



Battery
technology
calls for the
best protection
there is

Finding the correct
fuse for your
energy storage system –
in four steps

Our protection.
Your benefit.

SIBA
Sicherungen | Fuses



Photos: ads-tec, istockphoto/lunarchy, Photolia/Pavel Losevsky

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 .

$$U_{n \text{ sich}} \geq U_i$$

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:

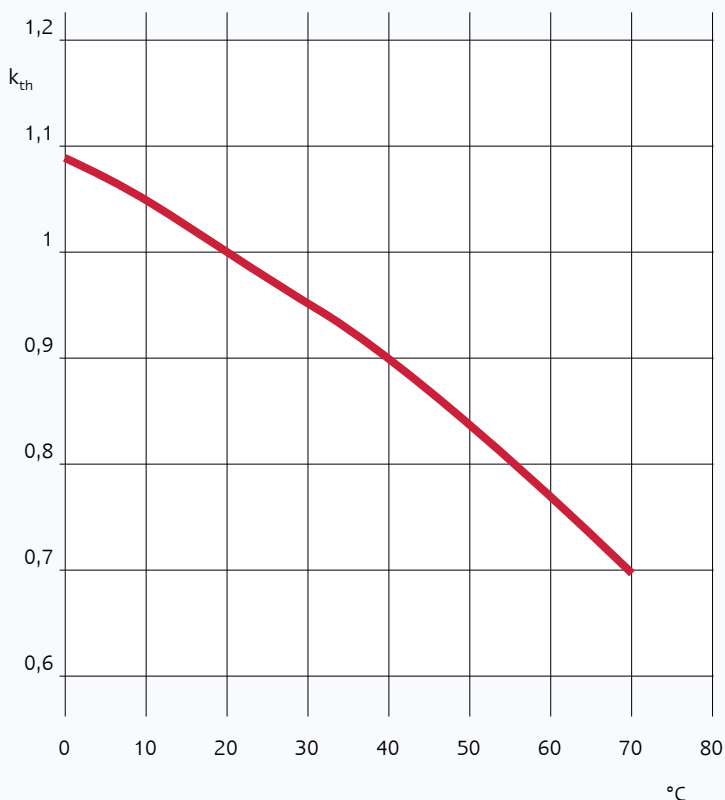
Determination of the fuse's lowest rated current

The relevant value in determining the fuse's lowest rated current $I_{n \text{ min}}$ 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 output 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 %).

$$\begin{aligned} I_e &= S_n \times \cos \varphi / U_e / \eta \\ I_{n \text{ min}} &\geq I_e \end{aligned}$$

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

Factor k_{Batt} diverse combination of cycle and discharge time					Applica- tion 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.

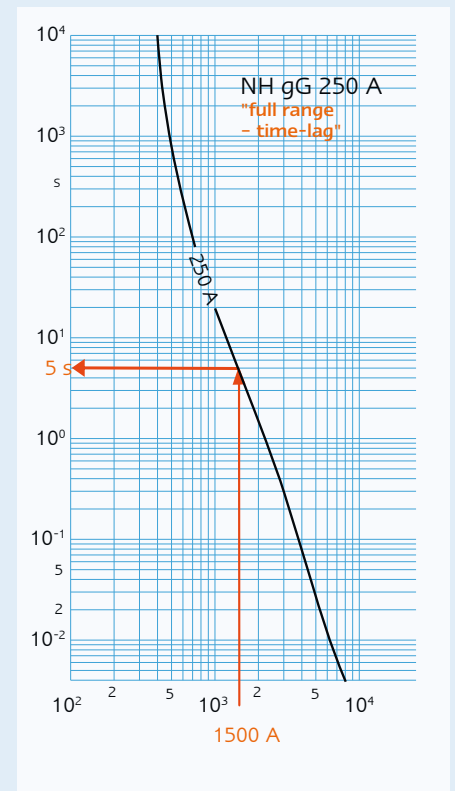
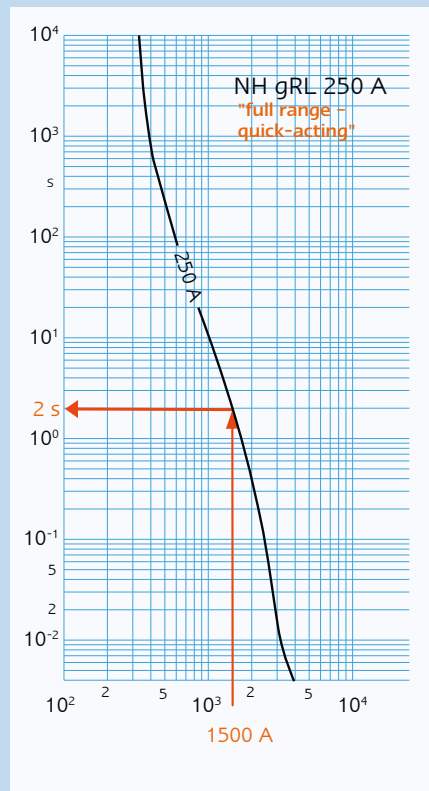
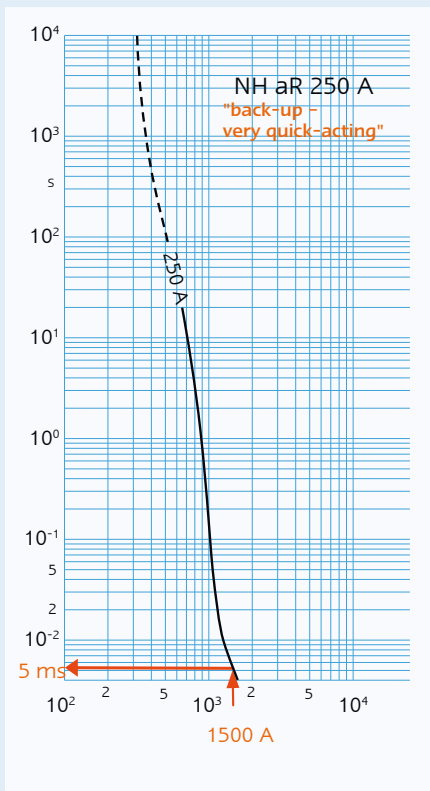
$$I_n \geq I_{n \min} / k_{Batt}$$

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.

SIBA fuses for Battery and Energy Storage Systems (BESS)

Bank	1000 V DC		1200 V DC	1500 V DC		
	SQB-DC102 200 – 630 A	SQB-DC104 800 – 1600 A	SQB-DC124 800 – 2000 A	SQB-DC153/ NH3L 200 – 500 A	SQB-DC153/NH3L 200 – 1250 A	SQB-DC154 630 – 1800A
Rack	1000 V DC		1500 V DC			
	NH0 50 – 200 A	SQB-DC101 63 – 400 A	27x88 mm 40 – 125 A	SQB-DC0 25-400 A	SQB-DC2 125-800 A	
Modul	150 V DC		250 V DC		500 V DC	
	35x59 mm 35 – 1200 A	17,5x25,5 mm 12 – 250 A	17,5x25,5 mm 12 – 180 A	22x58 mm 12 – 160 A	22x58 mm 12 – 100 A	

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:

The fuses described in this document have been developed to fulfil safety-relevant functions as components of a machine or full installation. Usually, a safety-relevant system comprises signal units, sensors, evaluation units, and concepts for safe interruption. The manufacturer of an installation or machine is responsible for ensuring the correct overall function. SIBA GmbH and its selling agencies (in the following referred to as "SIBA") are not in a position to guarantee all properties of a full installation or machine which has not been designed by SIBA. Any product selected should be tested by the user for all its intended applications. Neither does SIBA assume liability for recommendations based on or implied by the above description. No guarantee, warranty or liability claims going beyond SIBA's general terms of delivery may be derived from the description.

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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What sets SIBA apart



Specialists in fuses and fuse protection technology

Providing customers – their machinery and equipment and of course their personnel – with the highest possible level of protection. And we know that this is good for company profits too: production can continue without suffering lengthy disruptions because if anything untoward should happen our fuses will react immediately to prevent further damage.

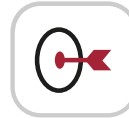


Maintaining a global presence

For us ‚made in Germany‘ means ‚selling to the world‘. With subsidiaries on every continent and sales partners in practically every country worldwide we can supply you with original SIBA fuses no matter where you are.



Photos: Lenfers | shutterstock/Monika Hunackova/GM



Staying close to our customers

Many of our products are the result of highly specialised requests from discerning clients. We therefore know our way around manufacturing and production, and our in-house R&D capabilities have also helped us face some of industry's major challenges – from digitisation and the DC factory through to e-mobility and the energy transition.