SIEMENS

Technical Series
Edition 2

Use of switch-fuse combinations at the medium-voltage level for the protection of distribution transformers

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1. Basis

Medium-voltage distribution transformers are either protected against short circuits by circuit-breaker-relay combinations or by switch-fuse combinations. The following factors determine the choice of a suitable protection device:

- Cost of investment
- Technical supply conditions of the distribution network operator
- Country-specific installation practice
- The degree of selectivity required towards the downstream low-voltage network
- Switching capacity of the switch-disconnector
- Operating currents
- The extent to which thermal and dynamic loads caused by short-circuits shall be allowed to affect the transformer
- Type of neutral-point connection in the medium-voltage network
- Switching frequency

Both protection variants for medium-voltage distribution transformers are used in infrastructure as well as in industrial applications. Table 1 benchmarks selected criteria briefly, but makes no claim for completeness; it is intended as a first aid for making decisions only.

The following statements do not intend to explain the advantages and disadvantages of the two switchgear assemblies in detail in order to reach at a decision pro or contra one of the two. Instead, it shall demonstrate the complexity of configuring a switch-fuse combination.

Table 1: Assessment of selected criteria of circuit-breaker-relay and switch-fuse combinations

	Circuit-breaker-relay combination	Switch-fuse combination
Cost of investiment	-	+
Selectivity towards the downstream low-voltage network	+	-
Switching capacity	+	-
Thermal / dynamic load on transformer in case of short circuit	-	+
Permissible operating currents	+	o
Independent of neutral-point connection in the MV network	+	o
Switching frequency	+	o

2. Switch-fuse combination

A switch-fuse combination consists of two functional units:

- the switch in accordance with DIN EN 62271-103 (VDE 0671-103), or respectively IEC 62271-103 and
- the high-voltage high-rupturing-capacity (HV HRC) fuse in accordance with DIN EN 60282-1 (VDE 0670-4), or respectively IEC 60282-1

which are linked through the striker pin system. The striker pin of the fuse must mechanically trip the switch so that a three-pole disconnection can be performed by the switch. Since the switch only switches operating currents, showing a limited current breaking capacity, the fuse must handle short-circuit protection. There is an overcurrent range between the rated operating current of the fuse and the short-circuit protection provided by the fuse in which switch and fuse may share the protection duty. To this end, both devices must be well matched. This coordination is specified in DIN EN 62271-105 (VDE 0671-105), or IEC 62271-105 respectively.

In order to better demonstrate the duties of each device in the combination, the operating ranges of a HV HRC backup fuse are simplified in Figure 1.

Rated operating current of switch-fuse combination

Owing to the thermal conditions at the mounting location of the fuse, e.g. inside the moulded plastic container, and the resulting limited dissipation of heat losses as compared to fuses in air, the rated operating current of the device combination is below the rated operating current of the fuse $I_{\text{r-HV HRC}}$. This means that the device combination cannot be loaded with the full rated fuse current. Only the switch operates in this range.

Overload range

The overload range is defined to be between the rated fuse current and the rated breaking current of the fuse ($I_{\text{HV HRCmin}}$ or respectively I_3). Within this range, the back-up fuse is thermally overloaded and approximately up to twice the rated fuse current, the fuse shows no defined breaking behaviour; therefore this is called the „forbidden“ range. There is the danger that the ceramic body may burst, which would cause the fuse to lose its breaking capacity. This can be prevented with the aid of a so-called thermal protection or a thermal striker pin which is triggered in case of overtemperature conditions, which in turn trips the switch-disconnector.

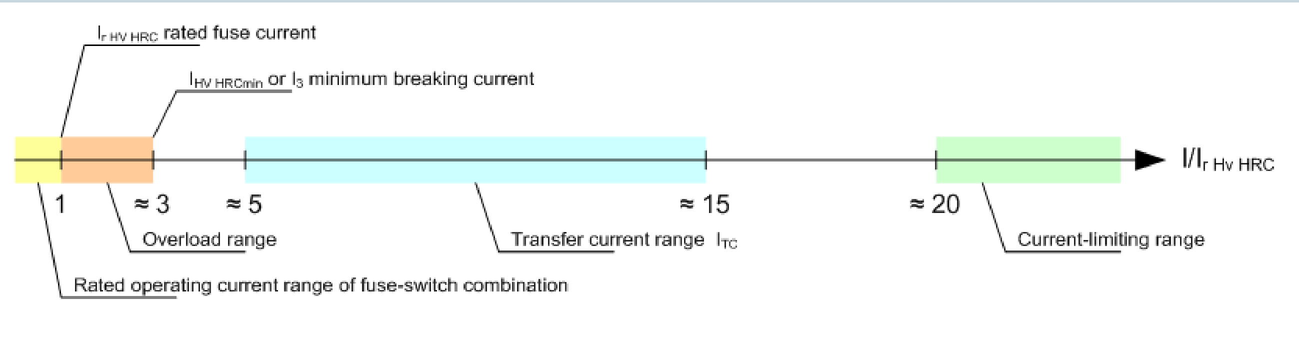
In the range of more than twice the rated fuse current up to the minimum breaking current, the major and minor fusible elements are melted. However, the electric arc generated in the fuse cannot be extinguished. This fault can be cleared by the striker pin being triggered which trips the switch-disconnector.

Minimum breaking current $I_{\text{HV HRCmin}}$ or I_3

Starting with this minimum breaking current, which amounts to approximately three times the rated fuse current, the fuse works in a defined range, i.e. after the major and minor fusible elements have thoroughly melted, the electric arc in the fuse can be extinguished.

In-production tolerances may be the reason that when such fault values occur or are exceeded, only one of the fuses initially clears the fault during a three-pole fault event, releasing the striker pin and tripping the switch. Due to the short switch response time it may happen that the switch clears the remaining two-pole fault faster than the other two intact fuses.

Figure 1: Schematic view of the current ranges of a HV HRC back-up fuse



Transfer current range („transfer current“ $I_{transfer}$ or I_{TC})

The transfer current $I_{transfer}$ or I_{TC} is defined as the current up to which at first only one fuse blows in case of a three-pole fault, and the switch then clears the remaining twopole fault. Under these conditions, the current breaking capacity of the switch must not be exceeded. This is a critical range for the switch. Usually, this current value is in the range of 5 to 15 times the rated fuse current.

In case of higher currents all fuses extinguish, before theswitch isolates or de-energizes. The current breaking capacity of the switch is referred to as the rated transfer current $I_{r\text{-}transfer}$ or I_4 and must be specified by the manufacturer.

Figure 2 below shows the principle of determining the transfer current with T_0 being the switch response time of the switch-disconnector (if applicable, plus an additional relay response time). The mathematical background of this method is described in DIN EN 62271-105 (VDE 0671-105), or IEC 62271-105 respectively.

Current limiting range

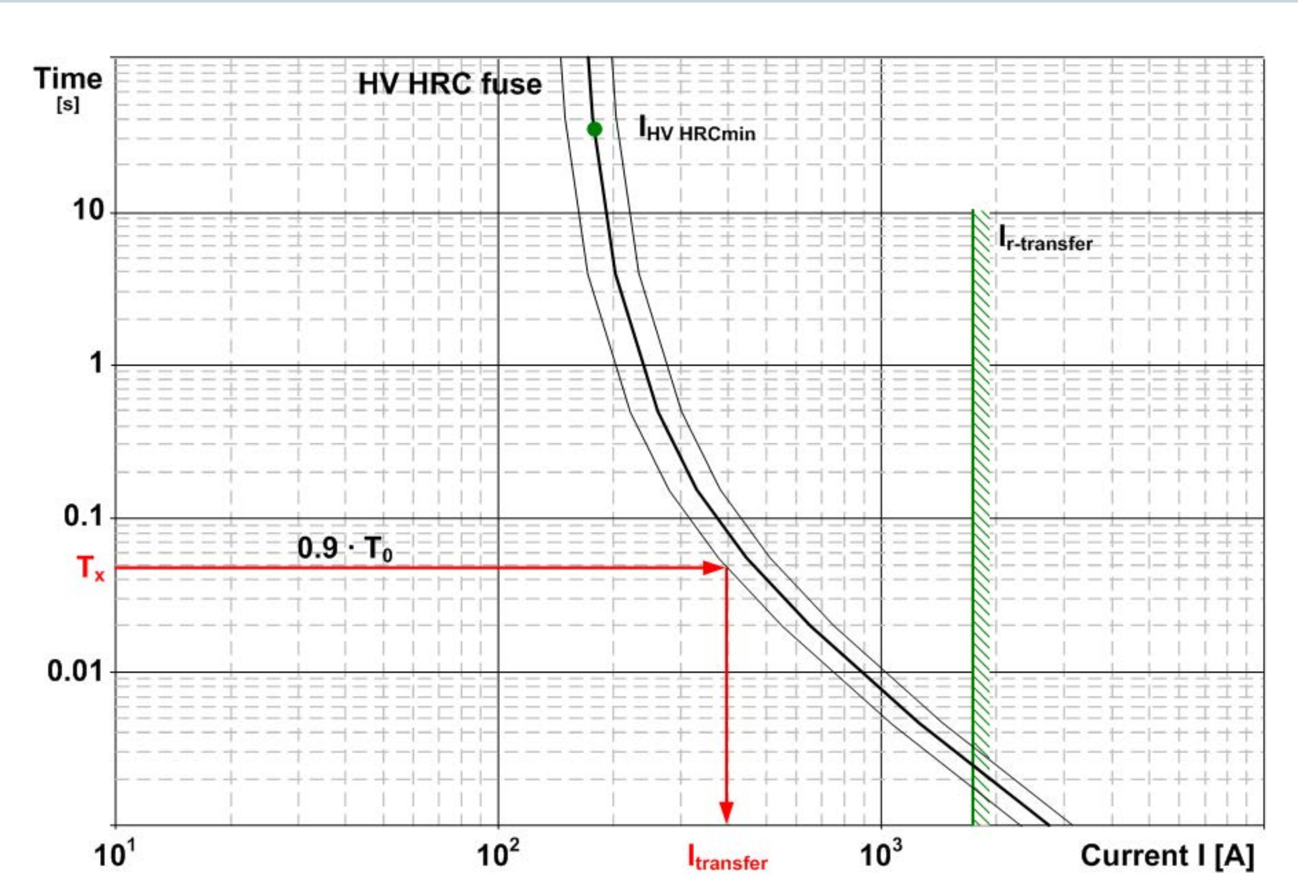
Current values of approximately 20 times the rated fuse-current or higher are broken in a current-limiting manner by the fuses within the first half-wave, and the switch then opens in a de-energized state due to the fact that it was triggered by the striker pin.

In accordance with IEC 60282-1 section 6.6, the breaking capacity of HV HRC fuses is only tested with 87 % of their rated voltage in type tests.

But in 3-phase power systems with a quenched or isolated neutral, it is possible that the full phase-to-phase voltage is applied to the HV HRC fuse during the break operation under phase-earth-phase-fault (double fault) and other conditions. Therefore, the maximum system operating voltage must be no greater than 87 % of the rated fuse voltage.

For this reason, it must already be ensured in the stage of switching device configuration and HV HRC fuse selection that only those fuse-links are used which either meet the above described requirement, or whose breaking capacity was at least tested with the maximum system voltage. In cases of doubt, a suitable HV HRC fuse should be selected according to the recommendations of the fuse manufacturer.

Figure 2: Determining the transfer current from the fuse characteristic



3. HV HRC fuse assignment

Besides the conditions required for the protection of distribution transformers in gas-insulated medium-voltage switchgear by switch-fuse combinations, as described in section 2,

- the continuous overcurrent permitted for the transformer,
- the heat effect of the inrush current

and

- the permissible power loss incurred by mounting the fuse in a moulded plastic container

must also be considered.

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DIN EN 62271-105 (VDE 0671-105). or IEC 62271-105 respectively, recommends a secondary-side interruption of a three-pole terminal short circuit at the transformer which should be handled by the HV HRC fuses alone in to order to protect the switch against excessive loads and the switchgear plant against damage. This three-pole terminal short circuit present at the secondary side of the transformer should be higher than the transfer current of the switch-fuse combinationn ($I''_{k3} > I_{transfer}$). The device assignments specified for HV HRC fuses in the Siemens catalogues (HA40.2 and HA35.41) for 8DJH and NXPLUS C switchgear meet this additional requirement.

Owing to their high quality standards, Siemens guarantees plant safety even if this condition is not always fulfilled completely. Based on the minimum breaking currents and transfer currents of SIBA type HV HRC fuses given in Table 2, and the rated transfer currents of switches used in gas-insulated Siemens 8DJH and NXPLUS C switchgear, HV HRC fuses listed in Tables 4 and 5 may generally be used in combination with distribution transformers of short-circuit voltage ratings up to $u_k \leq 7\,\%$.

Table 2: Minimum breaking and transfer currents of SIBA type HV HRC fuses

HV HRC fuse – Type SIBA – for 8DJH and NXPLUS C					
	HHD		SSK		
	*)	*)	*)	6–12 kV	10–24 kV
I_n in A	$I_{HV\,HRCmin}$ in A	$I_{transfer}$ in A	I_{HHmin} in A	$I_{transfer}$ in A	
6,3	22	40	–	–	–
10	34	69	–	–	–
16	56	101	–	–	–
20	70	178	–	–	–
25	90	228	–	–	–
31,5	110	266	–	–	–
40	140	360	–	–	–
50	170	461	–	–	–
63	210	647	210	490	480
80	280	880	280	640	580
100	320	1,124	320	825	780
125	–	–	450	1,080	–

*) applicable for rated fuse currents of 3–7.2 kV, 6–12 kV, 10–17.5 kV and 10–24 kV

Table 3: Rated transfer currents of Siemens 8DJH and NXPLUS C switchgear

Rated transfer current I_4 of switchgear		
	$U \leq 12$ kV	12 kV < $U \leq 24$ kV
8DJH	1,500 A	1,300 A
NXPLUS C	1,150 A	830 A

Transformer		Suitable HV HRC fuse – type SIBA – for 8DJH								
		HHD						SSK		
		3–7.2 kV	6–12 kV		10–17.5 kV		10–24 kV	6–12 kV		10–24 kV
		292 mm	292 mm	442 mm	292 mm	442 mm	442 mm	292 mm	442 mm	442 mm
U_r in kV	S_r in kVA	I_r in A	I_r in A		I_r in A		I_r in A	I_r in A		I_r in A
6–7.2	50	10–16	10–16		–		–	–		–
	75	16–20	16–20		–		–	–		–
	100	16–25	16–25		–		–	–		–
	125	20–31.5	20–31.5		–		–	–		–
	160	31.5–40	31.5–40		–		–	–		–
	200	31.5–50	31.5–50		–		–	63	–	–
	250	40–63	40–63		–		–	63–80	80	–
	315	50–63	50–63		–		–	63–80	80	–
	400	63–80	63–80		–		–	63–100	80–100	–
	500	80–100	80–100		–		–	80–125		–
	630	–	–		–		–	125	100–125	–
10–12	50	–	10		10		10	–		–
	75	–	10–16		10–16		10–16	–		–
	100	–	16		16		16	–		–
	125	–	16–20		16–20		16–20	–		–
	160	–	20–25		20–25		20–25	–		–
	200	–	25–31.5		25–31.5		25–31.5	–		–
	250	–	25–40		25–40		25–40	–		–
	315	–	31.5–50		31.5–50		31.5–50	–		–
	400	–	40–50		40–50		40–50	63–80	80	63–80
	500	–	50–63		50–63		50–63	63–80	80	63–80
	630	–	63–80		80	63–80	80	63–100	80–100	80–100
	800	–	63–100	80–100	–		–	80–125	80–125	100
	1,000	–	–	100	–		–	125	100–125	–
	1,250	–	–		–		–	–	125	–
13.8	50	–	–		–	6.3	6.3	–		–
	75	–	–		–	6.3–10	6.3	–		–
	100	–	–		–	10–16	16	–		–
	125	–	–		–	10–16	16	–		–
	160	–	–		–	16–20	20	–		–
	200	–	–		–	16–20	20	–		–
	250	–	–		–	20–25	25	–		–
	315	–	–		–	25–31.5	31.5	–		–
	400	–	–		–	31.5	31.5	–		–
	500	–	–		–	40	40	–		–
	630	–	–		–	50	50	–		–
	800	–	–		–	63	63	–		63
	1,000	–	–		–	80	–	–		80
15–17.5	50	–	–		–	6.3	6.3	–		–
	75	–	–		–	6.3–10	10	–		–
	100	–	–		–	10–16	16	–		–
	125	–	–		–	16	16	–		–
	160	–	–		–	16	–	–		–
	200	–	–		–	20	20	–		–
	250	–	–		–	25–31.5	25–31.5	–		–
	315	–	–		–	31.5	31.5	–		–
	400	–	–		–	31.5–40	31.5–40	–		–
	500	–	–		–	31.5–50	31.5–50	–		63
	630	–	–		–	40–63	40–63	–		63–80
	800	–	–		–	63	63	–		63–100
	1,000	–	–		–	80	–	–		80–100
	1,250	–	–		–	100	–	–		100
20–24	50	–	–		–		6.3	–		–
	75	–	–		–		6.3	–		–
	100	–	–		–		6.3–10	–		–
	125	–	–		–		10	–		–
	160	–	–		–		10–16	–		–
	200	–	–		–		16	–		–
	250	–	–		–		16–20	–		–
	315	–	–		–		16–25	–		–
	400	–	–		–		20–31.5	–		–
	500	–	–		–		25–40	–		–
	630	–	–		–		31.5–50	–		63
	800	–	–		–		31.5–50	–		63
	1,000	–	–		–		50–63	–		63–80
	1,250	–	–		–		80	–		80
	1,600	–	–		–		–	–		100
	2,000	–	–		–		–	–		on request

Table 4: Assignment of SIBA type HV HRC fuse to Siemens 8DJH switchgear
This assignment table is applicable to all distribution transformers with a short-circuit voltage $u_k \le 7$ %

Transformer		Suitable HV HRC fuse – type SIBA – for NXPLUS C								
		HHD						SSK		
		3–7.2 kV	6–12 kV		10–17.5 kV		10–24 kV	6–12 kV		10–24 kV
		292 mm	292 mm	442 mm	292 mm	442 mm	442 mm	292 mm	442 mm	442 mm
U_r in kV	S_r in kVA	I_r in A	I_r in A		I_r in A		I_r in A	I_r in A		I_r in A
6–7.2	50	10–16	10–16		–		–	–		–
	75	16–20	16–20		–		–	–		–
	100	16–25	16–25		–		–	–		–
	125	20–31.5	20–31.5		–		–	–		–
	160	31.5–40	31.5–40		–		–	–		–
	200	31.5–50	31.5–50		–		–	63	–	–
	250	40–63	40–63		–		–	63–80	80	–
	315	50–63	50–63		–		–	63–80	80	–
	400	63–80	63–80		–		–	63–100	80–100	–
	500	80–100	80–100		–		–	80–125		–
	630	100	100		–		–	100–125		–
	800	–	–		–		–	–	125	–
10–12	50	–	10		10		10	–		–
	75	–	10–16		10–16		10–16	–		–
	100	–	16		16		16	–		–
	125	–	16–20		16–20		16–20	–		–
	160	–	20–25		20–25		20–25	–		–
	200	–	25–31.5		25–31.5		25–31.5	–		–
	250	–	25–40		25–40		25–40	–		–
	315	–	31.5–50		31.5–50		31.5–50	–		–
	400	–	40–50		40–50		40–50	63–80	80	63–80
	500	–	50–63		50–63		50–63	63–80	80	63–80
	630	–	63–80		63–80		63–80	63–100	80–100	63–100
	800	–	63–100		80–100		100	80–125		80–100
	1,000	–	100	100	–		–	100–125		100
	1,250	–	–		–		–	125		–
13.8	50	–	–		–	6.3	6.3	–		–
	75	–	–		–	6.3–10	6.3	–		–
	100	–	–		–	10–16	16	–		–
	125	–	–		–	10–16	16	–		–
	160	–	–		–	16–20	20	–		–
	200	–	–		–	16–20	20	–		–
	250	–	–		–	20–25	25	–		–
	315	–	–		–	25–31.5	31.5	–		–
	400	–	–		–	31.5	31.5	–		–
	500	–	–		–	40	40	–		–
	630	–	–		–	50	50	–		–
	800	–	–		–	63	63	–		63
	1,000	–	–		–		–	–		80
	1,250	–	–		–		–	–		100
15–17.5	50	–	–		–	6.3	6.3	–		–
	75	–	–		–	6.3–10	10	–		–
	100	–	–		–	10–16	16	–		–
	125	–	–		–	16	16	–		–
	160	–	–		–	16	–	–		–
	200	–	–		–	20	20	–		–
	250	–	–		–	25–31.5	25–31.5	–		–
	315	–	–		–	31.5	31.5	–		–
	400	–	–		–	31.5–40	31.5–40	–		–
	500	–	–		–	31.5–50	31.5–50	–		63
	630	–	–		–	40–63	40–63	–		63–80
	800	–	–		–	63	63	–		63–100
	1,000	–	–		–	63	–	–		63–100
	1,250	–	–		–	–	–	–		100
20–24	50	–	–		–		6.3	–		–
	75	–	–		–		6.3	–		–
	100	–	–		–		6.3–10	–		–
	125	–	–		–		10	–		–
	160	–	–		–		10–16	–		–
	200	–	–		–		16	–		–
	250	–	–		–		16–20	–		–
	315	–	–		–		16–25	–		–
	400	–	–		–		20–31.5	–		–
	500	–	–		–		25–40	–		–
	630	–	–		–		31.5–50	–		63
	800	–	–		–		31.5–50	–		63
	1,000	–	–		–		50–63	–		63–80
	1,250	–	–		–		63	–		63–80
	1,600	–	–		–		–	–		80–100
	2,000	–	–		–		–	–		100

Table 5: Assignment of SIBA type HV HRC fuse to Siemens NXPLUS C switchgear
This assignment table is applicable to all distribution transformers with a short-circuit voltage $u_k \leq 7$ %

4. Use in distribution transformers with additional fans

The performance of GEAFOL transformers can be enhanced by using cross-flow fans. If they are installed in an open space and sufficiently ventilated, a performance increase of up to 50 % can be achieved. In practice, and in particular if transformer housings are used, the maximum output will be limited to 140 % of the power rating of the distribution transformer. Besides the performance increase, cross-flow fans can be employed to ensure the nominal transformer output continuously even under hot ambient conditions.

Since losses rise as a square of the load current, cross-flow fans are only cost-efficient above a transformer output of 400 kVA. For the same reason, the use of cross-flow fans should only be considered for transformer loads above the nominal rating during back-up operation, not during normal operation.

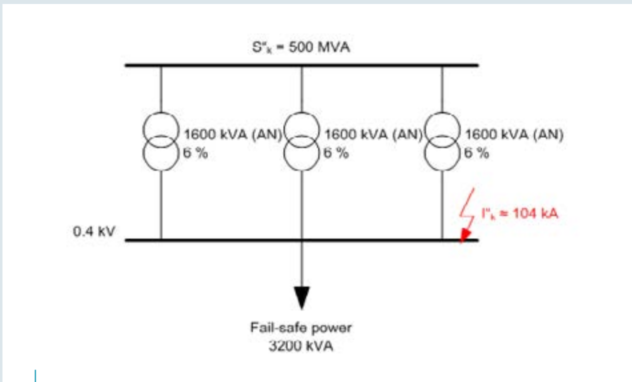
Especially in industrial applications and infrastructure projects, a big feed-in power is concentrated in one spot. With a rising transformer output and parallel operation of several transformers, the necessary short-circuit current carrying capacity of the low-voltage main distribution board fed by the transformers also rises. If cross-flow fans are employed, the short-circuit power can be limited or reduced in such cases, thus attaining a more cost-efficient low-voltage main distribution system. Example 1 below shall illustrate this.

Example 1:
Three transformers rated 1,600 kVA each with a short-circuit voltage u_{kr} = 6 %, not equipped with cross-flow fans, supply a fail-safe power of 3,200 kVA, taking a transformer failure into account. If all of the three transformers are operated in parallel and a line short-circuit power S''_k = 500 MVA is applied, this will result in a maximum short-circuit AC current I''_k of approx. 104 kA at the low-voltage main distribution board (U_n = 0.4 kV).

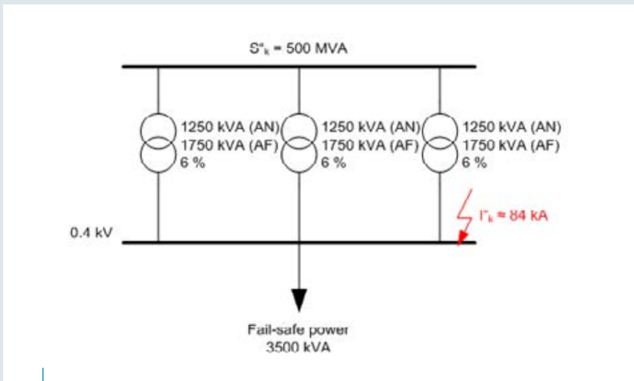
If those transformers rated 1,250 kVA each and a shortcircuit voltage u_{kr} = 6 % are used in combination with cross-flow fans, their fail-safe output is even 3,500 kVA (2 x 1,250 kVA x 1.4) and their maximum short-circuit current I''_k at the low-voltage main distribution board (U_n = 0.4 kV) is only about 84 kA.

Note:
Without additional ventilation, the transformer power is marked as AN (air natural), with additional ventilation, it is marked as AF (air forced).

If transformers with integrated cross-flow fans shall be protected by a switch-fuse combination, as a rule, this protection must be geared to the nominal transformer rating (in non-ventilated mode of operation) under consideration of section 3 and the tables presented there.



Transformers without cross-flow fans



Transformers with cross-flow fans

Figure 3: Application examples of cross-flow fans

Max. load of HV HRC fuse – type SIBA – for 8DJH and NXPLUS C										
Fuse			HHD				SSK			
			8DJH	NXPLUS C			8DJH	NXPLUS C		
U_r in kV	Length	I_r in A	I_{bmax} in A		P_v in W	MRPD	I_{bmax} in A		P_v in W	MRPD
3–7.2	292	10	8.1	9.2	17	SIB:3009813-10	–	–	–	–
		16	13.1	14.0	17	SIB:3009813-16	–	–	–	–
		20	16.3	18.4	13	SIB:3009813-20	–	–	–	–
		25	20.4	23.0	16	SIB:3009813-25	–	–	–	–
		31.5	25.7	29.0	21	SIB:3009813-31.5	–	–	–	–
		40	32.7	36.8	27	SIB:3009813-40	–	–	–	–
		50	40.8	46.0	30	SIB:3009813-50	–	–	–	–
		63	51.5	58.0	38	SIB:3009913-63	–	–	–	–
		80	53.0	63.2	47	SIB:3009913-80	–	–	–	–
		100	54.5	79.0	64	SIB:3009913-100	–	–	–	–
6–12	292	10	8.1	9.2	28	SIB:3000413-10	–	–	–	–
		16	13.1	14.7	28	SIB:3000413-16	–	–	–	–
		20	16.3	18.4	23	SIB:3000413-20	–	–	–	–
		25	20.4	23.0	29	SIB:3000413-25	–	–	–	–
		31.5	25.7	25.7	38	SIB:3000413-31.5	–	–	–	–
		40	26.2	29.3	50	SIB:3000413-40	–	–	–	–
		50	32.8	36.6	56	SIB:3000413-50	–	–	–	–
		63	46.2	49.8	63	SIB:3001213-63	46.1	46.1	62	SIB:3001243-63
		80	49.9	55.0	76	SIB:3001213-80	49.9	55.0	76	SIB:3001243-80
		100	53.7	62.0	104	SIB:3001213-100	54.5	62.5	98	SIB:3001243-100
		125	–	–	–	–	65.0	74.0	135	SIB:3002043-125
	442	10	8.2	8.2	28	SIB:3010113-10	–	–	–	–
		16	13.2	13.2	19	SIB:3010113-16	–	–	–	–
		20	16.5	16.5	22	SIB:3010113-20	–	–	–	–
		25	20.6	20.6	28	SIB:3010113-25	–	–	–	–
		31.5	26.0	26.0	37	SIB:3010113-31.5	–	–	–	–
		40	33.0	33.0	48	SIB:3010113-40	–	–	–	–
		50	36.0	40.4	54	SIB:3010113-50	–	–	–	–
		63	42.5	51.0	58	SIB:3010213-63	–	–	–	–
		80	54.0	54.0	70	SIB:3010213-80	54.0	55.2	72	SIB:3010243-80
		100	59.2	68.0	96	SIB:3010213-100	60.6	69.0	93	SIB:3010243-100
		125	–	–	–	–	72.2	81.0	128	SIB:3010343-125
10–17.5	292	10	8.1	8.1	38	SIB:3025513-10	–	–	–	–
		16	13.1	13.1	37	SIB:3025513-16	–	–	–	–
		20	16.3	16.3	40	SIB:3022113-20	–	–	–	–
		25	16.9	19.7	56	SIB:3022113-25	–	–	–	–
		31.5	21.3	21.6	65	SIB:3022113-31.5	–	–	–	–
		40	26.2	26.2	84	SIB:3022113-40	–	–	–	–
		50	28.9	31.2	101	SIB:3022113-50	–	–	–	–
		63	35.7	37.3	106	SIB:3022213-63	–	–	–	–
		80	41.3	47.0	137	SIB:3022213-80	–	–	–	–
	442	6.3	5.2	5.2	21	SIB:3023113-6.3	–	–	–	–
		10	8.3	8.3	38	SIB:3023113-10	–	–	–	–
		16	13.2	12.7	37	SIB:3023113-16	–	–	–	–
		20	16.5	16.5	42	SIB:3023113-20	–	–	–	–
		25	20.4	20.4	56	SIB:3023113-25	–	–	–	–
		31.5	22.7	22.4	60	SIB:3023113-31.5	–	–	–	–
		40	24.5	27.2	84	SIB:3023113-40	–	–	–	–
		50	30.0	34.0	101	SIB:3023213-50	–	–	–	–
		63	37.8	43.0	106	SIB:3023213-63	–	–	–	–
		80	41.8	46.0	137	SIB:3023213-80	–	–	–	–
		100	48.1	55.0	182	SIB:3023313-100	–	–	–	–
10–24	442	6.3	5.2	5.2	29	SIB:3000613-6.3	–	–	–	–
		10	8.3	8.3	52	SIB:3000613-10	–	–	–	–
		16	12.7	12.7	59	SIB:3000613-16	–	–	–	–
		20	16.5	16.5	46	SIB:3000613-20	–	–	–	–
		25	20.4	20.4	56	SIB:3000613-25	–	–	–	–
		31.5	22.7	22.4	72	SIB:3000613-31.5	–	–	–	–
		40	24.5	27.2	106	SIB:3000613-40	–	–	–	–
		50	32.0	34.0	108	SIB:3001413-50	–	–	–	–
		63	33.5	36.2	132	SIB:3001413-63	33.5	–	–	–
		80	37.8	46.0	174	SIB:3001413-80	41.8	46.0	143	SIB:3001443-80
		100	–	53.0	234	SIB:3002213-100	48.1	58.0	188	SIB:3002243-100

Table 6: Max. load currents of SIBA type HV HRC fuses for Siemens 8DJH and NXPLUS C switchgear
All specifications apply to standard ambient conditions.

Owing to the fact that these HV HRC fuses are used in moulded plastic containers in gas-insulated switchgear applications, their power loss must not exceed a defined value so that their contact material is not damaged and the fuse does not blow (false tripping) as a result of excess heat. Table 6 shows the continuous load data of HV HRC SIBA fuses used in Siemens 8DJH or NXPLUS C switchgear.

The information given there applies to standard ambient conditions only, i.e. in cases of mean ambient temperatures above 30 °C and altitudes of installation higher than 1,000 m above sea level, the maximum permissible load data must be requested from the manufacturer.

Example 2 demonstrates how to proceed.

Example 2:

Our transformer of Example 1 (S_n = 1,250 kVA, u_{kr} = 6 %) is supplied from a 20 kV grid. A Siemens 8DJH switchgear unit shall be used. According to Table 4, both a SIBA HV HRC fuse of type HHD and SSK with a nominal fuse current of 80 A may be used. According to Table 6, the HHD fuse may only be continuously loaded with max. 37.8 A and an SSK fuse with 41.8 A if mounted in 8DJH switchgear. But this merely equals to approx. 105 % or 116 % of the nominal transformer rating.

In analogy, a combination of a Siemens NXPLUS C switchgear unit and the corresponding SSK fuse would be ableto carry an approximate continuous load of 127 % of the nominal transformer rating.

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Example 2 demonstrates that switch-fuse combinations for the protection of transformers that use cross-flow fans for output enhancements are only suitable for outputs below that of forced-ventilated transformer output, meaning that they can only be fully utilized if the AF transformer output (140 % of the nominal transformer rating) is only applied for a very short time.

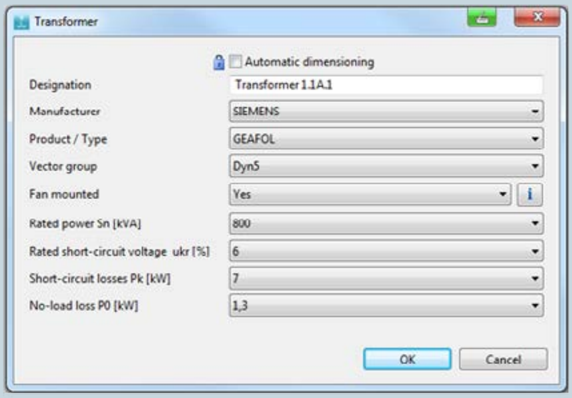
In cases where AF transformer output is permanently required, we recommend to use circuit-breakers. For Siemens 8DJH, a circuit-breaker of type 2 is available. Although it does not command of the full performance features of a type 1.2 model, it is completely sufficient for transformer feeder applications and more cost-effective.

5. Design with SIMARIS design

Automatic dimensioning of ventilated transformers is implemented in SIMARIS design 9. In order to use this feature in calculations we suggest to proceed as follows:

Step 1

In the settings of the transformer (pop-up menu, after clicking the left mouse click at the selected transformer) “Fan mounted: Yes” can be selected. Thus a maximum power of 140 % of the rated power of the transformer will be considered automatically as well for automatic dimensioning as for manual selection.



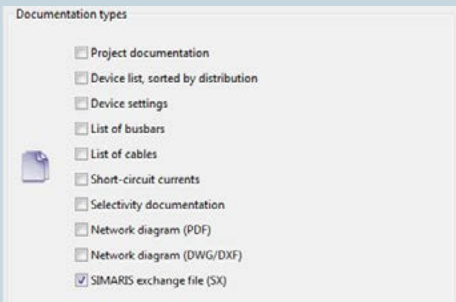
Step 2

Then the network can be dimensioned in familiar way with consideration of the correct selection of MV and LV circuit-breaker in the infeed current circuit (including settings). Also the adapted dimensioning of the connection (cable/busbar) between transformer and main distribution board will be considered automatically. With use of HV fuses the Tables 4 and 5 have to be checked. The maximum load carrying capacity of the device combination must be taken into account in compliance with Table 6.

A possible warning regarding the minimum breaking current in case of minimal 1-pole faults has nothing to do with this manual adjustment, but constitutes a general problem of protecting transformer feeders with HV HRC fuses. In this case, the electrical designer must decide whether a short-circuit proof wiring of the connection between transformer and low-voltage main distribution board was implemented. If this is not the case, an alternative must be chosen, such as using a low-voltage circuit-breaker right at the beginning of this connection, or a medium-voltage circuit-breaker instead of a switch-fuse combination, whose protection relay, if correctly set, is also capable of ensuring short-circuit protection of the whole path to the low-voltage main distribution board.

Step 3

At „project output“ menu of SIMARIS design a transfer file can be generated. With importing this file in SIMARIS project the fan mounted transformers will be automatically considered for size-determination, budget calculation and tender specification.



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