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PROTECTION AGAINST INTERFERENCE

CHARACTERISTICS OF SEMI-CONDUCTOR ARRESTER ASSEMBLIES FOR THE PROTECTION OF TELECOMMUNICATIONS INSTALLATIONS

ITU-T Recommendation K.28

(Previously "CCITT Recommendation")

FOREWORD

The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of the International Telecommunication Union. 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, established the topics for study by the ITU-T Study Groups which, in their turn, produce Recommendations on these topics.

ITU-T Recommendation K.28 was revised by the ITU-T Study Group V (1988-1993) and was approved by the WTSC (Helsinki, March 1-12, 1993).

NOTES

1 As a consequence of a reform process within the International Telecommunication Union (ITU), the CCITT ceased to exist as of 28 February 1993. In its place, the ITU Telecommunication Standardization Sector (ITU-T) was created as of 1 March 1993. Similarly, in this reform process, the CCIR and the IFRB have been replaced by the Radiocommunication Sector.

In order not to delay publication of this Recommendation, no change has been made in the text to references containing the acronyms "CCITT, CCIR or IFRB" or their associated entities such as Plenary Assembly, Secretariat, etc. Future editions of this Recommendation will contain the proper terminology related to the new ITU structure.

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

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CHARACTERISTICS OF SEMI-CONDUCTOR ARRESTER ASSEMBLIES FOR THE PROTECTION OF TELECOMMUNICATIONS INSTALLATIONS

(revised at Helsinki, 1993)

Foreword

Careful survey of the electrical environment that telephone equipment must safely survive, has led to the conclusion that semi-conductor devices that are robust enough to act as primary protectors are now possible. Semi-conductor devices provide for tightly toleranced and stable over-voltage control, which does not change with age or activity within their design capability. Furthermore, they introduce negligible circuit noise on the circuits they are protecting.

Widespread trials of these semi-conductor overvoltage protectors for primary protection are taking place and this Recommendation provides detailed guidance on the particular qualities which should be sought when manufacturing or purchasing such devices. The trials and initial applications are ongoing and some details of the technology may change in the light of the results. Nevertheless, to bring the trials and initial applications to the notice of a wider audience and to acquaint potential users with both the advantages and disadvantages of these devices, CCITT considers the subject to be important and stable enough to publish a Recommendation on the new technology.

0 Introduction

The purpose of this Recommendation is to provide technical guidelines for purchasers and manufacturers of semi-conductor arrester assemblies (SAA) to ensure their satisfactory operation in the applications for which they are intended. Figure I.1 shows examples of such arresters.

It is intended to be used for the harmonization of specifications issued by manufacturers of semi-conductor arrester assemblies (SAA) and network operators.

Only 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, the requirements of this Recommendation may be modified or further requirements added to suit local conditions. It is for Administrations to classify the environment for a particular device, taking into account business policy, and economic and technical considerations.

The requirements detailed for arresters in this Recommendation may entail statistical analysis of samples. Standard statistical analysis techniques can be applied and therefore no description of this analysis approach is given.

1 Scope

This Recommendation applies to semi-conductor arrester assemblies to be used for primary protection against voltage surges due to lightning or power disturbances on telecommunications circuits, in accordance with Recommendation K.11. It deals with semi-conductor arrester assemblies of the type that limit voltages from line to earth to a few volts when conducting sufficient current to switch the device.

It does not deal with:

- mountings for SAAs and their effect on arrester characteristics;
- semi-conductor arresters which are connected in series with voltage-dependent resistors to limit follow-on currents in electrical power systems;
- mechanical dimensions;
- quality assurance requirements;
- units containing heat-coils.

2 Definitions

These are given in Annex A.

3 Environmental requirements

The semi-conductor arrester assemblies should operate satisfactorily in, and be capable of storage in, temperature and humidity ranges selected for the intended application. The selected temperature range should be between the extreme values of –40 °C and +65 °C. The selected humidity range should be between the extreme values of 0 and 95% RH.

4 Electrical requirements

4.1 Maximum voltage limiting

When tested according to 5.1, the SAA voltage limiting should not be outside the limits given in Table 1.

TABLE 1/K.28

Voltage limiting – maximum limits

Maximum voltage limiting at stated rate of rise		
(100 V/s to 100 kV/s)	100 V/µs	1 kV/µs
400 V	400 V	400 V
NOTE – The maximum voltage limiting may be set by either equipment protection requirements (e.g. Recommendation K.21 or Recommendation K.20), or by technology capability. Values shown are typical.		

4.2 Minimum voltage limiting

The current in an SAA when tested according to 5.2 should not exceed the values given in Table 2 for the voltage limits shown.

TABLE 2/K.28

Minimum voltage limiting – requirements

Ramp maximum peak voltage (V)	R_1 nominal value (kΩ)	Maximum measured current (mA)
265	1.0	20
NOTE – The minimum voltage limit is set by the summation of the peak ringing, battery, and 50/60 Hz long-term induction voltages. The current is set by ensuring non-operation of a ring-trip mechanism or by not unduly loading the ringer. Values shown are typical, and it should be noted that this Recommendation may be modified to suit local conditions.		

4.3 Insulation resistance

4.3.1 This test measures the effect of two parameters simultaneously, semi-conductor junction leakage and insulation resistance.

4.3.2 When tested according to 5.3, the values of combined leakage and insulation resistance should not be outside the values given in Table 3.

TABLE 3/K.28

Minimum isolation resistance

DC text voltage (V)	Minimum R_1 (Ω)
50	10^8
100	50×10^6
200	165×10^3
NOTES 1 Voltages of both polarities should be applied. 2 Limit the source current to 10 mA maximum at 200 V.d.c., and proportionally at other test voltages. 3 The 200 V limit takes into account voltage levels that may be impressed on to some lines for specific operational purposes.	

4.4 Capacitance

The capacitance between each pair of electrodes (excluding protector assembly capacitance) should not exceed 200 picofarads (pF) when tested according to 5.4 at a frequency of 1 MHz.

4.5 Impulse reset

The SAA should revert to its high impedance state in less than 30 ms when tested to subclause 5.5 using appropriate row(s) from Table 4 for the parameters that apply to Figure 1. Select the appropriate row depending on the expected SAA application.

TABLE 4/K.28

Impulse reset circuit parameters
(see Figure 1)

PS_1 (V)	R_3 (Ω)	R_2 (Ω)	C_1 (μF)
52	200	(Note 5)	(Note 5)
135	690	150	0.1
80	330	150	0.1

NOTES

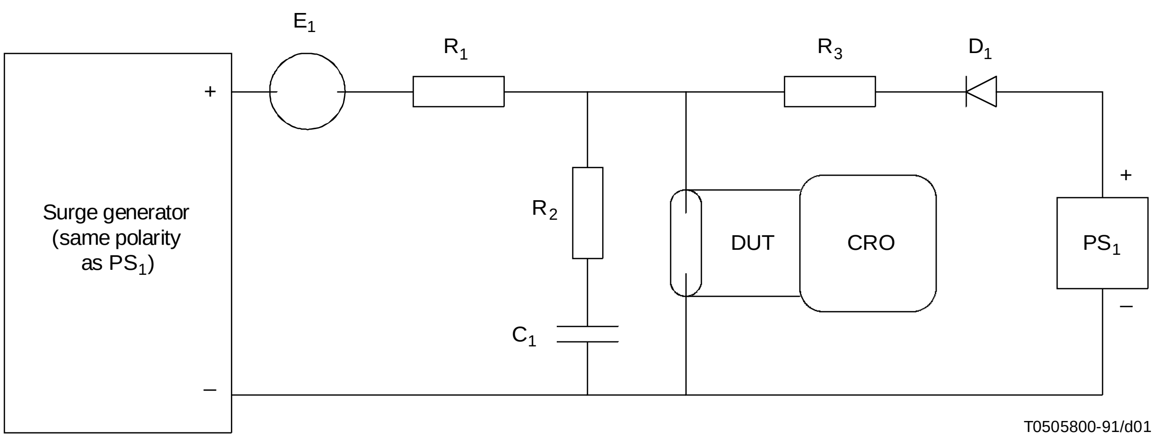
1 Test using a large generator having an open circuit peak voltage of 1 kV minimum, and capable of delivering a short circuit current surge of 25 A (see 5.5) with a 10/1000 μs waveform or a 10/700 μs waveform.

2 Perform all required tests with both polarities, line to earth.

3 When an SAA is intended for use on both tip and ring, the surge described in Note 1 may be applied to both tip and ring simultaneously. Appropriate impulse reset circuit parameters should be used.

4 In no case should *di/dt* exceed 30 A/μs.

5 Components omitted in this test.



PS_1 Constant voltage supply
E_1 Isolation gap or equivalent
C_1 Optional capacitor for simulating application conditions
R_1 Impulse limiting resistor or wave shaping network
R_2 Optional resistor for simulating circuit resistance
R_3 d.c. current limiting resistor
CRO Oscilloscope
DUT Device under test
D_1 Diode

FIGURE 1/K.28

Impulse reset test

4.6 Rate of change of current

The SAA, when tested to subclause 5.6, should not fail short circuit and should meet the maximum voltage limiting requirement of 4.1 following application of the surge.

4.7 Surge life tests

4.7.1 SAAs should be measured for their performance in the categories of impulse life and 50/60 Hz current carrying capacity, according to 5.7. The types of protectors in which the SAAs are mounted for testing should be identified and the life tests should apply only when the SAAs are used in those, or similar, protectors. Table 5 indicates the requirements. The 10 A impulse tests may be curtailed or waived if it can be demonstrated satisfactorily that no wear-out mechanisms are present in the design.

4.7.2 The surge life requirements of Table 5 may not be sufficient for protectors intended for applications where they are directly connected to open wire lines, or in other high-exposure areas.

TABLE 5/K.28

Surge life criteria for SAAs

Test	Current (Note 1)	Total number of applications at specified current
Impulse current (Note 2)	10 A peak	1500(10/1000) or 2500(10/700)
	10 A peak	100(10/1000) or 160(10/700)
a.c. 48-62 Hz for 1 s	1 A rms 10 A rms	60 5
a.c. 48-62 Hz for 30 s	0.5 A rms	1

NOTES

1 Currents are given for one pair of terminals (e.g. tip to ground or ring to ground).

2 *di/dt* must not exceed 30 A/µs.

4.7.3 Devices that can be shown to have a surge life that is temperature sensitive should be tested to subclause 5.7 at the maximum and minimum operating temperatures for the intended application.

4.8 The SAA, when tested to subclause 5.8, shall fail in a short circuit or low resistance mode. There shall be no externally visible damage.

5 Test methods

5.1 Maximum voltage limiting (see 4.1)

5.1.1 The test current should be chosen from the range 10 A to 100 A. The maximum rate of change of current applied to the SAA throughout the test shall not exceed 30 A/µs. The device shall be tested with both positive and negative waveforms.

5.1.2 With rate of rise as specified in Table 1, apply sufficient impulse voltage to cause breakdown. Repeat the test with opposite polarity and using the same device. Allow a one or two second waiting time between applications.

5.1.3 For impulse testing, the voltage generator used for this test must be capable of maintaining the open circuit voltage rate of rise of Table 1 (rate of rise defined in IEC 60).

5.2 **Minimum voltage limiting** (see 4.2 and Figure 2)

The generator shown in Figure 2 should provide a ramp of 100 V/s to 100 V/ms to the terminals under test. The circuit current can be determined by monitoring the voltage drop across a 1 kΩ resistor. The generator voltage should be no more than the value shown in Table 2.

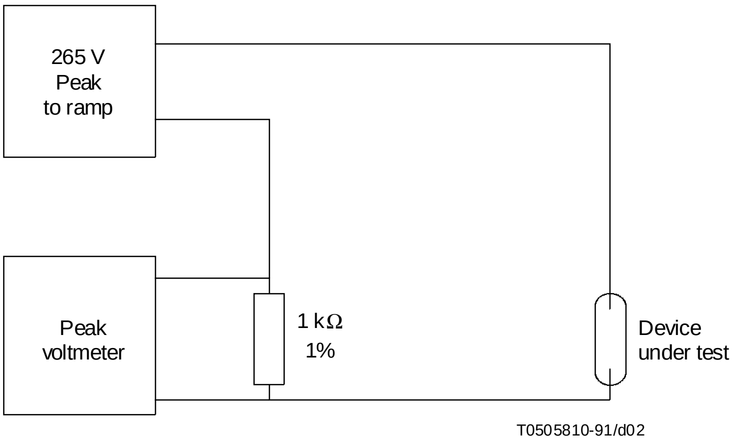


FIGURE 2/K.28

Test cirucit for minimum voltage limiting

5.3 **Insulation resistance** (see 4.3)

Combined insulation resistance and leakage (known jointly as R_I) should be measured between each terminal and every other terminal of the SAA by applying a specified direct current voltage source of both polarities with values as shown in Table 3. Insulation resistance readings should be taken after insulation stabilization or after one minute of applied voltage, whichever occurs first. Terminals not involved in the measurement should be left floating.

5.4 **Capacitance** (see 4.4)

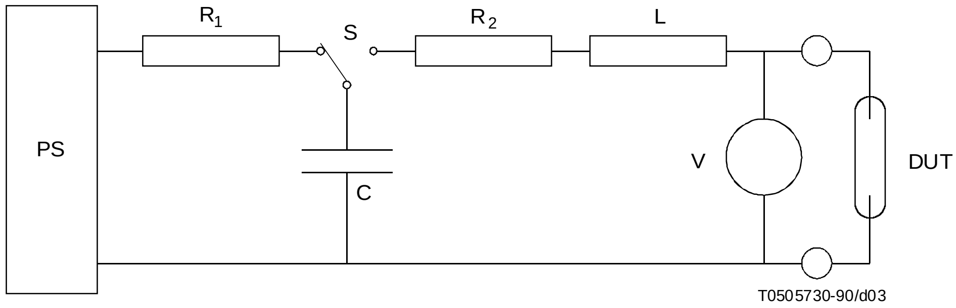
The capacitance of the SAA shall be measured between each terminal and every other terminal. All terminals not involved in the test shall be connected to an earth plane in the measuring instrument. The measurement voltage should be small enough to not interfere with the measurement and should in any case not exceed 1 V rms.

5.5 **Impulse reset** (see 4.5)

The maximum impulse current should be 25 A, with a 10/1000 or 10/700 waveform measured through a short circuit. The maximum rate of change of current applied to the SAA throughout the test should not exceed 30 A/µs. The impulse current should be applied to the SAA in the same polarity as the d.c. source. Three impulses should be applied at not greater than one minute intervals. The tests should be repeated with the specimen connections reversed. The 30 ms requirement applies to the time between application of the impulse and device reset. If required, the impulse generator may be disconnected from the SAA 10 ms after the application of the surge.

5.6 **Rate of change of current** (see 4.6 and Figure 3)

A surge with a rate of change of current of 25 A/µs to 30 A/µs and having a maximum current of 100 A and open circuit voltage of 1 kV, should be applied to the SAA (see Figure 3). This should be repeated with surges of the opposite polarity.



PS 1kV voltage power supply. Rated load ripple and output regulation shall be ≤ 3.0% under full power
R_1 50 kΩ charging current-limiting resistor
C 1.0 μF charging capacitor (non-electrolytic)
S Switch to initiate discharge
R_2 Discharge current limiting resistor (20 Ω)
L Total inductance of the discharge circuit. Nominally 20 μH to 25 μH
V Voltmeter or oscilloscope for observing breakdown and initial conditions
DUT Device under test

NOTE – The discharge circuit inductance may need to be varied in order to bring the current rate-of-rise at time zero to between 25 and 30 A/μs. Test with a short circuit as the DUT prior to using an actual device.

FIGURE 3/K.28

Test circuit for rate-of-change of current

5.7 **Surge life tests** (see 4.7 and Figure 4)

5.7.1 SAAs should be tested for impulse and 50/60 Hz life. When subjected to the various impulse and 50/60 Hz test currents shown in Table 5, at 20 °C ± 2 °C, a sample should have a surge life in accordance with the number of operations specified in that table. Half the specified number of tests should be carried out with one polarity followed by half with the other polarity. Alternatively, half the number in a sample quantity may be tested with one polarity and the other half with the opposite polarity. Tests for failure by insulation resistance, maximum and minimum voltage limiting should be conducted after each application of the test currents. Impulse reset should be measured after the number of operations specified as surge life criteria in Table 5 for those SAAs surviving to that point.

5.7.2 The open circuit voltage for the impulse life tests should measure at least 1000 V peak. The current amplitudes should be measured with the SAA replaced by a short circuit having minimum inductance.

5.7.3 The test circuit for the 10 A rms alternating current test should consist of a 50/60 Hz supply feeding a parallel pair of non-inductive series limiting resistors, one for each line terminal. The supply-resistor combination should deliver 1000 V rms under open circuit conditions and 10 A rms to each line terminal under short circuit conditions.

5.7.4 The 1 A alternating current tests should be conducted using the circuits shown in Figures 4a) and 4b).

5.7.5 A device should be considered to have reached end-of-surge life if any of the following conditions apply:

1) the minimum voltage limit test results fall outside the limits in Table 2;

2) the maximum voltage limit test results fall outside the limits in Table 1;

3) the SAA fails to extinguish in less than 30 ms at the component combinations listed for SAAs in Table 4;

4) the life test insulation resistance (R_I) is less than or equal to 50 MΩ at 100 V d.c.

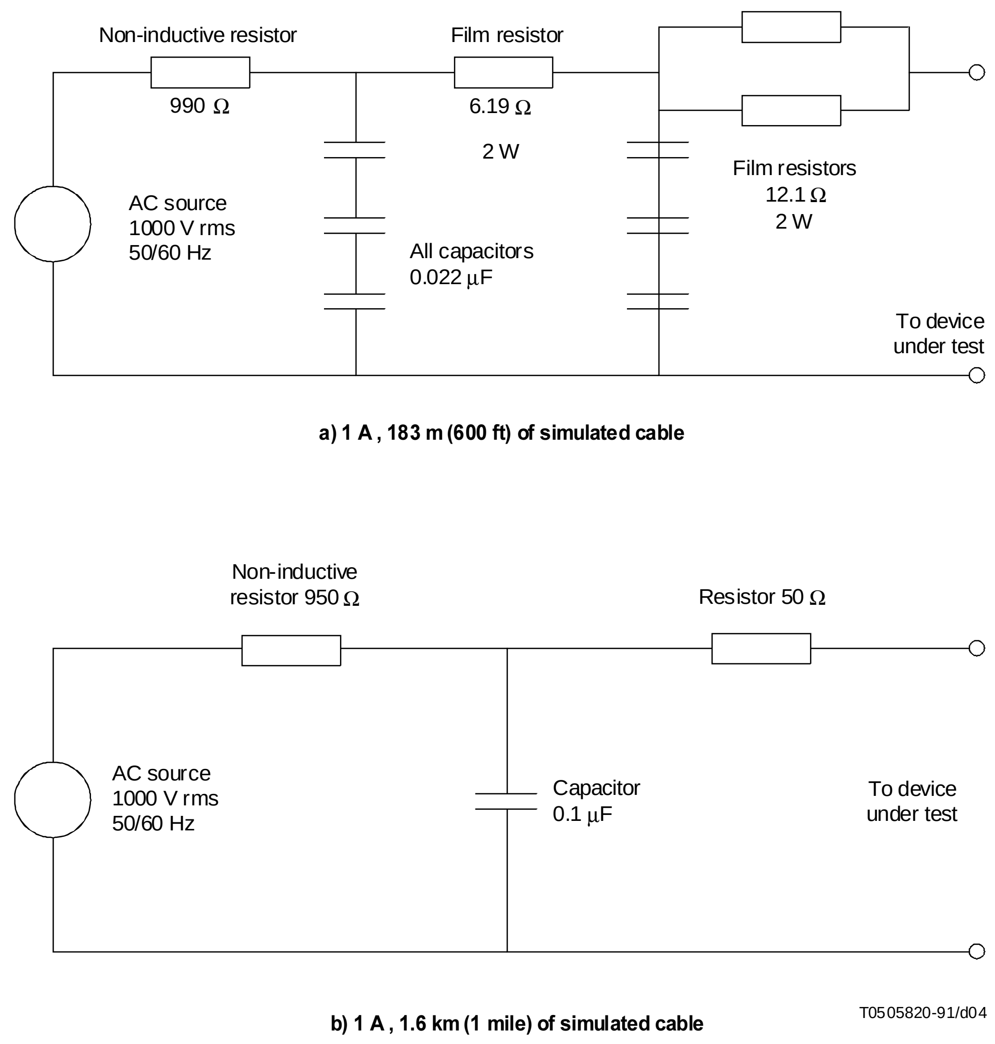


FIGURE 4/K.28

Test circuits for 1 second life tests

5.8 Overstress test

Apply simultaneously to both tip and rig connected in parallel a surge current of 10 kA peak amplitude with a waveform of 8/20 microseconds.

6 Mechanical requirements

6.1 Mechanical durability

The SAA should be sufficiently mechanically durable to withstand normal installation and maintenance procedures, as well as shipping, storage, and environmental stress.

7 High temperature conditioning

Samples should be subjected to the high temperature test specified here, and should display no warping, fading, or degradation of any material within 12 hours of return to ambient temperature. They should be conditioned for seven days in a circulating air oven, maintained at the maximum temperature of intended application with no humidity control. After the seventh day, the samples should be removed from the oven and allowed to return to ambient temperature.

8 General test requirements

This clause describes the performance criteria against which an SAA is analysed.

1) Certain tests require previous testing of samples for stress and environment. Also, subsequent tests may be necessary to determine whether the samples are still operational. If possible, the former tests should be completed, and these samples should proceed to the test programme with the untested samples.

2) Surge testing can cause semi-conductor devices to heat. Accordingly, allow sufficient cooling time between surges, as recommended by the manufacturer.

3) In all testing, the rate of change of discharge current must not exceed 30 A/µs at any time nor must the specified peak current be exceeded. Monitoring equipment to record these parameters is recommended.

9 Product identification

9.1 Operating voltage identification

Each SAA should be marked in a clear, permanent, and distinctive manner to indicate the nominal operating voltage.

9.2 Manufacturer's identification

On each SAA, the manufacturer's name, part number, and date code should be indelibly marked.

9.3 Customer's identification

If requested and agreed, the customer's identification should be indelibly marked, on each SAA.

10 Documentation

10.1 Complete instructions on installation and use should be included within every package of SAAs (or should be available on request).

10.2 Instructions and documentation should indicate whether the enclosed devices should be installed only in subscriber premises, or switching centres, or both.

10.3 Documentation should be provided so that the purchaser can determine the full characteristics as set out in this Recommendation.

11 Ordering information

The following information should be provided by the purchaser:

a) a drawing giving all dimensions, finishes and termination details of protector package into which the SAA will be fitted;

b) nominal limiting voltage;

c) the required markings;

d) quality assurance requirements.

Annex A

Definitions of terms special to this Recommendation

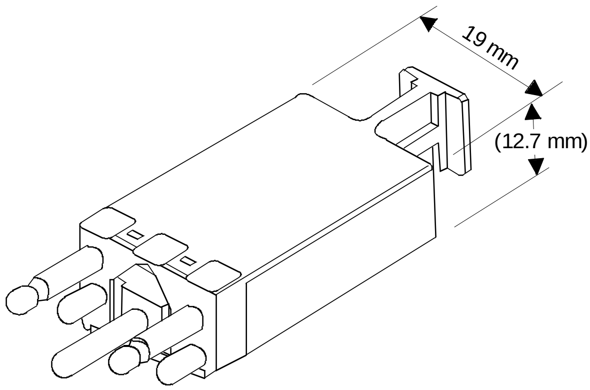
(This annex forms an integral part of this Recommendation)

A.1 semi-conductor arrester (SA): A semi-conductor device that is intended to go low impedance when the voltage across two terminals exceeds a defined value, and go high impedance when that voltage is removed.

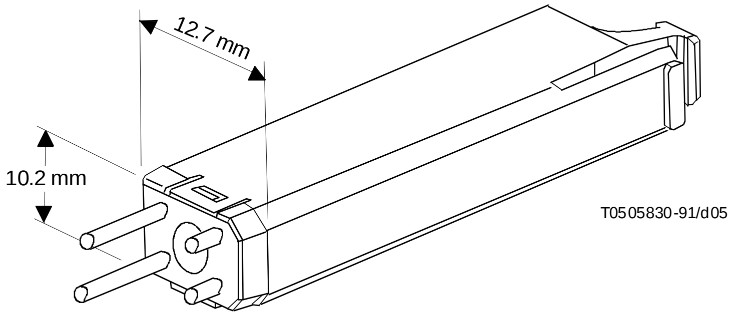
A.2 SA assembly (SAA): One or more SAs assembled into a housing in such a way as to form a readily identifiable, purchasable and testable unit. The function of an SAA is to divert overvoltages to earth, when installed in a protector. Examples of SAA are shown in Figure I.1.

Appendix I

(This appendix does not form an integral part of this Recommendation)



a) Typical United States switching centre housing



b) Typical Canadian switching centre housing

NOTE – Housings may be used to package semi-conductor, gas discharge tube, or carbon electrode arrester assemblies.

FIGURE I.1/K.28

Representative housings of semi-conductor arrester assemblies