



# The Basics of ELECTRICAL FUSES



**Fuses are essential safety devices that protect against faults such as electrical overloads and short circuits.**

They are used in virtually every electrical system that involves voltages and currents high enough to be dangerous to personnel or equipment. Choosing the right fuse for the application requires a basic understanding of fuse operation and specification, especially in industrial settings, where electrical faults can be lethal and cause catastrophic damage.

## The basic concept behind conventional fuse operation is simple:

When too much current flows through a fuse, its internal conductor (the fusing element) melts due to resistive heating. Melting the conductor breaks the circuit, preventing further current flow. A fuse's rating specifies the maximum current it can carry before the fuse opens. Such conventional fuses have been in use for more than a century

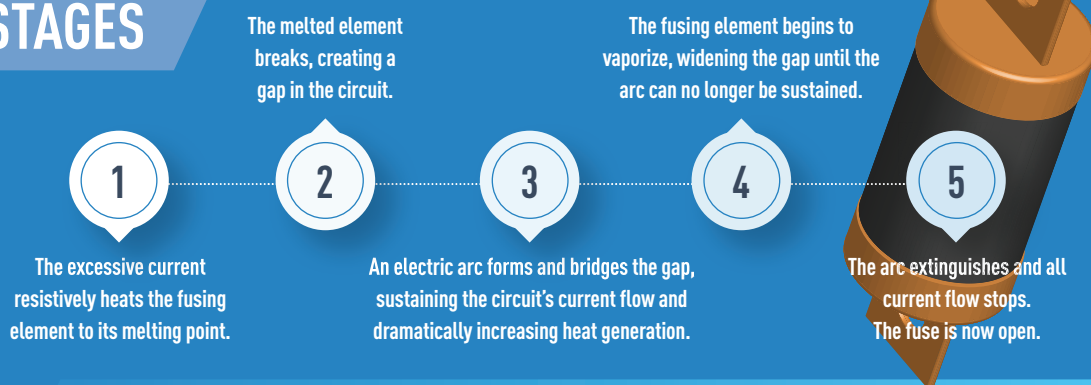
and are so common that virtually everyone has encountered them at some time.

Solid-state devices called PTC (positive temperature coefficient) fuses operate on a different principle. The conductor in a PTC fuse is a crystalline material that changes from conductor to insulator when it overheats, preventing current flow without breaking the circuit. Removing the excess current allows

the material to cool and return to a conductive state, effectively resetting the fuse. Such fuses are typically limited to operations below 100 V or currents below 16 A, so they are most often used in battery-powered applications. Conventional fuses, on the other hand, are available to handle virtually any line voltage and current combination employed in an industrial application.

## FUSE-OPENING STAGES

Despite the conventional fuse's basic melt-and-break operating concept, there is a layer of complexity that can be especially significant in industrial applications. A closer look at what's happening when a fuse opens reveals several distinct stages.



Completing all these stages takes time, during which the overcurrent condition remains in effect. The heating and arcing within the fuse can rupture its housing, sometimes violently. A rupture can also expose the arc before it extinguishes, creating an ignition hazard. Understanding these stages and their consequences is thus an essential first step in selecting the right fuse for an industrial application.



# SELECTING THE RIGHT FUSE

An industrial fuse's basic specifications reflect both the faults the fuse must protect against and the way the fuse will respond. Core specifications include:

## ✓ VOLTAGE RATING —

the maximum circuit voltage the fuse can safely open. This should exceed the circuit's normal operating voltage.

## ✓ CURRENT RATING —

the maximum sustained current the fuse can carry without opening during normal operating conditions. This should exceed the circuit's normal current draw and be equal to or less than the wiring's safety rating.

## ✓ INTERRUPT RATING —

the maximum current the fuse can interrupt at the rated circuit voltage without rupturing or exploding, also known as the breaking capacity. This rating should equal or exceed the maximum current that might occur with a short-circuit fault.

## ✓ TIME-CURRENT CHARACTERISTICS —

how quickly the fuse will open under specific over-current conditions. Circuits with regular current spikes, such as motor start-up transients, require a slow-acting fuse that can tolerate brief over-currents without opening, preventing nuisance faults. High-power circuits without start-up transients, on the other hand, may require fuses that open extremely quickly to prevent catastrophic damage during short circuits. Circuits with complex current profiles may require a detailed analysis of fuse time-current characteristics to secure the best match.

Beyond these basic operational specifications, there are many other considerations when selecting a fuse. In addition to amperage limits, for example, there may be a need to account for the voltage drop that occurs across the fuse during normal operation. Fuse size, shape, connection method, and visual indications of fuse opening are all application-dependent.

The environment may also impose special requirements on fuse selection. An environment containing fuel vapor, for instance, may need a fuse with ignition protection. Expulsion fuses — quick-acting fuses that incorporate boric acid or mineral oil for arc suppression and vent the resulting vapor — may not be suitable where such venting can contaminate the surroundings. Because fuses operate on heat, high ambient temperature expectations may require fuses to be rerated to compensate.

Regulatory and specification compliance is an additional key consideration. Basic facility or equipment safety requirements may involve fuse certification from Underwriters Laboratories ([UL](#)), the Canadian Standards Association ([CSA](#)), the International Electrotechnical Commission ([IEC](#)), or another agency. Specific application classes can also have unique standards requirements, such as [ANSI/IEEE C37.40](#) (Service Conditions and Definitions for High-Voltage Fuses) for circuits operating above 600 V.



Fuses come in many shapes, sizes, and electrical capabilities. Choosing the right one for an industrial application involves a wide range of considerations.

## CONCLUSION

Ultimately, choosing the right fuse requires considerable research up front to ensure the fuse matches the application needs. Having the right fit will help ensure safety and efficiency as well as equipment longevity. Look for a trusted brand that delivers both quality and affordability as well as a reliable supply chain. For help in finding the right fuse, contact us at [Electrical.com](https://www.electrical.com). We specialize in providing power distribution equipment to businesses all over the world, with a host of items from multiple distributors. We can help you find exactly what you need at competitive prices.



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