



Specification for
Klystrons of assessed quality:
Generic data and methods of test

Spécification des klystrons de qualité assurée:
données génériques et méthodes d'essai

Spezifikation für Klystrone bestätigter Güte:
generische Daten und Prüfverfahren

Confirmed

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Cooperating organizations

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Foreword

This British Standard, which has been prepared under the direction of the Electronic Components Standards Committee, is the generic specification for klystrons in the system of standards for electronic components of assessed quality.

British Standard Specification for

Klystrons of assessed quality: Generic data and methods of test

Section one. General matters

1.1 Scope

This British Standard forms part of the system of common standard specifications for electronic components of assessed quality and should be read in conjunction with the standards in the series BS 9000 to BS 9009 inclusive.

This standard applies to klystrons, as defined in 1.3, and gives the terms, definitions, symbols, test methods and other material necessary to implement fully the detail specifications for these tubes. The material herein is applicable only when called up by the detail specification, except for 1.6 to 1.18, which are mandatory requirements.

1.2 Related documents

BS 448	Dimensions of electronic tubes and valves
BS 1991	Letter symbols, signs and abbreviations
BS 2011	Basic environmental testing procedures
BS 3939	Graphical symbols for electrical power, telecommunication and electronics diagrams
BS 4727	Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms
BS 6001	Sampling procedures and tables for inspection by attributes
BS 9000	General requirements for electronic components of assessed quality
PD 9002	BS 9000 Component selection guide
IEC 235-1	Measurement of the electrical properties of microwave tubes and valves Part 1: General terms and definitions
IEC 50(531)	IEV CHAPTER 531: Electronic tubes

1.3 Terminology

For the purposes of this British Standard, the following terms and definitions apply, in addition to those from the relevant Part of BS 4727.

NOTE. A number of the following definitions are identical with those given in IEC Publications; these are indicated by the inclusion of the relevant IEC reference in parentheses at the end of the definition.

1.3.1 klystron. A linear beam type tube containing at least one drift space and in which the space charge waves interact with stationary r.f. fields that are confined to one or more interaction gaps (531-32-12).

1.3.2 linear beam tube (O-type). A space-charge-wave tube in which the directions of the electron beam, the electric field and the static magnetic field, if any, are parallel

(co-linear). In this type of tube the kinetic energy of the electron beam is converted into r.f. energy.

1.3.3 reflex klystron. A single-cavity klystron in which the beam direction is reversed within the drift space so that the beam passes a second time through the interaction gap (531-32-13).

1.3.4 multicavity klystron. A klystron having more than two interaction gaps.

1.3.5 floating-drift-tube klystron. A klystron in which a drift space is located within a cavity.

1.3.6 extended interaction klystron. A klystron in which the space-charge wave interacts with stationary r.f. fields that are confined to two or more interaction regions at least half a wavelength long.

1.3.7 hybrid tube. A linear-beam tube that utilizes the principles of a klystron at the input of an extended interaction amplifier at the output, or vice versa.

1.3.8 instantaneous bandwidth (amplifiers). The frequency band over which the available power and/or gain of an amplifier tube does not vary beyond prescribed limits when the rate of frequency change is rapid enough to exclude thermal drift effects.

1.3.9 available power gain. The ratio (in decibels) of r.f. output power to incident r.f. input power.

1.3.10 harmonic output power. R.F. output power that is coherently related to the frequency of the input and is therefore observed at multiples of that frequency (clause 23 of 235-1).

1.3.11 AM-PM conversion coefficient. The quotient of (1) the deviation in phase change of the output relative to the input of a carrier and (2) the magnitude of the amplitude modulation of the same carrier at the input.

1.3.12 compression (or expansion) factor. The quotient of (1) the difference between the numerical values of gain and incremental gain by (2) the gain.

1.3.13 synchronizing pulse compression factor.

The quotient of (1) the amplitude of the synchronizing pulse at the output by (2) the amplitude of the synchronizing pulse at the input, each pulse amplitude expressed as a percentage of the total amplitude (picture and synchronization) of the signal.

1.3.14 incremental power gain. The ratio of (1) the incremental change of output power to (2) the incremental change of input power.

1.3.15 differential gain. The difference of the values of incremental power gain between two stated levels of input (or output) power. (Usually it is the maximum value within a specified range of output powers and is expressed in decibels.)

1.3.16 differential phase. The maximum difference in phase shift of the envelopes of an amplitude modulated carrier at the output of the tube between two levels of the carrier at the input (or output). (Usually it is the maximum value within a specified range of output powers.)

1.3.17 transient overswing. The maximum deviation of the output amplitude response of the tube from a step function modulation of the input carrier.

1.3.18 level dependency of sideband frequency response. The maximum difference of frequency responses of a non-linear amplifying tube to a modulated signal passing through it between two stated levels of carrier output power, thermal effects being avoided.

1.3.19 efficiency. The ratio of (1) the output power to (2) the total input power excluding the cathode heater supply power and the focusing power requirements, where applicable. The output and input powers are measured over a specified period of time.

1.3.20 noise. An incoherent, low-level output over a wide spectrum of frequencies, arising mainly from the activity of electrons and ions within the tube.

1.3.21 noise factor. The ratio of (1) signal to noise ratio at the input to (2) signal to noise ratio at the output, the temperature of the input termination being maintained at a stated reference temperature, usually 290 K.

1.3.22 r.f. input power (available power). The power which is delivered to a matched load substituted for the input cavity (or terminal) of the tube.

1.3.23 output power. The power at the reference frequency which is delivered to the load at the output reference plane (or terminal) of the tube (3.3.1 of 235-1).

1.3.24 power gain. The ratio of (1) the output power of a tube to (2) the r.f. input power under specified conditions, expressed in decibels (24.1 of 235-1).

1.3.25 gain flatness. The difference between maximum and minimum values of gain over a given range of frequency with the output power maintained constant (24.5 of 235-1).

1.3.26 small signal gain. Gain in the input power range in which a decrease of the driving power has no effect on the gain (24.9 of 235-1).

1.3.27 saturation output power. The first maximum value of output power observed as the input power is gradually increased with the tube operated under stated conditions (21 of 235-1).

1.3.28 input or output v.s.w.r. The v.s.w.r. looking into the input/output of the amplifier tube observed under stated operating conditions.

1.3.29 mismatch stability and short circuit stability. The stability of a tube when operated with the r.f. input and/or output mismatched or short circuited.

1.3.30 operating frequency range. The frequency range over which the tube can be adjusted to meet the stated performance requirements.

1.3.31 integral magnet tube. An assembly incorporating the tube, focusing system and r.f. terminals so that the tube cannot be replaced in the assembly by the user.

1.3.32 pulse. A brief variation of a quantity above or below a stated datum level: this variation is characterized by a rise and a decay and has a finite duration (12.1 of 235-1).

1.3.33 pulse shape (See figure 1.)

1.3.34 pulse rise time. The time required for the pulse to rise from 10 % of the pulse amplitude to 90 % of the pulse amplitude.

1.3.35 pulse duration. The time interval between the instants at which the instantaneous value of the pulse quantity equals 50 % of the pulse amplitude unless otherwise stated.

1.3.36 pulse fall time. The time required for the pulse to fall from 90 % of the pulse amplitude to 10 % of the pulse amplitude.

1.3.37 pulse rate of rise. The slope of the tangent to the leading edge of the pulse at an instant under consideration.

1.3.38 pulse amplitude. The maximum value of a smooth curve drawn through the average of the variations on the top of the pulse, any spike on the leading edge of duration less than a defined percentage of the pulse duration being ignored. For example, in the case of a pulse whose duration is of the order of 1 μ s or more, it is normal to ignore spikes having a duration of less than 10 % of the pulse duration.

1.3.39 spike. A short duration surge above the pulse amplitude. A spike on the leading edge of a pulse is often called 'overshoot'.

1.3.40 pulse ripple. The deviations from the smooth curve drawn through the average of the variations on the top of the pulse. It is normally expressed as a percentage of the pulse amplitude.

1.3.41 pulse droop. A distortion of an otherwise essentially flat-topped pulse characterized by a decline of the smooth line drawn through the average of the variations on the top of the pulse (15.4 of 235-1).

1.3.42 inter-pulse period. The time interval between the finish of one pulse and the start of the following pulse (16.1 of 235-1).

1.3.43 pulse repetition frequency. The number of times the pulse waveform repeats per stated unit of time, usually per second (16.2 of 235-1).

1.3.44 pulse repetition period. The reciprocal of pulse repetition frequency (16.3 of 235-1).

1.3.45 duty factor. The product of pulse repetition frequency and pulse duration over a stated averaging period.

1.3.46 post-pulse oscillation (see figure 1). Damped oscillation of the pulse quantity which occurs after the finish of the main pulse, comprising back swing and forward swing (13.4 of 235-1).

1.3.47 back swing. The excursion of the pulse quantity of opposite polarity to that of the main pulse and which occurs immediately after the main pulse (13.5 of 235-1).

1.3.48 forward swing. The excursion of the pulse quantity immediately following the back swing, in opposite polarity thereto (13.6 of 235-1).

1.3.49 mode. One of a series of discrete power versus frequency envelopes, generally semi-ellipsoid in shape.

1.3.50 moding. The operation of a tube partly or fully, in any undesired mode (531-41-07).

1.3.51 pulse output power. The ratio of (1) the average output power to (2) the r.f. pulse duty factor (17.2 of 235-1).

1.3.52 heater or filament modulation effect.

The modulation of the r.f. output caused by an a.c. heater

or filament current or by ripples on a d.c. heater or filament current (3.5.4 of 235-1).

1.3.53 heater or filament modulation factor. The heater or filament modulation factor may be expressed as:

- (a) the amplitude modulation depth, at n hertz, per ampere of heater/ripple current;
- (b) the phase modulation index, at n hertz, per ampere of heater/ripple current;
- (c) the frequency modulation excursion, at n hertz, per ampere of heater/ripple current;

where n is the relevant frequency component of the a.c. heater or filament current, or ripple on a d.c. heater or filament current (3.3.5 of 235-1).

1.3.54 incidental (self-generated) frequency modulation. Unwanted random and/or periodic variations in the frequency of oscillation.

1.3.55 power stability. The ability of an amplifier or oscillator tube, when operated under given conditions, to re-establish the original value of output power after an interruption of the h.t. supply. The change in output power is usually expressed as a percentage change of the initial value (3.3.3 of 235-1).

1.3.56 frequency of oscillation. The frequency of oscillation of an oscillator is the value of the frequency at which the power output is a maximum.

1.3.57 reference frequency. The specified frequency or frequencies at which measurements are to be made.

1.3.58 spectrum width. The difference in frequency between the most widely separated points at which the power is a specified fraction of the highest value of power occurring in the spectrum (see figures 2(a) and 2(b)).

1.3.59 minor lobe ratio. The ratio between (1) the maximum power in the major lobe and (2) the maximum power in the highest minor lobe, expressed in decibels (see figures 2(a) and 2(b)).

1.3.60 emission stability. The capability of the tube to deliver cathode current with limited change as a result of variation of heater power.

1.3.61 frequency drift. A slow continuous change of frequency of oscillation (clause 47 of 235-1).

1.3.62 response drift. The change in the frequency response of an amplifier tube.

1.3.63 frequency pushing. The phenomenon of the change in the frequency of oscillation with a change of electrode current (clause 43 of 235-1).

1.3.64 pushing figure. The quotient of (1) the difference between the extremes of frequency of oscillation to (2) the change in electrode current which produces the change in frequency (thermal effects excluded). Numerically the frequency pushing figure is expressed in megahertz per ampere (clause 44 of 235-1).

1.3.65 frequency pulling. The phenomenon of the change in the frequency of oscillation with a change of load impedance (clause 45 of 235-1).

1.3.66 pulling figure. The difference between the extremes of frequency of oscillation occurring when the phase angle of the reflection coefficient of a given load mismatch varies through 360° (thermal effects excluded) (clause 46 of 235-1).

1.3.67 temperature coefficient of frequency.

(a) *Oscillators*

The quotient of (1) the change in the frequency of

oscillation to (2) the change of the temperature which caused it when measured at constant current.

The temperature is measured at a defined point on the tube body.

(b) *Amplifiers*

The quotient of (1) the change in the frequency response of the tube to (2) the change of the temperature which caused it when measured at constant current. The temperature is measured at a defined point on the tube body.

1.3.68 h.t. delay time (pre-heat). The time interval between the instant at which a given heater or filament voltage is reached and the instant of application of the h.t.

1.3.69 warm-up time. The time interval between the start of application of the h.t. and the moment at which a given drift rate, or stated value of frequency, output power or current is achieved (2.2 of 235-1).

1.3.70 mechanical tuning sensitivity. The change of resonant frequency of a given cavity or cavities with respect to the change of position of the mechanical tuner control at a given operating point.

NOTE. With a local oscillator klystron, this will result in a change in the output frequency and, in the case of an amplifier, a change in the frequency response.

1.3.71 electronic tuning sensitivity. The rate of tuning with respect to a change of the controlling electronic tuning voltage at a stated operating point.

1.3.72 tuning rate or tuning speed. The rate of change of frequency of operation per unit change of tuning controlling parameter.

1.3.73 mechanical tuner resetability. The ability of the tuning mechanism to reproduce the same value of a stated quantity, e.g. frequency or output power when a tuner setting is always approached from the same direction.

1.3.74 tuner backlash. The maximum amount of motion of the tuner which just produces a change in value of a stated quantity, e.g. frequency or output power, on reversal of the direction of tuner motion.

1.3.75 tuner hysteresis. The difference between the values of a stated quantity, e.g. frequency or output power, observed when a given tuner setting in mechanical or electronic controlling parameter is approached from opposite directions. In the case of mechanical tuning this includes the effects of backlash.

1.3.76 tuner starting torque. The value of torque required to initiate tuner motion (4.2.6 of 235-1).

1.3.77 tuner operating torque. The value of torque required to drive the tuner over the entire tuning range at a stated temperature.

1.3.78 tuner stop torque. The stop torque or force, including inertia forces, that the parts of the tuning mechanism can withstand at the ends of the travel without sustaining damage (4.2.10 of 235-1).

1.3.79 spurious oscillations. Unwanted oscillations which, when occurring under given conditions, are not part of the principal mode series.

1.3.80 load effect. The variation in output power of a tube operating under given conditions and coupled into a load causing a specified mismatch, when the phase of the reflection coefficient of the mismatch is varied.

1.3.81 reflector mode width. A range of reflector voltages over which the tube continues to oscillate at the desired

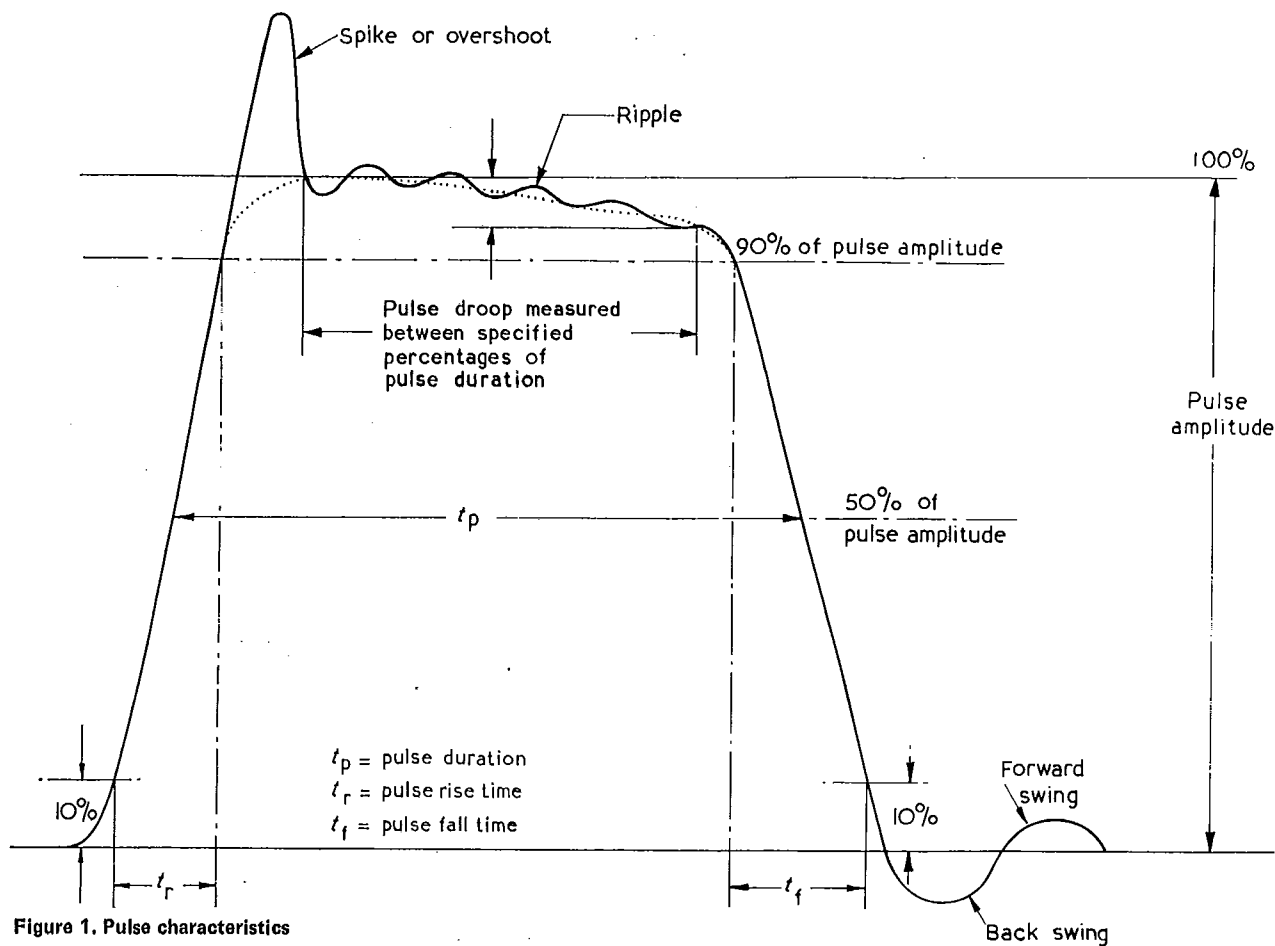


Figure 1. Pulse characteristics

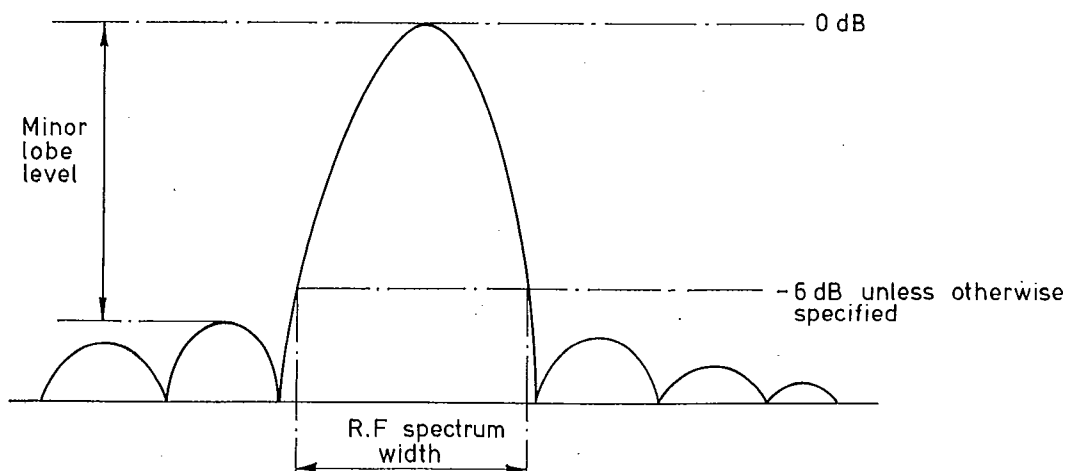


Figure 2(a). R.F. spectrum width (highest minor lobe below spectrum width reference level)

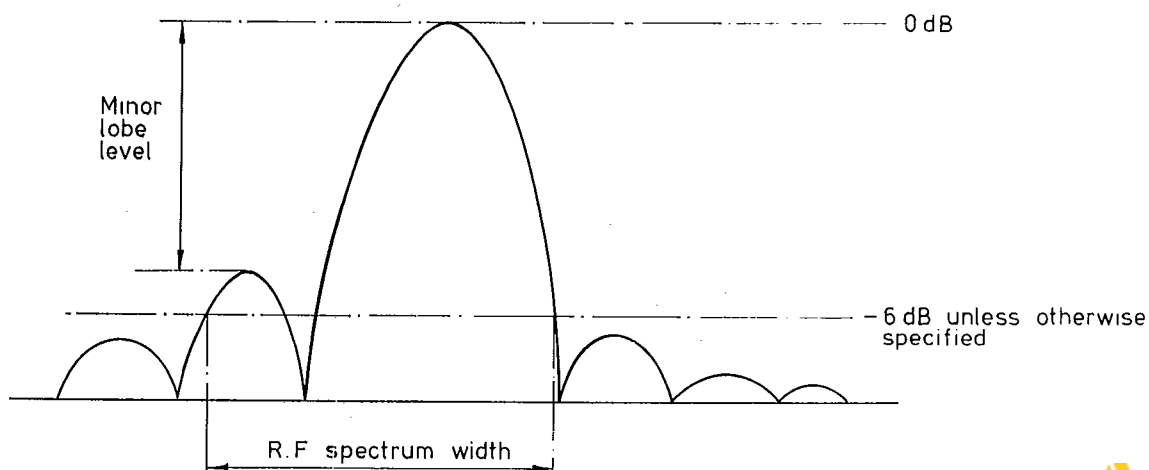


Figure 2(b). R.F. spectrum width (highest minor lobe exceeds spectrum width reference level)

frequency or frequencies and maintains (where applicable) a minimum power output.

1.3.82 perveance. The quotient of (1) the mean convection current by (2) the three halves power of the voltage that corresponds to the mean kinetic energy of the charge carriers within a stated cross-section of the beam, or by (2) the three halves power of the voltage of the accelerating electrode (531-17-18).

1.4 Letter symbols, signs and abbreviations

The following symbols apply in addition to those specified in BS 1991.

Collector voltage = V_{col}

Collector current = I_{col}

Noise factor = NF

Tube under test = TUT

1.5 Graphical symbols

Graphical symbols shall be in accordance with BS 3939.

The graphical symbol for the tube under test (TUT) in the following test methods is as shown in figure 3.

The r.f. input to the klystron amplifier tube shall be in the direction of arrow A and the r.f. amplified output shall be in the direction of arrow B.

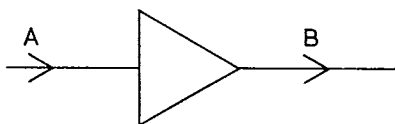


Figure 3. Graphical symbol for tube under test

1.6 Marking of the tube and packing

The following symbols or codes shall be clearly and durably marked on the tube in the following order of preference as space permits. All symbols and codes except terminal marking and operating conditions shall also appear on the primary pack, e.g. carton, box, plastics envelope, etc. used as initial protection or wrapping for delivery.

- Manufacturer's part designation number and special marking related to hazard and special operating conditions.
- Manufacturer's factory identification code.
- Date code.
- BS number of the detail specification.

1.7 Eligibility for qualification approval

A klystron tube shall be eligible for submission for qualification approval in accordance with BS 9000 only when the assembly and final shaping of the interaction gap(s), the activation or formation of the cathode and all subsequent processing and fabrication have been carried out by an approved manufacturer. The use of clause 2.3.2(3) of BS 9000 : 1971 is excluded.

1.8 Structurally similar tubes

When several variants of any one type of tube are being produced simultaneously, or in uninterrupted succession, the total production may be sampled for all common features and characteristics but each of the variant types shall be fully inspected in accordance with the relevant detail specification for the deliberately varying feature or features.

Structurally similar tubes shall preferably be included on the same detail specification but in any case the claim for grouping shall be declared in the qualification approval test report.

1.9 Delayed delivery

Tubes held by the manufacturer for a period exceeding twelve months following acceptance inspection shall be reinspected for those tests that are specified in the detail specification.

1.10 Supplementary procedure for qualification approval

The table below supersedes the sample size requirements of 2.3.1 of BS 9000 : Part 1 : 1971 for production lot sizes below 280 specimens. The samples may be drawn from one production lot. When using the table a second sample as shown shall be taken when the quantity of defectives exceeds the acceptance quantity but is less than the reject quantity.

Where production rates are 12 tubes per month or fewer, permission to release prior to approval may be granted on successful completion of the specified tests on two tubes for groups A and B and one tube for groups C and D.

On receipt of such permission the manufacturer may begin to release tubes complying with this specification.

Qualification approval will be granted when the number of tubes quoted in the table below have satisfied the specified requirements, provided that, during this period, no inspection lots have been rejected.

Permission to release tubes will be withdrawn

- in the event of the rejection of an inspection lot prior to the granting of qualification approval;
- in the event of qualification approval not being granted within 18 months of the date of permission to release.

When permission to release is granted, the specification number will be shown in Part 4 of PD 9002 but there will be no entry in Part 1 until qualification approval is granted.

All release documentation including the certificate of conformity shall be prominently marked 'This tube is released in advance of qualification approval' and the reference of the document granting permission to release shall be quoted.

Group	Lot size	Sample size	Accept	Reject	2nd sample	Total sample	Accept	Reject
A and B	2 to 7	100 % (See note)	0	1				
	8 to 280	6	0	2	2	8	1	2
C and D	Any	2	0	2	2	4	1	2

NOTE. Qualification approval is dependent on at least six samples being tested.



Documents

Document Sharing Hub

[1.11

Defective tubes may be used for those tests where the validity of the result is not affected by the particular defect(s).

Results obtained on development samples which have been produced using substantially final production techniques and tested by approved methods may be included in the test report to cover part of the requirements for qualification approval with the agreement of the National Supervising Inspectorate.

1.11 Certified test records

The requirements of 2.8 of BS 9000 : 1971 : Part 1 shall apply.

1.12 Standard ratings and characteristics

Not applicable.

1.13 Unchecked parameters

Not applicable.

1.14 Procedure to be followed in the event of failure at group C or group D inspection

The procedures of 2.6.4.1 and 2.6.4.2 of BS 9000 Part 1 : 1971 shall apply.

1.15 Ordering information

Ordering information will be found in the appropriate detail specification.

1.16 Release prior to completion of group B tests

Not applicable.

1.17 Inspection procedures for low rates of production

Clause 2.5.1.2 of BS 9000 : Part 1 : 1971 shall apply.

1.18 Inspection procedure for continuous production

For the purposes of this British Standard, continuous production is defined as in 2.5.1.1(5) of BS 9000 : Part 1 : 1971, except that in subclause (iii) the period shall be increased from 1 month to 9 months. In addition, structural similarity with similar types may be taken into account.

Section two. Test procedures

2.1 Test and measurement conditions

All tests and measurements shall be carried out under the standard atmospheric conditions for testing as specified in 5.3 of BS 2011 : Part 1.1 : 1977. The limits given in detail specifications are absolute. Measurement inaccuracies shall be taken into account when demonstrating conformity to detail specification.

2.2 Visual inspection

Unless otherwise specified, visual inspection shall be performed under normal factory lighting conditions and without visual aids.

Visual inspection shall be carried out for good appearance and workmanship, and shall include the following items where applicable.

- (a) Shape.
- (b) Alignment of connectors.
- (c) Straightness of pins or leads.

(d) Cleanliness and surface finish of parts and electrical (especially r.f.) contact surfaces.

(e) Clarity of marking.

(f) Correctness of marking including marked values.

(g) Position of marking.

(h) Finish.

(i) Materials (The materials and finish for external parts shall comply with the requirements of the detail specification and/or the quality of the qualification approval samples).

2.3 Dimensions and gauging procedures

Dimensional measurements shall be made either by the use of conventional measuring instruments (vernier calipers, rules, micrometers, etc.) or by gauges. Gauges shall be in accordance with the requirements of BS 448, where applicable, or shall have dimensions and characteristics that comply with the requirements given on the inspection drawing of the tube. All drawings shall state the projection used.

2.4 Electrical test procedures

2.4.1 Alternative methods of test. See 2.4.2 of BS 9000 : Part 1 : 1971.

2.4.2 Measuring equipment. All microwave measuring equipment shall be verified to ensure satisfactory operation over the required frequency range. This shall be carried out using swept frequency techniques.

The measuring equipment shall be such that the time constants or pulse response characteristics will not significantly affect the measurement results. Care shall be taken to ensure that any stray electromagnetic fields do not significantly affect the measurement results.

2.4.3 Setting-up procedures. Where applicable, the setting-up procedures given in the detail specification shall be followed.

2.4.4 Temperature conditions. Where the measurement of temperature is required for operating conditions or temperature coefficients, it is necessary to measure the temperature at a stated part of the tube rather than to measure the ambient temperature.

It is necessary to maintain steady conditions for a sufficient time to ensure that all parts of the tube have reached equilibrium temperature.

2.4.5 Forced cooling. When forced cooling is required the following shall be checked.

- (a) Type of coolant.
- (b) Method of application.
- (c) Rate of flow, or pressure difference between inlet and outlet at stated ambient conditions.
- (d) Limits of inlet temperature.
- (e) Maximum permitted body temperature of the tube at a stated point.

2.4.6 Pressurizing. Where pressurizing is required, the following items shall receive attention before and during operation of the tube.

- (a) The system shall be clean and free from condensation and be capable of adequate sealing to maintain gas purity.

(b) The minimum or maximum limits of gas pressure to which the microwave components can be subjected without damage or mechanical distortion shall be observed.

(c) The nature, purity, dryness and temperature of the gas shall be within the stated limits.

2.4.7 Reference point. Unless otherwise stated the polarity of all voltages applied to the electrodes shall be relative to the cathode.

2.4.8 V.S.W.R. measurement. Voltage standing wave ratios are expressed as a value greater than 1.

2.4.9 Matched r.f. termination. Where a 'matched termination' is specified in a test procedure it shall have a v.s.w.r. not exceeding 1.1 to 1 over the frequency range in which the tube is being measured.

2.4.10 General. The following general precautions shall be followed.

(a) The signal source shall be sufficiently decoupled from its load.

(b) The harmonic content of the input signal shall not significantly affect the accuracy of measurement.

(c) Screening shall be provided where stray r.f. radiation is likely to affect the measurements.

(d) Isolators may be required at the input and output of the tube under test.

2.4.11 Index of test methods. For convenience of identification in detail specifications the following numbering system for test methods has been used. These methods are described in this standard after 2.7.3.

Index of test methods

Title	Method
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2.5 Mechanical test procedures

See method 1019.

2.6 Environmental test procedures

The following tests from BS 2111 : Part 2.1 : 1977 shall be performed as required by the detail specification.

2.6.1 Test N: change of temperature. (This test is non-destructive.) The test shall be either Test Na or Nb, except that the tube shall be non-operating and the duration at each temperature extreme shall be as given in the following table.

Mass of tube	Minimum period
kg	h
0.15 and less	0.5
Over 0.15 up to 1.5	1.0
Over 1.5 up to 15	2.0
Over 15 up to 150	4.0

The following temperatures are preferred: -55°C and $+85^{\circ}\text{C}$.

The preferred number of cycles is five.

2.6.2 Test Ca: Damp heat, steady state. (This test is non-destructive.) The marking shall be legible at the completion of the test.

The preferred duration is 21 days.

2.6.3 Test Da: Accelerated damp heat. The preferred number of cycles is six.

2.6.4 Test Ea: Shock. (This test is non-destructive.) The preferred values of acceleration and duration of the shock pulse are 147 m/s^2 and 3 ms respectively. The waveform shall be half sine wave unless otherwise specified in the detail specification.

Tubes having structural symmetry in two of the three axes need be subjected to shock in only two dissimilar axes.

2.6.5 Test Fc: Vibration (swept frequency). Procedure B4.

Tubes having structural symmetry in two of the three axes need be subjected to vibration in only two dissimilar axes.

2.6.6 Test Fc: Vibration (fixed frequency). Procedure B2.

Tubes having structural symmetry in two of the three axes need be subjected to vibration in only two dissimilar axes.

2.6.7 Test Kb: Salt mist. The preferred severity is severity 2.

2.6.8 Robustness of terminations

Purpose. The purpose of the test is to determine the ability of terminations to withstand the mechanical strains likely to be applied during normal assembly of the tube into the equipment.

Test U: Procedure. The following tests shall be performed as required by the detail specification.

(a) Torque: Test Ud.

(b) Tensile: Test Ua 1.

(c) Bending: Test Ub.

The loading to nominal wire size shall be as shown in the table overleaf.

2.6.9 Test Aa: Cold. The severity shall be specified in the detail specification.

2.6.10 Test Ba: Dry heat. The severity shall be specified in the detail specification.

Nominal wire size (diam.)	Mass
mm	kg
Up to and including 0.5	0.25
Over 0.5 up to and including 0.8	0.5
Over 0.8 up to and including 1.25	1.0
Over 1.25	2.5

NOTE. Tests for r.f. connectors and waveguide are under consideration.

2.6.11 Test Eb: Bump. The severity shall be specified in the detail specification.

2.7 Endurance test procedures

2.7.1 Non-operating endurance test (holding test).

After completion of the essential manufacturing processes, all tubes shall be held in storage for a specified holding period during which they shall not be operated. During the holding period, processes such as marking, low temperature potting, painting and gauging may be carried out.

Where the holding period is not specified in the detail specification the tubes shall undergo a minimum holding period of 48 h.

Specified conditions. The values of the following conditions shall be given in the detail specification:

- (a) Tests to be performed before/after the holding period.
- (b) Duration of holding period (if other than 48 h).

2.7.2 Non-operating endurance test (storage test).

Where storage is specified the period shall be twelve months under standard atmospheric conditions for testing as given in BS 2011 : Part 1.1.

2.7.3 Operating endurance test. The tube shall be set up and operated in accordance with the setting-up procedure given in the detail specification. Unless otherwise specified, tubes undergoing endurance shall be measured at least at the following time intervals:

0 h, 160 h, 500 h, 1000 h,

and thereafter at 1000 h intervals, to within +48 h and -24 h.

The manufacturer may make measurements at additional time intervals at his own discretion.

Tubes rejected for those characteristics that are not the subject of post-endurance tests may be used for this test.

Vacuum factor

Purpose. To assess the vacuum quality of the tube.

Procedure. With normal heater voltage applied, a stated positive voltage shall be applied to the first accelerating electrode and a stated negative voltage shall be applied to a stated electrode chosen for its good insulation against leakage. The cathode current shall then be adjusted to a suitable value, I_k , by means of the positive electrode voltage, and any current, I_1 , flowing in the negative electrode circuit shall be measured.

To measure the leakage current, the heater voltage shall be reduced to zero, and the voltages on the accelerating and negative electrodes left unchanged. The negative electrode current, I_2 , is then noted after a stated time interval.

The vacuum factor is given by the ratio:

$$\frac{I_1 - I_2}{I_k}$$

NOTE 1. Although there may be some discrepancy between cathode current and beam current, this does not affect the validity of comparison between tubes of the same geometry.

NOTE 2. A relatively low positive accelerator voltage (typically 40 V to 250 V) should be chosen to effect a compromise between sensitivity and minimization of the residual current which may be caused by leakage, soft X-rays, or photoelectric effects. In order to minimize measuring errors caused by parasitic oscillations and/or leakage current, a range of negative voltage, typically 30 V to 100 V, is recommended.

Precautions

- (a) The maximum permissible electrode dissipation and voltage ratings for d.c. operation shall not be exceeded in this measurement.
- (b) Unless otherwise specified, in order to prevent damage to the cathode when the measurement of vacuum is made directly after the tube has been stored, residual gases shall be removed by operating the tube briefly at a reduced level in the same circuit prior to the measurement.
- (c) It may be necessary to exclude extraneous light from the tube during this measurement.

Conditions prescribed in the detail specification

- (a) Heater current or voltage.
- (b) Electrode voltage(s).
- (c) Accelerator voltage.

Ion pump current

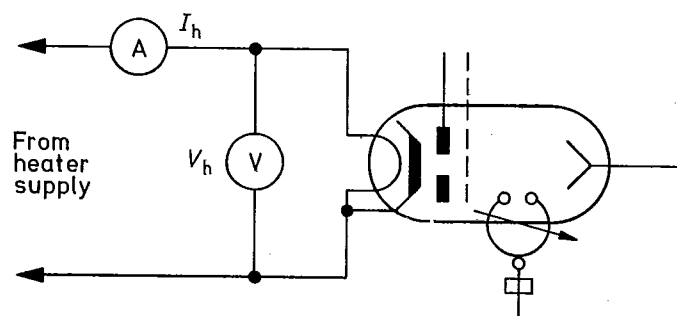
Purpose. To verify that, after a period of non-operation, the quantity of gas within the tube can be rendered negligible by means of the ion pump when this is provided.

Procedure. The necessary voltage shall be applied to the ion pump and shall be maintained for at least the prescribed conditioning time. If necessary, the pumping operation shall be continued up to the maximum specified time when the ion pump current falls below the specified limit.

If there is no indication of ion pump current, ensure that the tube is not down to air and that the ion pump is connected.

Conditions prescribed in the detail specification

- (a) Ion pump supply voltage.
- (b) Maximum pumping time.
- (c) Maximum settled pump current.

Heater current (or voltage)**Test circuit**

Procedure. Where applicable, the ion pump shall be operated for the prescribed period with the ion pump current below the prescribed limit and with the cooling medium applied in the electron gun region.

The specified heater voltage (or current) shall be applied and the heater current (or voltage) measured (directly at the tube terminals) after the steady state condition has been achieved.

No other voltages shall be applied.

Precaution. The instruments employed shall read true r.m.s. values including harmonic content, and thermal type instruments are recommended.

Conditions prescribed in the detail specification

- (a) Heater voltage (or current) and polarity if d.c. supply is required.
- (b) Any limitation on heater surge current.
- (c) Heater supply frequency if other than 50 Hz.
- (d) Ion pump current and pumping time, where applicable.
- (e) Cooling, if applicable.

Pulse voltage amplitude

Purpose. To measure the applied pulse voltage amplitude under specified conditions (6.1 of 235-2).

Procedure. Pulse voltage amplitude shall be measured by one of the following methods as specified. In the event of a specific method not being detailed, the manufacturer may choose any of these methods at his own discretion.

NOTE. Methods 1 and 2 are not applicable to non-repetitive pulses.

Standard voltmeter methods

Method 1. Peak diode voltage. The pulse voltage shall be measured with the standard voltmeter circuit as shown in figure 1003/1. This circuit shall be calibrated either with a standard d.c. voltage or by measurement of resistor R and calibration of meter A.

Test circuit

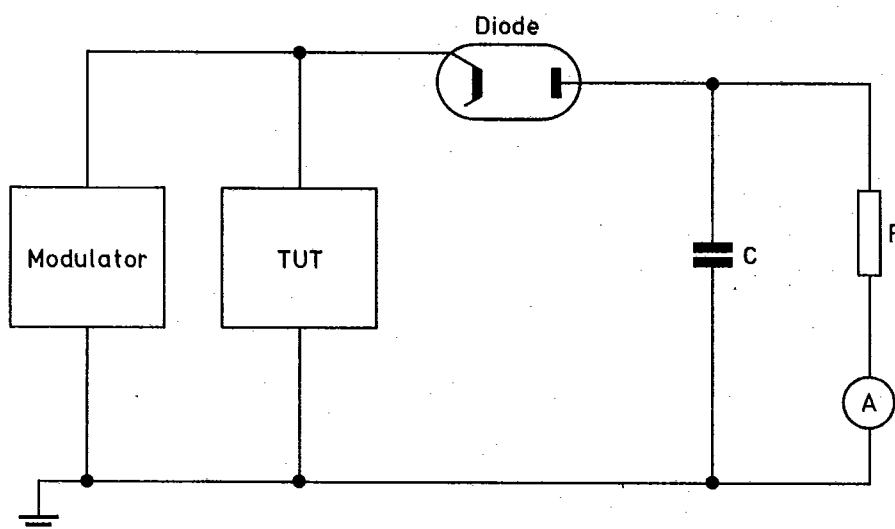


Figure 1003/1

Precautions. The peak inverse voltage rating of the diode under pulsed conditions shall exceed the maximum applied pulse voltage plus any resultant backswing voltage. In general this restricts the application of the circuit to pulse voltages below 35 kV.

The diode shall have adequate current-carrying capacity.

BS 9035 : 1979

1003/2

The input capacitance, which comprises the diode inter-electrode capacitance and the heater supply circuit capacitance plus other strays, shall be kept low to avoid undue loading of the modulator. Distributed line techniques will be advantageous at very short pulse durations, to avoid distortion of the pulse because of the complex nature of the input impedance. The time constant (CR) shall be at least two orders of magnitude greater than the inter-pulse period. The resistor, R , shall produce negligible loading of the modulator. Capacitor C shall be of adequate voltage rating and possess acceptable r.f. characteristics for the pulse length applied.

The time constant at the input resulting from the diode series impedance in combination with capacitor C shall be less than one-quarter of the duration of the voltage pulse to be measured. The components shall be enclosed within a dustproof box and at the higher voltages anti-corona precautions shall be used.

NOTE 1. It is recommended that the modulator output be examined for distortion, using an oscilloscope display method.

NOTE 2. Should a spike occur on the voltage pulse, a resistor should be added in series with the diode, the most suitable value being chosen by trial (see figure 1003/2).

NOTE 3. In order to avoid corona discharge the components may be immersed in oil.

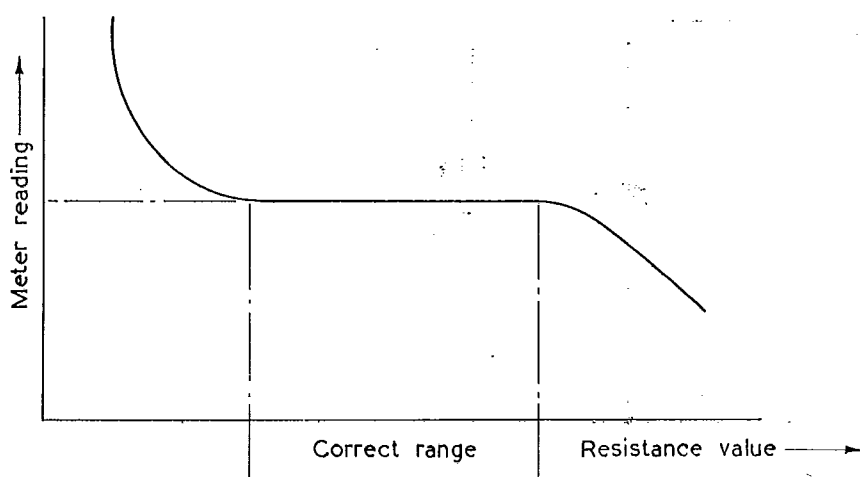


Figure 1003/2

Method 2. Peak diode voltage (with a potential divider). For pulse voltages in excess of the capabilities of method 1, the standard potential divider voltmeter circuit, as shown in figure 1003/3, shall be used. This circuit shall be calibrated either with a standard d.c. voltage or by measurement of resistor R and calibration of meter A .

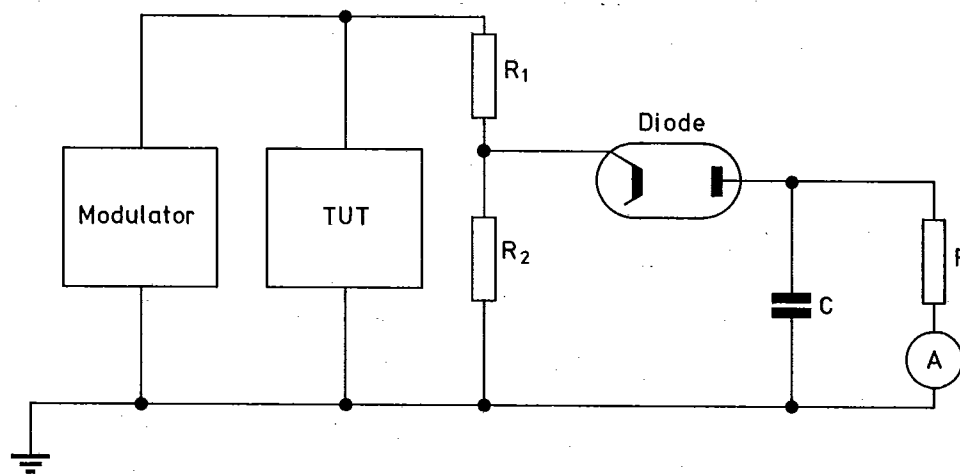


Figure 1003/3

Precautions. The potential divider resistors, R_1 and R_2 , shall be non-inductive and shall provide a division ratio that enables the diode to operate within its voltage rating. The precautions of method 1 shall apply.

NOTE. It may be necessary to compensate for the frequency response of the divider.

Oscilloscope display methods

Method 3. Resistive divider method. The pulse voltage as reduced in amplitude, using the circuit illustrated in figure 1003/4, shall be measured on a suitable calibrated oscilloscope. The divider shall be calibrated by measuring the ratio directly with low d.c. voltage.

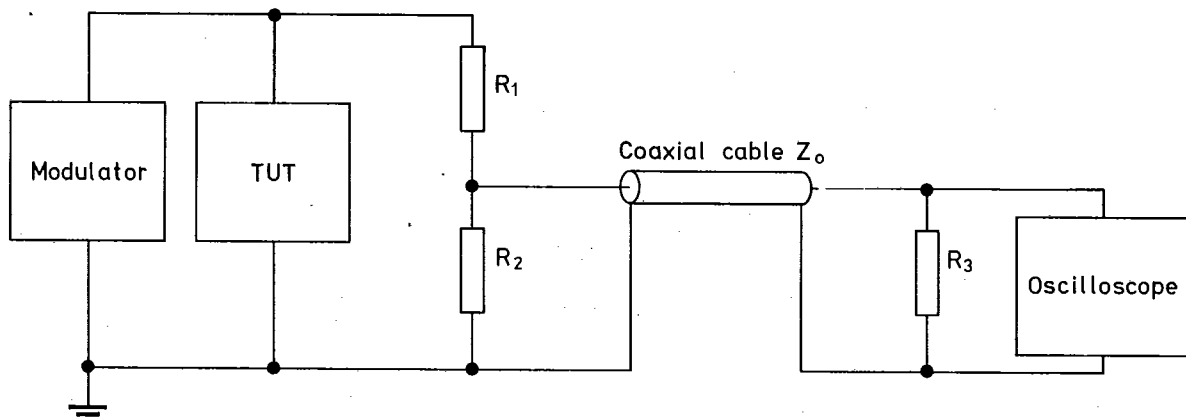


Figure 1003/4

Precautions. The resistors shall be of low inductance construction and capable of withstanding the applied pulse voltage with an acceptable voltage coefficient of resistance. The total resistance shall be kept as low as possible to avoid errors, because of reactive components, without causing undue loading of the modulator. Resistor R shall preferably have a value between $10\text{ k}\Omega$ and $40\text{ k}\Omega$. The dissipation rating of the resistors shall be at least 2.5 times the expected value. The connecting coaxial cable shall be terminated with its characteristic impedance to avoid reflections. Termination at both ends is essential at short pulses if the cable is long, i.e. $R_2 = R_3 = Z_0$.

At very high voltages the potential divider shall be immersed in oil to avoid corona discharge effects.

BS 9035 : 1979

1003/4

Method 4. Capacitance divider method. The pulse voltage, as reduced in amplitude using the circuit illustrated in figure 1003/5, shall be measured on a suitable oscilloscope. Although the arrangement is well suited to short pulses, its use for long pulses is restricted by the acceptable or tolerable droop.

The divider shall preferably be calibrated using a resistive divider as standard. Alternatively, the divider shall be calibrated by measurement of the values of C_1 and C_2 .

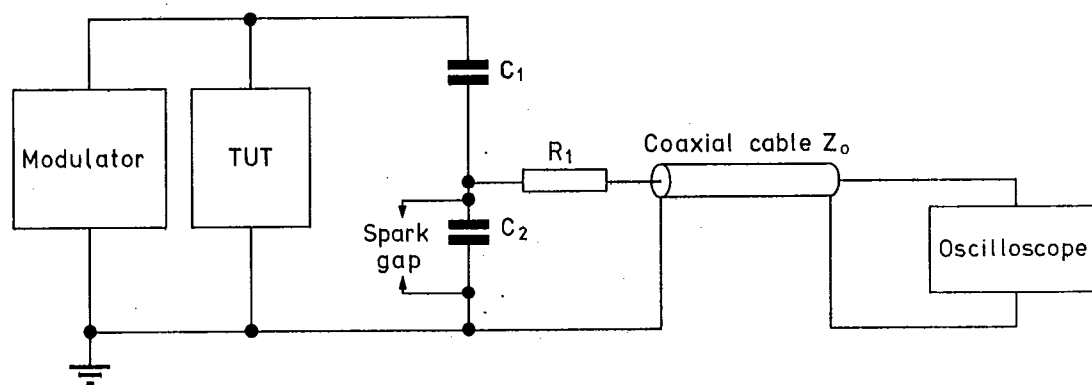


Figure 1003/5

Precautions. The input capacitance shall be kept low to avoid undue modulator loading. Capacitor C_1 shall be of suitable voltage rating and shall be enclosed in an earthed shield to avoid stray pickup. Capacitor C_1 shall preferably have a value between 1 pF and 10 pF. Capacitor C_2 shall be of low inductance construction and be shunted by a spark gap as a safety precaution. The divider network shall be connected to the oscilloscope through the coaxial cable and the series matching resistor R_1 so that $R_1 = Z_0$. The input resistance of the oscilloscope shall be two or three orders greater than R_1 .

Allowance shall be made for the stray capacitance of the spark gap. For pulse lengths greater than 0.05 μ s, the length of the coaxial cable shall not exceed that which has a two-way transit time of one-tenth of the pulse duration. For shorter pulses connection shall preferably be made directly to the oscilloscope plates.