Questions and Answers related to power fuses and their applications

Know the answers, avoid mistakes!

Get the answer by a click of your mouse button!

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Why using fuses?

In many applications fuses have proven to provide more benefits to users than other protective devices. The benefits are based on the following outstanding technical features. –

- Accurate, tamperproof characteristics
- Outstandingly high breaking capacity in minimum physical dimensions
- Unsurpassed current and let-through energy limitation
- Maintenance-free long service life
- Worldwide standardized characteristics
- Most cost effective protection
- Easy selection and simple co-ordination

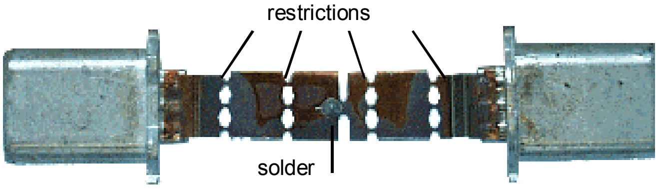

Fig.1 – Fuse-element with blade contacts

How do fuses operate?

The fuse, or more precisely the restrictions in cross section of the fuse-element (figs. 1 and 2), represent the weakest link in an electric circuit. Fuse operation is initiated by overcurrents of sufficient intensity and time duration to melt the designated areas of the fuse-element (fig. 2). The time required to open a circuit is dependant on the intensity of overcurrent and the relationship of time and current laid down in time-current characteristics (fig 3). Time-current characteristics are essential tools to co-ordinate fuses or fuses with other protective devices. Fuse-elements made of pure copper or silver, having melting temperatures of 1080 °C and 960 °C respectively, are suitable for partial range (back-up) protection only. Full-range protection can be achieved by applying a spot of solder (low melting point material or alloy) near the centre restrictions (fig. 1).

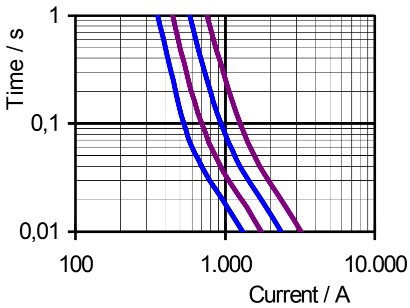

Fig 3 – Time-current characteristics

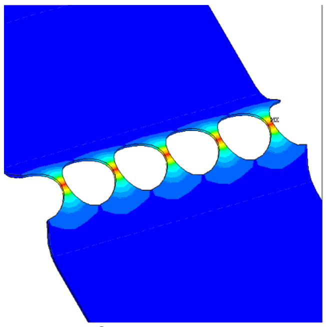
Fig. 2 – fuse-element temperature profile

Fuse operation comprises two consecutive processes and time periods respectively (fig. 4). –

a) Heating of the restrictions to the melting point and vaporisation of the metal (pre-arcing time)
b) Arcing and arc extinction (arcing time).

Arc extinction is achieved by the cooling effect of melting silica sand surrounding the fuse-element and absorbing more energy than is supplied by the arc.

How do fuses interrupt short-circuit currents?

Under the influence of short-circuit currents, all longitudinally arranged restrictions of a fuse-element open simultaneously. Electric arcs, one each per restriction, are formed and the arcing voltage adds up to a value that temporarily exceeds the power supply voltage and forces the current to zero. While electro-mechanical overcurrent protective devices interrupt the current at natural current zero only, fuses are able to clear high faults much before periodic current zero and to cut off a.c. currents much below prospective peak values (fig. 4).

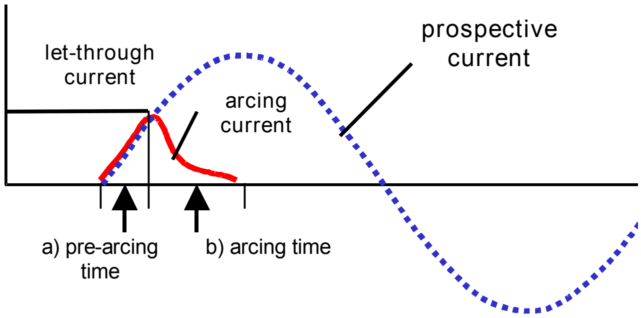

Fig. 4 – Current-limiting fuse operation

How do fuses interrupt over-load currents?

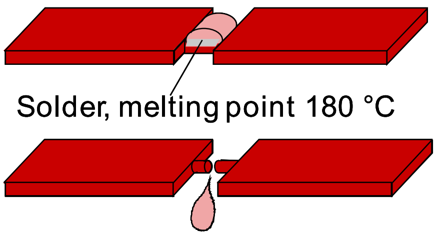

Fig. 5 – Overload operation

Fuse-links for overload protection (full-range fuse-links) exhibit fuse-elements with a solder applied to the centre restrictions where maximum temperatures are reached under overload conditions (figs. 2 and 5). The solder melts at its melting point and dissolves the underlying metal of the fuse-element. This way, current interruption is initiated at a temperature much lower than that of copper, e.g. 180 °C instead of 1080 °C. The physical process of overload current interruption is similar to that of a mechanical switching devices. Only one arc is formed at the centre restriction of the fuse-element which arc expands to both sides until it extinguishes at periodic current zero.

Are fuses able to interrupt d.c. currents

Yes, fuses are universal protective devices as far as a.c. and d.c. voltage applications are concerned. The ratings are different however, and published a.c. ratings cannot easily be converted to d.c. ratings. Under high fault conditions, i.e. in the range of current-limiting operation, the physical process of a.c. and d.c. current interruption is very much alike. Under overload conditions, i.e. non-current-limiting operation the d.c. and a.c. breaking processes are completely different. While periodic current zero (i.e. zero stored magnetic energy) eases arc extinction in a.c. circuits, in d.c. circuits, the fuse has to absorb the full stored magnetic energy during arcing period (fig. 6). Consequently, the d.c. breaking capacity of fuses is generally dependant on the stored magnetic energy, i.e. time constant of the d.c. circuit and, as a rule, is below the a.c. breaking capacity. D.c. ratings and a.c. ratings are marked separately on fuse-links.

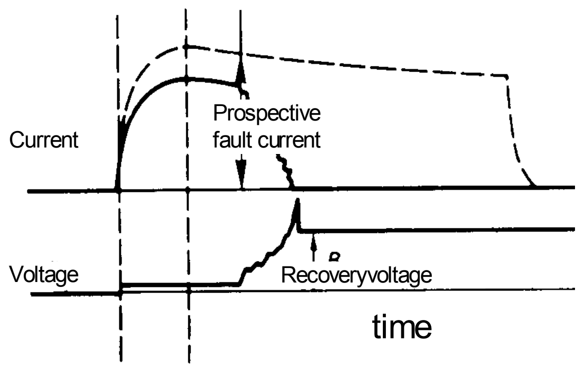

Fig. 6 – D.c. breaking process

Are fuses suitable for capacitor circuit protection?

Yes, fuses are frequently used to protect capacitor circuits against the effects of dielectric breakdowns in capacitors. Protection against overheating is usually provides by internal pressure sensitive devices. Selection of fuses shall make sure to avoid operation under overload currents including harmonics. Fuse rated currents for shunt capacitors shall therefore be at least 1,5 times the capacitor rated current and at least one step above that value if several capacitor units are arranged in close proximity, e.g. in capacitor banks.

Why is selectivity of protection useful?

Selectivity of protection or over-current discrimination is of paramount importance when designing complex electric power supply networks. Selectivity of protection is advisable to minimize damage to equipment and to maximize the availability of power under all fault and overload conditions. The aim of over-current discrimination is to disconnect the overloaded or faulted circuit or device only, while leaving all other circuits and devices unaffected. In a network according to fig. 7, e.g. the fault indicated by the arrow symbol would be disconnected by the fuse F_3 only, without operation of the fuse F_1 or of the circuit-breaker C_1.

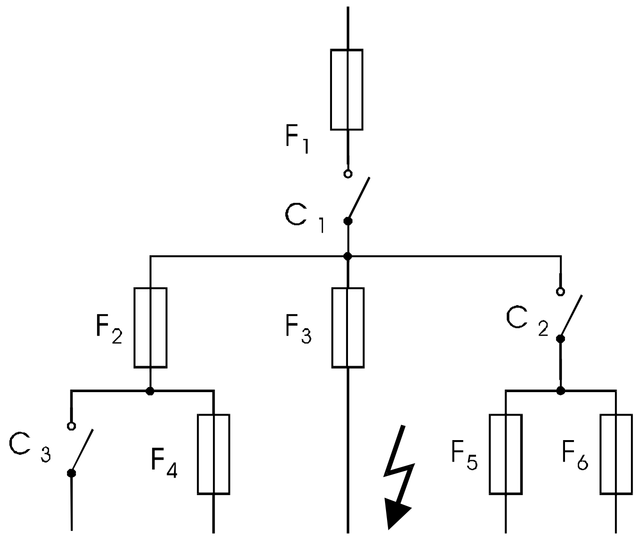

Fig. 7 – Schematic of radial network

How to achieve selectivity of protection?

Correct discrimination requires thorough co-ordination of the operating characteristics of all over-current protective devices connected in series. The relevant characteristics for the co-ordination of fuses and other protective devices, mainly circuit-breakers, are time-current and Joule-integral (I^2t) characteristics.

Depending on the characteristics of two protective devices in series, discrimination may exist for all fault current levels (total discrimination) or only for currents up to a defined discrimination limit current I_D (partial discrimination). In cascaded power supply systems as depicted in fig.7, selectivity of protection can easiest and most reliably be achieved by means of fuses.

How to achieve selectivity between fuses?

Fuses are very easy to co-ordinate for over-current discrimination as their time-current characteristics are essentially running in parallel (fig. 8). Discrimination requires that the total operating time of the fuse F_3 in fig. 7 is smaller than the pre-arcing time of F_1. For the purpose of co-ordination of fuses or fuses and other protective devices, l.v. fuse characteristics are closely defined in IEC 60269. A typical l.v. power supply networks of radial structure, e.g. as shown in fig 7, would ideally be protected by general purpose ("gG") fuses on all hierarchic levels. "gG" fuses acc. to IEC 60269 provide over-current discrimination within a wide range of rated currents from 16 A up to 1.250 A, independent on their physical size or mechanical design. To achieve total discrimination between fuses connected in series, a rated current ratio of 1:1,6 or less (i.e. two or more steps in rated currents of standard "gG" fuse-links) is the only selection criteria to be met.

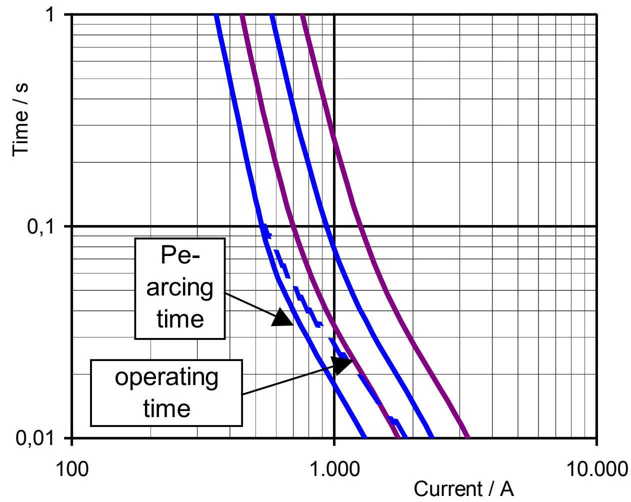

Fig. 8 – Time-current characteristics of fuses

How to achieve selectivity between fuses and circuit-breakers?

The relevant time-current characteristics may be used for periods down to 100 ms. For high fault levels that lead to fuse operation in less than 100 ms, the relevant I^2t values may be used. If time-current characteristics are plotted for a time range below 100 ms, it is essential to kow, that the time values are virtual values, calculated from I^2t values, and do not compare to real time values.
Due to the inertia of moving parts, circuit-breaker tripping characteristics run almost horizontally under high fault conditions, while fuse pre-arcing characteristics exhibit a constant slope (see fig. 9). Consequently, partial discrimination only can be achieved between fuses and downstream circuit-breakers. In a network acc. to fig. 7, circuit-breaker C_3 and fuse F_2 discriminate up to the discrimination limit current I_D. Fault currents above I_D will open both protective devices and de-energize additionally the branch of F_4. Circuit-breakers upstream fuses, e.g. C_1 upstream F_2 or C_2 upstream F_5 and F_6 are less difficult to co-ordinate, as the characteristics don't necessarily intersect (see fig. 9). Total

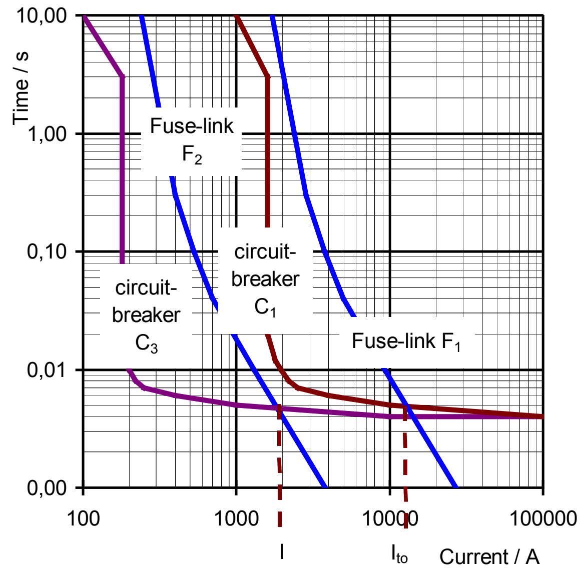

Fig. 9 – Co-ordination of fuses and circuit-breakers

Note – In the range below 100 ms, time-current characteristics represent virtual time values calculated from I^2t values.

discrimination is achieved if the operating time-current characteristic of the fuse F_2 does not intersect with the minimum tripping characteristic of circuit-breaker C_1. The intersection of the time-current characteristic of fuse F_1 and tripping characteristic of circuit-breaker C_1 at I_{to} does not represent a discrimination issue, but a back-up protection application that follows different rules of co-ordination.

Are fuses suitable for isolation?

Yes, fuses according to IEC 60269 are suitable for isolation with either the fuse-links removed, or the equipment in open position with the fuse-links inside the fuse-carrier.

Are gG fuses and MCBs equivalent protective devices with respect to cable overload protection?

Yes, gG fuse-links according to IEC 60269 satisfy the requirement of cable overload protection at 1,45 I_N in typical three-phase applications.

Can fuses prevent fire?

No, but they can significantly reduce the hazard of fire!
When properly selected, fuses are able to reliably protect wires and equipment from overheating by overloads and short-circuit faults. Consequently, fuses significantly reduce the hazard of electric fire. Fuses can however not prevent fire caused by local overheating of poor contacts or damaged conductors as may occur at normal load current. The same applies in case of high impedance arc faults or surface discharges carrying currents to low to melt the fuse.

How to properly select fuses?

Fuses shall be selected according to the following criteria. -

a) Maximum operational voltage –shall be equal or greater than the system operating voltage (see table 1).
b) Rated breaking-capacity -shall be equal or greater than the maximum fault current expected in the circuit downstream the fuse.
c) Rated current –shall be equal or greater than the continuous operating current of the circuit protected by the fuse
d) Breaking range –partial range or full-range breaking capacity according to the type of protection required.
e) Utilization category –according to the nature of equipment to be protected (see table 2).

Fuse Type	Rated voltage V	Maximum operational voltage V
gG, gM, aR, aM, gR, gS	230	253
	400	440
	400	440
	690	725
gN, gD	600	600

Table 1 - Maximum operational voltages of fuses

How to read the fuse markings?

L.v. power fuse-links are marked with all essential information to select a replacement fuse-link or to select fuses for most common applications. Additional more detailed information, e.g. characteristics will be supplied by the fuse manufacturer. Standard markings are. -

a) Fuse standard, size and reference define the operating performance and mechanical design of fuses.
b) Voltage rating, (fuses may be operated up to the maximum voltages listed in table 1). Voltage ratings may be colour coded to reduce the risk of misinstallation.
c) Rated current, represents the value of current that the fuse-link can carry continuously without deterioration under specified conditions
d) Rated breaking capacity, the maximum value of prospective current that a fuse is capable of breaking under standard conditions.

Letter code	Application (characteristic)	Breaking range
gG	General purpose fuse-link, mainly for conductor protection	Full range
gM	Motor circuit protection	Full range
aM	Short-circuit protection of motor circuits	Partial range
gN	North American general purpose for conductor protection	Full range
gD	North American general purpose time-delay	Full range
aR	Semiconductor protection	Partial range
gR, gS	Semiconductor protection	Full range
gU	Interim type intended to be aligned with gG	Full range
gL, gF, gI, gII	Former type of fuse for conductor protection (replaced by gG type)	Full range

Table 2 - Letter codes

Industrial fuses acc. to IEC 60269-2 have a minimum breaking capacity of a.c. 50 kA and d.c. 25 kA respectively.

e) Breaking range and utilization category are indicated by letter codes (see table 2) The first (lower case) letter indicates the breaking range, i.e. the range of prospective currents the fuse is able to break, the second (capital) letter indicates the utilization category, i.e. time-current characteristics for typical applications.
f) Fuse manufacturer or trade mark
g) Manufacturers product reference, required for additional information on the fuse.
h) Rated frequency if other than 50 or 60 Hz

Additional markings may include .-

i) Date of manufacturing, useful to trace back product design changes.
j) Certification mark, asserting product quality by an independent certification body
k) Conformity mark, stating conformity to applicable national directives
l) Recycling mark, identifying responsible recycling organization

When do I need back-up protection?

Switching devices, e.g. relays, switches, contactors and electronic controls, are designed to make and break normal operating currents including overloads. Because of their limited breaking capacity they are not able to cope with high fault currents. Even circuit-breakers may have insufficient breaking capacity when installed in powerful networks. If fault currents above the breaking capacity of these devices are likely to occur, complimentary (back-up) protective devices are required to interrupt these currents before damage occurs to the circuit-breaker or switching device. Fuses are excellent for back-up protection as their breaking capacity is virtually unlimited compared with that of mechanical or electronic devices. Switches, electronic controls or circuit-breakers combined with back-up fuses represent in many applications the most favourable full range protection.

What striker type do I need on h.v. fuses?

IEC 60282-1 defines three types of strikers classified by their mechanical energy delivered during operation. –

- light: (0,3 ± 0,25) Joule
- medium (1 ± 0,5) Joule and
- heavy (2 ± 1) Joule.

The striker selected shall deliver the amount of energy required to release the switching or signalling device without damaging the release.

What mean the dual voltage ratings printed on h.v. fuse-links, e.g. 10/24 kV?

The greater value represents the fuse-link rated voltage, i.e. the maximum operating voltage of the system or equipment the fuse-link shall protect. The lower value indicates the minimum system voltage at which the fuse-link is supposed to operate. This lower value is based on the requirement that the switching voltage of the fuse-link must not exceed the insulation level of the equipment.

Why did the indicator or striker not operate in spite of fuse operation?

Strikers and indicators are usually triggered by a limited current through a wire bypassing the fuse-elements. According to l.v. fuse standard IEC 60269, they require a recovery voltage of at least 20 V or 4 % of the fuse-link rated voltage to operate. H.v. fuse-links according to IEC 60282-1 require at least 7,5 % of their rated voltage to operate. There are several reasons for why a non-defective striker or indicating device may not operate. –

a) Short-circuit currents in 3-phase power supply systems without grounded neutral will be fully interrupted after operation of the first two fuse-links. The fuse-link in the remaining phase will not be subjected to a recovery voltage sufficiently high to trigger the striker or indicator.
b) After overload operation in interconnected l.v. networks, the recovery voltage is usually to low to initiate striker operation. (Special fuse-links are offered by fuse manufacturers to for this application.)
c) In circuits with motors or generators on the load side, recovery voltage may be to low to trigger the indicator or striker.

When do I need to replace all three fuse-links in a faulted circuit, including the one whose striker or indicator did not operate?

After a fault in a three-phase system all three fuse-links of the faulted circuit shall be replaced unless it is definitely known that no overcurrent passed through a specific phase. In systems without grounded neutral, only two fuses are needed to interrupt a three phase fault. The third fuse-link seems to be completely operational as it still exhibits a low impedance and an intact indicator or striker. However, most of the time, the fuse-elements are damaged and partly interrupted and their current carrying capacity is very limited.
Re-using damaged partial range fuse-links may be specifically dangerous in h.v. installations as the fuse-elements may melt at currents much below the minimum breaking current and cause disastrous damage to the installation.

What is an “a” fuse-link?

An “a” fuse-link or partial-range breaking-capacity fuse-link, formerly back-up fuse-link, is a l.v. current-limiting fuse-link capable of breaking under specified conditions all currents between the lowest current k_2I_n indicated on its operating time-current characteristic and its rated breaking capacity. "a" fuse-links are generally used to provide short-circuit protection. Where protection is required against over-currents less than k_2I_n, they are used in conjunction with another suitable switching device designed to interrupt such small overcurrents.

What is a “g” fuse-link?

A “g” fuse-link or full-range breaking-capacity fuse-link, formerly general purpose fuse-link, is a l.v. current-limiting fuse-link capable of breaking all currents, which cause melting of the fuse-element up to its rated breaking capacity

What materials are fuse-elements made of?

Most l.v. fuse-elements are made of copper (Cu). Fuse-elements of fast acting fuse-links and h.v. fuse-links are primarily made of silver (Ag). Silver-plated copper can be found too. As a rule, fuse-elements of time-delay fuses contain low melting point materials, e.g. tin (Sn) or zinc (Zn) and alloys thereof. Formerly used alloys containing lead (Pb) and cadmium (Cd) have widely been eliminated.

Why do some fuse-links contain a number of fuse-elements in parallel?

The number of paralleled restrictions and fuse-elements is governed by the operating current. The total restricted cross section has to be adequate to carry the operating current without deterioration and without dissipating to much heat. Greater current ratings require greater total width of fuse-elements that are subdivided in individual strips for easier assembly and more compact arrangement inside the fuse body.

How are h.v. fuses classified?

There are three classes of current-limiting fuses defined in IEC 60282-1 according to their breaking range. -

a) Back-up fuses break all currents from the rated minimum breaking current I_3 up to the rated maximum breaking current I_1.
b) General-purpose fuses break all currents from the current I_3 that causes melting of the fuse-elements in one hour up to the rated maximum breaking current I_1
c) Full-range fuses break all currents that cause melting of the fuse-elements up to the rated maximum breaking current I_1

What means the dotted line in time-current characteristics of h.v. fuses?

The dotted line indicates the melting time-current characteristic below the rated minimum breaking current I_3. If currents in this range are likely to occur, additional protective devices or full range fuse-links are required.

What is a fuse?

According to the fuse standard IEC 60269-1, a fuse is “a device that by the fusing of one or more of its specially designed and proportioned components opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time. The fuse comprises all the parts that form the complete device”. That means, the fuse comprises an entire set consisting of fuse-base or fuse-mount, fuse-link and where applicable, replacement handle, fuse-carrier or covers. In common language the term “fuse” is synonymous for fuse-link. Fuse-base and fuse-carrier may be joined to a fuse-holder. A fuse-carrier hinged to the fuse-holder may form a fuse-switch using the fuse-link as moving contact. Several fuse-systems, showing different shape, contacts etc. have historically developed in different countries. Their electrical performance and operating characteristics are however worldwide accepted and covered by the International Standard IEC 60269 “Low Voltage Fuses”.

What do l.v. fuse-links look like inside?

The design principle of electric fuses is quite simple and has not changed since the early days of electric power application. Basic components are the fuse-element to interrupt overcurrents and two contacts to connect it to the electric circuit to be protected (fig. 10). The fuse-element consists of a wire or, for greater current ratings, of notched metal strips. The number of restrictions along the fuse-element depends on the system voltage, about one each per 100 V. Solder may be applied to the centre of the fuse-element to extend the fuse-link’s breaking range to lower currents. Enclosed fuse-links have an hollow insulating fuse body, mounted between end plates or end caps and surrounding the fuse-element, to prevent any harmful external effects, e.g. ejection of hot gases, metallic particles and flames produced during fuse operation. The breaking capacity can be significantly increased and current-limitation achieved by means of a granular filler, mainly quartz sand, embedding the fuse-element. Some fuse-links have indicators or strikers, tripped by the recovery voltage, to indicate whether the fuse has operated and to allow for easier detection of faulted circuits.

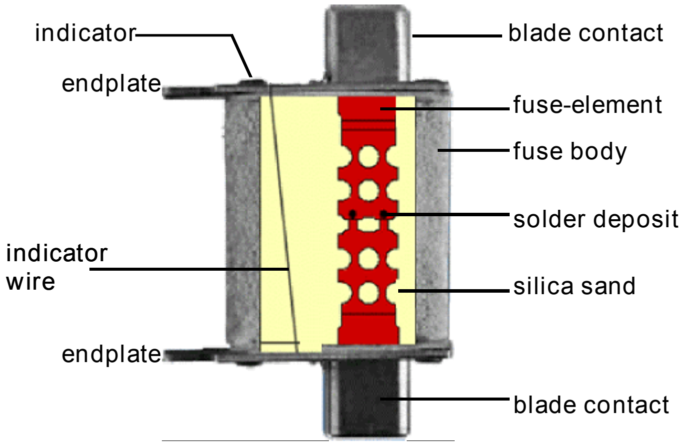

Fig. 10 - Cross-sectional view of enclosed fuse-link

What do h.v. fuse-links look like inside?

As mentioned above, the number of restrictions in series increases with the system voltage. After reaching the melting temperature, one arc is formed per each restriction building up an arcing voltage of about 100 V. Consequently, the number of restrictions in series can be roughly estimated dividing the system

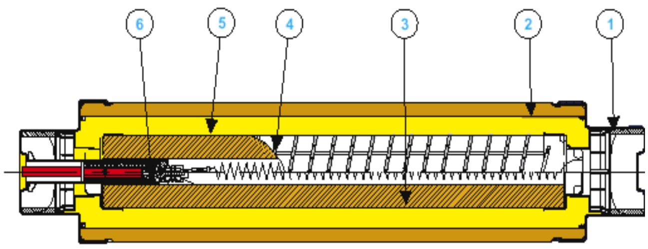

Fig. 11a – longitudinal section of h.v. fuse-link
1 end caps, 2 tube insulator, 3 core insulator
4 fuse-element, 5 silica sand, 6 striker system

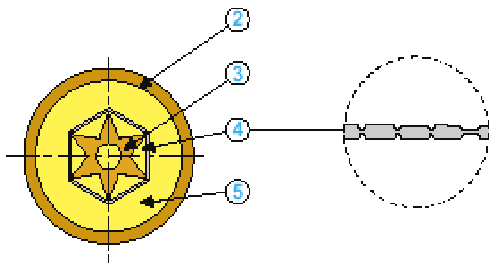

Fig. 11b - cross section of h.v. fuse-link
2 tube insulator, 3 core insulator
4 fuse-element, 5 silica sand

voltage by 100 V. The fuse-elements of h.v. fuse-links easily exceed the length of the fuse body and are therefore helically wound on a star shaped insulator (fig. 11 a and b).

Why are fuse-links filled with sand?

Current-limiting fuse-links contain a granular filler, usually high purity quartz sand of a defined grain size and packing density. The specific grain size distribution provides room to expand for the vapours and gases produced by the arc and offers a large surface for efficient cooling. The filler does also melt under the influence of high arc temperatures, absorbing an enormous amount of energy and extinguishing the arc well before current zero (see current limitation). Fused quartz and metal form a non-conductive fulgurite body that prevents restriking of the arc.

Can a fuse tell the story of operating conditions?

Yes, to fuse experts!
The fulgurite formed inside a fuse-link during arcing period develops different patterns depending on the intensity of arcing currents (fig. 13) and recovery voltage. Technical experts in fuse manufacturers' laboratories can read from fulgurite patterns quite precise information on the circumstances of fuse operation. The fulgurites shown in fig. 13 have developed at a recovery voltage corresponding to the fuse rated voltage. At low recovery voltages, e.g. in interconnected networks, only minor or no fulgurites at all can be found.

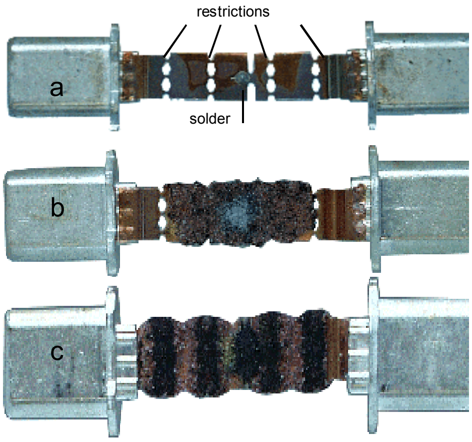

Fig. 13 - Fulgurite patterns
a) new fuse-element
b) after overload interruption
c) after short-circuit interruption

Can current-limiting fuse-links be renewed after operation?

No! Current-limiting fuse-links are non-renewable fuse-links! Most of the time, fuse-links still seem to be perfectly intact after operation, except the fuse-elements that are melted. It was therefore natural for users and manufacturers alike to think of repair rather than disposal. While repair by users has never been recommended, manufacturers have for long given up, for rising labour costs and product liability by far outweigh economic considerations. European fuse manufacturers recommend to forward used fuse-links to a recognized recycling organization (fig. 14).

Can fuse-links be recycled after operation?

Yes! After operation, fuse-links still contain all valuable materials they were originally made of. Users have therefore commonly dismantled or shredded the fuse-links and sold the valuable metal parts. Dismantling or shredding is however by no means an easy task and cannot be considered safe at all, as harmful breathable substances, e.g. quartz dust and -from earlier fuse-links- asbestos will be released.

Fig. 14 - Protected marks of German Fuse-link Recycling Association [NH/HH Recycling e. V.]

State of the art recycling technology is to smelt used fuse-links in a copper converter, to recover copper and silver and to use the slag for road paving. Any remaining harmful substances will be safely contained in the slag.
The average yield of recycled l.v. fuse-links is shown in fig. 15. H.v. fuse-links contain less copper but three times more silver. It was generally found that one ton of power fuse-links can yield as much copper and silver as 100 tons of ore. Recycling of operated fuse-links represents therefore a significant contribution to preservation of resources. In some countries fuse manufacturers participating in recycling organizations mark their products accordingly (fig. 14).

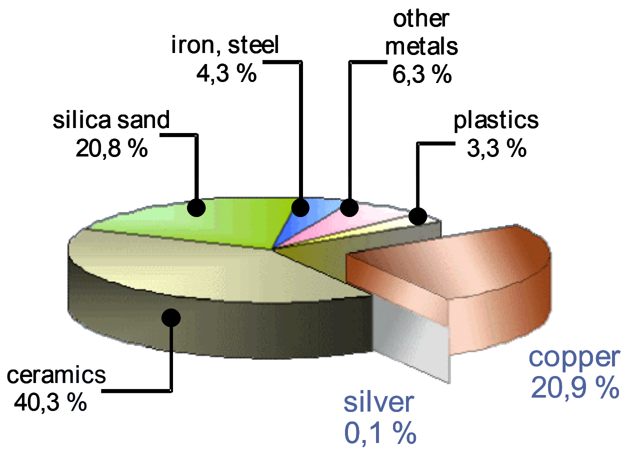

Fig. 15 – Contents of a typical NH fuse-link (Analysis by NH/HH Recycling e. V)

Do fuse-links contain asbestos?

Not anymore, but older fuses do! Asbestos is not used anymore in fuse-links of contemporary design. Earlier products may contain small amounts of asbestos in end seals and spacers. Care must be taken when replacing these fuse-links. It is generally advisable to give used fuse-links as a whole to a recognized recycling organization.

What materials are fuse-link bodies made of?

The bodies of current-limiting fuse-links have to withstand very high temperatures and internal pressure during operation. The materials are selected accordingly, e.g. engineering grade technical ceramics or resin-bonded fabrics.

What materials are fuse-link contacts made of?

Blade contacts are generally made of solid material and silver plated. Other surface platings may be used if they fulfil the type test requirements.
Nickel plating is common for installations in corrosive atmospheres containing sulphur, e.g. in rubber factories or waste water treatment plants. For current ratings above 63 A de-rating may apply for nickel plated contacts to avoid critical contact temperatures.
For fuse-links intended to be inserted or removed under load, e.g. in fuse-switches, shall have solid contacts of copper or copper alloy.
Bolted contacts are either silver or tin plated.

What is a full-range fuse?

"Full range" means that the fuse can break any current able to melt the fuse-element up to the rated breaking capacity. Full range fuses can be used as stand-alone protection devices. L.v. fuse-links having full range breaking capacity are also called “g fuse-links” and marked with the letter “g”.

What is a partial range fuse?

Partial range, or back-up fuses, are designed to interrupt short-circuit currents only. They are generally used to extend the breaking range of other overcurrent protection devices, e.g. electronic controls or circuit-breakers. L.v. partial range fuse-links are also called “a fuse-links” and marked with the letter “a”.

Who is an authorized person?

Authorized persons may be instructed (persons adequately advised or supervised by skilled persons to enable them to avoid dangers which electricity may create, e.g. operating and maintenance staff) or skilled (persons with technical knowledge or sufficient experience to enable them to avoid dangers which electricity may create, e.g. engineers and technicians).

What are fuses for use by unskilled persons?

These formerly called “fuses for domestic and similar applications” are fuses intended to be used in installations where the fuse-links are accessible to and can be replaced by unskilled persons. These fuses may require protection against direct contact with live parts and constructional means to prevent interchangeability. Fuses according to IEC 60269-3 are fuses for use by unskilled persons.

What are fuses for use by authorized persons?

These formerly called “fuses for industrial application” are fuses intended to be used in installations where the fuse-links are accessible to and intended to be replaced by authorized persons only. The fuses may be interchangeable and constructional means to prevent accidental access to live parts may not exist. Fuses according to IEC 60 269-2 shall be used by authorized persons only.

Do fuses require periodic maintenance work?

No! Fuses are absolutely maintenance-free and do not deteriorate under normal service conditions. Regular inspection of critical installations for extraordinary pollution and hotspots are sufficient to identify damaged fuses.

May I connect fuse-links in parallel?

Yes, fuse-links of the same type, reference and rating may be connected in parallel in order to achieve a higher current rating. The manufacturer should be consulted to ascertain that the specific fuse-links qualify for parallel connection. The following rules should be observed when connecting n fuse-links having a rated current I_n in parallel. –

a) The current rating of n fuse-links in parallel is somewhat less than n x I_n.
b) The I^2t value of the combination will be approximately n^2 x I^2t of the individual fuse-link.
c) The cut-off current of the combination will be approximately n x the cut-off current of a single fuse-link at a prospective current of I_P/n
d) The breaking capacity of the combination must be assumed not greater than I_1 of a single fuse-link and the minimum breaking current not less than n x I_3 of a single fuse-link

How to select the rated voltage of a h.v. fuse?

The rated voltage of h.v. fuse-links shall be selected with regard to the treatment of neutral .-

a) In a three-phase system with solidly earthed or impedance or resistance earthed neutral the fuse-link rated voltage shall be at least equal to the highest line-to-line voltage.
b) In a single-phase system the rated voltage of the fuse-link shall be at least 1,15 times the highest circuit voltage.
c) In a three-phase system with isolated neutral or resonant earthed system the possible occurrence of double earth fault may require additional fuse-link tests in case the system voltage exceeds 0,87 % of the fuse-link rated voltage.

May I increase the voltage rating by connecting fuses in series?

No, unlike fuses connected in parallel, fuses connected in series do not add on performance data, e.g. voltage rating as one may assume. Because of product tolerances, each fuse has to be able to interrupt the circuit at full recovery voltage.