IS 13703-1 (1993): LV Fuses for voltages not exceeding 1000 V ac or 1500 V dc, Part 1: General requirements [ETD 39: Fuses]

BLANK PAGE

IS 13703 (Part 1) : 1993
IEC Pub 269-1 (1986)
[Superseding IS 9224 (Part 1) : 1979]
(Reaffirmed 2004)

भारतीय मानक

1 000 वो० ए सी अथवा 1 500 वो० डी सी से अनधिक वोल्टता के लिये अल्प वोल्टता फ्यूजों की विशिष्टि

भाग 1 सामान्य अपेक्षाएं

Indian Standard

SPECIFICATION FOR LOW-VOLTAGE FUSES FOR VOLTAGES NOT EXCEEDING 1 000 V AC OR 1 500 V DC

PART 1 GENERAL REQUIREMENTS

(First Reprint FEBRUARY 1998)

UDC 621·316·923·027·2

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

June 1993

Price Group 15

Indian Standard

SPECIFICATION FOR LOW-VOLTAGE FUSES FOR VOLTAGES NOT EXCEEDING 1 000 V AC OR 1 500 V DC

PART 1 GENERAL REQUIREMENTS

NATIONAL FOREWORD

This Indian Standard (Part 1) which is identical with IEC Pub 269-1 (1986) 'Low-voltage fuses — Part 1 : General requirements', issued by the International Electrotechnical Commission (IEC) is being brought out to align the requirements for LV fuses with the corresponding requirements at the IEC level.

This standard is being published in several parts. Supplementary requirements for fuses such as those intended for industrial applications, domestic and similar use and protection of semiconductor devices are covered in the subsequent parts of the standard.

The text of the IEC Standard has been considered and approved by ET 39, Fuses Sectional Committee of BIS as suitable for publication as Indian Standard, superseding the contents of IS 9224 (Part 1) which covered general requirements for all types of LV fuses.

CROSS REFERENCES

In this Indian Standard, the following International Standards are referred to. Read in their respective place the following:

International Standard (IEC)	*Indian Standard*
38 (1983)	
50 (441) (1984)	IS 1885 (Part 17)
127 (1974)	—
257 (1968)	—
269-2 (1973)	Part 2/Sec 1 of this standard
291 (1969)	IS 1885 (Part 17)
364-3 (1977)	SP 30 (1985)
364-5-523 (1983)	IS 732
408 (1972)	IS 13947 (Part 3)
417 (1973)	—
529 (1976)	IS 12063
584-1 (1977)	—
695-2-1 (1980)	—
International Standard (ISO)	
3-1973	IS 1076
478-1974 593-1974	IS 1064
4046-1978	IS 7186

All these standards are technically equivalent to the IEC/ISO publications referred. In the case of IEC Pub 127, 257, 417, 584-1 and 695-2-1, the technical committee responsible for the preparation of this standard has decided that they are acceptable for use in conjunction with this standard.

NATIONAL ANNEX

Keeping in view the application of this standard in Indian conditions, the Technical Committee responsible for this standard has felt the need to provide elaboration and interpretation where felt necessary. These are summarized in the National Annex. The text of this standard shall be read in conjunction with this annex which is the integral part of it.

As in the Original Standard, this Page is Intentionally Left Blank

CONTENTS

1. General

1.1 *Scope*

This standard is applicable to fuses incorporating enclosed current-limiting fuse-links with rated breaking capacities of not less than 6 kA, intended for protecting power-frequency a.c. circuits of nominal voltages not exceeding 1 000 V or d.c. circuits of nominal voltages not exceeding 1 500 V.

Subsequent parts of this standard, referred to herein, cover supplementary requirements for such fuses intended for specific conditions of use or applications.

Fuse-links intended to be included in fuse-switch combinations according to IEC Publication 408: Low-voltage Air-break Switches, Air-break Disconnectors, Air-break Switch Disconnectors and Fuse-combination Units, should also comply with the following requirements.

Notes 1. - For "a" fuse-links, details of performance (see Sub-clause 2.2.4) on d.c. circuits should be subject to agreement between user and manufacturer.

2. - Modifications of, and supplements to, this standard required for certain types of fuses for particular applications - for example certain fuses for rolling stock, or fuses for high-frequency circuits - will be covered, if necessary, by separate standards.

3. - This standard does not apply to miniature fuses, these being covered by IEC Publication 127: Cartridge Fuse-links for Miniature Fuses, and IEC Publication 257: Fuse-holders for Miniature Cartridge Fuse-links.

1.2 *Object*

The object of this standard is to establish the characteristics of fuses or parts of fuses (fuse-base, fuse-carrier, fuse-link) in such a way that they can be replaced by other fuses or parts of fuses having the same characteristics provided that they are interchangeable as far as their dimensions are concerned. For this purpose, this standard refers in particular to:

1.2.1 The following characteristics of fuses:

a) their rated values;
b) their insulation;
c) their temperature rises in normal service;
d) their power dissipation and acceptance;
e) their time/current characteristics;
f) their breaking capacity;
g) their cut-off current characteristic and their I^2t characteristics.

1.2.2 *Type test for verification of the characteristics of fuses*

1.2.3 *The marking on fuses*

2. Definitions

Note. - For general definitions concerning fuses, see also IEC Publication 291: Fuse Definitions, and IEC Publication 50 (441): International Electrotechnical Vocabulary (IEV), Chapter 441: Switchgear, Controlgear and Fuses.

For the purpose of this standard, the following definitions shall apply.

2.1 *Fuses and their component parts*

2.1.1 *Fuse*

A device that by the fusing of one or more of its specially designed and proportioned components opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete device.

2.1.2 *Fuse-holder*

The combination of the fuse-base with its fuse-carrier. (Where in this standard the term "fuse-holder" is used, it covers fuse-bases and/or fuse-carriers, if no clearer distinction is necessary.)

2.1.2.1 *Fuse-base* (fuse-mount)

The fixed part of a fuse provided with contacts, terminals and covers, where applicable.

2.1.2.2 *Fuse-carrier*

The movable part of a fuse designed to carry a fuse-link.

2.1.3 *Fuse-link*

The part of a fuse including the fuse-element(s), intended to be replaced after the fuse has operated.

2.1.4 *Fuse-contact*

Two or more conductive parts designed to ensure circuit continuity between a fuse-link and the corresponding fuse-holder.

2.1.5 *Fuse-element*

A part of a fuse-link designed to melt when the fuse operates. The fuse-link may comprise several fuse-elements in parallel.

2.1.6 *Indicating device* (indicator)

A device provided to indicate whether the fuse has operated.

2.1.7 *Striker*

A mechanical device forming part of a fuse-link which, when the fuse operates, releases the energy required to cause operation of other apparatus or indicators or to provide interlocking.

2.1.8 *Terminal*

A conductive part of a fuse provided for electric connection to external circuits.

Note. – Terminals may be distinguished according to the kind of circuits for which they are intended (e.g. main terminal, earth terminal, etc.) and also according to their design (e.g. screw terminal, plug terminal, etc.).

2.1.9 *Dummy fuse-link*

A test fuse-link with defined power dissipation and dimensions.

2.1.10 *Test rig*

A defined test fuse-base.

2.1.11 *Gauge-piece*

An additional part of a fuse-base intended to achieve a degree of non-interchangeability.

2.2 *General terms*

2.2.1 *Enclosed fuse-link*

A fuse-link in which the fuse-element(s) is (are) totally enclosed, so that during operation within its rating it cannot produce any harmful external effects, e.g. due to development of an arc, the release of gas or the ejection of flame or metallic particles.

2.2.2 *Current-limiting fuse-link*

A fuse-link that during and by its operation in a specified current range, limits the current to a substantially lower value than the peak value of the prospective current.

2.2.3 *"g" fuse-link* (formerly general purpose fuse-link)

A current-limiting fuse-link capable of breaking under specified conditions all currents which cause melting of the fuse-element up to its rated breaking capacity.

2.2.4 *"a" fuse-link* (formerly back-up fuse-link)

A current-limiting fuse-link capable of breaking under specified conditions all currents between the lowest current indicated on its operating time-current characteristic ($k_2 I_n$ in Figure 2, page 101) and its rated breaking capacity.

Note. – "a" fuse-links are generally used to provide short-circuit protection. Where protection is required against overcurrents less than $k_2 I_n$ in Figure 2, they are used in conjunction with another suitable switching device designed to interrupt such small overcurrents.

2.2.5 *Temperatures*

2.2.5.1 *Ambient air temperature* (T_a)

The ambient air temperature T_a is that of the air surrounding the fuse (at a distance of about 1 m from the fuse or its enclosure, if any).

2.2.5.2 *Fluid environment temperature* (T_e)

The fluid environment temperature T_e is the temperature of the fluid cooling the fuse-components (contact, terminal, etc.). It is the sum of the ambient air temperature T_a and the temperature rise ΔT_c with respect to the ambient temperature of the internal fluid in contact with the fuse-components (contact, terminal, etc.) if the latter is in an enclosure. If it is not in an enclosure, it is assumed that T_c is equal to T_a.

2.2.5.3 *Fuse-component temperature* (*T*)

The fuse-component (contact, terminal, etc.) temperature *T* is that of the relevant part.

2.2.6 *Overcurrent discrimination*

Co-ordination of the relevant characteristics of two or more overcurrent protective devices such that, on the occurrence of overcurrents within stated limits, the device intended to operate within these limits does so, while the other(s) do(es) not.

2.2.7 *Fuse-system*

A family of fuses following the same physical design principles with respect to the shape of the fuse-links, type of contacts, etc.

2.2.8 *Size*

Specified set of dimensions of fuses within a fuse-system. Each individual size covers a given range of rated currents for which the specified dimensions of the fuses remain unchanged.

2.2.9 *Homogeneous series of fuse-links*

A series of fuse-links, within a given size, differing from each other only in such characteristics that for a given test, the testing of one or a reduced number of particular fuse-links of that series may be taken as representative for all the fuse-links of the series itself (see Sub-clause 8.1.5.2).

Note. - The characteristics by which the fuse-links of a homogeneous series may differ and details on which of the fuse-links shall be tested are specified in association with the tests concerned (see Tables VIIB and VIIC).

2.2.10 *Utilization category* (of a fuse-link)

A combination of specified requirements related to the conditions in which the fuse-link fulfils its purpose, selected to represent a characteristic group of practical applications (see Sub-clause 5.7.1).

2.2.11 *Fuses for use by authorized persons* (formerly called fuses for industrial application)

Fuses intended to be used in installations where the fuse-links are accesssible to and intended to be replaced by authorized persons only.

Notes 1. - Non-interchangeability and protection against accidental contact with live parts need not necessarily be ensured by constructional means.

2. - Authorized person is understood to have the meaning defined for categories BA4 "Instructed"* and BA5 "Skilled"** in IEC Publication 364-3: Electrical Installations of Buildings, Part 3: Assessment of General Characteristics.

---

* Instructed: Persons adequately advised or supervised by skilled persons to enable them to avoid dangers which electricity may create (operating and maintenance staff).

** Skilled: Persons with technical knowledge or sufficient experience to enable them to avoid dangers which electricity may create (engineers and technicians).

2.2.12 *Fuses for use by unskilled persons* (formerly called fuses for domestic and similar applications)

Fuses intended to be used in installations where the fuse-links are accessible to and can be replaced by unskilled persons.

Note. – For these fuses protection against direct contact with live parts is recommended and non-interchangeability may be required, if necessary.

2.2.13 *Non-interchangeability*

Limitations on shape and/or dimensions with the object of avoiding in a specific fuse-base the inadvertent use of fuse-links having electrical characteristics other than those ensuring the desired degree of protection.

2.3 *Characteristic quantities*

2.3.1 *Rating*

A 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. – Rated values usually stated for low-voltage fuses are: voltage, current, breaking capacity, power dissipation and acceptance and frequency, where applicable. In the case of a.c., rated voltage and rated current are stated as r.m.s. symmetrical values; in the case of d.c., when ripple is present, the rated voltage is stated as a mean value, the rated current as an r.m.s. value. The above applies to any value of voltage and current, if not indicated otherwise.

2.3.2 *Prospective current of a circuit* (with respect to a fuse)

The current that would flow in a circuit if a fuse situated therein were replaced by a link of negligible impedance.

The prospective current is the quantity to which the breaking capacity and characteristics of the fuse are normally referred, e.g. I^2t and cut-off current characteristics (see Sub-clause 8.5.7).

2.3.3 *Gate*

Limiting values within which the characteristics, for example time-current characteristics, shall be contained.

2.3.4 *Breaking capacity of a fuse-link*

A value (for a.c. the r.m.s. value of the a.c. component) of prospective current that a fuse-link is capable of breaking at a stated voltage under prescribed conditions of use and behaviour.

2.3.5 *Breaking range*

Breaking range is a range of prospective currents within which the breaking capacity of a fuse-link is assured.

2.3.6 *Cut-off current*

The maximum instantaneous value reached by the current during the breaking operation of a fuse-link when it operates in such a manner as to prevent the current from reaching the otherwise attainable maximum.

2.3.7 *Cut-off current characteristic*

A curve giving the cut-off current as a function of the prospective current under stated conditions of operation.

Note. – In the case of a.c., the values of the cut-off currents are the maximum values reached whatever the degree of asymmetry. In the case of d.c., the values of the cut-off currents are the maximum values reached related to the time constant as specified.

2.3.8 *Peak withstand current* (of a fuse-holder)

The value of cut-off current that the fuse-holder can withstand.

Note. – The peak withstand current is not less than the highest cut-off current of any fuse-link with which the fuse-holder is intended to be associated.

2.3.9 *Pre-arcing time*

The time between the commencement of a current large enough to cause the fuse-element(s) to melt and the instant when an arc is initiated.

2.3.10 *Arcing time*

The interval of time between the instant of the initiation of the arc and the instant of final arc extinction.

2.3.11 *Operating time*

The sum of the pre-arcing time and the arcing time.

2.3.12 I^2t (Joule integral)

The integral of the square of the current over a given time:

$$I^2t = \int_{t_0}^{t_1} i_1 \mathrm{d}t$$

Notes 1. – The pre-arcing I^2t is the I^2t integral extended over the pre-arcing time of the fuse.

2. – The operating I^2t is the I^2t integral extended over the operating time of the fuse.

3. – The energy in joules released in 1 Ω of resistance in a circuit protected by a fuse is equal to the value of the operating I^2t expressed in A^2 s.

2.3.13 *I^2t characteristic*

A curve giving I^2t values (pre-arcing I^2t and/or operating I^2t) as a function of prospective current under stated conditions of operation.

2.3.14 *I^2t zone*

The range contained by the minimum pre-arcing I^2t characteristic and the maximum operating I^2t characteristic, under specified conditions.

2.3.15 *Rated current of a fuse-link (I_n)*

A value of current that the fuse-link can carry continuously without deterioration under specified conditions.

2.3.16 *Time-current characteristic*

A curve giving the pre-arcing time or operating time as a function of the prospective current under stated conditions of operation.

Note. – For times longer than 0.1 s for practical purposes the difference between pre-arcing and operating time is negligible.

2.3.17 *Time-current zone*

The range contained by the minimum pre-arcing time-current characteristic and the maximum operating time-current characteristic, under specified conditions.

2.3.18 *Conventional non-fusing current (I_{nf})*

A value of current specified as that which the fuse-link is capable of carrying for a specified time (conventional time) without melting.

2.3.19 *Conventional fusing current (I_f)*

A value of current specified as that which causes operation of the fuse-link within a specified time (conventional time).

2.3.20 *Overload curve of an "a" fuse-link*

A curve showing the time for which an "a" fuse-link shall be able to carry the current without deterioration (see Sub-clause 8.4.3.4 and Figure 2, page 101).

2.3.21 *Power dissipation of a fuse-link*

The power released in a fuse-link carrying rated current under specified conditions.

2.3.22 *Power acceptance of a fuse-holder*

The maximum value of power released in a fuse-link which a fuse-holder is designed to tolerate under specified conditions.

2.3.23 *Recovery voltage*

The voltage which appears across the terminals of a fuse after the breaking of the current.

Note. – This voltage may be considered in two successive intervals of time, one during which a transient voltage exists (Sub-clause 2.3.23.1) followed by a second one during which only the power frequency or d.c. recovery voltage (Sub-clause 2.3.23.2) exists.

2.3.23.1 *Transient recovery voltage*

The recovery voltage during the time in which it has a significant transient character.

Notes 1. – The transient voltage may be oscillatory or non-oscillatory or a combination of both, depending on the characteristics of the circuit and the fuse. It includes the voltage shift of the neutral of a polyphase circuit.

2. – The transient recovery voltage in three-phase circuits is, unless otherwise stated, that which appears across the first pole to clear because this voltage is generally higher than that which appears across each of the other two poles.

2.3.23.2 *Power-frequency or d.c. recovery voltage*

The recovery voltage after the transient voltage phenomena have subsided.

Note. – The power-frequency or d.c. recovery voltage may be referred to as a percentage of the rated voltage.

2.3.24 *Arc voltage*

The instantaneous value of the voltage which appears across the terminals of a fuse during the arcing time.

3. Conditions for operation in service

Where the following conditions apply, fuses complying with this standard are deemed capable of operating satisfactorily without further qualification. These conditions also apply for tests except those otherwise specified in Clause 8.

3.1 *Ambient air temperature (T_a)*

The ambient air temperature T_a (see Sub-clause 2.2.5.1) does not exceed 40° C, its mean value measured over a period of 24 h does not exceed 35 °C and its mean value measured over a period of one year is lower.

The minimum value of the ambient air temperature is −5° C.

Notes 1. – The time-current characteristics given are related to a reference ambient air temperature of 20 °C. These time-current characteristics also approximately apply to a temperature of 30° C.

2. – In cases where the temperature conditions vary significantly from these values, this should be taken into consideration from the points of view of operation, temperature rises, etc. See Appendix D.

3.2 *Altitude*

The altitude of the site of installation of the fuses does not exceed 2000 m above sea level.

3.3 *Atmospheric conditions*

The air is clean and its relative humidity does not exceed 50% at the maximum temperature of 40 °C.

Higher relative humidities are permitted at lower temperatures, e.g. 90% at 20 °C.

Under these conditions, moderate condensation may occasionally occur due to variation in temperature.

Note. – Where fuses are to be used under conditions different from those mentioned in Sub-clauses 3.1, 3.2 and 3.3, in particular outdoors without protection, the manufacturer should be consulted. This applies also in cases where deposits of sea salt or abnormal deposits of industrial origin may occur.

3.4 *Voltage*

The system voltage has a maximum value not exceeding 110% of the rated voltage of the fuse. For d.c. when obtained by rectifying a.c., the ripple shall not cause a variation of more than 5% above or 9% below the mean value of 110% of the rated voltage.

Note. – Attention is drawn to the fact that the indicating device or striker of a fuse may not operate if the fuse-link operates at a voltage which is considerably lower than its rated voltage (see Sub-clause 8.4.3.6).

3.5 *Current*

The currents to be carried and to be broken are within the range specified in Sub-clauses 7.4 and 7.5.

3.6 *Frequency, power factor and time constant*

3.6.1 *Frequency*

For a.c. the frequency is the rated frequency of the fuse-link.

3.6.2 *Power factor*

For a.c. the power factor is not lower than that shown in Table XIIA, appropriate to the value of prospective current.

3.6.3 *Time constant*

For d.c. the time constant corresponds to that shown in Table XIIB.

Some service duties may be found which exceed the limits shown in the table as regards time constant. For such an application a fuse-link which has been tested to verify that it meets the required time constant and is marked accordingly shall be used.

3.7 *Conditions of installation*

The fuse is installed in accordance with the manufacturer's instructions.

If the fuse is likely to be exposed in service to abnormal vibrations or shocks, the manufacturer should be consulted.

3.8 *Utilization category*

Utilization categories (e.g. "gG") are specified according to Sub-clause 5.7.1.

3.9 *Discrimination of "gG" and "gM" fuses*

Limits of discrimination for times greater than 0.1 s are given in Tables II and III.

Pre-arcing I^2t values are given in Table VI; operating I^2t values will be given in subsequent parts because they are dependent upon the system, the rated voltage and the application of the fuse.

4. Classification

Fuses are classified according to Clause 5 and the subsequent parts.

5. Characteristics of fuses

5.1 *Summary of characteristics*

The characteristics of a fuse shall be stated in the following terms, where such terms are applicable.

5.1.1 *Fuse-holders*

a) Rated voltage (see Sub-clause 5.2)
b) Rated current (see Sub-clause 5.3.2)

c) Kind of current and rated frequency, if applicable (see Sub-clause 5.4)
d) Rated power acceptance (see Sub-clause 5.5)
e) Dimensions or size
f) Number of poles, if more than one
g) Peak withstand current

5.1.2 *Fuse-links*

a) Rated voltage (see Sub-clause 5.2)
b) Rated current (see Sub-clause 5.3.1)
c) Kind of current and rated frequency, if applicable (see Sub-clause 5.4)
d) Rated power dissipation (see Sub-clause 5.5)
e) Time-current characteristics (see Sub-clause 5.6)
f) Breaking range (see Sub-clause 5.7.1)
g) Rated breaking capacity (see Sub-clause 5.7.2)
h) Cut-off current characteristics (see Sub-clause 5.8.1)
i) I^2t characteristics (see Sub-clause 5.8.2)
k) Dimensions or size

5.1.3 *Complete fuses*

Degree of protection according to IEC Publication 529: Classification of Degrees of Protection provided by Enclosures.

5.2 *Rated voltage*

For a.c. the standard values of rated voltages are given in Table I.

TABLE I

Standard values of a.c. rated voltages for fuses

Series I (V)	Series II (V)
	120*
	208
220 (230)*	240
	277*
380 (400)*	415
500	480*
660 (690)*	600

The values marked with an asterisk are standardized values according to IEC Publication 38: IEC Standard Voltages. In the meantime the other values of the table will also be used.

For d.c., the preferred values for rated voltages are given as follows: 110* - 125* - 220* - 250* - 440* - 460 - 500 - 600* - 750 V.

Note. - The rated voltage of the fuse-link may be a value other than the rated voltage of the fuse-holder in which the fuse-link is to be used. The rated voltage of the fuse is the lowest value of the rated voltages of its parts (fuse-holder, fuse-link).

5.3 *Rated current*

5.3.1 *Rated current of the fuse-link*

The rated current for the fuse-link, expressed in amperes, should be selected from the following values:

2 - 4 - 6 - 8 - 10 - 12 - 16 - 20 - 25 - 32 - 40 - 50 - 63 - 80 - 100 - 125 - 160 - 200 - 250 - 315 - 400 - 500 - 630 - 800 - 1 000 - 1 250

Notes 1. - If higher or lower values are required, these values should be selected from the series R10 of ISO Standard 3.

2. - If, in exceptional cases, it is necessary to choose an intermediate value, this value should be selected from the series R20 of ISO Standard 3.

5.3.2 *Rated current of the fuse-holder*

The rated current of the fuse-holder, expressed in amperes, should be selected from the series of rated currents of fuse-links if not otherwise specified in subsequent Parts. For "gG" and "aM"-fuses the rated current of the fuse-holder represents the highest rated current of the fuse-link with which it is intended to be used.

5.4 *Rated frequency* (see Sub-clauses 6.1 and 6.2)

The absence of any marking regarding rated frequency shall imply that the fuse meets the conditions laid down in this standard for frequencies between 45 Hz and 62 Hz only.

5.5 *Rated power dissipation of a fuse-link and rated power acceptance of a fuse-holder*

The rated power dissipation of a fuse-link is stated by the manufacturer if not otherwise specified in subsequent parts. That value shall not be exceeded under specified test conditions.

The rated power acceptance of a fuse-holder is stated by the manufacturer if not otherwise specified in the subsequent parts. It is intended to be the maximum power dissipation the fuse-holder can tolerate under specified test conditions without exceeding the specified temperature rise.

5.6 *Limits of time-current characteristics*

The limits are based on a reference ambient air temperature T_a of + 20 °C.

5.6.1 *Time-current characteristics, time-current zones*

They depend on the design of the fuse-link, and, for a given fuse-link, on the ambient air temperature and the cooling conditions.

Note. - For ambient air temperatures deviating from the temperature range according to Sub-clause 3.1, consultation with the manufacturer is necessary.

For fuse-links not complying with the standardized time-current zones as specified in the subsequent parts, the manufacturer should keep available (with their tolerances):

- the pre-arcing and operating time-current characteristics

or

- the time-current zone

Note. - For pre-arcing times smaller than 0.1 s the manufacturer should keep available I^2t characteristics with their tolerances (see Sub-clause 5.8.2).

When the time-current characteristics are presented for pre-arcing times exceeding 0.1 s, they should be given with current as abscissa and time as ordinate. Logarithmic scales shall be used on both co-ordinate axes.

The basis of the logarithmic scales (the dimensions of one decade) shall be in the ratio 2/1 with the longer dimensions on the abscissa. However, because of long-established practice in the United States of America, a ratio of 1/1 is recognized as an alternative standard. The presentation shall be made on standardized paper A3 or A4, according to ISO Standard 478 or 593.

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

2 cm, 4 cm, 8 cm, 16 cm, and 2.8 cm, 5.6 cm, 11.2 cm

Note. - It is recommended that, whenever possible, the preferred values 2.8 cm (ordinate) and 5.6 cm (abscissa) should be used.

5.6.2 *Conventional times and currents*

The conventional times and currents are given in Table II.

TABLE II

Conventional time and current for "gG" fuse-links

Rated current I_n for gG Characteristic current I_{ch} for gM** (A)	Conventional time (h)	Conventional current (I_{nf})	(I_f)
$I_n < 16$	1	*	*
$16 \leqslant I_n \leqslant 63$	1		
$63 < I_n \leqslant 160$	2	$1.25\, I_n$	$1.6\, I_n$
$160 < I_n \leqslant 400$	3		
$400 < I_n$	4		

* Under consideration.
** For "gM" fuse links, see Sub-clause 5.7.1.

5.6.3 *Gates*

For "gG" and "gM" fuse-links the gates given in Table III apply.

TABLE III

Gates for specified pre-arcing times of "gG" and "gM" fuse-links

I_n for gG I_{ch} for gM** (A)	I_{min} (10 s)*** (A)	I_{max} (5 s)*** (A)	I_{min} (0.1 s) (A)	I_{max} (0.1 s) (A)
16	33	65	85	150
20	42	85	110	200
25	52	110	150	260
32	75	150	200	350
40	95	190	260	450
50	125	250	350	610
63	160	320	450	820
80	215	425	610	1 100
100	290	580	820	1 450
125	355	715	1 100	1 910
160	460	950	1 450	2 590
200	610	1 250	1 910	3 420
250	750	1 650	2 590	4 500
315	1 050	2 200	3 420	6 000
400	1 420	2 840	4 500	8 060
500	1 780	3 800	6 000	10 600
630	2 200	5 100	8 060	14 140
800	3 060	7 000	10 600	19 000
1 000	4 000	9 500	14 140	24 000
1 250	5 000	13 000	19 000	35 000

* Values for fuses with rated current less than 16 A are under consideration.

** For "gM" fuse-links see Sub-clause 5.7.1.

*** I_{min} (10 s) is the minimum value of current for which the pre-arcing time is not less than 10 s.
I_{max} (5 s) is the maximum value of current for which the operating time is not more than 5 s. (see Figure 1, page 100).

5.7 *Breaking range and breaking capacity*

5.7.1 *Breaking range and utilization category*

The first letter shall indicate the breaking range:
- "g" fuse-links (full-range breaking-capacity fuse-link);
- "a" fuse-links (partial-range breaking-capacity fuse-link).

The second letter shall indicate the utilization category; this letter defines with accuracy the time-current characteristics, conventional times and currents, gates:

For example - gG indicates fuse-links with a full-range breaking capacity for general application;
- gM indicates fuse-links with a full-range breaking capacity for the protection of motor circuits;
- aM indicates fuse-links with a partial range breaking capacity for the protection of motor circuits.

Notes 1. – At present "gG" fuse-links are often used for the protection of motor circuits, which is possible when their characteristics are suitable to be capable of withstanding the motor starting current.

2. – A "gM" fuse-link, which has a dual rating is characterized by two current values. The first value I_n denotes both the rated current of the fuse-link and the rated current of the fuse-holder; the second value I_{ch} denotes the time-current characteristic of the fuse-link as defined by the gates in Tables II, III and VI.

These two ratings are separated by a letter which defines the applications.
For example: I_n M I_{ch} denote a fuse intended to be used for protection of motor circuits and having the characteristic G. The first value I_n corresponds to the maximum continuous current for the whole fuse and the second value I_{ch} corresponds to the G characteristic of the fuse-link.

3. – An "aM" fuse-link is characterized by one current value I_n and time-current characteristic as defined in Sub-clause 8.4.3.3.1 and Figure 2, page 101.

5.7.2 *Rated breaking capacity*

The rated breaking capacity of a fuse-link is given by the manufacturer corresponding to the rated voltage. Values of minimum rated breaking capacity are given in subsequent parts.

5.8 *Cut-off current and I^2t characteristics*

The value for cut-off and I^2t characteristics shall take into account manufacturing tolerances and shall refer to the service conditions as specified in subsequent parts, e.g. the values of voltage, frequency and power factor.

5.8.1 *Cut-off current characteristic*

The cut-off current characteristics shall represent the maximum instantaneous values of current likely to be experienced in service. (See Sub-clause 8.6.1 and Appendix C.)

Where the cut-off current characteristic is required and unless specified in subsequent parts, they should be given by the manufacturer according to the example shown in Figure 3, page 102, in a double logarithmic presentation with the prospective current as abscissa.

5.8.2 *I^2t characteristics*

The pre-arcing I^2t characteristics for pre-arcing times of less than 0.1 s down to a time corresponding to the rated breaking capacity shall be given by the manufacturer. They shall represent the lowest values likely to be experienced in service as a function of the prospective current.

The operating I^2t characteristics with specified voltages as parameters shall be given by the manufacturer for pre-arcing times less than 0.1 s. They shall represent the highest values likely to be experienced in service as a function of the prospective current.

When presented graphically, the I^2t characteristics shall be given with prospective current as abscissa and I^2t values as ordinate. Logarithmic scales shall be used on both co-ordinate axes. (For using the logarithmic scales, see Sub-clause 5.6.1.)

6. **Markings**

Markings shall be legible. Tests are given in subsequent parts.

6.1 *Markings of fuse-holders*

The following information shall be marked on all fuse-holders:

- name of the manufacturer or a trade mark by which he may be readily identified;
- manufacturer's identification reference enabling all the characteristics listed in Sub-clause 5.1.1 to be found;
- rated voltage;
- rated current;
- kind of current and rated frequency, when applicable.

Note. – A fuse-holder marked with a.c. ratings may also be used for d.c. If a fuse-holder contains a removable fuse-base and a removable fuse-carrier, both should be separately marked for the purpose of identification.

6.2 *Markings of fuse-links*

The following information shall be marked on all fuse-links except small fuse-links where this is impracticable:

- name of the manufacturer or a trade mark by which he may be readily identified;
- manufacturer's identification reference, enabling all the characteristics listed in Sub-clause 5.1.2 to be found;
- rated voltage;
- rated current (for "gM" type see Sub-clause 5.7.1);
- breaking range and utilization category (letter code), where applicable (see Sub-clause 5.7.1);
- kind of current and, if applicable, rated frequency (see Sub-clause 5.4).

Note. – Fuse-links shall be marked separately for a.c. and d.c. if the fuse-link is provided for a.c. and d.c.

For small fuse-links, where it is impracticable to include all the specified information on the fuse-link, the trade mark, list reference of the manufacturer, rated voltage and the rated current shall be marked.

6.3 *Marking symbols*

For the kind of current and frequency, use symbols in accordance with IEC Publication 417: Graphical Symbols for Use on Equipment. Index, Survey and Compilation of the Single Sheets.

Note. – The marking for rated current and rated voltage may, for instance, be as follows:

10 A 500 V or 10/500 or $\frac{10}{500}$

7. Standard conditions for construction

7.1 *Mechanical design*

7.1.1 *Replacement of fuse-links*

It shall be possible to replace the fuse-links easily and safely.

7.1.2 *Connections including terminals*

The fixed connections shall be such that the necessary contact force is maintained under the conditions of service and operation.

No contact force on connections shall be transmitted through insulating material other than ceramic or other material with characteristics not less suitable, unless there is sufficient resilience in the metallic parts to compensate for any possible shrinkage or other deformation of the insulating material. Tests are specified in subsequent parts, where necessary.

Terminals shall be such that they cannot turn or be displaced when the connecting screws are tightened, and such that the conductors cannot be displaced. The parts gripping the conductors shall be of metal and shall have such a shape that they cannot unduly damage conductors.

Terminals shall be so arranged that they are readily accessible (after removal of covers, if any) under the intended conditions of installation.

Note. – Other requirements concerning terminals are under consideration.

7.1.3 *Fuse-contacts*

Fuse-contacts shall be such that the necessary contact force is maintained under the conditions of service and operation, in particular under the conditions corresponding to Sub-clause 7.5.

Contact shall be such that the electromagnetic forces occurring during operation under conditions in accordance with Sub-clause 8.1.6 shall not impair the electrical connections between:

a) the fuse-base and the fuse-carrier;
b) the fuse-carrier and the fuse-link;
c) the fuse-link and the fuse-base, or if applicable, any other support.

In addition, fuse contacts shall be so constructed and of such material that, when the fuse is properly installed and service conditions are normal, adequate contact is maintained:

a) after repeated engagement and disengagement;
b) after being left undisturbed in service for a long period (see Sub-clause 8.10).

Fuse contacts of copper alloy shall be free from season cracking.

These requirements are verified by the tests according to Sub-clauses 8.4.3.4 and 8.11.2.1 and in Clause 8 of IEC Publication 269-2: Low-Voltage Fuses, Part 2: Supplementary Requirements for Fuses for Use by Authorized Persons (Fuses Mainly for Industrial Application).

7.2 *Insulating properties*

The fuses shall be such that they do not lose their insulating properties at the voltages to which they are subjected in normal service. A fuse shall be deemed to satisfy this condition if it passes the test for verification of insulating properties in accordance with Sub-clause 8.2.

The minimum creepage distances, clearances and distances through insulating material or sealing compound shall comply with the values specified in subsequent parts.

7.3 *Temperature rise, power dissipation of the fuse-link and power acceptance of the fuse-holder*

The fuse-holder shall be so designed and proportioned as to carry continuously, under standard conditions of service, the rated current of the fuse-link with which it is provided without exceeding:

- the temperature-rise limits specified in Table IV at the rated power acceptance of the fuse-holder as indicated by the manufacturer or otherwise specified in subsequent parts.

The fuse-link shall be so designed and proportioned as to carry continuously, under standard conditions of service, its rated current without exceeding:

- the rated power dissipation of the fuse-link as indicated by the manufacturer or otherwise specified in subsequent parts.

In particular, the temperatuie-rise limits specified in Table IV shall not be exceeded:

- when the rated current of the fuse-link is equal to the rated current of the fuse-holder intended to accommodate this fuse-link;
- when the power dissipation of the fuse-link is equal to the rated power acceptance of the fuse-holder.

These requirements are verified by the tests according to Sub-clause 8.3.

TABLE IV

Temperature rise limits $\Delta T = (T - T_a)$ for contacts and terminals

			Temperature rise in kelvins	
			Unenclosed[1]	Enclosed[2]
Contacts[7][9]	Spring loaded	Bare copper	40	45
		Bare brass	45	50
		Tin plated	55[6]	60[6]
		Nickel plated	70[5][3] [8]	75[5][8] [3]
		Silver plated	[3]	[3]
	Bolted	Bare copper	55	60
		Bare brass	60	65
		Tin plated	65[6]	65[6]
		Nickel plated	80[3][5][8]	85[3][5][8]
		Silver plated	[3]	[3]
Terminals		Bare copper	55	60
		Bare brass	60	65
		Tin plated	65	65
		Silver or nickel plated	70[4]	70[4]

1) In the case $T_e = T_a$ (see Sub-clause 2.2.5).

2) Applicable for values of ΔT_e between 10 K and 30 K (10 K $\leqslant \Delta T_e \leqslant$ 30 K), the ambient air temperature T_a should not be higher than 40 °C.

3) Limited only by the necessity of not causing any damage to adjacent parts.

4) The limit of temperature rise is governed by the use of PVC insulated conductors.

5) The given values do not apply for fuse-systems for which the cross-sectional area and the material of the contacts are given in the subsequent parts.

6) These limits may be exceeded if it is verified that no deterioration of the contact is caused by the actual temperature during the test for non-deterioration of contact.

7) The values given in this table do not apply to certain fuses which are too small, so the temperature cannot be measured without the risk of failure. Therefore, the verification of non-deterioration of contacts will be done by a test given in Sub-clause 8.10.

8) The use of nickel-plated contacts requires, due to its relatively high electrical resistance, certain precautions in the design of the contact, among others the use of a relatively high contact pressure.

9) The test for non-deterioration of contacts is given in Sub-clause 8.10.

7.4 *Operation*

The fuse-link shall be so designed and proportioned that when tested in its appropriate test arrangement at rated frequency and an ambient air temperature of 20 ± 5 °C:

- it is able to carry continuously any current not exceeding its rated current;
- it is able to withstand overload conditions as they may occur in normal service (see Sub-clause 8.4.3.4).

For a "g" fuse-link within the conventional time:

- its fuse-element does not melt, when it carries any current not exceeding the conventional non-fusing current (I_{nf});
- it operates when it carries any current equal to or exceeding the conventional fusing current (I_f).

Note. - Time-current zones, if any, are to be considered.

For an "a" fuse-link,

- its fuse-element does not melt when it carries a current not exceeding $k_1 I_n$ for the corresponding time indicated in the overload curve (see Figure 2, page 101);
- when carrying a current between $k_1 I_n$ and $k_2 I_n$, the fuse-element may melt, provided that the pre-arcing time is greater than the value indicated in the pre-arcing time-current characteristic;
- it operates when it carries a current exceeding $k_2 I_n$ within its time-current zone including the arcing time.

The time-current values measured in Sub-clause 8.4.3.3 shall fall within the time-current zone provided by the manufacturer.

A fuse-link is deemed to satisfy these conditions if it passes the tests prescribed in Sub-clause 8.4.

7.5 *Breaking capacity*

The fuse shall be capable of breaking, at rated frequency, and at a voltage not exceeding the recovery voltage specified in Sub-clause 8.5, any circuit having a prospective current between:

- for "g" fuse-links, the current I_f;
- for "a" fuse-links, the current $k_2 I_n$ and:
- in the case of a.c., the rated breaking capacity at power factors not lower than those shown in Table XIIA appropriate to the value of the prospective current;
- in the case of d.c., the rated breaking capacity at time constants not greater than those limits shown in Table XIIB appropriate to the value of the prospective current.

During operation of the fuse-link in a test circuit as described in Sub-clause 8.5, the arc voltage shall not exceed the values given in Table V.

Note. - Where fuse-links are used in circuits with system voltages belonging to a range lower than that corresponding to the rated voltage of the fuse-links, consideration should be given to the arc voltage which should not exceed the value in Table V corresponding to the system voltage.

TABLE V

Maximum arc voltage

Rated voltage U_n of the fuse-link (V)		Maximum arc voltage, peak value (V)
A.C. and D.C. currents	Up to and including - 60	1 000
	61 - 300	2 000
	301 - 660	2 500
	661 - 800	3 000
	801 - 1 000	3 500
D.C. only	1 001 - 1 200	3 500
	1 201 - 1 500	5 000

Note. - For fuse-links having rated current less than 16 A, the maximum arc voltage is not specified in this standard but is under consideration.

A fuse shall be deemed to satisfy these conditions if it passes the tests prescribed in Sub-clause 8.5.

7.6 *Cut-off current characteristic*

If not otherwise specified in subsequent parts, the values of cut-off current measured as specified in Sub-clause 8.6 shall be less than, or equal to, the values corresponding to the cut-off current characteristic assigned by the manufacturer (see Sub-clause 5.8.1).

7.7 *I^2t characteristics*

The pre-arcing I^2t values verified according to Sub-clause 8.7 shall not be less than the characteristics stated by the manufacturer in accordance with Sub-clause 5.8.2 and lie within the limits given in Table VI for "gG" and "gM" fuse-links. For pre-arcing times smaller than 0.01 s, limits are given in subsequent parts, if required.

The operating I^2t values verified according to Sub-clause 8.7 shall be less than, or equal, to, the characteristics stated by the manufacturer in accordance with Sub-clause 5.8.2 or specified in subsequent parts.

TABLE VI

Pre-arcing I^2t values at 0.01 s for "gG" and "gM" fuse-links

I_n for gG I_{ch} for gM* (A)	I^2t_{min} $10^3 \times (A^2s)$	I^2t_{max} $10^3 \times (A^2s)$
16	0.3	1.0
20	0.5	1.8
25	1.0	3.0
32	1.8	5.0
40	3.0	9.0
50	5.0	16.0
63	9.0	27.0
80	16.0	46.0
100	27.0	86.0
125	46.0	140.0
160	86.0	250.0
200	140.0	400.0
250	250.0	760.0
315	400.0	1 300.0
400	760.0	2 250.0
500	1 300.0	3 800.0
630	2 250.0	7 500.0
800	3 800.0	13 600.0
1 000	7 840.0	25 000.0
1 250	13 700.0	47 000.0

*For "gM", see Sub-clause 5.7.1.

7.8 *Overcurrent discrimination of "gG" and "gM" fuse-links*

Requirements concerning overcurrent discrimination are dependant upon the fuse-system, the rated voltage and the application of the fuse; relevant requirements may be given in subsequent parts.

7.9 *Protection against electric shock*

For the protection of persons against electric shock, three states of the fuse shall be taken into consideration.

- when the complete fuse is properly mounted, installed and wired with fuse-base, fuse-link and, where applicable, gauge-piece, fuse-carrier and enclosure forming part of the fuse (normal service condition);
- during the replacement of the fuse-link;
- when the fuse-link, and where applicable, the fuse-carrier is removed.

The requirements are specified in subsequent parts. See also Sub-clause 8.8.

7.10 *Resistance to heat*

All components shall be sufficiently resistant to heat which may occur in normal use.

If not otherwise specified in subsequent parts, this requirement is considered as being met when satisfactory results are obtained in tests according to Sub-clauses 8.9 and 8.10.

7.11 *Mechanical strength*

All components of the fuse shall be sufficiently resistant to mechanical stresses which may occur in normal use.

If not otherwise specified in the subsequent parts, this requirement is considered as being met when satisfactory results are obtained on tests according to Sub-clauses 8.3 to 8.5 and 8.11.1.

7.12 *Resistance to corrosion*

All metallic components of the fuse shall be resistant to corrosive influences which may occur in normal use.

7.12.1 *Resistance to rusting*

Ferrous components shall be so protected that they meet the relevant tests.

If not otherwise specified in subsequent parts, this requirement is considered as being met when satisfactory results are obtained on tests according to Sub-clauses 8.2.4.2 and 8.11.2.3.

7.12.2 *Resistance to season cracking*

Current-carrying parts shall be sufficiently resistant to season cracking. Relevant tests are specified in Sub-clauses 8.2.4.2 and 8.11.2.1.

7.13 *Resistance to abnormal heat and fire*

All components of the fuse shall be sufficiently resistant to abnormal heat and fire. The test is specified in Sub-clause 8.11.2.2.

8. **Tests**

8.1 *General*

8.1.1 *Kind of tests*

The tests specified in this clause are type tests and are performed under the responsibility of the manufacturer.

If during one of these tests a failure occurs and the manufacturer can furnish evidence that this failure is not typical of the fuse-type, but due to an individual fault of the tested sample, the relevant test shall be repeated. This does not apply to the breaking capacity test.

If acceptance tests are agreed upon between user and manufacturer, the test shall be selected from the type tests.

Type tests are performed in order to verify that a particular type of fuse or a range of fuses forming a homogeneous series (see Sub-clause 8.1.5.2) corresponds to the specified characteristics and operates satisfactorily under normal conditions of service or under particular specified conditions.

Compliance with the type test is deemed to prove that all fuses of identical construction meet the requirements of this standard.

Type tests shall be repeated if any part of the fuse is modified in a manner liable to adversely affect the results of the type tests already performed.

8.1.2 *Ambient air temperature (T_a)*

The ambient air temperature shall be measured by measuring devices protected against draughts and heat radiation, placed at the height of the centre of the fuse and at a distance of approximately 1 m. At the beginning of each test, the fuse shall be approximately at the ambient air temperature.

8.1.3 *Condition of the fuse*

Tests shall be made on fuses in a clean and dry condition.

8.1.4 *Arrangement of the fuse and dimensions*

Except for the degree of protection test (see Sub-clause 8.8) the fuse shall be mounted in free air in draught-free surroundings in the normal operation position, e.g. vertical and, unless otherwise specified, on insulating material of sufficient rigidity to withstand the forces encountered without applying external load to the fuse under test.

The fuse-link shall be mounted either as in normal use or in the fuse-holder for which it is intended or in a test rig in accordance with the indications given in the relevant Sub-clause in a subsequent part.

Before the tests are started, the specified external dimensions shall be measured and the results compared with the dimensions specified in the relevant data sheets of the manufacturer or specified in subsequent parts.

8.1.5 *Testing of fuse-links*

Fuse-links shall be tested with the kind(s) of current and, for a.c., frequency for which they are rated, unless otherwise specified in subsequent parts.

8.1.5.1 *Complete tests*

Before the tests are commenced, the internal resistance R of all samples shall be measured at an ambient-air temperature of 20 ± 5 °C with a measuring current of not more than 0.1 I_n. The value R shall be recorded in the test report.

A survey of the complete tests is given in Table VIIA.

8.1.5.2 *Testing of fuse-links of a homogeneous series*

Fuse-links of different rated currents are considered to form a homogeneous series provided:

- they have enclosures identical in form and construction and with the exception of fuse-elements, in dimension. This condition is also met when only the fuse-link contacts differ, in which case tests are performed with the fuse-link having the fuse-link contacts most likely to produce the least favourable test results;
- they have the same arc-extinguishing medium and the same completeness of filling;
- their fuse-elements consist of identical materials. They shall have the same length and form.

Note. – For example, they may be formed with identical tools from material of different thickness.

- their cross-section, which may vary along the length of fuse-elements, as well as the number of fuse-elements, shall not exceed the cross-section and the number of fuse-elements, respectively, of those fuse-links having the highest rated current;
- the minimum distances between adjacent fuse-elements and between the fuse-elements and the inner surface of the cartridge is not less than those in the fuse-link having the highest rated current;
- they are suitable to be used with a given fuse-holder or are intended to be used without a fuse-holder but in an arrangement identical for all rated currents of the homogeneous series.
- With respect to the temperature-rise test the product $RI_n^{3/2}$ does not exceed the corresponding value for the fuse-link which has the largest rated current of the homogeneous series. The resistance R shall be measured with the fuse-link as indicated in Sub-clause 8.1.5.1.
- With respect to the breaking-capacity test, the rated breaking capacity is not greater than that of the fuse-link having the largest rated current within the homogeneous series. Otherwise, the fuse-link of the largest rated current among those having the greater rated breaking capacity shall be subjected to tests No. 1 and No. 2.

For fuse-links of a homogeneous series:

- the fuse-link having the largest rated current shall be tested completely according to Table VIIA;
- the fuse-link having the smallest rated current shall be tested only according to Table VIIB;

TABLE IV

Tests of fluid circuit

(These tests are applicable only to assemblies whose response is dependent on flow-rate)

Influence quantity	Range of variation of influence quantity	Limits of variation of nominal flow-rate	Reference (sub-clause)
Time	1 h to 100 h	±10%	28.1
Filter pressure drop	In accordance with manufacturer's specifications	-10%	28.2
Power supply voltage	From 80% U_N to 110% U_N	±5%	28.3
Power supply frequency	From 47 Hz to 51 Hz *	±10%	28.4

* From 57 Hz to 61 Hz for countries where nominal frequency is 60 Hz.

TABLE VIIA

Survey of complete tests on fuse-links and number of fuse-links to be tested

Test according to sub-clause		Number of tests																									
		"g" fuse-links																"a" fuse-links									
		1	1	1	1	1	1	3	3	1	3	3	1	1	1	1	1	1	1	1	1	3	3	1	3	1	3
8.1.4	Dimensions	×	×	×														×	×	×							
8.1.5.1	Resistance	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
8.3	Temperature-rise, power dissipation	×																×									
8.4.3.1 *a)*	Conventional non-fusing current	×																									
8.4.3.1 *b)*	Conventional fusing current			×																							
8.4.3.2	Rated current		×																								
8.4.3.3	Time-current characteristics, gates																										
	Gates "g" fuse-links *a)* I_{min} (10 s)												×														
	b) I_{max} (5 s)													×													
	c) I_{min} (0.1 s)														×												
	d) I_{max} (0.1 s)															×											
	Gates "a" fuse-links[7]																								×		
8.4.3.4	Overload											×															×
8.4.3.5	Conventional cable overload protection										×																
8.4.3.6	Indicating device[4]			×	×	×	×	×	×									×		×	×	×	×				
	Striker[5]		×	×	×	×	×	×	×									×		×	×	×	×	×			
8.5 no. 5	Breaking capacity[1]				×														×[3]								
no. 4	Breaking capacity[1]					×														×							
no. 3	Breaking capacity[1]						×														×						
no. 2	Breaking capacity[2]							×														×					
no. 1	Breaking capacity[2]								×														×				
8.6	Cut-off current characteristic[5]																										
8.7	I^2t characteristic[5]																										
8.8	Degree of protection[5]																										
8.9	Resistance to heat[5]																										
8.10	Non-deterioration of contacts[5]																										
8.11.1	Mechanical strength[5]																										
8.11.2.1	Freedom from season cracking[5] [6]																×									×	
8.11.2.2	Resistance to abnormal heat and fire[5]																										
8.11.2.3	Resistance to rusting[5]																										

[1] Valid also for time-current characteristic, if ambient air temperature is between 15 °C and 25 °C (see Sub-clause 8.4.3.3).

For fuse-links tested in test-rigs tests in accordance with 3*a*), 4*a*) and 5*a*) of Sub-clause 8.4.3.3 may be used.

[2] Valid also for cut-off current and I^2t characteristics (see Sub-clauses 8.6 and 8.7).
[3] See Sub-clause 8.1.6, note.
[4] For fuse-links with indicating device or striker only.
[5] Test according to 8.6 to 8.11 relating to fuse-systems which are mentioned in subsequent parts may be possible. Number of samples to be tested depends on system and material.
[6] For fuse-links with current-carrying parts made of rolled copper alloy with less than 83% copper.

[7] Values are given in subsequent parts.

Survey of tests on fuse-links of smallest rated current of homogeneous series and number of fuse-links to be tested

Test according to sub-clause		Number of tests																							
		"g" fuse-links													"a" fuse-links										
		1	1	1	1	1	3	1	3	3	1	1	1	1	1	1	1	3	1	3	3	1	1	1	3
8.1.4	Dimensions	×	×	×											×	×	×								
8.1.5.1	Resistance	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
8.4.3.1 *a)*	Conventional non-fusing current				×																				
8.4.3.1 *b)*	Conventional fusing current					×																			
8.4.3.2	Rated current				×																				
8.4.3.3.1	Time-current characteristics, gates no. 3 a[2]	×													×										
	no. 4 a[2]		×													×									
	no. 5 a[2]			×													×								
8.4.3.3.2	Gates "g" fuse-links *a)* I_{min} (10 s)										×														
	b) I_{max} (5 s)											×													
	c) I_{min} (0.1 s)												×												
	d) I_{max} (0.1 s)													×											
	Gates "a" fuse-links[5]																				×				
8.4.3.4	Overload																								×
8.4.3.5	Conventional cable overload protection								×																
8.4.3.6	Indicating device						×																		
	Striker						×	×																	
8.5 No. 1	Breaking capacity[1]						×											×							
8.6	Cut-off current characteristic[3]																								
8.7	I^2t characteristic[3]																								
8.8	Degree of protection[3]																								
8.9	Resistance to heat[3]																								
8.10	Non-deterioration of contacts[3]																								
8.11.1	Mechanical strength[3]																								
8.11.2.1	Freedom from season cracking[3] [4]													×											×
8.11.2.2	Resistance to abnormal heat and fire[3]																								
8.11.2.3	Resistance to rusting[3]																								

1) Valid also for cut-off characteristic (see Sub-clause 8.6).
2) As guidance for the manufacturer (see Sub-clause 8.4.3.3).
3) Test according to Sub-clauses 8.6 to 8.11 relating to fuse-systems which are mentioned in subsequent parts may be possible. Number of samples to be tested depends on system and material.
4) For fuse-links with current-carrying parts made of rolled copper alloy with less than 83% copper.

5) Values are given in subsequent parts.

TABLE VIIC

Survey of tests on fuse-links of rated currents between the largest and the smallest rated current of a homogeneous series and number of fuse-links to be tested

Test according to sub-clause		Numbers of tests "g" fuse-links							"a" fuse-links	
		1	2	3	1	1	1	1	3	
8.1.4	Dimensions	×	×						×	
8.1.5.1	Resistance	×	×	×	×	×	×	×	×	
8.4.3.1 *a)*	Conventional non-fusing current	×								
8.4.3.2	Rated current	×								
8.4.3.3.1	Time-current characteristics No. 4a	×								
8.4.3.3.2	Gates									
	a) I_{min} (10 s)				×					
	b) I_{max} (5 s)					×				
	c) I_{min} (0.1 s)						×			
	d) I_{max} (0.1 s)							×		
8.4.3.5	Conventional cable overload protection			×						

Note. – The tests according to Table VIIC may be performed at reduced voltages.

8.1.6 *Testing of fuse-holders*

The fuse-holders shall be subjected to the tests according to Table VIII.

TABLE VIII

Survey of complete tests on fuse-holders and number of fuse-holders to be tested

Test according to sub-clause		Number of tests fuse-holders			
		1	1	1	1
8.1.4	Dimensions	×		×	×
8.2	Insulating properties	×			
8.3	Temperature-rise and power acceptance		×		
8.5	Breaking capacity Test No. 1		×	×	
8.8	Degree of protection	×			
8.9	Resistance to heat			×	
8.10	Non-deterioration of contacts				×
8.11.1	Mechanical strength[1]		×		
8.11.2.1	Freedom from season cracking[1]	×			
8.11.2.2	Resistance to abnormal heat and fire				×
8.11.2.3	Resistance to rusting	×			

[1] For fuse-holders with current-carrying parts made of rolled copper alloy with less than 83% copper.

Note. – Additional tests relating to special fuse-systems which are mentioned in subsequent parts may be necessary. Number of samples depends on system and material.

8.2 *Verification of the insulating properties*

8.2.1 *Arrangement of the fuse-holder*

In addition to the conditions of Sub-clause 8.1.4:

The fuse-holder shall be fitted with fuse-links of the largest dimensions envisaged for the type of fuse-holder concerned.

When the fuse-base itself is depended upon for insulation, metal parts shall be placed at their fixing points in accordance with the conditions of installation of the fuse indicated by the manufacturer, and these parts shall be considered as part of the frame of the apparatus. Unless otherwise specified by the manufacturer, the fuse-base shall be fixed to a metal plate.

If the fuse-link is intended to be replaceable while live, the surfaces of the fuse-link, of the device for replacing it or of the fuse-carrier, if any, which may be touched in the course of a correct replacement are considered as forming part of the fuse. Thus, these surfaces, if of insulating material, shall be provided with metal coverings connected during the tests to the frame of the apparatus; if of metal, they shall be connected directly to the frame.

If additional insulating means, e.g. partition walls, are provided by the manufacturer, these insulating means shall be in position during the tests.

8.2.2 *Points of application of the test voltage*

The test voltage shall be applied:

a) between live parts and the frame with the fuse-link and the device for replacing it or the fuse-carrier, if any, in position;

b) between the terminals when the fuse-link and the device for replacing it or the fuse-carrier, if any, are removed;

c) between live parts of different polarity in the case of a multipole fuse-holder with fuse-links of the maximum dimensions intended for that fuse-holder inserted and the device(s) for replacing the fuse-link(s) or the fuse-carrier(s), if any, in position;

d) between live parts which in the case of a multipole fuse-holder can reach different potentials after the fuse-link has operated, with the fuse-carrier(s) or the device(s) for replacing the fuse-link(s) alone (without fuse-links) in position.

8.2.3 *Value of test voltage*

The r.m.s. values of the power-frequency test voltage are shown in Table IX as a function of the rated voltage of the fuse-holder.

TABLE IX

Test voltage

Rated voltage U_n of the fuse-holder (V)		A.C. test voltage (r.m.s.) (V)
A.C. and D.C. currents	Up to and including 60	1 000
	61- 300	2 000
	301- 660	2 500
	661- 800	3 000
	801-1 000	3 500
D.C. only	1 001-1 200	3 500
	1 201-1 500	5 000

8.2.4 *Test method*

8.2.4.1 The test voltage shall be applied progressively and maintained at its full value given in Table IX for 1 min.

Note. - The test voltage source should have a short-circuit current of at least 0.1 A at the setting corresponding to the test voltage on open circuit.

8.2.4.2 The fuse-holder shall be subjected to humid atmospheric conditions.

The humidity treatment shall be performed in a humidity cabinet containing air with a relative humidity maintained between 91% and 95%.

The temperature of the air, at the place where the sample is located, shall be maintained within 2 K of any convenient value T between 20 °C and 30 °C.

Before being placed in the humidity cabinet, the sample shall be brought to a temperature differing from the above-mentioned value T by not more than + 2 K.

The sample shall be kept in the cabinet for 48 h.

Immediately after this treatment and after wiping off any drops of water that result from condensation, the insulation resistance shall be measured between the points prescribed in Sub-clause 8.2.2 by applying a d.c. voltage of approximately 500 V.

8.2.5 *Acceptability of test results*

8.2.5.1 Throughout the application of the test voltage, there shall be no breakdown of insulation or flashover. Glow discharges unaccompanied by a drop in voltage can be neglected.

8.2.5.2 The insulation resistance measured according to Sub-clause 8.2.4.2 shall be not less than 5 MΩ.

8.3 *Verification of temperature rise and power dissipation*

8.3.1 *Arrangement of the fuse*

One fuse shall be used for the test unless otherwise stated by the manufacturer.

The fuse shall be mounted in free air as specified in Sub-clause 8.1.4 in order to make sure that the test results are not influenced by particular conditions of installation.

The test shall be performed at an ambient air temperature of 20 ± 5 °C.

The connections on either side of each single fuse shall be not less than 1 m in length. In cases where it might be necessary or desirable to arrange more than one fuse in a combined test, the fuses may be connected in series. This would result in a total length of about 2 m between two fuse terminals in series. The cables should be as straight as possible. The cross-sectional area shall be selected in accordance with Table X. For rated currents up to 400 A, single-core copper-conductor cables insulated with black polyvinyl chloride (PVC) shall be used as connections. For rated currents of 500 A to 800 A either single-core copper conductors insulated with black PVC or bare copper bars may be used. For higher rated currents matt black painted copper bars only are used. Torques for the screws connecting the cables to the terminals are given in subsequent parts.

8.3.2 *Measurement of the temperature rise*

The values of the temperature rise given in Table IV for the contacts and terminals of the fuse shall be determined by means of measuring devices that appear most suitable, provided that the measuring device cannot appreciably influence the temperature of the fuse part. The method used shall be indicated in the test report.

8.3.3 *Measurement of the power dissipation of the fuse-link*

The fuse-link shall be mounted in the fuse-holder or test rig as specified in subsequent parts. The test arrangement shall be as specified in Sub-clause 8.3.1.

The power dissipation shall be measured in watts, the points between which the measurement is taken being chosen on the fuselink so as to give the maximum value. Points for the measurement are given in subsequent parts.

8.3.4 *Test method*

The tests (Sub-clauses 8.3.4.1 and 8.3.4.2) shall be continued until it becomes evident that the temperature rise would not exceed the specified limits if the tests were continued until a steady temperature were reached. A steady temperature shall be deemed to have been reached when the variation does not exceed 1 K per hour. The measurement shall be made during the last quarter hour of the test. It is permissible to make the test at reduced voltage.

8.3.4.1 *Temperature rise of the fuse-holder*

The test for temperature rise shall be made with a.c. by using a fuse-link which, at the rated current of the fuse-holder, attains a power dissipation equivalent to the rated acceptance of the fuse-holder or with a dummy fuse-link where specified in subsequent parts. The current applied shall be the rated current of the fuse-holder.

8.3.4.2 *Power dissipation of a fuse-link*

The test shall be made with a.c. at the rated current of the fuse-link.

TABLE X

Cross-sectional area of copper conductors for tests corresponding to Sub-clauses 8.3 and 8.4

Rated current (A)	Cross-sectional area (mm^2)
2	1
4	1
6	1
8	1.5
10	1.5
12	1.5
16	2.5
20	2.5
25	4
32	6
40	10
50	10
63	16
80	25
100	35
125	50
160	70
200	95
250	120
315	185
400	240
500	2 × 150 or 2 × (30 × 5)*
630	2 × 185 or 2 × (40 × 5)*
800	2 × 240 or 2 × (50 × 5)*
1 000	2 × (60 × 5)*
1 250	2 × (80 × 5)*

* Recommended cross-sectional areas for fuses designed to be connected to copper bars. The type and arrangement of the connections used shall be stated in the test report. For matt black painted bars: the distance between the two parallel bars of the same polarity should be approximately 5 mm.

Note. - The values given in Table X as well as the temperature-rise limits fixed in Table IV of Sub-clause 7.3, should be considered as a convention which is valid for the temperature-rise test specified in Sub-clause 8.3.4. A fuse used or tested according to conditions which correspond to a given installation may have connections of a type, nature and disposition which are different from these test conditions. In consequence, another temperature-rise limit may result, be required or accepted.

8.3.5 *Acceptability of test results*

The temperature rises shall not exceed the values specified in Table IV of Sub-clause 7.3.

The power dissipation of the fuse link shall not exceed its rated power dissipation or the value specified in subsequent parts. The power acceptance of the fuse-holder shall be not less than the rated power dissipation of the fuse-links intended to be used in that fuse-holder or the values specified in subsequent parts.

After the test, the fuse shall be in a satisfactory condition. In particular, the insulating parts of the fuse-holders shall withstand the test voltage according to Sub-clause 8.2 after having cooled down to ambient temperature (see Table IX); in addition, they shall not have suffered any deformation that would impair their correct operation.

8.4 *Verification of operation*

8.4.1 *Arrangement of the fuse*

The test arrangement is that specified in Sub-clause 8.1.4.

Length and cross-sectional area of conductors connected shall correspond to those specified in Sub-clause 8.3.1 and shall be selected according to the rated current of the fuse-base or fuse-holder. See Table X.

8.4.2 *Ambient air temperature*

The ambient air temperature during these tests shall be 20 ± 5 °C.

8.4.3 *Test method and acceptability of test results*

8.4.3.1 *Verification of conventional non-fusing and fusing current*

a) The fuse-link is subjected to its conventional non-fusing current (I_{nf}) for a time equal to the conventional time specified in Table II. It shall not operate during this time.

b) The fuse-link after having cooled down to ambient temperature is subjected to the conventional fusing current (I_f). It shall operate within the conventional time as specified in Table II.

8.4.3.2 *Verification of rated current of "g" fuse-links*

For the verification of the rated current of a fuse-link the following tests are performed, the fuse being mounted as specified in Sub-clause 8.4.1. It is permissible to make these tests at a reduced voltage.

One fuse-link is submitted to a pulse test for 100 h, in which the fuse-link will be cyclically loaded. Each cycle with an on-period of the conventional time and an off-period of 0.1 of the conventional time, the test current being equal to 1.05 of the rated current of the fuse-link. After the test the fuse-link shall not have changed its characteristics. Verification shall be carried out by the test as described in Item *a)* of Sub-clause 8.4.3.1.

8.4.3.3 *Verification of time-current characteristics and gates*

8.4.3.3.1 *Time-current characteristics*

The time-current characteristics may be verified on the basis of the results obtained from the oscillographic records taken during the performance of the tests according to Sub-clause 8.5.

The following periods are determined:

1) from the instant of closing the circuit until the instant when the voltage measurement shows the beginning of the arc;

2) from the instant of closing the circuit until the instant when the circuit is definitely broken.

The values of pre-arcing and operating times so determined, referred to the abscissa corresponding to the value of prospective current, shall be within the time-current zone indicated by the manufacturer, or specified in subsequent parts.

When for the fuse-links of a homogeneous series (see Sub-clause 8.1.5.2) the complete test according to Sub-clause 8.5 is only made on that fuse-link having the largest rated current, it shall be sufficient for the smaller current ratings to verify only the pre-arcing time. In this case, the supplementary tests shall be made at an ambient air temperature of 20 ± 5 °C and at the following values of prospective current only:

- for "g" fuse-links, with the exception of "gG" and "gM" as adequate tests are carried out in connection with verification of the gates (Sub-clause 8.4.3.3.2):

  test 3a) between 10 and 20 times;
  test 4a) between 5 and 8 times;
  test 5a) between 2.5 and 4 times the rated current of the fuse-link;

- for "a" fuse-links:

  test 3a) between 5 k_2 and 8 k_2 times;
  test 4a) between 2 k_2 and 3 k_2 times;
  test 5a) between k_2 and 1.5 k_2 times the rated current of the fuse-link (see Figure 2, page 101).

These supplementary tests may be performed at a reduced voltage. In this case, where the pre-arcing time exceeds 0.02 s, the value of the current measured during the test shall be considered to be the value of the prospective current.

8.4.3.3.2 *Verification of gates*

The following tests may be made at a reduced voltage. Additional to the above-mentioned tests the following shall be verified for "gG" and "gM" fuse-links.

a) A fuse-link is subjected to the current of Table III, column 2 for 10 s. It shall not operate.

b) A fuse-link is subjected to the current of Table III, column 3. It shall operate within 5 s.

c) A fuse-link is subjected to the current of Table III, column 4 for 0.1 s. It shall not operate.

d) A fuse-link is subjected to the current of Table III, column 5. It shall operate within 0.1 s.

8.4.3.4 *Overload*

The test arrangement is the same as that for the temperature-rise test (see Sub-clause 8.3.1). Three fuse-links shall be submitted to 50 pulses having the same duration and the same test current.

For "g" fuse-link the test current shall be 0.8 times the current determined from the manufacturer's minimum pre-arcing time-current characteristics for a pre-arcing time of 5 s. The duration of each pulse shall be 5 s and the time interval between pulses shall be 20% of the conventional time specified in Table II.

For "a" fuse-links the test current shall be equal to $k_1 I_n \pm 2\%$. The pulse duration shall correspond to that indicated on the overload curve for $k_1 I_n$ as stated by the manufacturer. The intervals between pulses shall be 30 times the pulse duration.

This test may be carried out at a reduced voltage.

Note. – With the manufacturer's consent, the interval between pulses may be reduced.

After having been allowed to cool down to ambient air temperature, the fuse-links shall be subjected to a current equal to that used during the overload test. The pre-arcing time, when passing this current, shall be shown to lie within the manufacturer's time-current zone.

8.4.3.5 *Conventional cable overload protection* (for "gG" fuse-links only)

In order to verify that fuse-links are capable of protecting cables against overload, fuse-links are submitted to the following conventional test. Each fuse-link is mounted in its appropriate fuse-holder or test rig as specified in Sub-clause 8.4.1, but provided with PVC insulated copper conductors of a cross-sectional area as specified in Table XI. The fuse and the conductor connected to it shall be preheated with the rated current of the fuse-link for a time equal to the conventional time.

The test current is then increased to a value of 1.45 I_z (I_z being specified in Table XI). The fuse-links shall operate in a time less than the conventional time.

This test may be carried out at a reduced voltage.

Note. - It is not necessary to perform this test if the product 1.45 I_z is greater than the conventional fusing current.

TABLE XI

Table for test in Sub-clause 8.4.3.5

I_n of fuse-link (A)	Nominal cross-sectional area of copper conductors (mm^2)	I_z* (A)
12	1	15
16	1.5	19.5
20 and 25	2.5	26
32	4	35
40	6	46
50 and 63	10	63
80	16	85
100	25	112
125	35	138
160	50	168
200	70	213
250	120	299
315	185	392
400	240	461

* Current-carrying capacity I_z for two loaded conductors (see Table 52-C1/C of IEC Publication 364-5-523: Electrical Installations of Buildings, Part 5: Selection and Erection of Electrical Equipment. Chapter 52: Wiring Systems, Section 523: Current-carrying Capacities).

8.4.3.6 *Operation of indicating devices and strikers, if any*

The correct operation of indicating devices is verified in combination with the verification of breaking capacity (see Sub-clause 8.5.5).

For verifying the operation of strikers, if any, an additional test sample shall be tested at a current:

- I_4 (see Table XIIA and XIIB) in the case of "g" fuse-links;
- $2k_1I_n$ in the case of "a" fuse-links (see Figure 2, page 101);

and at a recovery voltage of:

- 20 V for rated voltages not exceeding 500 V;
- 0.04 U_n for rated voltages exceeding 500 V.

The values of the recovery voltage may be exceeded by 10%.

The striker shall operate during all tests made at a recovery voltage of:

- at least 20 V.

If during one of these tests, the indicating device or striker fails, the test shall not be considered as negative on this account, if the manufacturer can furnish evidence that such failure is not typical of the fuse type, but it is due to a fault of the individual tested sample.

8.5 *Verification of the breaking capacity*

8.5.1 *Arrangement of the fuse*

The test arrangement is that specified in Sub-clause 8.1.4.

Suitable conductors shall be arranged for a length of approximately 0.2 m on either side of the complete fuse in the plane of the connecting device and in the direction of the connecting line between the terminals of the fuse. At this distance, they shall be rigidly supported. Beyond this point, they shall be bent at right angles towards the back. This arrangement is considered to be met when using test rigs as specified in subsequent parts.

8.5.2 *Characteristics of the test circuit*

The test circuit is shown by way of example in Figure 4, page 103.

The test circuit shall be of the single-pole type, i.e. one fuse shall be tested at a voltage based on its rated voltage.

Note. – The single-phase test is deemed to give sufficient information also for application in three-phase circuits.

The source of energy supplying the test circuit shall be of sufficient power to enable the specified characteristics to be proved.

The source of energy shall be protected by a circuit-breaker or other suitable apparatus D; an adjustable resistor R in series with an adjustable inductor L shall allow the characteristics of the test circuit to be adjusted. The circuit shall be closed by means of a suitable apparatus C.

The values to be considered are indicated in Tables XIIA and XIIB.

- For a.c.:

When the rated frequency of the fuse is 50 Hz or 60 Hz or is not indicated (see Sub-clause 5.4), the test shall be made at a supply frequency between 45 Hz and 62 Hz. If other frequencies are indicated, the tests shall be performed at these frequencies with a tolerance of ±20%.

The inductor L shall be an air-cored inductor for tests Nos. 1 and 2.

The peak value of the power-frequency recovery voltage within the first full half-cycle after clearing and for the next five successive peaks shall correspond to the peak value relating to the r.m.s. value specified in Table XIIA.

- For d.c.:

Breaking capacity tests shall be made with d.c. on an inductive circuit with series resistance for the adjustment of the prospective current. The inductance can be made up by series and parallel connection of suitable inductance coils. They may have iron cores, provided they do not saturate during the test.

The time constant shall lie between the limits indicated in Table XIIB.

The mean value of d.c. recovery voltage during 100 ms after final arc extinction shall be not less than the value specified in Table XIIB.

8.5.3 *Measuring instruments*

The current trace shall be recorded by one of the measuring circuits O_1 of an oscillograph connected to the terminals of an appropriate measuring device. Another measuring circuit O_2 of the oscillograph shall be connected by means of resistors or a voltage transformer, as the case may be, to the terminals of the source of energy during the calibration test, and to the terminals of the fuse during the test of the latter.

The arc voltages occurring during tests Nos. 1 and 2 shall be measured by means of a measuring circuit (i.e. transducer, transmission and recording device) which has adequate sensitivity and frequency response. An oscillograph may be used provided it meets these requirements.

8.5.4 *Calibration of test circuit*

The test circuit shall be calibrated with a provisional connection A of a negligible impedance compared with that of the test circuit (see Figure 4, page 103) in place of the fuse to be tested.

The resistors R and the inductors L shall be so adjusted as to obtain at the desired instant the desired value of current and

- in the case of a.c., the desired power factor at a power-frequency recovery voltage 110^{+5}_{-0}% of the rated voltage of the fuse to be tested. The power factor shall be determined by one of the methods specified in Appendix A or by other methods giving improved accuracy;

- in the case of d.c., the desired time constant at a mean value of recovery voltage 115^{+5}_{-9}% of the rated voltage of the fuse to be tested.

Table XIIA

Values for breaking-capacity tests on a.c. fuses

		Test according to Sub-clause 8.5.5.1				
		No. 1	No. 2	No. 3	No. 4	No. 5
Power-frequency recovery voltage		110^{+5}_{-0} % of the rated voltage*				
Prospective test current	For "g" fuse-links	I_1	I_2	$I_3 = 3.2\, I_f$	$I_4 = 2.0\, I_f$	$I_5 = 1.25\, I_f$
	For "a" fuse-links			$I_3 = 2.5\, k_2\, I_n$	$I_4 = 1.6\, k_2\, I_n$	$I_5 = k_2\, I_n$
Tolerance on current		$^{+10}_{-0}$ %*	Not applicable	± 20%	$^{+20}_{-0}$ %	
Power factor		0.2–0.3 for prospective current up to and including 20 kA 0.1–0.2 for prospective current above 20 kA	Same range as used for test No. 1	0.3–0.5**		
Making angle after voltage zero		Not applicable	$0^{+20°}_{+0}$	Not specified		
Initiation of arcing after voltage zero***		For one test: 40°–65° For two more tests: 65°–90°	Not applicable	Not applicable		

* This tolerance may be exceeded with the manufacturer's consent.

** Power factors lower than 0.3 may be permitted with the manufacturer's consent.

*** Where difficulty is experienced in meeting the requirement for initiation of arcing between 40° and 65° after voltage zero, a test shall be performed with a making angle after voltage zero of $0^{+10°}_{-0}$.

If, on this test, arcing is initiated at an angle of more than 65° after voltage zero, then the test shall be accepted in lieu of that meeting the 40° to 65° requirements for start of arcing. Should, however, arcing be initiated at an angle of less than 40° after voltage zero, then the three tests specified in the table shall be achieved.

I_1: current which is used in the designation of the rated breaking capacity (see Sub-clause 5.7).

I_2: current which shall be chosen in such a manner that the test is made under conditions which approximate those giving maximum arc energy.

Note. – This condition may be deemed to be satisfied if the instantaneous value of the current at the beginning of arcing has reached a value between $0.60\sqrt{2}$ and $0.75\sqrt{2}$ times the prospective current (r.m.s. value of the a.c. component).

As a guide for practical application, the value of current I_2 may be found between three and four times the current (symmetrical r.m.s value) which corresponds to a pre-arcing time of one half-cycle.

I_3, I_4, I_5: the tests made with these test currents are deemed to verify that the fuse is able to operate satisfactorily in the range of small overcurrents.

I_f: conventional fusing current (see Sub-clause 8.4.3.1) for the conventional time indicated in Table II of Sub-clause 5.6.2.

k_2: see Figure 2, page 101.

TABLE XIIB

Values for breaking-capacity tests on d.c. fuses

	Test according to Sub-clause 8.5.5.1				
	No. 1	No. 2	No. 3	No. 4	No. 5
Mean value of recovery voltage*	115^{+5}_{-0}% of the rated voltage**				
Prospective test current	I_1	I_2	$I_3 = 3.2\, I_f$	$I_4 = 2.0\, I_f$	$I_5 = 1.25\, I_f$
Tolerance on current	$^{+10}_{-0}$% **	Not applicable	± 20%	$^{+20}_{-0}$%	
Time constant**	15 ms to 20 ms				

*This tolerance includes ripple.
**With the manufacturer's consent this value may be exceeded.

I_1: current which is used in the designation of the rated breaking capacity (see Sub-clause 5.7).
I_2: current which shall be chosen in such a manner that the test is made under conditions which approximate those giving maximum arc energy.

Note. – This condition may be deemed to be satisfied if the current at the beginning of arcing has reached a value between 0.5 and 0.8 times the prospective current.

I_3, I_4, I_5: the tests made with these test currents are deemed to verify that the fuse is able to operate satisfactorily in the range of small overcurrents.
I_f: conventional fusing current (see Sub-clause 8.4.3.1) for the conventional time indicated in Table II of Sub-clause 5.6.2.

The value of the time constant is deemed to be given by the abscissa OA (see Figure 6a, page 105) of the point of the current trace corresponding to 0.632 I.

Where iron core inductors are used, the above indicated method may give misleading results due to residual magnetism of the core. In such cases the inductor may be energized at the required test current via a series resistor and the inductor short-circuited via the test-circuit to measure the time taken for the current to fall to 0.368 I. The supply circuit must be disconnected immediately after the inductor is short-circuited.

The test circuit may be calibrated at reduced voltage, provided that the ratio between the voltage and the current in the test circuit is ensured.

The circuit shall be prepared by closing the apparatus D, the time lag of which is so adjusted as to allow an approximately steady value of current to be reached before it opens; apparatus C shall then be closed and the current trace recorded by measuring circuit O_1, and the voltage trace before the closing of apparatus C and after the opening of apparatus D recorded by measuring circuit O_2.

The value of current shall be computed from the oscillogram in Appendix A. Appendix A is given as an example.

8.5.5 *Test method*

8.5.5.1 In order to verify that the fuse-link satisfies the conditions of Sub-clause 7.5, tests Nos. 1 to 5 as described below shall be made with the values stated in Table XIIa for a.c. and in Table XIIB for d.c. (see Sub-clause 8.5.2), if not otherwise specified in subsequent parts.

Tests Nos. 1 and 2:

For each of these tests, three samples shall be tested in succession.

For a.c., if during test No. 1 the requirements of test No. 2 are met during one or more tests, then these tests need not be repeated as part of test No. 2.

For d.c., if during test No. 1 arcing commences at a current equal to or greater than 0.5 I_1, test No. 2 need not be performed.

For a.c., if the prospective current necessary to comply with the requirements of test No. 2 is greater than the rated breaking capacity, tests Nos. 1 and 2 shall be replaced by a test made with the current I_1, on six samples at six making angles which differ approximately 30° between each test.

To verify the peak withstand current of a fuse-holder test No. 1 shall be made on a complete assembly of fuse-base and fuse-link (see Sub-clause 8.1.6) without or with fuse-carrier, where applicable. For these tests the initiation of arcing should be between 65° and 90° after voltage-zero.

Tests Nos. 3 to 5:

For each of the tests, when performed with a.c., the closing of the circuit in relation to the passage of the voltage through zero may be at any instant.

If the testing arrangement does not permit the current to be maintained at the full voltage during all of the time required, the fuse may be pre-heated at reduced voltage by applying a current approximately equal to the value of the test current. In this case, switching over to the test circuit according to Sub-clause 8.5.2 shall take place before the arc is initiated, and the switching time T_1 (interval without current) shall not exceed 0.2 s. The time interval between reapplication of the current and beginning of arcing shall be not less than three times T_1.

8.5.5.2 For one of the three tests No. 2 and test No. 4, the recovery voltage shall be maintained at a value of

- 100^{+15}_{-0}% of the rated voltage for a.c.,
- 100^{+20}_{-0}% of the rated voltage for d.c.,

for at least:

- 30 s after operation of fuse-links not containing organic materials, in their body or filler;
- 5 min after operation of the fuse-links in all other cases, switching over to another source of supply being permitted after 15 s if the switching time (interval without voltage) does not exceed 0.1 s.

For all other tests, the recovery voltage shall be maintained at the same value for 15 s after operation of the fuse.

In a lapse of time of at least 6 min and maximum 10 min after operation (with the manufacturer's consent, shorter times are possible, if the fuse-link does not contain organic materials in its body or filler) the resistance between the contacts of the fuse-link shall be measured and noted.

8.5.6 *Ambient air temperature*

If the test results are also to be used for the verification of the time-current characteristics (see Sub-clause 8.4.3.3), the breaking-capacity tests shall be made at an ambient air temperature of 20 ± 5 °C.

If these limits cannot be adhered to, it is permissible to make the breaking-capacity tests at an ambient air temperature between − 5 °C and + 40 °C. In this case, however, tests Nos. 4 and 5 of Tables XIIA and XIIB shall be repeated at an ambient-air temperature of 20 ± 5 °C with reduced voltage in order to verify the pre-arcing time-current characteristics.

8.5.7 *Interpretation of oscillograms*

Figures 5 and 6 give, by way of example, the method of interpreting the oscillograms in the different cases.

The recovery voltage shall be determined from the oscillogram corresponding to the fuse tested and shall be evaluated as shown in Figures 5b and 5c (page 104) for a.c. and Figures 6b and 6c (page 105) for d.c.

The value of the a.c. recovery voltage shall be 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.

The value of the d.c. recovery voltage shall be measured as the mean value during the period of 100 ms after final arc extinction.

In order to determine the value of prospective current, the current trace obtained during the calibration of the circuit (Figure 5a for a.c. and Figure 6a for d.c.) shall be compared with that obtained in the breaking test (Figures 5b and 5c for a.c., Figures 6b and 6c for d.c.).

For a.c. the value of prospective current is the r.m.s. value of the alternating component of the calibration curve corresponding to the instant of initiation of the arc.

If the time between the instant when the circuit is closed and the instant when the arc is initiated is shorter than one-half cycle, the value of prospective current shall be measured after a time lapse equal to a half-cycle.

For d.c., where cut-off does not occur, the value of prospective current shall be measured from the calibration oscillogram at the instant corresponding to the initiation of the arc. Where ripple is present, the r.m.s. curve shall be drawn and the value of this curve corresponding to the instant of initiation of the arc is considered as the prospective current.

Where cut-off occurs, the value of prospective current is the maximum steady value obtained from the calibration oscillograms. Where ripple is present, the r.m.s. curve shall be drawn and the maximum value of this curve is considered as the prospective current.

8.5.8 *Acceptability of test results*

The arc voltage occurring during operation of the fuse-link in tests Nos. 1 and 2 shall not exceed the values stated in Sub-clause 7.5 (Table V).

The fuse-link shall operate without external effects or damage to the components of the complete fuse beyond those specified below.

There shall be no permanent arcing, flashover or any ejection of flames which may be dangerous to the surroundings.

After operation, the components of the fuse, with the exception of those intended to be replaced after each operation, shall not have suffered damage capable of hindering their further use.

Fuse-links shall not be so damaged that their replacement might be difficult or dangerous for the operator. The fuse-links or their parts may have changed their colour or may show cracks, provided that the fuse-link remains in one piece before its removal from the fuse-carrier or test rig.

The resistance between fuse-link contacts measured after each test (see Sub-clause 8.5.5.2) with a d.c. voltage of approximately 500 V shall be equal to at least:

- 50 000 Ω when the rated voltage of the fuse-link does not exceed 250 V;
- 100 000 Ω in all other cases.

8.6 *Verification of the cut-off current characteristic*

8.6.1 *Test method*

If the manufacturer has stated the cut-off current characteristic, this characteristic shall be verified for the prospective current in connection with test No. 1 (see Sub-clause 8.5), and the corresponding value shall be computed from the oscillograms.

8.6.2 *Acceptability of test results*

The values measured shall not exceed those indicated by the manufacturer (see Sub-clause 5.8.1).

8.7 *Verification of I^2t characteristics and overcurrent discrimination*

8.7.1 *Test method*

The I^2t characteristics indicated by the manufacturer shall be verified from the results of the breaking-capacity test or can be given by a calculation based on measured values taking into account service conditions (see Appendix B).

8.7.2 *Acceptability of test results*

The operating I^2t values measured shall not exceed the values indicated by the manufacturer or specified in subsequent parts. The pre-arcing I^2t values shall be not less than the minimum pre-arcing values given by the manufacturer or they shall lie within the limits indicated in Table VI (see Sub-clause 5.8.2 and Appendix B).

8.7.3 *Verification of compliance for "gG" and "gM" fuse-links at 0.01s*

Compliance with Table VI is determined from the pre-arcing I^2t values obtained from the test duty I_2 and the pre-arcing I^2t values at 0.1 s.

The pre-arcing I^2t values for test duty I_2 for the smaller current ratings of a homogeneous series can be calculated from the formula given in Appendix B.

8.7.4 *Verification of overcurrent discrimination*

The discrimination of the fuse-links is verified by means of the time-current characteristics and the pre-arcing and operating I^2t values.

Note. – In most cases discrimination between "gG" and/or "gM" fuses occurs on prospective currents giving pre-arcing times greater than 0.01 s. Compliance with the values of pre-arcing I^2t given in Table VI is deemed to ensure a discrimination with ratio 1.6 to 1 between rated currents for these times.

8.8 *Verification of the degree of protection of enclosures*

If the fuse is fitted in an enclosure, the degree of protection as specified in Sub-clause 5.1.3 shall be verified under the conditions stated in IEC Publication 529.

8.9 *Verification of resistance to heat*

If not otherwise specified in subsequent parts the resistance to heat is judged by the results of all operating tests, in particular with respect to Sub-clauses 8.3 to 8.5 and 8.10.

8.10 *Verification of non-deterioration of contacts*

By means of a test representing severe service conditions it shall be verified that contacts do not deteriorate when left undisturbed in service for a long period.

8.10.1 *Arrangement of the fuse*

This test shall be performed on three samples. The test samples are arranged in the test circuit in such a way that they cannot influence each other. The test arrangement and the dummy fuse-links shall be the same as used for verification of temperature rise and power dissipation (see Sub-clauses 8.1.4, 8.3.1 and 8.3.4.1).

The samples are provided with standardized dummy fuse-links of the highest current rating intended to be used in the fuse-holder (see subsequent parts).

8.10.2 *Test method*

A test cycle consists of a load period and a non-load period referred to the conventional time. The test current for the load period and the non-load period are specified in subsequent parts.

The test samples are submitted to a first test of 250 cycles. If the test results are satisfactory after this, the test is stopped. If the test results exceed the specified limits, the test is continued up to 750 cycles.

Before the beginning of the cycling test, the temperature rise and/or the voltage drop of the contacts as specified in subsequent parts shall be measured at rated current when steady state conditions have been obtained. The test shall be repeated after 250 cycles and, if necessary, after 750 cycles.

If the fuses are so small that reliable measurements on the contacts could not be expected, the measurement at the terminals may be used as the criteria for the test.

8.10.3 *Acceptability of test results*

After 250 cycles, and if necessary, after 750 cycles, the measured values shall not exceed the limits given in subsequent parts.

8.11 *Mechanical and miscellaneous tests*

8.11.1 *Mechanical strength*

If not otherwise specified in the subsequent parts, the mechanical characteristics of a fuse and its parts are judged in the context of normal handling and mounting as well as with the results shown after the breaking-capacity test (Sub-clause 8.5).

8.11.2 *Miscellaneous tests*

8.11.2.1 *Verification of freedom from season cracking*

In order to verify that current-carrying parts made of rolled copper alloy with less than 83% copper content are free from season cracking, the following test is performed:

All grease is removed from 3 samples by immersing them for 10 min in a suitable solution (e.g. CH_2Cl_2 or C_2Cl_4). Fuse-links are tested individually, while fuse-holders are only tested with the complete fuse.

The samples shall be placed for 4 h in a test cabinet having a temperature of 30 ± 10 °C.

After this, samples are placed for 8 h in a test cabinet, on the bottom of which is an ammonium chloride solution having a pH value of 10–11.

For a 1 litre ammonium chloride solution the proper pH value may be achieved as follows:

> 107 g ammonium chloride (NH_4Cl p.a.) is mixed with 0,75 l of distilled water and made up to one litre by adding 30% sodium hydroxide (prepared from NaOH AR grade and distilled water). The pH value does not vary. The measurement of the pH value has to be made with a glass electrode.

The ratio of the volume of the test cabinet to that of the solution shall be 20:1.

The samples shall show no cracks visible to the unaided eye when any bluish film is removed by means of a dry cloth. Contact caps of fuse-links shall not be removable by hand.

8.11.2.2 *Verification of resistance to abnormal heat and fire*

If not otherwise specified in subsequent parts, the following applies: parts of insulating materials, except ceramic, not necessary to retain current-carrying parts in position even though they are in contact with them are tested according to Item *a)* of Sub-clause 8.11.2.2.5.

Note. – Enclosures which are a part of a fuse shall be tested in the same manner as the fuse. In other cases the enclosure is to be tested in accordance with IEC Publication 529.

Parts of insulating materials, except ceramic, necessary to retain current-carrying parts and parts of the earthing circuit, if any, in position are tested according to Item *b)* of Sub-clause 8.11.2.2.5.

8.11.2.2.1 *General description of the test*

The test is applied to ensure that:

- a specified loop of resistance wire, which is electrically heated to the temperature specified for the relevant equipment, does not cause ignition of parts of insulating material, or
- a part of insulating material, which might be ignited by the electrically heated test wire under defined conditions, has a limited duration of burning, without spreading fire by flames or burning droplets or glowing particles falling from the specimen.

The test is made on one specimen. In the case of doubt with regard to the results of the test, the test is repeated on two further specimens.

8.11.2.2.2 *Description of test apparatus*

The glow-wire consists of a specified loop of a nickel/chromium (80/20) wire; when forming the loop, care needs to be taken to avoid fine cracking at the tip.

A sheathed fine-wire thermocouple, having an overall diameter of 0.5 mm and wires of chromel and alumel with the welding point located inside the sheath, is used for measuring the temperature of the glow-wire.

The glow-wire, with the thermocouple, is shown in Figure 7, page 106.

The sheath consists of a metal resistant to a temperature of at least 960 °C. The thermocouple is arranged in a pocket hole, 0.6 mm in diameter, drilled in the tip of the glow-wire, as shown in detail Z of Figure 7. The thermovoltages shall comply with IEC Publication 584-1: Thermocouples, Part 1: Reference tables; the characteristics given in this publication are practically linear. The cold connection shall be kept in melting ice unless a reliable reference temperature is obtained by other means, for example, by a compensation box. The instrument for measuring the electromotive force of the thermocouple should be of class 0.5.

The glow-wire is electrically heated; the current necessary for heating the tip to a temperature of 960 °C is between 120 A and 150 A.

The test apparatus shall be so designed that the glow-wire is kept in a horizontal plane and that it applies a force of 1 N to the specimen, the force being maintained at this value when the glow-wire and the specimen are moved horizontally towards each other over a distance of at least 7 mm.

A piece of white pinewood board, approximately 10 mm thick and covered with a single layer of tissue paper, is positioned at a distance of 200 mm below the place where the glow-wire is applied to the specimen.

Tissue paper is specified in Clause 6.86 of ISO Standard 4046; as thin, soft, relatively tough paper generally intended for packing delicate articles, its substance being between 12 g/m² and 30 g/m².

An example of the test apparatus is shown in Figure 8, page 107.

8.11.2.2.3 *Pre-conditioning*

The specimen is stored for 24 h in an atmosphere having a temperature between 15 °C and 35 °C and a relative humidity between 35% and 75% before starting the test.

8.11.2.2.4 *Test procedure*

The test apparatus is placed in a substantially draught-free dark room so that flames occurring during the test are visible.

Before starting the test, the thermocouple is calibrated at a temperature of 960 °C, which is carried out by placing a foil of silver, 99.8% pure, 2 mm square and 0.06 mm thick, on the upper face of the tip of the glow-wire.

The glow-wire is heated and a temperature of 960 °C is reached when the silver foil melts. After some time calibration has to be repeated to compensate for alterations in the thermocouple and in the connections. Care should be taken to ensure that the thermocouple can follow the movement of the tip of the glow-wire caused by thermal elongation.

For the test, the specimen is arranged so that the face in contact with the tip of the glow-wire is vertical. The tip of the glow-wire is applied to that part of the surface of the specimen which is likely to be subjected to thermal stresses occurring in normal use.

The tip of the glow-wire is applied at places where the section is thinnest, but not more than 15 mm from the upper edge of the specimen. This applies to cases where the areas subject to thermal stress during normal use of the equipment are not specified in detail.

If possible, the tip of the glow-wire is applied to flat surfaces and not to grooves, knock-outs, narrow recesses or sharp edges.

The glow-wire is electrically heated to the temperature specified which is measured by means of the calibrated thermocouple. Care must be taken to ensure that, before starting test, this temperature and the heating current are constant for a period of at least 60 s and that heat radiation does not influence the specimen during this period or during the calibration, for example, by providing an adequate distance or by using an appropriate screen.

The tip of the glow-wire is then brought into contact with the specimen and is applied as specified. The heating current is maintained during this period. After this period, the glow-wire is slowly separated from the specimen, avoiding any further heating of the specimen and any movement of air which might affect the result of the test.

The movement of the tip of the glow-wire into the specimen when pressed to it shall be mechanically limited to 7 mm.

After each test, it is necessary to clean the tip of the glow-wire of any residue of insulating material, for example by means of a brush.

8.11.2.2.5 *Severities*

a) The temperature of the tip of the glow-wire and the duration of its application to the specimen shall be 650 ± 10 °C and 30 ± 1 s.

b) The temperature of the tip of the glow-wire and the duration of its application to the specimen shall be 960 ± 10 °C and 30 ± 1 s.

Other test temperatures are specified in subsequent parts.

Note. – The values should be chosen from table "Severities" of IEC Publication 695-2-1: Fire Hazard Testing, Part 2: Test Methods – Glow-wire Test and Guidance.

8.11.2.2.6 *Observations and measurements*

During application of the glow-wire and during a further period of 30 s, the specimen, the parts surrounding the specimen and the layer of tissue paper placed below it shall be observed.

The time at which the specimen ignites and the time when flames extinguish during or after the period of application are noted.

The maximum height of any flame is measured and noted, the start of the ignition, which might produce a high flame for a period of approximately 1 s, being disregarded.

The height of flame denotes the vertical distance measured between the upper edge of a glow-wire, when applied to the specimen, and the visible tip of the flame.

The specimen is considered to have withstood the glow-wire test:

- if there is no visible flame and no sustained glowing, or
- if flames or glowing of the specimen extinguish within 30 s after removal of the glow-wire.

There shall be no burning of the tissue paper or scorching of the pinewood board.

8.11.2.3 *Verification of resistance to rusting*

All grease is removed from the parts to be tested, by immersion in trichloroethane or an equivalent degreasing agent, for 10 min. The parts are then immersed for 10 min in a 10% solution of ammonium chloride in water at a temperature of 20 ± 5 °C.

Without drying, but after shaking off any drops, the parts are placed for 10 min in a box containing air saturated with moisture at a temperature of 20 ± 5 °C.

After the parts have been dried for 10 min in a heating cabinet at a temperature of 100 ± 5 °C, their surface shall show no signs of rust.

Traces of rust on sharp edges and any yellowish film removable by rubbing are ignored.

For small springs and for inaccessible parts exposed to abrasion, a layer of grease may provide sufficient protection against rusting. Such parts are subjected to the test only if there is doubt about the effectiveness of the grease film, and the test is then made without previous removal of the grease.

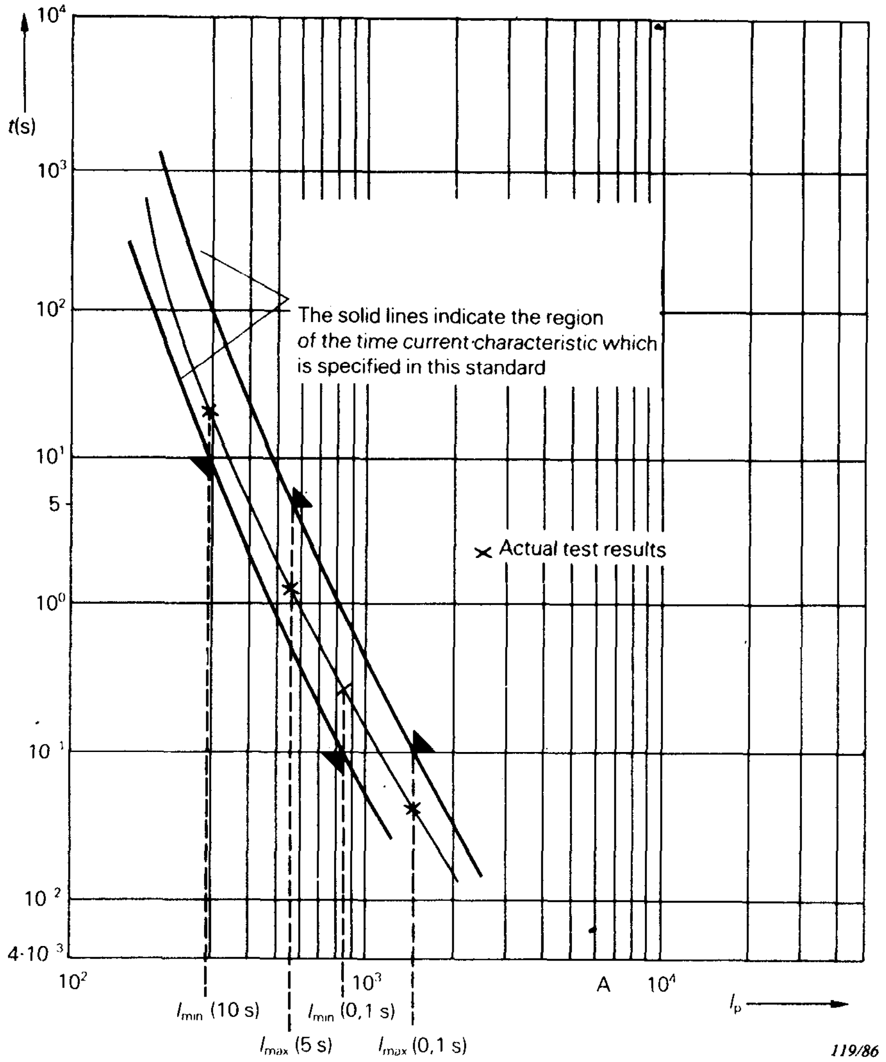
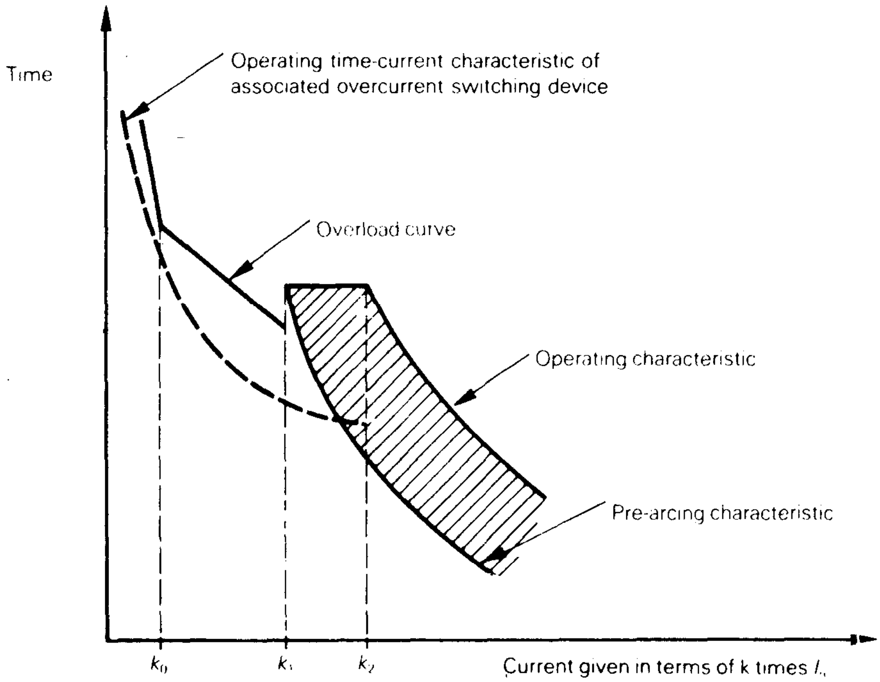
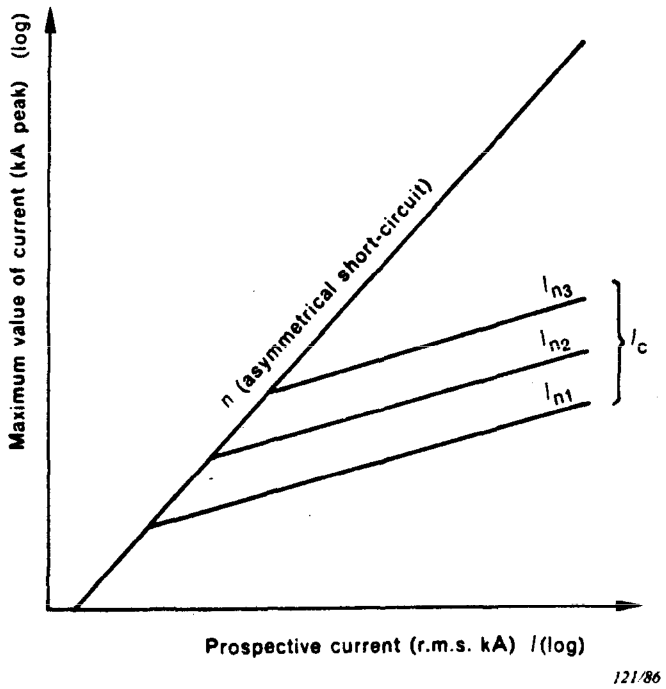


FIG. 1. - Diagram illustrating the means of verification of the time-current characteristic, using the results of the tests at the "gate" currents (example).



The overload curve between $k_0 \times I_n$ and $k_1 \times I_n$ corresponds to a constant I^2t value.

FIG. 2. - Overload curve and time-current characteristic for "a" fuse-links.

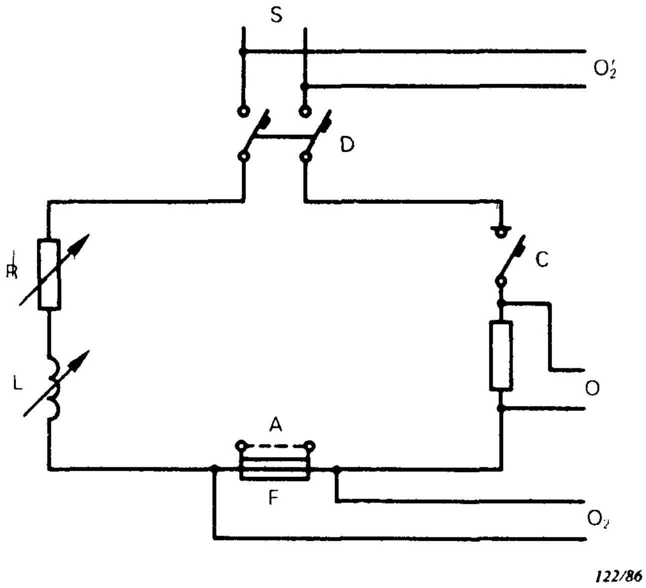


I_{n1}, I_{n2}, I_{n3} = rated currents of fuse-links

I_c = maximum value of cut-off current

n = factor depending on the value of the power factor

FIG. 3. - General presentation of the cut-off characteristics for a series of a.c. fuse-links.



A = removable link used for the calibration test

C = apparatus for closing the circuit

D = circuit breaker or other apparatus for protection of the source

F = fuse on test

L = adjustable inductor

O_1 = measuring circuit for recording the current

O_2 = measuring circuit for recording the voltage during the test

O′ = measuring circuit for recording the voltage during calibration

R = adjustable resistor

S = source of power

FIG. 4. – Typical diagram of the circuit used for breaking capacity tests (see Sub-clause 8.5).

Applied voltage for the calibration = B_{00}

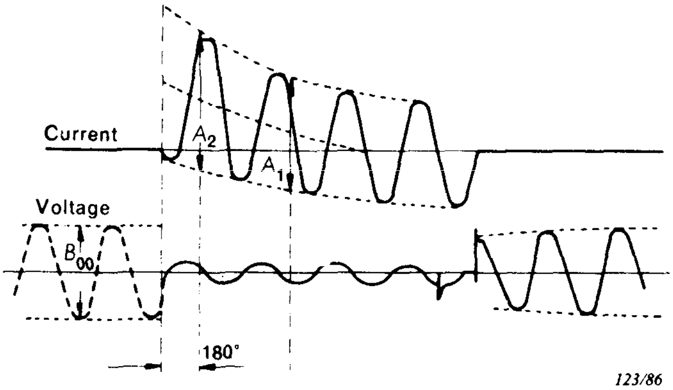


FIG. 5a. – Etalonnage du circuit.
Calibration of the circuit.

Current $I_{r.m.s.} = \frac{A_1}{2\sqrt{2}} \cdot \frac{B_0}{B_{00}}$

Recovery voltage $U_{r.m.s.} = \frac{B_1}{2\sqrt{2}}$

Applied test voltage = B_0

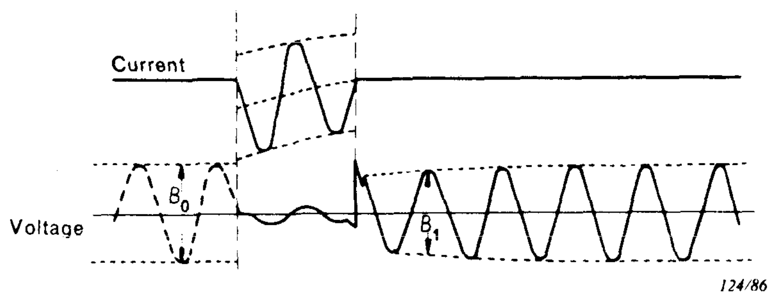


FIG. 5b. – Oscillogram corresponding to a breaking operation where the arc is initiated later than 180 electrical degrees after making

Current $I_{r.m.s.} = \frac{A_2}{2\sqrt{2}} \cdot \frac{B_0}{B_{00}}$

Recovery voltage $U_{r.m.s.} = \frac{B_2}{2\sqrt{2}}$

Applied test voltage = B_0

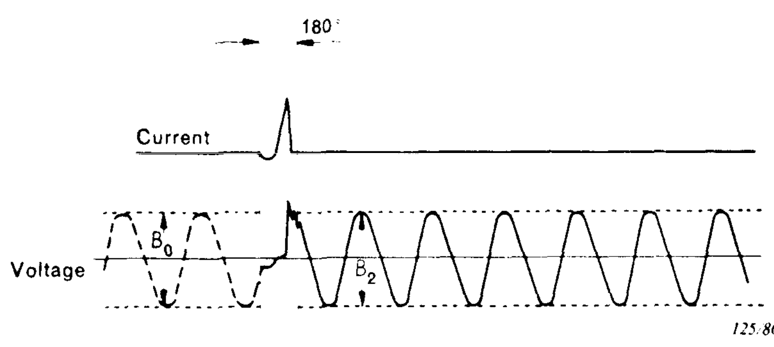
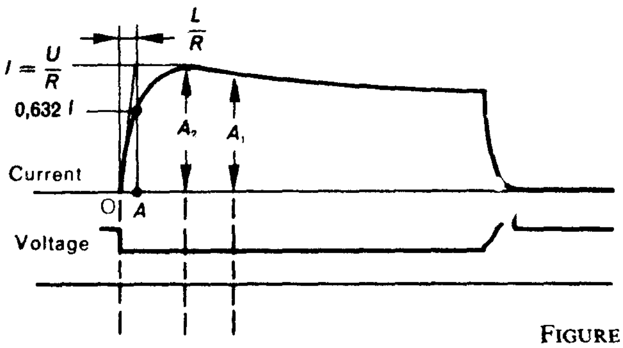


FIG. 5c. – Oscillogram corresponding to a breaking operation where the arc is initiated earlier than 180 electrical degrees after making.

FIG. 5. – Interpretation of oscillograms taken during the a.c. breaking-capacity tests (see Sub-clause 8.5.7).



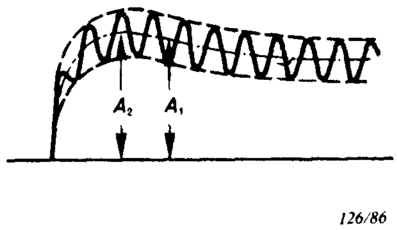
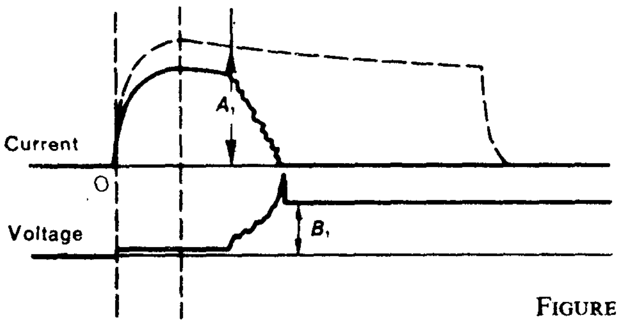


FIGURE 6a

Calibration of the circuit

Where ripples exist, the corresponding values 0.632 I, A_1, A_2 of the r.m.s. curve shall be measured.



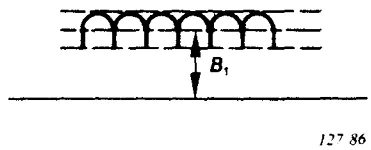
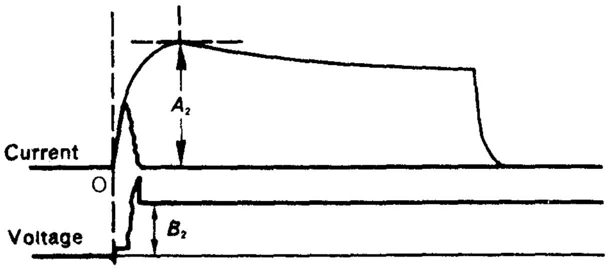


FIGURE 6b

Oscillogram corresponding to a breaking operation where the arc is initiated after the current has passed its maximum value.

Current $I = A_1$ at voltage $U = B_1$.

Where no steady value of voltage exists, the mean value during the period of 100 ms after final arc extinction shall be measured.



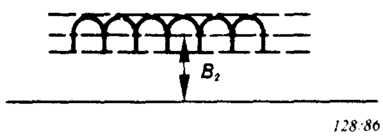


FIGURE 6c

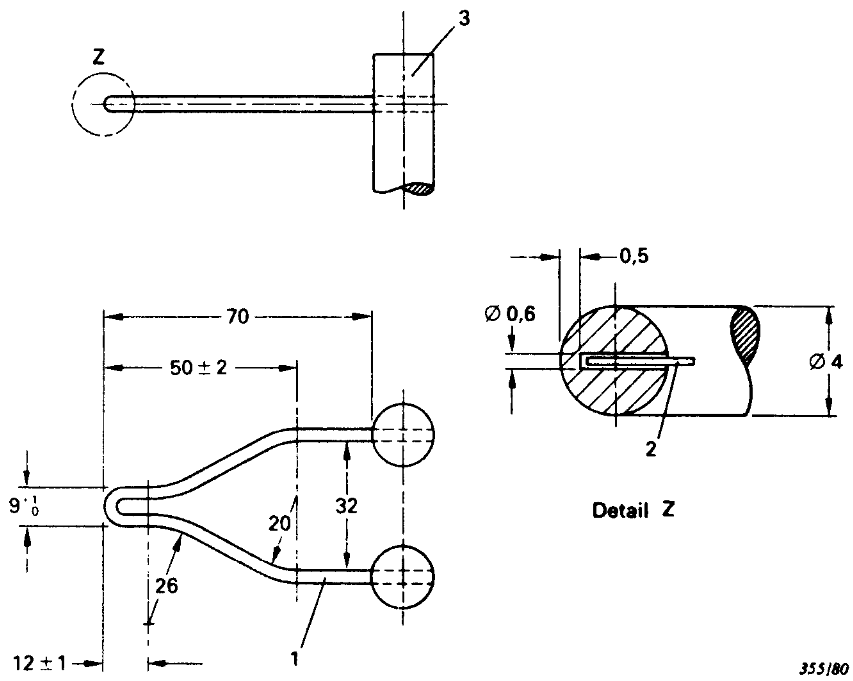
Oscillogram corresponding to a breaking operation where the arc is initiated before the current has reached its maximum value.

Current $I = A_2$ at voltage $U = B_2$.

Where no steady value of voltage exists, the mean value during the period of 100 ms after final arc extinction shall be measured.

FIG. 6. – Interpretation of oscillograms taken during the d.c. breaking-capacity tests (see Sub-clause 8.5.7).

Dimensions in millimetres

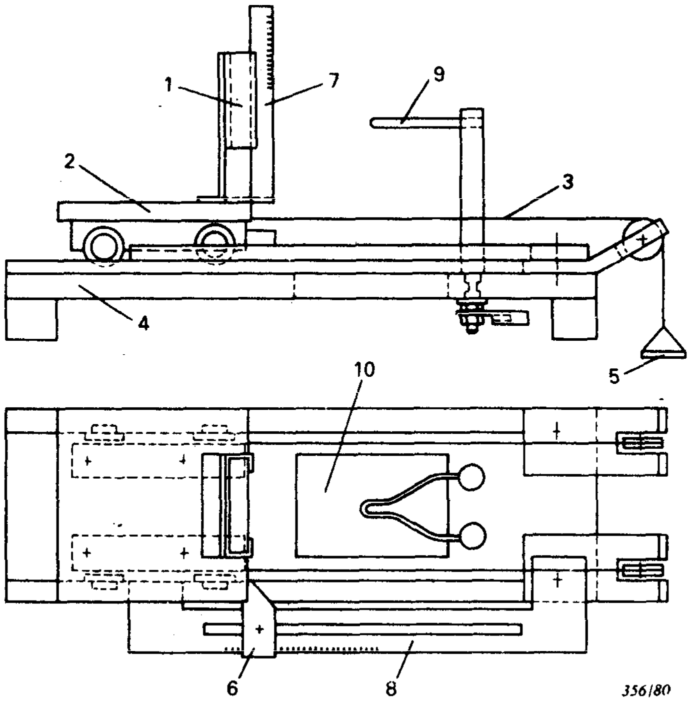


1 glow-wire hard soldered at 3

2 thermocouple

3 stud

FIG. 7. – Glow-wire and position of the thermocouple.



1 positioning clamp

2 carriage

3 tensioning cord

4 base plate

5 weight

6 adjustable stop

7 scale for measurement flame

8 scale for penetration measurement

9 glow-wire (fig. 7)

10 break-through in base plate for particles falling from the specimen

FIG. 8. – Test apparatus (example).

APPENDIX A

MEASUREMENT OF SHORT-CIRCUIT POWER FACTOR

There is no method by which the short-circuit power factor can be determined with precision, but for the purpose of this standard, the determination of the power factor in the test circuit may be made with sufficient accuracy by whichever of the three following methods is the more appropriate.

Method I: Calculation from circuit constants

The power factor may be calculated as the cosine of an angle φ where $\varphi = \text{arc tan } X/R$, X and R being respectively the reactance and resistance of the test-circuit during the period in which the short-circuit exists.

Owing to the transitory nature of the phenomenon, no accurate method can be given for determining X and R, but for compliance with this standard the values may be determined by the following method:

R is measured in the test circuit with direct current; if the circuit includes a transformer the resistance R_1 of the primary circuit and the resistance R_2 of the secondary circuit are measured separately and the required value R is then given by the formula:

$$R = R_2 + R_1 r^2$$

in which r is the ratio of transformation of the transformer

X is then obtained from the formula:

$$\sqrt{R^2 + X^2} = \frac{E}{I}$$

the ratio $\frac{E}{I}$ (circuit-impedance) being obtained from the oscillogram as indicated in Figure A1, page 111.

Method II: Determination from d.c. component

The angle φ may be determined from the curve of the d.c. component of the asymmetrical current wave between the incidence of short circuit and the beginning of arcing as follows:

1. The formula for the d.c. component is:

$$i_d = I_{do} \, e^{-Rt/L}$$

where:

i_d = value of the d.c. component at any instant
I_{do} = initial value of the d.c. component
L/R = time-constant of the circuit in seconds
t = time-interval, in seconds, between i_d and I_{do}
e = base of Napierian logarithms.

The time-constant L/R can be ascertained from the above formula as follows:

a) measure the value of I_{do} at the instant of short-circuit and the value of i_d at any other time t before beginning of arcing;
b) determine the value of $e^{-Rt/L}$ by dividing i_d by I_{do};
c) from a table of values of e^{-x} determine the value of $-x$ corresponding to the ratio i_d/I_{do};
d) the value x then represents Rt/L, from which R/L can be determined by dividing x by t, and so L/R is obtained.

2. Determine the angle φ from:

$$\varphi = \arc\tan \omega L/R$$

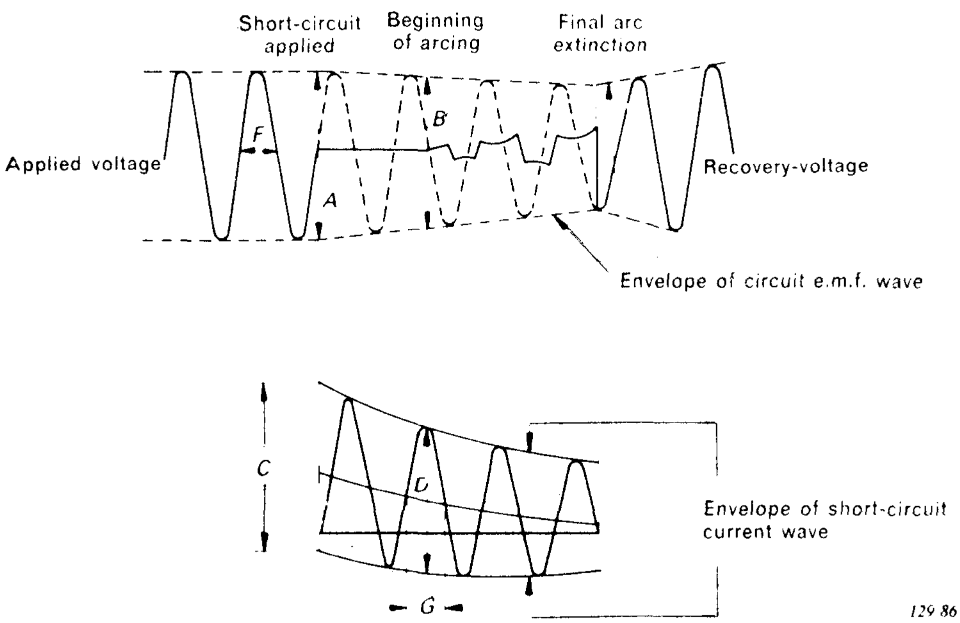
where ω is 2 π times the actual frequency.

This method should not be used when the currents are measured by current transformers.

Method III: Determination with pilot generator

When a pilot generator is used on the same shaft as the test generator, the voltage of the pilot generator on the oscillogram may be compared in phase first with the voltage of the test generator and then with the current of the test generator.

The difference in the phase angles between pilot generator voltage and main generator voltage on the one hand and pilot generator voltage and test generator current on the other hand gives the phase angle between the voltage and current of the test generator, from which the power factor can be determined.



$$\text{Circuit-impedance} = \frac{E}{I} = \frac{B}{D} = \frac{A}{C} \times \frac{F}{G}$$

where:

E = circuit e.m.f. at the beginning of arcing = $\frac{B}{2\sqrt{2}}$, expressed in volts

I = breaking current = $\frac{D}{2\sqrt{2}}$, expressed in amperes

A = twice the peak value of the applied voltage, expressed in volts

C = twice the peak value of the symmetrical component of the current wave at the beginning of the short-circuit, expressed in amperes

F = duration in seconds of one half-cycle of the applied voltage wave

G = duration in seconds of one half-cycle of the current wave at the beginning of arcing

FIG. A1. - Determination of circuit-impedance for calculation of power factor in accordance with method I.

APPENDIX B

CALCULATION OF PRE-ARCING I^2t VALUES FOR "gG" AND "gM" FUSE-LINKS

B1. Evaluation of the pre-arcing I^2t at 0.01 s

The approximate evaluation of the pre-arcing I^2t values at 0.01 s as a function of the value of pre-arcing I^2t at 0.1 s and measured values at Test No. 2 is possible by means of the following formula:

$$I^2t_{(0.01\ s)} = F\sqrt{I^2t_{(0.1\ s)} \cdot I^2t\ \text{(Test No. 2)}}$$

$F = 0.7$

The factor F corrects the curvature in the time-current characteristic in this region of time.

B2. Calculation of the value of pre-arcing I^2t under the conditions of Test No. 2

For smaller ratings of a homogeneous series where no direct tests are provided in the specification the evaluation of the value of pre-arcing I^2t under the condition of Test No. 2 is possible by means of the formula:

$$(I^2t)_2 = (I^2t)_1 \times \left(\frac{A_2}{A_1}\right)^2$$

where:

$(I^2t)_2$ = pre-arcing I^2t under the conditions of Test No. 2 for the smaller rating

$(I^2t)_1$ = pre-arcing I^2t under the conditions of Test No. 2 for the largest rating measured in the breaking-capacity tests

A_2 = minimum cross-sectional area of the element of smaller rating

A_1 = minimum cross-sectional area of the element of the largest rating

The calculated value can be used for the evaluation of the I^2t value at 0.01 s (see Clause B1).

APPENDIX C

CALCULATION OF CUT-OFF CURRENT-TIME CHARACTERISTIC

FOREWORD

Sub-clause 7.6 of this standard prescribes the cut-off characteristic as a function of the prospective current.

The following method constitutes a means by which the cut-off current characteristic may be calculated as a function of the actual pre-arcing time.

The result will be different for every fuse-link, and thus, for full interchangeability, calculations should be based upon the maximum I^2t values permitted in this standard. It should also be noted that the following method gives the peak current during the pre-arcing period, whereas for many fuses (especially the types for protection of semiconductors), the current continues to rise during the arcing period, and hence the following method will give a somewhat low estimate, dependent upon circuit conditions.

However, it is included as a good approximation which will enable a user to calculate these curves when necessary (e.g. for studies of contact welding).

C1. **Preliminary note**

The cut-off current characteristic as a function of prospective current is defined in Sub-clause 2.3.7; the characteristic is the subject of Sub-clause 5.8.1 and of Figure 3, page 102; the tests are described in Sub-clause 8.6.

The supply of this characteristic is not mandatory.

Moreover, the information that it gives is generally imprecise, especially in the zone at the beginning of the limitation (pre-arcing time of about 5 ms for symmetrical operation or up to 10 ms for asymmetrical operation).

Users who have to protect components (e.g. contactors) which withstand with difficulty currents of short duration and large amplitude (e.g. those which the fuses let through before clearance of the short-circuit) need to know with accuracy the maximum instantaneous value reached by the current during the breaking operation in order to make the most economical "fuse-component" association.

A characteristic which accurately gives the cut-off current as a function of the actual pre-arcing time provides more useful information for this purpose.

C2. **Definition**

Cut-off current characteristic as a function of actual pre-arcing time:
A curve giving cut-off current as a function of actual pre-arcing time for a symmetrical operation.

C3. **Characteristic**

If the cut-off current characteristic is indicated as a function of actual pre-arcing time, it shall be evaluated for symmetrical making current and shall be given according to the example shown in Figure C1, page 121, in a double logarithmic presentation with current as abscissa, and time as ordinate.

C4. **Test Condition**

The cut-off current corresponding to a given pre-arcing time depends also on the degree of asymmetry of the short-circuit, and since there are as many characteristics as making conditions an infinite number of tests would be required.

For a given fuse-link, in a given region of operating time, and for each value of cut-off current, the value I^2t is approximately independant of the degree of asymmetry of the short-circuit current.

This property makes the following procedure possible:

1) Measurement of the cut-off current characteristic for symmetrical operation as a function of the actual pre-arcing time for a symmetrical operation;

2) Calculation of the cut-off current characteristic corresponding to any degree of asymmetry.

C5. **Calculation from the measured values**

The experimental characteristic gives cut-off current as a function of pre-arcing time.

The short circuit being symmetrical, it is easy to calculate from the above values the prospective short-circuit current and the Joule integral.

Of:

ω: pulsation
I_p: prospective short-circuit current
I_{ps}: with symmetrical conditions
I_{pa}: with asymmetrical conditions
I_c: cut-off current
φ: phase of the current with respect to the voltage
ψ: making angle, with respect to the natural zero of the voltage

R, L: resistance and inductance symmetrical conditions
t_s: pre-arcing time with symmetrical conditions
t_a: pre-arcing time with asymmetrical conditions

With symmetrical conditions:

(1) $I_c = I_{ps}\sqrt{2}\sin\omega t_s$

(2) $\int I_c^2 dt = 2I_{ps}^2 \int_0^{t_s} \sin^2\omega t \, dt$

By definition : $\psi = 0$

The calculation is independant of the values of R, L, φ.

With asymmetrical conditions:

(3) $I_c = I_{pa}\sqrt{2}\,[\sin(\omega t_a + \psi - \varphi) - e^{-\frac{Rt_a}{L}}\sin(\psi - \varphi)]$

(4) $\int I^2 dt = 2I_{pa}^2 \int_0^{t_a} [\sin(\omega t + \psi - \varphi) - e^{-\frac{Rt}{L}}\sin(\psi - \varphi)]^2 dt$

Assuming that the cut-off current and the Joule integral are the same for both conditions

$$I_{ps}\sqrt{2}\sin\omega t_s \approx I_{pa}\sqrt{2}\,[\sin(\omega t_a + \psi - \varphi) - e^{-\frac{Rt_a}{L}}\sin(\psi - \varphi)]$$

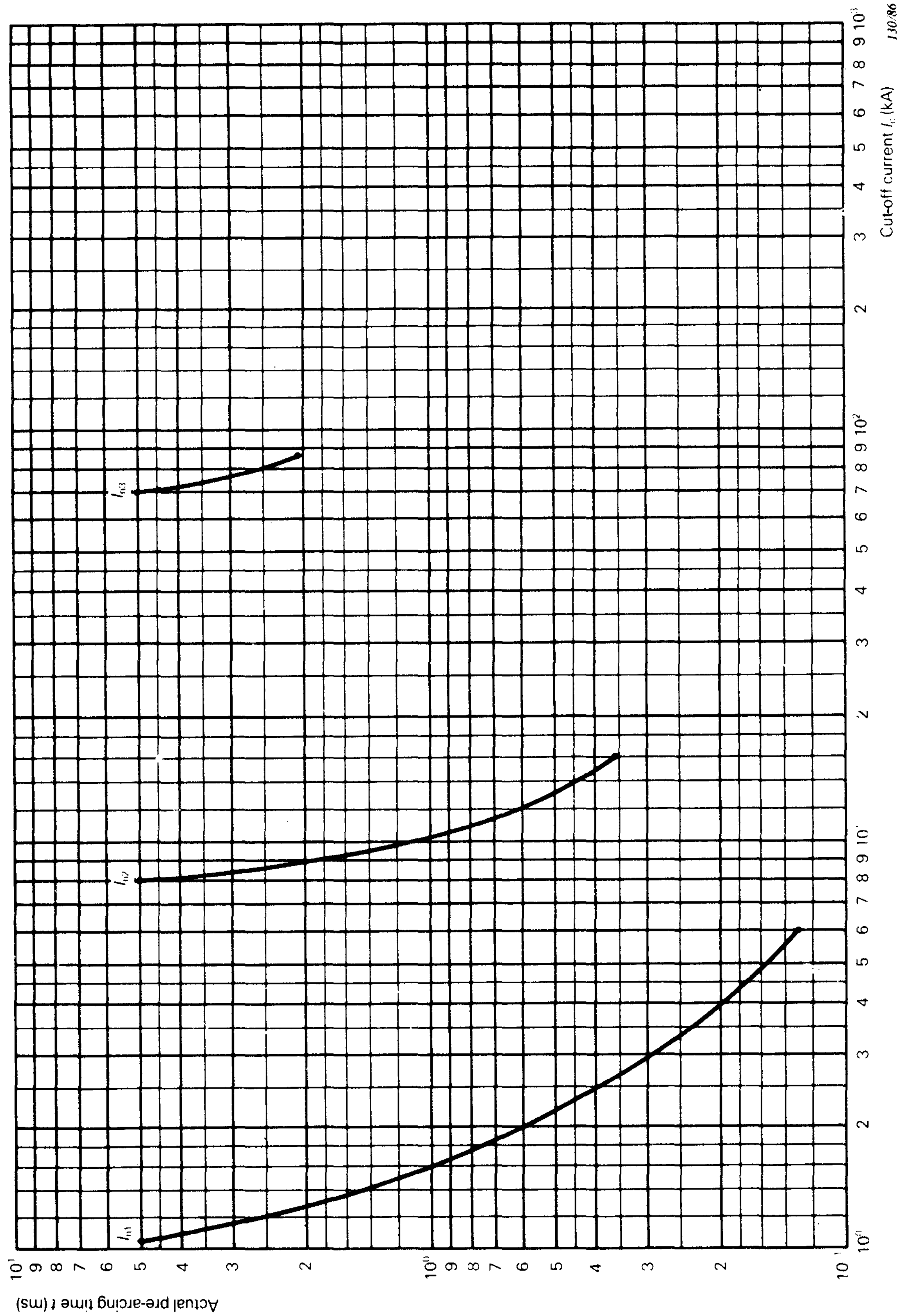
$$2I_{ps}^2\int_0^{t_a}\sin^2\omega t\,dt \approx 2I_{pa}^2\int_0^{t_a}[\sin(\omega t + \psi - \varphi) - e^{-\frac{Rt}{L}}\sin(\psi - \varphi)]^2 dt$$

it is possible to calculate any two values if the seven others are known.

In particular, from the value of cut-off current and Joule integral, obtained by experience and by calculation, it is possible to calculate the pre-arcing time and the prospective short-circuit current corresponding to imposed asymmetrical conditions.

This assumption is approximately true for pre-arcing times of the order of 1 to 5 ms.

For pre-arcing times inferior to 1 ms, the characteristic giving cut-off current as a function of prospective short-circuit current gives precise information.


130/86
Cut-off current I_c (kA)
Actual pre-arcing time t (ms)
I_{n1}
I_{n2}
I_{n3}

APPENDIX D

EFFECT OF CHANGE OF AMBIENT TEMPERATURE OR SURROUNDINGS ON THE PERFORMANCE OF FUSE-LINKS

D1. Effect of increase of ambient temperature

D1.1 *On current rating*

For fuse-links that operate at full load for long periods in an average ambient temperature above the value given in Sub-clause 3.1, a reduction of the current rating may be required. The de-rating factor should be as agreed by the manufacturer and the user after taking into account all the circumstances.

D1.2 *On temperature rise*

An increase in average ambient temperature causes a relatively small increase in temperature rise.

D1.3 *On conventional fusing and non-fusing current (I_f and I_{nf})*

An increase in average ambient temperature causes a decrease, usually small, in the fusing and non-fusing current (I_f and I_{nf}).

D1.4 *For motor starting conditions*

It is not necessary to de-rate fuse-links for increases in average ambient temperature of the fuse-link caused by the starting of a motor.

D2. Effect of decrease of ambient air temperature

A decrease in ambient air temperature below the value given in Sub-clause 3.1 may permit an increase in current rating but it may also cause an increase in the conventional fusing current, conventional non-fusing current and pre-arcing times for smaller over-currents. The magnitude of the relevant increases will be dependent upon the actual temperature and on the design of the fuse-link. In this case the manufacturer should always be consulted.

D3. Effect of installation conditions

Different installation conditions, such as:

a) enclosure in a box or mounting in the open,
b) the nature of the mounting surface,
c) the number of fuses mounted in a box,
d) the cross-section and insulation of connections

can affect the operating conditions and should be taken into account.

NATIONAL ANNEX

Clause	*Remarks*
3.1	Reference is invited to the following Indian Standards: IS 9676 : 1980 Reference ambient temperature for electrical equipment IS 10580 : 1983 Service conditions for electrical equipment
5.2 (Table I)	For the purpose of the Indian Standard, standard values of ac rated voltages fuses shall be selected from series II. The ratings 240 V, 415 V, 500 V and 660 V are preferred for ac. For dc, the values 110 V, 220 V, 440 V, 500 V, 600 V and 750 V are preferred.
8.3.1 (Table X)	*Connections for carrying out temperature-rise test* For the purpose of this Indian Standard, unless otherwise specified by the manufacturer, tests for temperature rise shall be made with aluminium conductor with cross-sections given in Table X A and Table X B. The test report shall clearly state the material, type and size of conductors used for connections.

Table X A Standard Cross-Section of Aluminium Conductors for Values of Test Current Up to and Including 400A

Range of Test Current (A)	AC Conductor Size mm²
0-8	1·5
8-12	1·5
12-15	2·5
15-20	4·0
20-25	6
25-32	10
32-50	16
50-65	25
65-85	35
85-100	50
100-115	50
115-130	70
130-150	70
150-175	95
175-200	150
200-225	150
225-250	185
250-275	240
275-300	240
300-350	240
350-400	300

NOTES

1 Connections shall be single-core, PVC insulated, aluminium cables or wires as indicated.

2 For single phase or multiphase tests the minimum length of each temporary connections from terminal to terminal or to the test supply or to a star point shall be:

— 1 m for cross-section up to and including 50 mm²

— 2 m for cross-sections larger than 50 mm².

Table X B Standard Test Connections for Test Currents Higher than 400A

Range of Test Current (A)	Aluminium Bars	
	Quality	Dimensions
400-500	2	32×8
500-630	2	40×8
630-800	2	50×8
800-1 000	2	50×10
1 000-1 250	2	63×12
1 250-1 600	4	50×8
1 600-2 000	3	100×10
2 000-2 500	4	100×10
2 500-3 150	4	150×10

NOTES

1 The connections shall be made with matt black finished aluminium bars of the sizes stated in Table X B.

2 The minimum length of each temporary connection from terminal to terminal shall be 2 m.

8.4.1 The cross-sectional area of conductors for the test for verification of operation shall be as given in Tables X A and X B.

8.4.3.5 (Table X I) The nominal cross-sectional area of conductors for aluminium shall be selected for the corresponding I_n as given in Table X A.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc : No. ET 39 (3680).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 323 01 31, 323 94 02, 323 33 75

Telegrams: Manaksanstha (Common to all offices)

Regional Offices:	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	323 76 17 323 38 41
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola CALCUTTA 700054	337 84 99, 337 85 61 337 86 26, 337 86 62
Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 38 43 60 20 25
Southern : C. I. T. Campus, IV Cross Road, CHENNAI 600113	235 02 16, 235 04 42 235 15 19, 235 23 15
Western : Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	832 92 95, 832 78 58 832 78 91, 832 78 92

Branches : AHMADABAD. BANGALORE. BHOPAL. BHUBANESHWAR. COIMBATORE. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. KANPUR. LUCKNOW. NAGPUR. PATNA. PUNE. THIRUVANANTHAPURAM.

Printed at New India Printing Press, Khurja, India