

# Fuse Construction and Operation

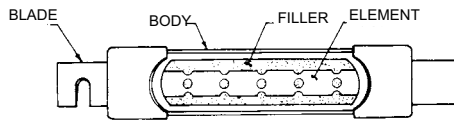
The typical fuse consists of an element which is surrounded by a filler and enclosed by the fuse body. The element is welded or soldered to the fuse contacts (blades or ferrules).

The element is a calibrated conductor. Its configuration, mass and the materials employed are selected to achieve the desired electrical and thermal characteristics. The element provides the current path through the fuse. It generates heat at a rate dependent on its resistance and the load current.

The heat generated by the element is absorbed by the filler and passed through the fuse body to the surrounding air. The filler material, such as quartz sand, provides effective heat transfer and allows for the small element cross-section typical in modern fuses. The effective heat transfer allows the fuse to carry harmless overloads. The small element cross

section melts quickly under short-circuit conditions. The filler also aids fuse performance by absorbing arc energy when the fuse clears an overload or short circuit.

When a sustained overload occurs, the element will generate heat at a faster



rate than the heat can be passed to the filler. If the overload persists, the element will reach its melting point and open. Increasing the applied current will heat the element faster and cause the fuse to open sooner. Thus, fuses have an inverse time current characteristic: that is, the greater the overcurrent, the less time

required for the fuse to open the circuit.

This characteristic is desirable because it parallels the characteristics of conductors, motors, transformers, and other electrical apparatus. These components can carry low-level overloads for relatively long periods without damage.

However, under high-current conditions, damage can occur quickly. Because of its inverse time current characteristic, a properly applied fuse can provide effective protection over a broad current range, from low-level overloads to high-level short circuits.

## How to Talk Fuses

### Commonly used terms

**$I^2t$  (Ampere Squared seconds):** A measure of the thermal energy associated with current flow.  $I^2t$  is equal to  $(I_{RMS})^2 \times t$ , where  $t$  is the duration of current flow in seconds.

**Clearing  $I^2t$ :** The total  $I^2t$  passed by a fuse as the fuse clears a fault, with  $t$  being equal to the time elapsed from the initiation of the fault to the instant the fault has been cleared.

**Melting  $I^2t$ :** The minimum  $I^2t$  required to melt the fuse element.

**Ampere Rating:** The continuous current carrying capability of a fuse under defined laboratory conditions. The ampere rating is marked on each fuse.

**Available Fault Current:** The maximum short-circuit current that can flow in an unprotected circuit

**Coordination:** The use of overcurrent protective devices that will isolate only that portion of an electrical system that has been overloaded or faulted.

**Current-Limiting Range:** The available fault currents a fuse will clear in less than  $\frac{1}{2}$  cycle, thus limiting the actual magnitude of current flow.

**Element:** A calibrated conductor inside a fuse that melts when subjected to excessive current. The element is enclosed by the fuse body and may be surrounded by an arc-quenching medium such as silica sand. The element is sometimes referred to as a link.

**Fast-Acting Fuse:** This is a fuse with no intentional time-delay designed into the overload range. It is sometimes referred to as a "single-element fuse" or "non-delay fuse."

**Fault Current:** Short-circuit current that flows partially or entirely outside the intended normal load current path of a circuit component. Values may be from hundreds to many thousands of amperes.

**Ferrule:** The cylindrical brass, bronze or copper mounting terminals of fuses with amp ratings up to 60 amperes. The cylindrical terminals at each end of a fuse fit into fuse clips.

**Current-limiting Fuse:** A fuse that meets the following three conditions:

1. **Interrupts all available overcurrents within its interrupt rating.**
2. **Within its current limiting range, limits the clearing time at rated voltage to an interval equal to, or less than, the first major or symmetrical current loop duration.**
3. **Limits peak let-through current to a value less than the available peak current.**

**Interrupting Rating:** The maximum level of fault current that the fuse has been tested to safely interrupt.