

## INTRODUCTION

Selecting, specifying or recommending a Fuse Link for a particular application can be critical and carries with it a great deal of responsibility. It is reassuring to know that the Fuse Link selected is the result of over 100 years of experience and cumulative knowledge gained in the invention, design, development and manufacture of Fuse Links.

Information recorded in a letter from a W H Preece to the Society of Telegraph Engineers in 1887, stated that Fuses had been used to protect cables since 1864. The earliest enclosed Fuse Links were patented by Edison in 1880, but these were air-filled. The primary purpose of the glass envelope in which the Fuse Link elements were enclosed was to prevent molten droplets falling from the element, and to relieve the tensile strain on the element. In 1890, W M Mordy, chief engineer of the Brush Electrical Engineering Company, patented the first cartridge Fuse Link filled with arc-quenching materials. This device comprised a copper foil or wire conductor enclosed in a glass tube filled with a granular material. The filler could be chalk, sand, marble or any number of substances. Development in Fuse Technology has come a long way since the early days of Edison and Mordy. More recent developments have been incremental, with evolutionary improvements in design offering better performance. However the phenomena that occurs during the fusing of the elements is still shrouded in some mystery. When a Fuse conductor (or element) melts and interrupts the current, a very powerful "ARC" bridges the gap. This "ARC" is nearly as hot as the surface of the sun and although small in size it contains a tremendous amount of energy. Computer modelling of Fuse Link behaviour is now helping designers to better understand these mysterious processes that occur when a Fuse Link operates.

The majority of Fuse Links are designed and tested for compliance with one or other of the recognised standards, and whereas a section of these notes will cover "Standards and Approvals" frequent reference will be made to the terms; Fuse Link and Fuse, and therefore we should define the difference. A Fuse Link is a device with a strip or element of easily melted metal placed in an electric circuit so as to interrupt an excessive current by melting. The term Fuse is referred to when a Fuse Link is fitted into a Fuse Holder, or when mounted onto a Fuse Block, therefore the Fuse comprises all the parts that form the complete device.

Fuse Links are an important component used in almost every electrical installation, protecting both equipment and personal safety. Bussmann Fuse Links are manufactured under Quality Systems independently assessed to BS5750 Part 2 ( ISO 9002 ) and many ratings carry the ASTA 20 endorsement. You can be assured that at Bussmann we offer the customer the highest level of quality and integrity across every product line.

## THE WEAKEST LINK

All electrical equipment that we use; lighting, domestic appliances, motors, heaters etc., together with the cables connecting them, are designed to operate safely provided that only the normal current flows. Occasionally things can go wrong: the cable insulation wears away, motors suffer overloads, and people drop a spanner in the works, or across live terminals. The immediate effect of any such incident is for the current to rise to a value far above what is safe for the rest of the system to carry. The consequence is usually overheating which can lead to fire or even explosion. This is when the Fuse Link comes to the rescue - it is the specially designed weak link in the chain. When the current in the system rises above a prescribed danger level the conductors ( thin wires or strips of metal; the element ) inside the Fuse Link melt and form a gap so that the current is safely interrupted and the rest of the system is saved from the consequence of the fault.

Fuse Links are complex devices to design, not only must they react quickly in the event of a fault and interrupt the current without damage to the system, they are also expected to have a long service life when carrying normal current. Few things are more annoying to a user than a Fuse Link operating needlessly when there is no actual fault. Spurious operating is inherent in alternative protective devices dependent on mechanical operation such as miniature circuit breakers.

The heart of the Fuse Link is the wires or strips of metal which carry the current. These must be designed to melt and break the current flow when the current rises above a certain value. These wires or strips of metal are called the elements.

Thin elements carry less current than fat ones, therefore a Fuse Link rated to carry 1 Amp of current will obviously have far thinner elements than a 100 Amp Fuse Link. For larger current ratings we do not have to use a very fat element, instead we use several thinner ones running alongside each other or in parallel. In practice a 1 Amp Fuse Link might have a single thin wire element, while a 1000 Amp Fuse Link, one of the largest ones we manufacture, could have many thick strip elements. For this reason, Fuse Links of high current rating have much larger bodies than small ratings.

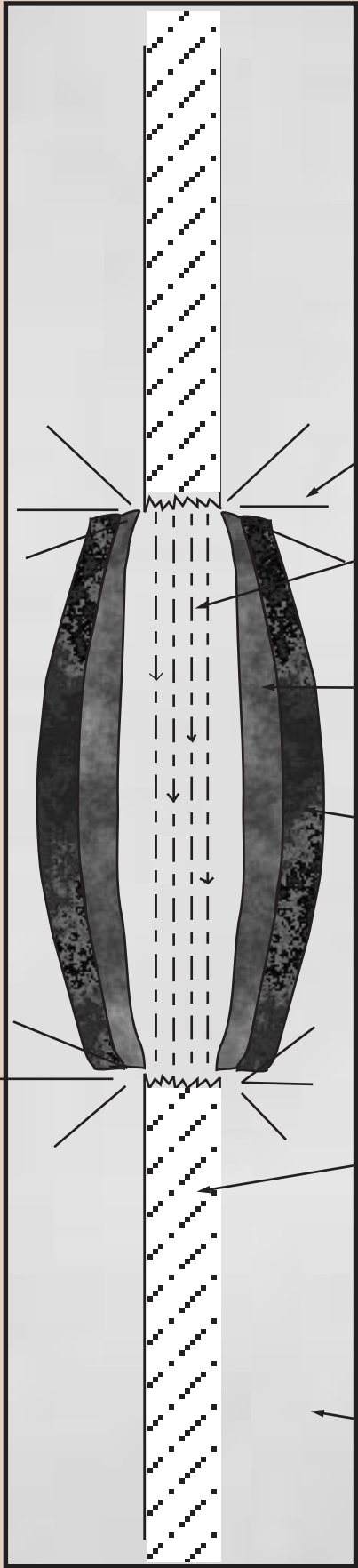
The sand filler packed around the element helps to carry away the heat generated due to the resistance of the elements. The ceramic body forms the outer housing, while the metal caps and fixing tags lead the current into and out of the Fuse Link.

### Fuse Link Operation:

a) When normal load current flows, the elements get quite hot but the heat is carried away by the sand and the metal connections so the elements don't reach their melting temperature.

b) If the current flow rises above the rated current of the Fuse Link, the elements get much hotter and the excess heat cannot be carried away quickly enough. The element therefore reaches melting temperature and breaks. The current is then interrupted and the Fuse Link has done its job.

# INSIDE A FUSE WHEN IT IS OPERATIVE



A - Arc burning away ends of element.

B - Hot Ionised gas carries current between broken element ends.

C - Sand grains are molten to form glass 'tube'.

D - Sand grains stick together to form pumice stone - like mass called 'Fulgurite'.

E - Element wire or strip.

F - Fuse Body

G - Sand Filler

## FUSE LINK CONSTRUCTION

A Fuse Link is a safety valve, its presence in an electrical circuit must permit full flow of energy to the equipment or installation which it serves without contributing in any way to potential weakness during normal function. However, the link must still maintain the ability to react when a fault condition occurs within the circuit, containing the fault energy within the body of the Fuse Link. Construction and characteristics are therefore the key features in the Fuse Link design and operation. Let us now consider how the fault energy is contained within the Fuse Link by examining the construction of a typical Fuse Link.

**The Fuse Link Body:** This is produced to very precise dimensions from high grade ceramic or fibre material which must be able to withstand the high thermal and mechanical stresses which occur when the Fuse Link operates.

**The Element:** The very heart of the Fuse Link. Operating characteristics are the key feature of every Fuse Link, as they control the action of the Fuse Link under operating conditions, and consequently its prospective capability in an over-current situation. Specific parameters are usually based on the current surge over a measured period of time (referred to as  $I^2t$ ) as on graphs. To achieve such exacting characteristics the choice of element material is a very important factor. Silver plated copper or silver elements manufactured to close limits are constructed. On each strip element there are accurately machined restrictions, the configuration of these being designed with the aid of a computer to provide the required operating characteristics. Conditions of small overloads are controlled by the use of special alloy melted onto the elements. These are known as the 'M' effect.

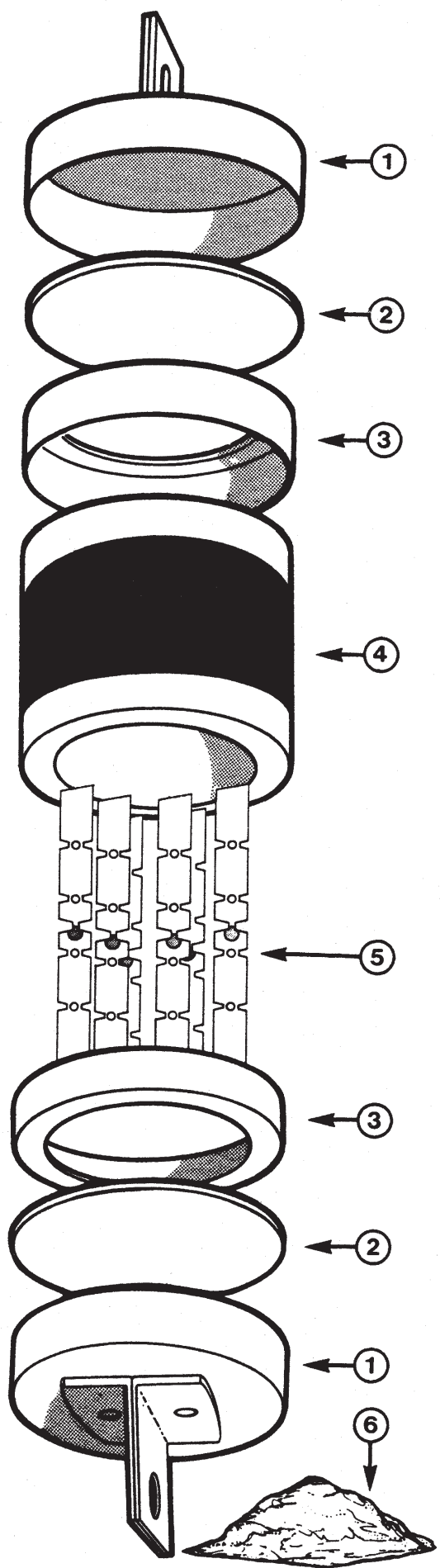
**Filler:** A quartz filler of controlled size, free from organic and metallic impurities and in a moisture free form, is compacted into the ceramic body.

**Inner Caps:** These are made of copper or brass and electro-tinned. They are interference fitted to the ends of the ceramic body and the outer caps are then pressed on to them ensuring a good mechanical fit and sound electrical connection.

**Discs:** These are used to provide resilience between the inner and outer caps and act as an arc barrier.

**Connectors and Outer Caps:** These are of copper or brass, the connectors (tags) being fixed to the end caps by welding and soldering or by riveting and soldering. The whole component is electro-tinned. Current rating or reference numbers are stamped on either the cap or the tag.

The Bussmann range of Industrial Fuse Links is manufactured in eleven body sizes covering ratings from 2 to 1250 Amps. A number of tag forms exist including those preferred by BS88. The Bussmann range of Industrial Fuse Links meet the requirements of BS88 Parts 1, 2 and 6 and IEC269 Parts 1 and 2 in voltages of 240, 415, 550 and 660.



1 Connector and Outer Cap

2 Disc

3 Inner Cap

4 Body

5 Fuse Elements

3 Inner Cap

2 Disc

1 Connector and Outer Cap

6 Filler

## FUSE LINK CHARACTERISTICS

Fuse Links are used in a variety of applications, each having its own special requirements. It is necessary to design Fuse Links specially for different applications. It is, of course, possible to meet many different applications with the same basic design, however certain circuits, such as motor starting, protection of semiconductor devices, dc operation, etc., may require specially designed Fuse Links. Fuse Link operation must be considered under three different conditions; normal running conditions, small sustained overload conditions, heavy overload or short circuit conditions. Therefore when designing and selecting a Fuse Link for a particular application, the operating characteristics are the most important consideration.

**Time-Current Characteristic:** A characteristic of all Fuse Links is that the speed at which they operate is directly linked to the level of the fault current. Example: a 100 Amp Fuse Link might take 10 minutes to operate at 200 Amps but would operate in one tenth of a second at 1000 Amps. A graph plotting the operating time of a Fuse Link against fault current is called a Time - Current graph. Time - Current curves are produced according to BS or IEC Standards, which are termed average curves. This average allows for manufacturing tolerances on a given type of Fuse Link. Time - Current curves according to North American Standards are plotted differently with each Fuse Link design having two curves. These represent the fastest time that the Fuse Link would operate for given values of current. The second plots the slowest time that the same Fuse Link would operate at the same currents.

**Cut-Off Characteristics:** When a Fuse Link interrupts a high value of fault current, it chops off the current before it has time to reach its full value, in other words the Fuse Link current - limits. Current limiting is the most important feature of Fuse Link operation as it ensures that cables, motors, transformers and other equipment are protected from the potentially catastrophic effects of many thousands of amps of fault current which could otherwise flow. The rate at which the Fuse Link chops off the potential fault current is shown on the cut-off current graph.

**$I^2t$  or Joule-Integrated Data:** A calculation of energy which is controlled or cuts off through the Fuse Link, by convention this energy is sometimes referred to as the Joule-integral. The calculation of this current let through is more commonly referred to as the  $I^2t$  formula (current let through by the Fuse Link, squared multiplied by the time in seconds for which the current flows) These values represent the total operating and pre-arcing times of

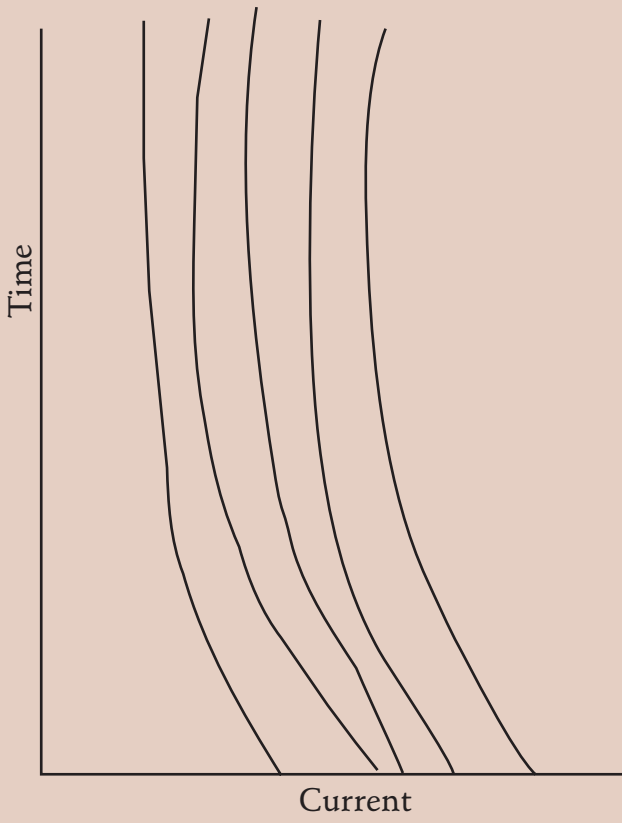
the Fuse Link under onerous conditions of maximum arc energy. Two values or curves are always given for each Fuse Link:

- 1) minimum pre-melting  $I^2t$  and
- 2) maximum clearing  $I^2t$ .

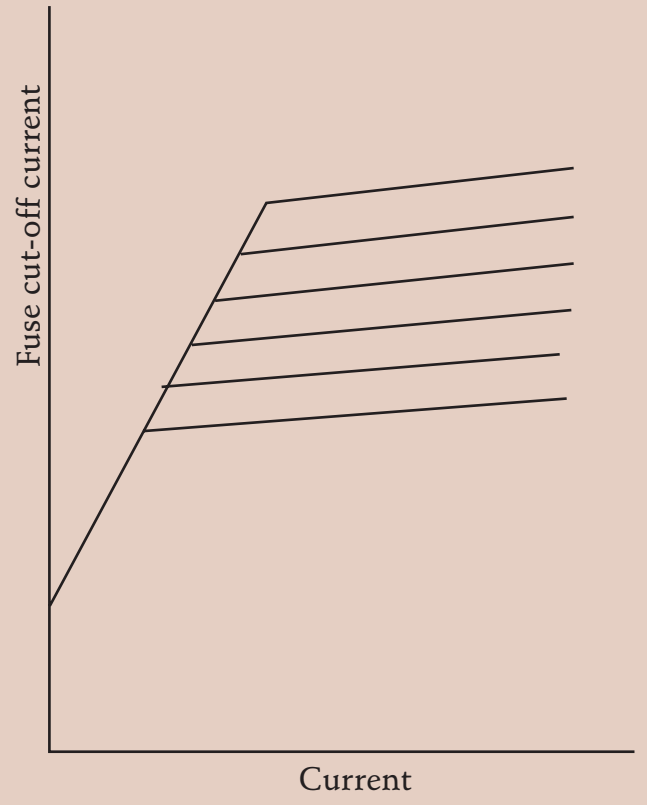
The first represents the amount of energy let through by the Fuse Link from the start of the fault up until the time the Fuse Link actually begins to operate. The second represents the total package of energy let through by the Fuse Link until the instant when the Fuse Link finally interrupts the fault current.

# Examples

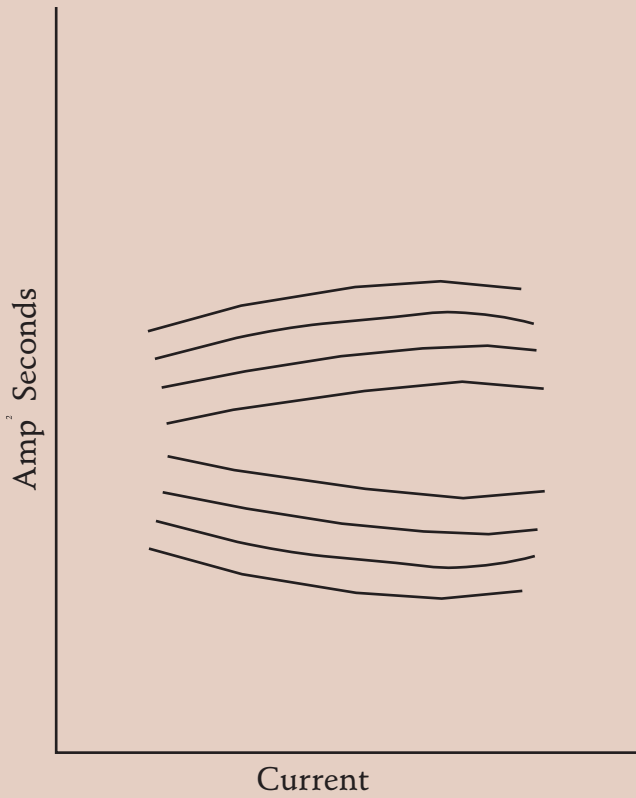
1. Time-current characteristics



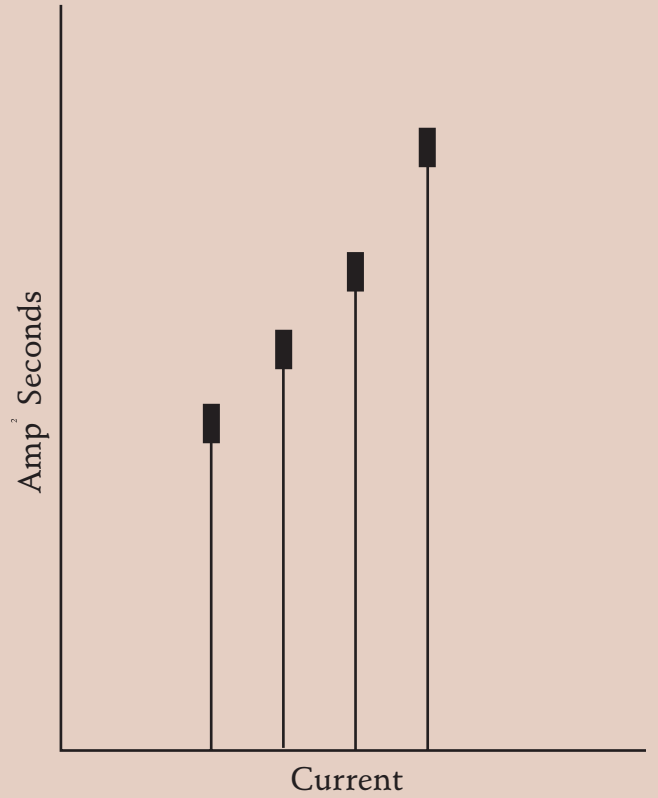
2. Cut-off Current Characteristics



3 (a)  $I^2t$  Characteristics



3 (b)  $I^2t$  'Bull Rushes'



## DEFINITIONS

**HRC or HBC:** High Rupturing Capacity or High Breaking Capacity denotes the ability of the Fuse Link to interrupt extremely high fault currents.

**Rated Voltage:** The maximum voltage that the Fuse Link is designed to interrupt. Rated voltage may be in volts ac, dc or both. Fuse Links are voltage-sensitive devices, and it is important to note that satisfactory operation of a Fuse Link under fault conditions is dependent upon the applied voltage. They must not therefore be applied in circuits above their voltage capability. They can however be used satisfactorily in circuits at lower voltages.

**Current Rating:** The value of current that a Fuse Link will carry continuously without deterioration under specified conditions. The continuous current rating of the Fuse Link should not be less than the full load current of the circuit.

**Minimum Fusing Current:** The minimum value of current to cause melting of the fusible elements.

**Rated Breaking Capacity:** The highest value of fault current that the Fuse Link has been tested to interrupt e.g. 80 kA. The standard values of breaking capacity are 80kA for voltages of 415V ac. and above, 40kA for dc. applications. The 240V ac. designs have a breaking capacity of 50kA.

**Power Dissipation:** The power released in a Fuse Link carrying rated current under specified conditions. The quoted power dissipation of a Fuse Link must be the maximum value at the extremity of the tags. The power loss values relate to a maximum test ambient temperature of 25 degrees C.

**Discrimination:** In determining if discrimination occurs between two Fuse Links in a circuit with a fault, the minor Fuse Link should operate and leave the major Fuse Link unimpaired.

**Time/Current Characteristics:** To comply with the requirements of BS88 (or other relevant standard) the time/current characteristics must lie within specified zones. These zones have the minimum pre-arcing time and maximum total operating time at 415 volts as their limiting values. All the Bussmann standard current ratings fall within the limiting values of the time / current zones.

**Ambient Temperature:** Fuse Links are thermal devices and as such may require some de-rating when used at elevated ambient temperatures. A de-rating in terms of current of 0.5% per degree centigrade above an ambient of 35 degrees C is recommended.

**Fuse:** A device which by the fusing of one or more of its components opens the circuit it is inserted in by breaking the current when this current exceeds a given value for sufficient time. A Fuse comprises all the parts that form the complete device.

**Fuse Holder:** The combination of the Fuse-Base with its Fuse-Carrier.

**Fuse Carrier:** The moveable part of a Fuse, designed to carry the Fuse Link.

**Fuse Base:** The fixed part of a Fuse including terminals, contacts and covers.

**Switching:** Ability to make and break defined load and overload currents at a rated operational voltage, for the useful life of the device.

**Switch:** A mechanical device capable of making, carrying and breaking current under circuit conditions.

**Switch Fuse:** A switch connected in series with the Fuse, or Fuses to make a composite device.

**Fuse Switch:** A Fuse, or a number of Fuses, mounted on the moving contact system of a specially designed switch.

**Short Circuit:** Short time current capability and/or through fault and/or fault making capability.

**Protection:** Overload and short circuit interruption.

**Isolation:** Ensures disconnection of the supply for safe working.

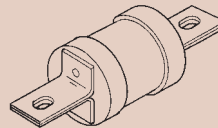
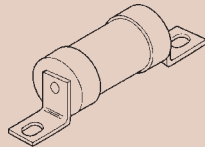
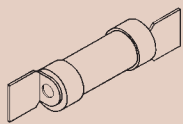
**Full Range Fuse Link:** A Fuse Link with a full range breaking capability, capable of interrupting all currents from rated breaking current generally down to the minimum fusing current.

**Current Limiting Fuse Link:** A Fuse Link which during its operation limits the circuit current to a value much lower than the peak value of the prospective current. In practice, the terms HRC and current limiting are synonymous.

**Back-up Fuse Link:** A Fuse Link with partial range breaking capability having a minimum breaking current greater than the minimum fusing current.

## LOW VOLTAGE FUSE LINKS TO BS88 & IEC269

The Bussmann range of high breaking capacity Fuse Links for Low Voltage industrial and General Purpose applications meet the requirements of BS88 and IEC269. By using advanced Fuse technology the current ratings up to 400 Amps have compact dimensions but are still within the standardised dimensional and performance requirements. These designs have been optimised for 415 / 240 Volt systems. The standard range of Fuse Links are available from 2 to 1250 Amp in the following tag forms: Offset Blade -      Offset Bolted -      Centre Bolted.



Supplementary ranges cover applications up to 660 Volt ac and 500 Volt dc including those with non-standard tag fixings.

The Bussmann range of Fuse Links for the protection of Semiconductor Devices were introduced in 1965. Manufacturer's literature will refer to these Fuse Links as high speed, fast acting, or for semiconductor protection. Unfortunately there is no universally recognised term, however in British practice the dimensions of these Fuse Links are quite different to those for normal Industrial use so there is no possibility of fitting the wrong type. Bussmann offer two voltage ranges, 240V ac / 150V dc (6 to 900Amps) and 660V ac / 450V dc (6 to 700Amps).

The Bussmann range of Low Voltage Feeder Pillar Fuse Links are designed for use with wedge type fuse carriers with fixing centres of 82mm and 92mm. These are primarily for use by Electricity Supply Industries in distribution pillars, open type substations boards, heavy duty service cut-outs and underground disconnecting boxes.

### Standards:

BS88: Part 1 (IEC269 - 1)	General Requirements.
BS88: Section 2.1 & 2.2 (IEC269-2)	Additional Requirements for Industrial Fuse Links (bolted tag).
BS88: Part 3 - 1 (IEC269 - 3)	Additional Requirements for Household Fuse Links (domestic).
BS88: Part 4 (IEC269 - 4)	Additional Requirements for Semiconductor Protection Fuse Links.
BS88: Part 5	Additional Requirements for Electricity Supply Network (Feeder Pillar) Fuse Links.
BS88: Part 6	Additional Requirements for Compact Fuse Links (bladed tag).

## UTILISATION CATEGORIES

gG	Full Range breaking capability, General Application
gM	Full Range breaking capability, Motor Application
aM	Partial Range breaking capability, Motor Application
aR/ gR	Semiconductor Protection, Fast Acting ( Superfink )
gTr	Transformer Protection

## FUSE STANDARDS:

Most electrical equipment is sold as complying with some relevant standard or specification. The familiar Kitemark and British Standard number is familiar on most domestic appliances and is the only guarantee of quality that the user has. The majority of our Fuse Devices are designed and tested for compliance with one or more of the recognised fuse standards.

**IEC Standard** (International Electrotechnical Commission) is now accepted by most countries world-wide, and many countries such as UK, Germany, France, Australia, India etc. have altered their own National Standards to comply with IEC. Therefore, if we confirm to the user that our Fuse equipment complies with the relevant IEC Standard, this will usually be acceptable.

**VDE Standard** (Verband Deutscher Elektrotechniker) In Germany, VDE 0660 for Low Voltage Fuses has been aligned with the relevant IEC Standard. The dimensions of German Fuse Links (now widely adopted in many parts of the world) are specified to Din 43620 for Low Voltage Fuse Links. Note: Din (Deutsche Industrie Norm) is a dimensional standard only.

**UL Standard** (Underwriters Laboratories) In the USA, standards are quite different from those adopted in Europe. Electrical tests are specified in standards written by UL. Low Voltage Fuse Links have dimensions according to NEMA (National Electrical Manufacturers Association)

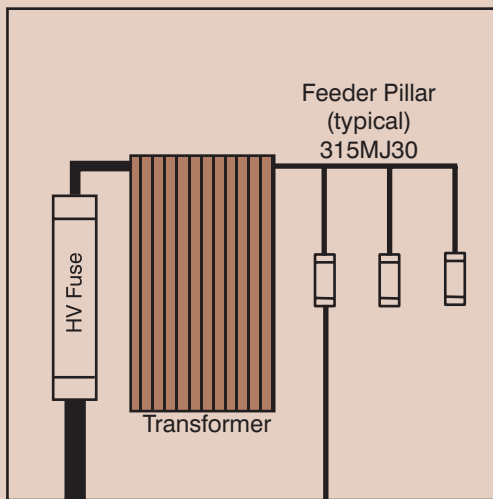
**CSA Standard** (Canadian Standards Authority) In Canada, Low Voltage Fuses have to comply with CSA, which is a mixture of UK and USA practice.

The harmonisation of standards developed from the International Electrical Certificate ( IEC ) is being adopted for use in Europe with European Norm ( EN ) under a slightly different name, for example Fuse Links tested to BS/IEC269 will in future be approved to BSEN60269.

## FROM SUB-STATION TO TABLE LAMP

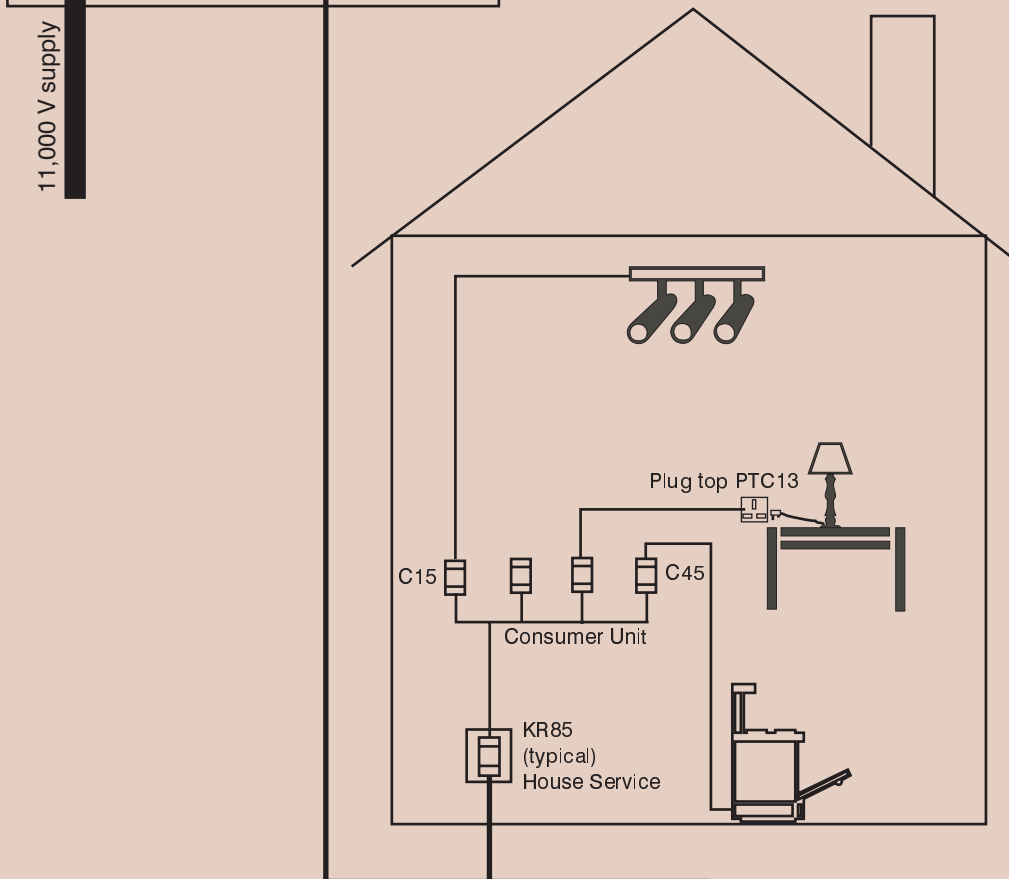
Electricity sub-stations which we can see in our neighbourhood securely fenced, receive power via cables at 11,000 volts. This supply is transformed down to 415 volts, using what is known as a distribution frame. The supply is broken up into several separate 240 volt outlets which run via cables under the adjacent streets to our homes. Each outlet on the distribution frame is protected by a Fuse Link known as a Feeder Pillar or J-type. This Fuse Link protects the entire length of underground cable from the sub-station to our domestic meter.

Protecting the supply at the front end of our domestic meter, is the House Service Fuse Link (Types KR85 or LR85). These Fuse Links are designed to ensure minimum temperature rise within their sealed box (commonly referred to as cut-outs) but at the same time to chop the fault current down



to a low enough value to save any miniature circuit breaker in the consumer unit (miniature circuit breakers cannot stand high fault currents as well as Fuse Links). Reassuring to know that our domestic consumer units incorporating miniature circuit breakers are backed up by the tried and tested Fuse.

From the House Service Fuse Link, current flows via the meter to a consumer unit where the supply is split up as required (lighting, ring mains, cooker etc). Protecting each



of these circuits could be a Consumer Unit Fuse Link, although it is common practice to install miniature circuit breakers into the domestic consumer unit. Consumer Unit Fuse Links are rated at 240 volt and are available in current ratings 5 to 45 Amps.

The Plug Top Fuse Link is the final link in this protective chain, which began with the Feeder Pillar Fuse. Plug Top Fuse Links are rated at 240 volt with current ratings 1 to 13 Amps.

## LOW VOLTAGE FUSE APPLICATIONS

From Power Station to the Home, Fuses play a vital part in protecting electrical circuits. Bussmann manufacture a wide range of Fuse Links, from the large hand made version used in power distribution systems to the tiny, surface-mount chips on the circuit boards inside electronic equipment. Fuses are probably the most common of all electrical components used in electrical circuits. The following chart gives just a few of the many applications utilising the Low Voltage Fuse.

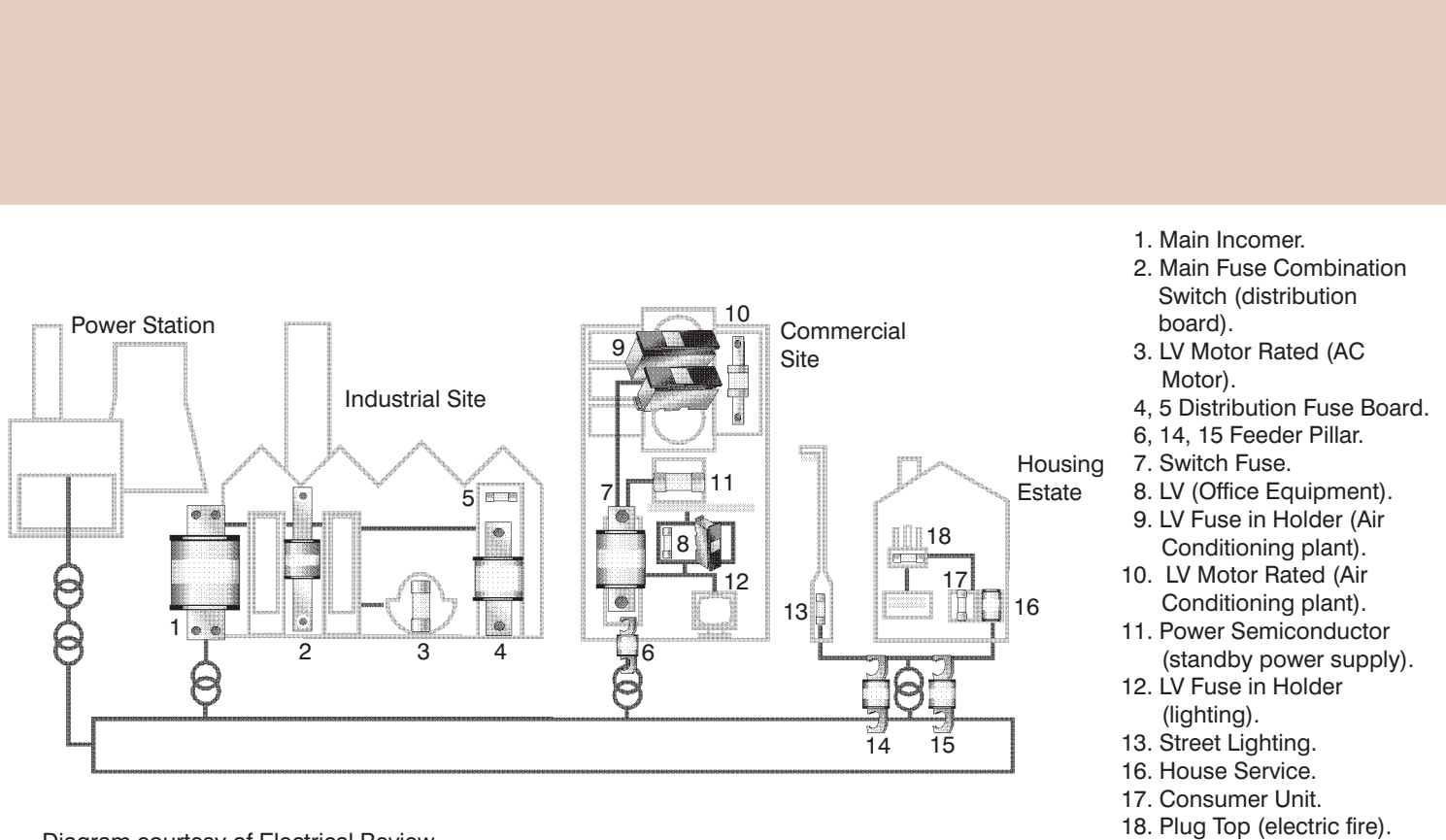


Diagram courtesy of Electrical Review.

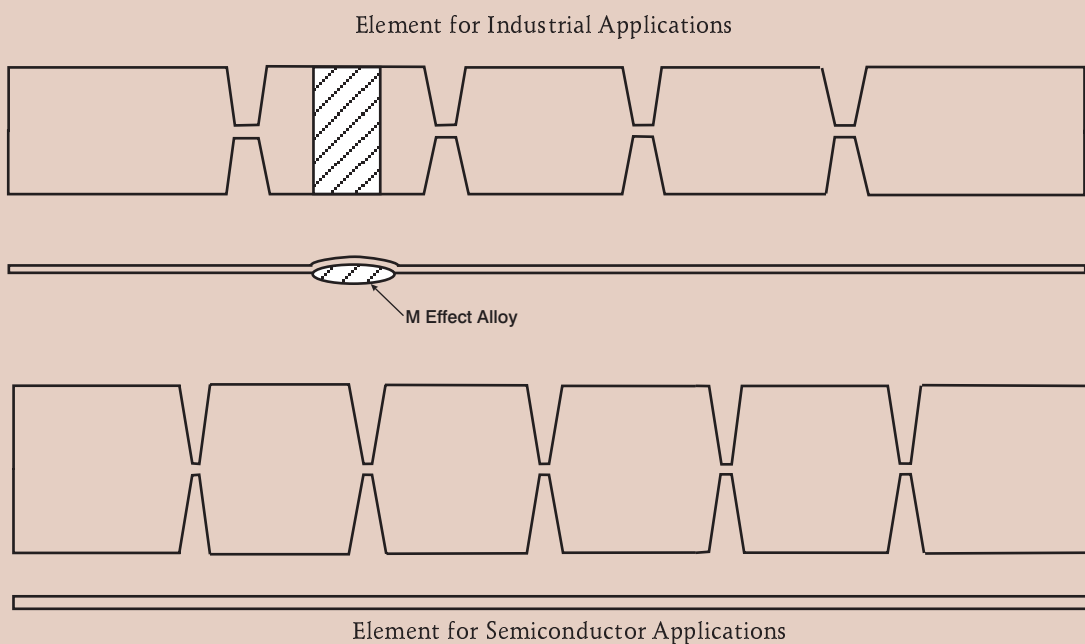
## MOTOR CIRCUIT PROTECTION

In motor circuits the Fuse Link has to withstand the starting current of the motor, typically 7 x full load current (FLC) for the run-up period in the case of direct on line (DOL) start motor, and provide back up protection with the motor starter and associated cables. Extended dual ratings of motor protection Fuse Links with gM characteristics are available in most popular sizes of Fuse Links.

## FUSE LINKS FOR THE PROTECTION OF SEMICONDUCTORS

The term semiconductor in electrical circuits can best be described as a switch, however unlike the domestic light switch, there are no moving parts. When a small amount of electricity is applied to one part of the semiconductor, the complete device changes from being an insulator (a material that does not pass electric current) to a conductor (a material that does pass electric current). Like many other circuit components, the semiconductor is sensitive to excesses in both current and voltage. When an over-current is evident the wafer thin sections of the device over-heat and are damaged. Similarly, when the current is not flowing through the device, but a high circuit voltage is present, the construction of the device will again be damaged.

Semiconductors were first marketed in 1953, and it was realised from the outset that these devices had very limited overload capacities and, as they were expensive, the Fuse manufacturers attempted to produce Fuse Links which were more sensitive to overloads and which would operate more quickly than their conventional designs. Fuse Links designed to protect semiconductors incorporate elements machined to finer tolerances and rarely employ the M-effect as used in the Industrial range. A Fuse Link element with finer tolerances will reduce the ability of the Fuse to provide low over-current protection, and will therefore provide increased protection to the semiconductor. As a consequence of interrupting the current flow more quickly, an over-voltage is produced by the Fuse Link. This voltage must be limited or other circuit components (including the semiconductor) could be damaged. To limit this over-voltage, additional bonding agents are added to improve the sand compaction around the element, reducing the energy of the arc on operation. The Fuse Link body material may also be of a higher grade material, and the end connections may employ a solid metal construction or be assembled using higher temperature solders.



Manufacturers and users alike, will refer to these Fuse Links as 'high speed', 'fast acting', or, 'for semiconductor protection'. Unfortunately there is no universally recognised term, though in British practice the dimensions of the Fuse Link are quite different to those for the normal Industrial use, so there is no possibility of fitting the wrong type.

In the UK, the majority of power semiconductors are used in three-phase and single-phase circuits operating at 240V per phase. Fuse Links are dimensionally standardised to comply with BS 88: Part 4, and are available for single-phase applications with ratings up to 900Amp at 240Volts. They are also available for use in three-phase circuits operating at 660V in current ratings up to 710 Amps. The standard dimensions are as small as practicable because many Fuse Links are used in applications where space is at a premium.

The square-ceramic NH' dimensioned designs are very popular, the body lengths being much shorter than those used for Industrial applications. End terminations suitable for bolted connection with fixing centres at 80 or 110mm are widely used, but alternative versions with tapped holes in the ends are available. The latter design has the advantage of being more compact and it is normally used for ratings above 1000 Amps. The overall dimensions of Fuse Links for semiconductor protection are specified in DIN 43653.

Many Fuse Links for the protection of semiconductors used in Europe incorporate indicators. These are similar to those used in Industrial Fuse Links and they may be either positioned at one of the ends or in the central regions of the Fuse Link body. As well as giving local indication as to the status of the Fuse Link, these devices may be adopted to operate microswitches so that remote indication of the Fuse operation may be provided.

Fuse Links provided in North American circuits containing semiconductors are similar in construction to those used in Industrial applications. However, as in the UK, the special performance requirements have been obtained by using suitable materials and element construction. The dimensions of these Fuse Links have not been standardised by any national body but industry standards have evolved by usage in the voltage ratings of 130, 250, 500, and 700.

Protection of expensive semiconductors can only be achieved by devices having an extremely rapid circuit breaking action coupled with current and energy limitation. The Fuse Link is the only device available at an economic price, which is fast enough in operation to protect semiconductors. Fuse Link operation depends upon the heat generated by the passage of excess currents in specially designed elements. This gives the Fuse Link the important property of current limitation in clearing fault currents, i.e., the Fuse Link element melts before the first peak of the fault current is reached. This therefore, limits the magnitude and duration of the fault current. Fuse Links do not depend upon any mechanical system, with inherent inertia, in their mode of operation and therefore Fuse Links are able to respond immediately to the thermal state of semiconductors.



Range of Semiconductor Devices

# NH' FUSE SYSTEM

The NH' Fuse Link designs ( blade type ) are used in factory distribution systems and in the distribution cabinets of the electricity- supply industry protecting power-distribution networks. NH' Fuse Links are generally available for applications up to and including 1600 Amps, for ac. circuits operating at levels up to 500v, and dc. circuits of voltages up to 440v. Designs with restricted current ratings are available for 660v ac. systems. NH' Fuse Links incorporate indicators, a feature which is not normally provided on low voltage Fuse Links to British Standard.

NH - NIEDERSPANNUNGS HOCHLEITUNGS  
( Low Voltage High Breaking Capacity )

Din - DEUTSCHE INDUSTRIE NORM  
( German Industry Norm )

VDE - VERBAND DEUTSCHER ELEKTROTECHNIKER  
(German Electrotechnical Association)

Construction of Part No:

AMP + NH + BODY SIZE + CHARACTERISTIC

Example: 100 + NH + C00 + G (gL) = 100NHC00G

100 + NH + 00 + M (aM) = 100NH00M

100 + NH + 00 + G (gL-660V) = 100NH00-660

Body Sizes:	Maximum Current Rating (Amps)
C00	100 Amps
00	160 Amps
0	160 Amps
1	250 Amps
2	400 Amps
3	630 Amps
4a / 4	1600 Amps

Voltages:

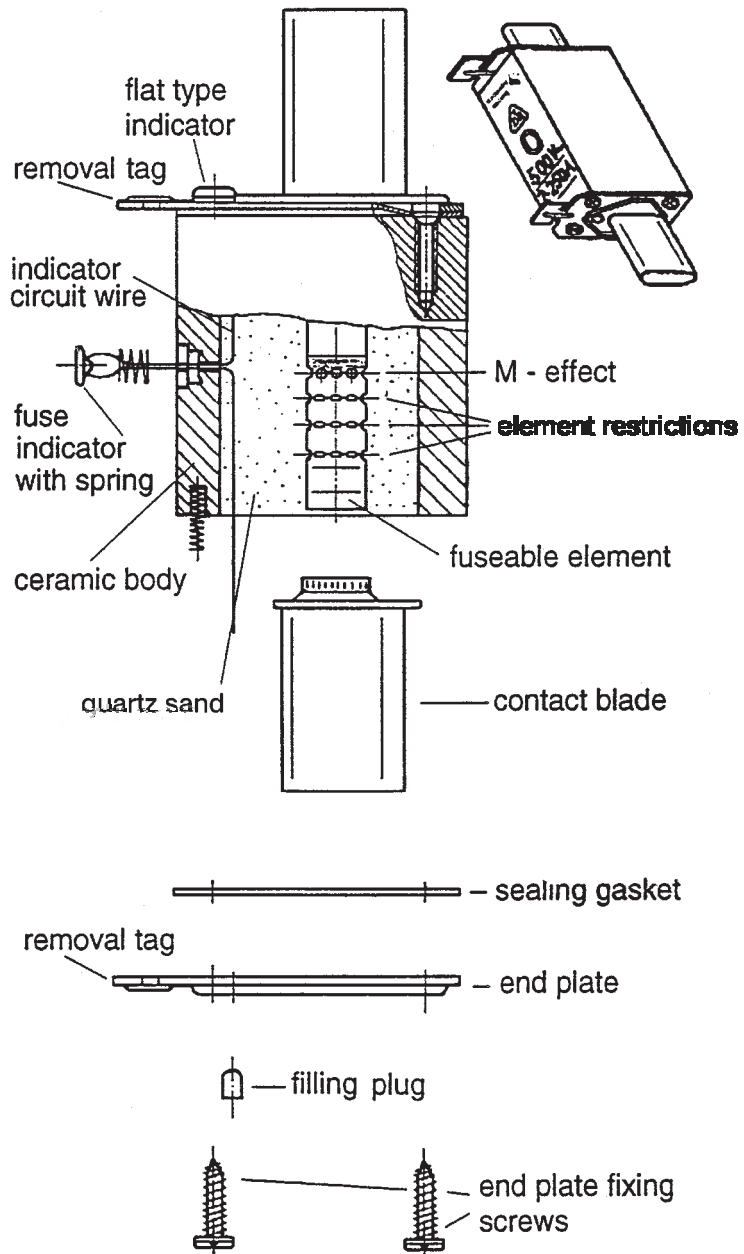
400v ac.

500v ac.

660 / 690v ac.

800v ac.

Note: System Voltage must be less than rated voltage of the Fuse Link.

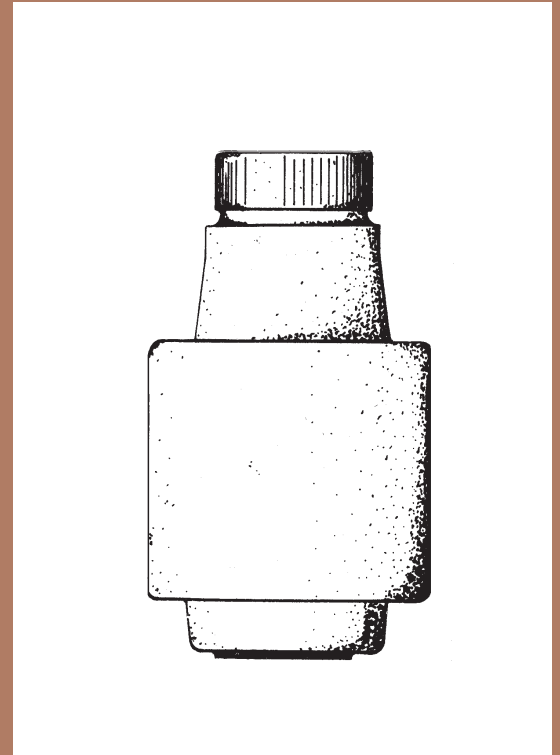
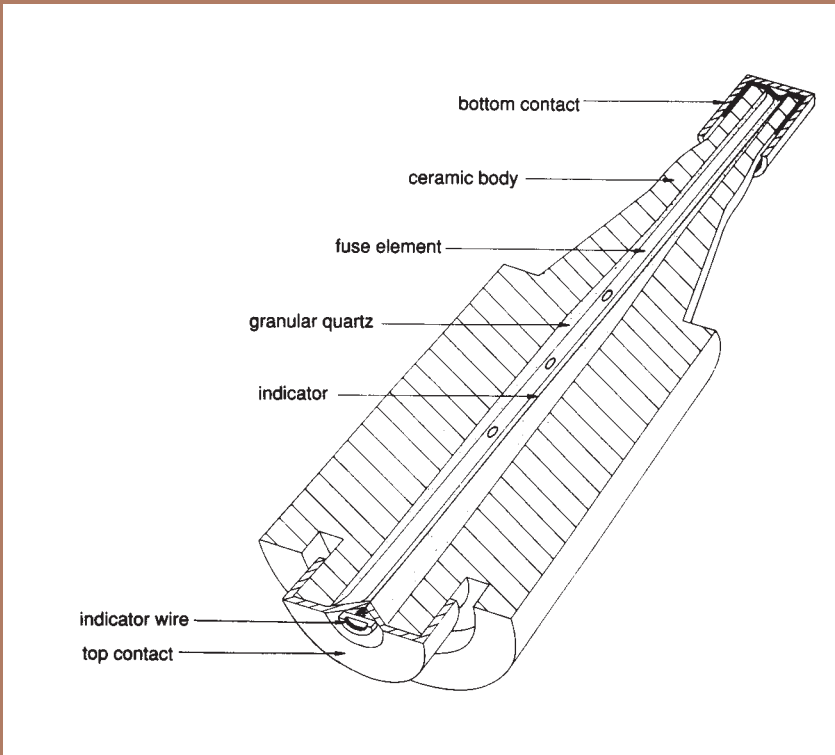


**NH-FUSE LINK**

## D' /'DO' TYPE FUSES (End - Contact or Screw - Type)

This is an old type of Fuse System, often referred to as Bottle type, clearly stemming from the characteristic shape of the Fuse Link. There are two designs, the 'D' (Diazed) and the 'DO' (Neozed).

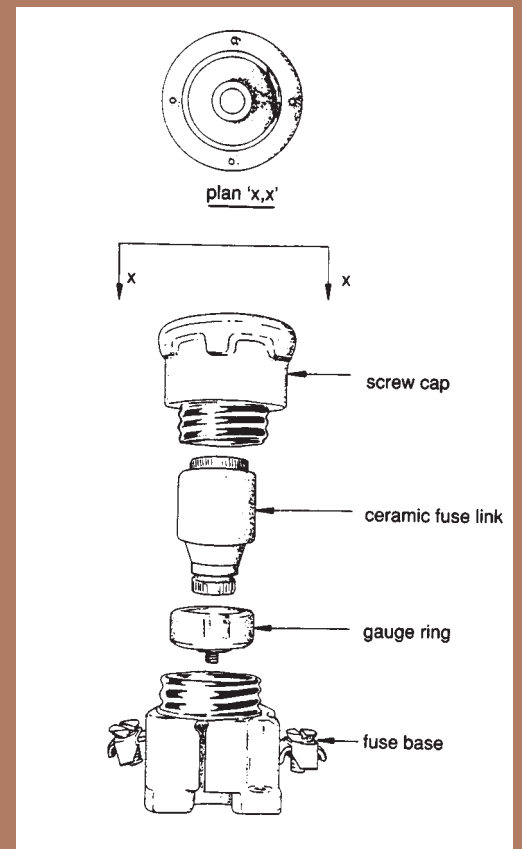
D' Type Fuse Links are manufactured to Din Specification 49365 and 49360 and have delayed, quick acting or ultra quick acting characteristics. They conform to VDE regulations 0635 for line Fuse Fittings with totally enclosed Fuse Links rated 500 volts. The ratings available range from 2 - 100 amps.



These Fuse Links are fitted with operation indicators which generally take the form of a button head which is pushed out through the end contact by a weak spring when the Fuse Link operates.

'DO' Type Fuse Links with advanced compact design features of a cooler running Fuse Link, giving advantages in space saving, performance and reliability are considered to be the successor to the 'D' type. 'DO' Fuse Links are suitable for 440 volt ac with 10% excess capability. Tested to IEC 269 - 1 specification and this design is approved by Lloyds Register of Shipping. Ratings range from 2 - 63 amps.

A standard range of ceramic Fuse Bases is available to accommodate the range of both 'D' and 'DO' Fuse Links. Gauge rings are supplied to ensure that the correct Fuse Link is installed to protect the selected circuit. The gauge rings are colour coded for ease of identification.



## CYLINDRICAL FUSE LINKS

Fuse Links with cylindrical bodies and ferrule end caps are now widely used for both domestic and industrial applications. Ratings up to 45 Amps for use in 240 volt ac are available for domestic circuits. We are all familiar with the tried and tested designs of the Plug Top and Consumer Unit Fuse Links which have been protecting our domestic appliances for many years. For industrial applications, Fuse Links with ratings up to 125 amps are produced for use in circuits in which the voltages do not exceed 500V. The Cylindrical types, available for protecting industrial circuits, are becoming more popular, replacing the 'D' and 'DO' types in new and refurbished installations. We can also claim that Cylindrical designs are now beginning to replace the BS 88 small dimensioned designs with bladed tags up to 63 amps.

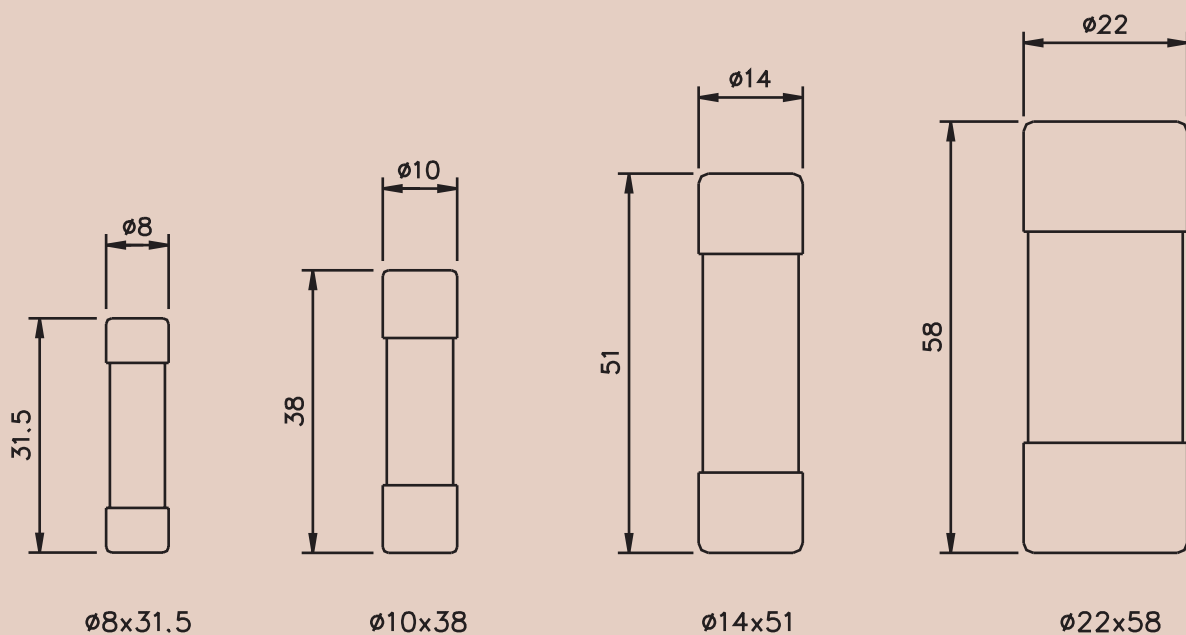
The more popular sizes of Cylindrical Fuse Links for industrial applications are:

8.5 x 31.5mm, in ratings 0.5 - 25 amps. (500V ac up to 20 amp/400V ac at 25 amp)

10.3 x 38mm, in ratings 1 - 32 amps. (500V ac up to 25 amp/400V ac at 32 amp)

14 x 51mm, in ratings 2 - 50 amps. (500V ac up to 32 amp/400V ac at 40 & 50 amp)

22 x 58mm, in ratings 6 - 125 amps. (500V ac up to 100 amp/400V ac at 125 amp)



Cylindrical Fuse Links are approved to IEC 269, and are available in gL and aM categories.

The 10 x 38, 14 x 51, and 22 x 58mm Fuse Links have a breaking capacity of 100 kA.

The 8 x 31.5mm has a breaking capacity of 50 kA.

## NORTH AMERICAN FUSE LINKS

The internal demand for electrical equipment is so great in the USA that Fuse Links unique to the home market have been developed. Several types of Low Voltage Fuse Links are available with current ratings up to 6000 amps, with the ability to operate at voltages of 250V or 600V.

In order to develop safety test procedures, agencies regulating the test procedures have developed basic performance and physical specifications or standards for a product. These standards have culminated in the establishment of distinct classes of Low Voltage Fuse Links, the main classes being:

Class R - up to 600 amps, 250V and 600V

Class H - up to 600 amps, 250V and 600V

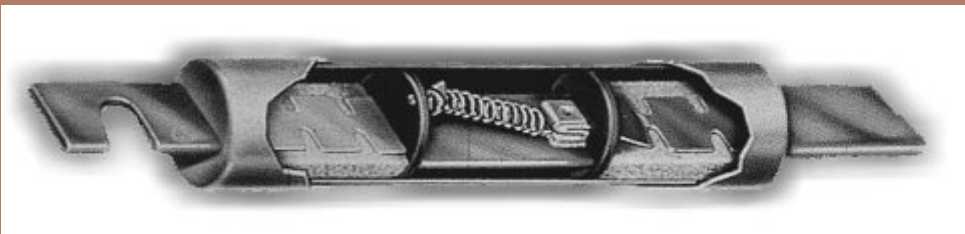
(The Class R Fuse Link has a high breaking capacity of 200 kA, whereas the Class H has a low breaking capacity of 10 kA)

Class J - up to 600 amps, 600 V

Class L - from 600 amps to 6000 amps, 600 V

Fuse Links to North American designs are not dissimilar in appearance to BS/IEC designs in that ratings up to 60 amps are generally Cylindrical, and higher ratings are fitted with blade type tags for mounting in spring contacts, and either bolted or slotted tags which allow for bolted connection. Ceramic bodies are used, however the Class R Fuse Link bodies are usually made of materials ranging from vulcanised fibre, to pultruded thermoset polyester. The elements are generally made of copper but silver is used when the let-through energies under high faults are to be kept to a low level.

The dual element Fuse Link employs a centre section which does not require any sand filling material. This is because the metal parts slow the temperature rise and allow free movement of these metal parts when clearing an overload.



### **Class CC Fuse Links**

600V, 200,000 ampere interrupting rating, branch circuit fuse links with overall dimensions of  $\frac{13}{32} \times 1\frac{1}{2}$  inches. Their design incorporates a rejection feature that allows them to be inserted into rejection fuse holders and fuse blocks that reject all lower voltage, lower interrupting rating  $\frac{13}{32} \times 1\frac{1}{2}$  inch fuse links. They are available from 0.01 amps to 30 amps.

### **Class G Fuse Links**

480V, 100,000 ampere interrupting rating branch circuit fuse links that are size rejecting to eliminate over fusing. The Fuse Links' Diameter is  $\frac{13}{32}$  inch while the length varies from  $\frac{15}{16}$  to  $2\frac{1}{4}$  inches. These are available in ampere ratings of 1 amp to 600 amps.

### **Class H Fuse Links**

250V and 600V; 10,000 ampere interrupting rating branch circuit fuses that may be renewable or non-renewable. These are available in ampere ratings from 1 amp to 600 amps.

### **Class J Fuse Links**

These fuse links are rated to interrupt a minimum 200,000 amperes AC. They are labeled as 'Current Limiting', are rated for 600 Volts AC and are not interchangeable with other Class K fuse Links. These are fuse links listed as k-1, K-5 or K-9. Each subclass has designated  $I^2t$  and  $I_p$  maximums. These are dimensionally the same as Class H fuse links and they can have interrupting ratings of 50,000; 100,000 or 200,000 amps. These fuse links are current limiting. However, they are not marked 'current limiting' on their label since they do not have a rejection feature.

### **Class K Fuse Links**

These are fuse links listed as K-1, K-5 or K-9. Each subclass has designated  $I^2t$  and  $I_p$  maximums. These are dimensionally the same as Class H fuse links and they can have interrupting ratings of 50,000; 100,000 and 200,000 amps. These fuse links are current limiting. However they are not marked 'current limiting' on their label since they do not have a rejection feature.

### **Class L Fuse Links**

These fuse links are rated for 601 to 6000 amperes and are rated to interrupt a minimum of 200,000 amperes AC. They are labeled 'current limiting' and are rated at 600 Volts AC. They are intended to be bolted into their mountings and are not normally used in clips. Some Class L fuse links have designed-in time delay features for all purpose use.

### **Class R Fuse Links**

These are high performance fuse links rated at  $\frac{1}{10}$  to 600 amps in 250 volt and 600 volt ratings. All are marked 'current limiting' on their label and all have a minimum of 200,000 Amp interrupting rating. They have identical outline dimensions with the Class H fuse links, but have a rejection feature which prevents the user from mounting a fuse of lesser capabilities (lower interrupting capacity) when used with special Class R Clips. Class R fuse links will fit into either rejection or non-rejection clips.

### **Class T Fuse Links**

An industrial class of fuse links in 300 and 600 volt, with ratings from 1 Amp to 1200 Amps. They are physically very small and can be applied where space is at a premium. They are fast acting and time-lag fuse links, with an interrupting rating of 200,000 Amps RMS.

## MINIATURE FUSE LINKS

Although miniature, domestic plug-top and other small dimensioned Fuse Links are physically similar, they are grouped into several different application categories and must comply with different specification standards. Many different types are available with current ratings from 32mA to 20A, most have cylindrical type bodies and ferrule-type end caps, though an increasing number are produced for ease of fitting on to printed circuit boards (PCBs) Miniature Fuse Links are covered by the IEC standard (IEC127)

Parts; 1, 2, 3, 4.

IEC 127, Part 1, Covers the definitions and general requirements

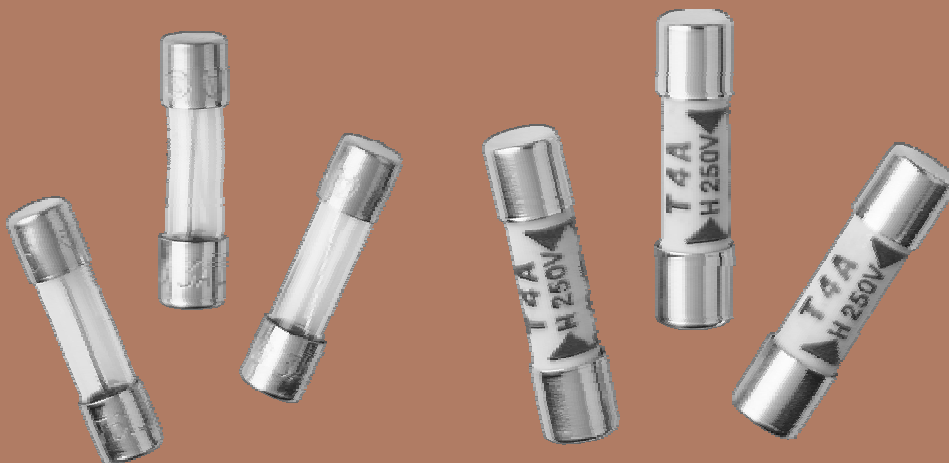
IEC 127, Part 2, Covers Cartridge type Fuse Links

IEC 127, Part 3, Covers Sub-Miniature type Fuse Links

IEC 127, Part 4, Covers Universal Modular Fuse Links

The category of speed of operation are also signified by internationally accepted letters that are marked on the Fuse Link. The letters and corresponding categories are as follows:

- F Quick-acting
- FF Super-quick-acting
- M Medium-time-lag
- T Time-lag or Anti-surge
- TT Super-time-lag



## DOMESTIC PLUG FUSES

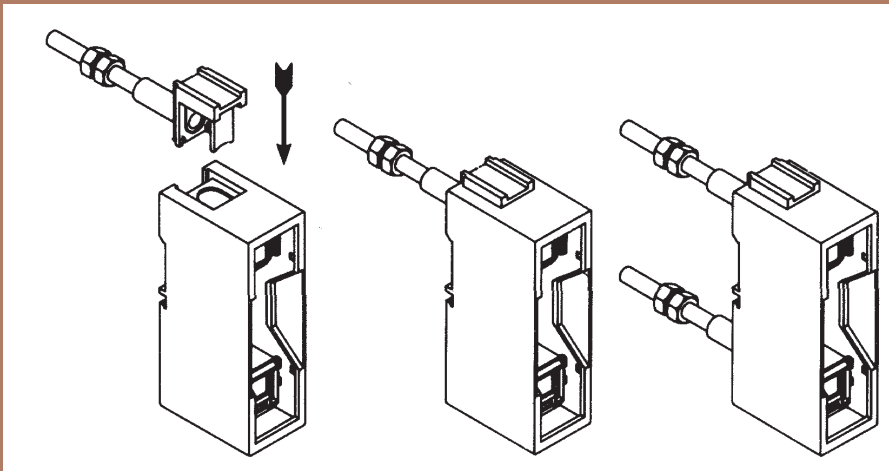
The UK plug and socket system is so familiar that we take it for granted. Fused plugs and sockets have provided a level of safety in the home since 1947. The Fuse Links used are commonly referred to as 'plug-top cartridge' (PTC) and are available in a range of current ratings up to 13A. Cylindrical in design, 25.4mm in length, with a diameter of 6.35mm and complying with the requirements of BS 1362. The two preferred ratings of 3A and 13A also conform with IEC 269. The Bussmann range of PTC Fuse Links, catalogue reference TDC180 are available in ratings of 1, 2, 3, 5, 7, 10, and 13Amp, at 240V ac. They are ASTA Certified and have the BSI Kite Mark Licence..



## FUSE HOLDERS: BRITISH STANDARD TYPES

There are two distinct designs of British Standard Fuse Holder; BS88: Part 2, with popular ratings of 20, 32, 63, and 100 amp. These Fuse Holders accommodate offset bolted tag Fuse Links to BS88: Parts 1 & 2, 1988 (IEC 269- 1 & 2 1986). A 200 and 400 amp version is available, however at ratings above 100 amps, a more cost effective solution is to install a Fuse Switch Disconnect. BS88: Part 6, with popular ratings of 32, and 63 amps, accommodate offset blade tag Fuse Links to BS 88: Part 6, 1988. A 125 amp is available (GEC only).

The present day Fuse Holder has many features, one being that live metal cannot be touched when the Fuse Carrier is being removed from or inserted into the Fuse Base. The cable terminals within the Fuse Base must also be fitted with barriers or shutters so that live metal is not exposed when the Fuse Carrier is removed. The Bussmann Camaster range, which accommodates offset bolted tag Fuse Links, is fitted with a Cam for ease of removal from the Fuse Base allowing significantly improved contact pressure between the Fuse Carrier contacts and Base contacts, with an enhanced electrical performance level. This design overcomes the major problem of all other manufactures of British Standard Fuse Holders world-wide who have to compromise between difficulties of Fuse Carrier removal from the Base and achievable contact pressure. The standard front connected Camaster Fuse Holder can be readily converted from front connected to front/back stud connected, and double back stud connected with the use of a unique back stud accessory and a screw driver.



The patented Safeloc Fuse Holders provide a simple safe range designed to accommodate the compact range of offset blade tag Fuse Links. Safeloc offers significant savings in volume and cost as well as a reduction in fitting time, and power loss. These Fuse Holders incorporate a unique slide/snap action Carrier which eliminates the need for Fuse Carrier contacts. This provides positive, stress free fitting of the Fuse Link and locks the Fuse Link in position ensuring safe insertion and withdrawal from the Base. Safeloc Fuse Holders provide a safe and easy method of protecting a wide range of electrical equipment such as lighting, heating, motor and control circuits.



## FUSE HOLDERS: MODULAR TYPES

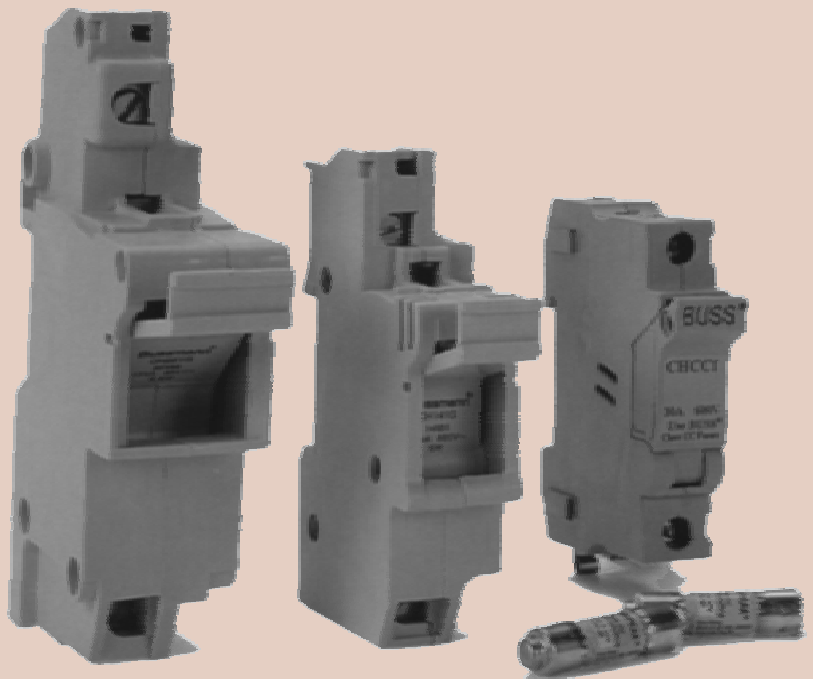
This design of Fuse Holder is a definite spin-off from the miniature circuit breaker (mcb) frame design. The need for a comparable Fuse package, similar in overall dimensions to the MCB was needed, but with improved performance. Modular Fuse Holders accommodate Cylindrical type Fuse Links, and therefore global acceptability can be achieved using the one 10 x 38mm design incorporating Fuse Link ratings 0.05 - 32 amps. The 10 x 38mm designs are manufactured to European IEC, North American UL, and Canadian CSA Standards.

Modular Fuse Holders are the most versatile of all Fuse Holders available, offering Fuse protection in three popular sizes up to a maximum Fuse Link rating of 125 amps:

Size 10 x 38mm Accommodating  
Fuse Links 0.05 - 32 amps

Size 14 x 51mm Accommodating  
Fuse Links 2-50 amps

Size 22 x 58mm Accommodating  
Fuse Links 16 - 125 amps



Features of the Bussmann 10 x 38mm Modular Fuse Holder:

Dovetail design provides maximum flexibility in the assembly of multi - poles.

Touchsafe design IP20 - No exposed metal parts.

Din rail mounted ( 35mm )

Optional open Fuse indication lights.

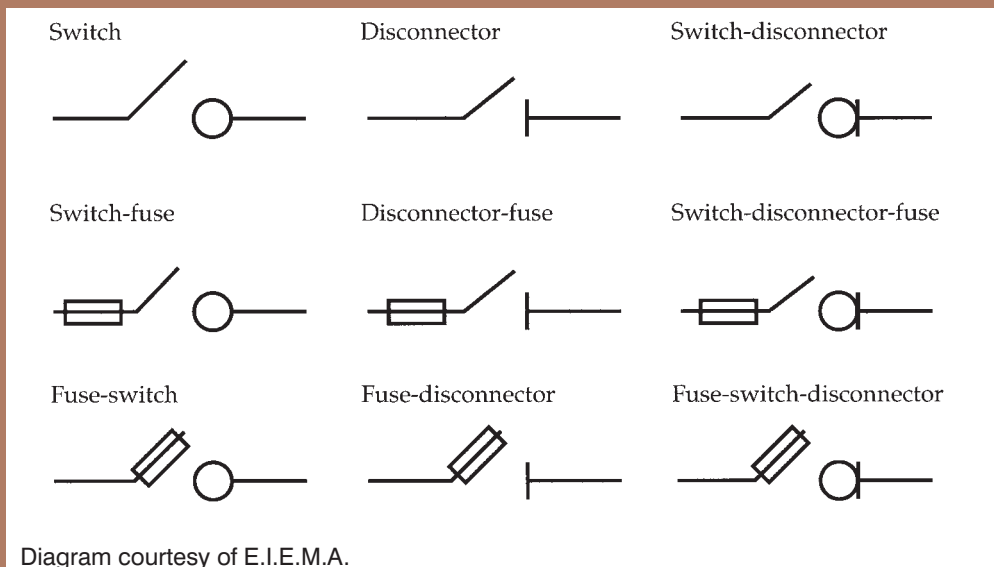
Available in single pole or multi-pole configurations.

Bussmann Modular Fuse Holders are excellent for switchboards, control panels, protection of small motors, transformer protection, and many more industrial applications.

## LOW VOLTAGE SWITCH AND FUSEGEAR

A definitive description is difficult as both Switch and Fusegear products are perceived as being part of the same family of equipment. One distinction that can be made is that finished Switchgear cubicles tend to be custom designed and therefore can require heavy investment in both financial and human resource. Fusegear is usually described as a range of stand alone enclosed Fuse components which can be installed as individual units or stacked into a modular distribution system. Switch / Fusegear covers quite a variety of devices, all intended to carry out the function of controlling and protecting electrical circuits so that the electricity supply can be safely utilised.

The following symbols have been agreed internationally and are based on IEC 617 - 7.



Whilst at first sight these definitions appear complex and confusing, each device has its own specific features and functions, and there is logic to the terminology. The use of one or more of these terms in the description of a device defines and identifies the function of the device. In addition the position of the word 'Fuse' at the beginning of the description identifies that the Fuse forms part of the moving contact system. The word 'Fuse' at the end indicates a static Fuse. It is important to note that the definitions do not indicate whether the device is capable of being isolated at both ends of the Fuse. Where this is not the case adequate marking of the line / load terminals is essential for safe use.

Following the introduction of the 16th Edition of the IEE (Institute of Electrical Engineers) Regulations for Electrical Installations, which is now BS 7671: 1995, the subject of isolation has been prominent and the Industry Standard now calls up the requirement of BS 60947 - 3 for all disconnects (isolators).

## SWITCH FUSE OR FUSE SWITCH?

Quite simply, a Switch Fuse is a combination of Isolator Switch (usually rotary type) and Fuse or Fuses connected in series to make a composite device. A Fuse Switch, on the other hand, is when the Fuse or Fuses are mounted on the moving contact system of a specially designed switch. The position of the word 'Fuse' in the description is important; at the beginning of the description it identifies that the fuse forms part of the moving contact system. The word 'Fuse' at the end indicates a static fuse. Without confusing the issue, what then is a Switch Isolator? Basically view the Switch Isolator as a simple switch that is used to isolate a circuit after the load has been turned off. It is not to be used to isolate a circuit under load.

The Bussmann Compact range of Switch Fuse tends to be a stand alone unit housed in an enclosure, usually sheet steel. And is a tried and tested approach to distribution networks, switching, isolating and for protecting individual loads. A Fuse Switch is commonly found being used on urban secondary distribution networks up to 22Kv. A Fuse Switch is generally regarded as safer because the circuit cannot be in the live state when a fuse is being replaced and, unlike a Switch Fuse it cannot be closed on a fault between the switch and the fuse. Although selection and specification really depend upon the application, either device should have the ability to carry rated current either continuously or for a period of eight hours under defined conditions. Often the question is raised in respect of the neutral. Where the neutral is reliably earthed it is accepted that the neutral need not be switched except in defined circumstances ie. Incoming switch in the consumer unit, even though the Wiring Regulations (BS7671) class the neutral as a live conductor. For applications where the neutral should be switched simultaneously with the phase(s) or alternatively may be arranged to make before and break after the phase(s).

The descriptive terminology used for many years has now been changed. The European norm (BSEN 60947) now refers to the simple switch as a switch disconnecter. Basically under IEC 617-7 the terms 'switch' 'disconnecter' and 'fuse' are used together in such a way as to describe the actual function of the device. A good reference to the new terminology can be found in diagrammatic format on the previous page, everything from the accepted symbol for the simple switch right up to the more complex fuse switch disconnecter.

Given that you don't want unauthorised persons tampering with the supply, either turning it on or off, or actually gaining access to live circuits, look for enclosures that offer features like lockable handles locking in the ON or OFF position.

Switch Fuses and Fuse Switches are still the most reliable and easy to install approach, offering the busy engineer a high level of quality and appropriate test approvals.

## COMPACT SWITCHFUSES AND SWITCH ISOLATORS

Bussmann offers a versatile range of reliable and easy to install surface/wall mounting Compact Switchfuse and Switch Isolator units for distribution and motor circuit protection applications. Designed and tested in accordance with the requirements of BS.5419:1977 and IEC947- 3:1990. The Switches are ASTA certified up to 50 kA at 415V ac with the appropriate BS88 Fuse Link.

### Switchfuses:

20, 32, 63, and 100 amp units at 415 volts ac Single Pole & Neutral, Triple Pole & Neutral.

Switchfuse complies with the definitions in IEC947- 3 for 'Switch Disconnecter - Fuse'

### Switch Isolators:

20, 32, 63, and 125 amp units at 415 volts ac Triple Pole, Triple Pole & Neutral.

Switch Isolator complies with the definitions in IEC947- 3 for 'Switch Disconnecter'

Additional ratings available in British designs are: 200, 315, 400, and 630 amp. These Switch Disconnects can be specified as enclosed or un-enclosed units.

## FUSE COMBINATION SWITCHES

The Bussmann range of Fuse Combination Switches is designed and tested in accordance with BS EN 60947- 3, 1992 complying with the definitions for 'Fuse Switch Disconnecter'

A range of enclosed triple pole and neutral, and un-enclosed triple pole units are available with ratings from 63 to 630 amps.

Within Europe, harmonisation of the electrical industry is being achieved by CENELEC (Comite Européen de Normalisation Electrotechnique) which produces, whenever possible, European Standards based on the work of the IEC. Adoption of the European Standard within the EEC is mandatory. In the UK such standards are further endorsed with the additional BS prefix, for example BS EN ---

## HRC DISTRIBUTION FUSE BOARDS

Camaster Distribution Fuseboards feature 3 phase Fuse Banks, Neutral Bar and Earth Bar available in 32 amps, 63 amps, 4 to 12 outgoing ways and 100 amps, 4 to 8 outgoing ways. Fully insulated and shrouded busbars and Fuse Holder base terminals provide complete personnel protection against direct contact of live parts. The range is complemented with the innovative 32 amp Distribution Fuseboard packaged into the traditional 20 amp dimensions offering the end user economies in size and cost. Camaster Distribution Fuseboards accommodate bolted tag Fuse Links to BS88:Part 1 and 2, 1988. The Fuseboards fully comply with the requirements of BS5486:Part11, 1989 and can be ordered as factory built assemblies in single pole and neutral or triple pole and neutral. The degree of enclosure protection is IP42, however an IP55 level of protection is also available.



Safeloc Distribution Fuseboards are available in 32 amp and 63 amp outgoing ways utilising the Safeloc Fuse Banks which accommodate offset blade tag Fuse Links to BS 88: Part 6; 1988. The Fuseboards fully comply with the requirements of BS5486: Part 11: 1989 with a protection standard of IP42 to BS EN 60947-1. They are also available to higher specification of IP55. Single pole and neutral or triple pole and neutral Fuseboards can be ordered as factory built assemblies. The fully insulated busbars and shielded Fuse Holder bases contacts provide complete internal personnel protection against direct contact electric shock.

Camloc is a unique Distribution Fuseboard System, comprising a family of innovative components. The main Pan Assembly is fitted with either an integral on-load isolator or direct connection facility. The system has a fully shrouded, centrally mounted busbar arrangement fully rated at 200 amps. This is designed for plug in Fuse Holders which take the offset blade tag Fuse Links to BS88:Part 6, 1988. A range of accessories complete the package. The Fuse Holders rated at 16, 32, and 63 amp are of uniform size. Mixed rating capability can therefore be achieved. The Fuse Holders have special Z stab connectors so that they can be plugged in directly onto the central busbar. The Camloc Distribution Fuseboard System has all the flexibility of the miniature circuit Distribution Board but with an increased breaking capacity of 50 kA.

## **NH (HRC-LV) FUSE SWITCH DISCONNECTOR** (for fuse links sizes: C00, 00, 1, 2 and 3)

The NH Fuse Switch Disconnecter (part reference LBS) is completely insulated and touch protected. It consists of thermally stable self extinguishing synthetic material. There are no metal parts except the current carrying contact system. The contact system is torsion resistant, the metal parts of the fuse switch disconnecter are corrosion resistant, the copper contacts are either silver or nickel galvanised with stainless steel springs. The requirements exceed those demanded in applicable standards (IEC, VDE, ÖVE etc).

The protection cover, produced as one-piece or two-piece, depending on size, is snapped into the switch base.

Upper as well as lower touch protection cover can be sealed and protected against unauthorised opening. (Size 00 to size 2).

The switch door and the hinges consist of impact resistant synthetic material. In the ON position a flexible lock arrests the retractable switch door. In the OFF position the switch door can be removed to change the fuse links. Large windows placed in the switch door allow a view of the label and indicator of the fuse links. The windows are equipped with pierceable testing holes to check the switching condition of the fuse links.

The NH Fuse Switch Disconnecter is approved to the following standards: IEC408; VDE0660; ÖVE; SN40; IEC947; SEV1089; KEMA3104-90 - 3106-90.





## NH VERTICAL FUSE SWITCH DISCONNECTOR.

A Low Voltage Vertical Load Break Fuse Switch Disconnecter to take NH style fuse links in size 00 Acc. DIN43620/1 and IEC269-2-1.

### Assembly.

Switch Base: is isolated and touch protected (degree of protection IP2Lx).

Base Body: consists of glass-fibre, which is strengthened thermally, has high-stability with self-extinguishing properties. There are no metal parts except the current carrying contact system.

Contact System: the one-piece contact system with stainless steel springs, is corrosion resistant as well as torsion resistant. The copper contacts are nickel galvanised or, on special order, silver coated.

Protection Cover: the one-piece protection cover consists of a glass fibre strengthened, thermally high stable and self extinguishing thermoplastic, free of halogen. It is snapped into the base body and does not have to be removed for mounting.

Switch Door: in ON position a flexible lock arrests the attachable door of the vertical fuse switch.

In OFF position the door can be removed to change the fuse links.

Label and indicator of the fuse links can be seen through large windows placed in the switch door.

The shiftable windows are equipped with testing holes to check switching condition of the fuse links or voltage. After withdrawing the test leads the front degree of protection IP3Lx is again re-established.

The switch door can be sealed in closed position; the switch door can be parked (parking position). These approved to IEC947-3.

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## ASSURANCE:

Since the initial conception of the idea, the HRC Fuse Link has undergone considerable evolution and sophistication. The device, originally designed simply to isolate circuits and to protect equipment and personnel against the dangers of high overloads, today finds an application in almost every electrical installation, from television to space research, from plug-top to nuclear power station. This is a continuous process and there is no doubt that in the years to come there will be further improvements in the design and manufacture of Fuse and Fusegear equipment, so keeping in step with the ever-changing requirements for circuit protection.

## ACKNOWLEDGEMENTS

The application of Fuses is detailed in the book "Electric Fuses" written by A Wright and P G Newbery. Copies can be obtained from The Institute of Electrical Engineers or alternatively from Bussmann. Wright and Newbery's classic guide to the world of electric Fuses has now been substantially revised and remains the comprehensive reference work on the subject. We also acknowledge the work of Mr D. Whitaker for writing and compiling this training manual.

Additional publications: Guide to Fuse Link Application and Guide to Switch & Fusegear Devices, both available from EIEMA (Electrical Installation Equipment Manufacturers Association) or alternatively Bussmann.

The information contained in this publication is intended to introduce the reader to the basics of Fuse Technology and should not be used to assist in the design, construction or maintenance of any electrical installation. Bussmann's policy is one of continuing improvement, we reserve the right to supply Fuse Data/Catalogue information and Product which may differ from that described and illustrated in this publication.