Rated voltage U_n

The rated voltage is the designated voltage of the fuse and and is used to determine its test conditions and operational voltage limits.

For LV HRC and SITOR fuse links, the rated voltage is always the r.m.s. value of an AC voltage.

In the case of NEOZED and DIAZED fuse links, a distinction is made between AC and DC voltage values.

Rated current I_n

The rated current of a fuse link is the designated current of the fuse link and is the current up to which it can be continuously loaded under prescribed conditions without adverse affects.

Rated frequency

The rated frequency is the frequency for which the fuse link is rated with regard to power dissipation, current, voltage, characteristic curve and breaking capacity.

Selectivity

Several fuses are usually connected in series in one system. And when things get serious, selectivity ensures that only the faulty electrical circuit of a system is switched off and not the entire operational process.

Siemens fuses of operational class gG, at an operational voltage of up to 400 V AC and a ratio of 1:1.25, are interselective, i.e. from rated current level to rated current level. This is achieved by means of the considerably smaller spread of ±5 % of the time/current characteristic curve, which far exceeds the demand for a ratio of 1:1.6 specified in the standard.

It is therefore possible to use smaller conductor cross-sections due to the lower rated currents.

Breaking capacity

The rated breaking capacity is the highest prospective short-circuit current Ip that the fuse link can blow under prescribed conditions.

A key feature of these fuses is their high rated breaking capacity with the smallest footprint. The basic demands and circuit data for tests – voltage, power factor, actuating angle, etc.– are specified in both national (DIN VDE 0636) and international (IEC 60269) regulations.

However, for a constant failsafe breaking capacity, from the smallest non-permissible overload current through to the highest breaking current, a number of quality characteristics need to be taken into account when designing and manufacturing fuse links. These include the design of the fuse element with regard to dimensions and punch dimension and its position in the fuse body, as well as its compressive strength and the thermal resistance of the body. The chemical purity, particle size and the density of the quartz sand also play a key role.

The rated breaking capacity for AC voltage for NEOZED- and the majority of DIAZED fuses - is 50 kA, and in the case of our LV HRC fuses, it is even 120 kA. The various type ranges of SITOR fuses have different switching capacities ranging from 50 to 100 kA.

Faster arcing and precise arc quenching are the requirements for a reliable breaking capacity.

Operational classes

Fuses are categorized according to function and operational classes. The first letter defines the function class and the second the object to be protected:

<u>1st letter</u>

a = Partial range protection
(<u>a</u>ccompanied fuses):
Fuse links that carry currents at least up to their rated current and can switch currents above a specific multiple of their rated current up to their rated breaking current.

g = Full range protection
(<u>g</u>eneral purpose fuses):
Fuse links that can continuously carry currents up to at least their specified rated current and can switch currents from the smallest melting current through to the breaking current. Overload and short-circuit protection.

<u>2nd letter</u>

G = Cable and line protection (general applications)

M = Switching device protection in motor circuits
(for protection of motor circuits)

R, S=Semiconductor protection/thyristor protection
(for protection of rectifiers)

L = Cable and line protection
(in acc. with the old, no longer valid DIN VDE)

B = Mine equipment protection

Tr = Transformer protection

The designations "slow" and "quick" still apply for DIAZED fuses. These are defined in IEC/CEE/DIN VDE.

In the case of "quick" characteristics, the fuse blows in the breaking range faster than those of the gG operational class.

In the case of DIAZED fuse links for DC railway network protection, the "slow" characteristic is particularly suitable for switching off direct currents with greater inductance. Both characteristics are also suitable for the protection of cables and lines.

Full range fuses (gG, gR, quick, slow) reliably break the current in the event of non-permissible overload and short-circuit currents.

Partial range fuses (aM, aR) exclusively serve short-circuit protection.

The following operational classes are included in the product range:

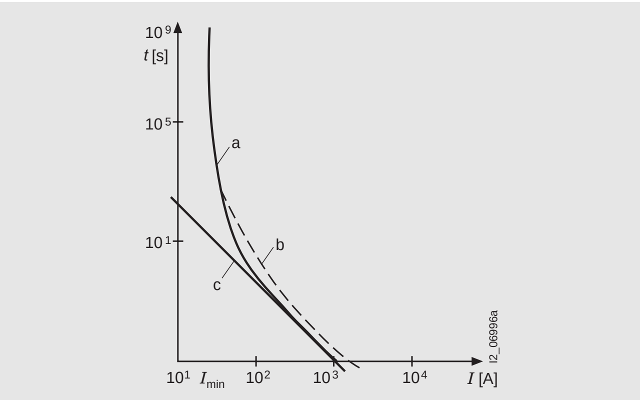
gG	(DIN VDE/IEC) = Full range cable and line protection
aM	(DIN VDE/IEC) = Partial range switching device protection
aR	(DIN VDE/IEC) = Partial range semiconductor protection
gR	(DIN VDE/IEC) = Full range semiconductor protection
gS	(DIN VDE/IEC) = Full range semiconductor protection and cable and line protection
Quick	(DIN VDE/IEC/CEE) = Full range cable and line protection
Slow	(DIN VDE) = Full range cable and line protection

Characteristic curves

Time/current characteristic curves

The time/current characteristic curve specifies the virtual time (e.g. the melting time) as a function of the prospective current under specific operating conditions.

Melting times of fuse links are shown in the time/current diagrams with logarithmic scale and depending on their currents. The melting time characteristic curve runs from the smallest melting current, which just about melts the fuse element, asymptotic to the I^2t lines of the same melting heat value in the range of the higher short-circuit currents, which specifies the constant melting heat value I^2t.
To avoid overcomplication, the time/current characteristic curves diagrams omit the I^2t lines (c).



General representation of the time/current characteristic curve of a fuse link of gL/gG operational class

I_{min}: Smallest melting current
a: Melting time characteristic curve
b: OFF time characteristic curve
c: I^2t line

The shape of the characteristic curve depends on the outward heat transfer from the fuse element. DIN VDE 0636 specifies tolerance-dependent time/current ranges within which the characteristic curves of the fuse must lie. Deviations of ± 10 % are permissible in the direction of the current axis. With Siemens LV HRC fuse links of gG operational class, the deviations work out at less than ± 5 %, a mark of our outstanding production accuracy. For currents up to approx. 20 I_n, the melting time-current characteristic curves are the same as the OFF time characteristic curves. In the case of higher short-circuit currents, the two characteristic curves move apart, influenced by the respective arc quenching time.

The difference between both lines (= arc quenching time) also depends on the power factor, the operational voltage and the breaking current.

The Siemens characteristic curves show the mean virtual melting time characteristic curves recorded at an ambient temperature of (20 ± 5) °C. They do not apply to preloaded fuse links.

Virtual time t_v

The virtual time is the time span calculated when a I^2t value is divided by the square of the prospective current:

$$t_v = \frac{\int i^2 dt}{I_p^2}$$

The time/current characteristic curve specifies the prospective current I_p and the virtual melting time t_{vs}.

Prospective short-circuit current I_p

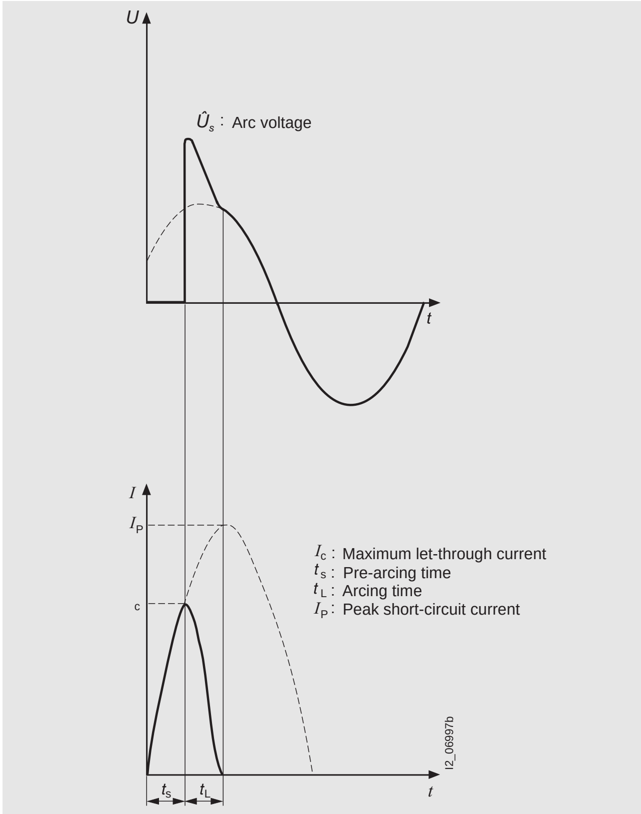
The prospective short-circuit current is the r.m.s. value of the line-frequency AC component, or the value of the direct current to be expected in the event of a short-circuit occurring after the fuse, were the fuse to be replaced by a component of negligible impedance.

Let-through current characteristic curves

The let-through current characteristic curve specifies the value of the let-through current at 50 Hz as a function of the prospective current.

The let-through current I_c is the maximum instantaneous value of the current reached during a switching operation of the fuse.

The fuse element of the fuse links melts so quickly at very high currents that the surge short-circuit current I_p is prevented from occurring. The highest instantaneous value of the current reached during the shutdown cycle is called the let-through current I_c. The current limitations are specified in the current limiting diagrams, otherwise known as let-through current diagrams.

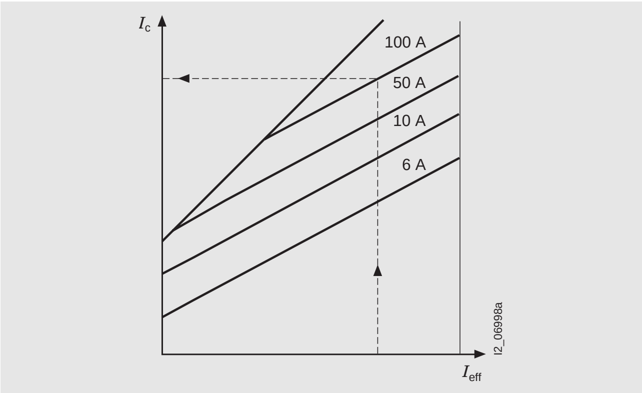


Oscillograph of a short-circuit current shutdown through a fuse link

Current limitation

As well as a failsafe rated breaking capacity, the current-limiting effect of a fuse link is of key importance for the cost effectiveness of a system. In the event of short-circuit breaking by a fuse, the breaking current continues to flow through the network until the fuse link is switched off. However, the breaking current is limited by the system impedance.

The simultaneous melting of all the bottlenecks of a fuse element produce a sequence of tiny partial arcs that ensure a fast breaking operation with strong current limitation. The current limitation is also strongly influenced by the production quality of the fuse - which in the case of Siemens fuses is extremely high. For example, an LV HRC fuse link, size 2 (224 A) limits a breaking current with a possible r.m.s. value of approximately 50 kA to a let-through current with a peak value of approx. 18 kA. This strong current limitation provides constant protection for the system against excessive loads.



Current limitation diagram;
let-through current diagram of LV HRC fuse links, size 00,
operational class gL/gG,
rated currents, 6 A, 10 A, 50 A, 100 A

Legend

t_{vs} = Virtual melting time

I_c = Max. let-through current

I_{eff} = R.m.s. value of the prospective short-circuit current

I^2t_s = Melting I^2t value

I^2t_a = Breaking I^2t value

I_n = Rated current

P_v = Rated power dissipation

$\Delta\vartheta$ = Temperature rise

k_a = Correction factor for I^2t value

U_w = Recovery voltage

$\hat{U}_s$ = Peak arc voltage

i_p = Peak short-circuit current

① = Peak short-circuit current with largest DC component

② = Peak short-circuit current without DC component

U = Voltage

i = Current

t_s = Melting time

t_L = Arc quenching time

Rated power dissipation

Rated power dissipation is the power loss during the load of a fuse link with its rated current under prescribed conditions.

The cost effectiveness of a fuse depends largely on the rated power dissipation (power loss). This should be as low as possible and have low self-heating. However, when assessing the power loss of a fuse, it must also be taken into account that there is a physical dependence between the rated breaking capacity and the rated power dissipation. On the one hand, fuse elements need to be thick in order to achieve the lowest possible resistance value, on the other, a high rated breaking capacity requires the thinnest possible fuse elements in order to achieve reliable arc quenching.

Siemens fuses have the lowest possible rated power dissipation while also providing the highest possible load breaking reliability.

These values lie far below the limit values specified in the regulations. This means low temperature rises, reliable breaking capacity and high cost effectiveness.

I^2t value

The I^2t value (joule integral) is the integral of the current squared over a specific time interval:

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

Specifies the I^2t values for the melting process (I^2t_s) and for the shutdown cycle (I^2t_A, - sum of melting and quenching I^2t value). The melting I^2t value, also known as the total I^2t value or breaking I^2t value, is particularly important when dimensioning SITOR fuses for semiconductor protection. This value depends on the voltage and is specified with the rated voltage.

Peak arc voltage $\hat{U}_s$

The peak arc voltage is the highest value of the voltage that occurs at the contacts of the fuse link during the arc quenching time.

Residual value factor RW

The residual value factor is a reduction factor for determining the permissible load period of the fuse link with currents that exceed the permissible load current I_n' (see rated current I_n). This factor is applied when dimensioning SITOR fuses for semiconductor protection.

Varying load factor WL

The varying load factor is a reduction factor for the rated current with varying load states. This factor is applied when dimensioning SITOR fuses for semiconductor protection.

Recovery voltage U_w

The recovery voltage (r.m.s. value) is the voltage that occurs at the contacts of a fuse link after the power is cut off.