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SERIES K: PROTECTION AGAINST INTERFERENCE

Characteristics of gas discharge tubes for the protection of telecommunications installations

ITU-T Recommendation K.12

(Formerly CCITT Recommendation)

ITU-T RECOMMENDATION K.12

CHARACTERISTICS OF GAS DISCHARGE TUBES FOR THE PROTECTION OF TELECOMMUNICATIONS INSTALLATIONS

Summary

This Recommendation gives the basic requirements to be met by gas discharge tubes for the protection of exchange equipment, telecommunication lines and subscribers' or customer equipment from overvoltages. It is intended to be used for the harmonization of existing or future specifications issued by gas discharge tube manufacturers, telecommunication equipment manufacturers or Administrations.

Only the minimum requirements are specified for essential characteristics. As some users may be exposed to different environments or have different operating conditions, service objectives or economic constraints, these requirements may be modified or further requirements may be added to adapt them to local conditions.

This Recommendation provides guidance on the use of gas discharge tubes to limit overvoltages on telecommunications lines.

Source

ITU-T Recommendation K.12 was revised by ITU-T Study Group 5 (1997-2000) and was approved under the WTSC Resolution No. 1 procedure on 25 February 2000.

FOREWORD

ITU (International Telecommunication Union) is the United Nations Specialized Agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the ITU. The ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Conference (WTSC), which meets every four years, establishes the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

The approval of Recommendations by the Members of the ITU-T is covered by the procedure laid down in WTSC Resolution No. 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

INTELLECTUAL PROPERTY RIGHTS

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As of the date of approval of this Recommendation, the ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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CHARACTERISTICS OF GAS DISCHARGE TUBES FOR THE PROTECTION OF TELECOMMUNICATIONS INSTALLATIONS

(Geneva, 1972, modified at Malaga-Torremolinos, 1984 and at Melbourne, 1988; revised in 1995 and 2000)

1 Scope

This Recommendation:

a) gives the characteristics of gas discharge tubes used in accordance with Recommendation K.11 for protection of exchange equipment, telecommunication lines and subscribers' or customer equipment against overvoltages;

b) deals with gas discharge tubes having 2 or 3 electrodes;

c) does not deal with mountings and their effect on tube characteristics. Characteristics given apply to gas discharge tubes by themselves mounted only in the ways described for the tests;

d) does not deal with mechanical dimensions;

e) does not deal with quality assurance requirements;

f) does not deal with gas discharge tubes which are connected in series with voltage-dependent resistors in order to limit follow-on currents in electrical power systems.

2 Definitions

Appendix I provides definitions for a number of terms used in connection with gas discharge tubes.

3 Environmental conditions

Gas discharge tubes shall be capable of withstanding during storage the following conditions without damage:

– Temperature: –40 to +90° C;

– Relative humidity: up to 95%.

See also 7.5 and 7.7.

4 Electrical characteristics

Gas discharge tubes should have the following characteristics when tested in accordance with clause 5.

Subclauses 4.1 to 4.5 apply to new gas discharge tubes and also, where quoted in 4.6, to tubes subjected to life tests.

4.1 Spark-over voltages (see 5.1, 5.2 and Figures 1, 2 and 3)

4.1.1 Spark-over voltages between the electrodes of a 2-electrode tube or between either line electrode and the earth electrode of a 3-electrode tube shall be within the limits in Table 1.

Table 1/K.12 – Spark-over voltage value

d.c.					Impulse			
	Initial (1)		After life tests (2)		at 100V/µs		at 1000 V/µs	
					Initial (3)	After life tests (4)	Initial (5)	After life tests (6)
Nominal (V)	Min. (V)	Max. (V)	Min. (V)	Max. (V)	(V)	(V)	(V)	(V)
90	72	108	65	120	450	550	500	600
150	120	180	110	195	500	600	600	700
230	184	280	170	300	600	700	700	800
250	200	300	180	325	600	700	700	800
350	280	420	260	455	900	1000	1000	1100
420	300	500	300	550	900	1000	1000	1100
500	400	600	400	650	1100	1200	1200	1300
600	480	720	450	780	1300	1400	1400	1500

4.1.2 For 3-electrode tubes, the spark-over voltage between the line electrodes shall not be less than the minimum d.c. spark-over voltage in Table 1. It is recommended to achieve at least 1.2 times the minimum d.c. spark-over voltage given in Table 1 (under study).

4.1.3 The spark-over voltages of gas discharge tubes are random variations. They will conform approximately to a normal distribution provided that a sufficient number of tests are conducted with the time interval between spark-overs specified in 5.1 and 5.2. When tested as specified in 5.1.1 and 5.2, an appropriate optical isolation between samples is necessary. The spark-over voltages should be assessed with the method specified in Table 2.

Table 2/K.12 – Spark-over voltage assessment method

	Measured values initial	
	Probability of the measured values to be within the tolerance	Assessment expression
d.c. spark-over voltage	99.7%	U + 3S ≤ Maximum U − 3S ≥ Minimum
Impulse spark-over voltage	99.7%	U + 3S ≤ Maximum U − 3S ≥ Minimum
NOTE – U is the statistical average value of spark-over voltages. S is the standard deviation.		

4.2 Holdover voltages (see 5.5 and Figures 4 and 5)

All types of tube shall have a current turn-off time less than 150 ms when subjected to one or more of the following tests according to the projected use:

4.2.1 2-electrode tubes tested in a circuit equivalent to Figure 4 where the test circuit components have the values in Table 3. Gas discharge tubes with a nominal d.c. voltage of 230V or higher shall be tested according to the test circuit shown in Annex A.

Table 3/K.12 – Holdover test values for 2-electrode tubes

Component	Test 1	Test 2	Test 3
PS1	52 V	80 V	135 V
R3	260 Ω	330 Ω	1300 Ω
R2	(Note)	150 Ω	150 Ω
C1	(Note)	100 nF	100 nF
NOTE – Components omitted in this test.			

4.2.2 3-electrode tubes tested in a circuit equivalent to Figure 5 where components have the values in Table 4.

Table 4/K.12 – Holdover test values for 3-electrode tubes

Component	Test 1	Test 2		Test 3	
PS1	52 V	80 V		135 V	
PS2	0 V	0 V		52 V	
R3	260 Ω	330 Ω		1300 Ω	
R2	a)	150 Ω	272 Ω b)	150 Ω	272 Ω b)
C1	a)	100 nF	43 nF b)	100 nF	43 nF b)
R4 c)	136 Ω	136 Ω		136 Ω	
C2 c)	83 nF	83 nF		83 nF	
a) Components omitted in this test. b) Optional alternative. c) Optional.					

4.3 Insulation resistance (see 5.3)

Not less than 1000 Mohms initially.

4.4 Capacitance

Not greater than 20 pF.

4.5 Impulse transverse voltage – 3-electrode tubes (see 5.9 and Figure 6)

The difference in time not to exceed 200 ns.

4.6 Life tests (see 5.6, 5.7 and 5.8)

The currents specified in 4.6.1 for the appropriate nominal current rating of the tube shall be applied. After each current application, the gas discharge tube shall be capable of meeting the requirements of 4.6.2. On completion of the number of current applications specified, the tube shall be capable of meeting the requirements of 4.6.3.

4.6.1 Test currents

Gas discharge tubes shall be subjected to the currents of columns 2, 3, 4 and 5 of Table 5. For each life test new gas discharge tubes shall be used.

Table 5/K.12 – Life test current values

	Nominal alternating discharge current	Nominal impulse discharge current		
Class	50-60 Hz 10 applications	8/20 µs 10 applications	10/350 µs 1 application	10/1000 µs 300 applications
(1)	A rms (2)	kA peak (3)	kA peak (4)	A peak (5)
1	2.5	2.5	1	50
2	5	5	2.5	100
3	10	10	4	100
4	20	10	4	100
5	20	20	4	200

4.6.2 Requirements during life test

Insulation resistance: not less than 10 Mohms.

d.c. and impulse spark-over voltage: not more than the relevant value in columns 2, 4 and 6 of Table 1.

4.6.3 Requirements after completion of life test

Insulation resistance: not less than 100 Mohms.

d.c. and impulse spark-over voltage: not more than the relevant value in columns 2, 4 and 6 of Table 1.

Holdover voltage: as in 4.2.

4.7 Short-circuit behaviour

A short-circuit mechanism is necessary for gas discharge tubes intended for use in telecommunication applications, where an a.c. current can occur, flowing for an unpredictable time.

Depending on the a.c. current flow, the short-circuit mechanism shall operate in a sufficient time, to prevent the gas discharge tube from being overheated.

5 Test methods

Gas discharge tubes shall be tested accordingly to the methods described in subclauses 5.1 to 5.8. A proposed type test procedure is given in Appendix II.

5.1 d.c. spark-over voltage (see 4.1 and Figures 1 and 2)

5.1.1 Initial values

For testing the initial values of a gas discharge tube, the gas discharge tube shall be placed in darkness for at least 24 hours immediately prior to testing and tested in darkness with a voltage which increases so slowly that the spark-over voltage is independent of the rate of rise of the applied voltage. Typically, a rate of rise of 100 V/s is used, but higher rates may be used if it can be shown that the spark-over voltage is not significantly changed thereby. The tolerances on the wave-shape of the rising test voltage are indicated in Figure 1. The voltage is measured across the open-circuited terminals of the generator. U_{max} of Figure 1 is any voltage greater than the maximum permitted d.c. spark-over voltage of the gas discharge tube and less than three times the minimum permitted d.c. spark-over voltage of the gas discharge tube.

The test shall employ a suitable circuit such as that shown in Figure 2. A minimum of 3 seconds shall elapse between repetitions of the test, with either polarity, on the same gas discharge tube.

For 3-electrode tubes, the spark-over voltage between the line electrodes shall not be less than the minimum d.c. spark-over voltage in Table 1.

Each pair of terminals of a 3-electrode gas discharge tube shall be tested separately with the other terminal unterminated.

NOTE – The use of Figure 1 may be explained as follows:

A single mask will do for all values of U_{max} and the nominal rate of rise, provided that it is a suitable size for the display of the waveform and that the scales of U and T of the waveform can be adjusted. This follows because the Y-axis has arbitrary points marked 0 and U_{max} with 0.2 U_{max} at the appropriate point between them while the X-axis has arbitrary points marked 0 and T_2 with T_1 (= 0.2 T_2), 0.9 T_1, 1.1 T_1, 0.9 T_2, 1.1 T_2 marked at the appropriate points. The X and Y zeros need not coincide and, in fact, need not be shown at all.

To compare a waveform trace with the mask, it is necessary to know the values of U_{max} and the nominal rate of rise for the waveform in question. As an example, consider a waveform with U_{max} = 750 V and nominal rate of rise = 100 V/sec.

Then 0.2 U_{max} = 150 V, = T_2 = 7.5 s, T_1 = 1.5 s.

Hold the mask against the trace and adjust the vertical scale so that the 150 V calibration is against 0.2 U_{max} and the 750 V point against U_{max}. Adjust the horizontal scale similarly for 1.5 s = T_1 and 7.5 s = T_2. Slide the mask so that the 150 V point on the trace is within the bottom boundary of the test window; the remainder of the trace up to 750 V must be within the test window.

5.1.2 After life test

This test shell be performed on gas discharge tubes which are subject to life conditions specified in 5.6 and 5.7. In order to achieve a test procedure as close to real practice as possible, the test has to be carried out under daylight conditions. All other test details should comply to subclause 5.1.1.

5.2 **Impulse spark-over voltage** (see 4.1 and Figures 1 and 3)

The voltage waveform measured across the open circuit test terminals shall have a nominal rate of rise selected from 4.1.1 and shall be within the enclosed limits indicated in Figure 1. Figure 3 shows a suggested arrangement for testing with a voltage impulse having a nominal rate of rise of 1.0 kV/µs.

A minimum of 3 seconds shall elapse between repetitions of the test, with either polarity, on the same gas discharge tube.

Each pair of terminals of a 3-electrode gas discharge tube shall be tested separately with the other terminal unterminated.

5.3 Insulation resistance (see 4.3)

The insulation resistance shall be measured from each terminal to every other terminal of the gas discharge tube. The measurement shall be made at an applied potential of at least 100 V and not more than 90% of the minimum permitted d.c. spark-over voltage. The measuring source shall be limited to a short circuit current of less than 10 mA. Terminals of three-electrode gas discharge tubes not involved in the measurement shall be left unterminated.

5.4 **Capacitance** (see 4.4)

The capacitance shall be measured between each terminal and every other terminal of the gas discharge tube. In measurements involving 3-electrode gas discharge tubes, the terminal not being tested shall be connected to a ground plane in the measuring instrument.

5.5 **Holdover test** (see 4.2)

5.5.1 **2-electrode gas discharge tube** (see Figure 4)

Tests shall be conducted using the circuit of Figure 4. Values of PS1, R2, R3 and C1 shall be selected for each test condition from Table 3. The current from the surge generator shall have an impulse waveform of 100 A, 10/1000 µs measured through a short circuit replacing the gas discharge tube under test. The polarity of the impulse current through the gas discharge tube shall be the same as the current from PS1. The time for current turn-off shall be measured for each direction of current passage through the gas discharge tube. Three impulses shall be applied at not greater than 1-minute intervals and the current turn-off time measured for each impulse.

5.5.2 **3-electrode gas discharge tube** (see Figure 5)

Tests shall be conducted using the circuit of Figure 5. Values of circuit components shall be selected from Table 4. The simultaneous currents that are applied to the gaps of the gas discharge tube shall have impulse waveforms of 100 A, 10/1000 µs measured through a short circuit replacing the gas discharge tube under test. The polarity of the impulse current through the gas discharge tube shall be the same as the current from PS1 and PS2.

For each test condition, measurement of the time to current turn-off shall be made for both polarities of the impulse current. Three impulses in each direction shall be applied at intervals not greater than 1 minute and the time to current turn-off measured for each impulse.

5.6 **Impulse life – All types of gas discharge tube** (see 4.6)

New gas discharge tubes shall be used for each of the tests and impulse currents shall be applied as specified in Table 5, for the relevant class of the tube. The pulse repetition rate should be such as to prevent thermal accumulation in the gas discharge tube.

5.6.1 Impulse discharge current 8/20 µs

Half the specified number of tests shall be carried out with one polarity followed by half with the opposite polarity. Alternatively, half the tubes in a sample may be tested with one polarity and the other half with the opposite polarity.

For 3-electrode gas discharge tubes, independent impulse currents each having the value specified in Table 5, column 3, shall be discharged simultaneously from each electrode to the common electrode.

5.6.2 Impulse discharge current 10/350 µs

This test shall be applied only one time.

For 3-electrode gas discharge tubes, independent impulse currents each having the value specified in Table 5, column 4, shall be discharged simultaneously from each electrode to the common electrode.

5.6.3 Impulse discharge current 10/1000 μs

In order to carry out this test, the methods 1 to 4, described in Table 6, can alternatively be applied.

Table 6/K.12 – Impulse discharge current method

Test method	Number of applications	Polarity
1	300 times	++++++++++++
2	300 times	--------------------
3	150 times + and 150 times -	+++++…/------…
4	300 times +/-	+/-/+/-/+/…

The voltage of the source shall exceed the maximum impulse spark-over voltage of the gas discharge tube by not less than 50 per cent. The specified impulse discharge current and waveform shall be measured with the gas discharge tube replaced with a short circuit. For 3-electrode gas discharge tubes, independent impulse currents each having the value specified in Table 5, column 5, shall be discharged simultaneously from each electrode to the common electrode.

The gas discharge tube shall be tested after each passage of impulse discharge current or at less frequent intervals if agreed between the manufacturer and the user to determine its ability to satisfy the requirements of 4.6.2.

On completion of the specified number of impulse currents, the tube shall be allowed to cool to ambient temperature and tested for compliance with 4.6.3.

5.7 a.c. life – All types of tube (see 4.6)

New tubes shall be used and alternating currents applied as specified in Table 5, column 2, for the relevant nominal current of the tube, with a duration of 1 second.

The time between applications should be such as to prevent thermal accumulation in the tube. The rms a.c. voltage of the current source shall exceed the maximum d.c. spark-over voltage of the gas discharge tube by not less than 50 per cent.

The specified a.c. discharge current and duration shall be measured with the gas discharge tube replaced with a short circuit. For 3-electrode gas discharge tubes, a.c. discharge currents each having the value specified in Table 5, column 2, shall be discharged simultaneously from each electrode to the common electrode.

The gas discharge tube shall be tested after each passage of a.c. discharge current to determine its ability to satisfy the requirements of 4.6.2.

On completion of the specified number of current applications, the tube shall be allowed to cool to ambient temperature and tested for compliance with 4.6.3.

5.8 Short-circuit test

An a.c. current capable of activating the thermal overload shall be applied to the gas discharge tube. The short-circuit mechanism shall be operated after it is subjected to a given a.c. current and time. The values and duration should be specified by the manufacturer of the gas discharge tubes.

The test procedure and the requirements after passing the test shall be in detail arranged between the manufacturer and the user of gas discharge tubes.

5.9 Impulse transverse voltage (see 4.5 and Figure 6)

The duration of the transverse voltage shall be measured while an impulse voltage having a virtual steepness of impulse wavefront of 1 kV/µs is applied simultaneously to both discharge gaps. Measurement may be made with an arrangement as indicated in Figure 6. The difference in time between the spark-over of the first gap and that of the second is specified in 4.5.

6 Radiation

Gas discharge tubes shall not contain radioactive material. A transitional period of two years is available for manufacturers to conform to this requirement after the approval of this Recommendation.

7 Environmental tests

7.1 Robustness of terminations

The user shall specify a suitable test from International Electrotechnical Commission (IEC) standard IEC 60068-2-21 (1999-01) Environmental testing, Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices, if applicable.

7.2 Solderability

Soldering terminations shall meet the requirements of IEC standard IEC 60068-2-20 (1979-01) Environmental testing, Part 2: Tests. Test T: Soldering, Test Ta Method 1.

7.3 Resistance to soldering heat

Gas discharge tubes with soldering terminations shall be capable of withstanding IEC standard IEC 60068-2-20 (1979-01) Environmental testing, Part 2: Tests. Test T: Soldering, Test Tb Method 1B. After recovery, the gas discharge tube shall be visually checked and show no signs of damage and its d.c. spark-over shall be within the limits for that tube.

7.4 Vibration

A gas discharge tube shall be capable of withstanding IEC standard IEC 60068-2-6 (1995-03) Environmental testing, Part 2: Tests – Test Fc: Vibration (sinusoidal) 10-500 Hz, 0.15 mm displacement for 90 minutes without damage. The user may select a more severe test from the document. At the end of the test, the tube shall show no signs of damage and shall meet the d.c. spark-over and insulation resistance requirements specified in 4.1 and 4.3.

7.5 Damp heat cyclic

A gas discharge tube shall be capable of withstanding IEC standard 60068-2-30 (1980-01). At the end of the test, the tube shall meet the insulation resistance requirement specified in 4.3.

7.6 Sealing

A gas discharge tube shall be capable of passing IEC standard IEC 60068-2-17 (1994-07) Basic environmental testing procedures, Part 2: Tests – Test Q: Sealing, Test Qk, severity 600 hours, for fine leaks. Helium shall be used as the test gas. The fine leak rate shall be less than 10^{-7} bar·cm^{3}·s^{-1}.

The tube shall then be capable of passing the coarse leak test Qc Method 1.

7.7 Low temperature

A gas discharge tube shall be capable of withstanding IEC standard IEC 60068-2-1 (1990-05) Environmental testing, Part 2: Tests. Tests A: Cold, Test Aa. –40 °C, duration 2 hours, without damage. At the end of the test, the tube must meet the d.c. and impulse spark-over requirements of 4.1.

8 Identification

8.1 Marking

Legible and permanent marking shall be applied to the tube as necessary to ensure that the purchaser can determine the following information by inspection:

a) manufacturer;

b) year of manufacture;

c) code.

The purchaser may specify the codes to be used for this marking.

8.2 Documentation

Documents shall be provided to the user so that from the information in 8.1 he can determine the following additional information:

a) full characteristics as set out in this Recommendation;

b) name of radioactive material used in the tube or statement that such material has not been used.

9 Ordering information

The following information should be supplied by the user:

a) drawing giving all dimensions, finishes and termination details (including numbers of electrodes and identifying the earth electrode);

b) nominal d.c. spark-over voltage, chosen from 4.1.1;

c) nominal current rating chosen from 4.6.1;

d) holdover voltage tests required in 4.2;

e) marking codes required for 8.1;

f) robustness of terminations – test required for 7.1;

g) destruction characteristic, if required, including failure mode (see Note);

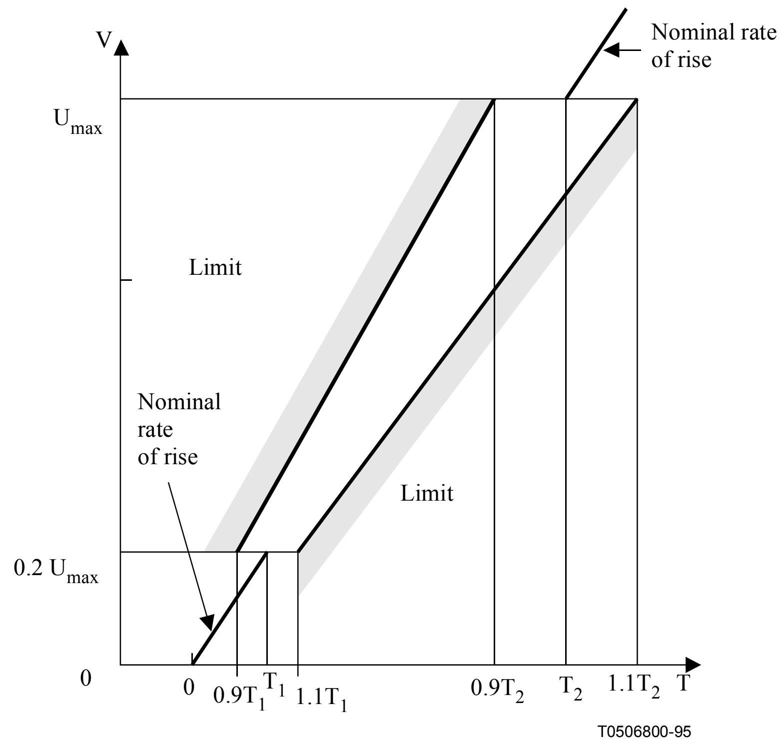
h) quality assurance requirements.

NOTE – After passage of an alternating or impulse current of value much higher than that shown in 4.6.1, the gas discharge tube may be destroyed, i.e. its electrical characteristics may be greatly modified. Two situations may occur:

1) The gas discharge tube becomes in effect an insulator and presents a higher dielectric strength than it had initially – that is to say, it becomes open circuit.

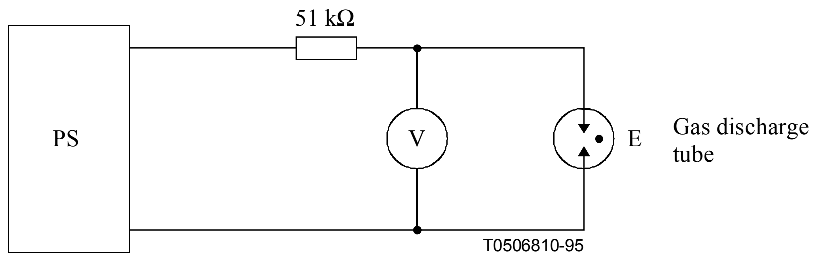
2) The gas discharge tube becomes of limited resistance – generally a low value which does not allow normal operation of the line – that is to say it becomes a short circuit. (This situation may be preferable from the point of view of protection and maintenance.)

Test methods and the relations between the value and duration of the destructive current are not detailed in this Recommendation nor is the state of the element after destruction. Administrations should cover their requirements in these respects in their own documentation.



NOTE – Spark-over test waveform (non-conducting) must be within enclosed limits.

Figure 1/K.12 – Spark-over test waveform (see 4.1, 5.1 and 5.2)



PS Variable voltage power supply

NOTE – Means shall be included to ensure that the gas discharge tube sparks over once only.

Figure 2/K.12 – Circuit for d.c. spark-over test (see 4.1 and 5.1)

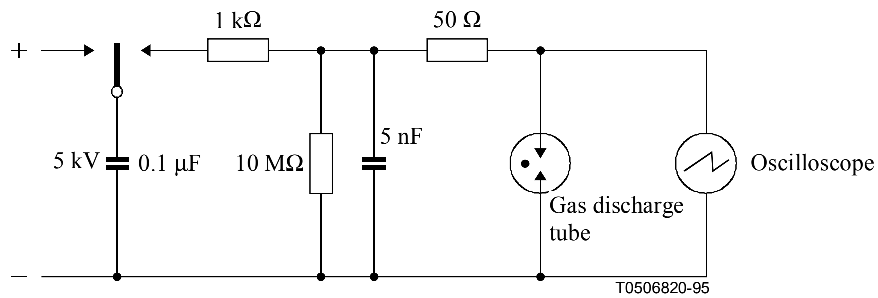
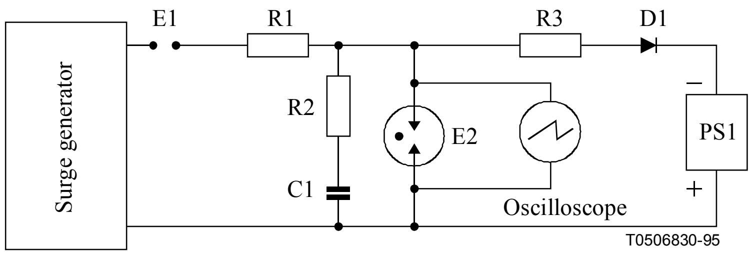
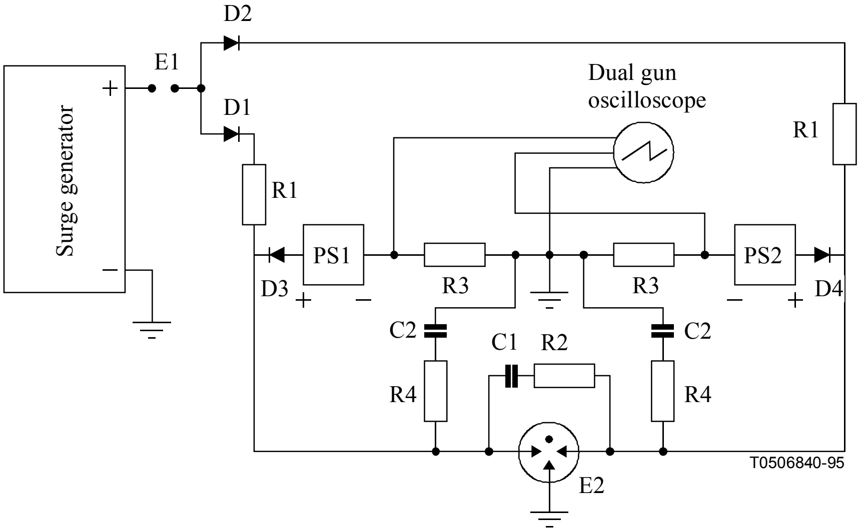


Figure 3/K.12 – Testing arrangement producing a voltage impulse having a wavefront with a virtual steepness of 1 kV/µs (see 4.1 and 5.3)



PS1	Constant voltage d.c. supply or battery
E1	Isolation gap or equivalent device
E2	Gas discharge tube
D1	Isolation diode or other isolation device
R1	Impulse current limiting resistor or wave-shaping network

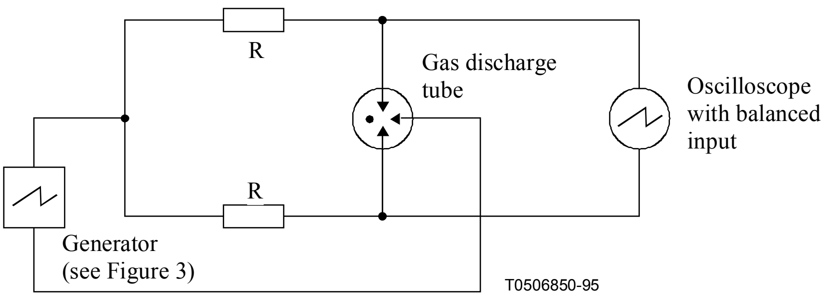
Figure 4/K.12 – Circuit for holdover test of 2-electrode gas discharge tube (see 4.2.1 and 5.5.1)



E1	Isolation gap or equivalent device
E2	Gas discharge tube
PS1, PS2	Bateries or d.c. power supplies
R1	Impulse current limiting resistors or wave-shaping networks

NOTE 1 – C2 and R4 optional.
NOTE 2 – The polarity of diodes D1 to D4 shall be reversed when the politary of the d.c. power supplies and surge generators are reversed.

Figure 5/K.12 – Circuit for holdover test of 3-electrode gas discharge tube (see 4.2.2 and 5.5.2)

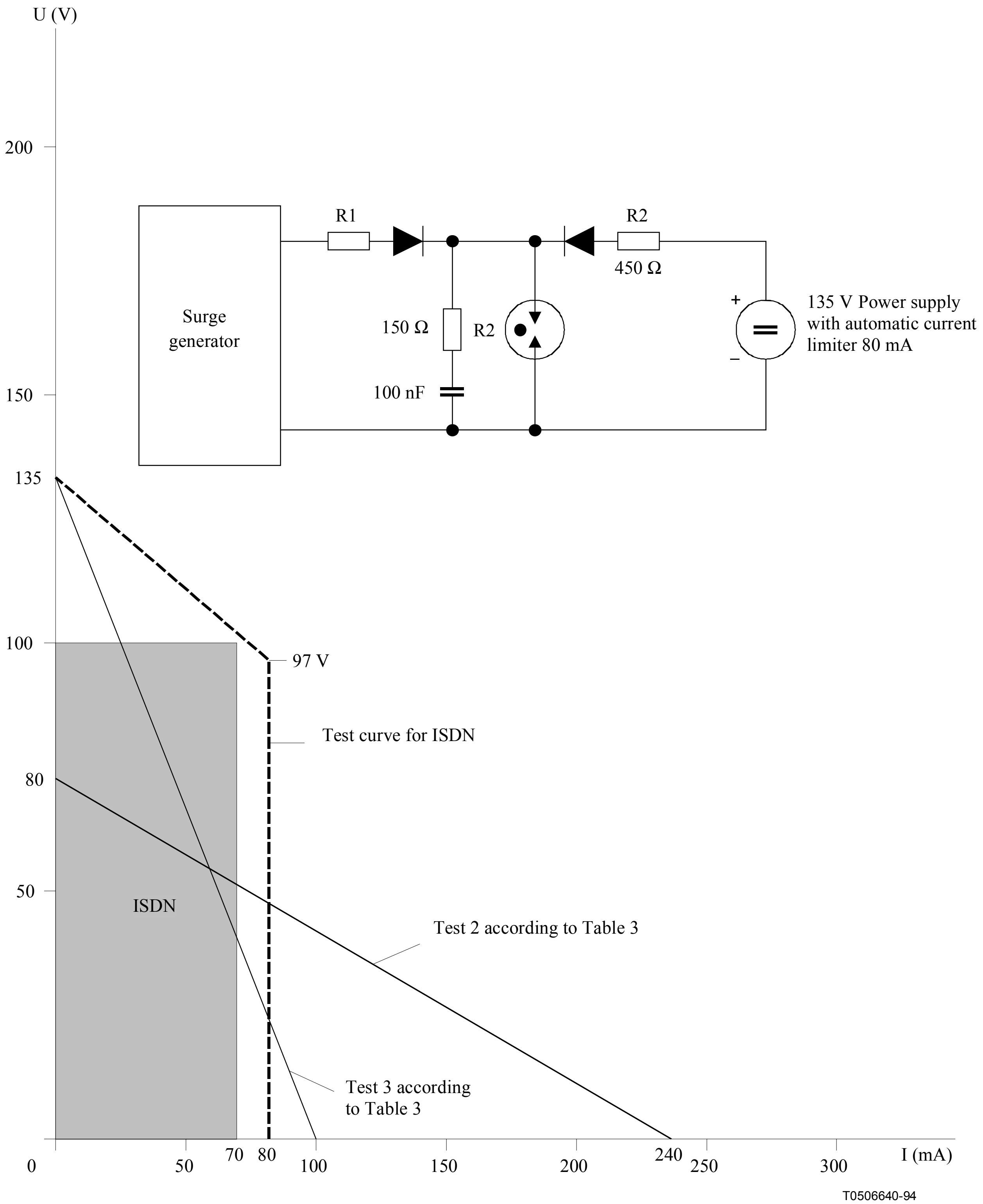


R Line impedance

Figure 6/K.12 – Circuit for impulse transverge voltage test (see 4.5 and 5.9)

ANNEX A

Test circuit for GDT for ISDN



APPENDIX I

Definitions of terms associated with gas discharge tubes

I.1 breakdown: See "spark-over".

I.2 current turn-off time: The time required for the gas discharge tube to return itself to a non-conducting state following a period of conduction.

I.3 destruction characteristic: The relationship between the value of the discharge current and the time of flow until the gas discharge tube is mechanically destroyed (break, electrode short circuit). For periods of time between 1 μs and some ms, it is based on impulse discharge currents, and for periods of time of 0.1 s and greater, it is based on alternating discharge currents.

I.4 discharge current: The current that passes through a gas discharge tube when spark-over occurs.

I.5 discharge current, alternating: The rms value of an approximately sinusoidal alternating current passing through the gas discharge tube.

I.6 discharge current, impulse: The peak value of the impulse current passing through the gas discharge tube.

I.7 discharge voltage: The voltage that appears across the terminals of a gas discharge tube during the passage of discharge current. Also referred to as "residual voltage".

I.8 gas discharge tube: A gap, or several gaps, in an enclosed discharge medium, other than air at atmospheric pressure, designed to protect apparatus or personnel, or both, from high transient voltages. Also referred to as "gas tube surge arrester".

I.9 glow current: The current which flows after spark-over when circuit impedance limits the discharge current to a value less than the glow-to-arc transition current.

I.10 glow-to-arc transition current: The current required for the gas discharge tube to pass from the glow mode into the arc mode.

I.11 holdover voltage: The maximum d.c. voltage across the terminals of a gas discharge tube under which it may be expected to clear and to return to the high impedance state after the passage of a surge, under specified circuit conditions.

I.12 impulse waveform: An impulse waveform designated as x/y has a rise time of *x* μs and a decay time to half value of y μs as standardized in IEC Publication 60068.

I.13 nominal alternating discharge current: For currents with a frequency of 15 Hz to 62 Hz, the alternating discharge current which the gas discharge tube is designed to carry for a defined time.

I.14 nominal d.c. spark-over voltage: The voltage specified by the manufacturer to designate the gas discharge tube (type designation) and to indicate its application with respect to the service conditions of the installation to be protected. Tolerance limits of the d.c. spark-over voltage are also referred to the nominal d.c. spark-over voltage.

I.15 nominal impulse discharge current: The peak value of the impulse current with a defined waveshape with respect to time for which the gas discharge tube is rated.

I.16 residual voltage: See "discharge voltage".

I.17 spark-over: An electrical breakdown of a discharge gap of a gas discharge tube. Also referred to as "breakdown".

I.18 spark-over voltage: The voltage which causes spark-over when applied across the terminals of a gas discharge tube.

I.19 spark-over voltage, d.c.: The voltage at which the gas discharge tube sparks over with slowly increasing d.c. voltage.

I.20 spark-over voltage, impulse: The highest voltage which appears across the terminals of a gas discharge tube in the period between the application of an impulse of given waveshape and the time when current begins to flow.

I.21 transverse voltage: For a gas discharge tube with several gaps, the difference of the discharge voltages of the gaps assigned to the two conductors of a telecommunications circuit during the passage of discharge current.

APPENDIX II

Type test procedure

II.1 Impulse and a.c. life

It is recommended that the following sample sizes be used:

Test	Sample size	Test performed in accordance with
Impulse life	20	5.6; column 3 Table 5/K.12
Impulse life	20	5.6; column 4 Table 5/K.12
Impulse life	20	5.6; column 5 Table 5/K.12
A.c. life test	20	5.7; column 2 Table 5/K.12

It is recommended that a minimum of 4 spark-over voltage measurements be performed on each sample, 2 in each polarity.

For measured values after life test under consideration (5% failure rate accepted), see Table 1: values "After life tests".

II.2 Short-circuit

It is recommended that the following sample size be used:

Test	Samples size	Test performed in accordance with
Short-circuit	5 for each test condition	5.8/K.12

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