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**Surge protective devices connected to
telecommunications and signalling
networks — Performance requirements
and testing methods**

ICS 29.240;29.240.10

Reference number : JIS C 5381-21 : 2004 (E)

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard from Electronic Materials Manufacturers Association of Japan (EMAJ) / Japanese Standards Association (JSA), with a draft of Industrial Standard based on the provision of Article 12 Clause 1 of the Industrial Standardization Law. This Standard has been made based on IEC 61643-21 : 2000 *Low voltage surge protective devices—Part 21 : Surge protective devices connected to telecommunications and signalling networks—Performance requirements and testing methods* for the purposes of making it easier to compare this Standard with International Standard; to prepare Japanese Industrial Standard conforming with International Standard; and to propose a draft of an International Standard which is based on Japanese Industrial Standard.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Ministers and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

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Surge protective devices connected to telecommunications and signalling networks — Performance requirements and testing methods

Introduction This Japanese Industrial Standard has been prepared based on the first edition of IEC 61643-21 *Low voltage surge protective devices — Part 21 : Surge protective devices connected to telecommunications and signalling networks — Performance requirements and testing methods* published in 2000 without modifying the technical contents.

Portions underlined with dots are the matters not stated in the original International Standard.

1 General

1.1 Scope This part of JIS C 5381 specifies performance requirements and testing methods of surge protective devices (hereafter referred to as SPDs) connected to telecommunications and signalling networks with nominal system voltages up to 1 000 V (r.m.s.) a.c. and 1 500 V d.c.

SPDs limit surge voltage caused by indirect and direct effects of lightning or other transient overvoltages and contain one or more non-linear components to divert surge currents.

NOTE : The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and JIS are IDT (identical), MOD (modified), and NEQ (not equivalent) according to ISO/IEC Guide 21.

IEC 61643-21:2000 *Low voltage surge protective devices — Part 21 : Surge protective devices connected to telecommunications and signalling networks — Performance requirements and testing methods* (IDT)

1.2 SPD configurations The SPD configurations described in this Standard are shown in figure 1. Each SPD configuration is composed of one or more voltage-limiting components and may include current-limiting components.

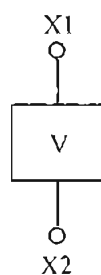


Figure 1a Two-terminal SPD

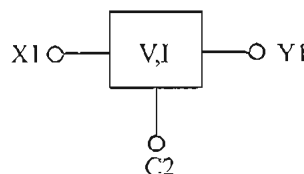


Figure 1b Three-terminal SPD

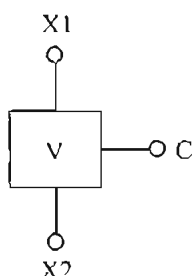


Figure 1c Three-terminal SPD

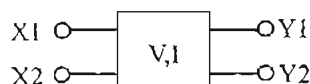


Figure 1d Four-terminal SPD

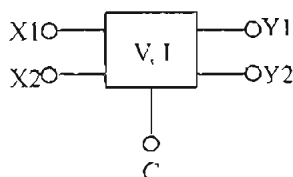


Figure 1e Five-terminal SPD

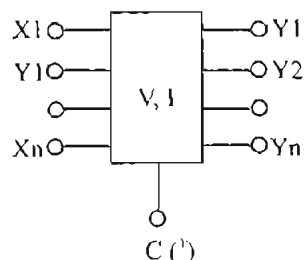


Figure 1f Multi-terminal SPD

Note (1) : The common terminal C may not be provided.

V : voltage-limiting component

V, I : voltage-limiting components or a combination of voltage-limiting and current-limiting components

X1, X2 ... Xn : line terminals

Y1, Y2 ... Yn : protected line terminals

C : common terminal

Figure 1 SPD configurations

1.3 Use of this Standard This Standard considers two basic types of SPD.

The first type of SPD contains at least one voltage-limiting component and no current-limiting component(s) in a housing. All the SPD configurations of figure 1 can be of this type. These SPDs shall satisfy the requirements of 5.1, 5.2.1 and 5.3 (see table

1). The SPDs shown in figures 1b, 1d, 1e and 1f may contain a linear component between the line terminal and the corresponding protected line terminal. These SPDs shall also satisfy the applicable requirements of 5.2.2.

The second type of SPD contains both voltage-limiting and current-limiting components in a housing. SPD configurations shown in figures 1b, 1d, 1e, and 1f are applicable for SPDs with both voltage-limiting and current-limiting components. This type of SPD shall satisfy the requirements of 5.1, 5.2.1, 5.2.2 and 5.3 (see table 1). Configurations of protective devices having only current-limiting components are covered in annex A.

SPDs may need to satisfy additional requirements depending on the application. The additional requirements are described in 5.2.3 and 5.4 (see table 1). Subclause 5.2.3 provides transmission tests that SPDs may need to conform to, depending on their communication and signalling application. Selection of the applicable transmission tests from 5.2.3 shall be made, based on the intended application of the SPDs. Annex B provides general guidance on how to select the applicable transmission tests.

Subclause 5.4 provides the environmental requirements when the SPDs are intended only for use in uncontrolled environments as described in 4.1. SPDs shall satisfy these requirements after an agreement between the user and the manufacturer. Table 1 provides examples of what requirements different types of SPD shall satisfy. Annex C gives the test sequence and the number of samples to be tested.

Table 1 General SPD requirements

Requirements Type of SPD	General 5.1	Voltage- limiting 5.2.1	Current- limiting 5.2.2	Transmis- sion 5.2.3	Mechani- cal 5.3	Environ- mental 5.4
SPD with only volt- age-limiting function	Yes	Yes	Yes	No	Yes	No
SPD with both volt- age-limiting and cur- rent-limiting functions	Yes	Yes	Yes	No	Yes	No
SPD with volt- age-limiting function and linear component between its terminals	Yes	Yes	Yes	No	Yes	No
SPD having both volt- age-limiting and cur- rent-limiting functions with enhanced trans- mission capabilities	Yes	Yes	No	Yes (select tests, see annex B)	Yes	No
SPD having only volt- age-limiting function but intended for use in uncontrolled environ- ment	Yes	Yes	No	No or Yes (select tests, see annex B)	Yes	Yes
SPD having both volt- age-limiting and cur- rent-limiting functions but intended for use in uncontrolled environ- ment	Yes	Yes	Yes	No or Yes (select tests, see annex B)	Yes	Yes

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. If the indication of the year of coming into effect or the year of publication is given to these referred standards, only the edition of the indicated year constitutes the provision of this Standard but the revision and amendment made thereafter do not apply. The normative references without the indication of the year of coming into effect or the year of publication apply only to the most recent edition (including amendments).

JIS C 60068-2-30:1988 *Basic environmental testing procedures Part 2: Tests Test Db: Damp heat, cyclic (12+12-Hour cycle)*

NOTE : IEC 60068-2-30:1980 *Environmental testing—Part 2: Tests. Test Db and guidance : Damp heat, cyclic (12+12-hour cycle)* is identical with the said standard.

JIS C 60695-2-11:1997 *Fire hazard testing—Glow-wire flammability test method for end-products*

NOTE : IEC 60695-2-1/1:1994 *Fire hazard testing—Part 2-1/1 : Test methods Sheet 1 : Glow wire end-product test and guidance* is identical with the said standard.

JIS C 0920:1993 *Tests to prove protection against ingress of water and degrees of protection against ingress of solid objects for electrical equipment*

NOTE : IEC 60529:1989 *Degrees of protection provided by enclosures (IP code)* is equivalent to the said standard.

JIS C 61000-4-5:1999 *Electromagnetic compatibility (EMC)—Part 4: Testing and measurement techniques—Section 5: Surge immunity test*

NOTE : IEC 61000-4-5:1995 *Electromagnetic compatibility (EMC)—Part 4 : Testing and measurement techniques—Section 5—Surge immunity test* is identical with the said standard.

JIS C 5381-1 *Surge protective devices connected to low-voltage power distribution systems—Performance requirements and testing methods*

NOTE : IEC 61643-1:1998 *Surge protective devices connected to low-voltage power distribution systems—Part 1 : Performance requirements and testing methods* is identical with the said standard.

IEC 60060-1:1989 *High-voltage test techniques Part 1 : General definitions and test requirements*

IEC 60950:1999 *Safety of information technology equipment*

IEC 60999-1:1990 *Connecting devices—Safety requirements for screw-type and screwless-type clamping units for electrical copper conductors—Part 1 : General requirements and particular requirements for conductors from 0.5 mm² up to 35 mm² (included)*

IEC 61083-1:1991 *Digital recorders for measurements in high voltage impulse tests—Part 1 : Requirements for digital recorders*

IEC 61180-1:1992 *High-voltage test techniques for low voltage equipment—Part 1 : Definitions, test and procedure requirements*

ITU-T Recommendation K.17:1988 *Test on power-fed repeaters*

ITU-T Recommendation K.30:1993 *Positive temperature coefficient (PTC) thermistors*

3 Definitions For the purpose of this part of JIS C 5381, the following definitions apply.

3.1 model number code, either applied to the SPD or included in its documentation, that is used to identify the SPD

3.2 preferred values values for the parameters listed in the tables for the various tests, preferred in the sense that their use promotes uniformity and provides a means of comparison among various protective devices. They also provide a common engineering language beneficial to the user and manufacturer of surge protectors used in telecommunications and signalling networks. However, specific applications may require values other than the preferred values of the tables.

3.3 overstressed fault mode

mode 1 condition wherein the voltage-limiting part of the SPD has been disconnected. The voltage-limiting function is no longer present, but the line is still operable

mode 2 condition wherein the voltage-limiting part of the SPD has been short-circuited by a very low impedance within the SPD. The line is inoperable, but the equipment is still protected by a short circuit.

mode 3 situation wherein the SPD has undergone an internal open circuit on the network side of the voltage-limiting part of the SPD. The line is inoperable but the equipment is still protected by an open line.

3.4 protection application of methods and means to prevent the propagation of stressful electrical energy beyond a designed interface

3.5 current response time time required for a current-limiting component to operate at a specified current and a specified temperature

3.6 maximum continuous operating voltage U_c maximum voltage (d.c. or r.m.s.) which may be continuously applied to SPD terminals without causing any degradation in the transmission characteristics of the SPD

3.7 maximum interrupting voltage maximum voltage (d.c. or r.m.s.) that can be applied to the current-limiting components of an SPD without degradation of the SPD. This voltage may be equal to the U_c of the SPD or may be a higher value depending on the arrangement of the current-limiting component(s) within the SPD.

3.8 surge protective device (SPD) device intended to limit transient overvoltages and divert surge currents. It contains at least one non-linear voltage-limiting component.

3.9 voltage limiting action of the SPD that causes all voltages exceeding a predetermined value to be reduced

3.10 current limiting action of an SPD, containing at least one non-linear current-limiting component, that causes all currents exceeding a predetermined value to be reduced

3.11 non-resettable current limiting action of an SPD that limits current only one time

3.12 resettable current limiting action of an SPD that limits current and can be manually reset after operating

3.13 self-resetting current limiting action of an SPD that limits current and will self-reset after the disturbing current is removed

3.14 voltage-clamping-type SPD SPD that has a high shunt impedance when no surge is present, but the impedance reduces continuously with increasing surge current and voltage. Common examples of components used as voltage clamping devices are varistors and suppression diodes. These are sometimes referred to as "limiting-type" SPDs.

3.15 voltage-switching-type SPD SPD that has a high shunt impedance when no surge is present, but has a sudden and large reduction in impedance in response to a voltage surge. Common examples of components used as voltage-switching devices are air gaps, sealed gas tubes, and thyristors. These are sometimes referred to as "crowbar-type" SPDs.

3.16 voltage protection level U_p parameter that characterizes the performance of the SPD in limiting the voltage across its terminals. This value of voltage is greater than the highest measured value of impulse-limiting voltage and is specified by the manufacturer.

3.17 multi-stage SPD SPD which has more than one voltage-limiting component. These voltage-limiting components may or may not be electrically separated by a series component. The voltage-limiting components may be either switching or clamping types.

3.18 blind spot situation where voltages above the maximum continuous operating voltage U_c may cause incomplete operation of the SPD. Incomplete operation of the SPD means not all of the stages in a multi-stage SPD have operated during the impulse test. This may result in overstressing of components in the SPD.

3.19 a.c. durability characteristic of an SPD which allows it to conduct alternating current of a specific magnitude and duration for a specified number of times

3.20 impulse durability characteristic of an SPD which allows it to conduct impulse current of a specified waveform and peak value for a specified number of times

3.21 current reset time time required for a self-resettable current limiter to revert to its normal or quiescent state

3.22 rated current maximum current a current-limiting SPD can conduct continu-

ously with no change in the operating characteristics of the current-limiting components

3.23 insulation resistance resistance between designated terminals of an SPD when U_c is applied to those terminals

3.24 return loss modulus of the reciprocal of the reflection factor, generally expressed in decibels (dB)

NOTE : When impedances can be defined, the return loss in dB is given by the formula:

$$20 \log \frac{Z_1 + Z_2}{Z_1 - Z_2}$$

where Z_1 is the characteristic impedance of the transmission line ahead of the discontinuity, or the impedance of the source, and Z_2 is the impedance after the discontinuity or load impedance seen from the junction between the source and the load.

3.25 bit error ratio (BER) ratio of the number of bit errors to the total number of bits transmitted in a given time interval

3.26 insertion loss loss resulting from the insertion of an SPD into a transmission system. It is the ratio of the power delivered to that part of the system following the SPD, before insertion of the SPD, to the power delivered to that same part after insertion of the SPD. The insertion loss is generally expressed in decibels.

3.27 near-end crosstalk (NEXT) crosstalk that is propagated in a disturbed channel in the direction opposite to the direction of propagation of the current in the disturbing channel. The terminal of the disturbed channel at which the near-end crosstalk is present is ordinarily near to, or coincides with, the energized terminal of the disturbing channel.

3.28 longitudinal balance (analogue voice frequency circuits) electrical symmetry of the two wires comprising a pair with respect to ground

3.29 longitudinal balance (data transmission) measure of the similarity of impedance to ground (or common) for the two or more conductors of a balanced circuit. This term is used to express the degree of susceptibility to common mode interference.

3.30 longitudinal balance (communication and control cables) ratio of the disturbing common mode (longitudinal) r.m.s. voltage (V_s) to ground and the resulting differential mode (metallic) r.m.s. voltage (V_m) of the SPD under test, expressed in decibels (dB)

NOTE : The longitudinal balance in dB is given by the formula:

$$20 \log \frac{V_s}{V_m}$$

where V_s and V_m are measured at the same frequency.

3.31 longitudinal balance (telecommunications) ratio of the disturbing common mode (longitudinal) voltage V_s and the resulting differential mode (metallic) voltage V_m

of the SPD under test, expressed in decibels (dB)

4 Service and test conditions

4.1 Service conditions

4.1.1 Normal service conditions

- a) **Air pressure** Air pressure 80 kPa to 106 kPa. This air pressure represents an altitude of -500 m to +2 000 m.
- b) **Temperature and humidity service conditions** For an uncontrolled environment, the temperature range is between the values of -40 °C and +70 °C. The humidity range is between the values of 5 % and 96 % RH. For a controlled environment, the temperature range is between the values of -5 °C and +40 °C. The humidity range is between the values of 10 % and 80 % RH.

4.1.2 Abnormal service conditions Exposure of the SPD to abnormal service conditions may require special consideration in the design or application of the SPD, and shall be called to the attention of the manufacturer.

4.2 Test temperature and humidity If it is known beforehand that a particular device technology causes an SPD to be insensitive to temperature when testing a particular characteristic, a temperature of 23 °C ± 2 °C with relative humidity from 45 % to 55 % may be used for that test. In other cases, testing shall be performed for an SPD, sensitive to temperature, at the extreme temperatures of the temperature range selected for the intended application. The selected temperature range may be narrower than the full range of 4.1 depending on the application.

For particular SPD technologies, it may be known beforehand that only one of the extreme temperatures of the selected temperature range represents the worst-case test condition. In this case, the testing shall be performed only at the extreme temperature representing the worst-case test condition. This extreme temperature may be different for each test described in clause 6 for the same SPD technology.

When testing is required to be performed at extreme temperatures, SPDs shall be gradually heated or cooled to the specified extreme temperature, taking sufficient time to avoid thermal shock. Unless otherwise specified, a minimum of 1 h should be used. SPDs shall be held at the specified temperature for a time sufficient to reach thermal equilibrium before testing. Unless otherwise specified, a minimum of 15 min should be used.

4.3 SPD testing The SPDs covered by this Standard shall be tested using the connections or terminations that are used when the SPDs are installed in the field. Also, the measurements should be made at the connections or terminations of the SPDs. For those that are intended to be used with a base or connector, that base or connector shall be part of the tests. When a base is used for testing, the measurements should be made as close as possible to the terminals of the SPD. Oscilloscopes used for measurements shall be in accordance with IEC 61083-1.

SPDs of figures 1c), 1e) and 1f) may have a common shunt element (component or wire) that conducts the total impulse current. The manufacturer shall state the maximum value of impulse current for this common shunt element. This value of impulse current may be less than n times the maximum current capability of each line terminal, where n equals the number of line terminals. These SPDs shall have all of their line terminals tested simultaneously with respect to the common terminal. For SPDs with separate shunt elements, each line terminal to common terminal shall be tested separately.

Matters of sample size and permissible failure rates are to be agreed between the customer and manufacturer.

4.4 Waveform tolerances The definition of the waveform parameters A/B where A is the front time in microseconds and B is the time to half-value in microseconds shall be in accordance with JIS C 61000-4-5 (see also IEC 60060-1). Table 2 shows the tolerances for the waveforms used in this Standard.

Table 2 Waveform tolerances

Waveform item	Unit : %		
	1.2/50 or 10/700 Open-circuit voltage	8/20 or 5/300 Short-circuit current	Other waveforms
Peak	$\pm 10 \%$	$\pm 10 \%$	$\pm 10 \%$
Front time	$\pm 30 \%$	$\pm 20 \%$	$\pm 30 \%$
Time to half-value	$\pm 20 \%$	$\pm 20 \%$	$\pm 20 \%$

5 Requirements

5.1 General requirements The following requirements apply to all SPDs covered by this Standard.

5.1.1 Identification and documentation The information indicated in items a) through n) shall either be marked on the body of the SPD, as described in 5.1.2, or included in the documentation or on the packaging. Any abbreviations used shall be explained in the data sheet. For each test performed on the SPD from clause 6, the test conditions shall be stated in the documentation.

- Manufacturer's name or trade mark
- Year and week of manufacture, or serial number
- Model number
- Service conditions
- Maximum continuous operating voltage U_c
- Rated current
- Voltage protection level U_p
- Impulse reset (if applicable)
- AC durability

- j) Impulse durability
- k) Overstressed fault mode
- l) Transmission characteristics
- m) Additional information, where applicable, concerning replaceable components and the use of radioisotopes
- n) Series resistance (if applicable)

5.1.2 Marking The SPDs shall be clearly marked with 5.1.1 items: a) the manufacturer's name or trademark, b) manufacturing traceability, c) model number, and e) the maximum continuous operating voltage. The marking material shall be wipe resistant and resistant to solvents normally used in the SPD application. Any notes for special handling shall be included in the documentation or on the packaging.

Compliance is checked in accordance with 6.1.2.

5.2 Electrical requirements The SPD shall meet the following requirements when tested in accordance with the subclauses of clause 6.

5.2.1 Voltage-limiting requirements When the SPD contains only voltage-limiting components, the SPD shall conform to all requirements of 5.2.1. An SPD that contains both voltage-limiting and current-limiting components shall conform to all requirements of 5.2.1 and to all applicable requirements of 5.2.2. An SPD that contains any linear component between its line terminals and protected line terminals shall conform to the applicable requirements of 5.2.2.

5.2.1.1 Maximum continuous operating voltage (U) The manufacturer shall state the maximum continuous operating voltage for the SPD. Compliance shall be checked in accordance with 6.2.1.1.

5.2.1.2 Insulation resistance This characteristic shall be stated by the manufacturer. Compliance shall be checked in accordance with 6.2.1.2.

5.2.1.3 Impulse-limiting voltage The SPD shall limit a specified impulse voltage when tested at the specified test conditions of table 3. The measured limiting voltage shall not exceed the specified voltage protection level U_p . (See IEC 61180-1.)

5.2.1.4 Impulse reset This requirement is applicable only to switching-type SPDs. The SPD, after having an impulse wave selected from table 3 applied, shall extinguish or return to its quiescent state. During the application of this impulse wave, a voltage selected from table 4 shall be applied to the SPD. Unless otherwise specified, the SPD shall return to its high impedance state in 30 ms or less.

5.2.1.5 AC durability The SPD, after having been tested according to 6.2.1.5 using current selected from table 5, shall meet the relevant requirements of 5.2.1 and 5.2.2, if applicable.

5.2.1.6 Impulse durability The SPD, after having been tested according to 6.2.1.6 using current and voltage waveforms selected from table 3, shall meet the relevant requirements of 5.2.1 and 5.2.2, if applicable.

5.2.1.7 Overstressed fault mode The SPD shall not become a fire hazard, explosion hazard or electrical hazard and shall not emit toxic fumes when tested in accordance with 6.2.1.7. The manufacturer shall provide the value of the impulse current (8/20) and the value of alternating current which will lead to a fault mode as described in 6.2.1.7.

5.2.1.8 Blind spot If no information regarding blind spots is available from the manufacturer, or verification of the manufacturer's information is desired, the testing of multi-stage SPDs shall be performed as described in 6.2.1.8.

5.2.2 Current-limiting requirements When the SPD contains a combination of both voltage-limiting and current-limiting components, the current-limiting components shall conform to all applicable requirements of 5.2.2. An SPD that contains a linear component (for example, resistor, inductor) between its line terminals shall conform to the requirements of 5.2.2.1, 5.2.2.2, 5.2.2.7 and 5.2.2.8.

5.2.2.1 Rated current The manufacturer shall specify the rated current. To confirm this value of rated current, the SPD shall be tested according to 6.2.2.1. Application of this test shall cause no change in the operating characteristics of the current-limiting component of the SPD.

5.2.2.2 Series resistance The manufacturer shall specify the value and tolerance of any series resistance. To confirm this value of series resistance, the SPD shall be tested according to 6.2.2.2.

5.2.2.3 Current response time When tested according to 6.2.2.3, the current-limiting component(s) shall operate at or below the value of response time specified by the manufacturer. Preferred values of test current are given in table 6. (See ITU-T Recommendation K.30.)

5.2.2.4 Current reset time The SPD containing one or more self-resettable current-limiting components shall be tested in accordance with 6.2.2.4. The reset time, or time required for the current-limiting component(s) to return to their quiescent state, shall be less than 120 s, unless otherwise specified. This requirement is not applicable to SPDs containing manually resettable current-limiting component(s).

5.2.2.5 Maximum interrupting voltage This requirement is applicable only to SPDs containing self-resettable or manually resettable current-limiting component(s). The SPD manufacturer shall specify the maximum interrupting voltage of the current-limiting component(s) in the SPD. Confirmation of this value is determined by performing the test in 6.2.2.5. There shall be no degradation in the operating characteristics of the current-limiting components after this test.

5.2.2.6 Operating duty test This requirement is applicable only to SPDs containing self-resettable or manually resettable current-limiting component(s). The SPD shall be subjected to repeated applications of the maximum interrupting voltage. The current shall be sufficient to operate the current-limiting component(s) and shall be selected from table 7. After exposure to these tests, the current-limiting component(s) shall meet the requirements of 5.2.2.3 and 5.2.2.4.

5.2.2.7 AC durability The SPD shall be subjected to repeated applications of a specified current. Table 8 shows preferred values of alternating currents. After exposure to these currents, the current-limiting component(s) in the SPD shall meet the requirements of 5.2.2.1, 5.2.2.2 and 5.2.2.3.

5.2.2.8 Impulse durability The SPD shall be subjected to a specified number of surges of specified peak current. Table 9 shows preferred values. After application of these surges in accordance with 6.2.2.8, the current-limiting component(s) of the SPD shall meet the requirements of 5.2.2.1, 5.2.2.2 and 5.2.2.3.

5.2.3 Transmission requirements The SPD, in addition to the requirements of 5.2.1 and 5.2.2, may need to conform to specific requirements of 5.2.3 depending on its communication and signalling application (for example, voice, data, video). Annex B provides guidance in the selection of applicable transmission tests.

5.2.3.1 Capacitance The manufacturer shall state the value of capacitance between specified terminals. Confirmation shall be determined by testing in accordance with 6.2.3.1.

5.2.3.2 Insertion loss The SPD shall be tested in accordance with 6.2.3.2 to determine whether the insertion of the SPD into the test system results in a voltage reduction between the generating and the measuring equipment.

5.2.3.3 Return loss The SPD shall be tested in accordance with 6.2.3.3. This will determine the amount of signal reflected back to the signal source, over a specified frequency range, caused by the insertion of the SPD into a matched transmission line.

5.2.3.4 Longitudinal balance The SPD shall be tested in accordance with 6.2.3.4. This test determines the minimum acceptable level of longitudinal balance of an SPD used in balanced circuits. The longitudinal balance shall be measured in the frequency range of interest.

5.2.3.5 Bit error ratio (BER) The SPD shall be tested in accordance with 6.2.3.5. This test determines whether the insertion of a surge protective device causes bit errors in a digital transmission system.

5.2.3.6 Near-end crosstalk (NEXT) The SPD shall be tested in accordance with 6.2.3.6. This test determines the amount of signal that is coupled from one circuit to another due to the insertion of the SPD.

5.3 Mechanical requirements The SPD shall conform to the following mechanical requirements.

5.3.1 Terminals and connectors

- a) Terminals and connectors shall be fastened to the SPD in such a way that they will not work loose if the clamping screws or the lock-nuts are tightened or loosened. A tool shall be required to loosen the clamping screws or the lock-nuts.
- b) Screws, current-carrying parts and connectors
 - 1) Connections, whether electrical or mechanical, shall withstand the mechanical stresses occurring in normal use, and the mechanical stresses generated by high