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**Characteristics of gas discharge tubes for the
protection of telecommunications installations**

Recommendation ITU-T K.12



Recommendation ITU-T K.12

Characteristics of gas discharge tubes for the protection of telecommunications installations

Summary

Recommendation ITU-T K.12 defines the basic characteristics to be met by gas discharge tubes for the protection of exchange and outdoor equipment, subscriber or customer equipment and telecommunication lines from surges. It is intended to be used for the harmonization of existing or future specifications issued by gas discharge tube manufacturers, telecommunication equipment manufacturers, administrations or network operators.

History

Edition	Recommendation	Approval	Study Group
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Keywords

Electrical characteristics and test methods, gas discharge tube (GDT).

FOREWORD

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 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.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at <http://www.itu.int/ITU-T/ipr/>.

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Recommendation ITU-T K.12

Characteristics of gas discharge tubes for the protection of telecommunications installations

1 Scope

This Recommendation:

- a) gives the characteristics of gas discharge tubes used in accordance with [b-ITU-T K.11] and [b-ITU-T K.46] for the protection of exchange and outdoor equipment, subscriber or customer equipment and telecommunication lines against overvoltages;
- b) deals with gas discharge tubes having two or three electrodes;
- c) does not deal with mountings and their effect on tube characteristics (see [ITU-T K.65]); characteristics apply to gas discharge tubes as a component, 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 to electrical power systems.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

- | | |
|------------------|---|
| [ITU-T K.65] | Recommendation ITU-T K.65 (2004), <i>Overvoltage and overcurrent requirements for termination modules with contacts for test ports or SPDs</i> . |
| [IEC 60060] | IEC 60060-1 and IEC 60060-2 (1989/1994), <i>High voltage test techniques – Part 1: General definitions and test requirements and Part 2: Measuring systems</i> . |
| [IEC 60068-2-1] | IEC 60068-2-1 (2007), <i>Environmental testing – Part 2-1: Tests – Test A: Cold</i> . |
| [IEC 60068-2-6] | IEC 60068-2-6 (2007), <i>Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)</i> . |
| [IEC 60068-2-17] | IEC 60068-2-17 (1994), <i>Basic environmental testing procedures – Part 2-17: Tests – Test Q: Sealing</i> . |
| [IEC 60068-2-20] | IEC 60068-2-20 (2008), <i>Environmental testing – Part 2-20: Test – Test T: Test methods for solderability and resistance to soldering heat of devices with leads</i> . |
| [IEC 60068-2-21] | IEC 60068-2-21 (2006), <i>Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices</i> . |
| [IEC 60068-2-30] | IEC 60068-2-30 (2005), <i>Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)</i> . |

3 Definitions

This Recommendation defines the following terms:

3.1 arc mode: The lowest impedance or on-state of a gas discharge tube during normal operation (Figure 6).

3.2 arc voltage: The voltage measured across the tube while in lowest impedance state or arc mode (Figure 6).

3.3 breakdown: See "spark-over".

3.4 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.

3.5 d.c. 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.

3.6 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 μ s 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.

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

- **discharge current, alternating:** The r.m.s. value of an approximately sinusoidal alternating current passing through the gas discharge tube.
- **discharge current, impulse:** The peak value of the impulse current passing through the gas discharge tube.

3.8 discharge voltage: The voltage that appears across the terminals of a gas discharge tube during the passage of discharge current.

3.9 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; see clause 9 for the electrical characteristics of GDT also referred to as "gas tube surge arrester".

3.10 glow mode: This is a semi on-state in the area of the V/I curve where only a limited glow-current flows and the device has not yet turned on or reached the lowest impedance arc-mode (Figure 6).

3.11 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.

3.12 glow voltage: The peak value of the voltage drop across the GDT when a glow current is flowing. It is sometimes called the glow-mode voltage (Figure 6).

3.13 glow-to-arc (transition) current: The current required for the gas discharge tube to pass from the glow-mode into the arc mode.

3.14 impulse waveshape: An impulse waveform designated as x/y has a rise time of x μ s and a decay time to half value of y μ s as standardized in [IEC 60060].

3.15 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.

3.16 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.

3.17 nominal impulse discharge current: The peak value of the impulse current with a defined wave-shape with respect to time for which the gas discharge tube is rated.

3.18 residual voltage: See "discharge voltage".

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

3.20 spark-over voltage: The voltage which causes spark-over when applied across the terminals of a gas discharge tube (Figure 6).

- **spark-over voltage, d.c.:** The voltage at which the gas discharge tube sparks over when a slowly rising d.c. voltage up to 2 kV/s is applied.
- **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 wave-shape and the time when current begins to flow.

3.21 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.

4 Abbreviations

This Recommendation uses the following abbreviations:

GDT Gas Discharge Tube

ISDN Integrated Services Digital Network

xDSL Digital Subscriber Line

5 Storage conditions

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

- Temperature: –40 to +70°C;
- Relative humidity: up to 95%.

See also clauses 8.6 and 8.8 for environmental conditions.

6 Electrical requirements

Gas discharge tubes should have the following characteristics when tested in accordance with clause 7. Clauses 6.1 to 6.5 apply to virgin gas discharge tubes and also, where quoted in clause 6.6, to tubes subjected to life tests.

NOTE – Using GDTs in circuits protecting certain systems can cause secondary effects like oscillations. This behaviour is dependent on certain circuit combinations like impedance and inductance in connection with certain GDT parameters like glow-to-arc transition current, etc.

This phenomenon has not been studied adequately at this time and will be added to future work of ITU-T.

6.1 Spark-over voltages (see clause 7.1)

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 either Table 1a or 1b.

NOTE 1 – For the definition of spark-over waveforms, see Annex B.

Two types of GDT may be differentiated by their voltage nominal values. By employing special design techniques on either types, the disadvantages of the different technologies, to a certain extent, could be compensated for.

The values for these types are given in Tables 1a and 1b. Type 1 (Table 1a) represents the common type with a technology well suited for high current protection accomplished by a low glow voltage and arc voltage. Type 2 (Table 1b) represents the low impulse spark-over voltage type which has a faster response time, thus achieving lower impulse spark-over voltages with higher glow voltage and arc voltage, but offer lower current carrying capabilities.

For 3-electrode tubes, the spark-over voltage between the line electrodes shall not be less than the minimum d.c. spark-over voltages in either Table 1a or 1b. It is recommended to achieve at least 1.2 times the minimum d.c. spark-over voltage given in either Table 1a or 1b.

NOTE 2 – For 3-electrode GDTs, the maximum d.c. spark-over voltage a-b (line-line) may be restricted; a reasonable value is about 1.8-2.0 times the voltage a/b-c.

6.1.1 Spark-over voltage values for type 1 GDT (common type)

This type represents a technology well suited for high current protection accomplished by a low glow-voltage and arc-voltage (Table 1a).

Table 1a – Spark-over voltage values for common types of GDT

Spark-over voltage								
d.c.					Impulse			
	Initial (1)		After life tests (2)		at 100 V/ μ s		at 1000 V/ μ s	
	Min. (V)	Max. (V)	Min. (V)	Max. (V)	Initial (3) (V)	After life tests (4) (V)	Initial (5) (V)	After life tests (6) (V)
Nominal (V)								
90	72	108	65	120	450	550	500	600
150	120	180	110	195	500	600	600	700
200	160	240	150	250	600	700	700	800
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	360	520	360	550	1000	1100	1100	1200
500	400	600	400	650	1100	1200	1200	1300
600	480	720	450	780	1300	1400	1400	1500

6.1.2 Spark-over voltage values for type 2 GDT (low impulse spark-over type)

This type (Table 1b) has a faster response time, thus achieving lower impulse spark-over voltages with higher glow-voltages and arc-voltages. Due to the design of this alternative type, the current capability according to Table 5 is, in general, much lower than for the comparable size of common type GDT.

Higher glow-voltage and arc-voltage in the gas discharge tube means higher power dissipation and thus reduction in class capability.

It should be noted that there might be some restrictions to the availability of certain higher classes of Table 5 for some of the enhanced impulse voltage limits listed in Table 1b.

Table 1b – Spark-over voltage values for type 2 GDT (low impulse spark-over type)

Spark-over voltage								
d.c.					Impulse			
Nominal (V)	Initial (1)		After life tests (2)		at 100 V/ μ s		at 1000 V/ μ s	
	Min. (V)	Max. (V)	Min. (V)	Max. (V)	Initial (3)	After life tests (4)	Initial (5)	After life tests (6)
	(V)	(V)	(V)	(V)	(V)	(V)	(V)	(V)
200	160	240	150	250	350	450	450	550
230	184	280	170	300	400	500	450	550
350	265	455	265	600	700	800	800	900
420	360	520	360	650	750	900	850	1000
500	400	600	400	700	800	950	900	1050
600	480	720	420	800	900	1100	1000	1200

6.1.3 Spark-over voltage assessment

The spark-over voltages are characterized by a normal distribution assuming that a sufficient number of samples are tested.

The spark-over voltages should be assessed with the criteria specified in Table 2, using the test methods specified in clause 7.1.

Table 2 – 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%	$U + 3S \leq \text{Maximum}$ $U - 3S \geq \text{Minimum}$
Impulse spark-over voltage	99.7%	$U + 3S \leq \text{Maximum}$ $U - 3S \geq \text{Minimum}$
NOTE – U is the statistical average value of spark-over voltages. S is the standard deviation.		

6.2 Insulation resistance (see clause 7.2)

Not less than 1 G Ω initially.

6.3 Capacitance

Typically GDTs have a capacitance value of few pF, but not greater than 20 pF.

6.4 Transverse voltage

The transverse voltage for a 3-electrode gas discharge tube is the difference in the discharge voltages between terminals a and b of the gaps assigned to the two conductors of the circuit during the passage of discharge current. For a 3-electrode gas discharge tube, the difference in time between the spark-over of the first and second gap shall not exceed 200 ns.

6.5 d.c. holdover voltages (see clause 7.5 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.

6.5.1 d.c. holdover test values for 2-electrode tubes

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

Table 3 – Holdover test values for 2-electrode tubes

Component	Test 1	Test 2	Test 3
PS1	52 V	80 V	135 V
R3	200 Ω	330 Ω	1300 Ω
R2	(Note)	150 Ω	150 Ω
C1	(Note)	100 nF	100 nF
NOTE – Components omitted in this test.			

6.5.2 d.c. holdover test values for 3-electrode tubes

3-electrode tubes are tested in a circuit equivalent to that of Figure 5, where components have the values given in Table 4.

Table 4 – 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	200 Ω	330 Ω		1300 Ω	
R2	(Note 1)	150 Ω	272 Ω (Note 2)	150 Ω	272 Ω (Note 2)
C1	(Note 1)	100 nF	43 nF (Note 2)	100 nF	43 nF (Note 2)
R4 (Note 3)	136 Ω	136 Ω		136 Ω	
C2 (Note 3)	83 nF	83 nF		83 nF	
NOTE 1 – Components omitted in this test.					
NOTE 2 – Optional alternative.					
NOTE 3 – Optional.					

6.6 Life tests (see clause 7.6)

The currents specified in clause 6.6.1 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 clause 6.6.2. On completion of the number of current applications specified, the tube shall be capable of meeting the requirements of clause 6.6.3.

6.6.1 Test currents

Gas discharge tubes shall be subjected to the currents of columns 1 to 5 of Table 5. For each life test new gas discharge tubes shall be used.

Table 5 – Life test current values

Test number	Nominal alternating discharge current	Nominal impulse discharge current			
	1	2	3	4	5
Waveform	a.c. 50-60 Hz	8/20 μ s	10/350 μ s ^{a)}	10/1000 μ s	10/1000 μ s
Applications	10	10	1	300	1500
Dimension	A rms	kA peak	kA peak	A peak	A peak
Class					
1	2.5	2.5	0.5	50	10
2	5	5	1	100	10
3	10	10	2.5	100	10
4	20	10	4	100	10
5	20	20	4	200	10
^{a)} Different high-energy test waveforms exist in some countries and regions, for example, see [IEC 61643-21].					

6.6.2 Requirements during life test

Insulation resistance: not less than 100 M Ω .

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

6.6.3 Requirements after completion of life test

Insulation resistance: not less than 100 M Ω .

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

NOTE – After passage of an alternating or impulse current of value much higher than that shown in Table 5, the electrical characteristics of the GDT may be severely altered or the GDT may be even destroyed.

Two extreme situations may occur:

- 1) The gas discharge tube vents and acts like an insulator and presents a higher dielectric strength than it had initially.
- 2) The gas discharge tube turns to a low resistance or even becomes a short-circuit which does not allow normal operation of the telecommunication service. (This situation may be preferable from the point of view of fault detection, fault signalling, 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. Operators should cover their requirements in these respects in their own documentation.

Holdover voltage: as in clause 6.5.

6.7 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 sufficient time to prevent the gas discharge tube from being overheated.

7 Test methods

Gas discharge tubes shall be tested according to the methods described in clauses 7.1 to 7.7 and, in given cases, according to Figure A.1 (Test circuit for GDT for ISDN or other telecommunications equipment using higher voltages or bitrates (xDSL)).

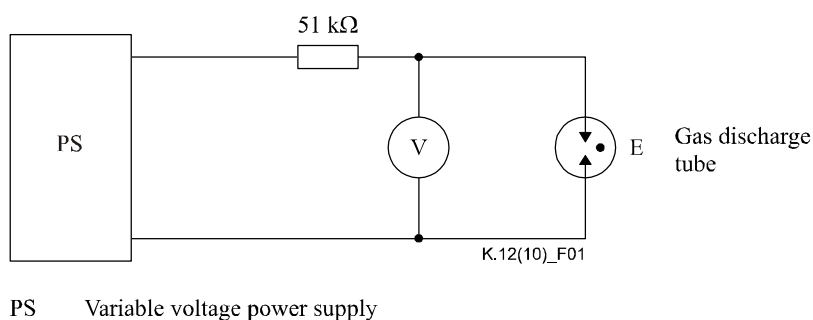
7.1 Spark-over voltage

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 shall be tested in darkness.

7.1.1 d.c. spark-over voltage

The gas discharge tube shall be tested 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 Annex B. The voltage is measured across the open-circuited terminals of the generator. U_{max} of Figure B.1 is any voltage greater than the maximum permitted d.c. spark-over voltage of the gas discharge tube.

The test shall employ a suitable circuit such as that shown in Figure 1. A minimum of 3 seconds shall elapse between repetitions of the test, with either polarity, on the same gas discharge tube.



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

Figure 1 – Circuit for d.c. spark-over test

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 either Table 1a or 1b.

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

7.1.2 Impulse spark-over voltage

The voltage waveform measured across the open circuit test terminals shall have a nominal rate of rise selected from Table 1a or 1b and shall be within the enclosed limits indicated in Figure B.1. Figure 2 shows a suggested arrangement for testing with a voltage impulse having a nominal rate of rise of 1.0 kV/ μ s.

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.

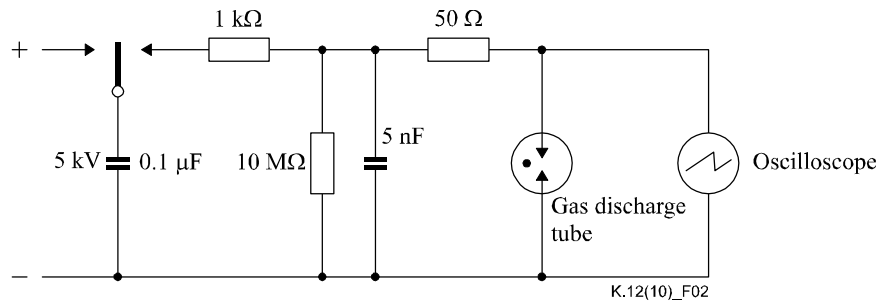


Figure 2 – Testing arrangement producing a voltage impulse having a wavefront with a virtual steepness of 1 kV/ μ s (see clauses 6.1 and 7.3)

7.2 Insulation resistance

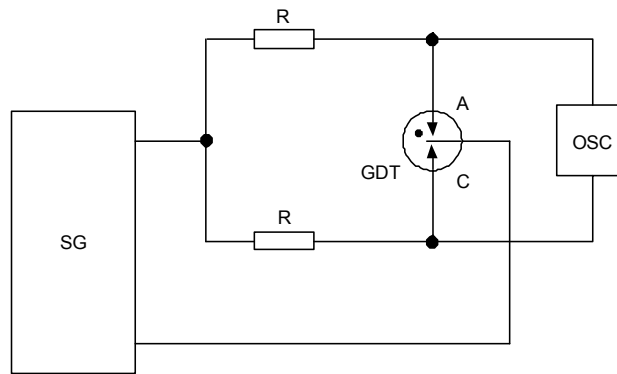
The insulation resistance shall be measured from each terminal to every other terminal of the gas discharge tube (see clause 6.2). The measurement shall be made at an applied potential of at least 100 V or not more than 90% of the minimum permitted d.c. spark-over voltage. The measuring source shall be limited to a short circuit current of less than 10 mA. Terminals of 3-electrode gas discharge tubes not involved in the measurement shall be left unterminated.

7.3 Capacitance

The capacitance shall be measured between each terminal and every other terminal of the gas discharge tube (see clause 6.3). In measurements involving 3-electrode gas discharge tubes, the terminal not being tested shall be connected to a ground plane in the measuring instrument.

7.4 Impulse transverse voltage for 3-electrode gas discharge tubes

The duration of the transverse voltage shall be measured while an impulse voltage having a virtual steepness of impulse wavefront of 1 kV/ μ s is applied simultaneously to both discharge gaps. Measurement may be made with an arrangement as indicated in Figure 3 (also see clause 6.4). The difference in time between the spark-over of the first gap and that of the second is specified in clause 6.4.



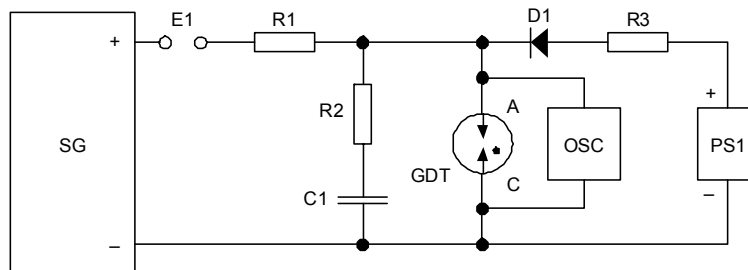
OSC Oscilloscope
 R Line impedance
 SG Surge generator (see Figure 2)

Figure 3 – Circuit for impulse transverse voltage test (see clause 6.4)

7.5 Holdover test

7.5.1 2-electrode gas discharge tube

Tests shall be conducted using the circuit of Figure 4 (see also clause 6.5). 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 μ s 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.

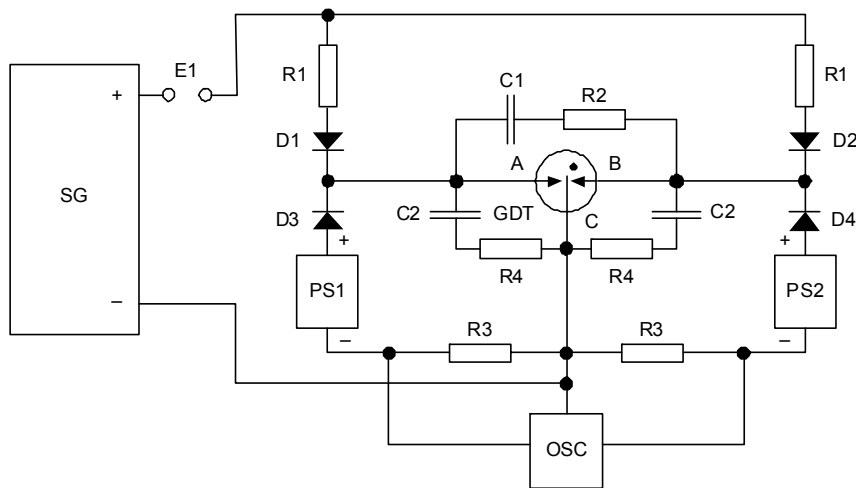


D1 Isolation diode or other isolation device
 E1 Isolation gap or equivalent device
 OSC Oscilloscope
 PS1 Constant voltage d.c. supply or battery
 R1 Impulse current-limiting resistor or waveshaping network
 R2, R3 See Table 3
 SG Surge generator, 100 A, 10/1 000 μ s

Figure 4 – Circuit for holdover test of 2-electrode gas discharge tube (see clause 6.5.1)

7.5.2 3-electrode gas discharge tube

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 μ s per side or chamber, 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.



- C1, C2 See Table 4
E1 Isolation gap or equivalent device
OSC Dual channel oscilloscope
PS1, PS2 Batteries or d.c. power supplies
R1 Impulse current-limiting resistors or wave-shaping networks
R2, R3, R4 See Table 4

NOTE 1 – The polarity of diodes D1 to D4 must be reversed when the polarity of the d.c. power supplies and surge generators is reversed.

Figure 5 – Circuit for holdover test of 3-electrode gas discharge tube (see clause 6.5.2)

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.

7.6 Life tests

New gas discharge tubes shall be used for each of the tests.

A proposed type test procedure is given in Table 6.

Table 6 – Recommended sample sizes to be used for a.c. and impulse life tests

Test	Sample size	Test performed in accordance with clause 6.6.1, Table 5, column
a.c. life	20	1
Impulse life	20	2
Impulse life	20	3
Impulse life	20	4
Impulse life	20	5

Alternating respectively impulse currents shall be applied as specified in Table 5 for the relevant class of the tube.

The time between applications should be such as to prevent thermal accumulation in the tube.

DC and impulse spark-over tests shall be performed on gas discharge tubes which are subject to life conditions specified in clause 6.6.1. 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 according to clause 7.1.

It is recommended that a minimum of four spark-over voltage measurements are performed on each sample, two in each polarity.

Measured values after life test under consideration (5% failure rate accepted), compare either Table 1a or 1b values after life.

7.6.1 a.c. life (see clause 6.6)

The alternating currents shall be applied as specified in Table 5, column 1, for a duration of 1 second.

The r.m.s. 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%.

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 1, 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 clause 6.6.2.

On completion of the specified number of current applications, the tube shall be allowed to cool to ambient temperature and tested for compliance with clause 6.6.3.

7.6.2 Impulse discharge current 8/20 μ s

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 2, shall be discharged simultaneously from each electrode to the common electrode.

7.6.3 Impulse discharge current 10/350 μ s

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 3, shall be discharged simultaneously from each electrode to the common electrode.

7.6.4 Impulse discharge current 10/1000 μ s

To carry out this test, one of the methods listed in Table 7, shall be applied. Methods 1 and 2 must be used together for testing 3-electrode gas discharge tubes by testing 50% of the sample lot with method 1 and the remaining 50% with method 2.

Although these four methods apply the same number of discharges, their end results may not be the same.

Table 7 – Impulse discharge current test method

Method	Number of applications 10/1000 μs (50..200 A) (see column 4 of Table 5)	Number of applications 10/1000 μs (10 A); (see column 5 of Table 5)	Polarity
1	300 times	1500 times	+++++
2	300 times	1500 times	-----
3	150 times + and 150 times –	750 times + and 750 times –	+++++.../-----...
4	300 times +/-	1500 times +/-	+/-/+/-/+/-/...
NOTE – The test results can vary depending on the test methods 1-4. It should be stated which test method was used or tested as agreed upon by the user and manufacturer.			

The voltage of the source shall exceed the maximum impulse spark-over voltage of the gas discharge tube by not less than 50%. 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, columns 4 and 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 clause 6.6.2.

On completion of the specified number of impulse currents, the tube shall be allowed to cool to ambient temperature and tested for compliance with clause 6.6.3.

7.7 Short-circuit test

New tubes shall be used and 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 proposed sample size to be used for short circuit tests is 5 for each test condition.

The values and duration should be specified by the manufacturer of the gas discharge tubes.

The behaviour of the short-circuit mechanism is particularly influenced by the environmental conditions and the termination module. Therefore, it is necessary that the test procedure and the requirements be in detail arranged between the manufacturer and the user of gas discharge tubes.

8 Environment tests

8.1 Radiation

Gas discharge tubes shall not contain radioactive material.

8.2 Robustness of terminations

The user shall specify a suitable test from [IEC 60068-2-21], if applicable.

8.3 Solderability

Soldering terminations shall meet the requirements of [IEC 60068-2-20], test Ta method 1.

8.4 Resistance to soldering heat

Gas discharge tubes with soldering terminations shall be capable of withstanding [IEC 60068-2-20], 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.

8.5 Vibration

A gas discharge tube shall be capable of withstanding [IEC 60068-2-6], Environmental testing, 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 this reference. 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 clauses 6.1 and 6.2.

8.6 Damp heat cyclic

A gas discharge tube shall be capable of withstanding [IEC 60068-2-30]. At the end of the test, the tube shall meet the insulation resistance requirement specified in clause 6.2.

8.7 Sealing

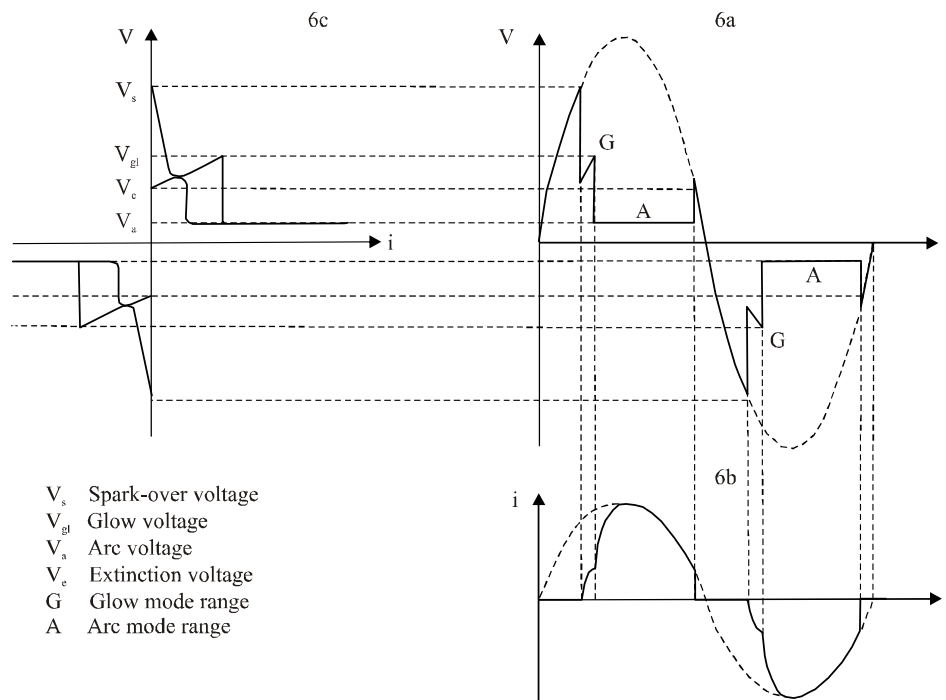
A gas discharge tube shall be capable of passing [IEC 60068-2-17] Test Qk, severity 600 hours, for fine leaks. The fine leak rate shall be less than 10^{-7} bar $\text{cm}^3 \text{s}^{-1}$. Helium shall be used as the test gas.

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

8.8 Low temperature

A gas discharge tube shall be capable of withstanding [IEC 60068-2-1] 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 clause 6.1.

9 Informative characteristics



NOTE 1 – Graph 6a shows voltage at the GDT as a function of time when limiting a sinusoidal voltage surge.

NOTE 2 – Graph 6b shows current at the GDT as a function of time when limiting a sinusoidal voltage surge.

NOTE 3 – Graph 6c shows the voltage/current characteristic of the GDT obtained by combining the graphs of voltage and current.

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6a – Voltage at the GDT as a function of time when limiting a sinusoidal voltage surge

6b – Current at the GDT as a function of time when limiting a sinusoidal voltage surge

6c – V/I characteristic of the GDT obtained by combining the graphs of voltage and current

Figure 6 – Electrical characteristics of GDT

10 Identification

10.1 Marking

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

- a) manufacturer;
- b) year of manufacture;
- c) code.

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

10.2 Documentation

Documents shall be provided to the user so that from the information in clause 10.1 he or she can determine the following further information:

- a) full characteristics as set out in this Recommendation;
- b) statement that no radioactive material has been used.

11 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 clause 6.1.1;
- c) nominal current rating chosen from clause 6.6.1;
- d) holdover voltage tests required in clause 6.5;
- e) marking codes required for clause 10.1;
- f) robustness of terminations – test required for clause 8.2;
- g) destruction characteristic, if required, including failure mode (see Note in clause 6.6.3);
- h) short-circuit mechanism;
- i) quality assurance requirements.

Annex A

Test circuit for GDT used in ISDN circuits

(This annex forms an integral part of this Recommendation)

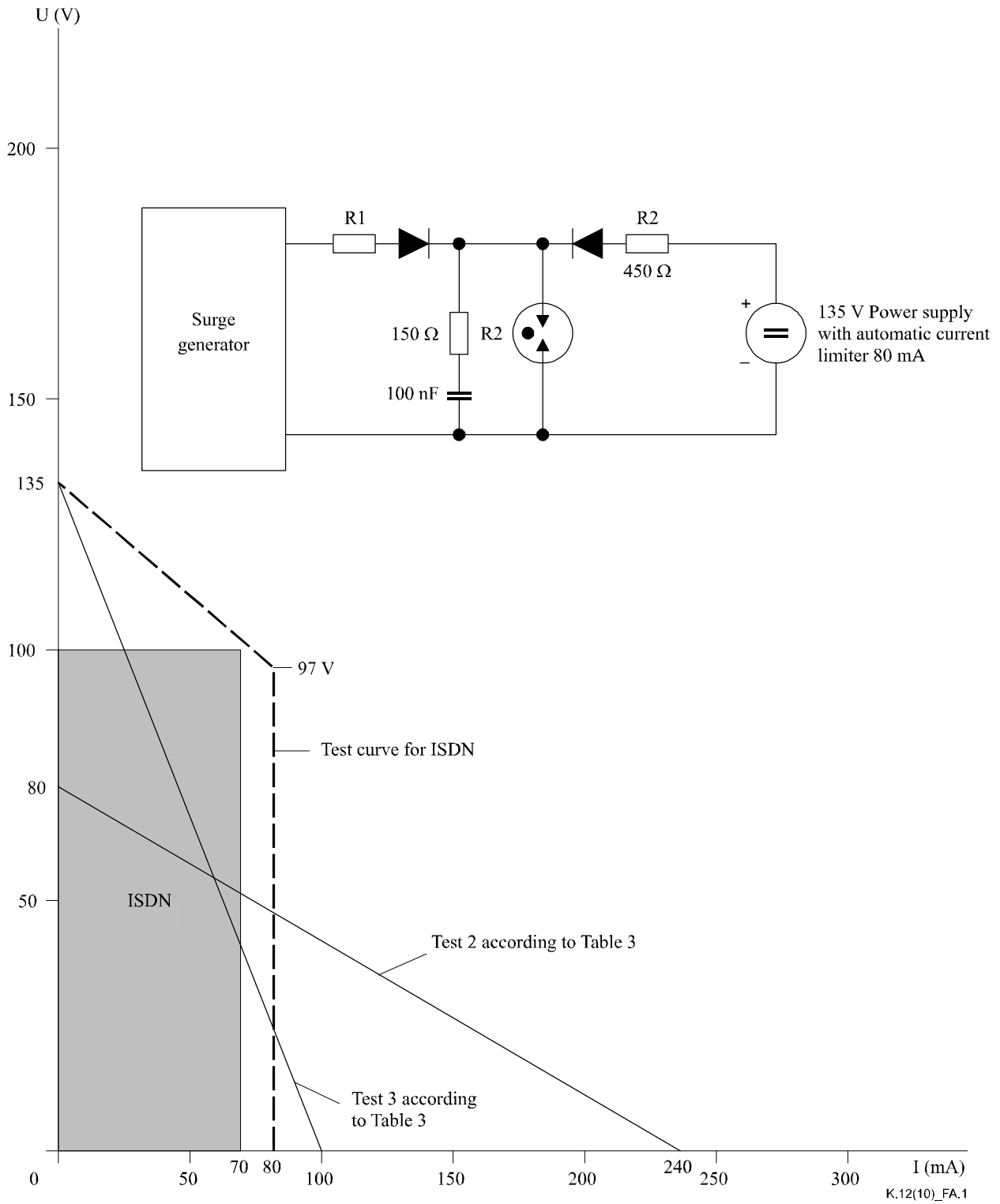


Figure A.1 – Test circuit for GDT used in ISDN circuits

Annex B

Spark-over test waveform

(This annex forms an integral part of this Recommendation)

The use of Figure B.1 :

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.

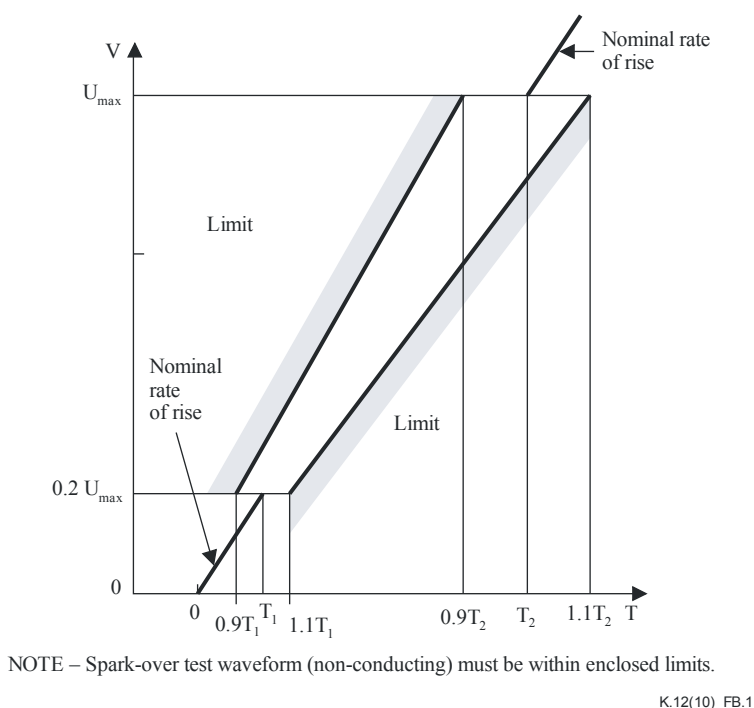


Figure B.1 – Spark-over test waveform

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/s:

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.

Annex C

Determining the special test protector (STP)

(This annex forms an integral part of this Recommendation)

Selection of the primary protector

A test house or laboratory needs to be given the characteristics of the "agreed" primary protector, for the equipment under test, so that they can select the special test protector. It is important that the nominated "agreed" primary protector and special test protector characteristics be recorded in the test report. This may prevent an additional compliance test having to be performed.

The characteristics of the special test protector are determined by the "agreed" primary protector. Unfortunately, there are many types of primary protector available. This Recommendation lists the many nominal d.c. firing voltages and other characteristics for GDTs. Furthermore, the network operator may require a change of one of the characteristics in ITU-T K.12 because of an agreement with a manufacturer. There are at least four reasons for the range of primary protectors used, and some of these are:

- The network operator has a specific requirement, e.g., minimum d.c. firing voltage to prevent ring trip or the use of a specific termination module. [ITU-T K.65] may limit the range of GDTs which can be used.
- The manufacturer may specify a maximum d.c. and a maximum impulse firing voltage to coordinate with their equipment.
- The administration may specify a minimum d.c. firing voltage to prevent operation due to 230 V a.c. for safety reasons.
- The environment, predominantly a.c. or lightning surges, may also limit the characteristics of the GDT.

The end result is an agreed primary protector. The characteristics of the agreed primary protector must be known to determine the characteristics of the special test protector. An equipment manufacturer needs to balance market opportunities (design the equipment to coordinate with the worst-case GDT) with design costs (design for the best case GDT). It should be noted that the term "worst case" does not indicate a poor quality GDT. GDTs may have a high firing voltage for many reasons, e.g., the GDT has to operate in an environment where a.c. surges predominate or the operator requires a high minimum d.c. firing voltage. A list of typical protection points and likely GDT used is given in Table C.1.

Table C.1 – Typical GDT application for equipment connected to external cables and for plant

Application	Standard GDTs (Type 1) Table 1a (Characteristics are better suited for withstanding a.c. currents)		Low impulse voltage GDTs (Type 2) Table 1b (May not be suitable when a.c. surges predominate)	
	d.c. (V)	Impulse at 1kV/μs (V)	d.c. (V)	Impulse at 1kV/μs (V)
Line cards, data circuits (nominally a 230 V GDT)	max. 300	max. 800	max. 300	max. 550
RFT circuits (nominally a 350 V GDT)	max. 455	max. 1100	max. 600	max. 900
Customer premises (nominally a 600 V GDT)	max. 780	max. 1500	max. 800	max. 1200
Cable protection (nominally a 600 V GDT)	max. 780	max. 1500	max. 800	max. 1200

To assist those manufacturers who wish to design for, or test for, a worst-case GDT, a table of protection purposes and a typical worst-case GDT is provided in Table C.2. These values are based on this Recommendation.

Table C.2 – Worst-case GDT voltages

Application	Worst-case GDT firing (voltages taken from Tables 1a and 1b)	
	d.c. (V)	Impulse at 1 kV/μs (V)
Line cards, data circuits (nominally a 230 V GDT)	max. 300	max. 800
RFT circuits (nominally a 350 V GDT)	max. 600	max. 1100
Customer premises (nominally a 600 V GDT)	max. 800	max. 1500
Cable protection (nominally a 600 V GDT)	max. 800	max. 1500

NOTE – The values in this table are given to assist manufacturers to determine a worst-case "agreed" primary protector for design and testing purposes. Use of these values does not guarantee compliance with the product recommendations for every application in every country. ITU-T will update these values when feedback is received.

Bibliography

- [b-ITU-T K.11] Recommendation ITU-T K.11 (2009), *Principles of protection against overvoltages and overcurrents*.
- [b-ITU-T K.46] Recommendation ITU-T K.46 (2008), *Protection of telecommunication lines using metallic symmetric conductors against lightning-induced surges*.

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