3. Spot displacement (leakage). The tube shall be operated as specified above and adjusted for focus with each of the free deflecting electrodes connected to anode No. 2 through a 10-Meg resistor. The spot displacement produced by the shorting of each resistor in turn shall not exceed the value specified. An equivalent combination of resistance and displacement limit may be used.

## MIL-STD-1311D

## METHOD 5236

## ZERO-BIAS ANODE CURRENT (Magnetic deflection)

(Cathode-ray tubes)

1. At the electrode voltages specified, the zero-bias anode current shall be measured, and shall be not less than the values specified in table 5236-I for tubes having the corresponding values of cutoff.

TABLE 5236-I. Grid No. 1 cutoff voltage versus minimum zero-bias current.

Grid No. 1 spot cutoff voltage	Minimum zero-bias current $\mu\text{A}$ dc	Grid No. 1 spot cutoff voltage	Minimum zero-bias current $\mu\text{A}$ dc
15	111	58	918
16	123	59	943
17	135	60	966
18	149	61	991
19	162	62	1015
20	176	63	1040
21	190	64	1065
22	205	65	1090
23	219	66	1115
24	235	67	1142
25	250	68	1165
26	270	69	1192
27	285	70	1217
28	300	71	1242
29	310	72	1271
30	335	73	1296
31	360	74	1322
32	377	75	1350
33	394	76	1378
34	419	77	1405
35	431	78	1431
36	449	79	1460
37	468	80	1486
38	487	81	1515
39	507	82	1543
40	527	83	1572
41	547	84	1600
42	567	85	1629
43	587	86	1658
44	607	87	1687
45	628	88	1716
46	650	89	1746
47	670	90	1775
48	692	91	1804
49	713	92	1834
50	735	93	1864
51	758	94	1894
52	780	95	1924
53	802	96	1955
54	825	97	1986
55	850	98	2016
56	872	99	2047
57	895	100	2079

MIL-STD-1311D

METHOD 5241

GRID-CUTOFF VOLTAGE

(Cathode-ray tubes)

The grid voltage shall be adjusted for visual extinction of the undeflected focused spot. The cutoff voltage shall be within the limit(s) specified.



MIL-STD-1311D

METHOD 5246

FOCUSING

(Cathode-ray tubes)

The beam shall be focused at the center of the tube under the test conditions specified. Unless otherwise specified, for magnetic deflection types, deflecting yoke JEDEC No. 120 (see EIA-256-A), or equivalent, shall be used.

1. Focusing voltage at cutoff. With the control-grid voltage adjusted so that the pattern is barely visible, the voltage necessary to bring the beam to focus shall be within the limit(s) specified.

2. Focusing voltage at modulation condition. The voltage necessary to bring the beam to focus at modulation shall be within the limit(s) specified.

3. Focusing ampere turns. JEDEC No. 106 focusing coil may be used. The number of ampere turns required for focus, as determined by multiplying the current in milliamperes by 4.5, shall be within the limit(s) specified. Alternately, JEDEC No. 122 focusing coil may be used. The number of ampere turns for focus, as determined by multiplying the current in milliamperes by 6.5 and by a correction factor 1.07, shall be within the limit(s) specified. The distance D from the center of the air gap of either focus to the reference line shall be as specified.

MIL-STD-1311D

METHOD 5248

DEFLECTION FACTOR

(Cathode-ray tubes)

1. Deflection factor. With the test conditions specified, the deflection factor (the ratio of the deflecting voltage to the corresponding deflection in inches as determined on each axis by deflecting the beam from a position 75 percent useful scan radius, left or up from center, to a position 75 percent useful scan radius, right or down from center) shall be within the limit(s) specified.

2. Deflection-factor uniformity. The deflection-factor uniformity on each deflection axis shall be determined. For any axis, the deflection factors corresponding to 25 and 75 percent of the minimum useful scan radius shall be measured from center of useful scan along the tube-face contour. Measurements on each axis shall be made on both sides from the center. The factor at 25-percent deflection shall not differ from the factor at 75-percent deflection, on the same side of the center of the useful scan, by more than 5 percent.

MIL-STD-1311D

METHOD 5250

INTERACTION FACTOR

(Cathode-ray multigun tubes)

The deflection per unit volt of the beam generated by an electron gun at any position of that beam within its useful scan, when a balanced voltage of at least 300 V dc is applied to the 1D2 deflection electrodes of all of the other electron guns, shall be not greater than the value specified. Each electron gun shall be subjected to this test.

MIL-STD-1311D

METHOD 5251

ELECTRODE LEAKAGE CURRENTS

(Cathode-ray tubes)

1. Heater-cathode leakage current. In testing tubes having unipotential cathodes not connected to the heater within the tube, rated heater voltage shall be applied to the heater terminals and the instantaneous potential of any part of the heater shall be maintained at not less than 125 volts with respect to the cathode. The heater-cathode leakage current shall not exceed 10  $\mu$ A dc.
2. Grid No. 1 leakage current. With the control grid biased to cutoff, the leakage current between grid No. 1 and all other electrodes shall not exceed 3  $\mu$ A dc.
3. Grid No. 2 leakage current. With the control grid biased to cutoff, the leakage current between grid No. 2 and all other electrodes shall not exceed 5  $\mu$ A dc.
4. Anode No. 1 leakage current. With the control grid biased to cutoff, the leakage current between anode No. 1 and all other electrodes shall not exceed 5  $\mu$ A dc.
5. Anode No. 2 leakage current. With the control grid biased to cutoff, the leakage current between anode No. 2 and all other electrodes shall not exceed 5  $\mu$ A dc.

MIL-STD-1311D

METHOD 5256

MAGNETIZATION

(Cathode-ray tubes)

1. The tube shall be demagnetized and shall then immediately be scanned with a raster as specified in method 5226 (line width (electrostatic deflection) or line width (magnetic deflection)), as applicable. The change in line width following demagnetization shall not exceed 20 percent of the line width measured in accordance with method 5226 (line width (electrostatic deflection) or line width (magnetic deflection)), as applicable. The change of position of the undeflected spot shall not exceed 40 percent of the maximum allowable spot-to-center distance. The entire tube shall then be exposed to a magnetic field of 500 gauss  $\pm$  10 percent, after which the tube shall not exceed the maximum limit(s) for the line width or spot-to-center distance specified.

2. During these tests the tube shall be located in exactly the same position in the mount.

MIL-STD-1311D

METHOD 5301

CURRENT

(Phototubes)

1. Anode current. With the specified luminous flux incident on the photocathode, and with the specified anode voltages applied, the anode current shall be within the limit(s) specified. For gas phototubes, this measurement shall be made 30 seconds after the application of the anode voltages.
2. Dynamic anode current. A toothed wheel (calibrated with a stroboscope against a beat-frequency oscillator) shall be used to modulate a light beam from a specified source incident on the phototube cathode. The speed of the toothed wheel shall be varied and the phototube output shall be fed into an amplifier which has been previously calibrated to insure its relative flatness of response over the desired frequency range. The dynamic sensitivity at each specified frequency shall be within the limit(s) specified. This test may be replaced by any suitable test demonstrated to be equivalent.
3. Dark current. Dark current is the current which flows between any two or more electrodes of a photoelectric device in the absence of such radiant energy as is normally used to excite the device during the test. The dark current, at the voltage specified, shall not exceed the limit(s) specified.
4. Dynode current. With the specified potentials applied to the electrodes, the dynode current shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 5302

GAS AMPLIFICATION FACTOR

(Phototubes)

The anode current of gas phototubes shall be measured at 90 and 25 volts, and the ratio between the two shall be within the limit(s) specified on the TSS. The series resistance shall be as specified.

## MIL-STD-1311D

## METHOD 5303

## SPECTRAL RESPONSE IDENTIFICATION

(Phototubes)

1. Identification of the type of phototube spectral response shall be made by using a series of light filters and standardized light sources. The following standard filters, manufactured by Corning Glass Works, of the melt indicated, or filters having equivalent transmission characteristics, shall be used.

<u>Filter number</u>	<u>Melt number (1943)</u>
2540 -----	439
3384 -----	422
3482 -----	521
5113 -----	491
5850 -----	219
9780 -----	8 of 10-20-43

2. The test shall be made using a 25-volt anode supply. Series resistance shall not exceed 1 Meg. Transmission tests shall be made by inserting the standard filters between the sources and the photocathode and measuring the relative response to the transmitted radiation (see table 5303-I). The filters shall be inserted in a position normal to the light beam, minimizing the effect of reflection. All currents recorded shall be the difference of currents measured with light on and off to eliminate dark-current error. The transmission (percent of no-filter current reading) for each filter or filter combination shall be within the limits for the spectral response specified. For phototubes of spectral responses S1, S4, S10, S11, the spectral response shall be measured with a monochromator. The response shall be within the limits shown in table 5303-II for the spectral response symbol specified on the TSS.

TABLE 5303-I. Percent response using filter or filter combination.

Spectral response symbol	Light source	Filter numbers							
		5113		3384 and 9780		3482 and 5850		2450	
		Min	Max	Min	Max	Min	Max	Min	Max
S3	LS1	1.0	4.0	9.0	35.0	3.0	32.0	0	1.0
S7	LS1	0.2	1.0	8.0	15.0	32.0	55.0	0.5	10.0
S8	LS1	1.5	6.0	15.0	45.0	1.0	6.0	0	0.1

TABLE 5303-II. Bandwidth limits (angstroms).

Spectral response symbol	Spectral response					
	100%		10% short wave		10% long wave	
	Min	Max	Min	Max	Min	Max
S1	6,500	8,500	2,700	3,300	9,000	12,400
S4	3,500	4,500	2,700	3,300	5,800	6,400
S10	4,200	4,800	3,050	3,350	6,600	7,300
S11	3,900	4,900	3,000	3,500	5,850	6,400



MIL-STD-1311D

METHOD 5306

SIGNAL-TO-NOISE RATIO

(Phototubes)

Prior to testing, the tubes shall be kept in the dark at an ambient temperature of  $24^{\circ}\text{C} \pm 3^{\circ}\text{C}$  for not less than 1 hour. The specified light source shall be modulated at 90 Hz, using a square wave, or equivalent. The light spot on the cathode shall be as specified on the TSS. The tube output shall be fed into a low-pass amplifier calibrated in dB, the bandwidth of which is 1,000 Hz. Read the amplifier output with a VU meter calibrated in dB. The signal-to-noise ratio shall be determined as follows:

- a. Signal: with light on, adjust attenuator so that the VU meter is at zero. Read attenuator setting.
- b. Noise: With light off, read as for signal.
- c. S/N ratio (in dB) = Signal minus noise.

MIL-STD-1311D

METHOD 5401

ELECTRODE

(Cathode-ray charge storage tubes)

1. Voltage breakdown. The maximum rated heater or filament voltage shall be applied with the potential of the control grid at maximum rating with respect to the cathode, and with the instantaneous potential of any part of the heater at its maximum rating with respect to the cathode (when unipotential cathode not internally connected to the heater is used) and with all other voltages equal to zero. Maximum rated heater or filament voltage shall be 7.0 volts for tubes with heater or filament voltage rating of  $6.3 \pm 10$  percent and 2.75 volts for tubes with maximum heater or filament voltage of  $2.5 \pm 10$  percent. There shall be no recurrent breakdown between elements.

2. Voltage breakdown (single or multigun types). The control grid of each cathode-ray gun structure shall be adjusted for cutoff, and all other electrodes set at values within their maximum ratings which will provide the maximum stress between adjacent elements. There shall be no breakdown between elements.

MIL-STD-1311D

METHOD 5402

GRID-CUTOFF VOLTAGE

(Cathode-ray charge storage tubes)

1. For display storage tubes, the grid voltage shall be adjusted for visual extinction of the undeflected, nonstored cathode-ray spot. The cutoff voltage shall be within the limit(s) specified.
2. For either display storage tubes or electrical output storage tubes, the grid voltage shall be adjusted to reduce the cathode or beam current to the small value specified on the TSS. The cutoff voltage shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 5403

MODULATION

(Cathode-ray charge storage tubes)

The grid drive (grid voltage above cutoff) required for the specified minimum beam current shall be not greater than the value specified on the TSS. The beam current shall be the current value measured at the electrode(s) specified on the TSS.

MIL-STD-1311D

METHOD 5404A

SPOT POSITION

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this method is the determination of the undeflected spot position of the TUT.

2. Equipment.

Pulse generators, amplifiers, deflection systems, monitoring equipment, as required, shall be adequate to operate and observe the TUT.

3. Procedure. The TSS shall specify which of the following shall be used.

3.1 Method A for magnetic-deflection tubes.

- a. The TUT shall be operated at the test conditions specified in the TSS.
- b. Special attention shall be given to the control-grid to cathode voltage in order to assure a value which will avoid damage to the storage surface or screen, under the undeflected spot conditions of this test. It is permissible to employ a variable amplitude and variable duty cycle intensification pulse.
- c. If the TUT is a magnetic focus type, it shall be operated with the focus coil at the focus coil position as specified in the TSS and with no external alignment fields present. The focus current shall be a minimum consistent with a viewable spot. It shall then be demonstrated that a variation in focusing field does not cause deflection.
- d. If the TUT has electrostatic focus, the spot shall be adjusted for focus.
- e. With the tube operating as above (no deflection), the distance between the center of the undeflected spot and the center of the storage surface or screen shall be recorded and it shall be within the limits specified in the TSS. With off-centered guns, the undeflected spot position shall fall within a circle whose radius and center position are specified in the TSS.

3.2 Method B for electrostatic-deflection tubes.

- a. The TUT shall be operated at the test conditions specified in the TSS.
- b. Special attention shall be given to the control-grid to cathode voltage in order to assure a value which will avoid damage to the storage surface or screen, under the undeflected spot conditions of this test. It is permissible to employ a variable amplitude and variable duty cycle intensification pulse.
- c. The tube shall be adjusted for focus with each of the deflecting electrodes connected to the average dc potential specified in the TSS and with no external alignment fields present.
- d. The undeflected spot position shall be recorded and shall be within the rectangular limits specified in the TSS, the center of which coincides with the specified location on the storage surface or screen and one side to be parallel to a trace produced by one set of deflecting electrodes.

4. Precautions.

- a. For electrical output storage tubes, the linearity of the reading sweeps on the tube and on the monitor shall be adequate for determining spot location.
- b. Utmost care should be taken in preventing surface damage due to lack of deflection.
- c. Shielding may have to be provided if the TUT is influenced by external magnetic and electrical fields.

MIL-STD-1311D

5. TSS requirements. In addition to the operating conditions for the TUT, the TSS shall specify the following:

- a. The use of method A or method B.
- b. If magnetic focus: Focus coil number;  
Focus coil position;  
Focus current range.

Limits of position of the undeflected spot as:

Limiting radius;  
Position of circle center.

- c. If electrostatic deflection, the limit(s) of the undeflected spot position shall be stated as a rectangular width, height, and center position. Orientation of the undeflected spot shall be specified in terms of one dimension being parallel to a specified pair of deflecting electrodes.

MIL-STD-1311D

METHOD 5405

DETERMINATION OF STORAGE SURFACE REFERENCE DIMENSION

(Cathode-ray charge storage tubes - electrical output)

1. Purpose. To establish a reproducible standard for dimensional comparison.
2. Procedure. By overscanning the storage surface and viewing the output on a monitor, the boundary of the usable storage surface is identified as an abrupt change in the output. The diameter (or diagonal if rectangular) of the area within this boundary is the storage surface reference dimension. The dimensions of other characteristics of the storage surface as observed on the monitor are measured with reference to the storage surface reference dimension.

MIL-STD-1311D

METHOD 5406

DEFLECTION

(Cathode-ray charge storage tubes)

1. Deflection factor (visual output tubes). With the test conditions specified, for visual output tubes the deflection factor (the ratio of the deflecting voltage to the corresponding deflection, in inches, as determined on each axis by deflecting the beam from a position 75 percent of useful scan radius, left or up from center, to a position 75 percent of useful scan radius, right or down from center) shall be within the limit(s) specified.

2. Deflection factor (electrical output tubes). With the test conditions specified, for electrical output tubes, the deflection factor (deflecting voltage per diameter) shall be determined on each axis by deflecting the beam across the SSRD (storage surface reference dimension), see method 5405, and shall be within the limit(s) specified.

3. Deflection-factor uniformity (visual output tubes). In visual output tubes, for any axis, the deflection factors corresponding to 25 and 75 percent of the minimum useful scan radius shall be measured from the center of useful scan along the tube-face contour. Measurements on each axis shall be made on both sides from the center. The value of the deflection-factor uniformity on each deflection axis shall be determined from the formula:

$$DFU = \frac{DF (25\%) - DF (75\%)}{DF (75\%)}$$

and shall be within the limit(s) specified.



MIL-STD-1311D

METHOD 5407

ELECTRODE LEAKAGE

(Cathode-ray charge storage tubes)

1. Heater-cathode leakage. In testing tubes having unipotential cathodes not connected to the heater within the tube, rated heater voltage shall be applied to the heater terminals and the instantaneous potential of any part of the heater shall be maintained at not less than 125 volts with respect to the cathode. The heater-cathode leakage current shall not exceed 10  $\mu$ A dc.
2. Interelectrode leakage. With the control grid biased to cutoff, the leakage between the specific electrode and all other electrodes shall not exceed the limit(s) specified.

MIL-STD-1311D

METHOD 5408A

BLEMISHES, ELECTRICAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to determine the blemish quality of a tube by measuring the following parameters:

- a. The blemish output signal levels relative to the output signal levels of adjacent areas.
- b. The size of the blemishes relative to the storage surface reference dimensions (SSRD) (see method 5405).
- c. The number of blemishes within a stated zone of the storage surface.
- d. The spacing of the blemishes.

2. Definitions.

- a. A blemish is a localized imperfection of the storage assembly that produces an abrupt variation in the amplitude of the output signal.
- b. Static blemishes are blemishes whose presence is not a function of writing or erasing rates.
- c. Dynamic blemishes are blemishes whose presence is a function of writing or erasing rates.
- d. Light blemishes are blemishes which, under specified test conditions, result in output greater than that from adjacent storage surface areas. Signal polarity shall be such that writing results in increased output.
- e. Dark blemishes are blemishes which, under specified test conditions, result in output less than that from adjacent storage surface areas.
- f. Saturation level is that output level beyond which no further increase in output is produced by further writing.
- g. Erasing rate is the time rate of erasing the stored information from one specified level to another.
- h. Decay time is the time interval during which the stored information decays to a stated fraction of its initial value.

3. Equipment.

- a. The reading and writing deflection system(s) shall produce a rectilinear (e.g., TV) type raster repeated at a rate specified in the TSS.
- b. The TUT output shall be monitored on a CRT with a raster scan synchronized to the reading raster, and on an oscilloscope with provisions for selecting the video signal from any line of the reading raster and identifying the line on the CRT display.
- c. The output-signal amplifier shall be linear, compensated for the output impedance of the TUT, and have a frequency response that is flat within 1 dB between frequencies ( $f_1$ ) and ( $f_2$ ), to insure accurate reproduction of the screen quality of the TUT. The low-frequency response shall be such that a pulse at the input of the amplifier, having a duration equal to the reading raster line-sweep duration, will be reproduced at the output with no more than 5 percent droop.

$f_1$  = the read scan-line repetition rate (Hz).

$f_2 = \frac{R J}{D}$  (MHz).

## MIL-STD-1311D

Where:

- R is the anticipated limiting resolution of the tube in WRSL/SSRD.
- J is the read scan-line length as a fraction of the SSRD.
- D is the active read scan-line duration in microseconds.
- SSRD is the storage surface reference dimension as determined by method 5405.
- WRSL is the written raster scan line.

(It is acceptable to compensate for bandwidth limitations of the amplifier by reducing the reading raster width (J) provided the signal decay time is as specified in the TSS.)

#### 4. Procedure.

##### a. General.

- (1) Operating conditions shall be as specified in the TSS.
- (2) The size of a blemish shall be measured between the blemish 50-percent amplitude levels and expressed as a percentage of the SSRD.
- (3) The oscilloscope line-selector and CRT display shall be used to determine the location of blemishes.
- (4) Both writing and reading focus shall be optimized to give highest resolution at the area being inspected for blemishes.
- (5) Unless otherwise specified in the TSS, the diameter of elongated blemishes shall be taken as half the sum of the length and width.

- b. Static-light blemishes. Static-light blemishes shall be observed under the specified test conditions in the absence of writing. The amplitude of the blemish signals with respect to the saturated signal level ( $\frac{B}{A} \times 100\%$  of figure 5408-1) and the sizes and spacing of the blemishes with respect to the SSRD shall be observed.

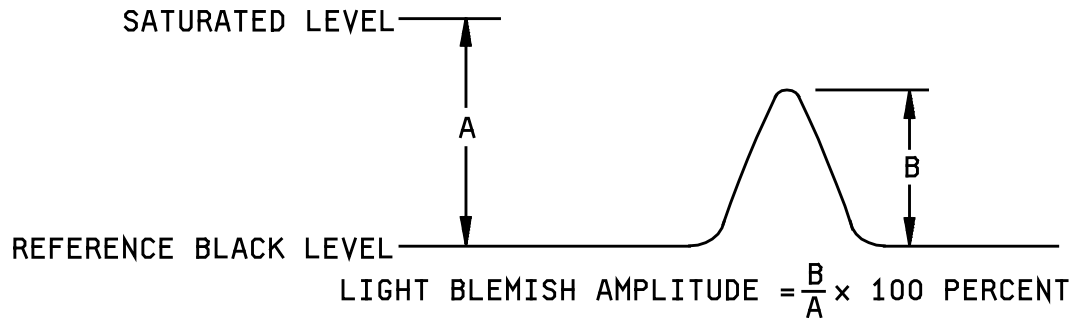
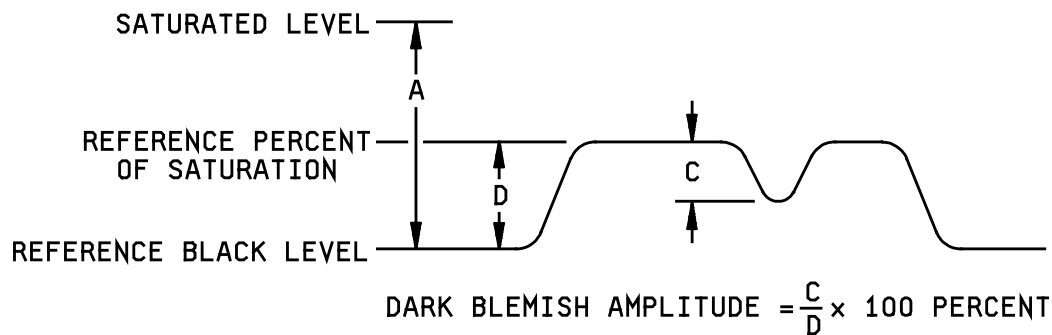
- c. Static-dark blemishes. Static-dark blemishes shall be observed with the entire storage surface written to a given percentage of the saturation level ( $\frac{D}{A} \times 100\%$  on figure 5408-2). Unless otherwise specified in the TSS, this shall be 50 percent. The amplitudes of the blemish signals ( $\frac{C}{D} \times 100\%$  on figure 5408-2) and the sizes and spacing of the blemishes with respect to the SSRD shall be observed.

- d. Dynamic blemishes. Dynamic blemishes shall be observed with the entire storage surface written to a given percentage of the saturation level ( $\frac{D}{A} \times 100\%$  on figure 5408-2). Unless otherwise specified in the TSS, this shall be 90 percent. The erasing rate, if dynamic erasure is used, and decay time shall be as specified. At a specified time after writing, the blemishes shall be observed. The amplitudes of the blemish signals ( $\frac{C}{D} \times 100\%$  on figure 5408-2), the polarity of the blemish signals (light or dark), and the sizes and spacing of the blemishes with respect to the SSRD shall be observed.

## MIL-STD-1311D

5. TSS requirements.

- a. In addition to the operating conditions for the TUT, the TSS shall specify the following for this test:
  - (1) The maximum number of blemishes allowed in each blemish category.
  - (2) The blemish amplitude limit(s).
  - (3) The minimum blemish spacing.
  - (4) The erase conditions and decay time for dynamic blemish inspection.
  - (5) The time interval between writing and the dynamic blemish inspection.
- b. If values other than those specified in this test method are required, the TSS shall specify:
  - (1) Separate size limit(s) for elongated blemishes.
  - (2) Writing level, as a percentage of saturation, for static-dark blemish inspection.
  - (3) Writing level, as a percentage of saturation, for dynamic-blemish inspection.

FIGURE 5408-1. Light blemish.FIGURE 5408-2. Dark blemish.

MIL-STD-1311D

METHOD 5409A

BLEMISHES, VISUAL-OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to determine the blemish quality of a tube by measuring, or counting, the following parameters:

- a. The blemish output signal levels relative to the output signal levels of adjacent areas.
- b. The size of the blemishes.
- c. The spacing of the blemishes.
- d. The number of blemishes within a stated zone of the storage surface.

2. Definitions.

- a. A blemish is a localized imperfection of the storage assembly, phosphor screen, or faceplate that produces an abrupt variation in output luminance.
- b. Static blemishes are blemishes whose presence is not a function of writing or erasing rates.
- c. Dynamic blemishes are blemishes whose presence is a function of writing or erasing rates.
- d. Light blemishes are blemishes which, under specified test conditions, are brighter than the background luminance.
- e. Dark blemishes are blemishes which, under specified test conditions, are darker than the background luminance.

3. Equipment.

- a. A photometer shall be used to measure the background the background luminance of the TUT over a circular area  $10 \pm 5$  mm (approximately  $.4 \pm .2$  inch) in diameter.
- b. If specified in the TSS, a photometer with a small aperture size shall be specified in the TSS.
- c. The erase system shall produce the erase pulse width, amplitude, and repetition rated specified in the TSS.
- d. The write deflection system shall produce a linear raster of merged scanning lines at a repetition rate specified in the TSS.
- e. Optical magnification may be used in the measurement of blemish dimensions.

4. Procedure.

4.1 Tube not energized. Those sections of MIL-PRF-1 which apply to inspection of cathode-ray tubes for screen and faceplate defects shall also apply to visual output cathode-ray charge storage tubes with the exception of those items which require the tube to be energized.

4.2 Tube energized.

4.2.1 General.

- a. Operating conditions including the duty cycle of the erase pulse train, the erase pulse amplitude, and the ambient light level shall be as specified in the TSS.
- b. Unless otherwise specified in the TSS, the existence of blemishes shall be determined visually without requiring a small aperture photometer.

## MIL-STD-1311D

4.2.2 Static blemishes. Static blemishes shall be measured under conditions of dynamic erasure with no writing. When the erase pulse train is turned on, static blemishes which are present will appear as blemishes which do not change in size or intensity with time.

4.2.3 Dynamic blemishes. Dynamic blemishes shall be measured under conditions of dynamic erasure with writing.

- a. The write raster shall just overscan the useful viewing area in both directions.
- b. The write-gun drive shall be adjusted to write the display to the luminance specified and over the area specified.
- c. At a specified time after writing, the blemishes shall be observed.

5. TSS requirements.

- a. In addition to the operating conditions for the TUT, the TSS shall specify the following:
  - (1) The maximum number of blemishes allowed in each blemish category.
  - (2) The minimum blemish spacing.
  - (3) The erase pulse limit(s).
  - (4) Writing luminance level.
  - (5) The time interval between writing and the dynamic blemish inspection.
- b. If the TSS specifies that the light output from blemishes is to be measured with a photometer, the TSS shall specify the effective aperture of the photometer.

## MIL-STD-1311D

## METHOD 5410

## RESOLUTION, ELECTRICAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to measure the quantity of information that may be written in and read out of a storage tube.

2. Equipment.

- a. The writing-deflection system shall produce a raster of essentially parallel equally-spaced lines written at the sweep speed(s) and at the frame rate(s) as specified in the TSS. The spacing between the lines shall be adjustable.
- b. The reading-deflection system shall produce a rectilinear (e.g., TV) type raster with lines disposed essentially orthogonal to the written lines, and repeated at a rate as specified in the TSS.
- c. External focus and deflection components when used shall be located with respect to the TUT as specified in the TSS.
- d. The output-signal amplifier shall be linear, compensated for the output impedance of the TUT, and have a frequency response that is flat within 1 dB between frequencies ( $f_1$ ) and ( $f_2$ ), to insure accurate reproduction of the output signal from the TUT.

$f_1$  = the read scan-line repetition rate (Hz)

$$f_2 = \frac{RJ}{D} \text{ (MHz).}$$

Where:

R is the anticipated limiting resolution of the TUT in WRSL/SSRD.

J is the read scan-line length as a fraction of the SSRD.

D is the active read scan-line duration in microseconds.

SSRD is storage surface reference dimensions determined by method 5405.

WRSL is the written raster scan line.

(It is acceptable to compensate by bandwidth limitations of the amplifier by reducing the reading raster width (J), or by reducing the angle between the reading and writing scan directions.)

- e. The storage tube's output shall be monitored visually on a raster type (e.g., TV) display, scanned in synchronism with the reading scan; and on an oscilloscope.

3. Procedure. Resolution may be determined by either of the following methods:

3.1 Orthogonal write-read test method.

- a. Operating voltages and conditions shall be within the limits specified in the TSS.
- b. Adjust operating conditions so that visual representation of the entire storage target is seen on the raster type display.
- c. Adjust writing conditions to produce and establish write saturation level. Writing raster lines shall be spaced such that there is no discernible overlap.
- d. Adjust writing beam current to obtain the percentage of saturation specified in the TSS.

## MIL-STD-1311D

- e. Adjust read output signal amplitude and decay rate (when applicable) to the values specified in the TSS.
- f. Unless otherwise specified in the TSS, focus shall be adjusted for optimum at the location(s) under test.
- g. While examining on the oscilloscope the output signal from the reading raster-line(s) at the location(s) specified in the TSS, decrease the spacing between the writing-raster scan lines, erasing as necessary, until the amplitude of peak-to-peak output signal, relative to the amplitude of the peak-to-peak output signal for widely spaced writing scan lines, is as specified in the TSS. The orthogonal write-read resolution, at the amplitude specified in the TSS, is then equal to:

$$\frac{N}{h} \text{ (WRSL/SSRD)} \\ \text{amplitude specified.}$$

Where:

N is the number of scan lines written.

h is the written raster height as a fraction of the SSRD.

(For multi-gun tubes, writing, reading, and erasing may be simultaneous or sequential. For single gun tubes, these operations are performed sequentially.)

- h. When specified in the TSS, the test should be repeated with both rasters rotated 90°. A single compromise focus condition shall be used.

### 3.2 Shrinking raster test method.

- a. Operating voltages and conditions shall be within the limits specified in the TSS.
- b. Adjust operating conditions so that visual representation of the entire storage target is seen on the raster type display.
- c. Adjust writing conditions to produce and establish write saturation level. Writing raster lines shall be spaced such that there is no discernible overlap.
- d. Adjust writing beam current to obtain the percentage of saturation specified in the TSS.
- e. Adjust read output signal amplitude and decay rate (when applicable) to the values specified in the TSS.
- f. Unless otherwise specified in the TSS, focus shall be adjusted for optimum at the location(s) under test.
- g. While examining the TUT output on the raster display at the location(s) specified in the TSS, decrease the spacing between the writing-raster scan lines, erasing as necessary, until the individual lines in the written-raster first merge into a uniform brightness. The shrinking raster resolution is then equal to:

$$\frac{N}{h} \text{ (WRSL/SSRD)} \\ \text{merged raster.}$$

Where:

N is the number of scan lines written.

h is the written raster height as a fraction of the SSRD.

(For multi-gun tubes, writing, reading, and erasing may be simultaneous or sequential. For single gun tubes, these operations are performed sequentially.)

- h. When specified in the TSS, the test should be repeated with both rasters rotated 90°. A single compromise focus condition shall be used.



## MIL-STD-1311D

4. Precautions. The individual lines of the written raster are readily discernible at large spacings but blend into a relatively uniform brightness as the spacing between written lines is decreased.

It is essential to determine the condition where the written lines first merge in the specified faceplate location(s), before measuring the raster height (h). Shrinking the raster beyond the first-merge condition may give a false indication of line separation and subsequently result in a second-merge condition which will give an erroneous raster height measurement.

5. TSS requirements. The TSS shall specify the following:

5.1 Equipment.

- a. Sweep speed(s) and frame rate(s) (see 2a).
- b. Reading raster repetition rate (see 2b).
- c. When used, external focus and deflection component locations (see 2c).

5.2 Orthogonal write-read test method.

- a. Limits of operating voltages and conditions (see 3.1a).
- b. Percentage of saturation to result from writing beam (see 3.1d).
- c. Read output signal amplitude and decay rate (when applicable) (see 3.1e).
- d. Focus adjustment, only if it is to be other than optimum (see 3.1f).
- e. Location(s) from which the output signal is to be taken (see 3.1g).
- f. Relative amplitude of the peak-to-peak output signal at which the resolution is to be evaluated (see 3.1g).
- g. Whether or not the test should be repeated with both rasters rotated 90° (see 3.1h).

5.3 Shrinking raster test method.

- a. Limits of operating voltages and conditions (see 3.2a).
- b. Percentage of saturation to result from writing beam (see 3.2d).
- c. Read output signal amplitude and decay rate (when applicable) (see 3.2e).
- d. Focus adjustment, only if it is to be other than optimum (see 3.2f).
- e. Location(s) at which the resolution is to be measured (see 3.2g).

MIL-STD-1311D

METHOD 5411

RESOLUTION, VISUAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to measure the quantity of information that may be written in and read out of a storage tube.

2. Equipment.

- a. The writing-deflection system shall produce a raster of essentially parallel equally-spaced lines written at the sweep speed(s) and at the frame rate(s) as specified in the TSS. The spacing between the lines shall be adjustable.
- b. External focus and deflection components when used shall be located with respect to the TUT as specified in the TSS.
- c. The TUT output shall be monitored visually.
- d. A photometer shall be used to measure the luminance of the TUT over a circular area  $10 \pm 5$  mm (approximately  $.4 \pm .2$  inch) in diameter, or as specified in the TSS.

3. Procedure.

- a. Operating voltages and conditions shall be within the limits specified in the TSS.
- b. The raster repetition frequency, the total number of superimposed rasters, the scanning speed, and the erase conditions (when applicable) shall be as specified in the TSS.
- c. The resolution shall be measured at the luminance value(s) and at the faceplate location(s) specified in the TSS.
- d. Unless otherwise specified in the TSS, focus shall be adjusted for optimum at the location(s) under test.
- e. When examining the output display, the TUT shall be written at the location(s) specified in the TSS; then erased and rewritten with the lines spaced progressively closer until the individually written raster lines first merge into a uniform brightness. The shrinking raster resolution is then equal to:

$$\frac{N}{h} \text{ (WRSL/raster height)} \\ \text{merged raster.}$$

Where:

N is the number of scan lines written.

h is the written raster height.

WRSL is the written raster scan line.

(For multigun tubes, writing, reading, and erasing may be simultaneous or sequential. For single gun tubes, these operations are performed sequentially.)

- f. When specified in the TSS, the test should be repeated with the raster rotated  $90^\circ$ . A single compromise focus condition shall be used.

## MIL-STD-1311D

4. Precautions.

- a. To assure that stray light sources do not significantly affect luminance measurements, the light level recorded by the photometer in the measurement position shall be such that, with the TUT off, the photometer reading does not exceed 3 percent of the TUT luminance value to be measured.
- b. The individual lines of the written raster are readily discernible at large spacings but blend into a relatively uniform brightness as the spacing between written lines is decreased.

It is essential to determine the condition where the written lines first merge in the specified faceplate location(s), before measuring the raster height (h). Shrinking the raster beyond the first-merge condition may give a false indication of line separation and subsequently result in a second-merge condition which will give an erroneous raster height measurement.

5. TSS requirements. The TSS shall specify the following.5.1 Equipment.

- a. Sweep speed(s) and frame rate(s) (see 2a).
- b. When used, external focus and deflection component locations (see 2b).
- c. The area of the photometer measurement, only if it is to be other than as specified in 2d.

5.2 Procedure.

- a. Limits of operation voltages and conditions (see 3a).
- b. The raster repetition frequency, the total number of superimposed rasters, the scanning speed, and the erase conditions (when applicable) (see 3b).
- c. Luminance value(s) and faceplate location(s) at which resolution shall be measured (see 3c).
- d. Focus adjustment, only if it is to be other than optimum (see 3d).
- e. Location(s) at which rasters shall be written (see 3e).
- f. Whether or not the test should be repeated with both rasters rotated 90° (see 3f).

## MIL-STD-1311D

## METHOD 5412

## LUMINANCE (light output), VISUAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to measure the luminance of a visual output storage tube. It may be measured under different procedures depending on the characteristic of the tube that is to be measured. The TSS shall specify which of the following procedures shall be used.

2. Definitions.

- a. Luminance is the luminous intensity per unit area on the screen. Unless otherwise specified, it is measured in a direction normal to the faceplate.
- b. Saturation level is that level of luminance beyond which no further increase in luminance is produced by additional writing. The tube can be written to saturation level by writing up the entire viewing area with the erase pulse amplitude set at zero and then cutting off the write beam.

3. Equipment.

- a. A photometer shall be used to measure the luminance of the TUT over a circular area  $10 \pm 5$  mm (approximately  $.4 \pm .2$  inch) in diameter.
- b. Method B additionally requires a deflection system. The deflection system shall produce a raster from a linear sawtooth field sweep at a  $60 \frac{1}{\text{Hz}}$  repetition frequency and a  $53 \frac{1}{\text{microsecond}}$  linear sawtooth sweep having a  $63.5 \frac{1}{\text{microsecond}}$  period or as specified in the TSS.
- c. In method B the writing control circuits shall be adjustable, but once adjusted for this test shall maintain a constant unblanking level during the active periods of the write cycles.
- d. In method B an erase system shall produce rectangular erase pulses with a width of  $0.5 \frac{1}{\text{millisecond}}$  and a frequency of  $60 \frac{1}{\text{Hz}}$ , synchronized with the linear sawtooth field sweep or as specified in the TSS. Viewing screen current may be reduced or cut off during the erase period as specified in the TSS.

4. Procedures. The TSS shall specify which of the following procedures shall be used.4.1 Method A. This method is for the measurement of saturation luminance ( $B_s$ ).

- a. Operating conditions shall be as specified in the TSS.
- b. Without erasing, overscan the screen to write the entire target area to saturation level
- c. Stop writing. Without changing the operating conditions, wait approximately 10 seconds and measure the saturation luminance(s) at the center of the screen or at the location(s) specified on the TSS.

4.2 Method B. This method is for the measurement of the dynamic equilibrium luminance ( $B_E$ ) and is intended primarily for tubes whose applications include TV display.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write the entire area specified in the TSS to saturation level.
- c. Stop writing. Use the erase pulse width and frequency amplitude until the last portion of the entire area specified has just been erased. The erase pulse amplitude found shall be used throughout the remaining test procedure.

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1/ Typically, 525 line television system.

## MIL-STD-1311D

- d. While simultaneously writing and erasing, adjust the unblanking level until there is no further increase in luminance of the area specified in the TSS.
- e. Without changing operating conditions, measure the dynamic equilibrium luminance at the center of the screen or at the location(s) specified in the TSS.

5. Precautions.

- a. To assure that stray light sources do not significantly affect luminance measurements, the light level recorded by the photometer in the measurement position shall be such that, with the TUT off, the photometer reading does not exceed 3 percent of the TUT luminance value to be measured.
- b. Luminance measurements shall be made under carefully controlled conditions. Even under photometric laboratory conditions, accuracies within 5 percent are difficult to achieve. In the average production environment, accuracies within 10 percent may be expected. A major source of this error is the difference in ability of the different photometers to match the CIE (Commission Internationale de l'Eclairage) Standard Observer Luminosity Response. This error source is especially important when a large portion of the luminous energy is in the blue and red regions where deviations are most prevalent.

6. TSS requirements.

- a. The TSS shall specify the following:
  - (1) Which method(s) are to be used.
  - (2) Operating conditions for the TUT.
- b. If values other than those specified in this test method, the TSS shall specify:
  - (1) Photometer area (see 3a).
  - (2) Deflection system timing (see 3b).
  - (3) Erase system timing (see 3d).
  - (4) Location(s) on screen if other than center, at which the particular measurement is to be made.

7. Comments on luminance testing. These comments are offered as an aid in meeting the requirement stated in 5a.

- a. Light shields. To obviate the necessity of a photometric laboratory, an "in situ" test setup can be accommodated if the ambient illumination can be sufficiently deleted from its effect on the photometric readings. This desirable situation can best be obtained through the use of a light box as in figure 5412-1 or draped curtains. They may take the form of black painted cardboard in the shape of an inverted "U" channel or simply some black velvet cloth draped for best effect. The desired objective is to minimize the light leakage from affecting the photometer reading. It must be remembered that light leakage can be by direct illumination and by reflection. Small sources such as pilot lamps in the field of view of the photometer can introduce large errors.
- b. Intermediate baffles can be used to block direct light and also increase the leakage light distance. This type of baffle would consist of a wall with a hole cut in it so as not to affect the desired signal light reading and placed approximately midway between the entrance pupil of the photometer and the test plane. The effect is that spurious light would have to travel a greater distance in order to register on the photometer. Figure 5412-2 shows how the light from the left extraneous source is blocked and also how the specular reflection of the right source is blocked. In addition any resulting diffuse reflection is greatly reduced.
- c. Photometer optics light scattering. Light scattering in the photometer optics can introduce a large error when measuring a small dark area surrounded by a large bright area. A very small percentage of the light transmitted by the photometer optics is actually scattered rather than imaged as it should be in a "spot" photometer. If the surrounding luminance is much greater than the measured spot, the effect would be to bias the reading by means of the scattered light and the error could easily be of the same order as the true value. To reduce this effect, the use of target baffles can be employed. This may consist of an opaque material with a small hole cut into it. The hole should be just larger than the area under test and placed as close to the test plane as convenient. This procedure will reduce the light scattering effect in proportion to the area reduction.

MIL-STD-1311D

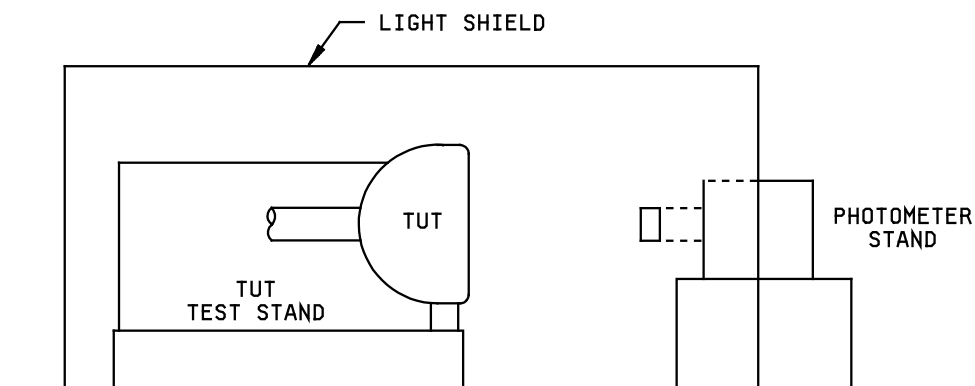


FIGURE 5412-1. Light box test setup.

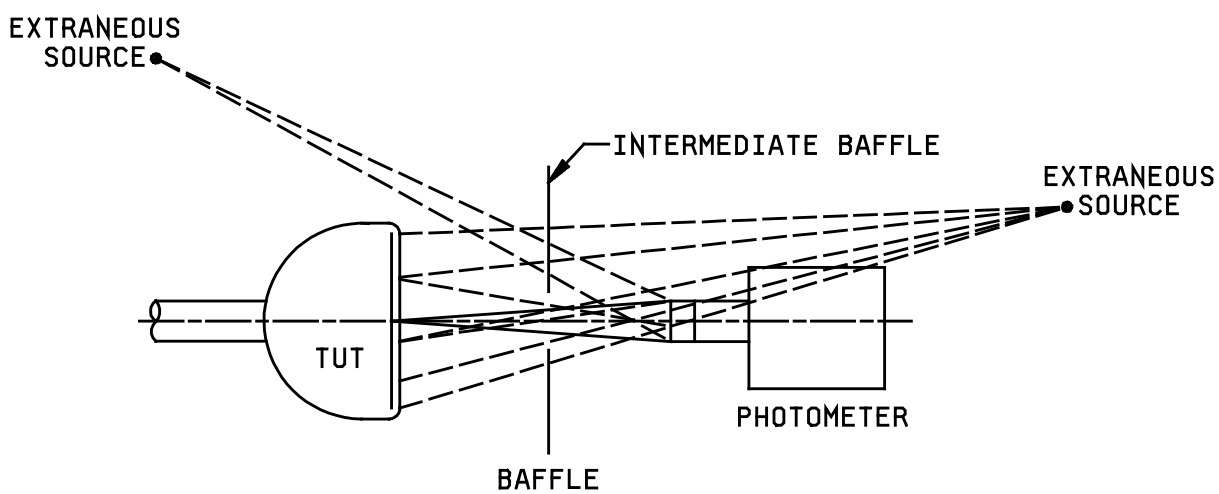


FIGURE 5412-2. Intermediate baffle.

## MIL-STD-1311D

## METHOD 5413

## UNIFORMITY, OUTPUT SIGNAL AMPLITUDE, ELECTRICAL OUTPUT

(Cathode-ray charge storage tube)

1. Purpose. The purpose of this test is the measurement of the evenness of output signal amplitude from the TUT. The test procedure measures the spatially fixed, gradual variations in output signal amplitude.

2. Equipment.

- a. A deflection system shall produce writing and reading rasters in the TUT, each with linear saw-tooth deflections in orthogonal directions. The line scan in the reading raster shall be orthogonal to the line scan in the writing raster.
- b. The TUT shall be monitored on a CRT with a raster scan synchronized to the reading raster, and on an oscilloscope with provisions for selecting the video output from any line of the reading raster.
- c. The output-signal amplifier shall be linear, compensated for the output impedance of the TUT, and have a frequency response that is flat within 1 dB between frequencies ( $f_1$ ) and ( $f_2$ ), to insure accurate reproduction of the line spread function from the TUT.

$f_1$  = the read scan-line repetition rate (Hz)

$$f_2 = \frac{RJ}{D} \text{ (MHz)}$$

Where:

R is 100 cycles/SSRD (arbitrarily set).

J is the read scan-line length as a fraction of the SSRD.

D is the active read scan-line duration in microseconds.

- d. The writing gun control circuits shall produce a square-wave signal of approximately 10 cycles, synchronized to the line scan and shall maintain constant unblanking level during the active portions of the write cycle.

3. Procedure.

- a. Operating conditions shall be as specified in the TSS.
- b. The oscilloscope display shall be synchronized to the line scan and shall display any line within the area specified within the TSS. Output signals from outside the area specified in the TSS shall be disregarded. The line select feature of the equipment shall be used to determine which portions of the output are within the area specified in the TSS.
- c. Operate the TUT such that the reading time is maximum, or as specified in the TSS.
- d. Without erasing, write the entire area specified to the saturation level.
- e. Stop writing. Use the erase procedure specified in the TSS and adjust conditions to obtain a single erase cycle that will cause the fastest erasing portion of the specified area to just be erased. Immediately proceed to 3f.
- f. Use a pattern of 10 black and 10 white bars, all of approximately equal width, orthogonal to the read line scan, and write with overlapping scan lines until the fastest writing portion of the specified area just reaches saturation level. Stop writing.

## MIL-STD-1311D

g. Using the line select feature of the equipment, determine the following parameters:

- (1) Maximum white signal,  $I_{w_{\max}}$ .
- (2) Minimum white signal,  $I_{w_{\min}}$ .
- (3) Maximum black signal,  $I_{bk_{\max}}$ .
- (4) Minimum black signal,  $I_{bk_{\min}}$ .

h. Calculate average signal output current  $I_{av}$  from the following expression:

$$I_{av} = \frac{(I_{w_{\max}} - I_{bk_{\min}}) + (I_{w_{\min}} - I_{bk_{\max}})}{2}$$

i. Calculate output signal uniformity factor  $S_w$  from the following expression:

$$S_w = \frac{(I_{w_{\max}} - I_{w_{\min}}) + (I_{bk_{\max}} - I_{bk_{\min}})}{I_{av}}$$

4. Precautions.

Determination of the levels called for in 3g above, shall be done as rapidly as possible to minimize errors due to change in signal level caused by signal decay.

5. TSS requirement.

a. In addition to the operating conditions for the TUT, the TSS shall specify the following:

- (1) The area of the target within which the uniformity is to be measured.
- (2) Erase procedure.

b. If values other than those specified in this test method are required, the TSS shall specify: Reading time, see 3c.



## MIL-STD-1311D

## METHOD 5414

## UNIFORMITY, LUMINANCE, VISUAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to measure the evenness of luminance from the TUT. Four separate methods using combinations of writing and erasing, and under static and dynamic operations are given.

2. Definitions.

Saturation level is that level of luminance beyond which no increase in luminance is produced by additional writing. The tube can be written to saturation level by writing up the entire viewing area with the erase pulse amplitude set at zero and then cutting off the write beam.

3. Equipment.

- a. A photometer shall be used to measure the luminance of the TUT over a circular area  $10 \pm 5$  mm (approximately  $.4 \pm .2$  inch) in diameter in the following four methods (A, B, C, and D).

In methods C and D, the photometer shall have a response time less than 0.1 second. (Such characteristic could be achieved through the use of a peak holding device coupled to a fast response light sensor.)

- b. A stop watch or other elapsed time indicator is required in method C.

- c. A deflection system shall produce a raster on the TUT with linear sawtooth deflections in orthogonal directions.

(1) In methods A and B, the raster shall be overmerged and its size adjusted such that the writing beam writes on all parts of the area specified in the TSS.

(2) In methods C and D the frame sweep shall be at a rate of 2 inches (50.8 mm) per second and the line sweep shall be at a rate of .016 inch (0.41 mm) per microsecond, or as specified in the TSS. In methods C and D, the frame and line periods shall be no greater than 125 percent of the resulting sweep times, or as specified in the TSS (for example: with a 4-inch by 4-inch (101.6 mm by 101.6 mm) raster:

Frame-sweep time	= 2 seconds
Frame period	= 2.5 seconds maximum
Line-sweep time	= 250 microseconds
Line period	= 312.5 microseconds maximum).

- d. The writing control circuits shall be adjustable, but once adjusted in methods A, C, and D, shall maintain a constant unblanking level during the active periods of the write cycle.

In method B, the writing control circuit shall be adjustable to permit writing to saturation level as specified.

- e. A random noise generator is required for method C. It shall provide a white gaussian noise signal with a bandwidth of approximately 20 Hz to 500 kHz or as specified in the TSS, at an amplitude specified in the TSS.

## MIL-STD-1311D

4. Procedure. Luminance uniformity may be measured by use of any of the following four methods. The choice of a given method or methods is determined by the display application contemplated. The TSS should specify only the method(s) applicable to the end use.

4.1 Method A. This method measures the luminance uniformity factor (SW) under static writing conditions.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write the entire usable area specified in the TSS to saturation level.
- c. Stop writing. Unless otherwise specified in the TSS, use a 1-second erase pulse and adjust its amplitude until application of a single pulse to the backing electrode will erase the last portion of a fully written area to just cutoff.
- d. Without simultaneously erasing, write the entire specified area until the brightest portion (found at the time of this measurement and within the specified area) is equal to the luminance level (Ba) specified in the TSS; then stop writing.
- e. Without changing the operating conditions, immediately measure the luminance (Bb) of the darkest area.
- f. Calculate the luminance uniformity factor (SW) for the specified value of (Ba) using the formula:

$$\text{Luminance uniformity factor (SW)} = \frac{Ba - Bb}{Ba}$$

4.2 Method B. This method measures the luminance uniformity factor (SE) under static erasing conditions.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write all of the area specified in the TSS to saturation level.
- c. Stop writing. Unless otherwise specified in the TSS, apply a 1-second erase pulse to the backing electrode; adjust its amplitude until application of a single pulse will erase the brightest remaining portion of the fully written specified area to the luminance level specified in the TSS (Bc). If luminance level (Bc) is not achieved, readjust the erase pulse amplitude; repeat the writing step and erase.
- d. Stop erasing and without changing the operating conditions, find and immediately measure the lowest luminance level (Bd) within the specified area.
- e. Calculate the luminance uniformity factor (SE) for the specified value of (Bc) from the formula:

$$\text{Luminance uniformity factor (SE)} = \frac{Bc - Bd}{Bc}$$

4.3 Method C. This method measures the luminance decay uniformity factor-dynamic decay write erase (DDWE) under conditions of dynamic writing and erasing in which the writing signal is generated by a random noise generator. The factor is a time ratio.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write the entire area specified in the TSS to saturation level (noise not applied).
- c. Stop writing. Use the erase pulse width and frequency within the ranges specified in the TSS. Slowly increase the erase pulse amplitude until the last portion of the specified area has just been erased within time period (T2), as specified in the TSS.

## MIL-STD-1311D

- d. Using the noise signal within specified limit(s), adjust the unblanking pulse, erase duty cycle, and erase amplitude within specified limit(s) to achieve a stabilized writing and erasing cycle whereby:
- (1) The slowest erasing portion of the specified area is completely erased immediately prior to being rewritten.
  - (2) The noise signal is writing to the peak luminance level specified in the TSS.
  - (3) The unblanking level is adjusted just below the point at which storing would occur in the absence of the noise signal.
  - (4) The display uniformity is optimized.

NOTE: The stability of the writing and erasing cycle shall be verified by observation over a period of 2 minutes or as specified in the TSS.

- e. Without any adjustments, find the fastest erasing area. Measure the time interval (T1) between peak luminance level and complete erasure.
- f. Calculate the luminance decay uniformity factor for the specified value of (T2) from the formula:

$$\text{Luminance decay uniformity factor (DDWE)} = \frac{T2 - T1}{T2}$$

Where:

T2 is the time interval between peak luminance level and complete erasure of the slowest erasing area.

T1 is the time interval between peak luminance level and complete erasure of the fastest erasing area.

4.4 **Method D.** This method measures luminance uniformity factor-dynamic/write erase (DWE) under conditions of dynamic writing and erasing in which the writing signal is an unblanking pulse.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write the entire area specified in the TSS to saturation level.
- c. Stop writing. Use the erase pulse width and frequency within the ranges specified in the TSS. Slowly increase the erase pulse amplitude until the last portion of the specified area has just been erased within the frame period specified in the TSS.
- d. Adjust the unblanking pulse, erase duty cycle and erase amplitude within specified limit(s) to achieve a stabilized writing and erasing cycle whereby:
  - (1) The slowest erasing portion of the specified area is completely erased immediately prior to being rewritten.
  - (2) The unmodulated, unblanking pulse is writing the brightest writing area to the peak luminance level (B2) specified in the TSS.
  - (3) The display uniformity is optimized.

NOTE: The stability of the writing and erasing cycle shall be verified by observation over a period of 2 minutes or as specified in the TSS.

- e. Without further adjustments, find the peak luminance level of the lowest brightness writing area. Measure and record as B1.
- f. Calculate the luminance uniformity factor (DWE) for the specified value of (B2) from the formula:

$$\text{Luminance uniformity factor (DWE)} = \frac{B2 - B1}{B2}$$

## MIL-STD-1311D

5. Precautions.

- a. To assure that stray light sources do not significantly affect luminance measurements, the light level recorded by the photometer in the measurement position shall be such that, with the TUT off, the photometer reading does not exceed 3 percent of the TUT luminance value to be measured.
- b. Luminance measurements shall be made under carefully controlled conditions. Even under photometric laboratory conditions, accuracies within  $\pm 5$  percent are difficult to achieve. In the average production environment, accuracies within  $\pm 10$  percent may be expected. A major source of this error is the difference in ability of the different photometers to match the CIE (Commission Internationale de l'Eclairage) Standard Observer Luminosity Response. This error source is especially important when a large portion of the luminance is in the blue and red regions where deviations are most prevalent.
- c. Where required to write the display area to saturation level, do not overdrive the write gun beyond the level necessary to reach saturation.

6. TSS requirements.

- a. In addition to the operating conditions for the TUT, and the specific method(s) of test to be used, the TSS shall specify the following when applicable:
  - (1) The area of the display within which luminance uniformity is measured.
  - (2) Amplitude of the random noise signal (see 3d, 4.3d).
  - (3) Luminance level (Ba) (see 4.1d).
  - (4) Luminance level (Bc) (see 4.2c).
  - (5) Erase pulse widths and frequencies (see 4.3c, 4.4c).
  - (6) Time period (T2) (see 4.3c).
  - (7) Unblanking pulse and erase pulse amplitudes (see 4.3d, 4.4d).
  - (8) Peak luminance level (see 4.3d(2)).
  - (9) Peak luminance level (B2) (see 4.4d(2), 4.4f).
  - (10) Time for erasure (see 4.4c).
- b. If values other than those specified in this test method are required, the TSS shall specify the following when applicable:
  - (1) Frame and line sweep rates (see 3c).
  - (2) Ratio of sweep periods to sweep times (see 3c).
  - (3) Random noise signal bandwidth (see 3d).
  - (4) Erase pulse widths (see 4.1c, 4.2c).
  - (5) Stability period (see 4.3d, 4.4d).

## MIL-STD-1311D

## METHOD 5415

## WRITING RESPONSE, STATIC, VISUAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is the measurement of the luminance that can be achieved by writing a single field at a specified grid drive level and at a specified scanning speed.

2. Equipment.

- a. A photometer shall be used to measure the luminance of the TUT over a circular area  $10 \pm 5$  mm (approximately  $.4 \pm .2$  inch) in diameter.
- b. A deflection system shall produce a raster on the TUT with linear sawtooth deflections in orthogonal directions. The raster size and line density shall be adjustable. The capability to change raster scan directions by  $90^\circ$  shall be provided.

3. Procedure.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write all of the area specified in the TSS to saturation level.
- c. Stop writing. Using the erase procedure specified in the TSS for this test, erase until the last portion of the specified area has just been erased.
- d. The tube shall be consecutively written with a single field, viewed, and erased with the lines spaced progressively closer until the individually written lines in the raster first merge into a uniform brightness.
- e. Once the first merged condition is obtained, measure and record raster height. Change the raster scan by  $90^\circ$ . The raster width shall be maintained equal when the raster direction is changed. Repeat 3d and adjust focus, if necessary, until raster heights in the two orthogonal directions are within 10 percent of one another. Consecutively erase and write again. Immediately measure the luminance of the specified area.

NOTE: For the purpose of this test, raster height shall be measured in a direction perpendicular to that of the line scan.

- f. The static writing response shall be measured at the grid drive, the scanning speed, and at the faceplate location(s) specified in the TSS.
- g. The static writing response shall be stated in terms of measured luminance at given grid drive and scanning speed.

Static writing response = Bsw, a function (V,S).

Where:

Bsw = luminance of specified area (foot lamberts)

V = grid drive (volts)

S = scanning speed (inches/second)

Alternatively, static writing response may be stated as a percentage,

$$Rsw(V, S) = \frac{\Delta B_{sw}(V, S)}{B_{sat}} \times 100\%.$$

$\Delta B_{sw}(V, S)$  is the luminance change between the written and the erased condition and  $B_{sat}$  is the saturated luminance.

MIL-STD-1311D

4. Precautions.

- a. To assure that stray light sources do not significantly affect luminance measurements, the light level recorded by the photometer in the measurement position shall be such that, with the TUT off, the photometer reading does not exceed 3 percent of the TUT luminance value to be measured.
- b. The individual lines of the written raster are readily discernable at large spacings but blend into a relatively uniform brightness as the spacing between written lines is decreased.

It is essential to determine the condition where the written lines first merge in the specified faceplate location(s), before measuring the raster height (h). Shrinking the raster beyond the first-merge condition may give a false indication of line separation and subsequently result in a second merge condition which will give an erroneous raster height measurement.

5. TSS requirements. In addition to the operating conditions for the TUT, the TSS shall specify the following:

- a. Area (see 3).
- b. Erase procedure (see 3c).
- c. Grid drive (see 3f).
- d. Scanning speed or the equivalent in terms of raster width and active line scan duration (see 2b and 3f).
- e. Faceplate location(s) for luminance measurement (see 3f).

MIL-STD-1311D

METHOD 5416

ERASING TIME, VISUAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to measure the minimum time required to erase stored information from a specified level of luminance to cutoff.

2. Definitions.

- a. Saturation level is that level of luminance beyond which no further increase in luminance is produced by additional writing. The tube can be written to saturation level by writing up the entire viewing area with the erase pulse amplitude set at zero and then cutting off the write beam.
- b. Pulse train gate time is the total time period during which the erase train is applied to the TUT.

3. Equipment.

- a. A photometer shall be used to measure the luminance of the TUT over a circular area  $10 \pm 5$  mm (approximately  $.4 \pm .2$  inch) in diameter.
- b. A deflection system shall produce a merged raster on the TUT with linear sawtooth deflections in orthogonal directions.

4. Procedure. Erasing time may be determined by either of the following test methods.

4.1 Method A. Erasure with a single pulse.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write all of the area specified in the TSS to saturation level or the luminance level specified in the TSS.
- c. Stop writing. Using an erase pulse of 1 second or less duration, establish the pulse amplitude necessary to reach the storage target cutoff point. This is accomplished by alternately writing to saturation (or the level specified) and erasing, while adjusting the amplitude of the erase pulse.
- d. Alternately write to saturation (or the level specified) and erase to the cutoff point while adjusting the erase pulse width and amplitude for the shortest erase time.

This will require increasing the pulse amplitude and decreasing the pulse width until a width is reached which, if further decreased, will not provide erasure regardless of pulse amplitude.

This pulse width is the single pulse erasing time.

4.2 Method B. Erasure with a pulse train.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write all of the area specified in the TSS to saturation level or the luminance level specified in the TSS.
- c. Stop writing. Using an erase pulse train whose product of pulse repetition frequency, width, and gate time is equal to or less than 1 second, establish the pulse train amplitude necessary to reach the storage target cutoff point. This is accomplished by alternately writing to saturation (or the level specified) and erasing, while adjusting the amplitude of the erase pulse train.

## MIL-STD-1311D

- d. Alternately write to saturation (or the level specified) and erase to the cutoff point while adjusting the pulse train duty cycle and amplitude for the shortest erase time. This will require increasing the pulse train amplitude and decreasing the pulse train duty cycle until a duty cycle is reached which, if further decreased, will not provide erasure regardless of pulse train amplitude.

The minimum erase time is the product of erase prf, pulse width, and gate time. That is:

$$\text{Erase time, minimum} = (\text{prf}) (\text{tp}) (\text{tg})$$

Where:

prf = erase pulse repetition frequency

tp = erase pulse width

tg = total time the erase train is applied.

#### 5. Precautions.

- a. To assure that stray light sources do not significantly affect luminance measurements, the light level recorded by the photometer in the measurement position shall be such that, with the TUT off, the photometer reading does not exceed 3 percent of the TUT luminance value to be measured.
- b. This test is not applicable to tubes operating in a bistable mode.
- c. The erase time of some tubes may by design be in excess of 1 second. In such cases, employ in method A, a single pulse of duration sufficiently long to permit erasure. In method B, employ a pulse train whose product of prf, tp, and tg, is sufficiently long to permit erasure.
- d. When pulse train erasure is used, the pulse train gate time shall be no greater than 10 percent of the TUT reading time (see reading time, method 5423) in order to reduce measurement error caused by ion discharge or dielectric leakage effects.
- e. The amplitude of the pulse(s) used to establish the minimum erasing time will be sufficient to result in target areas written to less than the level specified being erased below cutoff. This will reduce writing sensitivity in such areas.

#### 6. TSS requirements.

- a. In addition to the operating conditions for the TUT, the TSS shall specify the following: The area of the display within which erasing time is to be measured.
- b. If values other than those specified in this test method are required, the TSS shall specify: The luminance level to which the display is initially written (see 4.1c, 4.1d, 4.2c, and 4.2d).



## MIL-STD-1311D

## METHOD 5417

## WRITING AND ERASING RESPONSE, DYNAMIC, VISUAL OUTPUT

(Cathode-ray charge storage tube)

1. Purpose. The purpose of this test is to measure the dynamic writing and erasing response of a visual output cathode-ray charge storage tube at specified conditions of luminance, writing-gun grid drive, and scanning speed, while simultaneously erasing to the background luminance level. This test method is intended primarily for tubes used in radar display applications.

2. Equipment.

- a. A photometer shall be used to measure the luminance of the TUT over a circular area  $10 \pm 5$  mm (approximately  $.4 \pm .2$  inch) in diameter, or as specified in the TSS. The photometer shall have a response time less than 0.1 second. (Such a characteristic could be achieved through the use of a peak holding device coupled to a fast response light sensor.)
- b. The deflection system shall produce a linear sawtooth line sweep at a rate of .016 inch (0.41 mm) per microsecond or as specified in the TSS. The frame and line periods shall be no greater than 125 percent of the resulting sweep times, or as specified in the TSS. (For example: with a 4-inch x 4-inch (101.6 mm x 101.6 mm) raster:

Frame-sweep time = 2 seconds

Frame period = 2.5 seconds, maximum

Line-sweep time = 250  $\mu$ s

Line period = 312.5  $\mu$ s, maximum.)

- c. The writing control circuits shall be adjustable, but once adjusted for this test shall maintain a constant unblanking level during the active portions of the write cycles.
- d. A random generator shall provide a white gaussian noise signal with a bandwidth approximately 20 Hz to 500 kHz or as specified in the TSS, at an amplitude specified in the TSS.

3. Procedure.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write the entire area specified in the TSS to saturation level (without noise signal applied.)
- c. Stop writing. Use the erase pulse width and frequency within the ranges specified in the TSS. Slowly increase the erase pulse amplitude until the last portion of the specified area has just been erased within the frame period or as specified in the TSS.
- d. Using the noise signal (V) within the specified limit(s), adjust the unblanking pulse, erase duty cycle, and erase amplitude within specified limit(s) to achieve a stabilized writing and erasing cycle whereby:
  - (1) The slowest erasing portion of the specified area is completely erased immediately prior to being rewritten.
  - (2) The noise signal is writing to the peak luminance level specified in the TSS.
  - (3) The unblanking level is adjusted just below the point at which storing would occur in the absence of the noise signal.
  - (4) The display uniformity is optimized.

NOTE: The stability of the writing and erasing cycle shall be verified by observation over a period of 2 minutes or as specified in the TSS.

## MIL-STD-1311D

- e. Without further adjustments, measure the luminance ( $B_D$ ) at the center of the screen or at the faceplate location(s) specified in the TSS., immediately after the writing beam has stored in those location(s). (Luminance ( $B_D$ ) will always be less than the saturated luminance of the TUT because the stored signal density is always less than 100 percent. The attainable density is determined by such characteristics of the TUT as its resolution, writing speed, and bandwidth.) In addition, at these specified location(s) measure the time for the stored information to decay into the background luminance level. This is time ( $T_D$ ).
- f. The dynamic writing and erasing response ( $D_{W-E}$ ) shall be stated in terms of measured luminance at given grid drive, given decay time, and given scanning speed. The TSS shall specify the required value of ( $B_D$ ) in addition to the setup condition ( $V$ ), ( $S$ ), and ( $T_D$ ).

That is:  $D_{W-E}$  response =  $B_D$ , a function of ( $V$ ,  $S$ ,  $T_D$ ).

Where:

$B_D$  = peak luminance level of written noise (fL).

$V$  = grid drive of noise (rms volts).

$S$  = scanning speed (inches/second).

$T_D$  = time of luminance to decay into background luminance (seconds).

4. Precautions. To assure that stray light sources do not significantly affect luminance measurements, the light level recorded by the photometer in the measurement position shall be such that, with the TUT off, the photometer reading does not exceed 3 percent of the TUT luminance value to be measured.

5. TSS requirements.

- a. In addition to the operating conditions for the TUT, the TSS shall specify the following:
  - (1) Area of tube to be written (see 3b).
  - (2) Erase pulse width and frequency ranges (see 3c).
  - (3) Noise signal ( $V$ ), unblanking pulse, and erase amplitude (see 3d).
  - (4) Peak luminance level (see 3d(2)).
  - (5) Scanning speed and luminance decay time (see 3f).
- b. If values other than those specified in this test method are required, the TSS shall specify:
  - (1) Location(s) on the screen at which response is to be determined (see 3c).
  - (2) Noise bandwidth (see 2d).
  - (3) Photometer area (see 2a).
  - (4) Deflection system (see 2b).
  - (5) Erase observation period (see 3c).
  - (6) Stability observation period (see 3 (note)).

## MIL-STD-1311D

## METHOD 5418

## WRITING AND ERASING RESPONSE, DYNAMIC, ELECTRICAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to measure the dynamic writing and erasing response of an electrical output cathode-ray charge storage tube while writing at the specified scanning speed and while simultaneously erasing at the specified rate. This test method is intended primarily for dual-gun tubes used in radar display applications.

2. Definitions.

- a. Destructive reading is reading that partially or completely erases the information as it is being read.
- b. Write saturation level is that output level beyond which no further increase in output is produced by further writing.

3. Equipment.

- a. Unless otherwise specified in the TSS, the writing deflection system shall produce a raster of 100 equally-spaced lines from a linear sawtooth frame sweep with a 5-second duration at a 12-scan per minute repetition rate, and a linear sawtooth line sweep having an active period of 250 microseconds.

The reading deflection system shall produce a television-type raster in the TUT with the reading line scan orthogonal to the writing line scan.

- b. The output from the TUT shall be monitored on a CRT with raster scan synchronized to the reading raster, and on an oscilloscope with provisions for selecting the video output from any line of the reading raster.
- c. The output-signal amplifier shall be linear, compensated for the output impedance of the TUT, and have a frequency response that is flat within 1 dB between frequencies ( $f_1$ ) and ( $f_2$ ), to insure accurate reproduction of the output signal from the TUT. The low-frequency response shall be such that a pulse at the input of the amplifier, having a duration equal to the reading raster line-scan duration, will be reproduced at the output with no more than 5 percent droop.

$$f_1 = \text{the read scan-line repetition line (Hz).}$$

$$f_2 = \frac{R J}{D} \text{ MHz.}$$

Where:

R is the anticipated limiting resolution of the TUT in WRSL/SSRD.

J is the read scan-line length as a fraction of the SSRD.

D is the active read scan-line duration in microseconds.

SSRD is storage surface reference dimension as determined by method 5405.

WRSL is written raster scan line.

- (d) When operating tubes in other than the destructive reading mode, an erase control circuit shall be provided to give a time-shared, gradual-fade erasing function.

## MIL-STD-1311D

4. Procedure.

- a. Operating voltages and conditions shall be within the limits specified in the TSS.
- b. The size and position of the writing and reading rasters shall be adjusted such that both rasters are squares inscribed in the SSRD.
- c. Adjust reading and erasing conditions and writing-gun drive to achieve a stabilized writing and erasing cycle whereby:
  - (1) The slowest erasing portion of the reading raster area is just erased immediately prior to being rewritten.
  - (2) The written scan lines in the fastest writing area are written to 90 percent of saturation level.

NOTE: The stability of the writing and erasing cycle shall be verified by observation over a period of 2 minutes, or as specified in the TSS.
- d. Measure writing-gun drive.
- e. Locate the slowest writing area, and using the oscilloscope line selector, measure the peak signal in that area immediately after writing.
- f. If a separate erasing cycle is used, measure the cathode current during erase or the erasing-gun drive, as specified in the TSS.

5. TSS requirements.

- a. In addition to the operating conditions for the TUT, the TSS shall specify the following:
  - (1) Maximum writing-gun drive.
  - (2) Minimum reading-output signal immediately after writing.
  - (3) Maximum cathode current or maximum gun drive for a separate erasing cycle.
- b. If values other than those specified in this test method are required, the TSS shall specify:
  - (1) Writing scan rates.
  - (2) Erasing rate.
  - (3) Stability observation time.

## MIL-STD-1311D

## METHOD 5419

## GRAY SCALE RESPONSE, VISUAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to determine the response of the TUT to a gray scale test pattern input. The response is determined by examining the output signal resulting from writing with a staircase voltage input signal. This method is intended primarily for tubes whose application includes TV display.

2. Equipment.

- a. A photometer shall be used to measure the luminance of the TUT over a circular area  $10 \pm 5$  mm (approximately  $.4 \pm .2$  inch) in diameter.
- b. A deflection system shall produce a raster from a linear sawtooth field sweep at a  $60 \frac{1}{2}$  Hz repetition frequency, and a  $53 \frac{1}{2}$  microsecond linear sawtooth line sweep having a  $63.5 \frac{1}{2}$  microsecond period, or as specified in the TSS.
- c. A video signal generator shall produce a gray scale test pattern consisting of a 10-step linear staircase voltage synchronized with the linear sawtooth line sweep with individual step widths of 5.3 microseconds, with adjustable entire staircase voltage amplitude from 0 to 15 V peak-to-peak, with each step having maximum voltage overshoots of 1.0 percent maximum, undershoots of 1.0 percent maximum, and droops of 1.0 percent. Any of these parameters may be alternatively specified in the TSS.
- d. An erase system shall produce rectangular erase pulses with a width of  $0.5 \frac{1}{2}$  millisecond and a frequency of  $60 \frac{1}{2}$  Hz synchronized with the linear sawtooth field sweep, or as specified in the TSS. Viewing screen current may be reduced or cut off during the erase period as specified in the TSS.

3. Procedure.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write the entire area specified in the TSS to saturation level.
- c. Stop writing. Use the erase pulse width and frequency specified in 2d above. Starting from zero, adjust the erase pulse amplitude until the last portion of the specified area has just been erased.
- d. Continue erasing. Apply the video signals specified in 2c above to the write gun and adjust the linear staircase voltage amplitude and the unblanking level until a minimum of five distinguishable luminance levels (including black and white), or the number specified in the TSS, are obtained in the specified area. The erase pulse amplitude may be readjusted to obtain the best gray scale performance.
- e. The brightest portion of the test pattern within the specified area shall be at least equal to the peak luminance level specified in the TSS.
- f. To be counted as a luminance level, each step must be distinguishable from the adjacent step along the entire transition length. If two or more adjacent steps cannot be distinguished from each other along their entire length, they shall be counted as one level.

4. Precaution. To assure that stray light sources do not significantly affect luminance measurements, the light level recorded by the photometer in the measurement position shall be such that, with the TUT off, the photometer reading does not exceed 3 percent of the TUT luminance value to be measured.

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$\frac{1}{2}$  Typically, 525-line television system.

MIL-STD-1311D

5. TSS requirements.

- a. In addition to the operating conditions for the TUT, the TSS shall specify the following:
  - (1) Area to be examined.
  - (2) Peak luminance level.
- b. If values other than those specified in this test method are required, the TSS shall specify:
  - (1) Writing raster parameters.
  - (2) Gray scale video test pattern parameters and limits.
  - (3) Erase pulse width and frequency.
  - (4) Whether viewing screen current is to be reduced or cut off during the erase period.
  - (5) Minimum number of distinguishable luminance levels.

## MIL-STD-1311D

## METHOD 5420

## GRAY SCALE RESPONSE, ELECTRICAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to determine the response of the TUT to a gray scale test pattern input. The response is determined by examining the output signal resulting from writing with a linear staircase voltage input signal.

2. Equipment.

- a. A deflection system shall produce television-type writing and reading rasters in the TUT at television rates (approximately 50 to 60 Hz).
- b. The TUT shall be monitored on a CRT with a raster scan synchronized to the reading raster, and on an oscilloscope with provision for selecting the video output from any line of the reading raster.
- c. The output-signal amplifier shall be linear, compensated for the output impedance of the TUT and have a frequency response that is flat within 1 dB over a bandwidth wide enough to insure accurate display of the gray scale capabilities of the TUT.
- d. A video signal generator shall produce a gray scale test pattern from a linear staircase voltage synchronized to the writing raster. The staircase voltage waveform at the storage tube input shall have equal amplitude steps with overshoots of 1.0 percent maximum, undershoots of 1.0 percent maximum, and droops of 1.0 percent maximum, where the tolerances are expressed as a percentage of the staircase (cumulative stairstep) voltage amplitudes at the tube signal input electrode.

3. Procedure. Either method A or B may be used to determine the gray scale response.

3.1 Method A. This method measures the gray scale response under dynamic conditions of continuous writing, reading, and erasing.

- a. Operating conditions shall be as specified in the TSS.
- b. Read the area specified in the TSS and display the output on both the oscilloscope and monitor. The orientation of the reading raster shall be such that each line of the reading raster, within the specified area, scans all the steps of the stored gray scale pattern.
- c. Operate the TUT with a storage time such that a signal written to 90 percent of saturation will decay to 10 percent of saturation in the time specified.
- d. Write the gray scale video test pattern and adjust the write scan size so that the pattern covers the area specified in the TSS.
- e. Write and read the TUT with the storage time as utilized in 3.1c. Adjust the video test signal amplitude and write gun bias so that an equilibrium condition is obtained with the lowest amplitude step just written and the maximum number of steps discernible on the oscilloscope. Confirm that the TUT has reached an equilibrium condition after these writing adjustments have been made by waiting at least 10 times the decay period utilized in 3.1c.
- f. After confirming that the TUT has reached equilibrium, count the number of steps of the gray scale test pattern visible in the output of the oscilloscope. This is the gray scale response (dynamic). To be counted, each step must be distinguishable on the oscilloscope display from the adjacent step along the entire step transition within the specified area. Use the line selector on the oscilloscope to check the entire specified area.

## MIL-STD-1311D

3.2 Method B. This method measures the gray scale response under static, single-write conditions.

- a. Operating conditions shall be as specified in the TSS.
- b. Read the area specified in the TSS and display the output on both the oscilloscope and monitor. The orientation of the reading raster shall be such that each line of the reading raster, within the specified area, scans across all the steps of the stored gray scale pattern.
- c. Operate the TUT with storage time at maximum, or as specified in the TSS.
- d. Erase and/or prime the TUT until the lightest area is just black.
- e. Write the gray scale video test pattern with the write scan size adjusted so that the pattern covers the area specified in the TSS. Writing conditions should be set so that the lowest amplitude step is just written and the maximum number of steps can be seen on the oscilloscope.
- f. Stop writing. Count the number of steps of the gray scale test pattern visible in the output of the oscilloscope. This is the gray scale response (static). To be counted, each step must be distinguishable on the oscilloscope display from the adjacent step along the entire step transition within the specified area. Use the line selector on the oscilloscope to check the entire specified area.

4. Precautions.

- a. The gray scale test signal (input) is permitted to contain more steps than are required to be visible in the output. An excessive number of input steps should be avoided, however, as this makes determination of the transition between steps in the output signal difficult.
- b. Because of the non-linear characteristics of these devices, the number of gray scale steps which can be reproduced by the TUT is dependent on such operating conditions as applied target voltage and the selected scan rate. Therefore, each specification for gray scale response shall include the specific operating conditions for which the response is required.

5. TSS requirements.

- a. In addition to the operating conditions for the TUT, the TSS shall specify the following:
  - (1) Area to be examined.
  - (2) The minimum number of gray scale steps that must be counted in the output on the oscilloscope.
  - (3) Whether the test is to be performed under dynamic conditions by method A or under static conditions by method B.
  - (4) The storage time if method A is specified.
- b. If values other than those specified in this test method are required, the TSS shall specify: Storage time for method B.



## MIL-STD-1311D

## METHOD 5421

## READING TIME, USABLE, ELECTRICAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to determine the time period over which a usable output signal is obtained from an electrical output storage tube during continuous readout. Bistable devices are excluded from this method.

2. Definitions.

- a. Usable reading time is the time period over which a usable output is obtained during continuous readout.
- b. Saturation level is that signal output beyond which no further increase in signal is produced by further writing.

3. Equipment.

3.1 The deflection system shall produce writing and reading rasters in the TUT, each with linear sawtooth deflections in orthogonal directions.

3.2 The output of the TUT shall be monitored on the CRT with a raster scan synchronized to the reading raster and on an oscilloscope with provision for displaying the video output from any line of the reading raster.

3.3 The output-signal amplifier shall be linear, compensated for the output impedance of the TUT, and shall have an essentially flat response over a bandwidth wide enough to insure accurate display of the uniformity capabilities of the TUT.

3.4 The writing control circuits shall be adjustable, but once adjusted for this test shall maintain a constant unblanking level during the active periods of the write cycles.

3.5 A stop-watch or other clock suitable for recording the measured time interval is required.

4. Procedure.

4.1 Operating conditions shall be as specified in the TSS.

4.2 The oscilloscope display shall be synchronized to the reading line scan and shall display any line within the area specified in the TSS.

4.3 Without erasing, write the entire area specified to the saturation level.

4.4 Stop writing. Use the erase procedure specified in the TSS and adjust conditions to obtain a single erase cycle that will cause the fastest erasing portion of the specified area to just be erased. Immediately proceed to 4.5.

4.5 Use a pattern of 10 black and 10 white bars, all of approximately equal width, orthogonal to the read line scan, and write with overlapping scan lines until the fastest writing portion of the specified area just reaches saturation level.

4.6 Stop writing. Read while displaying the bar pattern on the monitor, and determine the region within the specified area in which contrast degrades most rapidly. Set the oscilloscope to display a single line scan approximately through the center of this region and note the position along the scan line corresponding to the approximate center of this region.

4.7 Repeat 4.3, 4.4, and 4.5.

4.8 Stop writing. Read and immediately start stopwatch or other suitable device for recording the time interval.

4.9 With respect to figure 5421-1, determine the output signal level through the fastest decaying portion of the specified area at the beginning of the time interval,  $I_s(O)$ .

4.10 Under continuous reading conditions, determine the elapsed time required for the signal level to drop to one half of the initial value determined in 4.9 or to the value(s) specified in the TSS.

4.11 The usable reading time ( $T_R$ ) is the elapsed time interval determined in 4.10; the initial output signal level ( $I_s(O)$ ), shall also be specified.

## MIL-STD-1311D

5. Precautions.

5.1 The TSS shall clearly indicate all operating conditions and electrode potentials during the reading time. The output signal amplitude at the beginning of the reading time interval ( $I_S(O)$ ), shall be specified.

5.2 This method is not applicable to tubes operating in a bistable mode.

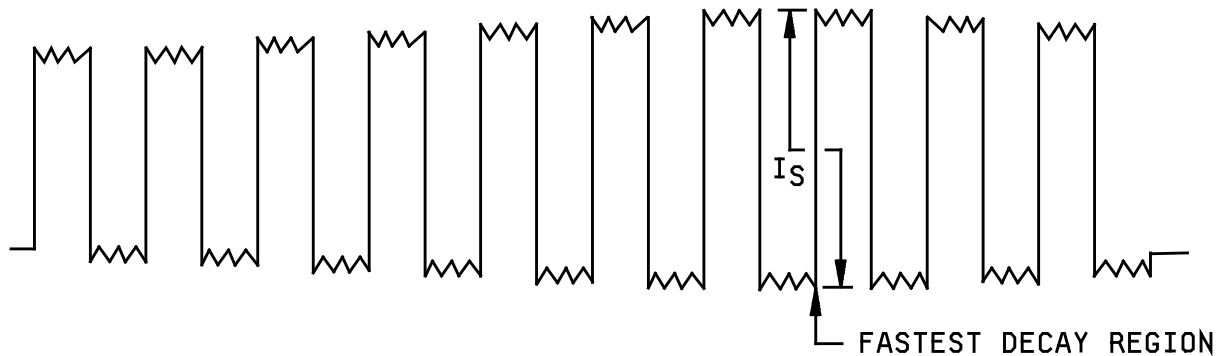


FIGURE 5421-1. Oscilloscope trace of output signal for a single line scan through the center of the fastest decaying region.

6. TSS requirements.

- a. In addition to the operating conditions for the TUT, the TSS shall specify the following:
  - (1) Area(s) of target in which reading time is to be determined.
  - (2) Output signal current ( $I_S(O)$ ) at beginning of reading time interval.
- b. If values other than those specified in this test method are required, the TSS shall specify: Residual output signal after elapsed reading time interval ( $T_R$ ) if different from 50 percent.

## MIL-STD-1311D

## METHOD 5422

## MODULATION TRANSFER FUNCTION, FROM LINE SPREAD FUNCTION, ELECTRICAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to provide a quantitative measure of the ability of the TUT to transfer sine wave signal information from its input to its output as a function of spatial frequency referred to its SSRD (storage surface reference dimension). This method gives the impulse response of the TUT which is its modulation transfer function (MTF).

2. Equipment.

- a. The writing-deflection system shall produce a pattern of one or more widely spaced parallel lines written at the sweep speed(s) specified in the TSS.
- b. The reading-deflection system shall produce a rectilinear (e.g., TV) type raster with lines disposed essentially orthogonal to the written lines, and repeated at a rate as specified in the TSS.
- c. External focus and deflection components when used shall be located with respect to the TUT as specified in the TSS.
- d. The output-signal amplifier shall be linear, compensated for the output impedance of the TUT, and have a frequency response that is flat within 1 dB between frequencies ( $f_1$ ) and ( $f_2$ ), to insure accurate reproduction of the line spread function from the TUT.

$f_1$  = the read scan-line repetition rate (Hz).

$$f_2 = \frac{R J}{D} \text{ (MHz).}$$

Where:

R is the anticipated limiting resolution of the TUT in cycles/SSRD.

J is the read scan-line length as a fraction of the SSRD.

D is the active read scan-line duration in microseconds.

SSRD is the storage surface reference dimension as defined in method 5405.

(It is acceptable to compensate for bandwidth limitations of the amplifier by reducing the reading raster width J.)

- e. An oscilloscope capable of displaying the output pulse shall be provided. Care should be taken in the use of interconnecting cables, triggered sweeps, and delayed expansion of the output pulse. No overshoot or ringing should be observable. The oscilloscope should be provided with line selection and waveform expansion capability either internally or by means of associated equipment.
- f. A camera or other recording means shall be provided to record the output pulse.
- g. It is suggested (though not necessary for this test) that a picture (e.g., TV) monitor synchronized to the read scan be used to monitor the video signals.
- h. Figure 5422-1 shows a representative test equipment configuration. It contains typical equipment as may be employed in a TV to TV format conversion and indicates one means for selecting a single scan line. Also shown is the optional use of a TV monitor.
- i. Automated computing equipment will simplify data reduction.

## MIL-STD-1311D

3. Procedure.

- a. The TUT shall be operated in accordance with the conditions specified in the TSS or other document calling for this test method. The area in which the measurement(s) is to be made shall be clearly specified in the TSS.
- b. For this test, the TUT shall be operated in the linear portion of its input-output transfer characteristics. To insure this condition, a background output signal corresponding to a level approximately halfway between cutoff and saturation shall be established. This may be achieved by uniformly charging the specified area up from cutoff or uniformly charging it down from saturation.
- c. The TUT writing gun input signal shall be a constant amplitude level that produces an output signal which falls within the linear portion of the output characteristics.
- d. In a single cycle, write a pattern of one or more widely spaced parallel lines at the sweep rate specified in the TSS.
- e. Using the read deflection system described above in 2b, display the output signal on the test oscilloscope. The output pulse shall first be displayed at a convenient height and time base, clearly showing the minimum and maximum levels of modulation. The time base shall then be expanded to clearly display the full output while assuring that the tails of the base still appear.

Record the following:

- (1) The output pulse waveform and the time base of the test oscilloscope in microseconds.
- (2) The read scan length as a fraction of the SSRD [symbol (J)].
- (3) The active read scan-line duration in microseconds [symbol (D)].
- f. Figure 5422-2 shows a representative output waveform that may be expected. Also shown in figure 5422-2 is its relationship relative to the storage surface area.
- g. Using the data obtained in 3e above, prepare a table of at least 20 amplitude points of the output pulse spaced at regular time intervals. The end points of the pulse must be zero amplitude but it is not necessary to center the pulse on the abscissa. A convenient time interval between data points (in microseconds),  $\Delta t$ , shall be selected for this purpose and recorded on the table.
- h. An example of the data table called for in 3g is shown in table I and consists of the tabulated amplitude values taken with a spacing of  $\Delta t$  as indicated on figure 5422-2. The recorded time calibration of the table is 0.02  $\mu\text{s}$ /interval. The values assigned to X shall be consecutive integers such as are illustrated in table 5422-1.
- i. The MTF is obtained directly by taking the Fourier transform of the output (line spread function) signal.
- j. A reference for the theoretical basis of MTF and also an aid in the data reduction process, is: *Modern Optical Engineering; The Design of Optical Systems*, Warren J. Smith, McGraw-Hill, 1966, p. 308-318. (If the manual data reduction is employed, the above reference provides a detailed step-by-step procedure.)

MIL-STD-1311D

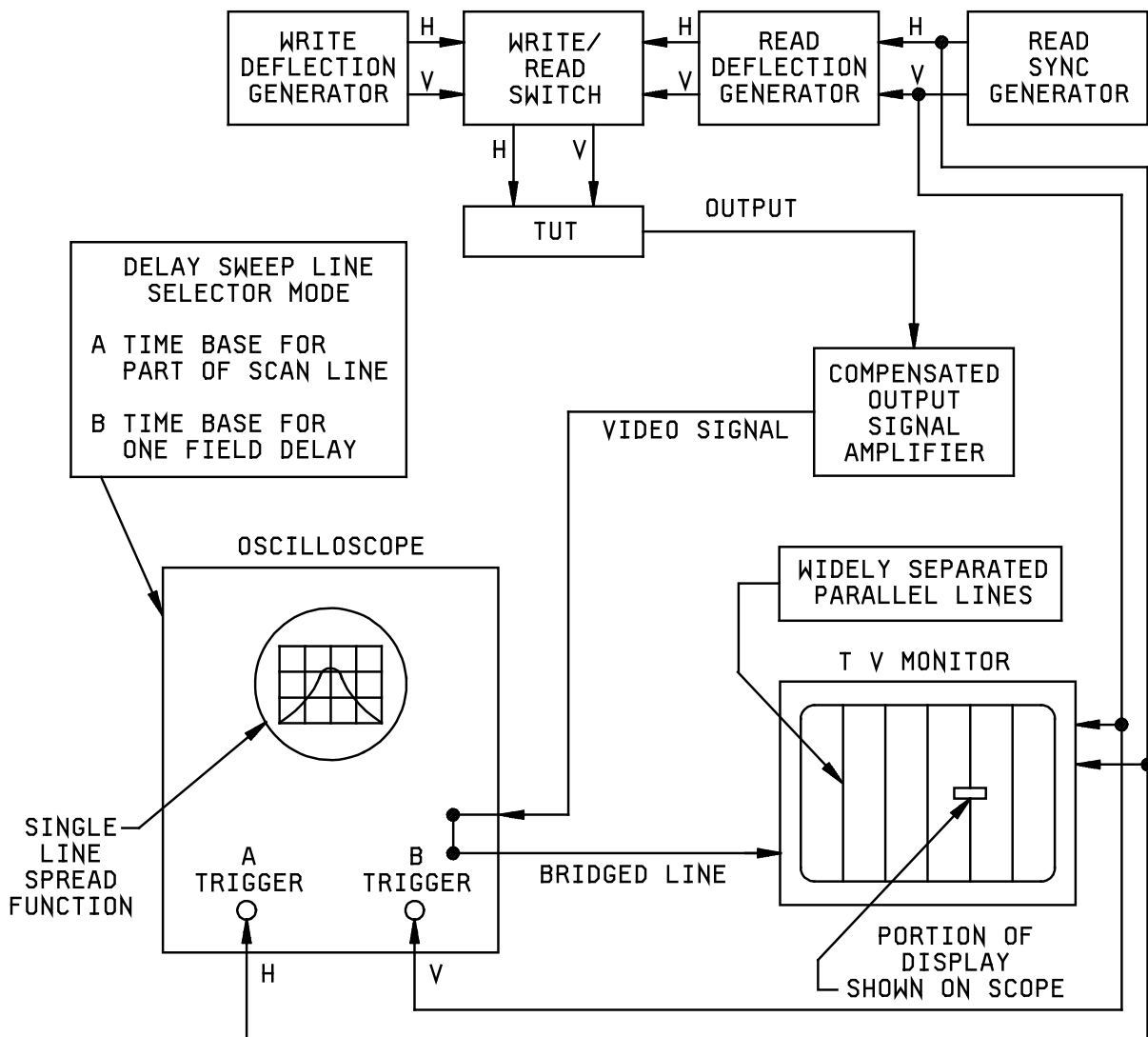


FIGURE 5422-1. Representative test equipment configuration.

## MIL-STD-1311D

The modulation transfer function and phase shift values are calculated using the following equations:

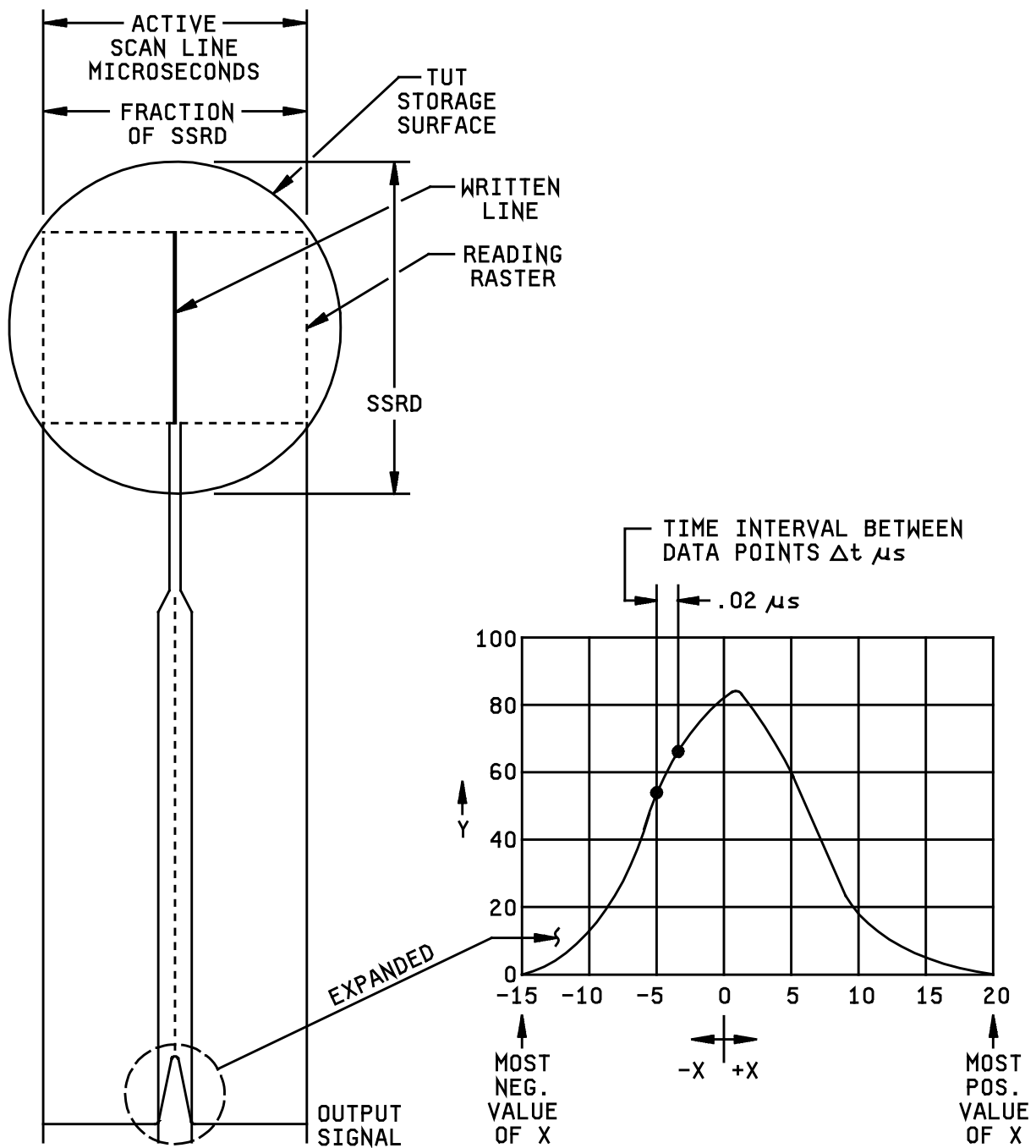
$$MTF_p = \left[ \left( \frac{\sum_i Y_i \cos 2\pi v_p X_i}{\sum_i Y_i} \right)^2 + \left( \frac{\sum_i Y_i \sin 2\pi v_p X_i}{\sum_i Y_i} \right)^2 \right]^{1/2}$$

$$\tan (PHI)_p = \frac{\sum_i Y_i \sin 2\pi v_p X_i}{\sum_i Y_i \cos 2\pi v_p X_i}$$

Where:

- P = Spatial frequency in terms of cycles/SSRD for which the modulation is determined.
  - $Y_i$  = The value of the line spread function at point  $X_i$ .
  - $v_p$  = The frequency equivalent of p (cycles/ $\Delta t$ ).
  - $\Delta t$  = Time increment between values of X.
  - $X_i$  = The assigned abscissa integer values of the line spread function.
- k. A typical computer program using the equations in 3j (in the super basic language) for obtaining MTF from tabulated line spread function data, as in table 5422-I, is shown in table 5422-II. This program will interrogate the user for the data required and ask for the maximum spatial frequency to which MTF calculations are required. Once these data are entered, the program will calculate and print out the cycles/SSRD in increments of 25 cycles with their respective MTF values. In addition, it calculates and prints the tangent of the phase shift between the input and output signals.
- l. The MTF data obtained from the Fourier transform may be presented in tabular or graphical form, the only requirement being that there be sufficient resolution in the presented data to permit visual review and interpretation, particularly in the response regions of 0.70, 0.50, 0.10, and 0.04. If graphical presentation is employed, this may be done using log-linear log-log, or linear scaled paper. The abscissa shall be in terms of "Spatial Frequency" in units of "cycles/SSRD", and the ordinate shall be in terms of "Modulation" in units of "relative response".
- m. A typical presentation of the modulation transfer function as in 3l above, may be in the form of computer print out as in table 5422-II or as shown on figure 5422-3.

MIL-STD-1311D

FIGURE 5422-2. Representative oscilloscope waveform.

## MIL-STD-1311D

TABLE 5422-I. Tabulation of data from recorded waveform.

Line spread function			
<u>X-position</u>	<u>Y-amplitude</u>	<u>X-position</u>	<u>Y-amplitude</u>
-15	0	10	18
-14	1	11	14
-13	2.8	12	11
-12	5	13	9
-11	7.5	14	7
-10	11	15	5.2
-9	15	16	3.8
-8	21	17	2.4
-7	29	18	1.3
-6	40	19	0.8
-5	51	20	0
-4	62		
-3	70		
-2	75		
-1	80		
0	82		
1	82		
2	80		
3	72.5		
4	64		
5	55		
6	47		
7	38.5		
8	30		
9	23		
0.02 $\mu$ s interval			



MIL-STD-1311D

TABLE 5422-II. Example of a computer run.

A computer run using the data from table I in 3h of the method. Following the run is a list of the steps in the computer program.

**INTRODUCTION**

**THIS PROGRAM WILL CALCULATE THE MTF AND THE TANGENT OF PHI (THE PHASE SHIFT) FROM LINE SPREAD (IMPULSE RESPONSE) DATA WHEN THE FOLLOWING QUESTIONS HAVE BEEN ANSWERED.**

**INTERROGATION STATEMENTS FOLLOWED BY TYPICAL ANSWERS**

**WHAT IS THE MOST NEGATIVE VALUE OF X? -15**  
**WHAT IS THE MOST POSITIVE VALUE OF X? 20**  
**WHAT IS THE TIME INTERVAL BETWEEN DATA POINTS IN MICROSECONDS? .02**  
**HOW MANY VALUES OF Y ARE THERE? 36**  
**NOW ENTER THE 36 VALUES OF Y? 0, 1, 2.8, 5, 7.5, 11, 15, 21, 29, 40, 51, 62, 70, 75, 80, 82, 82, 80, 72.5, 64, 55, 47, 38.5**  
**? 30, 23, 18, 14, 11, 9, 7, 5.2, 3.8, 2.4, 1.3, .8, 0**  
**WHAT IS THE ACTIVE SCAN LINE TIME IN MICROSECONDS? 25**  
**WHAT FRACTION OF THE SSRD IS THE SCAN LENGTH? .143**  
**WHAT IS THE MAXIMUM NUMBER OF CYCLES (DIVISIBLE BY 25) FOR WHICH MTF IS REQUIRED? 600**

## MIL-STD-1311D

TABLE 5422-II. Example of a computer run - Continued.

SAMPLE PRINT OUT		
MTF FROM LINE SPREAD FUNCTION		
-----		
WIDTH USED AS A FRACTION OF SSRD:		.143
ACTIVE HORIZONTAL SWEEP TIME: 25 MICROSECONDS		
<u>CYCLES</u> <u>/SSRD</u>	<u>MTF</u> <u>---</u>	<u>TAN(PHI)</u> <u>PHASE SHIFT</u>
.0	1.0000	.00
25.0	.9951	.01
50.0	.9807	.03
75.0	.9571	.04
100.0	.9250	.06
125.0	.8854	.07
150.0	.8394	.08
175.0	.7881	.09
200.0	.7330	.09
225.0	.6754	.10
250.0	.6167	.10
275.0	.5581	.10
300.0	.5008	.10
325.0	.4459	.09
350.0	.3940	.08
375.0	.3459	.07
400.0	.3018	.05
425.0	.2620	.03
450.0	.2264	.01
475.0	.1949	-.01
500.0	.1672	-.03
525.0	.1428	-.05
550.0	.1215	-.06
575.0	.1028	-.07
600.0	.0863	-.08

MIL-STD-1311D

TABLE 5422-II. Example of a computer run - Continued.

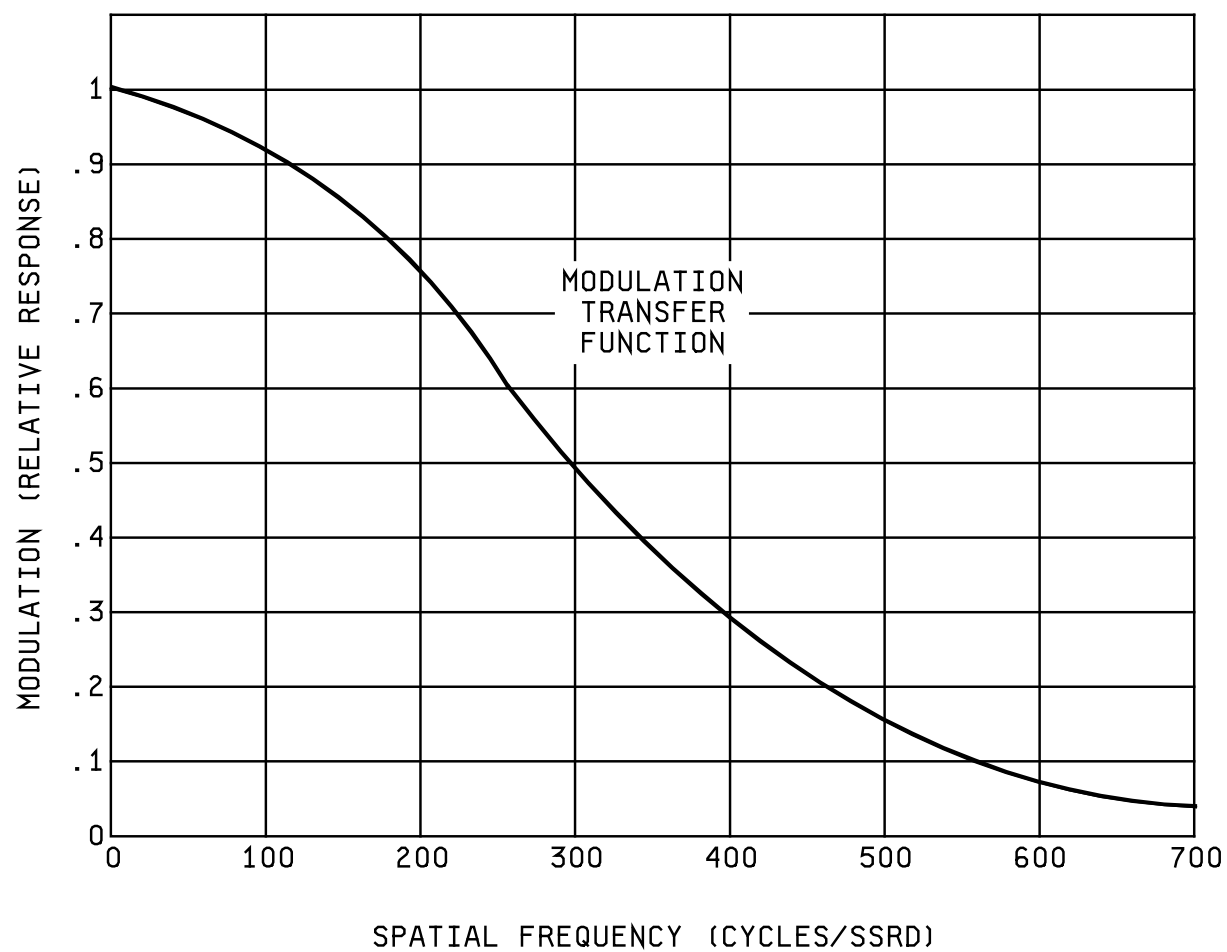
## SAMPLE COMPUTER PROGRAM

```

100 PRINT FOR I=ITO5
110 PRINT "THIS PROGRAM WILL CALCULATE THE MTF AND THE TANGENT OF PHI (THE PHASE"
120 PRINT "SHIFT) FROM LINE SPREAD (IMPULSE RESPONSE) DATA WHEN THE FOLLOWING"
130 PRINT "QUESTIONS HAVE BEEN ANSWERED"
140 PRINT FOR I=ITO2
150 PRINT "WHAT IS THE MOST NEGATIVE VALUE OF X":
160 INPUT U
170 PRINT "WHAT IS THE MOST POSITIVE VALUE OF X":
180 INPUT Z
190 PRINT "WHAT IS THE TIME INTERVAL BETWEEN DATA POINTS IN MICROSECONDS":
200 INPUT S8
210 PRINT "HOW MANY VALUES OF Y ARE THERE":
220 INPUT N
230 DIM Y(N)
240 PRINT "NOW ENTER THE ":N:" VALUES OF Y":
250 INPUT Y(1) FOR I=ITON
260 PRINT "WHAT IS THE ACTIVE SCAN LINE TIME IN MICROSECONDS":
270 INPUT D
280 PRINT "WHAT FRACTION OF THE SSRD IS THE SCAN LENGTH":
290 INPUT J
300 PRINT "WHAT IS THE MAXIMUM NUMBER OF CYCLES (DIVISIBLE BY 25) FOR WHICH MTF IS"
310 PRINT "REQUIRED":
320 INPUT S9
330 PRINT FOR I=I TO10
340 PRINT "                                MTF FROM LINE SPREAD FUNCTION"
350 PRINT "                                ====="
360 PRINT FOR I=IT03
380 PRINT "WIDTH USED AS A FRACTION OF SSRD: "; J
390 PRINT "ACTIVE HORIZONTAL SWEEP TIME: "; D; "MICROSECONDS"
400 PRINT FOR I=IT03
410 PRINT "CYCLES           MTF           TAN(PHI)"
420 PRINT " /SSRD           ---           PHASE SHIFT"
430 PRINT "-----"
440 PRINT
450 PRINT
460 FOR P=0 TO S9 STEP 25
470 V=P*S8*J/(D)
480 A=0,B=0,C=0,J5=0
490 FOR X=U TO Z STEP:
500 J5=J5+1
510 L=(Y(J5))*SIN(2*PI*V*X),W=(Y(J5))*COS(2*PI*V*X)
520 A=A+Y(J5),B=B+W,C=C+L
530 NEXT X
540 DI=B/A,E=C/A,F=SQR((D1↑2)+(E↑2)),G=C/B
550 PRINT
560 TI="4%.1%6B1%.4%3B8%.2%/"
570 PRINT IN FORM TI:P,F,G
580 NEXT P
590 STOP

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MIL-STD-1311D

FIGURE 5422-3. Example of modulation transfer function presentation.

## MIL-STD-1311D

4. Precautions.

- a. The purpose of this test method is to obtain the MTF of the TUT. Thus, read and oscilloscope amplifiers shall be provided that have bandwidths which, when referred to the scanned portion of the storage surface, provide responses at spatial frequencies well beyond the limiting resolution.
- b. For this test to provide meaningful results, the tube and its support equipment shall be operated in their linear ranges. The linear range is that range of operation over which the output signal is essentially proportional to the input signal.
- c. For a more comprehensive measurement of MTF, data can be taken at a number of locations on the storage surface, in different scan directions, and at different scan rates.
- d. When generating the data table called for in 3g, it is important that the end points (zero values) of the pulse be located at zero amplitude and not on a disturbance or perturbation of the baseline. Several measurements 3e(1) can be made at adjacent locations in the storage tube to help determine where the true baseline signal is located. Incorrect establishment of the baseline will cause the resultant MTF to be in error.

5. TSS requirements. The TSS shall specify the following.5.1 Equipment.

- a. Writing deflection system sweep speed(s) (see 2a).
- b. Reading deflection system repetition rate (see 2b).
- c. When used, external focus and deflection component locations (see 2c).

5.2 Procedure.

- a. Operating conditions for the test (see 3a).
- b. The area in which the measurement(s) is to be made (see 3a).
- c. Single-cycle writing sweep rate (see 3d).

MIL-STD-1311D

METHOD 5423

READING TIME, VISUAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to measure the time period over which a usable output is obtained during continuous readout.

2. Definitions.

Saturation level is that level of luminance beyond which no further increase in luminance is produced by additional writing. The tube can be written to saturation level by writing up the entire viewing area with the erase pulse amplitude set a zero and then cutting off the write beam.

3. Equipment.

- a. A photometer shall be used to measure the luminance of the TUT over a circular area  $10 \pm 5$  mm (approximately  $.4 \pm .2$  inch) in diameter.
- b. A stop watch or other elapsed time indicator shall be used.
- c. A deflection system shall produce a merged raster on the TUT with linear sawtooth deflections in orthogonal directions.

4. Procedure. Reading time may be determined by either of the following methods.

4.1 Method A. This method measures the time required for an erased display to rise in brightness to a specified percentage of saturation.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write the entire usable area to saturation level.

Caution: Do not overdrive the write gun beyond that required to reach saturation level.

- c. Stop writing. Use a 1-second erase pulse and adjust its amplitude until application of a single pulse to the backing electrode will erase the last portion of the fully written area to the cutoff point.
- d. Without simultaneously erasing, again write the entire usable area to saturation level.
- e. Stop writing. Apply a single, 1-second erase pulse of amplitude determined in 4.1c above to the backing electrode.
- f. Measure and record the time for the first area of the erased display to increase to 30 percent of saturation.

4.2 Method B. This method measures the time required for a specified degradation in contrast ratio between a written and an unwritten area.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write the entire usable area to saturation level.

Caution: Do not overdrive the write gun beyond that required to reach saturation level.

- c. Stop writing. Using a erase pulse of 1-second duration, determine the pulse amplitude necessary to reach the storage target cutoff point. This is accomplished by alternately writing to saturation and erasing, while adjusting the erase pulse amplitude.

## MIL-STD-1311D

- d. Without simultaneously erasing, again write the entire usable area specified in the TSS to saturation level.
- e. Stop writing. Apply a single, 1-second erase pulse of amplitude determined in 4.2c above to the backing electrode.
- f. Write a 1-inch by 1-inch (25.4 mm by 25.4 mm) raster to initial luminance level ( $B_1$ ), which is equal to 50 percent of saturation, at the location in the usable area that exhibits the shortest reading time for the operating conditions specified.
- g. Stop writing. Monitor the luminance level ( $B_2$ ) in a unwritten area .750 inch (19.05 mm) distance from the edge of the written raster.
- h. While monitoring ( $B_1$ ) and ( $B_2$ ), calculate the contrast ratio from the formula:

$$\text{Contrast ratio} = \frac{B_1}{B_2}$$

Typically, luminance ( $B_1$ ) and ( $B_2$ ) will both increase during this measurement.

5. Precautions.

- a. To assure that stray light sources do not significantly affect luminance measurements, the light level recorded by the photometer in the measurement position shall be such that, with the TUT off, the photometer reading does not exceed 3 percent of the TUT luminance value to be measured.
- b. This test is not applicable to tubes operating in a bistable mode.

6. TSS requirements.

- a. In addition to the operating conditions for the TUT, the TSS shall specify the following:
  - (1) Usable area (see 4.1d and 4.2d).
  - (2) Minimum reading time (see 4.2h).
  - (3) The applicable test, method A or B (see 4.1 and 4.2).
- b. If values other than those specified in this test method are required, the TSS shall specify: Contrast ratio (see 4.2h).

## MIL-STD-1311D

## METHOD 5424

## DYNAMIC RANGE, ELECTRICAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to determine the dynamic range over which a usable output is obtained. This is a small area measurement which reduces the influence of target shading and major blemishes. Shading and blemish count are the subjects of other test methods.

2. Definitions.

- a. Dynamic range, peak-to-peak disturbance level is the number of incremental output signal levels, each equal to the peak-to-peak target disturbance at that signal level, that may be obtained between cutoff and saturation.
- b. Dynamic range, rms disturbance level is the number of incremental output signal levels, each equal to the rms target disturbance at that signal level, that may be obtained between cutoff and saturation. By common practice, rms disturbance is taken as 20 percent of the peak-to-peak disturbance (see 4k).
- c. Target disturbance is that type of spurious signal, generated within a tube, which appears as abrupt variations in the amplitude of the output signal. These variations are spatially fixed with reference to the target area. A blemish, a mesh pattern, and moire present in the output are forms of disturbance. Random noise (e.g., thermal circuit noise) is not a form of disturbance.

3. Equipment.

- a. The reading and writing deflection system(s) shall produce a rectilinear (e.g., TV) type raster repeated at a rate specified in the TSS.
- b. External focus and deflection components and their location with respect to the reference line shall be as specified in the TSS.
- c. The output-signal amplifier shall be linear, compensated for the output impedance of the TUT, and have a frequency response that is flat within 1 dB between frequencies ( $f_1$ ) and ( $f_2$ ), to insure accurate reproduction of the required output signals from the TUT.

$f_1$  = the read scan-line repetition rate (Hz).

$f_2 = \frac{RJ}{D}$  (MHz).

Where:

R is the anticipated limiting resolution of the TUT in WRSL/SSRD.

J is the read scan-line length as a fraction of the SSRD.

D is the active read scan-line duration in microseconds.

SSRD is storage surface reference dimension as determined by method 5405.

WRSL is written raster scan line.

(It is acceptable to compensate for bandwidth limitations of the amplifier by reducing the reading raster width J).



## MIL-STD-1311D

- d. An oscilloscope capable of displaying a single line of the output signal shall be provided and shall have waveform expansion capability either internally or by means of associated equipment.
- e. A camera or other recording means shall be provided to record the output signal.
- f. It is suggested (although not necessary for this test) that a picture (e.g., TV) monitor, synchronized to the read scan, also be used to display the video signals.

4. Procedure.

- a. The TUT shall be operated in accordance with the conditions specified in the TSS. The area in which the measurement(s) is to be made shall be clearly specified.
- b. The TUT writing gun input signal shall be a constant amplitude level such that approximately 20 write cycles are needed to charge the storage target from cutoff to saturation. The writing scan lines shall be overlapping.
- c. Without erasing, write the entire area specified to the saturation level.
- d. Stop writing. Use the erase procedure specified in the TSS and fully erase the specified area of the TUT.
- e. Using the deflection system described in 3a and the writing cycle specified in 4b, write with a sufficient number of cycles to produce a measurable output signal on the test oscilloscope.
- f. Select a single line and display the portion of the video signal from the area specified. The size of the area selected shall be small enough that shading does not influence the measurement. Record both the output signal at the oscilloscope and the number of writing cycles that were required to write the target to that signal level.
- g. Without erasing, write a sufficient number of additional cycles to produce an incremental change in output signal. Typically each increment in signal level should be approximately equal to the peak-to-peak disturbance signal. Record the output signal at the oscilloscope and the cumulative number of write cycles that were required to write to this new signal level.

NOTE: For tubes that exhibit short reading time (i.e., such that signal level change during the entire measurement time is significant) or which operate in a destructive readout mode, it is necessary to erase to a fixed level prior to each multiple write cycle. This may be accomplished by using a long erase time or by writing to saturation prior to each erase cycle.

- h. Repeat 4g a number of times, recording the output signal and the cumulative number of write cycles each time, until the output signal indicates the target has reached saturation.
- i. An illustration typical of the data obtained above is shown in figure 5424-1. This is presented in graphical form in 5424-2, which is a plot of output signal current,  $I_s$ , with its peak-to-peak target disturbance signal current,  $\Delta I_s$ , as a function of the number of write cycles,  $N$ .
- j. Make a plot of the data obtained in 4f through 4h in the form shown on figure 5424-2.
- k. To determine dynamic range from this plot, construct a staircase within the boundaries of the two curves, as depicted in figure 5424-3. Observe that figure 5424-3 is the dynamic target transfer characteristic, and that the total number of vertical elements,  $L_{pp}$ , in the staircase is the dynamic range, peak-to-peak disturbance level. This may be expressed in decibels using the formula:

$$\text{Dynamic range, peak-to-peak disturbance level} = 20 \log L_{pp} \text{ (dB)}$$

NOTE: For many applications, the rms target disturbance level is more meaningful, and is approximately equal to 20 percent of the peak-to-peak target disturbance level. That is, the total number of vertical elements,  $L_{rms} \approx 5 L_{pp}$ , and;

$$\text{Dynamic range, rms disturbance level} = 20 \log L_{rms} \text{ (dB)}$$

MIL-STD-1311D

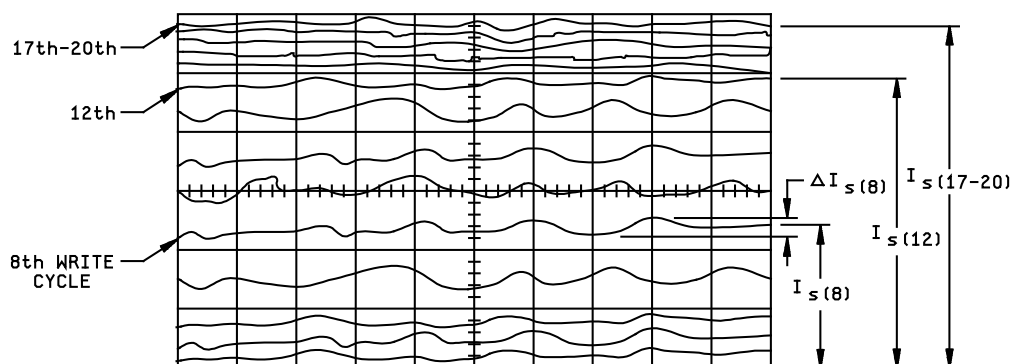
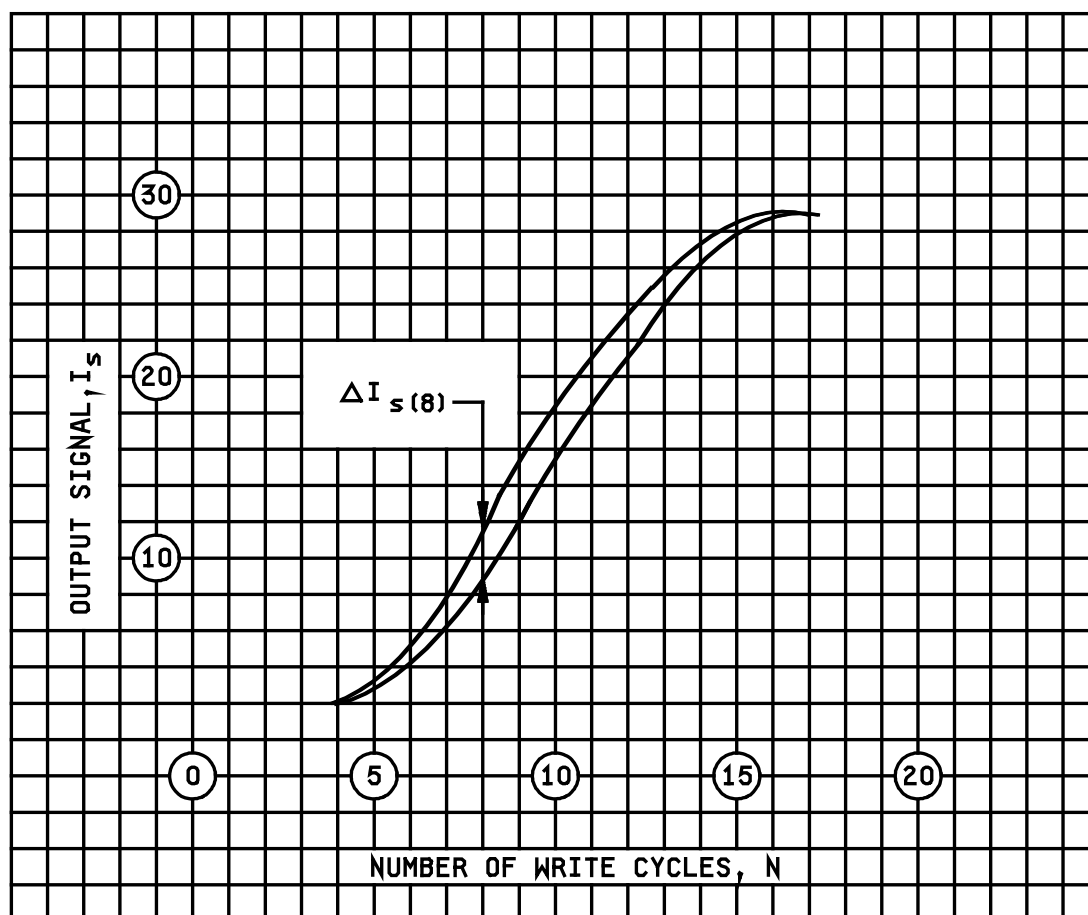
5. Precautions.

- a. This method requires that system or circuit noise amplitude be well below the amplitude of the target disturbance. Unless this condition is met, resulting in correlated noise appearing on the oscilloscope, this measurement cannot be made.
- b. Operating conditions for this test method, particularly reading beam current and scan size, shall be identical to those used in the determination of resolution (method 5410) or modulation transfer function (method 5422). Reading beam focus should be adjusted for optimum resolution at the measurement location(s).

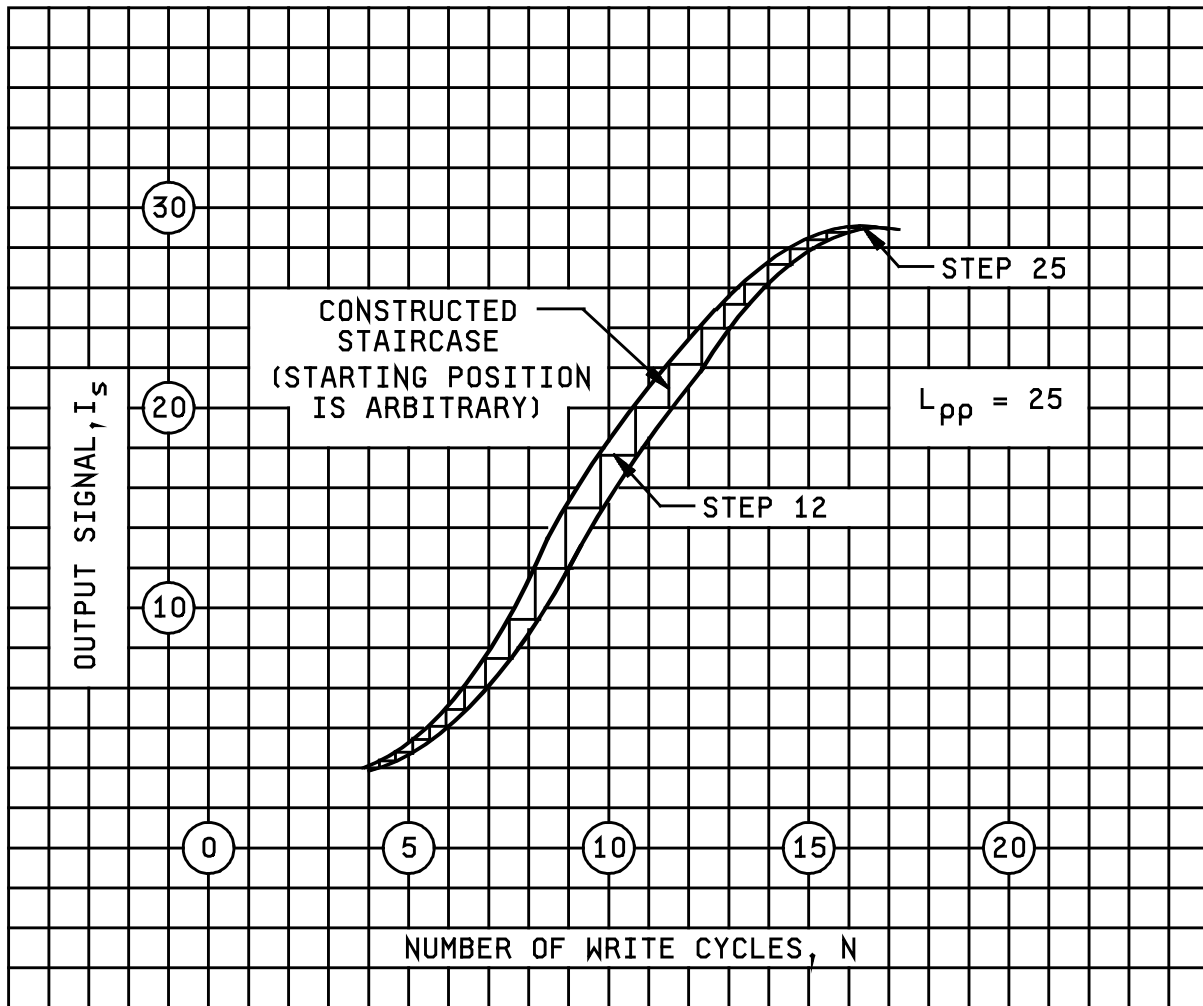
6. TSS requirements.

- a. In addition to the operating conditions for the TUT, the TSS shall specify the following for this test:
  - (1) Field and line rates for TV raster.
  - (2) Location of external focus and deflection components.
  - (3) Area(s) of target in which dynamic range is to be determined.
  - (4) Erase procedure.

MIL-STD-1311D

FIGURE 5424-1. Output levels; typical oscilloscope display.FIGURE 5424-2. Output levels plotted from oscilloscope data.

MIL-STD-1311D



(Example): Dynamic range<sub>pp</sub> =  $L_{pp}$  = 25,

or; Dynamic range<sub>pp</sub> (dB) =  $20 \log L_{pp} = 20(1.398) = 27.9$  dB

FIGURE 5424-3. Construction of staircase within curve boundaries.

## MIL-STD-1311D

## METHOD 5425

## DISPLAY PERSISTENCE, VISUAL OUTPUT

(Cathode-ray charge storage tubes)

1. Purpose. The purpose of this test is to determine the time required for a written display to decay from one luminance level to another under controlled erased conditions.

2. Definition.

Saturation level is that level of luminance beyond which no further increase in luminance is produced by additional writing. The tube can be written to saturation level by writing up the entire viewing area with the erase pulse amplitude set at zero and then cutting off the write beam.

3. Equipment.

- a. A photometer shall be used to measure the luminance of the TUT over a circular area  $10 \pm 5$  mm (approximately  $.4 \pm .2$  inch) in diameter.
- b. A stop watch or other elapsed time indicator shall be used.
- c. A deflection system shall produce a merged raster on the TUT with linear sawtooth deflections in orthogonal directions.

4. Procedure.

- a. Operating conditions shall be as specified in the TSS.
- b. Without simultaneously erasing, write all of the area specified in the TSS to the saturation level.
- c. Stop writing. Apply an erase pulse train of the specified duty cycle and establish the pulse train amplitude required to reach the cutoff point in the area of interest. This is accomplished by alternately writing to the saturation level and erasing, while adjusting the amplitude of the erase pulse train. The cutoff point is to be determined in the absence of background luminance caused by the erase pulse train.
- d. Without simultaneously erasing, write all of the area specified in the TSS to the saturation level or the luminance level specified.
- e. Stop writing. Apply an erase pulse train whose amplitude equals the value determined in 4c.
- f. Measure and record the time from the application of the erase pulse train until the written display decays to the level specified. This level shall not include the background luminance caused by the erase pulse train. This is display persistence.

5. Precautions.

To assure that stray light sources do not significantly affect luminance measurements, the light level recorded by the photometer in the measurement position shall be such that, with the TUT off, the photometer reading does not exceed 3 percent of the TUT luminance value to be measured.

6. TSS requirements.

- a. In addition to the operating conditions for the TUT, the TSS shall specify the following:
  - (1) The area of the display within which display persistence is to be determined (see 4b).
  - (2) Erase pulse train duty cycle (see 4c).
  - (3) The luminance level to which the display is permitted to decay (see 4f).
- b. If values other than those specified in this test method are required, the TSS shall specify: The luminance level to which the display is written (see 4d).

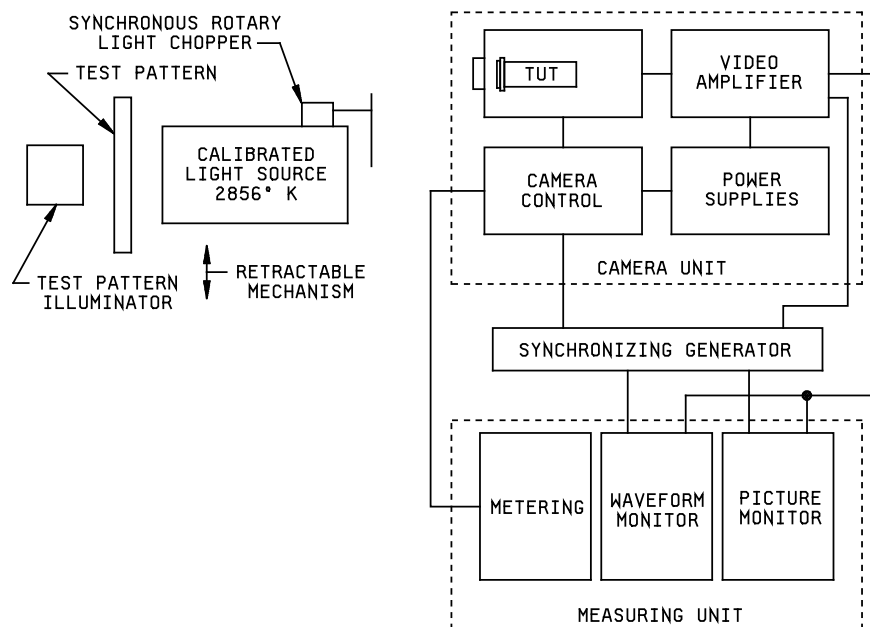
## MIL-STD-1311D

## METHOD 5426

## OPERATION TEST

(Vidicons)

The purpose of this test method is to illustrate a standardized test setup (camera system) to use when testing vidicon tubes.



## NOTES:

1. Video system requirements.

- (a) Bandwidth. The frequency response shall be flat,  $\pm 1$  dB, to a frequency greater than the fundamental frequency generated by scanning the required resolution.
- (b) Low frequency response. With a square wave input at either line or field rate the tilt shall not exceed 2 percent of the peak-to-peak amplitude.
- (c) Transient response to a unit step input. The overshoot shall not exceed 2 percent of final step amplitude. The rise time shall be consistent with the overshoot and frequency response.
- (d) Linearity. Amplitude nonlinearities shall not exceed 2 percent over the useful dynamic range.
- (e) Gain. At 50 nA signal current, the processing amplifier shall be capable of providing .50 volt of video plus setup to the monitor at an output impedance of 75 ohms.

2. Camera unit requirements.

Both horizontal and vertical scanning linearities shall be within 1.0 percent.

3. Unless otherwise specified, standard ECA television scan shall be used.

The raster size shall be specified.

FIGURE 5426-1. Block diagram of test equipment.

MIL-STD-1311D

METHOD 5427

RASTER BURN AND TARGET QUICK AGE

(Vidicons)

1. The tube shall be tested in a camera system with associated monitors as shown on the block diagram of figure 5426-1.
2. Align the tube in accordance with method 5437.
3. Raster burn test.
  - a. With conditions as specified, completely overscan target and adjust Ec1 and Esj until complete target is discharged.
  - b. Cap lens and adjust black level for about 20 percent setup.
  - c. Increase monitor bias until complete target is just visible.
  - d. If a raster burn or image burn is present:
    - (1) With no light on the tube, adjust horizontal, and vertical camera deflection, Ec3 and focus coil current to just overscan the target.
    - (2) Set the target voltage (Esj) at the specified test condition value and slightly defocus by adjusting Ec3. After the specified Esj value, a lower target voltage is permissible, if burn can be removed.
    - (3) Adjust Ec1 to obtain a complete white circular area on monitor with no distortion or dark areas present. The target current should read between the limit(s) specified.
    - (4) Age target as required if target burns are encountered.
  - e. Repeat steps a, b, and c.
  - f. Reject if raster burn is lighter than surrounding area. Reject for any permanent image burn.

MIL-STD-1311D

METHOD 5428

SIGNAL UNIFORMITY

(Vidicons)

1. The tube shall be tested in a camera system with associated monitors as shown on the block diagram of figure 5426-1.
2. Align the tube in accordance with method 5437.
3. Procedure.
  - a. Set up vidicon for optimum operation as specified for center resolution (method 5429).
  - b. The calibrated light source is adjusted to give  $2,856^{\circ}\text{K} \pm 20^{\circ}\text{K}$  color temperature.
  - c. The lens is replaced with the specified mask.
  - d. The scanning is adjusted to just see all of the edge of the aperture on the monitor and the camera scanning linearity is set to less than 1 percent error.
  - e. Vary the neutral density filter and the position of the light box on the track to give a signal current of 0.2 microamperes (total signal electrode current minus the dark current.)
  - f. Remove the light from the face of the vidicon and adjust the oscilloscope looking at the horizontal waveform so that the lower portion of the dark current trace lies on the "O" line of the graduated scale on the oscilloscope. Blanking level is set to -20 percent to prevent clipping or compression. Apply light and adjust oscilloscope gain and processor blanking level until the top of the envelope of signal current reaches 100 percent and dark current falls on "O" line of oscilloscope. Record the width of the highlight signal envelope as percent of the total dark-to-light signal. Neglect the few bright lines produced at the top of the picture and the few dark lines produced at the bottom of the picture.



MIL-STD-1311D

METHOD 5429

RESOLUTION

(Vidicons)

1. General.
  - a. The tube shall be tested in a camera system with associated monitors as shown on the block diagram of figure 5426-1.
  - b. Align the tube in accordance with method 5437.
  - c. Cap lens and adjust black level for about 20 percent setup. Uncap lens and adjust video gain control to see all steps of grey scale on ECA resolution chart, 1956, or equivalent, or as specified.
2. Center resolution. With Ec3 adjusted for balanced horizontal and vertical resolution, the resolution in the center of the pattern shall not be less than the specified limit.
3. Corner resolution. Without readjusting Ec3, the resolution in the four corners of the pattern shall not be less than the specified limit.

## MIL-STD-1311D

## METHOD 5430

## GAS RATIO

(Vidicons)

1. Gas ratio shall be determined as follows: With no light incident on the tube face, focus coil current "Off", scanning "On" or beam deflected, Esj open, Ef = 6.3 V or as specified, the following tests shall be made:

<u>Ec1</u>	<u>Ec3</u>	<u>Test procedure</u>	<u>Unit</u>
0 V	250-400 V dc	Record G3 current as Plc3	mA dc
0 V	-100 V dc	Record G3 current as Nlc3 when leakage becomes relatively stable, but not necessarily zero.	nA dc
-150 V	-100 V dc	Record G3 current as ILc3	nA dc

$$\text{Gas ratio (Gr)} = \frac{(Nlc3 - ILc3)}{Plc3}$$

2. The gas ratio (Gr) shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 5431

RASTOR CUTOFF

(Vidicons)

1. The tube shall be tested in a camera system with associated monitors as shown on the block diagram of figure 5426-1.
2. Align the tube in accordance with method 5437.
3. With test conditions as specified, remove blanking voltage from grid No. 1 and adjust Ec1 until test pattern just disappears as observed on monitor. Ec1 shall be within the limit(s) specified.

## MIL-STD-1311D

## METHOD 5432

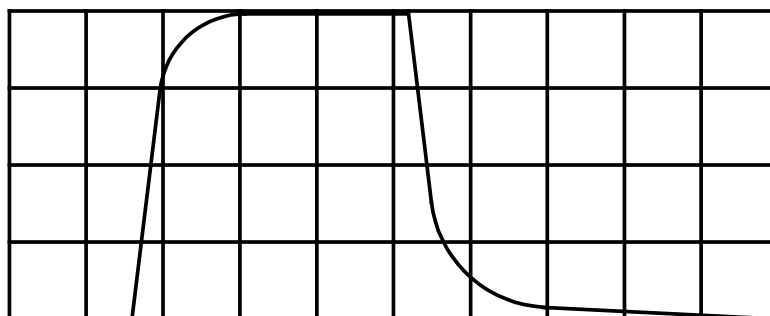
## LAG

(Vidicons)

1. The tube shall be tested in a camera system with associated monitors as shown on the block diagram of figure 5426-1.
2. Align the tube in accordance with method 5437.
3. Lag test.
  - a. Equipment.
    - (1) Calibrated light source of  $2,856^{\circ}\text{K} \pm 20^{\circ}\text{K}$  color temperature.
    - (2) Suitable filters and apertures to obtain specified faceplate illumination.
    - (3) Motor-driven light chopper capable of interrupting the path of light four times per second. The light chopper shall provide light to the vidicon target for .20 second and interrupt for .05 second such that the vidicon target receives light for about 12 TV fields and receives no light for about 3 TV fields.
    - (4) An oscilloscope capable of monitoring the signal output including the dc component.
  - b. Block diagram (see figure 5432-1).
  - c. Procedure.
    - (1) The tube shall be tested in camera with associated monitors as shown on the block diagram of figure 5426-1.
    - (2) Align the tube in accordance with method 5437.
    - (3) Set up vidicon for optimum operation as specified for center resolution.
    - (4) The light chopper is turned off and the calibrated light source is adjusted to give  $2,856^{\circ}\text{K}$  color temperature.
    - (5) Vary the neutral density filter and the position of the light box on the track to give the specified signal output level with the specified dark current (target voltage) setting.
    - (6) Switch vidicon signal electrode output directly to the dc input of the oscilloscope. A minimum scope sensitivity of 0.05 V/cm is required for satisfactory display. Adjust polarity of scope so that the white signal is positive.
    - (7) Cap the vidicon and adjust the vertical centering control to obtain 0 percent on the scope scale.
    - (8) Uncap the vidicon and adjust the scope gain control to obtain a white signal equal to 100 percent (4 cm to 5 cm).
    - (9) With light incident on vidicon faceplate, carefully adjust the scope triggering level and stability controls to "lock-in" the scope display.
    - (10) Turn on the chopper motor and carefully adjust the sweep multiplier control to "lock-in" the lag curve near the center of the display.
    - (11) Adjust the phasing control of the synchronizing circuitry until the last two fields of the white signal are identical. This indicates that the "light-cutoff" point of the chopper has been phased to occur during the vertical blanking period.

MIL-STD-1311D

- (12) The lag measurement is performed by reading the distance from the dark level (0 percent) to the lowest point 50 ms after the light cutoff point.



**TYPICAL OSCILLOSCOPE DISPLAY  
DURING LAG TEST**

- d. The lag shall be within the limit(s) specified.

MIL-STD-1311D

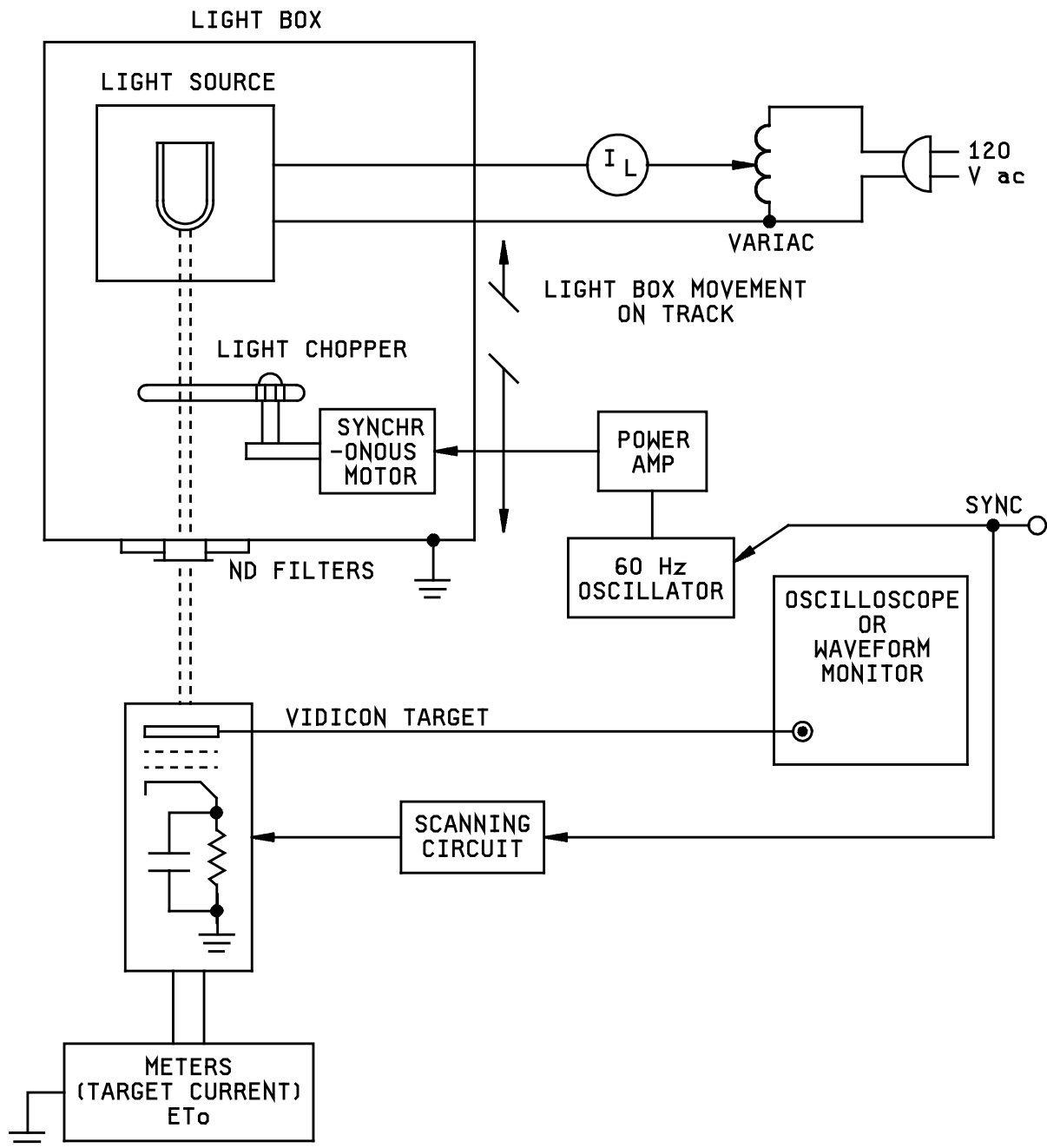


FIGURE 5432-1. Block diagram of lag test equipment.

## MIL-STD-1311D

## METHOD 5433

## SPURIOUS SIGNAL

(Vidicons)

1. General.

- a. The tube shall be tested in a camera system with associated monitors as shown on the block diagram of figure 5426-1.
- b. The test pattern shown on figure 5433-1 shall be used when performing this test.
- c. Align the tube in accordance with method 5437.
- d. Cap lens and adjust black level for 20 percent setup. Uncap lens and adjust video gain control to see all steps of gray scale on ECA resolution chart, 1956, or equivalent.

2. Spurious-signal criteria.

- a. There shall be no blemishes or spurious responses in zone 1 of the test pattern resulting in a video signal in excess of A or B of the peak black-to-white signal as indicated in the following table:

Size (in number of raster lines in any dimension)	Percentage of video signal
Over 3 3 to 1	A B

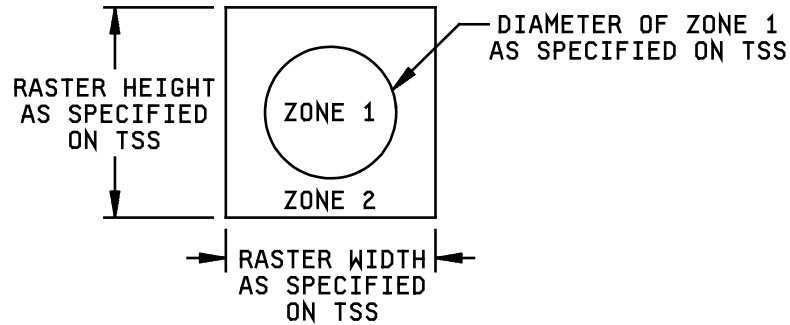
- b. There shall be no white spot in zone 2 with a video signal greater than D of the peak black-to-white signal and greater than two raster lines in size.
- c. Low contrast white spots having a video signal between C and D of the peak black-to-white signal, or white spots having a video signal greater than D of the peak black-to-white signal and one to two raster lines in size as well as black spots having a video signal greater than E of the peak black-to-white signal, are allowed as shown in the following table:

Size (in number of raster lines in any dimension)	Number allowed in Zone 2
Over 4 4 to 3 2 to 1	None 2 5

- d. Separation between any two spots shall be greater than 22 raster lines in any direction.

MIL-STD-1311D

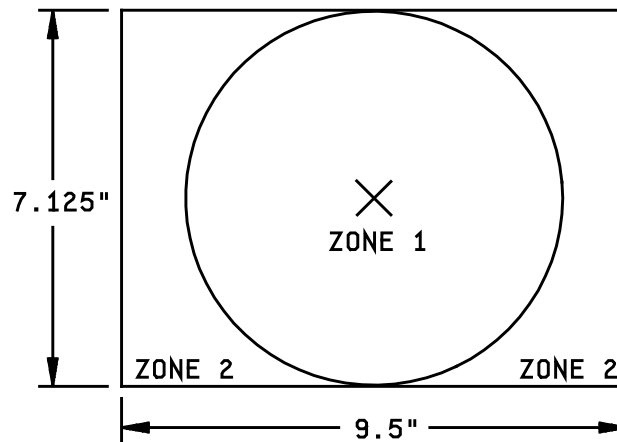
- e. There shall be no smudges, lines, streaks, mottled background, grainy background, or uneven background having a video signal greater than E of the peak black-to-white signal for a dark defect or a video signal greater than C of the peak black-to-white signal for a light defect.



NOTE: The test pattern shall be placed on a transparent slide and shall be illuminated from the rear of the slide.

FIGURE 5433-1. Spurious signal test pattern.

Percentages A, B, C, D, and E are as specified on the individual TSS.



ALL DIMENSIONS ARE IN INCHES

NOTE: The test pattern shall be placed on a transparent slide and shall be illuminated from the rear of the slide.

FIGURE 5433-2. Spurious signal test pattern.



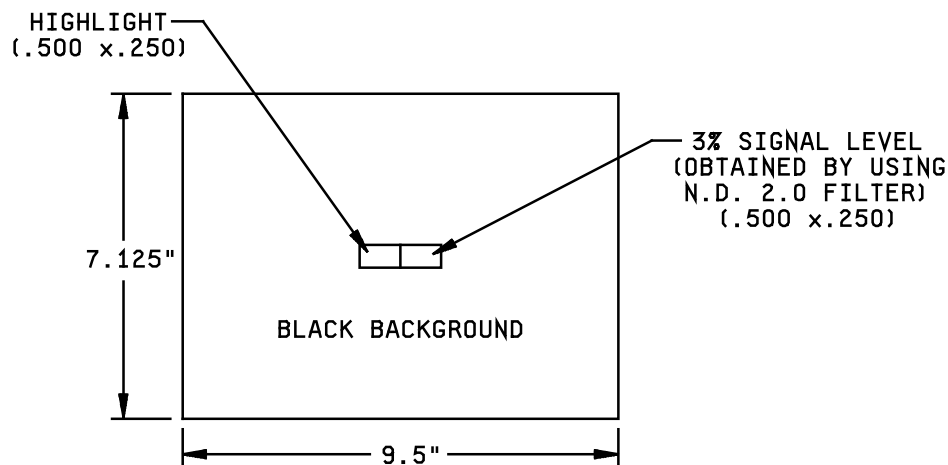
## MIL-STD-1311D

## METHOD 5434

## AFTER IMAGE

(Vidicons)

1. The tube shall be tested in a camera system with associated monitors as shown on the block diagram on figure 5426-1.
2. Align the tube in accordance with method 5437.
3. Using the spurious signal test pattern as shown on figure 5433-1, set up tube to specified conditions. Replace above test pattern by the "After image test pattern" as shown on figure 5434-1. The highlight brightness of the after image pattern shall be the same as the highlight brightness of the spurious signal test pattern. Line select the waveform monitor trace through the center information. (Use IEEE response to reduce noise.) Adjust gain to make peak black-to-white signal level equal to 100 percent. Using the step gain switch, increase the signal amplitude to where a 3 percent signal level can be clearly seen. Expose the vidicon to the test pattern for an exact 30 seconds. Cap up the tube. Record the time (in seconds, using a stopwatch) required for the residual peak white signal to decay to a 3 percent level (above black) as after image.

FIGURE 5434-1. After image test pattern.

MIL-STD-1311D

METHOD 5435

TARGET VOLTS

(Vidicons)

1. The tube shall be tested in a camera system with associated monitors as shown on the block diagram of figure 5426-1.
2. Align the tube in accordance with method 5437.
3. The target voltage shall be adjusted to yield the specified target current.
4. Recheck target volts ( $E_s$ ) after alignment is completed and  $E_s$  shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 5436

SENSITIVITY

(Vidicons)

1. The tube shall be tested in a camera system with associated monitors as shown on the block diagram of figure 5426-1.
2. Align the tube in accordance with method 5437.
3. The target voltage shall be adjusted to yield the specified target current.
4. Project specified faceplate illumination on vidicon target. The lamp current of the light source shall be adjusted for a color temperature of  $2,856^{\circ}\text{K} \pm 20^{\circ}\text{K}$ , or as specified. Sensitivity is the target current under these conditions minus dark current and it shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 5437

ALIGNMENT

(Vidicons)

1. The tube shall be tested in a camera system with associated monitors as shown on the block diagram of figure 5426-1.
2. The spurious signal test pattern on figure 5433-1 shall be used when performing this test.
3. The alignment coil currents of each horizontal and vertical coil shall be adjusted until the center of the test pattern remains stationary as  $E_{c3}$  is varied in and out of focus. The alignment coil currents shall be within the limit(s) specified.

MIL-STD-1311D

METHOD 6201

BACKGROUND, CONTAMINATION, AND PHOTOSENSITIVITY

(Radiation counter tubes)

1. Background and contamination. The tube response (count rate) determined using the circuit specified shall be not more than the limit specified. The tube shall be mounted in a horizontal position and may be shielded from extraneous radiation fields by lead of a maximum thickness of 2 inches (50.80 mm), with aluminum of a maximum thickness of .125 inch (3.18 mm) interposed between it and the tube. The counting time and the tube operating voltage for this test shall be as specified.
2. Photosensitivity. The photosensitivity shall be measured after a period of not less than 60 minutes during which time the tube has not been exposed to ultraviolet light. The tube response (count rate) shall be determined, using the circuit specified. The source of light radiation, the position and orientation of the tube with respect to the light source, the voltage at which the tube is operated, and the duration of the count shall be as specified. The testing procedure shall be as follows: Determine count rate with light off, then determine count rate with light on. The difference between the two count rates is the count rate due to photosensitivity. The difference shall be not more than the limit(s) specified.
3. Background, contamination, and photosensitivity. The tube response (count rate) due to the combined effects of background, contamination, and photosensitivity determined using the circuit specified, shall be not more than the limit(s) specified. The tube may be shielded from extraneous radiation fields by lead with aluminum interposed between it and the tube, with the maximum thickness as specified in 1 above.

MIL-STD-1311D

METHOD 6205

LEAKAGE CURRENT

(Radiation counter tubes)

The leakage current between anode and cathode, determined at the applied voltage specified, shall be not more than the limit(s) specified. The reading shall be taken 30 minutes after the humidity chamber has reached equilibrium at  $50^{\circ}\text{C} \pm 5^{\circ}\text{C}$  and  $90 \pm 5$  percent relative humidity.

## MIL-STD-1311D

## METHOD 6211

## STARTING VOLTAGE

(Radiation counter tubes)

The starting voltage is defined as the applied counter tube voltage at which uniform pulses of a specified average amplitude appear across the total resistance in the circuit shown on figure 6211-1. The test shall be performed using a calibrated high-impedance oscilloscope, a low-impedance power supply, and a high-impedance voltmeter (V). The count rate shall be less than 200 counts per second. The starting voltage shall be not greater than the limit specified.

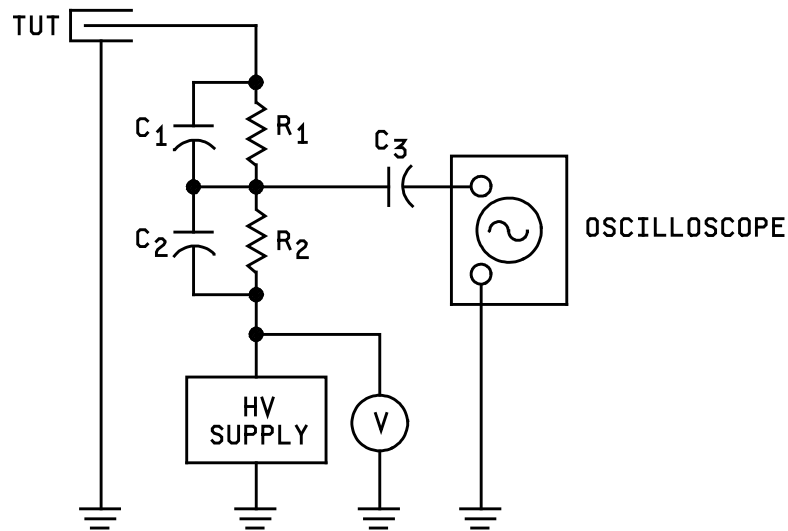


FIGURE 6211-1. Circuit used for measuring pulse amplitude and starting voltage.

## MIL-STD-1311D

## METHOD 6216

## PLATEAU CHARACTERISTICS

(Radiation counter tubes)

1. Plateau tracing (method A). When the plateau tracing (count rate versus applied tube voltage) of a radiation counter tube is made at the recommended operating voltage, at a counting rate of 100 Nps, and using a recording-rate meter having the following characteristics, the relative plateau slope, end-of-plateau voltage, and plateau length shall be within the limit(s) specified (see 1.1, 1.2, and 1.3, respectively).

- a. Resolving time. The resolving time shall be  $50 \pm 5 \mu\text{s}$ .
- b. Discrimination level. The discrimination level shall be  $1 \pm 0.1$  volts.
- c. Accuracy. The recording-rate meter shall be capable of measuring uniform recurrence rates ranging from 10 to 200 Nps, with an accuracy of 5 percent.
- d. Deflection sensitivity. The deflection sensitivity of the recorder shall be not less than 1 inch per 50 Nps.
- e. Full-scale deflection. The full-scale deflection of the recorder shall indicate not less than 200 Nps.
- f. Voltage drive. The potential across the tube shall be applied at a uniform rate of increase not greater than 100 volts per minute.
- g. Time constant. The time constant shall be not greater than 2.5 seconds.

1.1 Relative plateau slope. The relative plateau slope shall be determined from the average curve drawn through the plateau tracing obtained as specified in 1 above. A typical plateau tracing with an average curve drawn through it is shown on figure 6216-1. The relative plateau slope shall be determined over a voltage range specified. The relative plateau slope in percent per volt (see figure 6216-1) shall be given by  $100 a/bc$ , where:

a = Change in count rate (Nps) over specified voltage range.

b = Specified voltage range (volts).

c = Count rate (Nps) measured at the specified operating voltage.

1.2 End-of-plateau voltage. The end-of-plateau voltage is the lowest applied counter tube voltage at which the relative slope of a line drawn tangent to the smoothed average curve (see figure 6216-1), obtained as specified in 1 above, exceeds a value given on the TSS. The end-of-plateau voltage is the lowest voltage at which the relative slope,  $100 e/fg$ , is equal to the value given on the TSS, where:

$e/f$  = Slope of line drawn tangent to average curve (Nps).

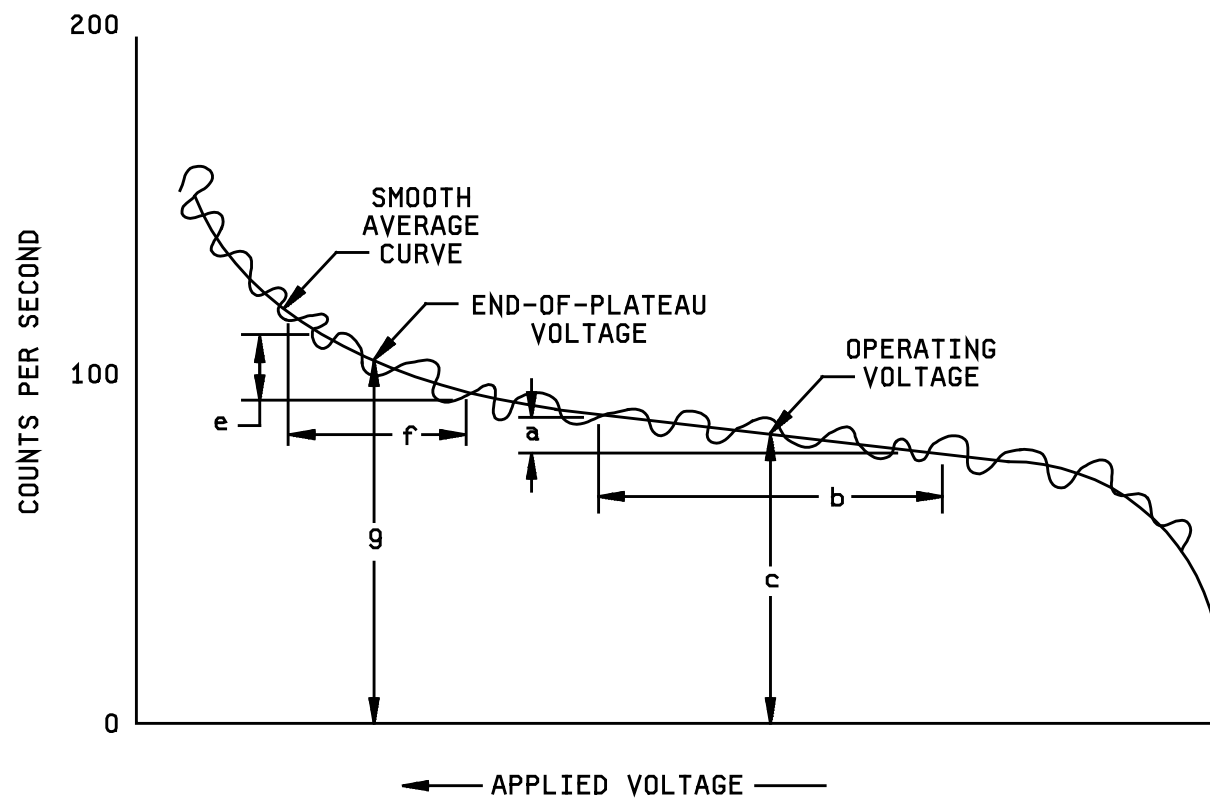
g = Absolute count rate measured at the point of tangency (Nps).

1.3 Plateau length. The plateau length of a counter tube shall be the difference between the end-of-plateau voltage and the plateau starting voltage.

2. Scaler (method B). When plateau characteristics are to be determined by use of a scaler, details will be given on the TSS.



MIL-STD-1311D

FIGURE 6216-1. Typical plateau tracing showing smoothed average curve.

MIL-STD-1311D

METHOD 6221

RESPONSE COUNT RATE AND CURRENT

(Radiation counter tubes)

The tube response count rate and response current, determined using a standard excitation unit or a specific radiation field and circuit as specified, shall be within limit(s) specified. The tube response count rate shall be measured using a scaler having a resolving time of 5  $\mu$ s or less, and a discrimination level of 0.25 volt. The counting time and the tube operating voltage for the test shall be as specified.

MIL-STD-1311D

METHOD 6226

PULSE AMPLITUDE

(Radiation counter tubes)

The pulse amplitude is defined as the peak pulse voltage developed across the total resistance shown on figure 6211-1. The test shall be performed using a calibrated high-impedance oscilloscope, a low-impedance power supply, and a high-impedance voltmeter (V). The pulse amplitude shall be within the limit(s) specified.

MIL-STD-1311D

Custodians:

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

Preparing activity:

DLA - CC

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Army - AR, AV, CR4, MI, SM  
Navy - AS, CG, OS, SH  
Air Force - 19, 99

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