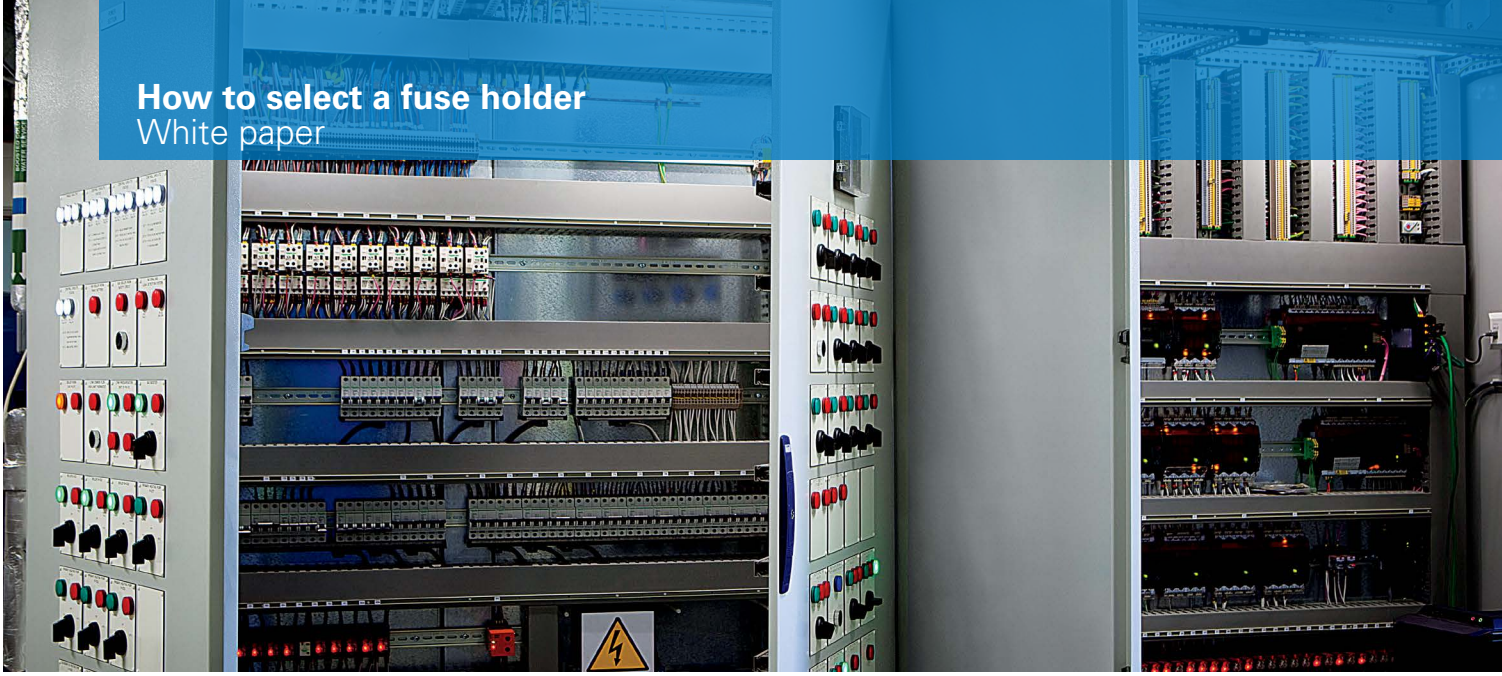

How to select a fuse holder

Executive summary

Just about every electrical circuit has the potential for unplanned, damaging overcurrent events, and in many of those cases, overcurrent circuit protection is needed to safely manage those events. The most common overcurrent protection is fuses. Many commonly available electronic fuses cannot be dropped into conductive paths due to their shape and size. Typically, a fuse accessory is required to integrate these fuses with a couple of primary functions: integrate fuses safely in electrical circuits, ensure a robust current path (voltage does not creep to other components) and provide a method to replace fuses once they manage overcurrent events as intended.

This document describes how to take advantage of those primary functions and explains some of the features of fuse accessories. It can also provide insight into how to select different types of fuse accessories and illustrate situations that may be encountered when selecting a fuse accessory. Lastly, there are a couple differentiating points between product types, potential to provide electrical safety for people, and why they are important to consider.

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Fuse Accessory Definition

There are many definitions of fuse accessories that can be found depending on how much searching is done. At a high level, fuse accessories can be considered devices that accept incoming power and assist in carrying it through the fuse as efficiently as possible. In doing so, the possibility exists that added features are built into the product to provide additional functionality that is beneficial for the OEM or to the end user of the assembly.

A few common components of fuse accessories can be defined as follows:

- Terminals are responsible for both accepting current from the circuit into the fuse accessory and delivering it back to the circuit.
- Contacts are responsible for engaging with the fuse to deliver current to and from the fuse, often in the form of a clip or an eyelet.
- Additional components can be found in various fuse holders, but they depend on the product type.

Categories (compare/contrast)

In reviewing how to select fuse accessories, it is also important to first review and define the different types of fuse accessories. Electronic fuse holders can typically be grouped into four different categories: Printed Circuit Board (PCB) Fuse Clips, Printed Circuit Board Fuse Holders, Panel Mount Fuse Holders and In-Line Fuse Holders.

PCB Fuse Clips – Most economical with typically the lowest acquisition cost, but the fewest amount of features. They generally need to be isolated and insulated from the environment, yet have wide application base.

PCB Holders – These have a fixed footprint and can provide isolation from external contact. If planned accordingly in the design process, these can allow for easier fuse replacement.

Panel Mount Fuse Holders – Mounted through an enclosure or on a back plane of an enclosure, they are generally wire-in, wire-out/line and load, and can provide protection for people from electrical hazards when installed properly.

In-Line Fuse Holders – These wire-in, wire-out/line and load fuse holders are basically a self-enclosed wire harness providing broad application flexibility. They can allow for both easy fuse replacement and make it more difficult to access fuses, depending on the goal of the designer and where they are installed.

Things to consider

When selecting a fuse accessory to integrate into an electrical circuit, here are a couple items to keep in mind:

Installation Type: For electronic circuits there are two installation types - printed circuit board applications and wire-in, wire-out applications. The fuseholders available and possible features will differ greatly depending on the application.

Fuses Accepted: The most common electronic fuses that require accessories are cylindrical; therefore, fuse accessories typically accept different cylindrical fuses based on the diameter of the fuse (most are 1/4" (6.3 mm) and 5 mm fuses), as shown in Figure 1 with different fuse carriers. Some fuse accessories within the Eaton Bussmann Series product line have the ability to accept multiple size fuses.

Figure 1. 1/4" and 5 mm fuse carriers for Eaton's HB fuse holder

Accessibility/Replaceability: During normal operation and after an overcurrent event is properly managed by the opened fuse, this brings two points of consideration: fuse accessibility and how easy it is to replace the fuse to regain operation. Fuse accessories can provide an easy way to change a fuse, as well as provide protection for people against electrical hazards interacting around the equipment in which it is installed. There are a couple different ways of defining this protection, sometimes referred to as Shock Safety, namely in IEC60127-6 or UL4248/IEC60529. It is very important to provide protection against electrical hazards, especially as voltages increase. While this is important, a designer also should consider how easy it is to replace the fuse and who can perform such functions. An end user of this equipment may prefer more difficult access to this fuse for electrical safety or easy access due to limited exposure to untrained persons. For more information on proper fuse replacement, please see Appendix or the Bussmann Series SPD

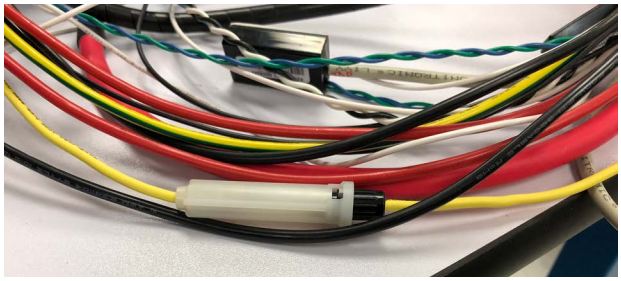

Figure 2. In-line fuse holder

Circuit Parameters: The electrical parameters are critical to evaluate when selecting fuses, and fuse accessories. Voltage ratings are important during both normal operating conditions (nominal current) and also during opening. The maximum voltage rating during operation is generally defined by the standard it is evaluated to. Factors include, but are not limited to, dielectric strength of materials, voltage creepage between conductive surfaces and voltage clearances to conductive surfaces, as well as additional conditions of acceptability.

Practically speaking, creepage and clearance of different circuit voltage levels should be considered in the application to reduce the conditions of acceptability not typically known to users in the field since fuse holders are often mounted in metal enclosures. Eaton does not recommend assuming that published voltage ratings can be field installed as such.

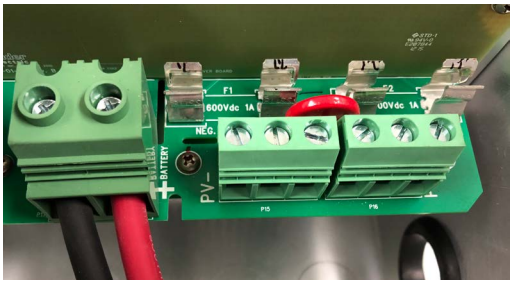

Figure 3. 600 Vdc PCBA with fuse clips

The current rating of a fuse accessory is listed as a maximum current rating and should not be exceeded by the nominal current. One of the primary factors in determining the current rating is defined by heat rise per UL standards or power dissipation according to IEC standards. Fuse holders are evaluated on heat rise and power dissipation with dummy fuses instead of actual fuses (which have higher resistance) at the maximum desired current to standardize testing. Since there are multiple different fuses with different resistances that can be placed inside electronic fuse holders, a standardized dummy fuse is chosen. This results in is a higher heat rise than the defined laboratory conditions. Therefore, a derating, similar to fuse derating, is recommended. Generally this derating factor is in line with fuse derating of 80% but could be more depending on additional environmental factors.

Lastly, ensuring fuse holders can withstand high short circuit currents is important as well. UL4248 recognized fuse holders achieve a 10 kA short circuit current rating by default, so each application should be evaluated individually.

Environmental conditions: As mentioned in the circuit parameters section, environmental conditions must be considered as well. The most applicable would be the ambient temperature and any airflow, or lack thereof, provided by the environment. The laws of physics dictate that sources of resistance will result in energy losses, commonly in thermal energy or heat. Fuses and fuse accessories (and all current paths) have inherent resistances making them a heat source. The management of that heat can affect fuse performance (outlined in Technical Note 10483) so this needs to be considered. Better airflow or less restriction can help. This is more important to consider as the fuse and fuse holder sizing is closer toward the nominal current of the circuit. Also, the more enclosed a fuse holder is, the more heat will be trapped.

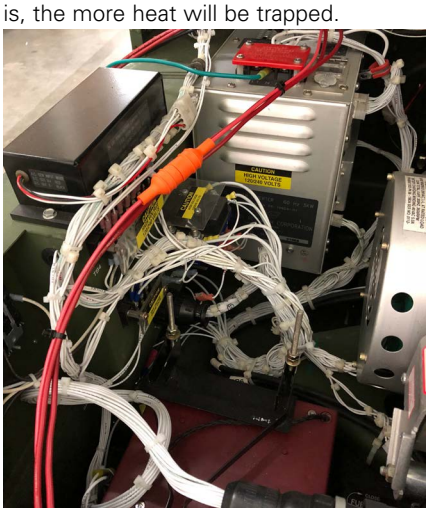

Figure 4. In-line fuse holder application

Other environmental considerations can be outside the electrical circuit itself, such as solid and/or liquid interactions with dust, water drops, equipment washing, complete water immersion, or other ambient conditions. Fuse holders may be capable of providing additional protection not otherwise provided by an enclosure to ensure these harmful contaminants do not interfere with the circuit path. Eaton has a group of fuse holders specifically evaluated to IEC 60529, which established ingress protection (IP) ratings, in order to allow easy understanding of environmental protection offered within the Bussmann Series portfolio. For more information, please see Technical Note 10709.

Figure 5. Testing for IP ratings on Eaton's HKP-W-R fuse holders

Potential Situation #1

As in many cases, electronic system designers and engineers desire a particular fuse with the right characteristics to help provide proper system protection and/or provide a positive disconnect to take the system offline to manage the cause of the overcurrent. There are often cases where a fuse is selected based on the application where a fuse accessory also is required. However, a particular fuse footprint may reduce the number of fuse accessory options commercially available and practical. Often times, the electrical ratings of the fuse and accessory can align, such as the voltage rating of the fuse holder being greater than or equal to the fuse itself, or the maximum current rating of the fuse holder being greater than or equal to the nominal current rating of the fuse. Eaton offers the Fuse Accessory Selection Guide (Technical Note 10575) to assist in this situation.

Supplemental fuses rated to UL 248-14 or miniature fuses conforming to IEC 60127 have many different nominal current ratings but share the same footprint. In certain applications, the nominal current rating of the fuse may be many times oversized to provide the proper opening characteristics. Since these electronic fuses share similar footprints, they can be physically installed in the same fuse holder. This can create a situation where the maximum nominal current rating of the fuse needed to provide the optimal opening characteristics can exceed the maximum current rating of the fuse holder. This situation must be studied very carefully to ensure that the nominal current of the circuit is lower than the maximum current rating of the fuse holder and low-level overcurrents in the circuit do not create too much heat due to the fuse holder and that situation is managed accordingly. For example, a fuse selected is double the nominal current of the circuit to allow for the short time inrush of an inductive or capacitive circuit, such as a Bussmann Series HTC-15M fuse holder paired with a Bussmmann Series S505-8-R fuse. These are temporary and short inrush curves and many times can be managed by a closely sized time delay fuse, but may be limited on other electrical characteristics. The same can be said for voltage ratings, but it is critical to ensure that the system voltage is not higher than the maximum voltage rating of the fuse holder, such as a Bussmann Series MDH-21-R fuse paired with a Bussmann Series HFB-R fuse holder. Testing is recommended in these cases and an evaluation of 3rd party certifications will need to be discussed with those 3rd party bodies. Generally it is highly desirable and recommended to have the amp rating of the fuse less than or equal to the maximum current rating of the fuse holder.

Potential Situation #2

Another situation that can be encountered is that a designer or engineer has a known footprint or fuse accessory in mind. The end application requires some feature of a fuse holder and there may be some flexibility in the fuse footprint or performance. The designer, based on the desired footprint, selects one of the four types described earlier, starting with wire-in/wire-out or PCB. From there, the key circuit parameters need to be reviewed to find the optimal footprint with the electrical ratings to match the application. Finally, the fuse is selected that can properly protect the system. For further information on fuse selection, please see Technical Note 10483. As an added benefit, some of Eaton's fuse holders do provide flexibility for different fuse sizes. In rare cases, the fuse accessory may need a revised evaluation if no fuse that fits inside the fuse holder provides the desired performance.

Recommended Testing

To ensure that the proper fuse and fuse holder are selected for the application, Eaton recommends that the combination is tested under worst case, or similar, conditions that the equipment could experience. This could be at higher ambient conditions, elevated currents, higher resistance fuses possibly installed/replaced by end user, smallest wire or PCB traces used, or no ambient air flow. Any combination of these factors could be experienced. By performing tests at worst case conditions, it helps ensure suitability of the combination in better electrical conditions.

Appendix

Safe Work Practices

This document has discussed various aspects of electrical equipment, including fuse replacement. Eaton encourages safe electrical work practices. Maintenance of electrical equipment should only be done by qualified individuals. This includes fuse replacement and re-energizing the circuit. Fuse replacement should always be done with the circuit fully removed from power and de-energized. Subsequent energizing should only be done when the circuit can safely be energized by ensuring the fault has been cleared. Many countries specifically outline definitions for qualified individuals so please consult the appropriate guidelines accordingly.

3rd Party Certifications

The two most common fuse holder standards are UL 4248 and IEC60127-6. Each generally govern the same type of products, electronic fuseholders, but have different testing methods and setups. For example, IEC60127-6 uses allowable power dissipation to determine the amp rating of the fuse holder, where UL 4248 uses heat rise limits. This is among other items that are considered for fuse holder design. This is why certain fuse holders with dual listings/certifications can have different maximum current ratings. As with all standards, they are intended to standardize measuring so design engineers using these products know how to compare. This is in addition to carrying ratings of being greater than or equal to the rating for the fuses it accepts.

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