Battery technology calls for the best protection there is

MADE IN GERMANY

Perfect solutions for your energy storage units
SIBA fuses in battery installations

*Our Protection.
Your Benefit.*

SIBA
Sicherungen | Fuses

Storage units supply only as long as they are in operation

- The applications of systems taking over when the mains fail range from small UPS installations to company-wide battery racks. Therefore it is critical for the emergency system not to become a case of worry itself. Fuses made by SIBA provide protection for installations supplying vital energy consumers in cases of mains failure.

- More and more often, controlling the mains frequency in power plants operating with renewable energies is performed by stationary power storage units with capacities of several megawatts which are correspondingly designed to be redundant. However, here, too, powerful protective installations are required to safeguard the systems against damage. This function can be fulfilled by SIBA fuses.

- Industrial plants use battery installations as network components to control their interaction with the public power network. Failure of these components can have negative consequences for production. This can be avoided, however – with fuses made by SIBA

Fuses are useful only as long as they are suitable

- Unless the data sheet explicitly allows for it, fuses designed for alternating currents cannot readily be used in DC current circuits. When, in the case of mains failure, the system changes to battery operation, this results in discharge currents whose magnitudes and temporal characteristics are similar to those of short-circuit currents. This requires faster and more specific fuses.

- Its extensive experience with ultrafast fuse solutions in comparable technical constellations, such as in power electronics, puts SIBA in a position to optimally safeguard also complex combinations of battery and mains current circuits.

- Even the standard programme of fast full-range and back-up fuses is so large that SIBA can supply you with suitable off-the shelf solutions. And SIBA's in-house R & D department is ready to help when more special solutions are called for.

Finding the correct fuse in four steps

Being a manufacturer of electrical fuses, SIBA has a portfolio which has grown over decades and comprises the most diverse products for protection against overloads and short circuits in electrical networks. While, for most areas of the installations, the fuses' applications have been standardized, it is particularly the sensitive battery circuits where the protective device is often still determined based on „best knowledge". As far as the fuses' dimensioning is concerned, a frequently heard opinion is: „rated current and rated voltage are sufficient".

With the emergence of photovoltaics, SIBA has begun to deal not only with developing special photovoltaics fuses but also with the battery circuits used in this field and requiring protection. Following technical discussions with battery manufacturers and with the help of technical universities covering this subject, SIBA has developed a rating scheme which can be applied extensively to the most common battery circuits.

This calculation scheme shows that, in addition to operating voltage and operating current, further factors have to be taken into consideration in order to be able to really interrupt the fault current in cases of fault before the installation is damaged.

Step 1:

Determination of the fuse's rated voltage

The rated DC voltage of the fuse is derived from the highest voltage occurring in the DC circuit, i.e. the battery charging voltage U_I.

$$U_{n\,sich} \geq U_I$$

In the data sheets it is stated whether the fuses have AC and/or DC breaking capacity. In cases where only a rated AC voltage is given, the fuses are only under certain conditions suitable for use in DC voltage circuits. The manufacturer should be consulted as to whether the commonly known statement "rated DC voltage = 0,7 x rated AC voltage" applies. Actually he should also be asked for the allowable time constant of the shorted circuit. Since, however, relatively small time constants (often less than 2 ms) are to be expected particularly in battery circuits, this is superfluous in most cases.

Step 2:

Determination of the fuse's lowest rated current

The relevant value in determining the fuse's lowest rated current $I_{n\,min}$ is the highest current value occurring in the battery discharge circuit, i.e. the battery discharge current I_e present at the end of the specified discharge duration t_e. This can be calculated from the inverter's input power S_n [kVA] and the end-of-discharge voltage U_e as well as from the power factor (e.g. 0.8) and the efficiency η (0,85 – 0,97 %).
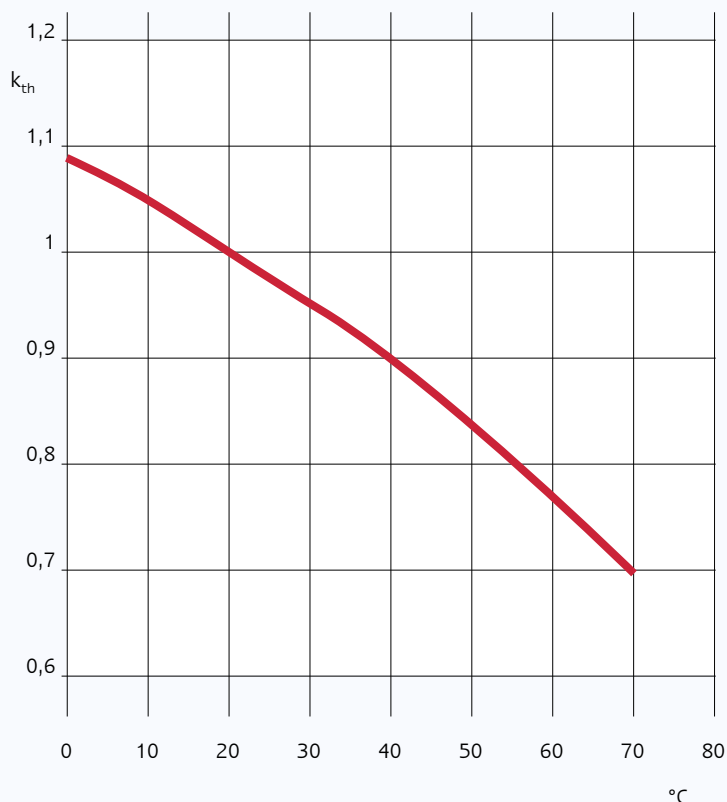
$$I_e = S_n \times \cos \varphi / U_e / \eta$$
$$I_{n\,min} \geq I_e$$

Table 1: Factor k_{Batt}

Charging/ dis- charging cycles	For the respect	
several times per day	0,7	0,7
daily	1	0,85
weekly	1	1
monthly or longer	1	1
Discharge durations	10 min	30 min

Factor k$_{Batt}$ ...tive combination of cycle and discharge time					Application in e.g.
0,6	0,6	-	-	-	PV storage unit
0,85	0,7	0,7	0,6	0,6	Storage unit
0,85	0,85	0,7	0,7	0,6	UPS
1	0,85	0,85	0,7	0,7	UPS
60 min	3 h	5 h	10 h	20 h	

Step 3: Taking secondary conditions into consideration

The intended use of the storage unit can be as influential on the selection of the fuse's rated current as are the ambient conditions present when the fuses are built into housings or control cabinets. As is generally known, there is not the ONE discharge duration, the ONE discharge current or the ONE charging/discharging frequency. Different applications are taken into consideration based on applying coefficient k$_{Batt}$ to the minimum rated current. After all, a discharge duration of 30 minutes, combined with one single charging/discharging cycle per month, has to be regarded as different from the situation present in a PV storage unit where several cycles take place per day. In Table 1 (see above) factors k$_{Batt}$ are given for the different applications in battery installations. In applying these factors, some required overload capability is accepted.

$$I_n \geq I_{n\,min} / k_{Batt}$$

An ambient temperature considerably deviating from 30 °C can also have an influence on the selection of the rated current. Here, the typical derating diagram for fuse-links can be used.

$$I_n \geq I_{n\,min} / k_{Batt} / k_{th}$$

As shown in the diagram (see above), an ambient temperature of e.g. 70 °C in the control cabinet can result in a fast reduction of a rated current of 100 A down to 70 A.

Operating classes and their time/current characteristics
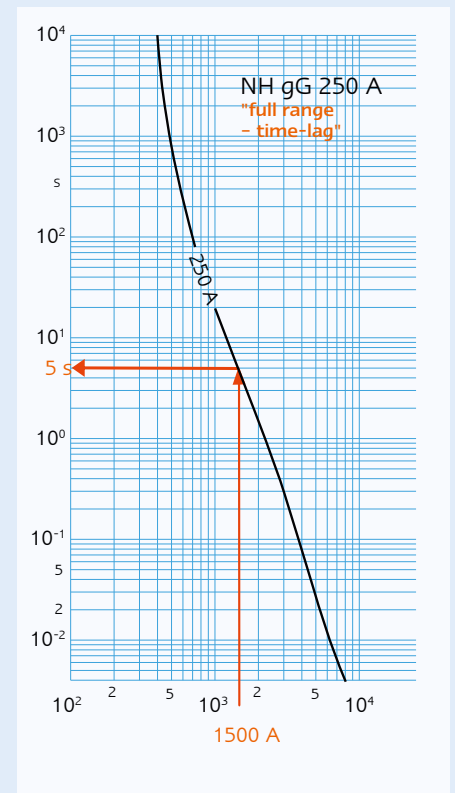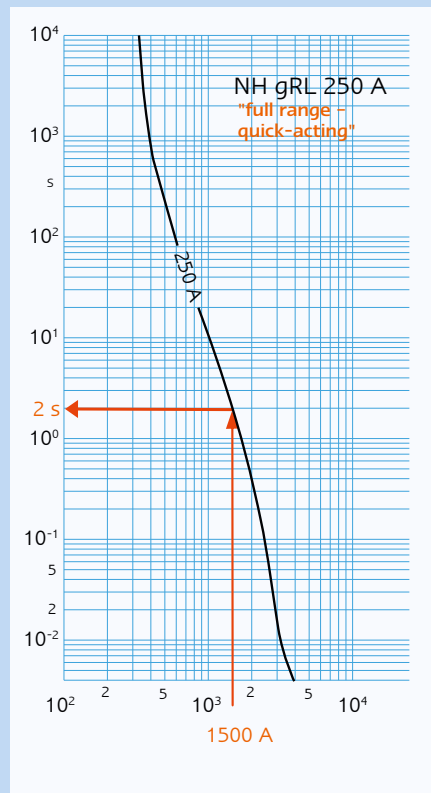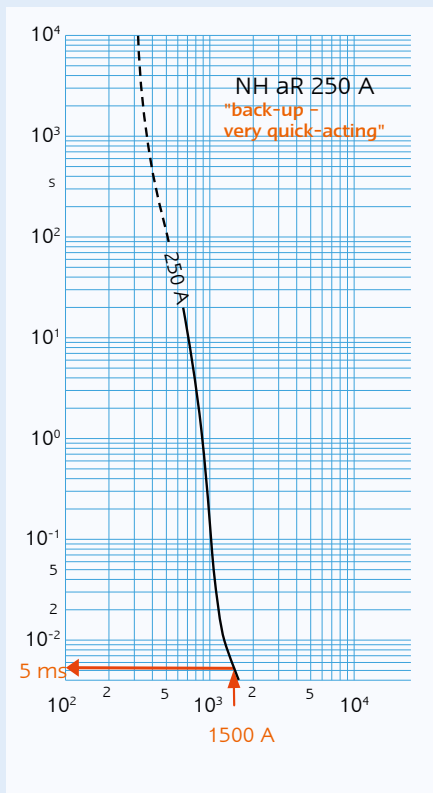
Step 4: Selection of the operating class

The following operating classes are applicable for use in DC discharge circuits (see the above diagrams):

aR – back-up fuses for semiconductor protection ("back-up – very quick-acting")

gRL – full-range fuses for semiconductor and line protection ("full range – quick-acting")

gG –full-range fuses for general applications ("full range – time-lag")

Which operating class will be used in the end can be decided based upon the maximum melting time required in the case of a short circuit. To do so, first the maximum short-circuit current I_{kB} of the charged battery is calculated from the open-circuit voltage U_B and the battery's internal resistance R_B:
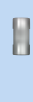
$$I_{kB} = 0{,}95 \times U_B / R_B$$

This value is plotted as the vertical line in the fuses' time/current diagram, then a point of interception with the selected rated current is created, now the melting time can be read off the vertical scale on the left-hand side.

If lower fault currents are to be taken into consideration, the value is plotted on the curve in the same manner, then the melting time can be read off. In the case of fault currents exceeding six to ten times the fuse's rated current also back-up fuses can be used; for fault currents below this value full-range fuses are indispensable. If the short-circuit current falls within the dashed part of the curve of a back-up fuse, this solution is not permitted.

Thus, the selection of the operating class (gG, aR, gRL) determines how fast the short-circuit current I_{kB} is interrupted.

Overview of SIBA's battery portfolio for direct current

80 V	440 V	550 V	720 V	1000 V	1200 V	1500 V	
NH000 … NH00 AC 690 V DC 240 V aR 6-160 A	SCT, SET, SMT, SMMT, AC 690 V DC 450 V aR, 8-710 A	NH1 … NH3 AC 690 V DC 550 V aR 40-630 A	NH1 … NH3 AC 1000 V DC 800 V aR 40-630 A	NH1 … NH3 DC 1000 V aR 40-400 A	SQB-DC94 DC 1200 V aR 1000-2000 A	SQB-DC153 DC 1500 V aR 200-630 A	Teilbereichsschutz
SLCT AC 240 V DC 150 V aR 5-20 A	NH1 … NH3 AC 690 V DC 500 V aR 700-1600 A	14x51mm, DC 700 V aR 8—63 A		SQB-DC103 SQB-DC104 DC 1000 V aR 200-1600 A		27x88mm DC 1500 V aR 40-125 A	„superflink"
				NH0 DC 1000 V aR/gR 50 - 200 A			
NH000 … NH00 AC 690 V DC 240 V gRL 6-160 A	14x51mm, 22x58 mm AC 690 V DC 440 V gRL, 6-100 A	NH1 … NH3 AC 690 V DC 500 V gRL 40-630 A	27x60mm DC 800 V gR 40-80 A	NH1XL … NH3L DC 1100 V gRL 40-400 A	NH1XL DC 1200 V gRL 50-200 A		Ganzbereichschutz
				14x51mm DC 1000 V gRL 20-25A		10/14x85mm DC 1500 V gRL 10-30 A	„flink"
NH000 … NH00 AC 500 V DC 240 V gG 6-160 A	NH1 … NH3 AC 500 V DC 440 V gG 40-630 A						Ganzbereichschutz
14x51mm AC 500/400 V DC 220 V gG 1-40 A							„träge"

In the "DC lines" of the overview table given above, we present our portfolio of fuses of the applicable operating classes for different voltage ranges.

Although, in this prospectus, we describe a four-step approach to finding the suitable protection for battery circuits, the relationships between complex power storage systems are not always easy to understand, and the input quantities for calculation not always easy to determine.

Within large applications of battery storage systems (BESS) maximum short-circuit currents of some hundred kA can be reached. Concerning these conditions SIBA has ordered a lot of series of tests in accredited laboratories (IPH Berlin, KEMA USA). Please feel free to discuss the results with our experts. Additionally, our competent consulting team is happy to help you with any special requirements. Do not hesitate either to contact SIBA's team in cases of doubt concerning your calculation.

Disclaimer:

State of technology and standardization:

Both technology and technical standards are subject to permanent further development. Thus, this document represents the state of technology available at the time of printing. This shall be taken into consideration when using the information and the types listed in the product programme.

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