



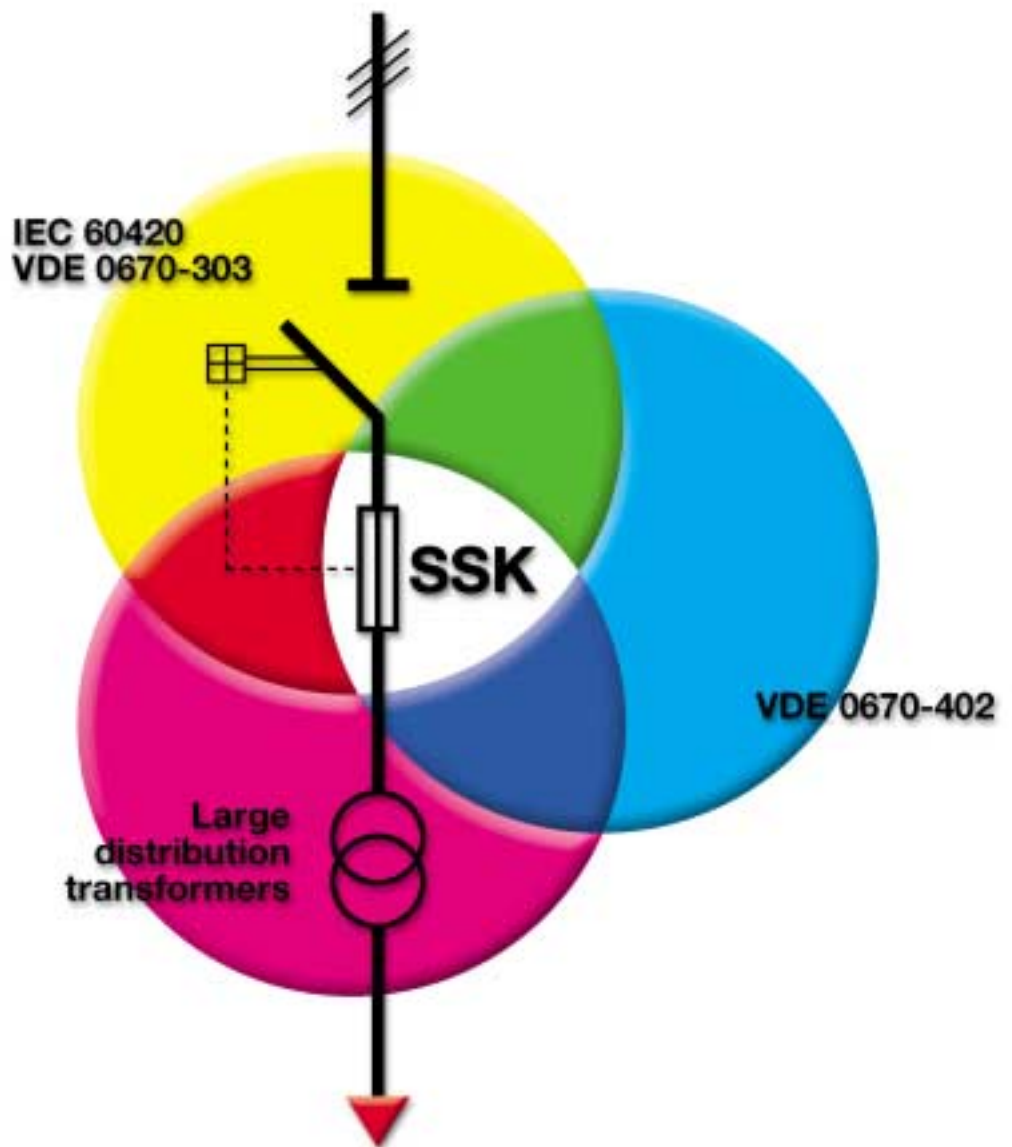
UMWELTMANAGEMENTSYSTEM



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SICHERUNGEN/FUSES



High-voltage fuse-links for switch-fuse combination

The SIBA high-voltage fuse-link type SSK extends the range of usage for switch-fuse combinations up to larger transformer sizes. In connection with the temperature sensitive striker pin, which avoids switchgear damage caused by higher temperatures, this high-voltage fuse type allows proper and cost-effective fusing of distribution transformers by means of switch-fuse combinations.

When fuse rated currents are selected for protection of distribution transformers, uncertainties may arise when the engineer considers the applicable standards. Whilst the fuse manufacturers recommendations usually refer to DIN VDE 0670-402 (VDE 0670 part 402): 1988-05 [1], the manufacturers of fused load break switches recommend fuse rated currents which comply with their testing according to DIN EN 60420 (VDE 0670 part 303): 1994-09 [3], respectively IEC 60420 [4], and many times these currents will be considerably lower. The application of both standards therefore leads to a different fuse-rated current so that one could come to the conclusion that fuse protection on the basis of both standards is practically impossible. A solution is provided here by using the newly developed SIBA high-voltage fuse links [5], which consider the specialities and practical advantages of both standards.

Fuse protection of distribution transformers

Because high-voltage fuses are related to transformers (and most of the time to the switch), their protective range extends up to the fuse on the low voltage side of the transformer. This means that overcurrents rise because of faults on the low voltage busbar, due to winding or earth faults inside the transformers which are reliably cut off by the high-voltage fuses fitted on the high-voltage side of the transformer before the dynamic effects can affect the medium voltage network.

Operating currents and times of the high-voltage fuse are coordinated with the transformer, the low-voltage fuse (NH-fuse-link service class gTr or gG)

and the medium voltage protective device respectively. Picture 1 a) to 1 c) show typical protection variants of transformers. The dependence of all components involved, as there are transformer high-voltage fuse-links, secondary side protection devices and upstream protection on the high-voltage side, are shown in the diagram (picture 2).

The high voltage fuse has to comply with the following criteria:

- The high voltage fuse must withstand the transformer inrush current (picture 2, point A), which can have a value of between 6 to 20 times the transformer rated current (for 0,1 second) depending on the transformer size.
- The maximum short circuit current, defined from the relative voltage u_k of the transformer, must be interrupted within the permitted short circuit time according to DIN 57532-5 (VDE 0532 part 5): 1984-05 [6].
- The high voltage fuse must be able to hold the transformer service current (transformer rated current) continuously.

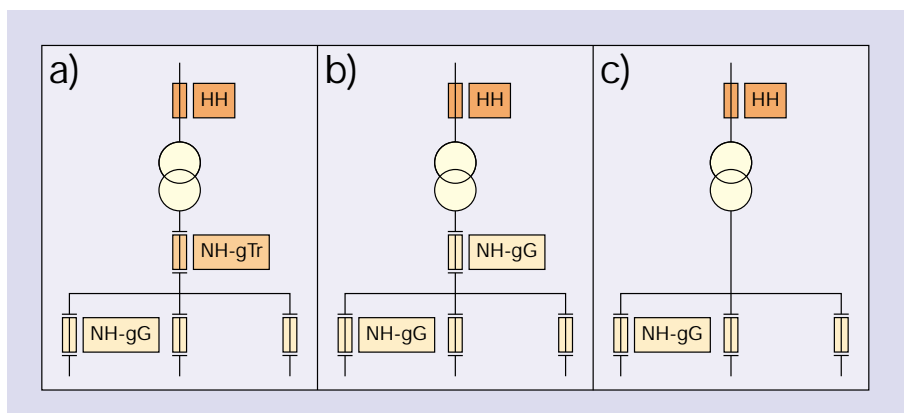
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- When the transformer is overloaded by 150% (permitted overload), the temperature that the switchgear is designed for must not be exceeded.
- In the time-current characteristic, the operating current and times of the high-voltage fuse must discriminate with the low-voltage fuse. Possible intersections of both characteristic currents can only be accepted above the maximum short-circuit current (picture 2, point B)
- On the transformer high-voltage side, there must be discrimination with the upstream protection of the high-voltage network.

Avoidance of undesirable high temperatures

High-voltage fuse-links are fitted with striker pins, which are also used as an indicator. Where high-voltage fuse-links are fitted in a switch-fuse combination, this striker pin will open the switch via its tripping mechanism and switch off all three phases.

In order to avoid undesirable high temperatures in switchgear, SIBA high-voltage fuse-links are fitted with integrated temperature limiting striker pins. High temperatures can for example arise when the fuses are operated in the so-called forbidden range, meaning below the minimum breaking current. Higher temperatures can also arise when lightning influences the fuse-links.



Picture 1: Distribution transformer with typical protection variants (a - c)

The response of the temperature sensitive striker pin leads to reliable interruption by means of the switch-fuse and avoids thermal damage to the switchgear [7].

High-voltage fuse-links according to VDE 0670 part 402

To make selection of fuse-links easier for the user, the time-current characteristics of high-voltage fuses were standardized in 1988 in DIN VDE 0670-402 (VDE 0670 part 402): 1988-05[1]. In the range between 10 Milliseconds and 10 seconds, an upper and a lower limit line was defined for each fuse rated current. In combination with the criteria already described for high-voltage fuses for protection of power transformers, the selection schedule was established. This schedule makes it easy for the user to select the appropriate fuse rated current without comparing time current characteristics, without studying discrimination and without observing the properties of various manufacturers. Transformer sizes up to 1 MVA and rated voltage 36 kV, are shown with their appropriate fuse-links. In order to comply with the users request for a reasonable range of fuses, this fuse recommendation shows several fuse rated currents for a certain transformer size.

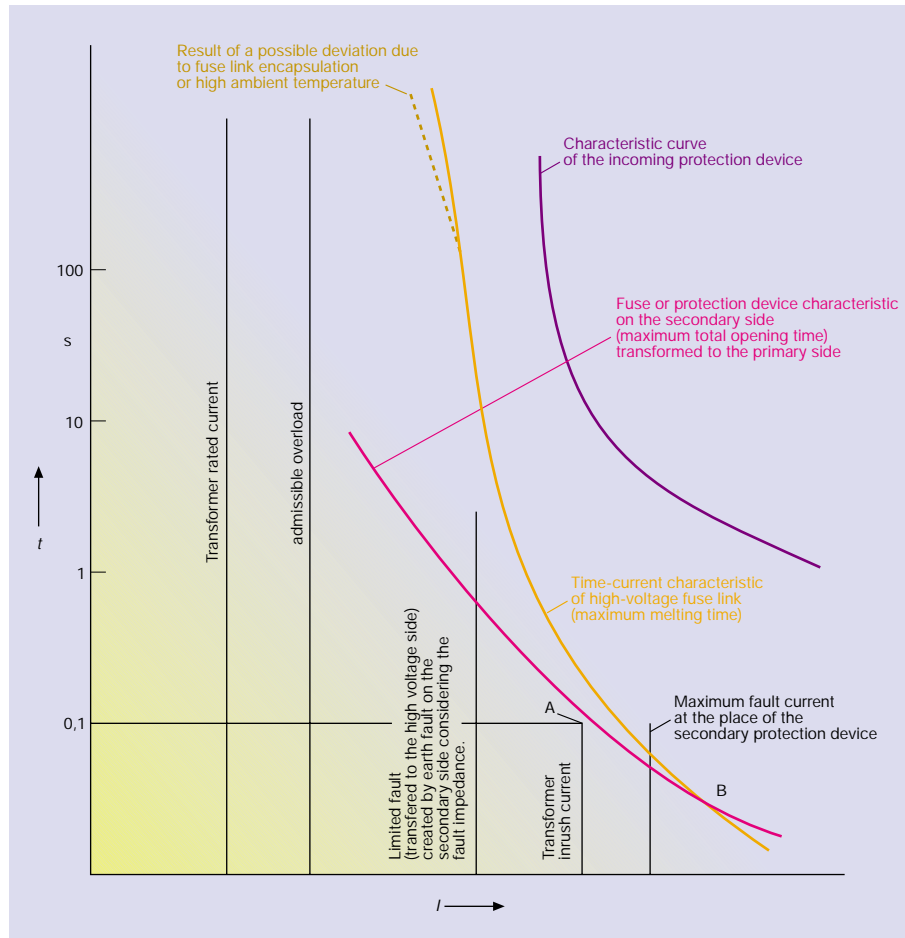
The fuse recommendation DIN VDE 0670-402 (VDE 0670 part 402): 1988-05 [1] has found wide acceptance with utilities and in industry. The recommendation does not only comprise NH fuses service class gTr (picture 1a) but also class gG- fuses (picture 1b), or even when isolating links only (picture 1c) are used on the secondary side.

Switch-fuse combination according to VDE 0670 part 303

DIN EN 60420 (VDE 0670 part 303): 1994-09 [3] represents the official basis for the coordination of high-voltage fuses and load break switches. Several mechanical and electrical tests are specified. Below we will comment only on the tests of the take-over current at striker pin operation, as well as the proof of primary cut-off operation due to secondary short-circuit at the terminals [3,4].

Take-over current at striker pin operation

The rated take-over current at striker pin operation is the highest fault current



Picture 2: Characteristic curves for protection of transformer circuits according to DIN VDE 0670-402 (VDE 0670 Teil 402):1988-05[1] und IEC 60787:1983-01[2]

the load break switch has to interrupt. It refers to the current range where the cut-off duty will be transferred from the fuse to the load break switch. The high-voltage fuse will open all currents above this value up to the maximum short-circuit current. Consequently the fuse striker pin will operate the load break switch and isolate the defective transformer from the network (isolating function of the load-break switch).

Currents below the rated take-over current will be interrupted by the load break switch. Here the striker pin of the fuse which operates first will trigger the load break switch. Whilst the fuses in the remaining conductor phases are still in the interrupting process, the switch will open and consequently isolate the circuit (switching function of the load break switch).

In order to ensure safe operation of the switch fuse combination, DIN EN60420 (VDE 0670 part 303): 1994-09 [3] requires the take-over current of the high voltage fuse to be smaller than the rated take-over current of the switchgear. The fuse take-over current is defined by the coordination of the fuse charac-

teristic and the switch opening time at striker pin operation and this figure is a characteristic value of the load break switch. In practice it has been shown that especially for protection of bigger transformer sizes with switch-fuse combination fuse rated currents have to be used which do not comply with the recommendations according to DIN VDE 0670-402 (VDE 0670 part 402): 1988-05 [1].

Short-circuit at secondary terminals

In case of a secondary short-circuit at the terminals, fuses have to be used which ensure cut-off operation by the fuses alone without assistance of the load break switch [3]. This means that the take-over current of the high-voltage fuse must be smaller than the primary fault current. The primary fault current, corresponding to the maximum short-circuit current, refers to VDE 0670-402 (VDE 0670 part 402): 1988-05 at the highest permitted duration of two seconds. The switchgear certification of some manufacturers however, shows

Rated voltage kV	Transformer rated capacity in kVA										
	100	125	160	200	250	315	400	500	630	800	1000
	$u_z = 4\% \text{ *)}$										$u_z = 5\% \text{ *)}$
Highest admissible short-circuit duration 2 s*)											
High-voltage fuse-links rated voltage in A											
6/7,2	20 and 25	25 and 31,5	31,5 and 40	40 and 50	50 and 63	63 and 80	80 and 100	100 and 125	125 and 160	160	160 and 200
10/12	16	16	20 and 25	25 and 31,5	31,5 and 40	40 and 50	50 and 63	63 and 80	80 and 100	100 and 125	125 and 160
20/24	10	10	16	16	16 up to 25	25	25 and 31,5	31,5 and 40	40 and 50	63	63 and 80
30/36	6,3	10	10	16	16 up to 25	20 and 25	25	25 and 31,5	31,5 and 40	40 and 50	40 and 50

*) Rated short circuit voltage u_z and highest admissible short circuit duration according to DIN 57532-5 (VDE 0532 Teil 5):1984-05 [6]
 Fuse recommendation to DIN VDE 0670-402 (VDE 0670 Teil 402):1988-05 [1]

values in the millisecond range (switch opening time at striker pin operation) according to DIN EN 60420 (VDE 0670 part 303): 1994-09. Considering both standards, this can also result in high voltage fuse rated currents of different values.

The responsible network engineer has two alternatives to solve this problem: Either he will make his own calculations and comparison of time-current characteristics in order to comply with the criteria for fuse protection of transformer circuits, or he can use the latest development in high-voltage fuse-links which comply with both standards.

High-voltage fuse-links SSK type

SIBA has made a new development in order to enable DIN high-voltage fuses [8] to comply with the requirements mentioned above. The result of this development is the high-voltage fuse-link SSK type.

The new fuse-links look identical to the existing design, only the designation "SSK-type" and "VDE 0670 part 402" indicate this specific application. The melting elements show the well-known profile. However, the dimensions of the notches and the correlation to the total cross section were optimized and modified.

The priority in development was to achieve a reduction in the melting times in the range below 100 milliseconds, without negatively influencing other fuse rated values. The switchgear manufacturer's requirements for low temperature rise are complied with; the power loss at rated value of the transformer is only 70-75Watts.

The well known low value of the minimum breaking current being 3.5 times fuse rated current was maintained from our standard high-voltage fuse-links. In the range below 100 milliseconds, the time-current characteristic of the new SSK high-voltage fuse-link is positioned on the lower limit-line of DIN VDE 0670-402 (VDE 0670 part 402): 1988-05 [1]. By this feature, the specific requirements of the switchgear manufacturers were fully realized. Discrimination with the low-voltage NH fuse-links of operating class gTr or gG is ensured, where the very steep time-current characteristics of the NH-fuse-links are advantageous.

DIN EN 60420 (VDE 0670 part 303): 1994-09 [3] requirements are also considered by the fast characteristic in the range below 100 milliseconds. This results in low take-over currents of the fuse-link which very positively comply with the standard requirements:

- rated take-over current of the switch \geq take-over current of the fuse-link
- maximum secondary short-circuit current $>$ take-over current of the fuse-link

High-voltage fuse-links SSK type are new products as an extension of the existing product range. The specific application is for switchgear with relatively low values of switch opening times and take-over currents, which are used to protect transformers \geq 630 kVA. For smaller transformers, the well known standard SIBA fuse-links can be used because of the better relationship between fuse take-over current and rated switch take-over current.

Literature

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