

High-voltage fuses —

Part 1: Current-limiting fuses

The European Standard EN 60282-1:1993 has the status of a British Standard

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Power Electrical Engineering Standards Committee (PEL/-) to Technical Committee PEL/78 upon which the following bodies were represented:

- Association of Supervisory and Executive Engineers
- ERA Technology Ltd.
- Electrical Installation Equipment Manufacturers' Association (BEAMA Ltd.)
- Electrical Power Engineers' Association
- Engineering Equipment and Materials Users' Association
- London Regional Transport
- National Economic Development Office

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- Association of Consulting Engineers
- Association of Short Circuit Testing Authorities
- Ministry of Defence

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National foreword

This revision of this Part of BS 2692 has been prepared under the direction of the Power Electrical Engineering Standards Committee, and covers current-limiting fuses for voltages exceeding 1 000 V a.c. It supersedes BS 2692-1:1975 which is withdrawn.

In 1993 the European Committee for Electrotechnical Standardization (CENELEC) accepted IEC 282-1:1985 as European Standard EN 60282-1:1993. As a consequence of implementing the European Standard this British Standard is renumbered as BS EN 60282-1:1993 and any reference to BS 2692-1:1986 should be read as a reference to BS EN 60282-1:1993.

It is identical with IEC Publication 282-1:1985, “*High-voltage fuses. Part 1: Current-limiting fuses*” incorporating Amendment No. 1:1988 published by the International Electrotechnical Commission (IEC).

Part 2 of BS 2692 covers requirements for expulsion fuses for voltages exceeding 1 000 V. Fuse links for the protection of semiconductor devices are covered by BS 88 “*Cartridge fuses for voltages up to and including 1 000 V a.c. and 1 500 V d.c.*” Part 4:1976 “*Supplementary requirements for fuse links for the protection of semiconductor devices*”. Fuses intended for the external protection of shunt power capacitors are covered by BS 5564:1978 “*Specification for high-voltage fuses for the external protection of shunt power capacitors*”.

Terminology and conventions. The text of the International Standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

The comma has been used in the data sheets in Appendix D and in Figure 4a as the decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Cross-references

International Standards	Corresponding British Standards
	BS 4727 <i>Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms</i>
IEC 50(151):1978	Part 1: <i>Terms common to power, telecommunications and electronics</i> Group 02:1980 <i>Electrical and magnetic devices terminology</i> (Technically equivalent)
IEC 50(441):1984	Part 2: <i>Terms particular to power engineering</i> Group 06:1985 <i>Switchgear and controlgear terminology</i> (including fuse terminology) (Technically equivalent)
	BS 923 <i>Guide on high-voltage testing techniques</i>
IEC 60-1:1973	Part 1:1980 <i>General</i> (Identical)
IEC 60-2:1973	Part 2:1980 <i>Test procedures</i> (Identical)
IEC 85:1984	BS 2757:1986 <i>Method for determining the thermal classification of electrical insulation</i> (Identical)
ISO 179:1982	BS 2782 <i>Methods of testing plastics</i> Method 359:1984 <i>Determination of Charpy impact strength of rigid materials</i> (Charpy impact flexural test) (Identical)

ISO R/442:1965

BS 131 *Methods for notched bar tests*
 Part 4:1972 *Calibration of pendulum impact testing machines for metals*
 (Technically equivalent)

The Technical Committee has reviewed the provisions of IEC 265-1, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. A related British Standard to IEC 265-1 is BS 5463:1977 "*Specification for a.c. switches of rated voltage above 1 kV*".

The Technical Committee has reviewed the provisions of IEC 420, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. The reference to IEC 56 in Appendix B is for information only.

Additional information. In 11.7, the duration of 1 min for power-frequency wet tests specified as European practice is appropriate. Similarly, in 18.6, the use of Table VI, based on European practice, rather than Table VII, based on North American practice, is appropriate for the selection of rated insulation; and in 18.9 the ratio of 2/1 for the basis of the logarithmic scales and the use of standardized paper A3 and A4 rather than the ratio 1/1 and the use of paper to the USA standard are appropriate for the presentation of time-current characteristics.

National appendix Z contains cross-references between the dimensional fuse reference letters in the withdrawn BS 2692-1:1975 and the dimensional data sheets in this edition of BS 2692-1.

The Technical Committee has decided to incorporate all the fuses in IEC Publication 282-1 into this Part of BS 2692 in order to maintain the identity between them. However, the fuses given in the first two tables of National appendix Z are considered to be preferred in the UK. The fuses with reference letters TA4, TA5 and TA6 are included in National appendix Z for information only and do not form part of this standard.

Fuses within the scope of this standard are not sensitive to normal electromagnetic disturbances, and therefore no immunity tests are required.

Significant electromagnetic disturbance generated by a fuse is limited to the instant of its operation. Provided that the maximum arc voltages during operation in the type test comply with the requirements of the clause in this standard specifying maximum arc voltage, the requirements for electromagnetic compatibility are deemed to be satisfied.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, the EN title page, pages 2 to 54, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Descriptors: Fuse, high voltage, current-limiting fuse, rating, condition of use, test, definition, application guide

English version

High-voltage fuses Part 1: Current-limiting fuses

(IEC 282-1:1985 + A1:1988 + A2:1992)

Fusibles à haute tension
Première partie: Fusibles limiteurs de courant
(CEI 282-1:1985 + A1:1988 + A2:1992)

Hochspannungssicherungen
Teil 1: Strombegrenzende Sicherungen
(IEC 282-1:1985 + A1:1988 + A2:1992)

This European Standard was approved by CENELEC on 1993-07-06. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

At the request of CENELEC Technical Committee TC 32A, High-voltage fuses, and as decided by the 73rd Technical Board, HD 492.1 S2:1989 (IEC 282-1:1985 + A1:1988) was submitted to the CENELEC voting procedure for conversion into a European Standard.

The CENELEC questionnaire procedure, performed for finding out whether or not the amendment 2:1992 to the International Standard IEC 282-1:1985 could be accepted without textual changes, has shown that no common modifications were necessary for the acceptance as a European Standard. The reference document was submitted to the CENELEC members for formal vote.

The documents were combined and approved by CENELEC as EN 60282-1 on 6 July 1993.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1994-03-01
- date of withdrawal of conflicting national standards (dow) 1994-03-01

For products which have complied with HD 492.1 S2:1989 and its amendment A1:1990 before 1994-03-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 1999-03-01.

Annexes designated “normative” are part of the body of the standard. In this standard, Annex ZA is normative.

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Section 1. General

1 Scope

This standard applies to all types of high-voltage current-limiting fuses designed for use outdoors or indoors on alternating current systems of 50 Hz and 60 Hz and of rated voltages exceeding 1 000 V. Some fuses are provided with fuse-links equipped with an indicating device or a striker. These fuses come within the scope of this standard, but the correct operation of the striker in combination with the tripping device of the switching device is outside the scope of this standard; see IEC Publication 420: High-voltage Alternating Current Fuse-switch Combinations and Fuse-circuit-breaker Combinations.

2 Conditions in normal service

Fuses complying with this standard are designed to be used under the following conditions:

- a) The maximum ambient air temperature is 40 °C and its mean measured over a period of 24 h does not exceed 35 °C.

The minimum ambient air temperature is – 25 °C.

NOTE This does not apply to time/current characteristics of fuses which will be modified appreciably at the minimum temperatures.

- b) The altitude does not exceed 1 000 m (3 300 ft).

NOTE 1 The rated voltages and insulation levels specified in this standard apply to fuses intended for use at altitudes not exceeding 1 000 m (3 300 ft). When fuses incorporating external insulation are required for use at altitudes above 1 000 m (3 300 ft) one or other of the following procedures should be adopted:

- 1) The test voltages for insulating parts in air should be determined by multiplying the standard test voltages given in Table VI and Table VII by the appropriate correction factor given in column (2) of Table I.
- 2) The fuses may be selected with a rated voltage which, when multiplied by the appropriate correction factor given in column (3) of Table I is not lower than the highest voltage of the system.

For altitudes between 1 000 m (3 300 ft) and 1 500 m (5 000 ft) and between 1 500 m (5 000 ft) and 3 000 m (10 000 ft), the correction factors can be obtained by linear interpolation between the values in Table I.

Table I

Maximum altitude m (ft) (1)	Correction factor for test voltages referred to sea level (2)	Correction factor for rated voltages (3)
1 000 (3 300)	1.0	1.0
1 500 (5 000)	1.05	0.95
3 000 (10 000)	1.25	0.80

Where the dielectric characteristics are identical at any altitude, no special precautions need to be taken.

NOTE 2 The rated current or the temperature-rise specified in this standard can be corrected for altitudes exceeding 1 000 m (3 300 ft) by using appropriate factors given in Table II, columns (2) and (3) respectively. Use one correction factor from columns (2) or (3), but not both, for any one application.

For altitudes between 1 000 m (3 300 ft) and 1 500 m (5 000 ft) and between 1 500 m (5 000 ft) and 3 000 m (10 000 ft), the correction factors can be obtained by linear interpolation, between the values in Table II.

Table II

Maximum altitude m (ft) (1)	Correction factor for rated current (2)	Correction factor for temperature-rise (3)
1 000 (3 300)	1.0	1.0
1 500 (5 000)	0.99	0.98
3 000 (10 000)	0.96	0.92

- c) The ambient air is not excessively (or abnormally) polluted by dust, smoke, corrosive or flammable gases, vapour or salt.

- d) For indoor installations, the conditions of humidity are under consideration but, in the meantime, the following figures can be used as a guide:

- the average value of the relative humidity, measured during a period of 24 h, does not exceed 95 %;
- the average value of the vapour pressure, for a period of 24 h, does not exceed 22 mbar;
- the average value of the relative humidity, for a period of one month, does not exceed 90 %;
- the average value of the vapour pressure, for a period of one month, does not exceed 18 mbar.

For these conditions, condensation may occasionally occur.

NOTE 1 Condensation can be expected where sudden temperature changes occur in periods of high humidity.

NOTE 2 To withstand the effects of high humidity and occasional condensation, such as breakdown of insulation or corrosion of metallic parts, indoor fuses designed for such conditions and tested accordingly or outdoor fuses may be used.

NOTE 3 Condensation may be prevented by special design of the building or housing, by suitable ventilation and heating of the station or by the use of dehumidifying equipment.

- e) Vibrations due to causes external to fuses or earth tremors are negligible.

Besides, for outdoor installations:

f) Account should be taken of the presence of condensation or rain and rapid temperature changes.

g) The wind pressure does not exceed 700 Pa (corresponding to 34 m/s wind speed).

h) The temperature due to sunlight does not exceed an equivalent black body temperature of 80 °C.

NOTE If the fuses are to be used under conditions different from those mentioned in Items a) to h) above, the manufacturer should be consulted.

Section 2. Definitions

[The reference numbers in brackets are those of IEC Publications 50(151)¹⁾ and 50(441)²⁾.]

3 Electrical characteristics

3.1

rated value (151-04-03)

a quantity value assigned, generally by a manufacturer, for a specified operating condition of a component, device or equipment

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

3.2

rating (151-04-04)

the set of rated values and operating conditions

3.3

prospective current (of a circuit and with respect to a fuse) (441-17-01)

the current that would flow in the circuit if the fuse were replaced by a conductor of negligible impedance

NOTE For the method to evaluate and to express the prospective current, see Sub-clauses 13.2.1 and 13.2.2.

3.4

prospective peak current (441-17-02)

the peak value of a prospective current during the transient period following initiation

NOTE The definition assumes that the current is made by an ideal switching device, i.e. with instantaneous transition from infinite to zero impedance. For circuits where the current can follow several different paths, for example polyphase circuits, it further assumes that the current is made simultaneously in all poles, even if only the current in one pole is considered.

3.5

prospective breaking current (441-17-06)

the prospective current evaluated at a time corresponding to the instant of the initiation of the breaking process

NOTE For the fuses, this instant is usually defined as the moment of the initiation of the arc during the breaking process. Conventions relating to the instant of the initiation of the arc are given in Sub-clause 13.2.3.

3.6

cut-off current (441-17-12)

let-through current

the maximum instantaneous value of current attained during the breaking operation of a fuse

NOTE This concept is of particular importance when the fuse operates in such a manner that the prospective peak current of the circuit is not reached.

3.7

breaking capacity (441-17-08)

a value of prospective current that a fuse is capable of breaking at a stated voltage under prescribed conditions of use and behaviour

3.8

pre-arcing time (441-18-21)

melting time

the interval of time between the beginning of a current large enough to cause a break in the fuse-element(s) and the instant when an arc is initiated

3.9

arcing time (441-17-37)

the interval of time between the instant of the initiation of the arc in a fuse and the instant of final arc extinction in that fuse

3.10

operating time (441-18-22)

total clearing time

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

3.11

I^2t ; Joule integral (441-18-23)

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

$$I^2t = \int_{t_0}^{t_1} i^2 dt$$

NOTE 1 The pre-arcing P^2t is the P^2t integral extended over the pre-arcing time of the fuse.

NOTE 2 The operating P^2t is the P^2t integral extended over the operating time of the fuse.

NOTE 3 The energy in joules liberated in one ohm (1 Ω) of resistance in a circuit protected by a fuse is equal to the value of the operating P^2t expressed in $A^2 \cdot s$.

¹⁾ Publication 50(151): International Electrotechnical Vocabulary (IEV), Chapter 151: Electrical and Magnetic Devices.

²⁾ IEC Publication 50(441): Chapter 441: Switchgear and Controlgear.

3.12**virtual time**

the value of the Joule integral divided by the square of the value of the prospective current

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

3.13**time-current characteristic (441-17-13)**

a curve giving the time, for example pre-arcing time or operating time, as a function of the prospective current under stated conditions of operation

3.14**cut-off (current) characteristic (441-17-14)****let-through (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 current are the maximum values which can be reached whatever the degree of asymmetry. In the case of d.c., the values of the cut-off current are the maximum values reached related to the time-constant as specified.

3.15**recovery voltage (441-17-25)**

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, followed by a second one during which the power frequency or the steady-state recovery voltage alone exists.

3.16**transient recovery voltage****(abbreviation T.R.V.) (441-17-26)**

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

NOTE 1 The transient recovery voltage may be oscillatory or non-oscillatory or a combination of these depending on the characteristics of the circuit and the fuse. It includes the voltage shift of the neutral point of a polyphase circuit.

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

3.17**power frequency recovery voltage (441-17-27)**

the recovery voltage after the transient voltage phenomena have subsided

3.18**D.C. steady-state recovery voltage (441-17-28)**

the recovery voltage in a d.c. circuit after the transient voltage phenomena have subsided, expressed by the mean value where ripple is present

3.19**prospective transient recovery voltage (of a circuit) (441-17-29)**

the transient recovery voltage following the breaking of the prospective symmetrical current by an ideal switching device

NOTE The definition assumes that the fuse, for which the prospective transient recovery voltage is sought, is replaced by an ideal switching device, i.e. having instantaneous transition from zero to infinite impedance at the very instant of zero current, i.e. at the "natural" zero. For circuits where the current can follow several different paths, for example a polyphase circuit, the definition further assumes that the breaking of the current by the ideal switching device takes place only in the pole considered.

3.20**short-circuit breaking power factor**

no definition at present

3.21**switching voltage (441-18-31)**

the maximum instantaneous value of voltage which appears across the terminals of a fuse during its operation

NOTE The switching voltage may be the arc voltage or may occur during the time of transient recovery voltage.

3.22**minimum breaking current (441-18-29)**

a minimum value of prospective current that a fuse-link is capable of breaking at a stated voltage under prescribed conditions of use and behaviour

3.23**power dissipation (of a fuse-link)**

the power released in a fuse-link carrying a stated value of current under prescribed conditions of use and behaviour

NOTE The prescribed conditions of use and behaviour usually include a constant r.m.s. value of current until steady temperature conditions are reached.

3.24**power acceptance of a fuse-base [fuse-holder]**

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

4 Fuses and their component parts**4.1****fuse (441-18-01)**

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

4.2**terminal**

a conducting part of a fuse provided for an 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.), but also according to their design (e.g. screw terminal, plug terminal, etc.).

4.3**fuse-base (441-18-02)****fuse-mount**

the fixed part of a fuse provided with contacts and terminals

NOTE The fuse-base comprises all the parts necessary for insulation. (See Figure 1, page 42.)

4.4**fuse-base contact (441-18-03)**

the contact piece of a fuse-base designed to engage with a fuse-carrier contact or with a fuse-link contact (See Figure 1.)

4.5**fuse-carrier (441-18-13)**

the movable part of a fuse designed to carry a fuse-link (See Figure 1.)

NOTE The fuse-carrier does not include the fuse-link.

4.6**fuse-carrier contact (441-18-05)**

the contact piece of a fuse-carrier designed to engage with a fuse-base contact (See Figure 1.)

4.7**fuse-holder (441-18-14)**

the combination of a fuse-base with its fuse-carrier

4.8**fuse-link (441-18-09)**

the part of a fuse [including the fuse-element(s)] intended to be replaced after the fuse has operated (See Figure 1.)

4.9**fuse-link contact (441-18-04)**

the contact piece of a fuse-link designed to engage with a fuse-base contact or with a fuse-carrier contact (See Figure 1.)

4.10**fuse-element (441-18-08)**

a part of the fuse-link designed to melt under the action of current exceeding some definite value for a definite period of time (See Figure 1.)

4.11**indicating device (441-18-17)****indicator**

a part of a fuse provided to indicate whether the fuse has operated (See Figure 1.)

4.12**striker (441-18-18)**

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

5 Additional terms**5.1****general Purpose fuse³⁾**

no definition at present

5.2**back-up fuse³⁾**

no definition at present

5.3**current-limiting fuse-link (441-18-10)**

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

5.4**isolating distance (for a fuse) (441-18-06)**

the shortest distance between the fuse-base contacts or any conductive parts connected thereto, measured on a fuse with the fuse-link or fuse-carrier removed

5.5**homogeneous series (of fuse-links) (441-18-34)**

a series of fuse-links, deviating from each other only in such characteristics that, for a given test, the testing of one or a reduced number of particular fuse-link(s) of that series may be taken as representative for all the fuse-links of the homogeneous series (See Sub-clause 13.3.1.)

5.6**external insulation**

the distances in atmospheric air and the surfaces in contact with atmospheric air of solid insulation of the equipment which are subject to dielectric stresses and to the effects of atmospheric and other external conditions such as pollution, humidity, vermin, etc.

³⁾ Term provisionally retained

Section 3. Ratings and standard conditions of use and behaviour

6 Ratings

6.1 Rated voltage

A voltage used in the designation of the fuse-base or fuse-link, from which the test conditions are determined.

NOTE This rated voltage is equal to the highest voltage for the equipment. (See Section 7.)

6.2 Rated current of the fuse-base

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

6.3 Rated current of the fuse-link

The current assigned to the fuse-link that a new clean fuse-link will carry continuously without exceeding specified temperature-rises when mounted on a fuse-base specified by the manufacturer and connected to the circuit with certain specified conductor sizes and lengths, at an ambient air temperature of not more than 40 °C. (See Section 7).

6.4 Rated frequency

The frequency for which the fuse has been designed and to which the values of the other characteristics correspond.

6.5 Rated breaking current

The value of breaking capacity specified for a fuse.

6.6 Rated insulation level (of a fuse-base)

The voltage values (both power-frequency and impulse) which characterize the insulation of the fuse-base with regard to its capability of withstanding the dielectric stresses (see Section 7).

6.7 Rated transient recovery voltage (rated T.R.V.)

The rated transient recovery voltage related to the rated breaking current (in accordance with Sub-clause 6.5) is the reference voltage which constitutes the upper limit of the prospective transient recovery voltage of circuits which the fuse shall be capable of breaking in the event of a short circuit.

6.7.1 Representation of T.R.V.

The waveform of transient recovery voltage varies according to the arrangement of the actual circuits.

For fuses covered by the scope of this standard, the transient recovery voltage approximates to a damped single-frequency oscillation. This waveform is adequately described by an envelope consisting of two line segments defined by means of two parameters (reference line)⁴⁾.

The influence of local capacitance on the source side of the fuse produces a slower rate-of-rise of the voltage during the first few microseconds of the T.R.V. This is taken into account by introducing a time delay.

This representation applies both to rated and to other specified transient recovery voltages which are represented by two parameter reference lines together with delay lines.

6.7.2 Representation of rated T.R.V.

The following parameters are used for the representation of the rated T.R.V. (see Figure 8, page 47):

u_c = T.R.V. peak voltage in kilovolts

t_3 = time in microseconds to voltage u_c

a delay line starting on the time axis at the rated time delay t_d running parallel to the first section of the reference line and terminating at a specified voltage u' (time co-ordinate t').

6.7.3 Standard values of rated T.R.V.

Standard values of rated T.R.V. are specified in Section 6. These values apply to the rated breaking current of a fuse.

7 Standard conditions of use and behaviour

7.1 Classes

Two classes of current-limiting fuses are defined according to the range in which they can be used: back-up fuses and general-purpose fuses.

7.1.1 General Purpose fuse⁵⁾

A current-limiting fuse capable of breaking, under specified conditions of use and behaviour, all currents from the rated breaking current down to the current that causes melting of the fuse-element in 1 h.

⁴⁾ See Appendix A.

⁵⁾ Term provisionally retained.

7.1.2 Back-up fuse⁶⁾

A current-limiting fuse capable of breaking, under specified conditions of use and behaviour, all currents from the rated breaking current down to the rated minimum breaking current.

Back-up fuses are generally associated with other apparatus such as a switch.

7.2 Breaking characteristics

7.2.1 General

When used in systems with service voltages less than the rated voltage of the fuse, the breaking capacity in kiloamperes is not less than the rated breaking current.

Current-limiting fuses should not be used in systems of voltages less than their rated voltage without regard to the switching-voltage produced by the fuse during operation in relation to the insulation level.

No tests have been specified to prove the performance of the fuse in the range of currents below that specified in the breaking tests in Section 4 with respect to its capability to with-stand the current of every possible time/current combination without deterioration leading to either premature operation or failure. (See Section 7.)

7.2.2 Standard conditions of use with respect to breaking capacity

Fuses shall be capable of breaking correctly any value of prospective current, irrespective of the possible d.c. component, provided that:

- the a.c. component is not lower than the minimum breaking current and not higher than the rated breaking current;
- the power-frequency recovery voltage is not higher than that specified in Table IV (for special conditions, see Sub-clause 22.5);
- the prospective transient recovery voltage is within the limits represented by the tests specified in Sub-clause 13.1.2;
- the frequency is between 48 Hz and 62 Hz;
- the power factor is not lower than that represented by the tests specified in Table IV;
- the prospective T.R.V. wave, while passing through the delay line and not recrossing it, does not exceed the reference line with the parameters specified in Sub-clause 13.1.2.

NOTE As regards the prospective T.R.V. characteristics, the time co-ordinate t_3 is not significant for the behaviour of fuses (except for those fuses, which cause high arc voltage peaks immediately after arc initiation; see Sub-clause 13.1.2.1).

7.2.3 Standard conditions of behaviour with respect to breaking capacity

According to the conditions of use indicated in Sub-clause 7.2.2, the behaviour of the fuse shall be as follows:

- a) A powder-filled fuse-link shall not emit flame or powder, although a minor emission of flame from a striker or indicating device is permissible, provided this does not cause breakdown or significant electrical leakage to earth.
 - b) After the fuse has operated, the components of the fuse, apart from those intended to be replaced after each operation, shall be in the original state. It shall be possible to remove the fuse-link in one piece after operation.
- However, it is permissible for the components designed to secure the fuse-element in renewable fuses to be slightly damaged, if such damage is not likely to prevent the replacement of the melted fuse-element, to decrease the breaking capacity of the fuse, to modify its operating characteristics, or to increase its temperature-rise in normal service.
- c) When fuse-links are provided with indicating devices or strikers:

- 1) indicating devices need not comply with specific requirements, but shall visually and fully operate;
- 2) strikers shall comply with the requirements specified in Sub-clause 18.13 and shall operate fully.

d) Operation shall not generate switching-voltages higher than the values specified in Sub-clause 18.8.

e) The values of cut-off current corresponding to each value of prospective breaking current shall not exceed the values corresponding to the cut-off characteristics given by the manufacturer.

f) After operation, the fuse shall be capable of withstanding the power-frequency recovery voltage across its terminals.

7.3 Time-current characteristics

The time-current characteristics of fuse-links are based on applying current to a new and unloaded fuse-link in a fuse-base specified by the manufacturer and connected to the test-circuit with conductor sizes and lengths as specified in Sub-clause 12.1.2.

Unless otherwise specified, the time-current characteristics shall be deemed to apply at an ambient air temperature of 20 °C.

⁶⁾ Term provisionally retained.

Section 4. Type tests

8 Conditions for making the tests

Type tests are made to check whether a type or particular design of fuse corresponds to the characteristics specified and functions satisfactorily under normal behaviour conditions or under special specified conditions. Type tests are made on samples to check the specified characteristics of all fuses of the same type.

These tests shall be repeated only if the construction is changed in a way which might modify the performance.

Tests made on fuse-links fitted with strikers are valid for fuse-links without strikers.

For convenience of testing, and with the previous consent of the manufacturer, the values prescribed for the tests, particularly the tolerances, can be so changed as to make the test conditions more severe. Where a tolerance is not specified, type tests shall be carried out at values not less severe than the specified values: the upper limits are subject to the consent of the manufacturer.

Tests specified in this standard are, in principle, type tests, and methods of sampling for acceptance tests are not given.

If the user wishes to make acceptance tests, these tests shall be selected from the type tests after agreement between manufacturer and user.

Where tests are made on a fuse whose report of type tests has already been accepted, the responsibility of the manufacturer to the user is limited to the least onerous of the specified values and not to the values obtained during the type tests.

For example, although breaking tests may have been made at 103 % of the specified power-frequency recovery voltage, nevertheless the manufacturer is not liable for any performance figures exceeding 100 % of the specified power-frequency recovery voltage.

9 List of type tests

The type tests to be conducted upon completion of a design or following a change that affects the performance are the following:

- dielectric tests;
- temperature-rise tests;
- breaking tests;
- tests for time-current characteristics;
- oil-tightness tests (only for fuses intended to be used in oil);
- test of strikers.

Before the tests are made, with the exception of dielectric and oil-tightness tests, the resistance of each fuse-link shall be measured with a current not exceeding 10 % of the rated current. The value of resistance shall be recorded together with the ambient air temperature at which the measurement was taken.

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

10 Common test practices for all type tests

The following shall be common test practices, unless otherwise specified.

10.1 Condition of device to be tested

The device shall be new, clean and in good condition.

10.2 Mounting of fuses

The fuse to be tested shall be mounted on a rigid earthed metal structure in the normal service position for which it is designed.

Unless otherwise specified, the connections shall be so positioned that the normal clearances are not reduced.

11 Dielectric tests

11.1 Test practices

Dielectric test practices shall be as specified in Clause 10 and as follows.

11.1.1 Mounting

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

11.1.2 Electrical connections

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

11.2 Application of test voltage for impulse and power-frequency tests

The test voltage specified in Table VI and Table VII for the fuse under test shall be applied successively with one terminal of the output of the impulse generator and one point of the power-frequency source connected to earth:

- a) Between terminals and all earthable metal parts:
 - 1) with the fuse including the fuse-link and its fuse-carrier completely assembled ready for service;
 - 2) with the fuse-link removed.

NOTE For multi-pole arrangements of fuses:

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

- b) Between terminals: these tests are made on fuse-bases only.

The earthable metal parts shall be connected to earth if isolating properties are not assigned to the fuses. If isolating properties are assigned to the fuse, earthable metal parts shall either be insulated from the earth or connected to the mid-point of the source.

NOTE For multi-pole arrangements of fuses, the terminals of one side should be connected together and the terminals of the opposite side should be connected together.

11.3 Atmospheric conditions during test

The test shall be made at atmospheric conditions as near as possible to the standard conditions specified in IEC Publication 60-1: High-voltage Test Techniques, Part 1: General Definitions and Test Requirements, Sub-clause 10.2.

The correction factors for air density and for air humidity as given in IEC Publication 60-1, Sub-clauses 10.3 and 10.4, may be used for fuses pending further information.

11.4 Test voltages

The test voltages to be used for the tests prescribed in Clause 11 shall be in accordance with those given in Section 6.

11.5 Lightning impulse voltage dry tests

Fuses shall be subjected to lightning impulse voltage dry tests with 1.2/50 impulses in accordance with IEC Publication 60-2: High-voltage Test Techniques, Part 2: Test Procedures, Section 4.

Fifteen consecutive impulses at the rated lightning impulse withstand voltages specified in Table VI and Table VII shall be applied as follows:

- at the rated withstand voltage to earth and between poles for all the test conditions a) of Sub-clause 11.2;
- at the rated withstand voltage to earth and between poles for the test condition b) of Sub-clause 11.2 if isolating properties are not assigned to the fuse-base;
- at the rated withstand voltage across the isolating distance for the test condition b) of Sub-clause 11.2 if isolating properties are assigned to the fuse-base.

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

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

11.6 Power-frequency voltage dry tests

Fuses shall be subjected to one-minute power-frequency voltage dry tests, as specified in IEC Publication 60-2, Section 3.

The test circuit (transformer with voltage-regulating device) shall have a short-circuit current of at least 0.2 A. It is permissible to check the magnitude of the current at approximately one-tenth of the specified voltage.

The values for the rated one-minute power-frequency withstand voltage tests are specified in Table VI and Table VII. The tests shall be made at the following values:

- at the rated withstand voltage to earth and between poles for all the test conditions a) of Sub-clause 11.2;
- at the rated withstand voltage to earth and between poles for the test conditions b) of Sub-clause 11.2 if isolating properties are not assigned to the fuse-base;
- at the rated withstand voltage across the isolating distance for the test condition b) of Sub-clause 11.2 if isolating properties are assigned to the fuse-base.

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

11.7 Power-frequency wet tests

Outdoor type fuses shall be subjected to power-frequency voltage wet tests under the same conditions as specified in Sub-clause 11.6 except for the duration, which is 1 min according to European practice and 10 s according to U.S.A. and Canadian practice. However, if a disruptive discharge on external self-restoring insulation occurs, this test shall be repeated with the same test conditions and the fuse shall be considered to have passed this test successfully if no further disruptive discharge occurs.

During these tests, the fuses shall be subjected to artificial rain at an angle of 45° to the vertical, the test procedure being in accordance with IEC Publication 60-1, Sub-clause 8.2.

12 Temperature-rise tests

12.1 Test practices

Temperature-rise tests shall be made as specified in Clause 10 on one fuse and as follows.

12.1.1 Test sample

The fuse-base shall be as specified by the manufacturer of the fuse-link being tested.

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

12.1.2 Arrangement of the equipment

The test shall be made in a closed room substantially free from air currents, except those generated by heat from the device being tested.

The fuse in air shall be mounted in the most unfavourable position within the instructions specified by the manufacturer and connected to the test circuit by bare copper conductors as follows: each conductor shall be approximately 1 m (3 ¼ ft) long, mounted in a plane parallel to the mounting surface of the fuse, but it may be in any direction in this plane. The sizes of the leads are given in Table III.

Oil-tight fuse-links for use in switchgear shall be tested in an oil-filled enclosure designed to simulate service conditions. The volume of this enclosure shall be about 30 times the volume of the fuse-link under test. The fuse-link shall be immersed in such a manner that the oil is equally distributed around the fuse-link. Appendix C gives an example of preferred testing arrangements for fuse-links up to 200 A in accordance with data sheet II of Appendix D. The test conductors external to the tank shall be arranged as given in the preceding paragraph, with the sizes as given in Table III.

Normal clearances need not be provided.

Tests shall be made with the rated current of the fuse-link and at a frequency between 48 Hz and 62 Hz. Each test shall be made over a period of time sufficient for the temperature rise to reach a constant value (for practical purposes, this condition is regarded as being obtained when the variation does not exceed 1 K per hour).

The temperature rise of the various parts of the fuse shall not exceed the specified values in Section 6.

12.2 Measurement of temperature

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

12.2.1 Temperature of fuse parts

The temperature of the various parts for which limits are specified shall be determined by devices such as thermocouples, thermometers or contact elements located and secured to provide good heat conduction at the hottest accessible spot. The temperature-rise shall be recorded at regular intervals throughout the test when the calculation of the thermal time constant is needed.

Table III

Current-rating of the fuse-link (A)	Size of bare copper conductors (mm ²)
Up to and including 25	From 20 to 30
Above 25 up to and including 63	From 40 to 60
Above 63 up to and including 200	From 120 to 160
Above 200 up to and including 400	From 250 to 350
Above 400 up to and including 630	From 500 to 600
Above 630 up to and including 1 000	From 800 to 1 000
NOTE 1 The equivalent area in MCM (one thousand circular mils) can be obtained by multiplying the above numbers in the second column by two.	
NOTE 2 For fuse-links in parallel, the current rating to be considered is the total current assigned by the manufacturer.	