WHICH TYPE OF FUSE SHOULD BE USED IN A RACK PDU?

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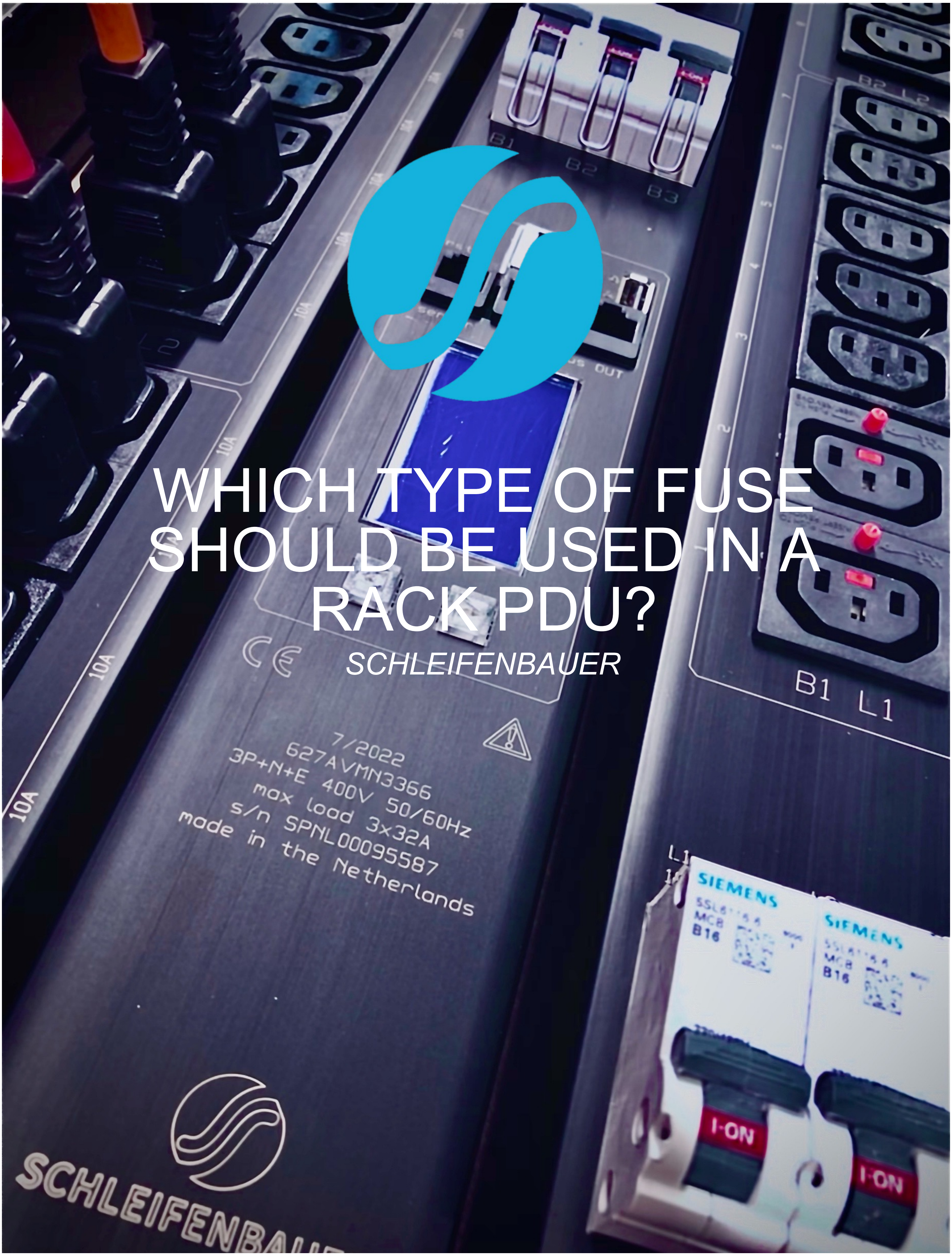


WHICH TYPE OF FUSE TO USE IN A RACK PDU?

There are many different theories concerning the need to protect a rack PDU (Power Distribution Unit). A fuse is, by definition, a single point of failure and is, therefore, not something you want to have in a data centre. However, there are situations in which a fuse is necessary and in some cases, even compulsory.

WHY DO YOU WANT TO USE A FUSE?

SAFETY is the most important reason: a fuse is used to prevent a fire caused by an overload or a short circuit. An output on a rack PDU must be protected by a protective device which has a rating equal to the output's maximum nominal value. This means that a rack PDU which is connected to a 32 A feed and which has outputs which can be subjected to a maximum load of 16 A (for example, CEE 7/4 (Schuko) or IEC 320 C19) must be protected with a fuse with a maximum rating of 16 A. IEC 320 C13 is an exception to this, because IEC 320 C13 can be subjec- ted to a maximum load of 10 A. Since they are usually used in groups, it is permitted to protect them with a 16 A fuse. A 32 A, 3-phase rack PDU with, for example, IEC 320 C13 and IEC 320 C19 outputs, therefore, requires at least six fuses.

ISOLATING FAULTS to a certain segment is another reason for using fuses. An unprotected rack PDU is fully shut down in the event of a fault. A protected rack PDU can isolate the fault to a certain segment of the rack PDU and, as a result, guarantee the continuity of the other devices. Fuses are installed at various levels in the installation network (see the diagram below).

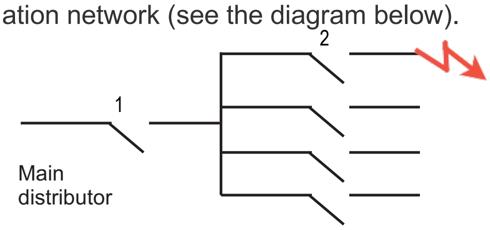


Diagram installation network

Subdistributor

You can look at a rack PDU in the same way. It is often con- nected to a current circuit and has its own protection (so- metimes shared between a number of rack PDUs). If a fault occurs after 2, you only want protective device 2 to be acti- vated and not protective device 1, to prevent the rest of the rack PDU from being shut down. This is called selectivity. It is one of the most important parameters that must be well understood when making a decision regarding the use of fuses.

Selectivity occurs if a fuse reacts before the preceding (main) fuse. If, in the above example, 2 always reacts before 1, there is 100% selectivity of 2 with regard to 1. However, in practice, 2 is only selective with regard to 1 up to a certain short circuit rating and not above.

WHAT DO YOU WANT TO PROTECT THE SYSTEM AGAINST?

It is a good idea to first ask yourself what you want to protect the system against: do you want to prevent overloading or short-circuiting, or maybe both? To help you decide, we will explain both risks below.

OVERLOADING occurs if more power is consumed than is permitted for the components concerned over an extended period of time. The speed at which the protective device is activated depends on the type of protective device and its spe- cifications. If you only want protection against overloading, we recommend a thermal protective device that uses a bimetallic strip. If the protective device is activated, the user can reset it himself by pressing the jump switch.

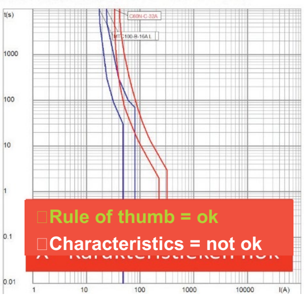
A SHORT CIRCUIT is caused by direct contact between the phase and neutral conductor (or earth), which creates a cur- rent equal to the maximum short circuit value at that point. It is important to know this value so that you can choose the right protective device. The short-circuit current is closest to the source (transformer or UPS) and reduces as a result of the attenuation and losses in the wiring and the contact resistan- ces at all the intermediate switches and fuses. Safety switches provide protection up to a certain maximum short-circuit cur- rent. If the short-circuit current aft er a protective device (fuse) is greater than the protective device's rating, there is a risk of electric arcing in the protective device. This can result in a fire and the current to the fault not being interrupted, which is ex- tremely undesirable.

WHAT DO YOU HAVE TO KNOW?

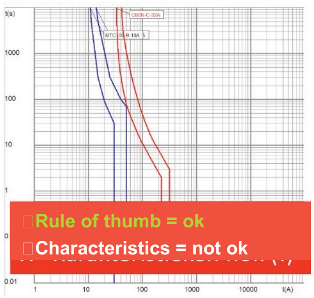
In order to be able to make the correct decision concerning fu- ses in your rack PDU, you must understand a couple of things. An overview of the terms involved in this decision making pro-cess, and a short explanation of each term, are given below.

SELECTIVITY is one of the most important properties of a fuse. A factor is used to calculate whether the selectivity between two consecutive fuses is guaranteed.
The legal selectivity value between glass fuses is 1.6. This means that a 16 A glass fuse is selective with regard to a 32 A glass fuse, but not with regard to a 25 A glass fuse (1.6 x 16 equals 25.6). The selectivity between Miniature Circuit Brea- kers (MCBs) or in a mixed environment is more difficult to de- termine. To determine this, you must place the time-switch graphs of both fuses over each other to show which fuse is ac- tivated first at which short-circuit current.

32A MCB & 16A MCB



32A MCB & 10A MCB



32A MCB & 16A Glass Fuse

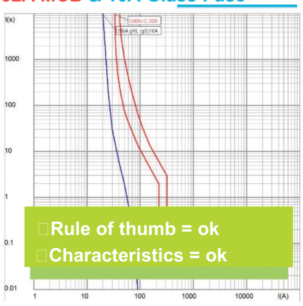


Diagram: Time-switch graphs of both fuses

The selectivity class is usually stated on the MCBs, but that value does not say much. You must calculate the short-circuit current for every location in the data centre. Only if you also know the technical details of the preceding fuses, are you able to determi- ne whether a fuse is selective with regard to the preceding fuse in the chain. Experience has shown that not everyone knows this, even though it is important to know what the consequences are in the event of a short circuit. Example: a 3-phase 32 A rack PDU must have at least six 16 A segments, with each segment having a separate protective device. If these protective devices are not selective with regard to the preceding fuse, a short circuit in one output results in the entire rack PDU shutting down. Is this a de- sirable situation?

“We recommend you have a specialist draw up a detailed diagram that contains all the short-circuit currents.”

SHORT-CIRCUIT CURRENT is the maximum current that can be generated at a certain point in an electrical installation. Once upon a time, a short-circuit current close to a transformer or UPS was many times greater than the current generated in a ser- ver rack. This was because of attenuation by the power cables and all the contact resistances in the installation. Increasing in- tegration of the distribution via busbar has resulted in an incre- ase in short-circuit currents in a server rack. Nowadays, busbars with a nominal value of 200 A to 1,000 A are found less than a metre from the server box. There is hardly any attenuation and short-circuit currents of up to 100 kA (kilo-amperes) are not uncommon.
Although there are programs that can calculate short-circuit currents, we recommend you have a detailed working diagram drawn up by a specialist, containing all the short-circuit cur- rents. This document allows you to make a well-founded deci- sion concerning which fuses to use in a rack PDU.

POWER CONSUMPTION A fuse consumes power. Since a fuse always reacts thermally (sometimes also magnetically), it is logical that a certain part of the electrical energy is used to produce heat. If too much heat is produced (the current is too high), the fuse trips. The power consumption is often indicated by the voltage drop across the fuse. This voltage drop multi- plied by the current (I) is the power consumption. A fuse that is subjected to a heavy load (> 80% of I nominal) consumes three to five watts of power. An MCB uses slightly less energy than a glass fuse. If a number of fuses are used in a rack PDU (often with thermal breakers), the number of fuses more or less compensates for the lower current strength per fuse: ten 1.5 A breakers consume approximately just as much power as one 15 A breaker.

AMBIENT TEMPERATURE The ambient temperature has an influence on a fuse's properties. The higher the temperature, the faster a fuse reacts to overloading. This must be taken into consideration if the rack PDU is located in the jet of warm ven- tilation air coming off IT equipment.

MAXIMUM THROUGHPUT ENERGY A fuse allows a certain amount of energy to pass before the current is interrupted. This energy is called the throughput energy and is calculated using the following formula: I2 * t (the short-circuit current squared multiplied by the time). This energy must be small enough to ensure that the equipment and wiring are not damaged or burnt. Usually, a glass fuse has a much lower throughput ener- gy than an MCB, because the melting process in a glass fuse is faster than the thermal-mechanical process in an MCB.

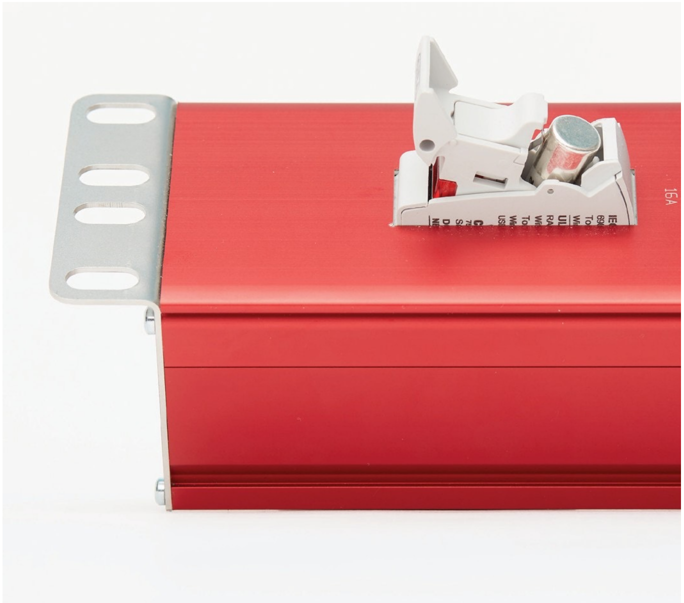
PROSPECTIVE SHORT-CIRCUIT CURRENT This term indicates the maximum short-circuit current a protective device can handle. A normal MCB usually has a prospective short-circuit current of 6,000 A (6 kA). This means that the device can inter- rupt currents up to 6,000 A. If there is a short-circuit current at that point of more than 6 kA, there is a risk of serious damage to the MCB, of a fire or of a persistent electric arc, which allows the current to jump to the following wiring, resulting almost certainly in a fire. It is, therefore, important to know what the short-circuit current is at the location where you want to use a fuse. Thermal fuses usually have a higher prospective short- circuit current; when the wire has melted, there is a large gap between the phase and the following wiring. In a sand-filled fuse, the melting silver wire reacts with the silicone in the fuse to produce a kind of glass wire with an infinite resistance.

FLEXIBILITY An integrated MCB or thermal fuse cannot be replaced without dismantling the entire rack PDU. If the fuse is broken or worn, the entire rack PDU must be dismantled. A glass fuse can always be replaced without having to dismantle the rack PDU. A risk in this is that the fuse may accidentally be replaced with a fuse of the wrong rating. With a permanent fuse, you do not run that risk.

RELIABILITY MCBs and thermal fuses work based on a mecha- nical principle. A glass fuse works based on a physical and a chemical reaction (melting and reacting). Both principles have advantages and disadvantages.

An MCB has more than one hundred components, which makes it more vulnerable than a single silver wire (or a wire of any alloy). When operating under normal conditions, the MCB has proven itself to be a reliable instrument. On the other hand, if an MCB has experienced a number of short-circuit situations (3-5) with high short-circuit currents, it must be replaced.

Furthermore, an MCB can fail in two different ways. If it is not used for a long time, it is possible that it does not interrupt the current when required, and secondly, it is possible that it cannot be reset after activation. A glass fuse appears to be straightforward: it either works, or it does not. However, a glass fuse can be weakened by short current surges, which create small melted points in the metal wire, which may change the properties of the fuse.



"The higher the temperature, the faster a fuse reacts to overloading. This must be taken into consideration if the rack PDU is located in the jet of warm ventilation air coming off IT equipment."

EASE OF USE An MCB is undeniably easier to use. A fault is visually displayed (also if the switch has a locking pin) and the MCB can immediately be reactivated after a fault.

An MCB must be replaced after three to five short-circuit situ- ations. There must, therefore, be some form of administration system to register which MCB has already experienced a fault. A glass fuse must be replaced after each fault. The user must know where to find a replacement fuse. As a result, a logistic system must be put in place. There is always the risk that the fuse is replaced with a fuse of an incorrect rating, resulting in a dangerous or undesirable situation. A faulty fuse can easily be replaced and the holder hardly ever breaks. On the other hand, an MCB can become faulty as a result of its complexity or get stuck so that it does not get activated when necessary. In the event of a fault in the MCB, the entire PDU must be shut down and repaired.

Images

1. *Glass fuse*
2. *Thermal fuse*
3. *MCB*

THE CHOICE

The choice of which protective device to use is ultimately the client's responsibility. The objective of this document is to provide you with information so that you can make a well- informed decision. You have to decide which type of fuse to use and how many you need. If you only need overload pro- tection, a thermal circuit breaker is a good and inexpensive so- lution. With that solution, you meet all the legal requirements concerning the protection of outputs. If you want protection against both overloading and short circuiting, the decision is slightly more complicated. You must then decide whether to use a glass fuse or an MCB (circuit breaker).

The disadvantage of a glass holder, namely the logistic process you have to put in place to ensure the availability of replace- ment fuses, is also an advantage: the fuse's characteristics can be altered to meet the situation. A gG cartridge is provided as standard. It has a nice balance between a delayed reaction in the event of overloading (a start-up current can trip a fuse if it reacts too quickly) and speed in the event of a short circuit. A gR cartridge is even quicker, but can sometimes cause problems with start-up currents. The ideal solution is, as is often the case, the most expensive solution: the gRL fuse. It is a special fuse which is slow to react in the overload area (up to 3x In) and extremely fast in the event of a short circuit. We often find that people do not understand what the charac- teristic of an MCB means. The characteristic says something about the tipping point: whether a circuit breaker reacts ther- mally or magnetically. For a type B characteristic, the tipping point is 3*In. For a type C characteristic, it is 5*In and for a type D characteristic, it is 10*In. Therefore, a 16 A circuit breaker with a type B characteristic, experiences a 50 A current as a short circuit and shuts down within a couple of milliseconds. For the same circuit breaker with a type C characteristic, a 50 A current is still in the thermal zone and it may take a couple of seconds before it trips (see the graph). This could be, for example, a start-up current which has a brief peak of 50 A and then falls to 10 A. A device with a type B characteristic trips in that situation, while a device with a type C characteristic does not. The characteristic of the circuit breaker only says something about the breaker's overload phase (thermal) and not about the breaker's short-circuit phase (magnetic). In the short-circuit phase, they are as fast as each other.

"An MCB consists of more than one hundred mechanical parts. That makes it more vulnerable than a glass fuse."

However, a glass fuse has the disadvantage that it ages over time and depending on the load it is subjected to, it must be re- placed every so many years. In short, the ideal protective device does not (yet) exist. Although there have been developments in the field of electronic safety switches, they are not yet available and will probably be much more expensive than the current so- lutions. In order to make the right decision, you must know your infrastructure (short-circuit currents, selectivity, etc.) and know what the consequences of your choice are. The number of fuses you have to use depends on a number of factors.

If there is a 32 A feed present, you have to use at least two 16 A fuses, otherwise you are only able to use 16 A of the available 32 A. However, you can also decide to use more than two fu- ses to restrict the faults in the system to the smallest possible area. If you also want to do this for short-circuit protection, you must pay close attention to the selectivity of the chosen fuses. A thermal breaker, for example, is not selective with regard to short circuiting. A glass fuse or MCB need a lot of space.

“Overloading can, for the most part, be prevented by using ammeters, while a short circuit cannot be predicted.”

CONCLUSION

If you want protection against overloading and/or short-circui- ting, you must analyse the risk of it happening and the cost in- curred if it does happen. Overloading can usually be prevented by using ammeters, but a short circuit cannot be predicted. If the risks are too great for you, you must install fuses to limit any faults. You can only make the right decision concerning the type of fuse to use if you have thorough knowledge of the electrical installation in your data centre. Schleifenbauer then produces the rack PDU with the fuses that are most suitable for your situation.

SCHLEIFENBAUER PRODUCTS

Schleifenbauer Products is a Dutch manufacturer of intelligent energy meters for data centres. The rack PDUs are built to customer specifications in ‘s-Hertogenbosch. You can compare the configuration and production proces-ses with Lego®: a limited number of building blocks can create an unlimited number of final products. Schlei-fenbauer rack PDUs are adapted to suit the electronic infrastructure of your data centre instead of the electro-nic infrastructure being adapted to the rack PDU. You can find more information at www.schleifenbauer.eu.

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