

... what, watt?

On the use of miniature fuse-holders

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The subject is fuses, namely miniature fuses – or to be more specific, miniature fuse-holders of the kind that are designed to be used on the appliance back panel or on the circuit board (Figure 1). These holders are frequently selected on the basis of their dimensions alone: 5 x 20 millimetres – it matches – and the job is done! Users who base their choice on 'current rating' tend to be a bit more circumspect: the fuse is rated at 6.3 A, the holder at 10 A – it matches – and the job is done! In many cases such an arrangement works, but more often than not the equipment manufacturer cannot understand why the fuse has operated too early or why there is a worrying increase in temperature at the fuse-holder. There is, alas, much more to selecting an appropriate fuse-holder than just looking at its size and current rating ... what about power dissipation, for example?



Figure 1a
Fuse-holder mounted on the back panel



Figure 1b
Fuse-holder mounted on the circuit board

Figure 1: Miniature fuse-holder

Heating and power dissipation of the fuse-link

Let us just pause for a moment and make a quick detour into the world of 'fuse physics'. Fuses work by reacting to the load current passing through them. When they are subjected to the designated load current, they become warm. If the current exceeds the fuse's specified rating, the fuse will become very warm and if the (fault) current exceeds the lowest fusing current, the fuse will become extremely hot - with the result that after a predetermined period of time the fuse wire inside the fuse will melt and the fuse will operate.

The longer the fuse takes to operate, the hotter it will become. The 'non fusing current' of ' $1.5 \times I_n$ ' represents a standardised value that will generally result in the maximum heating of the fuse. Cylindrical fuses are required to withstand this reference current for more than half an hour in standard design format, and under specified climatic conditions, before they operate (depending on the type and amplitude of the rated current). The drop in voltage recorded across the fuse at the end of this load period can then be multiplied by the non fusing current. This gives the power dissipation of the fuse in watts, which will be stated in the specifications provided by the fuse manufacturer.

The rated power dissipation is therefore a reference value that is based on defined criteria for the load current, fuse-holder and test arrangement as laid down in standard VDE 0820, part 2. Figure 2 shows the standardised fuse-holder that is used for testing the power dissipation. Users will immediately see that this version has little in common with the fuses normally found in everyday application. [1]

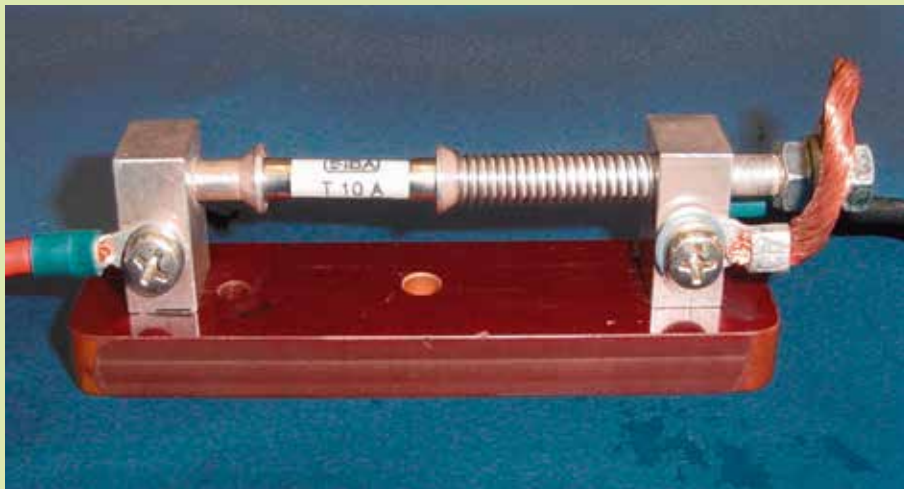


Figure 2: Standardised fuse-holder for testing miniature fuses

Table 1 shows test results that were actually recorded using a standardised test arrangement. Fuse current ratings of 6.3 and 10 A, which are the highest presently used in conventional fuse-holders, were fitted in order to achieve the maximum limit temperatures. A DC current was passed through the fuse-links. After temperature equalisation was reached between the test socket and the fuse, i.e. after a predefined duration, the values were recorded.

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Table 1: Temperature and power dissipation of a fuse-link in a standard test socket

Miniature fuse type	Typical voltage drop for rated current	Power dissipation at 1.5 times the rated current
	mV	W
5 x 20mm; T 6,3 A; L 250 V	70	1,3
5 x 20mm; F 6,3 A; L 250 V	100	2,0
5 x 20mm; T 6,3 A; H 250 V	90	1,6
5 x 20mm; F 6,3 A; H 250 V	130	2,6
5 x 20mm; T 10 A; L 250 V	70	2,4
5 x 20mm; F 10 A; L 250 V	100	2,4
5 x 20mm; T 10 A; H 250 V	90	2,5
5 x 20mm; F 10 A; H 250 V	100	3,0

Heating and power acceptance of the fuse-holder

The values for heating and power acceptance as given by manufacturers in their fuse specification sheets are based on tests laid down in VDE 0820, part 6. For the purpose of the test the fuse-holder is placed inside a housing of predefined dimensions. The ambient temperature is about 23 °C and the tests are carried out in still air. The wire cross-section for 6.3 A is 1 mm², while for 10 A it is 1.5 mm². A reference fuse-link with a predefined resistance is inserted into the fuse-holder. This resistance is sufficient to allow the fuse to achieve the maximum power acceptance as specified by the manufacturer. The resistance for 6.3 A and a given value of 3.2 W is 81 mΩ, while for 10 A and a power acceptance of 4 W the resistance is 40 mΩ [2].

The fuse-holder is then loaded with its rated current and temperature levels are recorded. The standard lays down the limit temperatures that apply. This means that the temperature of those parts that can be touched by the user must not exceed 85 °C. The manufacturer defines the limit value of the non-accessible surfaces on the basis of the plastic materials used. The electrical connections to the fuse-holder are also used as measurement points.

When temperature equalisation has been reached at the rated current, the fuse-holder is required to withstand a durability test over a period of 500 hours. At the end of the test the recorded temperatures also have to be compared with the specified values.

Resistance of the terminals

As a source of resistance in the load circuit the terminals of the fuse base naturally play a significant part in the heating process and therefore contribute to the power dissipation of the entire component. The standard permits a resistance of maximum 15 mΩ, as based on the durability test performed on the fuse-holder. Table 2 presents the results for the aforementioned fuse-holders as a function of different contact resistance values.

Table 2: Additional power dissipation as a function of the contact resistance of the fuse-holder

Contact resistance	5 mΩ	10 mΩ	15 mΩ
5 x 20 mm; 250 V; 6,3 A	0,2 W	0,4 W	0,6 W
5 x 20 mm; 250 V; 10 A	0,5 W	1,0 W	1,5 W

Final assessment

With this information the equipment designers should be clear as to what exactly has to be coordinated: the two 'power causers' (fuse-link and holder contacts) are added together and compared with the 'power bearer' (the fuse-holder). As can be seen from Table 3, the limit power acceptance of the fuse-holder is quickly reached, and in some cases even exceeded. If the power dissipation of the fuse-link and contacts exceeds the permitted power acceptance of the fuse-holder, there will be trouble ahead: the holder becomes too hot, the plastic melts and/or the fuse cuts out 'for no reason'.

Other factors

But this is not the whole story, for in most of the cases in question the ambient temperature will be above 23 °C. For such circumstances the manufacturers keep a derating diagram ready, as shown in Figure 3.

Table 3: Power dissipation in comparison with permitted power acceptance

Miniature fuse	Rated power dissipation -fuse- link z	Power dissipation incl. contact resistance of fuse-holder			Rated power acceptance -fuse- holder
		5 mΩ	10 mΩ	15 mΩ	
		W	W	W	
5 x 20 mm; T 6,3 A; L 250 V	1,3	(1,5	1,7	1,9)	≤ 3,2
5 x 20 mm; F 6,3 A; L 250 V	2	(2,2	2,4	2,6)	≤ 3,2
5 x 20 mm; T 6,3 A; H 250 V	1,6	(1,8	2,0	2,2)	≤ 3,2
5 x 20 mm; F 6,3 A; H 250 V	2,6	(2,8	3,0	3,2)	≤ 3,2
5 x 20 mm; T 10 A; L 250 V	2,4	(2,9	3,4	3,9)	≤ 4,0
5 x 20 mm; F 10 A; L 250 V	2,4	(2,9	3,4	3,9)	≤ 4,0
5 x 20 mm; T 10 A; H 250 V	2,5	(3,0	3,5	4,0)	≤ 4,0
5 x 20 mm; F 10 A; H 250 V	3,0	(3,5	4,0	4,5)	≤ 4,0

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The diagram can be used to determine the maximum power that the fuse-holder can cope with at temperatures above 23 °C. Separate characteristic curves are used to take account of fuse-holders with standardised values for the rated power acceptance. At a temperature of 40 °C, for example, the permitted power acceptance of the holder will drop from 2.5 W to just 1.8 W. This means that a fuse-holder originally designed for 6.3 A will very soon only be useable up to 4 A.

The limit values may also be affected by other factors when the layout is very confined and heat dissipation is restricted. Neighbouring components and/or too closely spaced cable runs can act as an additional source of heat. The amplitude of the continuous load can also have a favourable or less favourable effect on the thermal conditions.

In borderline cases no amount of calculation will provide the answer and the only way around the problem is to test the terminal equipment under conditions that are as near as possible to operating practice. The temperature values thus recorded will give some indication of how the fuse-holder will cope with the intended application

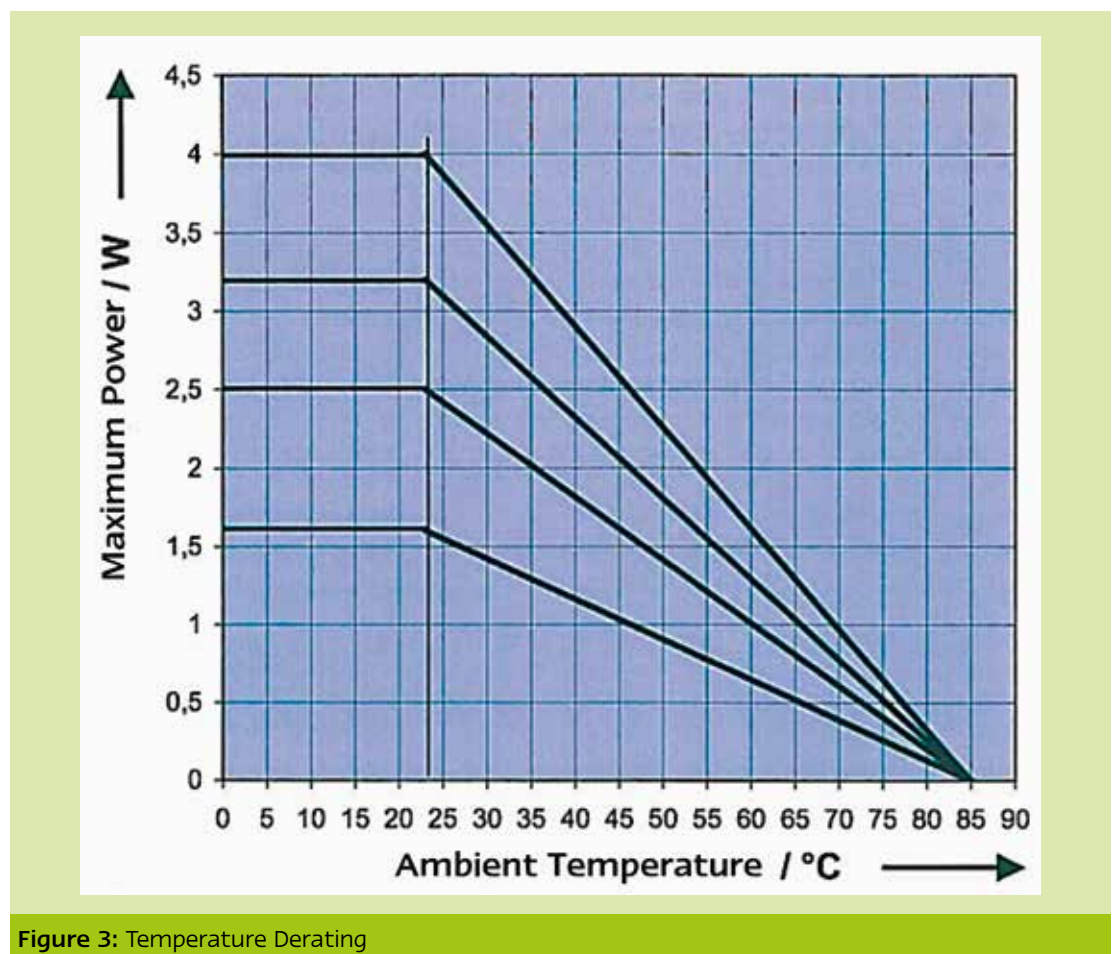


Figure 3: Temperature Derating

Summary

Selecting a safety fuse solely on the basis of its dimensions or rated current can result in outages at some point in the future, particularly when using fuse rated currents operating at their very limits. Here it is especially important to match the rated power dissipation of the fuse-link and the power loss resulting from the transfer contacts of the fuse-holder, on the one hand, with the power acceptance of the fuse-holder, on the other. If higher ambient temperatures are expected, or if additional influencing factors are anticipated, these too have to be taken into account. If there is any doubt whatsoever, a heating test is recommended prior to application. This is the only way to ensure troublefree operation for the lifetime of the appliance being protected.

References:

- [1] IEC 60127-2 (VDE 0820-2) Miniature fuses – part 2: Miniature fuse-links
- [2] IEC 60127-6 (VDE 0820-6) Miniature fuses – part 6: Fuse-holders for miniature fuse-links

Disclaimer:

The fuse-links described in this document were developed to perform safety-relevant functions as a component in a machine or installation. A safety-relevant system normally contains warning devices, sensors, evaluation units and safe cut-out devices. It is the responsibility of the manufacturer of the installation or machine to ensure that the overall system functions correctly. SIBA GmbH and its sales offices (hereafter known as 'SIBA') are not in a position to guarantee all the operating characteristics of a machine or installation that has not been designed by SIBA. When a product has been selected it is up to the user to perform the requisite checks in all intended applications. Neither will SIBA accept any liability for recommendations made or implied in the preceding description. No guarantee, warranty or liability claims that go beyond SIBA's general delivery terms and conditions can therefore be derived from the above description.

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