

# High-voltage fuses —

## Part 1: Current-limiting fuses

The European Standard EN 60282-1:2006 has the status of a British Standard

ICS 29.120.50

# National foreword

This British Standard is the official English language version of EN 60282-1:2006. It is identical with IEC 60282-1:2005. It supersedes BS EN 60282-1:2002 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee PEL/32, Fuses, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this committee can be obtained on request to its secretary.

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## Summary of pages

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English version

**High-voltage fuses**  
**Part 1: Current-limiting fuses**  
(IEC 60282-1:2005)

Fusibles à haute tension  
Partie 1: Fusibles limiteurs de courant  
(CEI 60282-1:2005)

Hochspannungssicherungen  
Teil 1: Strombegrenzende Sicherungen  
(IEC 60282-1:2005)

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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.

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**CENELEC**

European Committee for Electrotechnical Standardization  
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Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

## Foreword

The text of document 32A/235/FDIS, future edition 6 of IEC 60282-1, prepared by SC 32A, High-voltage fuses, of IEC TC 32, Fuses, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60282-1 on 2006-03-01.

This European Standard supersedes EN 60282-1:2002.

The main changes introduced by this EN 60282-1:2006 are as follows:

- definition and dedicated test requirements for so-called "organic fuses";
- definition and requirements for maximum application temperature in order to cover applications in which the fuses are used in surrounding temperatures above 40 °C;
- clarification and improvements for testing fuses that exhibit a cross-over current;
- information about fuses operated in parallel.

The following dates were fixed:

- |                                                                                                                                          |       |            |
|------------------------------------------------------------------------------------------------------------------------------------------|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2006-12-01 |
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Annex ZA has been added by CENELEC.

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## Endorsement notice

The text of the International Standard IEC 60282-1:2005 was approved by CENELEC as a European Standard without any modification.

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## HIGH-VOLTAGE FUSES –

### Part 1: Current-limiting fuses

#### 1 General

##### 1.1 Scope

This part of IEC 60282 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 mechanism of the switching device is outside the scope of this standard; see IEC 62271-105.

##### 1.2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60071-1:1993, *Insulation coordination – Part 1: Definitions, principles and rules*

IEC 60085:2004, *Electrical insulation – Thermal classification*

IEC 60265-1:1998, *High-voltage switches – Part 1: Switches for rated voltages above 1 kV and less than 52 kV*

IEC 60549:1976, *High-voltage fuses for the external protection of shunt power capacitors*

IEC 60644:1979, *Specification for high-voltage fuse-links for motor circuit applications*

IEC 60787:1983, *Application guide for the selection of fuse-links of high-voltage fuses for transformer circuit applications*

IEC 62271-105:2002, *High-voltage switchgear and controlgear – Part 105: Alternating current switch-fuse combinations*

ISO 148-2:1998, *Metallic materials – Charpy pendulum impact test – Part 2: Verification of test machines*

ISO 179 (all parts), *Plastics – Determination of Charpy impact properties*

## 2 Normal and special service conditions

### 2.1 Normal service conditions

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 1 The time-current characteristics of fuses will be modified at the minimum and maximum temperatures.

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

NOTE 2 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.

- a) The test voltages for insulating parts in air should be determined by multiplying the standard test voltages given in Tables 4 and 5 by the appropriate correction factor given in column (2) of Table 1.
- b) The fuses may be selected with a rated voltage which, when multiplied by the appropriate correction factor given in column (3) of Table 1 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 1.

**Table 1 – Altitude correction factors – Test voltage and rated voltage**

| Maximum altitude<br>m<br>ft<br>(1) | Correction factor for<br>test voltages referred<br>to sea-level<br>(2) | Correction factor<br>for rated voltages<br>(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 3 The rated current or the temperature rise specified in this standard can be corrected for altitudes exceeding 1000 m (3300 ft) by using the appropriate factors given in Table 2, 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 2.

**Table 2 – Altitude correction factors – Rated current and temperature rise**

| Maximum altitude<br>m<br>ft<br>(1) | Correction factor<br>for rated current<br>(2) | Correction factor<br>for temperature rise<br>(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 hPa;
  - the average value of the relative humidity, for a period of one month, does not exceed 90 %;
  - the average value of the water vapour pressure, for a period of one month, does not exceed 18 hPa.

For these conditions, condensation may occasionally occur.

NOTE 4 Condensation can be expected where sudden temperature changes occur in periods of high humidity.

NOTE 5 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 6 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.

In addition, 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 solar radiation does not exceed 1,1 kW/m<sup>2</sup>.

## 2.2 Other service conditions

Fuse-links intended for use at surrounding temperatures (see 3.3.11) above 40 °C are covered in this standard in Annex E.

## 2.3 Special service conditions

By agreement between the manufacturer and the user, high-voltage fuses may be used under conditions different from the normal service conditions given in 2.1. For any special service condition, the manufacturer shall be consulted.

## 2.4 Environmental behaviour

Fuses complying with this standard are inert devices during normal service. It is also a requirement of 5.1.3 that no significant external emission takes place. Therefore, they are regarded as environmentally safe devices in service and operation.

# 3 Terms and definitions

For the purposes of this document, the following definitions apply.

## 3.1 Electrical characteristics

### 3.1.1

#### rated value

value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment, or system

[IEV 441-18-35 modified]

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

### 3.1.2

#### **rating**

set of rated values and operating conditions

[IEV 441-18-36]

### 3.1.3

#### **prospective current** (of a circuit and with respect to a fuse)

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

[IEV 441-17-01, modified]

NOTE For the method to evaluate and to express the prospective current, see 6.6.2.1 and 6.6.2.2.

### 3.1.4

#### **prospective peak current**

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.

[IEV 441-17-02]

### 3.1.5

#### **prospective breaking current**

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

[IEV 441-17-06]

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 6.6.2.3.

### 3.1.6

#### **breaking capacity**

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

[IEV 441-17-08, modified]

### 3.1.7

#### **cut-off current**

#### **let-through current**

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

[IEV 441-17-12, modified]

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.

### 3.1.8

#### **pre-arcing time**

#### **melting time**

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

[IEV 441-18-21]

**3.1.9****arcing time**

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

[IEV 441-17-37, modified]

**3.1.10****operating time****total clearing time**

sum of the pre-arcing time and the arcing time

[IEV 441-18-22]

**3.1.11****Joule integral** **$I^2t$** 

integral of the square of the current over a given time interval  $t_0 - t_1$

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

[IEV 441-18-23 modified]

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

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

NOTE 3 The energy in joules liberated in 1  $\Omega$  of resistance in a circuit protected by a fuse is equal to the value of the operating  $I^2t$  expressed in  $A^2 \times s$ .

**3.1.12****virtual time**

value of 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.

[IEV 441-18-37 modified]

**3.1.13****time-current characteristic**

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

[IEV 441-17-13]

**3.1.14****cut-off (current) characteristic****let-through (current) characteristic**

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 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.

[IEV 441-17-14]

### 3.1.15

#### **recovery voltage**

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.

[IEV 441-17-25, modified]

### 3.1.16

#### **transient recovery voltage**

##### **TRV**

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.

[IEV 441-17-26, modified]

### 3.1.17

#### **power-frequency recovery voltage**

recovery voltage after the transient voltage phenomena have subsided

[IEV 441-17-27]

### 3.1.18

#### **prospective transient recovery voltage** (of a circuit)

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.

[IEV 441-17-29, modified]

### 3.1.19

#### **switching voltage**

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.

[IEV 441-18-31]

### 3.1.20

#### **minimum breaking current**

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

[IEV 441-18-29]

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

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

[IEV 441-18-38]

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

**3.2 Fuses and their component parts****3.2.1****fuse**

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

[IEV 441-18-01]

**3.2.2****terminal**

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 (for example, main terminal, earth terminal, etc.), but also according to their design (for example, screw terminal, plug terminal, etc.).

**3.2.3****fuse-base****fuse-mount**

fixed part of a fuse provided with contacts and terminals

[IEV 441-18-02]

NOTE The fuse-base comprises all the parts necessary for insulation (see Figure 1).

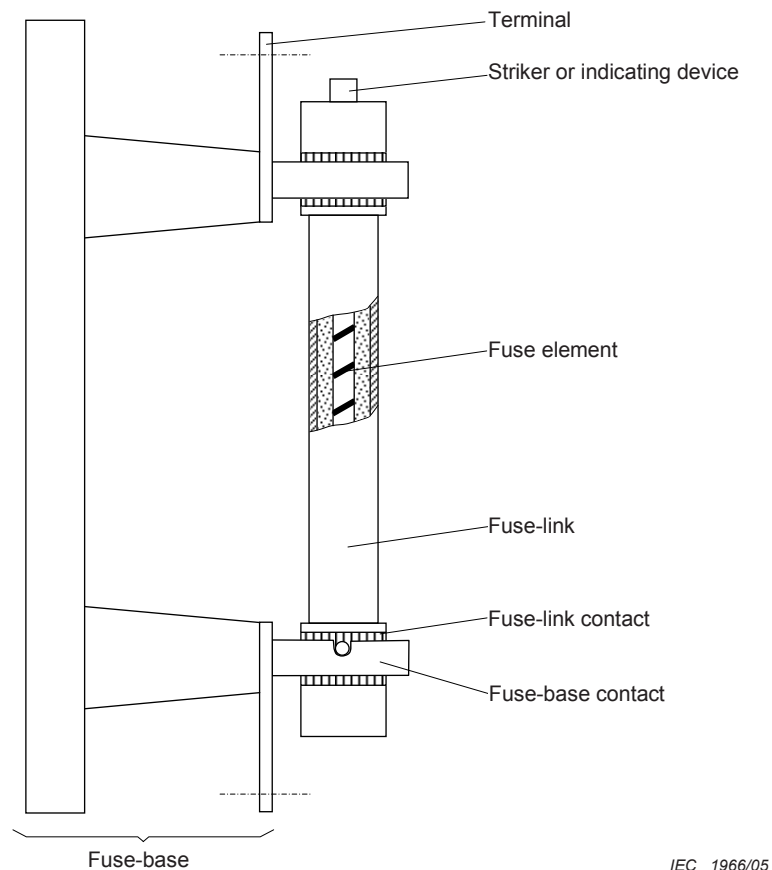


**Figure 1 – Terminology**

### 3.2.4

#### **fuse-base contact**

contact piece of a fuse-base designed to engage with a fuse-link contact (see Figure 1)

[IEV 441-18-03, modified]

### 3.2.5

#### **fuse-link**

part of a fuse (including the fuse element(s)) intended to be replaced after the fuse has operated (see Figure 1)

[IEV 441-18-09]

### 3.2.6

#### **fuse-link contact**

contact piece of a fuse-link designed to engage with a fuse-base contact (see Figure 1)

[IEV 441-18-04, modified]

### 3.2.7

#### **fuse-element**

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)

[IEV 441-18-08]

**3.2.8****indicating device  
indicator**

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

[IEV 441-18-17]

**3.2.9****striker**

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

[IEV 441-18-18]

**3.3 Additional terms****3.3.1****current-limiting fuse**

fuse 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

[IEV 441-18-10, modified]

**3.3.2****classes**

three classes of current-limiting fuses are defined according to the range in which they can be used:

- back-up fuses
- general-purpose fuses
- full-range fuses

See 9.3.3.

**3.3.3****back-up fuse**

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

**3.3.4****general-purpose fuse**

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

**3.3.5****full-range fuse**

current-limiting fuse capable of breaking, under specified conditions of use and behaviour, all currents that cause melting of the fuse element(s), up to its rated maximum breaking current (see 6.6.1.1, test duty 3)

**3.3.6****isolating distance** (for a fuse-base)

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

[IEV 411-18-06, modified]

### 3.3.7

#### **homogeneous series** (of fuse-links)

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 6.6.4.1)

[IEV 441-18-34]

### 3.3.8

#### **external insulation**

distances in atmospheric air and 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.

[IEV 604-03-02, modified]

### 3.3.9

#### **self-restoring insulation**

insulation which completely recovers its insulating properties after a disruptive discharge

[IEV 604-03-04]

### 3.3.10

#### **organic fuse-link**

a fuse-link that contains a significant proportion of organic (e.g. carbon based) material that could be a possible cause of excessive leakage current following fuse operation. If the manufacturer determines that the location and quantity of organic or other material in a design might lead to excessive post-operation leakage current and breakdown, the manufacturer shall designate the fuse-link as "organic".

### 3.3.11

#### **surrounding temperature**

surrounding temperature is the temperature of the gaseous or liquid dielectric surrounding the fuse-link

## 4 Ratings and characteristics

### 4.1 General

#### a) Ratings of the fuse-base

- 1) Rated voltage (4.2)
- 2) Rated current (4.5)
- 3) Rated insulation level (power-frequency, dry, wet and impulse withstand voltages) (4.3)

#### b) Ratings of the fuse-link

- 1) Rated voltage (4.2)
- 2) Rated current (4.6)
- 3) Rated maximum breaking current (4.8.1)
- 4) Rated frequency (4.4)
- 5) Rated minimum breaking current for back-up fuses and class (4.8.2)
- 6) Rated TRV (4.10)

- c) Characteristics of the fuse
  - 1) Temperature rise limits (4.7)
- d) Characteristics of the fuse-link
  - 1) Class (3.3.2 and 4.8.2)
  - 2) Switching voltages (4.9)
  - 3) Time-current characteristics (4.11)
  - 4) Cut-off characteristics (4.12)
  - 5)  $I^2t$  characteristics (4.13)
  - 6) Mechanical characteristics of the strikers (4.14)
  - 7) Maximum application temperature (see Annex E).

## 4.2 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 Clause 8).

The rated voltage of a fuse should be selected from the voltages given in Table 3.

**Table 3 – Rated voltages**

| Series I<br>kV | Series II<br>kV |
|----------------|-----------------|
| 3,6            | 2,75            |
| 7,2            | 5,5             |
| 12             | 8,25            |
| 17,5           | 15              |
| 24             | 15,5            |
| 36             | 25,8            |
| 40,5           | 38              |
| 52             | 48,3            |
| 72,5           | 72,5            |

## 4.3 Rated insulation level (of a fuse-base)

The voltage values (both power frequency and impulse) that characterise the insulation of the fuse-base with regard to its capability of withstanding dielectric stresses (see Clause 8).

Two levels of dielectric withstand are recognised for a fuse-base according to European practice. These are termed "List 1" and "List 2" and relate to different severities of application and corresponding different values of test voltage for the dielectric tests (see 9.3.5).

The rated insulation level of a fuse-base should be selected from Tables 4 and 5.

- Table 4 is based on practice in Europe, and standard reference conditions of temperature, pressure and humidity are 20 °C, 101,3 kPa and 11 g/m<sup>3</sup>, respectively, of water.

- Table 5 is based on practice in the U.S.A. and Canada where standard reference conditions of temperature, pressure and humidity are 25 °C, 101,3 kPa and 15 g/m<sup>3</sup>, respectively, of water.

It shall be stated whether the fuse is suitable for indoor or outdoor service.

**Table 4 – Fuse-base rated insulation levels – Series I**

| Rated voltage of the fuse<br>kV | Rated lightning impulse withstand voltage<br>(negative and positive polarity) |                                                           |                            |                                                           | Rated 1 min power-frequency<br>withstand voltage |                                                           |
|---------------------------------|-------------------------------------------------------------------------------|-----------------------------------------------------------|----------------------------|-----------------------------------------------------------|--------------------------------------------------|-----------------------------------------------------------|
|                                 | List 1<br>kV (peak)                                                           |                                                           | List 2<br>kV (peak)        |                                                           | (dry and wet)<br>kV (r.m.s.)                     |                                                           |
|                                 | To earth and between poles                                                    | Across the isolating distance of the fuse-base (see note) | To earth and between poles | Across the isolating distance of the fuse-base (see note) | To earth and between poles                       | Across the isolating distance of the fuse-base (see note) |
| 3,6                             | 20                                                                            | 23                                                        | 40                         | 46                                                        | 10                                               | 12                                                        |
| 7,2                             | 40                                                                            | 46                                                        | 60                         | 70                                                        | 20                                               | 23                                                        |
| 12                              | 60                                                                            | 70                                                        | 75                         | 85                                                        | 28                                               | 32                                                        |
| 17,5                            | 75                                                                            | 85                                                        | 95                         | 110                                                       | 38                                               | 45                                                        |
| 24                              | 95                                                                            | 110                                                       | 125                        | 145                                                       | 50                                               | 60                                                        |
| 36                              | 145                                                                           | 165                                                       | 170                        | 195                                                       | 70                                               | 80                                                        |
| 40,5                            | 180                                                                           | 200                                                       | 190                        | 220                                                       | 80                                               | 95                                                        |
| 52                              | 250                                                                           | 290                                                       | 250                        | 290                                                       | 95                                               | 110                                                       |
| 72,5                            | 325                                                                           | 375                                                       | 325                        | 375                                                       | 140                                              | 160                                                       |

NOTE An isolating insulation level should be specified only for those fuse-bases to which isolating properties are assigned.

**Table 5 – Fuse-base rated insulation levels – Series II**

| Rated voltage of the fuse<br>kV | Rated lightning impulse withstand voltage (negative and positive polarity)<br>kV (peak) |         |                                                           |         | Rated power-frequency withstand voltage<br>kV (r.m.s.) |           |          |                                                           |           |          |
|---------------------------------|-----------------------------------------------------------------------------------------|---------|-----------------------------------------------------------|---------|--------------------------------------------------------|-----------|----------|-----------------------------------------------------------|-----------|----------|
|                                 | To earth and between poles                                                              |         | Across the isolating distance of the fuse-base (see note) |         | To earth and between poles                             |           |          | Across the isolating distance of the fuse-base (see note) |           |          |
|                                 | Indoor                                                                                  | Outdoor | Indoor                                                    | Outdoor | Indoor<br>1 min dry                                    | Outdoor   |          | Indoor<br>1 min dry                                       | Outdoor   |          |
|                                 |                                                                                         |         |                                                           |         |                                                        | 1 min dry | 10 s wet |                                                           | 1 min dry | 10 s wet |
| 2,75                            | 45                                                                                      | –       | 50                                                        | –       | 15                                                     | –         | –        | 17                                                        | –         | –        |
| 4,76                            | 60                                                                                      | –       | 70                                                        | –       | 19                                                     | –         | –        | 21                                                        | –         | –        |
| 8,25                            | 75                                                                                      | 95      | 80                                                        | 105     | 26                                                     | 35        | 30       | 29                                                        | 39        | 33       |
| 15                              | 95                                                                                      | –       | 105                                                       | –       | 36                                                     | –         | –        | 40                                                        | –         | –        |
| 15,5                            | 110                                                                                     | 110     | 125                                                       | 125     | 50                                                     | 50        | 45       | 55                                                        | 55        | 50       |
| 25,8                            | 125                                                                                     | 150     | 140                                                       | 165     | 60                                                     | 70        | 60       | 66                                                        | 77        | 66       |
| 38                              | 150                                                                                     | 200     | 165                                                       | 220     | 80                                                     | 95        | 80       | 88                                                        | 105       | 88       |
| 48,3                            | –                                                                                       | 250     | –                                                         | 275     | –                                                      | 120       | 100      | –                                                         | 132       | 110      |
| 72,5                            | –                                                                                       | 350     | –                                                         | 385     | –                                                      | 175       | 145      | –                                                         | 195       | 160      |

NOTE An isolating insulation level should be specified only for those fuse-bases to which isolating properties are assigned.

#### 4.4 Rated frequency

Standard values of rated frequency are 50 Hz and 60 Hz.

#### 4.5 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.

The rated current of the fuse-base should be selected from the following values:

10 A; 25 A; 63 A; 100 A; 200 A; 400 A; 630 A; 1 000 A.

#### 4.6 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 Clause 8).

The rated current in amperes of the fuse-link should be selected from the R10 series. For special cases, additional values for the rated current of the fuse-link may be selected from the R20 series.

NOTE The R10 series comprises the numbers 1; 1,25; 1,6; 2; 2,5; 3,15; 4; 5; 6,3; 8 and their multiples of 10.

The R20 series comprises the numbers 1; 1,12; 1,25; 1,40; 1,6; 1,8; 2; 2,24; 2,5; 2,8; 3,15; 3,55; 4; 4,5; 5; 5,6; 6,3; 7,1; 8; 9 and their multiples of 10.

#### 4.7 Temperature-rise limits

The fuse-link and the fuse-base shall be able to carry their rated current continuously without exceeding the limits of temperature rise given in Table 6 and without deterioration.

NOTE For fuses used in enclosures, see 6.5.3, 9.3.2 and Annex F.

Where engaging contact surfaces have different coatings, the permissible temperatures and temperature rises shall be as follows:

- a) for bolted contacts and terminals, those of the component having the highest values permitted in Table 6;
- b) for spring-loaded contacts, those of the component having the lowest values permitted in Table 6.

**Table 6 – Limits of temperature and temperature rise for components and materials**

| Component or material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Maximum value of  |                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-----------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Temperature<br>°C | Temperature rise<br>K |
| <b>A Contacts in air:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                   |                       |
| 1 Spring-loaded contacts (copper or copper alloy)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                   |                       |
| – bare                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 75                | 35                    |
| – silver- or nickel-coated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 105               | 65                    |
| – tin-coated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 95                | 55                    |
| – other coatings <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                   |                       |
| 2 Bolted contacts or equivalent<br>(copper, copper alloy and aluminium alloy)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                   |                       |
| – bare                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 90                | 50                    |
| – tin-coated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 105               | 65                    |
| – silver- or nickel-coated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 115               | 75                    |
| – other coatings <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                   |                       |
| <b>B Contacts in oil (copper or copper alloy):</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                   |                       |
| 1 Spring-loaded contacts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                   |                       |
| – bare                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 80                | 40                    |
| – silver-, tin- or nickel-coated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 90                | 50                    |
| – other coatings <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                   |                       |
| 2 Bolted contacts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                   |                       |
| – bare                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 80                | 40                    |
| – silver-, tin- or nickel-coated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 100               | 60                    |
| – other coatings <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                   |                       |
| <b>C Bolted terminals in air:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                   |                       |
| – bare                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 90                | 50                    |
| – silver-, nickel- or tin-coated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 105               | 65                    |
| – other coatings <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                   |                       |
| <b>D Metal parts acting as springs <sup>b</sup></b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                   |                       |
| <b>E Materials used as insulation and metal parts in contact<br/>with insulation of following classes <sup>c</sup>:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                   |                       |
| Class Y (for non-impregnated materials)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 90                | 50                    |
| Class A (for materials immersed in oil)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 100               | 60                    |
| Class E                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 120               | 80                    |
| Class B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 130               | 90                    |
| Class F                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 155               | 115                   |
| Enamel: oil base                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 100               | 60                    |
| synthetic                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 120               | 80                    |
| Class H                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 180               | 140                   |
| Other classes <sup>d</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                   |                       |
| <b>F Oil <sup>e, f</sup></b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                   |                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 90                | 50                    |
| <b>G Any part of metal or of insulating material in contact with oil<br/>except contacts and springs</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                   |                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 100               | 60                    |
| <sup>a</sup> If the manufacturer uses coatings other than those indicated in Table 6, the properties of these materials should be taken into consideration.<br><sup>b</sup> The temperature or the temperature rise should not reach such a value that the elasticity of the metal is impaired.<br><sup>c</sup> Classes according to IEC 60085.<br><sup>d</sup> Limited only by the requirement not to cause any damage to surrounding parts.<br><sup>e</sup> At the upper part of the oil.<br><sup>f</sup> Special consideration should be given with regard to vaporisation and oxidation when low-flash-point oil is used. |                   |                       |

## 4.8 Rated breaking capacity

### 4.8.1 Rated maximum breaking current

The value of breaking capacity specified for a fuse.

The rated maximum breaking current in kA of the fuse-link should be selected from the R10 series.

NOTE The R10 series comprises the numbers 1; 1,25; 1,6; 2; 2,5; 3,15; 4; 5; 6,3; 8 and their multiples of 10.

### 4.8.2 Rated minimum breaking current and class

The manufacturer shall indicate the class (see 3.3.2) and, for back-up fuses, the rated minimum breaking current. In the case of general-purpose fuses, the minimum breaking current may also be indicated.

## 4.9 Limits of switching voltage

The value of switching voltages during operation in all test duties shall not exceed those given in Tables 7 and 8.

On request, the manufacturer shall indicate the maximum value of the switching voltages as determined in the breaking tests (see 6.6).

**Table 7 – Maximum permissible switching voltages**

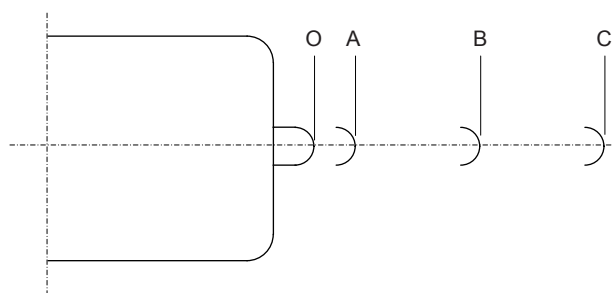
| Series I            |                                 | Series II           |                                 |
|---------------------|---------------------------------|---------------------|---------------------------------|
| Rated voltage<br>kV | Maximum switching voltage<br>kV | Rated voltage<br>kV | Maximum switching voltage<br>kV |
| 3,6                 | 12                              | 2,75                | 8                               |
| 7,2                 | 23                              | 5,5                 | 18                              |
| 12                  | 38                              | 8,25                | 26                              |
| 17,5                | 55                              | 15                  | 47                              |
| 24                  | 75                              | 15,5                | 49                              |
| 36                  | 112                             | 22                  | 70                              |
| 40,5                | 126                             | 25,8                | 81                              |
| 52                  | 162                             | 27                  | 84                              |
| 72,5                | 226                             | 38                  | 119                             |
|                     |                                 | 48,3                | 150                             |
|                     |                                 | 72,5                | 226                             |

**Table 8 – Maximum permissible switching voltages for certain fuse-links of small current ratings**

| Series I<br>up to and including 3,2 A |                                         | Series II<br>up to and including 12 A |                                      |
|---------------------------------------|-----------------------------------------|---------------------------------------|--------------------------------------|
| Rated<br>voltage<br>kV                | Maximum<br>switching voltage<br>kV a, b | Rated<br>voltage<br>kV                | Maximum<br>switching voltage<br>kV b |
| 3,6                                   | 26                                      | 2,75                                  | 13                                   |
| 7,2                                   | 36                                      | 5,5                                   | 25                                   |
| 12                                    | 50                                      | 8,25                                  | 38                                   |
| 17,5                                  | 63                                      | 15                                    | 68                                   |
| 24                                    | 85                                      | 15,5                                  | 70                                   |
| 36                                    | 120                                     | 22 to 25,8                            | 117                                  |
|                                       |                                         | 27                                    | 123                                  |
|                                       |                                         | 38                                    | 173                                  |

<sup>a</sup> For equipment with rated voltages of series I, switching voltages specified in Table 8 are permissible for associated rated lightning impulse withstand voltages of list 2 only (see 4.3).

<sup>b</sup> The switching voltage values may exceed the limits given in Table 7 for a duration not exceeding 200 µs but shall not exceed the limits given in Table 8 (see Figure 11).

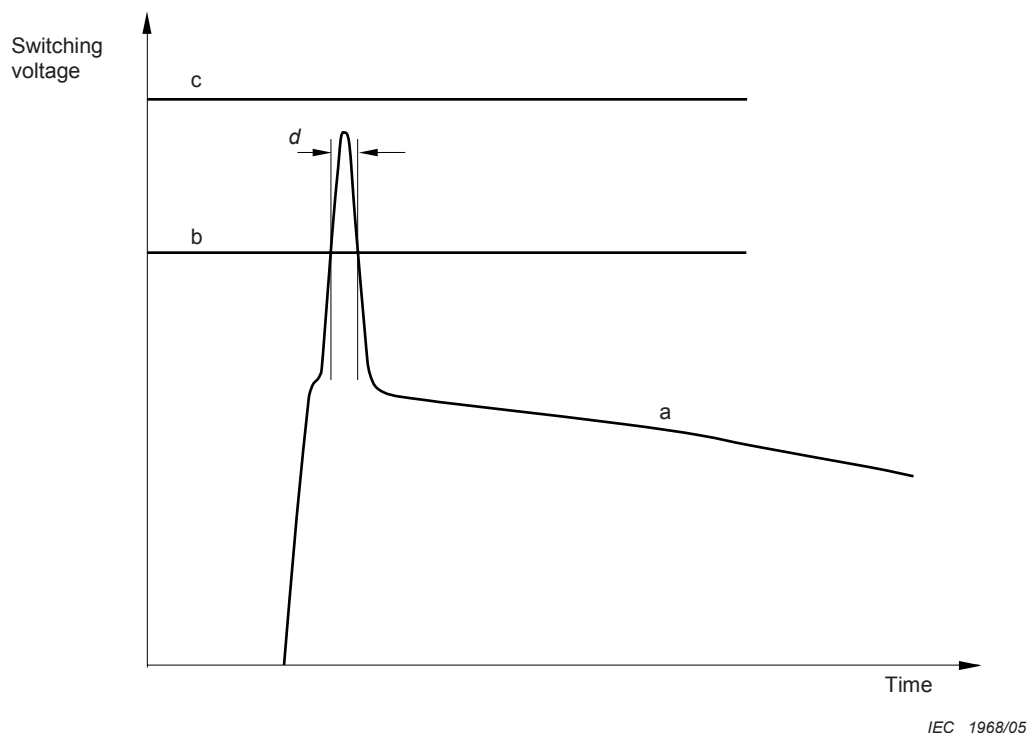


IEC 1967/05

**Key**

- OA Free travel – No energy output specified
- AB Further travel during which energy must be delivered
- OB Minimum actual travel
- OC Maximum actual travel
- CB Maximum permitted return travel under withstand force (when applicable)

**Figure 10 – Various stages of the striker travel**

**Key**

- a Switching-voltage curve
- b Switching-voltage limit – Table 7
- c Switching-voltage limit – Table 8
- d  $\leq 200 \mu\text{s}$

**Figure 11 – Permissible switching voltages for fuse-links of small current ratings (Table 8)**

## 4.10 Rated transient recovery voltage (rated TRV)

### 4.10.1 General

The rated transient recovery voltage related to the rated maximum breaking current (in accordance with 4.8) 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.

Standard values of rated TRV are specified in Tables 9 and 10. These values apply to the rated maximum breaking current of a fuse.

Table 9 – Standard values of rated TRV – Series I

| Rated voltage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Basic parameters |                 | Derived values          |                                 |                              |              |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------|-------------------------|---------------------------------|------------------------------|--------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Peak voltage     | Time coordinate | Time delay <sup>a</sup> | Voltage coordinate <sup>b</sup> | Time coordinate <sup>c</sup> | Rate of rise |
| $U_r$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | $u_c$            | $t_3$           | $t_d$                   | $u'$                            | $t'$                         | $u_c/t_3$    |
| kV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | kV               | μs              | μs                      | kV                              | μs                           | kV/μs        |
| 3,6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 6,2              | 40              | 6                       | 2,06                            | 19,4                         | 0,154        |
| 7,2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 12,4             | 52              | 7,8                     | 4,1                             | 25                           | 0,238        |
| 12                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 20,6             | 60              | 9                       | 6,9                             | 29                           | 0,345        |
| 17,5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 30               | 72              | 10,8                    | 10                              | 35                           | 0,415        |
| 24                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 41               | 88              | 13,2                    | 13,8                            | 42,5                         | 0,47         |
| 36                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 62               | 108             | 16,2                    | 20,6                            | 52                           | 0,57         |
| 40,5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 69               | 115             | 17,2                    | 23                              | 55,5                         | 0,60         |
| 52                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 89               | 132             | 6,6                     | 29,5                            | 51                           | 0,68         |
| 72,5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 124              | 168             | 8,4                     | 41,5                            | 64                           | 0,74         |
| $u_c = 1,4 \times 1,5 \times \sqrt{2/3} U_r$ $^b u' = 1/3 u_c$ <div style="display: flex; justify-content: space-between; align-items: center;"> <div> <math display="block">^a t_d = 0,15 t_3</math> <math display="block">^c t' = (0,15 + 1/3) t_3</math> </div> <div style="font-size: 2em;">}</div> <div>for <math>U_r &lt; 52</math> kV</div> </div> <div style="display: flex; justify-content: space-between; align-items: center;"> <div> <math display="block">^a t_d = 0,05 t_3</math> <math display="block">^c t' = (0,05 + 1/3) t_3</math> </div> <div style="font-size: 2em;">}</div> <div>for <math>U_r \geq 52</math> kV</div> </div> |                  |                 |                         |                                 |                              |              |

Table 10 – Standard values of rated TRV – Series II

| Rated voltage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Basic parameters |                 | Derived values          |                                 |                              |              |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------------|-------------------------|---------------------------------|------------------------------|--------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Peak voltage     | Time coordinate | Time delay <sup>a</sup> | Voltage coordinate <sup>b</sup> | Time coordinate <sup>c</sup> | Rate of rise |
| $U_r$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | $u_c$            | $t_3$           | $t_d$                   | $u'$                            | $t'$                         | $u_c/t_3$    |
| kV                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | kV               | μs              | μs                      | kV                              | μs                           | kV/μs        |
| 2,75                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 4,7              | 37              | 5,5                     | 1,6                             | 18,1                         | 0,127        |
| 5,5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 9,4              | 46              | 6,9                     | 3,1                             | 22,2                         | 0,204        |
| 8,25                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 14,4             | 54              | 8,1                     | 4,8                             | 26,1                         | 0,266        |
| 15                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 25,7             | 66              | 9,9                     | 8,6                             | 32,0                         | 0,390        |
| 15,5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 26,6             | 67              | 10,0                    | 8,8                             | 32,2                         | 0,400        |
| 25,8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 44               | 91              | 13,6                    | 14,7                            | 44,0                         | 0,48         |
| 38                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 65               | 111             | 16,6                    | 21,7                            | 53,6                         | 0,58         |
| 48,3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 83               | 127             | 19,0                    | 27,6                            | 61,2                         | 0,65         |
| 72,5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 124              | 168             | 8,4                     | 41,5                            | 64                           | 0,74         |
| $u_c = 1,4 \times 1,5 \times \sqrt{2/3} U_r$ $^b u' = 1/3 u_c$ <div style="display: flex; justify-content: space-between; align-items: center;"> <div> <math display="block">^a t_d = 0,15 t_3</math> <math display="block">^c t' = (0,15 + 1/3) t_3</math> </div> <div style="font-size: 2em;">}</div> <div>for <math>U_r \leq 48,3</math> kV</div> </div> <div style="display: flex; justify-content: space-between; align-items: center;"> <div> <math display="block">^a t_d = 0,05 t_3</math> <math display="block">^c t' = (0,05 + 1/3) t_3</math> </div> <div style="font-size: 2em;">}</div> <div>for <math>U_r &gt; 48,3</math> kV</div> </div> |                  |                 |                         |                                 |                              |              |

The values given in the tables are prospective values and take into account depression of recovery voltage. In the case of single-phase systems or where fuses are for use in an installation having more severe conditions, the values shall be subject to agreement between manufacturer and user.

The rated transient recovery voltage corresponding to the rated maximum breaking current is used for testing at breaking currents equal to the rated value with the permitted deviation given in 6.6.1.2.2. For testing at breaking current less than the rated value, other values of transient recovery voltage are specified (see 6.6.1.2.3).

#### 4.10.2 Representation of TRV

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) (see Annex A).

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 TRV. 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.

#### 4.10.3 Representation of rated TRV

The following parameters are used for the representation of the rated TRV (see Figure 8):

- $u_c$ : TRV 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 coordinate  $t'$ ).

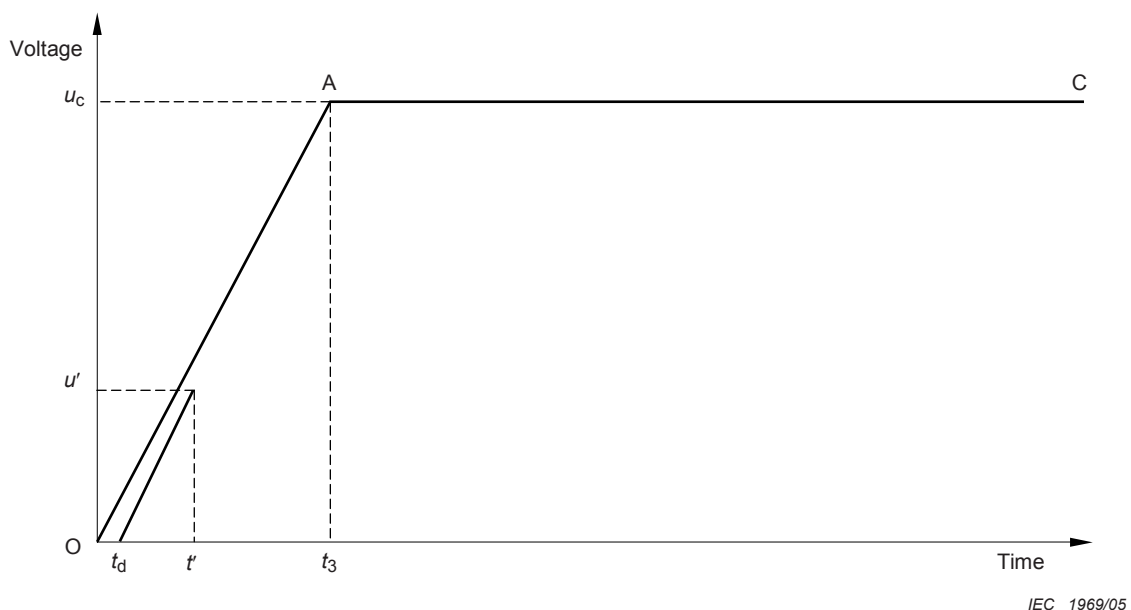


**Figure 8 – Representation of a specified TRV by a two-parameters reference line and a delay line**

#### 4.11 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 6.5.1.2.

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

The manufacturer shall make available curves from the data determined by the time-current characteristics type tests specified in 6.7.2.

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

Logarithmic scales shall be used on both coordinate axes. The basis of the logarithmic scales (the dimensions of one decade) shall be in the ratio 2:1 with the longer dimension on the abscissa. However, because of long-established practice in the USA, a ratio of 1:1 (5,6 cm) is recognised as an alternative standard.

The representation shall be made on standardised paper A3 or A4, or according to the USA standard.

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 the values 2,8 and 5,6 be used wherever possible.

The curves shall show

- the relation between the virtual pre-arcing time and the prospective current;
- the basis of current, whether mean or minimum. If mean current values are used, the tolerance shall not exceed  $\pm 20\%$ . If minimum values are used, the tolerance shall not exceed  $+50\%$ ;
- the type and rating of the fuse-link to which the curve data apply;
- the time range as specified in 6.7.2.2. For back-up fuses, a dotted line shall be plotted from minimum breaking current to 600 s if the minimum breaking current corresponds to a time less than 600 s.

For the purpose of coordination between fuses or between fuses and other protective devices, the relevant time-current characteristics may be employed for periods down to 0,1 s.

Where higher fault levels result in fuse operation in times less than 0,1 s, the relevant pre-arcing  $I^2t$  and operating  $I^2t$  data (see notes 1 and 2 of 3.1.11) may be used.

#### 4.12 Cut-off characteristic

The manufacturer shall indicate the upper limit of the cut-off current corresponding to each value of prospective breaking current up to the rated maximum breaking current of the fuse under specified conditions determined as part of the breaking type tests specified in 6.6.

It shall be stated whether the characteristic applies to 50 Hz or 60 Hz.

#### 4.13 $I^2t$ characteristics

The manufacturer shall make available values of operating  $I^2t$  and pre-arcing  $I^2t$  for those prospective currents for which the fuse exhibits cut-off characteristics.

Values stated for the operating  $I^2t$  shall represent the highest values likely to be experienced in service. These values shall refer to the test conditions of this standard, for example, the values of voltage, frequency and power factor.

Values stated for the pre-arcing  $I^2t$  shall represent the lowest values likely to be experienced in service.

The presentation of  $I^2t$  values may be in simple tabular or diagrammatic form (for example, histograms) or may employ graphical presentation with prospective current as abscissa and  $I^2t$  as ordinate, both scales being logarithmic with preferred dimensions as in 4.12.

The  $I^2t$  values determined as a part of the breaking type tests specified in 6.6 shall not be greater (for operating  $I^2t$ ) or less (for pre-arcing  $I^2t$ ) than the values stated by the manufacturer.

#### 4.14 Mechanical characteristics of strikers

Strikers may be classified by the amount of energy they are able to deliver to a mechanical switching device or a signalling device between two points A and B (see Figure 10) of their travel and by a minimum withstand force. The withstand force is the characteristic which prevents the return of the striker, after operation, to less than the minimum actual travel OB when a static external force is applied.

The mechanical characteristics of the strikers are given in Table 11.

**Table 11 – Mechanical characteristics of strikers**

| Type   | Energy     | Mechanical characteristics    |                                                                        |                        |                        |                         |                                         |
|--------|------------|-------------------------------|------------------------------------------------------------------------|------------------------|------------------------|-------------------------|-----------------------------------------|
|        |            | Values of                     |                                                                        | Actual travel          |                        | Minimum withstand force | Maximum duration of travel <sup>b</sup> |
|        |            | Free travel (OA) <sup>a</sup> | Further travel during which energy must be delivered (AB) <sup>a</sup> | Min. (OB) <sup>a</sup> | Max. (OC) <sup>a</sup> |                         |                                         |
|        | J          | mm                            | mm                                                                     | mm                     | mm                     | N                       | ms                                      |
| Light  | 0,3 ± 0,25 | 2                             | 8                                                                      | 10                     | 30                     | Not applicable          | 50                                      |
| Medium | 1 ± 0,5    | 4                             | 16                                                                     | 20                     | 40                     | 20                      | 50                                      |
| Heavy  | 2 ± 1      | 4                             | 6                                                                      | 10                     | 16                     | 40                      | 50                                      |

<sup>a</sup> See Figure 10.

<sup>b</sup> Duration of travel is defined as the time from commencement of arcing to the time when travel OB is reached. The additional 50 ms required for the arcing withstand (4.15.2) is to allow for the switch operating time.