When it's good to be the weakest link

John Bassford, product manager for fuse and fused products at MEM Circuit Protection and Control, summarises the latest developments in fuse technology.

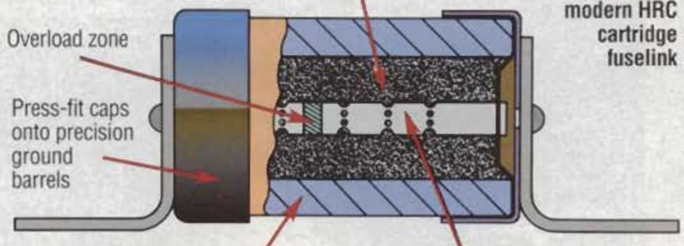
Although the fuse is a relatively cheap and essentially simple device, its behaviour is more complex than most people – even many engineers – appreciate. The fuse is the weak link in an electrical circuit; a few millimetres of element that protects many metres of electric cable and/or costly equipment against faults that could be catastrophic.

The modern fuselink comprises a metallic "element" enclosed in a ceramic tube filled with silica granules and closed at each end by a metal end-cap. It carries the entire electric current in a circuit. Its purpose is to break that current in if there is an overload or a short-circuit.

The most important component of the fuse is the element. It is generally made of a highly conductive material such as pure copper, silver-plated copper or even silver. For fuse ratings up to 12A the element may be a plain wire, but above this it will be one or more metal strips with accurately punched holes and an "overload zone" of low melting-point "m" effect solder.

When carrying normal current in a healthy circuit, the element becomes warm, but the heat is conducted away into the rest of the fuselink, and it dissipates harmlessly.

If there is an overload, the excess current will melt the solder in the overload zone and open the circuit.



Inside out: outline of a modern HRC cartridge fuselink

ARCING ABOUT

If there is a short-circuit, the element itself melts between the holes. Arcing occurs across the break until the element has burnt back sufficiently for the current to be interrupted rapidly.

The accuracy with which the fuse operates under short-circuit conditions is determined by the accuracy with which the elements are punched. The fuse elements are checked against resistance standards to ensure that the necessary performance is achieved.

An enormous amount of electrical energy has to be absorbed in a short time when clearing a fault because the entire supply network is feeding the fault. To absorb the short-circuit energy, the fuselink is filled with 99.5%-pure 25/52 mesh silica granules. These are compacted into the fuse by vibration to remove air gaps.

Under short-circuit conditions, the heat melts the sand, which vaporises to form a crude glass "fulgirite". On cooling, this solidifies to form a high-resistance barrier, so the fault current cannot flow in the circuit again.

A precision-ground, vacuum-extruded cordierite ceramic barrel contains the sand and elements. It is mechanically strong, resistant to heat and a good insulator.


Semiconductor fuses: HRC fuses protect semiconductors in UPS systems, variable-speed drives, electric traction systems, AC/DC converters and other equipment

Copper or brass inner covers are pressed onto each end of the barrel so the elements can be welded or soldered to the inner covers without touching each other or the inner wall of the barrel. Brass outer covers seal the fuse, and brass or copper conductors are riveted and soldered onto the covers, forming the electrical connection to the circuit.

It is important to reduce energy waste during normal operation, so the inner and outer covers are made from copper and brass, which have excellent thermal and electrical conductivity. The outer cover and connector assemblies are normally tin plated to stop corrosion and maintain electrical conductivity.

LOWER LOSSES

A washer of Kevlar or a similar insulating material is inserted between the covers as a last line of defence to prevent the arc burning through the end of the fuse.

Compact 415V fuselinks rated from 2 to 1,250A have been developed in recent years. Watts loss is typically 30% less with these devices than with conventional designs. This can represent a substantial reduction in energy waste across a network and allows cool, economic running.

Compact fuselinks are narrower, but retain the same fixing centres as conventional fuselinks. As a result, a smaller size and reduced watts loss are possible while retaining the vital electrical characteristics of traditional fuselinks. (They should not be confused with the "compact" fuselinks with staggered blade contacts and ratings up to 63A, covered by BS 88-6:1988.)

Utilities in various parts of the world are taking a fresh look at the requirements for fuses for feeder pillars and other low voltage distribution applications. They are particularly concerned about:

- the need for better co-ordination with medium voltage networks,
- the need to reduce watts loss in the interests of energy conservation, and
- the need to keep operating temperatures low, especially in hot environments.

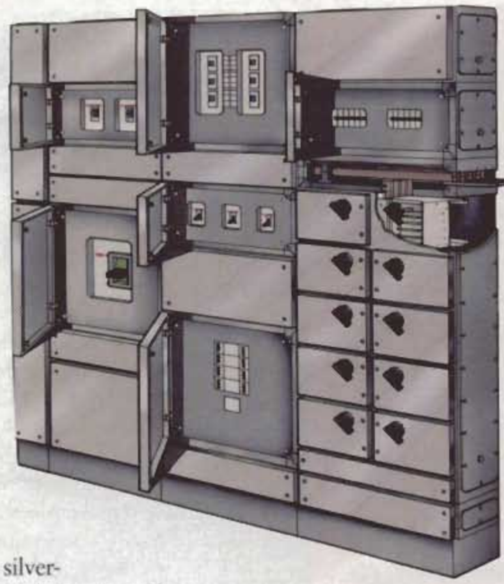
One solution in this application is the British J-type feeder pillar fuselink, which has recently been included in the international standard for low voltage fuses, IEC 269 (BS EN 60269), Part 2-1, Section VI.

J-type fuselinks are based on British Standard BS 88, Part 5. They have been designed specifically to satisfy the requirements of the electricity supply industry for feeder pillars and other distribution applications. They are small and have wedge-tightening contacts.

They are fast acting, industrial-type, current-limiting and energy-limiting fuselinks that comply with the time-current gates of IEC 269 at the faster end of the characteristic. Low fusing factors make them ideally suited to the protection of cables and feeder circuits. They are generally smaller than the alternative NH-type fuselinks, have lower watts loss and a gU-type characteristic. NH-type fuselinks are based on the German standard DIN 43620/1, and have gG and gL characteristics.

Another recent development is fuses with silver rather than copper or silver-plated copper elements. Silver elements work at higher operating temperatures – up to 220°C compared with 130°C for a comparable silver-plated copper element.

This is especially important in high temperature environments. One leading feeder pillar manufacturer has used MEM's J-type fuses with silver elements to achieve performance that was not possible with conventional fuselinks.



Best of both worlds: the Memshield 2 MPS modular panelboard allows the use of fuse or circuit-breaker incoming and outgoing devices

FUSE OR CIRCUIT-BREAKER?

There is a widespread misconception that the days of fuse-based switchgear are numbered, and that the future lies with circuit-breaker products alone. The facts prove otherwise. A recent survey of fuse use across Europe* revealed that in France, Germany and Austria, more than 80% of utility protection systems, and 90-95% of semiconductor protection systems, use fuses.

While circuit-breaker technology has benefits in homes and final distribution circuits, fuse-based switchgear still has significant technical advantages in applications such as industrial switchboards, motor protection, and semiconductor and electronic circuit protection. It is a case of "horses for courses".

For example, at the smaller end of the market, the HRC fuselink has a much higher short-circuit breaking capacity than the circuit-breaker, typically 80kA compared with 10kA for a current-limiting miniature circuit-breaker. On the other hand, the MCB can be re-set simply and quickly after operation. It also has better overload characteristics.

Modern domestic installations in the UK demonstrate the way in which the relative strengths of both technologies can be exploited. Regional electricity companies use a house service fuse for overall protection at the main incoming position. Circuit-breaker devices such as RCDs, MCBs and RCBOs protect individual circuits, and a fused plug or fused connection unit protects appliances.

There is an obvious market for fuse replacement in existing circuits, but this is far from being the entire story. There are many applications where they are used in new installations on grounds of safety, reliability or economy.

The fuse is an inherently reliable device that fails safe. Once a fuse has operated, it must be replaced, so the user knows that the circuit is protected by a new device – not one that may have been degraded by operating under punishing fault current conditions.

The benefits of coordination and discrimination play an important part in the choice of fuses, by utilities for example. They can provide discrimination with other fuse devices upstream or downstream, or backup protection for circuit-breaker systems.

In industrial power distribution and control panel applications, higher rated systems tend to favour fuse protection, with its higher breaking capacity and better discrimination. In the UK, for example, 40% of industrial power distribution circuits and half of control panel devices use fuses.

COMPLEMENTARY TECHNOLOGIES

Semiconductor protection represents a sector where the speed of operation of fuses is a major factor in their selection. In France and Austria, 95% of semiconductor protection systems use fuses, in Germany 90%, in the UK 80% and in the Netherlands 75%. Electronic and telecommunication circuit protection likewise makes extensive use of the high-speed operation of fuses.

Both fuse and circuit-breaker technologies have their strengths and weaknesses and can complement one-another in a harmonised low voltage system. Fuse technology has particular benefits in industrial power distribution and semiconductor protection. ●

* Statistics from Pro Fuse International, the European Association of manufacturers of fuses and fuse-based equipment.