IS 9385-2 (1980): High voltage fuses, Part 2: Expulsion and similar fuses [ETD 39: Fuses]

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Indian Standard (Reaffirmed 2002)

SPECIFICATION FOR HIGH VOLTAGE FUSES

PART II EXPULSION AND SIMILAR FUSES

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Indian Standard
SPECIFICATION FOR HIGH VOLTAGE FUSES
PART II EXPULSION AND SIMILAR FUSES

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Indian Standard
SPECIFICATION FOR HIGH VOLTAGE FUSES
PART II EXPULSION AND SIMILAR FUSES

0. FOREWORD

0.1 This Indian Standard (Part II) was adopted by the Indian Standards Institution on 16 January 1980, after the draft finalized by the High Voltage Switchgear and Controlgear Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 Three classes of high voltage fuses are in general use, the expulsion, liquid and high rupturing capacity cartridge types. The most common application is on distribution systems up to 33 kV, while the liquid and cartridge type fuses are available for use on systems up to 132 kV, and used largely for protecting voltage transformers.

0.3 This standard (Part II) forms part of a series of specifications on high voltage fuses and hence shall be used in conjunction with the other parts. Requirements and tests for all types of high voltage current limiting fuses for use outdoors and indoors and covered in Part I of this series. It is intended to cover in a subsequent part suitable guidelines for the application of high voltage current limiting fuses, expulsion fuses and similar fuses.

0.4 This standard (Part II) supersedes IS : 5792-1970*. In addition to updating the provisions, stipulated in the earlier version, in respect of insulation levels, details of test methods, etc, this standard aligns in presentation with the series of international standards on HV fuses.

0.5 As compared to earlier practices, this standard specifies two levels (Level 1 and Level 2) of severity of impulse withstand voltages. Specific guidelines on the applicability and choice of these values are provided in Part III of this standard.

0.6 In the preparation of this standard (Part II) considerable assistance has been derived from, IEC Pub 282-2 (1970) 'High voltage fuses : Part II Expulsion and similar fuses' published by the International Electrotechnical Commission.

0.7 In order to facilitate comparison with the international standards and for ease of reference, the Committee has decided to add in the form of an

*Specification for high voltage expulsion fuses and similar fuses.

Appendix, the major differences between this Indian Standard and the corresponding IEC Publication (s) (*see* Appendix A).

0.8 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part II) applies to high voltage expulsion fuses and similar fuses; in which the arc is extinguished by the expulsion effect of the gases produced by the arc, designed for use outdoors or indoors on alternating current systems of 50 Hz of rated voltages exceeding 1 000 V.

1.2 The classes of fuses covered by this standard are specified in **3**.

1.3 Fuses designed for the protection of single capacitor units within multi-unit capacitor banks may have to conform to additional requirements other than those specified in this standard (*see* IS : 9402-1980†).

1.4 Fuses complying to this standard are to be operated under the normal conditions of service as detailed in Appendix A of Part I of this standard.

2. TERMINOLOGY

2.0 For the purposes of this standard, the following definitions in addition to those given in IS : 1885 (Part XVII)-1969‡ shall apply.

2.1 Electrical Characteristics

2.1.1 *Rating* — General term employed to designate the characteristic values that together define the working conditions upon which the tests are based and for which the equipment is designed.

NOTE — Examples of rated values usually stated for fuses : voltage, current, breaking capacity.

2.1.2 *Pre-arcing Time* (*Melting Time*) — The time between the commencement of a current large enough to cause a break in the fuse-elements and the instant when an arc is initiated.

*Rules for rounding off numerical values (*revised*).

†Specification for high voltage fuses for external protection of shunt power capacitors.

‡Electrotechnical vocabulary : Part XVII Switchgear and controlgear.

2.1.3 *Arcing Time* — The interval of time between the instant of the initiation of the arc and the instant of final arc extinction.

2.1.4 *Operating Time* (*Total Clearing Time*) — The sum of the pre-arcing time and the arcing time.

2.1.5 *Joule Integral* (I^2t) — The integral of the square of the current over a given time interval : $I^2t = \int_{t_0}^{t_1} i^2 dt$.

NOTE 1 — When considered from the point of view of the circuit protected by a fuse, the value of the Joule integral over the operating time of the fuse is referred to a specific energy that is the energy released as heat in 1 Ω of circuit resistance.

NOTE 2 — The values of the Joule integral usually stated for fuse-links are : pre-arcing Joule integral and operating Joule integral extended over the pre-arcing time and the operating time respectively.

2.1.6 *Virtual Time* — The value of the Joule integral divided by the square of the value of the prospective current.

NOTE — The values of virtual times usually stated for a fuse-link are the values of pre-arcing time and operating time.

2.1.7 *Time/Current Characteristics* — A curve giving the virtual time as a function of the rms value of the symmetrical component of the prospective current under stated conditions of operation.

NOTE — Time/current characteristics usually stated for a fuse-link are referred to the pre-arcing time and the operating time.

2.1.8 *Recovery Voltage* — The voltage which appears across the terminals of a pole of a switching device after the breaking of the current.

NOTE — This voltage may be considered in two successive intervals of time, one during which a transient recovery voltage exists, followed by a second one during which the power-frequency recovery voltage (*see* **2.1.8.2**) alone exists.

2.1.8.1 *Transient recovery voltage* — The recovery voltage during the time in which it has a significant transient character.

NOTE — The transient recovery voltage may be oscillatory or non-oscillatory or a combination of these, depending on the characteristics of the circuit and the switching device. It includes the voltage shift of the neutral of a polyphase circuit.

2.1.8.2 *Power-frequency recovery voltage* — The recovery voltage after the transient voltage phenomena have subsided.

2.2 Fuses and Their Component Parts

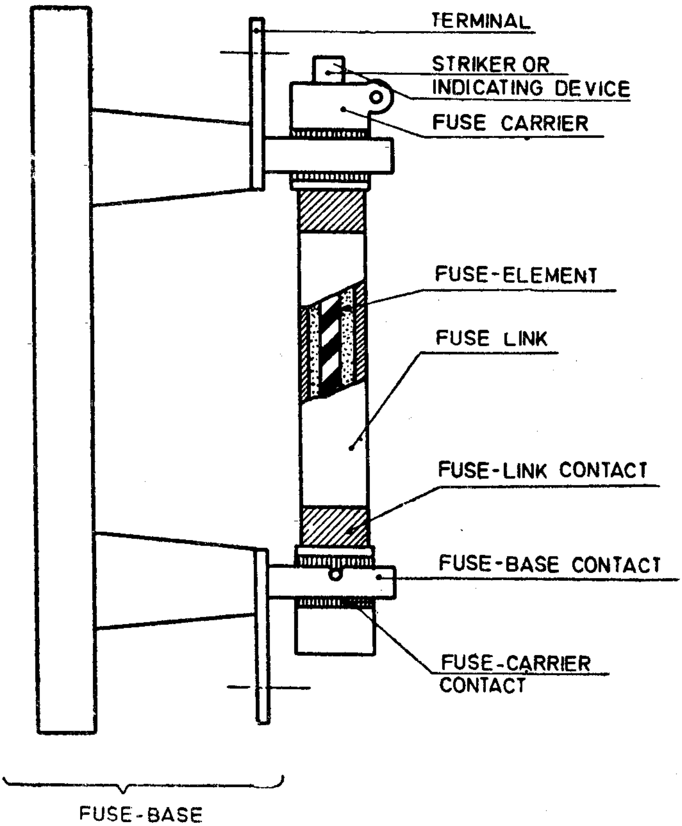
2.2.1 *Fuse* — A switching device that, by the fusion of one or more of its specially designed and proportioned components, opens the circuit in which it is inserted and breaks the current when it exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete switching device.

2.2.2 *Fuse-Base* (*Fuse-Mount*) — The fixed part of a fuse provided with terminals for connection to the external circuit. The fuse-base comprises all the parts necessary for insulation (*see* Fig. 1).

2.2.3 *Fuse-Base Contact* (*Fuse-Mount Contact*) — A conducting part of a fuse-base, connected to a terminal and intended to engage with a fuse-carrier contact or with a fuse-link contact (*see* Fig. 1).

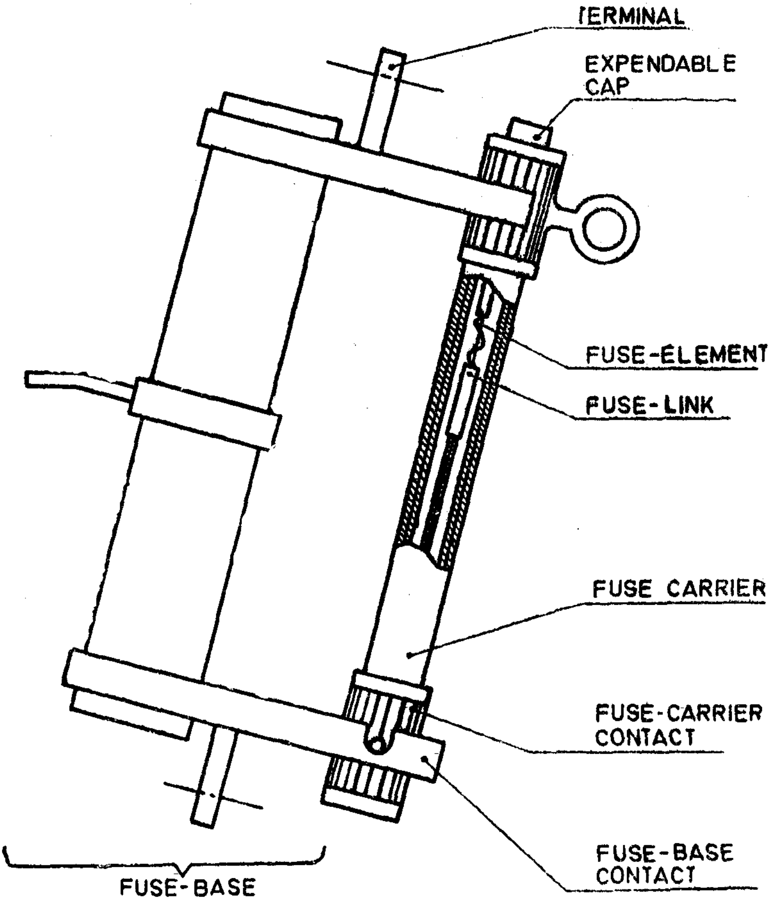
2.2.4 *Fuse-Carrier* — The movable part of a fuse designed to carry the fuse-link. The fuse-carrier does not include the fuse-link (*see* Fig. 1).

2.2.5 *Fuse-Carrier Contact* — A conducting part of a fuse-carrier connected to a fuse-link contact and intended to engage with a fuse-base contact (*see* Fig. 1).



1A (Class I Fuse)

FIG. 1 EXPULSION AND SIMILAR FUSE — *Contd*



IB (Class 2 Fuse)

FIG. 1 EXPULSION AND SIMILAR FUSE

2.2.6 *Fuse-Link* (*Fuse-Unit*) — A part of a fuse including the fuse-elements which requires replacement by a new fuse-link after the fuse has operated and before the fuse is put back into service (*see* Fig. 1).

2.2.7 *Fuse-Link Contact* — A conducting part of a fuse-link intended to engage with a fuse-base contact or with a fuse-carrier contact (*see* Fig. 1).

2.2.8 *Fuse-Element* — A part of a fuse designed to melt when the fuse operates (*see* Fig. 1).

2.2.9 *Indicating Device (Indicator)* — A device which is provided to indicate at the fuse whether the fuse has operated (*see* Fig. 1).

2.2.10 *Striker* — A mechanical device which is a part of a fuse and which operates during the fuse-operation satisfying specified requirements with respect to its force and travel. A striker may be used for the purpose of signalling, indicating and/or tripping other apparatus (*see* Fig. 1).

2.2.11 *Expendable Cap* — Replacement part or assembly for closing one end of the fuse-carrier. It includes a pressure-responsive section that opens to relieve the pressure within the fuse-carrier when a predetermined value is exceeded during breaking of the circuit (*see* Fig. 1).

2.2.12 *Refill-Unit* — A set of replacement parts sufficient to restore a fuse-link to its original condition after an operation.

2.2.13 *Renewable Fuse-Link* — A fuse-link that, after operation may be restored for service by a refill-unit.

2.3 Additional Terms

2.3.1 *Expulsion Fuse* — A fuse in which the arc is extinguished by expulsion of gases produced by the arc.

2.3.2 *Isolating Distance (for a Fuse)* — The shortest distance between the fuse-base contacts or any conducting parts connected thereto, measured on a fuse with the fuse-link or fuse-carrier:

a) in the disconnected position for disconnector fuses,

b) in the drop-out position for drop-out fuses, and

c) removed for other than disconnector or drop-out fuses.

2.3.3 *Disconnector Fuse* — Fuse in which the fuse-carrier can be manipulated to provide an isolating distance.

2.3.4 *Drop-Out Fuse* — A fuse in which the fuse-carrier drops into a position to provide an isolating distance after the fuse has operated.

2.3.5 *Homogeneous Design of Expulsion and Similar Fuses* — A homogeneous design of expulsion fuse or similar fuse comprises fuses that have the same physical dimensions, construction and materials for a given voltage rating and a given breaking capacity. The design shall be capable of using a range of fuse-links to achieve different current ratings; only the physical dimensions, construction and materials of the fuse-elements may be changed.

3. CLASSES OF FUSES

3.1 Expulsion and similar fuses are divided into two classes as given below.

3.1.1 *Class 1* — Fuses of class 1 are generally characterised by :

a) insulation level or dielectric properties equal to that of disconnectors,

b) higher breaking capacities than class 2 fuses, and

c) Higher maximum rated currents than class 2 fuses.

3.1.2 *Class 2* — Fuses of class 2 are generally characterised by :

a) Insulation level or dielectric properties less than that of disconnectors, and

b) use of replaceable fuse-links.

NOTE — Specific information as to the selection of fuse-class are provided in Part III of this specification.

4. RATINGS AND CHARACTERISTICS

4.0 List of Ratings and Characteristics

4.0.1 *Ratings*

a) *Rating of the fuse*
   1) Rated voltage (**4.1**);
   2) Rated current (**4.2**);
   3) Rated breaking capacity (**4.3**); and
   4) Rated frequency (**4.4**).

b) *Ratings of the fuse-base*
   1) Rated voltage (**4.1**);
   2) Rated maximum current (**4.2**); and
   3) Insulation level (power-frequency, dry, wet and impulse withstand voltages) (**4.5**).

c) *Ratings of the fuse-carrier*
   1) Rated voltage (**4.1**);
   2) Maximum current or range (**4.3**);
   3) Rated breaking capacity (**4.3**); and
   4) Rated frequency (**4.4**).

d) *Ratings of the fuse-link*
   1) Rated current (**4.3**); and
   2) Maximum voltage (**4.1**).

4.0.2 *Characteristics*

a) *Characteristics of the fuse*

1) Temperature-rise limits (**4.6**) ; and

2) Class (**3.1**).

b) *Characteristics of the fuse-link*

1) Time/current characteristics (**4.7**); and

2) Class (**3.1**).

4.1 Rated Voltage — A voltage used in the designation of the fuse-base or fuse-link from which the test conditions are determined.

NOTE — This rated voltage is equal to the highest voltage for the equipment.

4.1.1 The rated voltage shall be selected from the following values :

3·6, 7·2, 12, 24, 36, 72·5, and 145 kV.

These correspond to highest system voltage.

4.2 Rated Current of the Fuse-Base — The current assigned to a fuse-base that a new clean fuse-base will carry continuously without exceeding specified temperature-rises when equipped with a fuse-link of the same current-rating designed to be use in the particular fuse-base connected to the circuit with certain specified conductor sizes and lengths, at an ambient temperature of not more than 40°C.

The standard values of the rated current in amperes of the fuse-base are :

50, 100, 200 and 400 A.

4.3 Rated Current in Amperes and Rated Breaking Current of the Fuse-Link in Kiloamperes — The current assigned to the fuse-link that a new clean fuse-link will carry continuously without exceeding specified temperature-rises when mounted on a fuse-base specified by the manufacturers and connected to the circuit with specified conductor sizes and lengths at an ambient temperature not exceeding 40°C.

The rated breaking current is the value of the breaking capacity specified for a fuse.

4.3.1 The rated current and the rated breaking current shall be selected from the R10 series (*see* IS : 1076-1966*).

4.4 Rated Frequency — The frequency for which the fuse has been designed and to which the values of the other characteristics correspond. Standard value of rated frequency is 50 Hz.

*Preferred numbers (*first revision*).

4.5 Rated Insulation Level (of a Fuse-Base) — The voltage values (both power frequency and impulse) which characterize the insulation of the fuse-base with regard to its capability of withstanding the dielectric stresses.

The insulation level (power frequency, dry, wet and impulse withstand) of a fuse-base shall be selected from the values given in Table 1 of Part I of this standard.

NOTE — It shall be stated whether the fuse is suitable for indoor service only.

4.6 Temperature-Rise Limits — The fuse shall be able to carry continuously the rated current without exceeding the limits of temperature rise given in Table 1.

TABLE 1 LIMITS OF TEMPERATURE AND TEMPERATURE-RISE FOR MATERIALS AND PARTS

NATURE OF MATERIALS OR OF ELEMENTS	MAXIMUM VALUE	
	Temperature	Temperature-Rise
(1)	(2)	(3)
	°C	°C
Copper contacts in air:		
a) Not silver-faced	75	35
b) Silver-faced (*see* Note 1)	105 (*see* Note 2)	65 (*see* Note 2)
Terminals	90	50
Metal parts acting as springs	(*see* Note 3)	
Insulating materials or metal parts in contact with insulating materials of the following classes:		
Class A	105	65
E	120	30
B	130	90
F	155	115
H	180	140
C	(*see* Note 4)	

NOTE 1 — If the manufacturer uses other materials than those indicated above, such as nickel, cadmium, etc, the properties of these materials shall be taken into consideration.

NOTE 2 — Providing it does not cause damage to surrounding parts.

NOTE 3 — The temperature shall not reach such a value that the elasticity of the metal is changed.

NOTE 4 — Limited only by the requirement not to cause any damage to surrounding parts.

4.7 Time/Current Characteristics — The manufacturer shall make available curves from the data determined by the time/current characteristic type-tests specified in **7.6.2**.

The time/current characteristics shall be presented with current as abscissa and time as ordinate.

Logarithmic scales shall be used on both coordinate axes.

The basis of the logarithmic scales (the dimensions of one decade) shall be in the ratio 2/1 with the longer dimension on the abscissa.

When the ratio of 2/1 is used, representation shall be on size A3 or A4 paper.

The dimensions of the decades shall be selected from the following series:

2, 4, 8 and 16 cm, and

2·8, *5·6* and 11·2 cm

NOTE — It is preferred that wherever possible the values given in italics shall be used.

The curves shall show:

a) the pre-arcing time or the operating time;

b) the relation between the time and the rms symmetrical prospective current;

c) the basis of time (*see* **7.6.2.4**);

d) if the curve represents minimum values of time and current, the actual points established by tests shall lie within a distance corresponding to 20 percent maximum on the scale to the right of the curve. If the curve represents average values of time and current, the actual points established by tests shall lie within a distance corresponding to 10 percent maximum on the current scale on either side of the curve. Tolerances apply in range 0·1 second to 600 seconds for pre-arcing time;

e) the type and rating of the fuse-link to which the curve applies; and

f) the time range as specified in **7.6.2.2**.

5. STANDARD CONDITIONS OF USE AND BEHAVIOUR

5.0 General — When used in systems with voltages less than the rated voltage of the fuse, the breaking capacity in kiloamperes in not less than the rated breaking capacity.

No tests have been specified to prove the performance of the fuse in the range of currents below that specified in the breaking tests in **7.5** with respect to its capability to withstand the current of every possible time/current combination without deterioration leading to either premature operation or failure.

5.1 Standard Conditions of Use with Respect to Breaking Capacity — Fuses shall be capable of breaking correctly any value of prospective current, irrespective of the possible dc component, provided that:

a) the ac component is not higher than the rated breaking capacity and not less than the values demonstrated by the tests specified in Tables 3 and 4;

b) the natural frequencies and inherent peak recovery voltages, when specified, are within the limits specified in Tables 3 and 4;

c) the recovery voltage is not higher than the recovery voltage, specified in Tables 3 and 4 (for special conditions, *see* Part III of this standard);

d) the frequency is between 48 Hz and 52 Hz; and

e) the power factor is not lower than that represented by the tests specified in Tables 3 and 4.

5.2 Standard Conditions of Behaviour with Respect to Breaking Capacity — According to the conditions of use indicated in **5.1** the behaviour of the fuse shall be as follows:

a) Flashover to earth shall not occur during operation when mounted in accordance with the recommendations of the manufacturer.

b) After the fuse has operated, the components of the fuse, apart from those intended to be replaced after each operation, shall be in substantially the same condition as at the beginning of the test except for the erosion of the bore of the fuse tube. The fuse, after renewal of the components intended to be replaced after each operation, shall be capable of carrying rated current continuously at rated voltage.

   For non-renewable fuses, it shall be possible to remove the fuse-unit in one piece after the operation.

   However, it is permissible for the components designed to secure the fuse-link in renewable fuses to be slightly damaged, providing that such damage is not likely to prevent the replacement of the melted fuse-element, to decrease the breaking capacity of the fuse, to modify its operating characteristics, or to increase its temperature-rise in normal service.

c) After operation, the fuse shall be capable of withstanding the power-frequency recovery voltage across its terminals. When a drop-out has operated, it also shall provide the dielectric properties specified in Table 1 of Part I of this standard.

5.3 Time/Current Characteristics — The time/current characteristics of fuse-links are based on applying current to a new and unloaded fuse-link in a fuse-base specified by the manufacturer and connected to the test-circuit with conductor sizes and lengths as specified in **7.4**.

The manufacturer shall specify the temperature for which the time/current characteristics apply. Unless otherwise specified, the time/current characteristics shall be deemed to apply at an ambient air temperature of $27 \pm 2°C$.

6. MARKING

6.0 The markings which shall be in indelibly made on fuse-links, fuse-carriers and fuse-bases are given below:

The figures representing ratings shall in all cases be followed by the symbol of the unit in which they are expressed.

6.1 On the Fuse-Base:

a) Manufacturer's name or trade-mark,
b) Manufacturer's type designation (if any),
c) Class designation,
d) Rated voltage, and
e) Rated maximum current.

6.2 On the Fuse-Carrier

a) Manufacturer's name or trade-mark,
b) Rated voltage,
c) Rated maximum current or range of rated currents,
d) Rated breaking capacity, and
e) Rated frequency.

6.3 On the Fuse-Link

a) Manufacturer's name or trade-mark,
b) Manufacturer's type designation (if any),
c) Rated current, and
d) Rated voltage (if any).

6.4 It shall also be indicated if the fuse is designed for indoor service only.

6.5 Fuses may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

7. TESTS

7.0 The general conditions for tests as specified in **6.0** of Part I of this standard shall apply.

7.1 List of Type Tests

7.1.1 The type tests to be conducted upon completion of a design or following a change that effects the performance are as given below:

a) Dielectric tests (**7.3**);
b) Temperature-rise tests (**7.4**);
c) Breaking tests (**7.5**); and
d) Tests for time/current characteristics (**7.6**).

7.1.1.1 The results of all type tests shall be recorded in type test reports containing the data necessary to prove compliance with this standard.

7.2 Common Test Practices for all Type Tests — The following shall be common test practices, unless otherwise specified :

a) The device shall be new, clean and in good condition; and
b) The fuse to be tested shall be mounted on a rigid structure in the normal service position for which it is designed, with the mounting metal parts earthed. The connection shall be so positioned that the normal electrical clearances are not reduced.

7.3 Dielectric Tests

7.3.1 *Test Practices*

7.3.1.1 *Mounting* — For multi-pole arrangements of fuses, and when the distance between fuses is not fixed by their construction, it is necessary, for test purposes to provide the minimum distance between poles as specified by the manufacturer.

7.3.1.2 *Electrical connections* — Electrical connections shall be made by means of bare conductors connected to each terminal. These conductors shall project from the terminals of the fuse in substantially a straight line parallel to the fuse-link for an unsupported distance of at least the isolating distance of the fuse.

7.3.2 *Application of Test Voltage for Impulse and Power-Frequency Tests* — The test voltage specified in **4.5** for the fuse under test shall be applied successively with one terminal of the output of the impulse generator or one point of the power-frequency source, connected to earth.

a) Between the terminals and all earthable metal parts :

   1) With the fuse including the fuse-link and its fuse-carrier completely assembled ready for service, and

   2) with the fuse-link and its fuse-carrier removed.

   Note — For multi-pole arrangements of fuses :

   1) Between all live parts of all poles connected together and the earthable metal parts.

   2) Between the terminals of each pole and the earthable metal parts with all the live parts of the other poles connected to the earthable metal parts.

b) Between terminals :

   a) for drop-out fuses the fuse-carrier shall be in the drop out position;

   b) for disconnector fuses the fuse-carrier shall be in the open position; and

   c) for other types, the fuse-carrier or the fuse-link shall be removed from the fuse-base.

The earthable metal parts shall be insulated from earth for impulse tests and insulated from earth or connected to the mid-point of the source for power-frequency tests.

Note — For multi-pole arrangements of fuses, the terminals of one side shall be connected together and the terminals of the opposite side shall be connected together.

7.3.3 *Atmospheric Conditions During Tests* — The tests shall be made at atmospheric conditions as near as possible to the standard conditions specified in IS : 2071 (Part II)-1974*.

The correction factors for air density and for humidity are as given in IS : 2071 (Part II)-1974*.

7.3.4 *Test Voltages* — The test voltages to be used for the tests shall be in accordance with those given in Table 1 of Part I of this standard.

7.3.5 *Lightning Impulse Voltage Dry Tests* — Fuses shall be subjected to lightning impulse voltage dry tests with 1·2/50 impulses in accordance with IS : 2071 (Part II)-1974*.

Fifteen consecutive impulses at the rated lightning impulse withstand voltages specified in Table 1 of Part I of this standard.

a) at the rated withstand voltage to earth and between poles for all the test conditions (a) of **7.3.2** ;

*Methods of high voltage testing: Part II Test procedures (*first revision*).

b) at the rated withstand voltage to earth and between poles for the test condition (b) of **7.3.2** if isolating properties are not assigned to the fuse-base; and

c) at the rated withstand voltage across the isolating distance for the test condition (b) of **7.3.2** if isolating properties are assigned to the fuse-base.

The fuse shall be considered to have passed the test successfully if the number of disruptive discharges to earth, between poles or between terminals on self-restoring insulation, does not exceed two for each test condition and if no disruptive discharge on non-self-restoring insulation occurs.

The fuse shall be capable of passing the specified tests with voltages of both positive and negative polarity, but where there is evidence as to which polarity will give the lower breakdown voltage, it shall suffice to test that polarity only.

7.3.6 *Power-Frequency Voltage Dry Tests* — Fuses shall be subjected to one-minute power-frequency voltage dry tests, as specified in IS : 2071 (Part II)-1974*.

The test circuit (transformer with voltage regulating device) shall have a short-circuit current of at least 0·2 A. It is permissible to check the magnitude of the current at approximately one-tenth of the specified voltage.

The values for the rated one-minute power-frequency withstand voltage tests are specified in Table 1 of Part I of this standard. The tests shall be made at the following values:

a) At the rated withstand voltage to earth and between poles for all the test conditions (a) of **7.3.2**;

b) At the rated withstand voltage to earth and between poles for the test condition (b) of **7.3.2** is isolating properties are not assigned to the fuse-base; and

c) At the rated withstand voltage across the isolating distance for the test condition (b) of **7.3.2** if isolating properties are assigned to to the fuse-base.

If flashover or puncture occurs, the fuse shall be considered to have failed the test.

7.3.7 *Power-Frequency Wet Tests* — Outdoor type fuses shall be subjected to power-frequency voltage wet tests under the same conditions as specified in **7.3.6** except for the duration which is 1 minute. However, if a disruptive discharge on external self-restoring insulation occurs, this test

*Methods of high voltage testing : Part II Test procedures (*first revision*).

shall be repeated with the same test conditions and the fuse shall be considered to have passed this test successfully if no further disruptive discharge occurs.

During these tests, the fuses shall be subjected to artificial rain at an angle of 45° to the vertical the test procedure being in accordance with IS : 2071 (Part I)-1974*.

7.4 Temperature-Rise Tests

7.4.1 *Test Practices*

7.4.1.1 *Test sample* — All components of the fuse being tested shall be as specified by the manufacturer.

The fuse-link shall be of the highest current-rating for use in the fuse-base.

7.4.1.2 *Arrangements of the equipment* — The test shall be made in a closed room substantially free from air currents except those generated by heat from the device being tested.

The fuse shall be mounted in the most unfavourable position within the directions specified by the manufacturer and connected to the test circuit by bare copper conductors as follows : each conductor shall be approximately 1 m long, mounted in a place parallel to the mounting surface of the fuse but they may be in any direction this plane. The sizes of the leads shall be given in Table 2.

NOTE — Depending on the value of the test currents aluminium conductors of appropriate sizes in the place of bare copper conductors may also be used, for the purposes of temperature-rise tests. For details of standard cross-sections of aluminium conductors, *see* Tables 4 and 7 of IS : 9224 (Part I)-1979†.

TABLE 2 SIZES OF CONDUCTORS FOR TEMPERATURE-RISE TESTS

(*Clause* 7.4.1.2)

CURRENT RATING OF THE FUSE	SIZE OF BARE COPPER CONDUCTOR	
	Class 1	Class 2
(1)	(2)	(3)
A	mm²	mm²
$I_n \leqslant 50$	From 40 to 60	From 10 to 15
$50 < I_n \leqslant 100$	From 120 to 160	From 40 to 45
$100 < I_n \leqslant 200$	From 120 to 160	From 100 to 110
$200 < I_n \leqslant 400$	From 250 to 350	From 250 to 350

NOTE — The equivalent area is MCM (one thousand circular mils) can be obtained by multiplying the value in mm² by 2.

*Methods of high voltage testing : Part 1 General definitions and test requirements (*first revision*).

†Specification for low voltage fuses : Part I General requirements.

Normal clearances need not be provided.

Tests shall be made with the rated current of the fuse-line and at a frequency between 48 Hz and 52 Hz. Each test shall be made over a period of time sufficient for the temperature-rise to reach a constant value (for practical purposes this condition is regarded as being obtained when the variation does not exceed 1°C per hour).

The temperature-rise of the various parts of the fuse shall not exceed the specified values in **4.6** at an ambient air temperature not less than 10°C and not more than 40°C during the test. No correction shall be applied to any ambient air temperature within this range.

7.4.2 *Measurement of Temperature* — All reasonable precautions shall be taken to reduce the variations and the errors due to the time lag between the temperature of the fuse and the variations in the ambient air temperature.

7.4.2.1 *Temperature of fuse parts* — The temperature of the various parts for which limits are specified shall be determined by devices such as thermocouples, thermometers, or contact elements located and secured to provide good heat conduction at the hottest accessible spot.

The bulbs of thermometers shall be suitably protected against cooling from the outside. The protected area shall be negligible compared with the cooling area of the part to which the thermometer is secured.

7.4.2.2 *Ambient air temperature* — The ambient air temperature is the average temperature of the air surrounding the fuse or its elements. It shall be measured during the last quarter of the test period by means of thermocouples or thermometers at a distance of approximately 1 m from the fuse. It is permissible to use an additional fuse of the same construction as the fuse under test or an oil cup or any other suitable means for the determination of ambient air temperature.

7.5 Breaking Tests

7.5.1 *Test Practices*

7.5.1.1 *Description of tests to be made* — Tests shall be made in accordance with the instructions given in Tables 3 and 4 and shall include five test series.

Series 1 : Verification of the rated breaking capacity I.

Series 2 and 3 : Verification of breaking capacity in the following two ranges of fault currents :

Series 2 : from 0·7 I to 0·8 I ;

Series 3 : from 0·2 I to 0·3 I.

Series 4 and 5 : Verification of breaking capacity when the fuse is required to operate at comparatively low fault currents :

Series 4 : from 400 A to 500 A ;

Series 5 : from 2·7 I_n to 3·3 I_n with a minimum of 15 A, I_n being the rated current of the fuse-link.

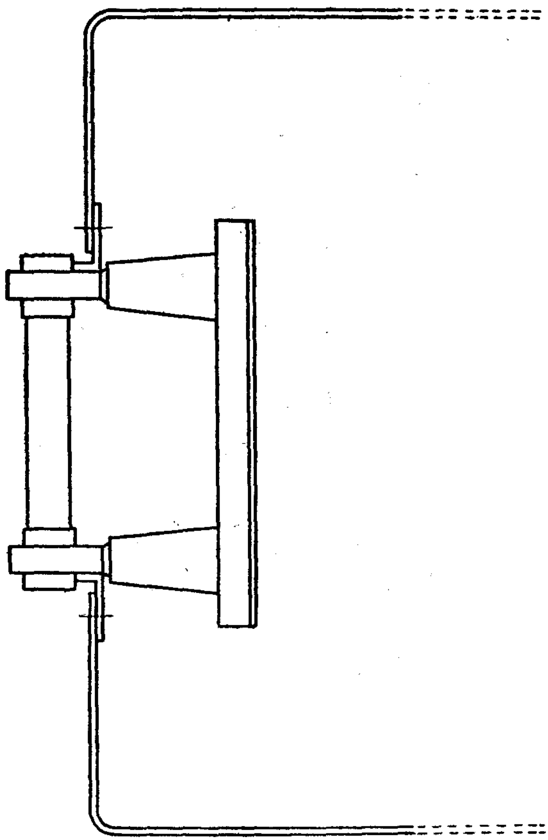
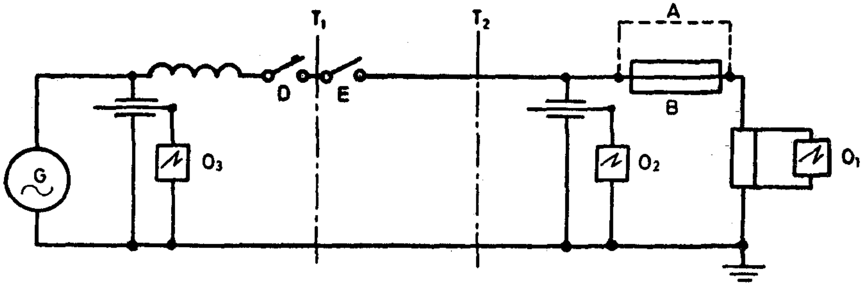


FIG. 2 BREAKING TESTS — ARRANGEMENT OF THE EQUIPMENT

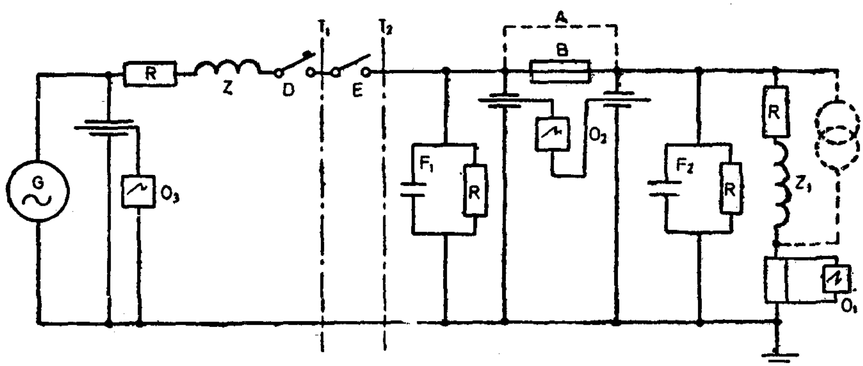
7.5.1.2 *Characteristics of the test circuit* — The breaking tests shall be made with single-phase alternating current.

The circuit elements used to control the current and power-factor shall be in series arrangement, as shown in Fig. 3A and 3B.

The test circuit frequency shall be between 45 Hz and 52 Hz.



3A Circuit Diagram for Test Series 1-2-3



3B Circuit Diagram for Test Series 4 and 5

FIG. 3 TYPICAL CIRCUIT DIAGRAM FOR BREAKING TEST

The characteristics of the test-circuit are specified in Tables 3 and 4.

7.5.1.3 *Test samples* — All components of the fuse being tested shall be as specified by the manufacturer.

In making tests within a series of renewable fuses, only the fuse-elements, refill units and parts normally replaceable shall be replaced. A new fuse-carrier shall be used as specified in Tables 3 and 4.

7.5.1.4 *Arrangement of the equipment* — For test series 1 and 2, the positioning of the conductors shall be as shown in Fig. 2, to produce electromagnetic forces which may occur in service. To prevent any movement of the conductors from causing excessive mechanical stresses on the fuse-base, the conductors shall be securely fastened at a distance equal to the insulator height if this height exceeds 0·50 m or at 0·50 m if the insulator height does not exceed 0·50 m.

NOTE — For testing of fuses rated above 40 kV alternative arrangements may be used.

On both sides of the fuse under test, a metal screen connected to earth shall be placed at a distance from the fuse equal to one half of the pole spacing specified by the manufacturer. In addition, a metal screen or screens connected to earth shall be placed in a path or paths of discharge at a distance specified by the manufacturer. The connection between the screens and earth shall be made by a resistor and a fine-wire to detect any current to earth.

The fine-wire fuse shall consist of a wire, approximately 0·1 mm in diameter, of copper-nickel alloy of a resistivity of approximately $40 \mu \Omega$/cm, and shall be approximately 100 mm in length, freely stretched in space. The resistor in series with the fine-wire fuse shall have a value such that the current set up in it when flashover occurs is approximately 10 A.

7.5.2 *Test Procedure*

7.5.2.1 *Calibration of the test circuit* — The fuse or the fuse-link under test shall be replaced by a link of negligible impedance compared with that of the test circuit, as shown in Fig. 3A and 3B.

The circuit shall be adjusted to give the specified prospective current. This shall be verified by an oscillographic record.

7.5.2.2 *Test method* — The link *A* is removed and replaced by the fuse or the fuse-link *B* under test.

The making switch *E* is closed at such an instant as to provide the conditions specified in Tables 3 and 4.

After the fuse has operated, the test voltage shall be maintained across the fuse for the following periods:

Drop-out fuses 0·5 seconds

Non-drop-out fuses 15 seconds

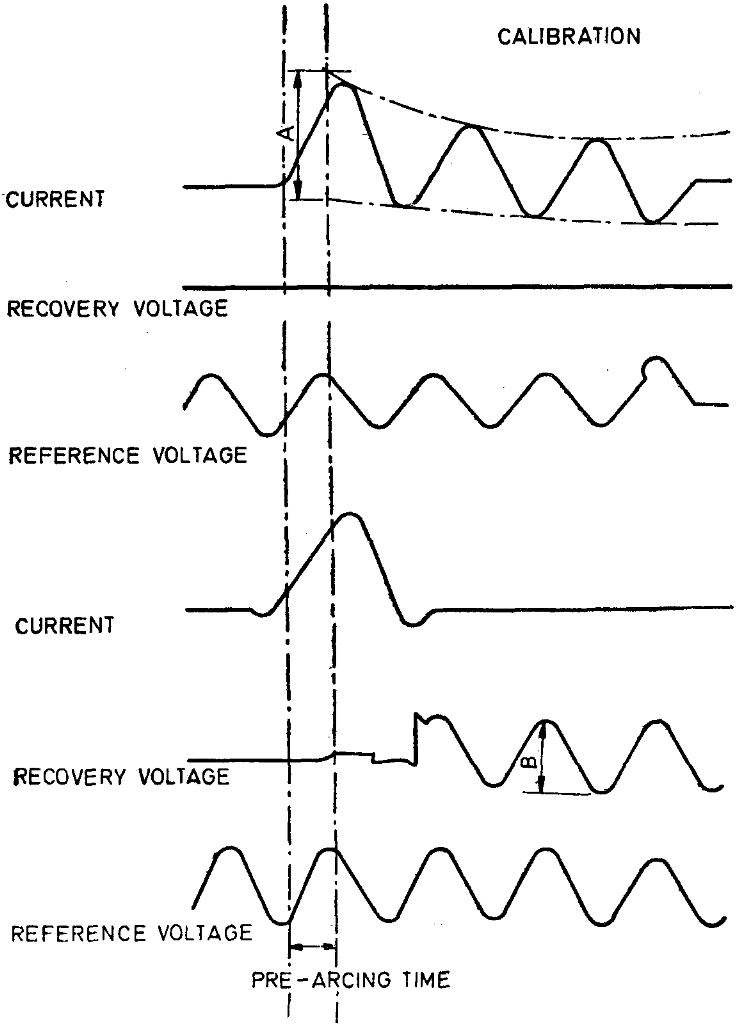
NOTE — During this period, the power frequency may be lower than the specified minimum value.

7.5.2.3 *Interpretation of oscillograms* (*see Fig. 4*) — For all series the prospective breaking current shall be the rms symmetrical current measured approximately at the end of the pre-arcing time.

The value of the power-frequency recovery voltage is measured between the peak of the second non-influenced half-wave and the straight line drawn between the peaks of the preceding and following half-waves.

7.5.2.4 *Parameters to be used for tests* — The parameters to be used when making the tests are given in Tables 3 and 4.

7.5.2.5 *Interpretation of breaking tests for fuses of homogeneous design* — When the minimum and maximum current ratings of fuses of a



RMS value of the ac component of prospective breaking current

$$I = \frac{A}{2\sqrt{2}}$$

Recovery voltage $U = \dfrac{B}{2\sqrt{2}}$

FIG. 4 BREAKING TESTS — INTERPRETATION OF OSCILLOGRAMS homogeneous design perform satisfactorily on the breaking tests specified in Tables 3 and 4, other current ratings within this range of ratings shall be deemed to meet this specification.

If fuses do not perform satisfactorily on one or more test series, such failure does not entail, as specified in **5.2** the rejection fuses of the same design in other current ratings.

A current rating or ratings of fuse-links that do not perform satisfactorily on the breaking tests specified in Tables 3 and 4 shall be rejected. If that current rating or group of current ratings within the original homogeneous design are redesigned, they shall perform satisfactorily in accordance with Tables 3 and 4 to meet the specification and may constitute a new homogeneous design.

TABLE 3 NATURAL FREQUENCIES FOR BREAKING TESTS

(*Clauses* 5.1, 7.5.1 and 7.5.2)

RATED VOLTAGES (kV)	NATURAL FREQUENCIES, kHz	
(1)	(2)	(3)
3·6	7·0	8·5
7·2	3·8	4·7
12	2·8	3·2
24	1·8	2·1
36	1·5	1·6
72·5	—	1·0
145	—	0·7

7.6 Tests for Time/Current Characteristics

7.6.1 *Test Practices*

7.6.1.1 *Ambient air temperature* — The time/current characteristics shall be verified at any ambient air temperature between 22°C and 37°C.

At the beginning of each test, the fuse shall he approximately at ambient air temperature.

7.6.1.2 *Arrangement of the equipment* — The ɜsts shall be made on a single-pole fuse and with the same arrangement of the equipment as for the temperature-rise tests (**7.4.1**) or for the breaking tests (**7.5.1.4**) (*see* **7.6.2.1**).

In particular :

a) the fuse-base shall be as specified by the manufacturer of the fuse-link being tested,

b) the size and the length of conductors connected to the terminals shall be as specified in **7.4.1**.

TABLE 4 PARAMETERS FOR BREAKING TESTS

(*Clauses* 5.1, 7.5.1 *and* 7.5.2)

<table>
<tr><th rowspan="2">Parameters</th><th rowspan="2">Class</th><th colspan="8">Test Series</th></tr>
<tr><th colspan="2">Series 1</th><th colspan="2">Series 2</th><th colspan="2">Series 3</th><th>Series 4</th><th>Series 5</th></tr>
<tr><td>Power-frequency recovery voltage</td><td>1 and 2</td><td colspan="8">Rated voltage $^{+5}_{0}$ percent</td></tr>
<tr><td rowspan="2">Natural frequency of transient recovery voltage (see Note 3)</td><td>1</td><td colspan="6">Column (3) of Table 3</td><td rowspan="4">Under consideration</td><td rowspan="4">Not applicable</td></tr>
<tr><td>2</td><td colspan="6">Column (2) of Table 3</td></tr>
<tr><td rowspan="2">Amplitude factor (see Note 3)</td><td>1</td><td colspan="6">From 1·4 to 1·5</td></tr>
<tr><td>2</td><td colspan="6">From 1·3 to 1·4</td></tr>
<tr><td>RMS symmetrical value of prospective current</td><td>1 and 2</td><td colspan="2">$I^{+5\%}_{0}$</td><td colspan="2">From 0·7 I to 0·8 I</td><td colspan="2">From 0·2 I to 0·3 I</td><td>From 400 A to 500 A (see Notes 1 and 2)</td><td>From 2·7 I_n to 3·3 I_n with a minimum of 15 A (see Note 1)</td></tr>
<tr><td rowspan="2">Power-factor</td><td>1</td><td colspan="6">Lower than 0·10</td><td>From 0·3 to 0·5</td><td>From 0·6 to 0·8</td></tr>
<tr><td>2</td><td colspan="6">Lower than 0·15</td><td>From 0·3 to 0·5</td><td>From 0·6 to 0·8</td></tr>
<tr><td>Making angle related to voltage zero (degrees)</td><td>1 and 2</td><td colspan="2">1st test : −5 to + 15
2nd test : 85 to 105
3rd test : 130 to 150</td><td colspan="2">1st test : −5 to + 15
2nd test : 85 to 105</td><td colspan="2">For all tests from 85 to 105</td><td colspan="2">Random timing</td></tr>
<tr><td>Current rating of fuse-links</td><td>1 and 2</td><td>Min</td><td>Max</td><td>Min</td><td>Max</td><td>Min</td><td>Max</td><td>Min</td><td>Max</td></tr>
<tr><td>Number of tests</td><td>1 and 2</td><td>3</td><td>3</td><td>2</td><td>2</td><td>1</td><td>1</td><td>2</td><td>2</td></tr>
<tr><td>Number of fuse-links to be tested for each fuse-carrier</td><td>1 and 2</td><td>3</td><td>3</td><td colspan="2">4</td><td colspan="2">2</td><td colspan="2">4</td></tr>
</table>

NOTE 1 — If the test involves an operating time appreciably higher than 2 seconds, the test shall be made with a higher current to obtain an operating time of approximately 2 seconds.

NOTE 2 — If the values are lower than those of series 5, test series 5 need not be made.

NOTE 3 — It is expected that service natural frequencies and amplitude factors will usually not exceed the specified values. For special cases, *see* Part III of this standard.

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7.6.2 *Test Procedure*

7.6.2.1 *Pre-arcing time/current tests* — Pre-arcing time/current tests shall be made at any convenient voltage with the test circuit so arrranged that the current through the fuse is held to an essentially constant value.

Time/current data obtained from breaking tests may be used.

7.6.2.2 *Time-range* — Tests shall be made in the time range of 0·01 second to 600 seconds.

7.6.2.3 *Measurement of current* — The current through the fuse during time/current tests shall be measured by ammeter, oscillograph or other suitable instrument.

7.6.2.4 *Determination of time* — The determination of the time shall be made by any suitable means.

From the oscillograms recorded during the tests, the pre-arcing time shall be the virtual time, which in the range longer than 0·1 second is practically equivalent to actual time.

APPENDIX A

(*Clause* 0.7)

COMPARISON WITH CORRESPONDING IEC PUBLICATION

A-1. This standard (Part II) makes the following major deviations from the IEC Publication referred to in **0.6** [The clause numbers given refer to those in this standard (Part II)].

Clause 4.1.1 — For the purposes of this standard, only these rated voltages applicable to Indian system conditions are recognized. These values are those chosen from those indicated as Series I in IEC Publication.

Clause 4.4 — Fuses covered by this standard are intended for rated frequency of 50 Hz. For guidance on fuses for 60 Hz, reference shall be made to the IEC Publication referred to in **0.6**.

Clause 7.4.1.2 — Use of aluminium conductors is recommended for conducting temperature rise test, with guidance on the appropriate sizes for the same.