FUTURE TRENDS IN LOW VOLTAGE FUSE SYSTEMS

P.G. Newbery
Hawker Fusegear Ltd.
Leicestershire, UK.

Summary

This paper outlines the advantages of fuse protection in low voltage distribution systems and covers the recent progress made in standardisation. Significant advances have been made in fuselink technology resulting in higher performance products in standard packages, or more compact fuselinks. The evolution of fuse systems must however include the associated fusegear and two examples are illustrated of recent innovations in fuseholders and fuse distribution boards by one manufacturer in the United Kingdom.

1. Introduction

Fuse protection has been used for over 100 years and is still widely used in high and low voltage applications, and for the protection of electronic circuits with miniature fuselinks. Recent developments in all these fields have been illustrated in this conference and the wide variety of papers from over 20 countries confirms that fuse protection is still evolving to meet the present and future needs of overcurrent protection. This paper will focus on fuses for low voltage industrial and commercial applications, and, in particular, for final distribution circuits.

2. Advantages of Fuse Protection

2.1 General

The following section highlights some of the main advantages of fuse protection in low voltage systems and takes into account the growth of other protective devices such as mcbs and mccbs.

2.2 Safe Operation and Safe Replacement

These two fundamental aspects of fuse operation are taken for granted and consequently often overlooked. First taking safe operation - when a cartridge fuselink operates, it does so quietly, and the by-products of arcing are safely enclosed within the fuse cartridge. The same cannot be said for mcbs and mccbs which can emit arc products and the position of the associated venting is not standardised which means they can only be replaced with identical products.

Turning to safe replacement - when a fuselink operates the reason for the fault has to be identified and corrected. A brand new fuselink is then inserted and the system is restored to its original state of security. When circuit breakers operate there is inherently some erosion of the contacts etc. Many of these breakers when tested to their "ultimate breaking capacity" are only capable of a limited number of operations and have to be replaced. The time taken to replace a fuselink is often quoted as a disadvantage. It is, however, insignificant compared with the fault diagnosis time, and that for corrective action.

2.3 High Breaking Capacity

The current and energy limitation provided by modern cartridge fuselinks gives them the ability to clear the highest of fault currents likely to arise in service. For example fuselinks used in North America are tested to 200kA to meet fault levels that can occur, such as in high-rise buildings. This current and energy limitation can occur at much lower fault currents, for example 20A industrial fuselinks can become current limiting at a current as low as 100A. Magnetic and thermal stresses in the faulty circuit are thus dramatically reduced, even at these low fault currents, restricting the damage at the seat of the fault and thus protecting sensitive circuit components.

This high breaking capacity means that detailed fault level calculations with fuse protected systems are unnecessary, and, in addition, allows for strengthening of the system at some future date.

2.4 Standardisation

Significant progress has been made in the past decade on the international standardisation of fuse characteristics. This has been brought about by the common requirement of compliance with international wiring regulations. A series of points or gates have been established through which all manufacturers characteristics should lie. These characteristics are referred to as gG - full range breaking capacity (g) and general application (G). This means that similar performance is achieved with any gG fuselink . The mcb also has non-adjustable characteristics but on the other hand, there are up to four types for various applications. A further feature of fuse characteristics is that they are relatively insensitive to changes in ambient temperature for example when placed inside an enclosure. Ambient temperature can have a significant effect, however, on the tripping current of breakers.

The gG characteristics do not cover North American practice, but standardisation work is currently addressing this aspect.

2.5 Discriminiation

The gG fuselinks give a discrimination ratio of 1.6:1 (two steps in the R10 series). In circuit breaker protected systems, a ratio of up to 4:1 in current rating is required and a detailed study of characteristics is required.

A fuselink is often used to give back-up protection for circuit breakers and this is an area where further standardised information is required on the withstand capabilities of modern breakers to co-ordinate with fuse characteristics.

2.6 Motor Circuit Protection

Recent papers show how the fuselink is the only effective means of giving Type 2 co-ordination of modern motor starters to IEC 947-4-1. There are special motor circuit fuselinks for example gM, aM or dual element which take account of the short time nature of the motor starting surge to give compact fuselinks. It should however be stressed that a large number of applications are covered with the appropriate selection of standard gG fuselinks.

Current work is being undertaken in the IEC low voltage standardisation committee which should enable the setting of universal total I^2t limits for gG fuselinks. These will be established on the requirements for protecting sensitive modern motor starters. This should in turn simplify fuse selection for the protection of motor circuits and obviate the undesirable practice of selective combination tests.

3. <u>Final Distribution Circuits</u>

3.1 General

Considerable advances have been made in fuselink performance for example:-

- In Europe 660V performance is now available in packages that were previously rated at 500V or less.

- In the United Kingdom there has been the consolidation of compact blade type fuselinks and associated fully shrouded fuseholders.

- In mainland Europe there has been the development of the compact size 000 or C00 fuselinks for ratings up to 100A.

- In North America there is the use of very compact class T fuselinks for non-motor circuit applications and a trend towards time delay fuselinks in the class J package.

To fully exploit the advantages of high breaking capacity fuselinks, consideration must also be given to the associated fusegear in which they are used and consequently the fuse system. In addition to performance requirements, other important aspects have to be addressed such as simplicity of application, ease of installation, aesthetics, availability, safety and of course cost competitiveness with other protection systems.

An IEC Working Group has been examining the feasibility of a unified system of fuses. The feasibility aspect must be stressed rather than any definitive proposals. In a similar way to the universal plug and socket system, such a task is fraught with dimensional rather than technical constraints, particularly with regard to the large and longstanding replacement need for existing systems. The Working Group concluded that in the short term it was not feasible to have a universal fuse system and the Working Group was redirected to consider a list of attributes for a future system so products can evolve with enhanced features.

This list of attributes includes a number of technical requirements such as defined characteristics and properties of materials. In addition safety and constructional features have been identified and include:-

* Electrical shock protection.

* Contact pressure independant of users skill.

* Good contact design including terminal connections.

* Fuselink easy to replace.

* Fusehandle an integral part of the fuse.

* Non interchangeable with different levels of rated current.

* Indicator, if required, to be a separate reliable unit.

* Compact physical size.

* Rail mounting option.

* Modular design.

These attributes have been addressed by one manufacturer in the United Kingdom in the development of innovative fuseholders to take standard bolted fuselinks and of a new generation of fuse distribution boards.

3.2 New Fuseholder

Safety requirements are becoming increasingly prevalent in both national and international legislation for installation equipment and the requirement for the protection against electric shock is an important feature for new designs of fuseholders. British fuseholders have traditionally been well shrouded and have an IP-2X degree of protection for all three states of installation i.e.

- when the complete fuse is properly mounted.
- during the replacement of the fuselink
- when the fuse carrier is removed

In the new fuseholder, particular attention has been given to these aspects and includes captive hinged internal terminal shields which overcome the nuisance factor on many existing designs where the shields are not captive and may get lost during installation.

A problem worldwide in electrical power components is the provision of an effective hand operated system to give ease of insertion and particularly withdrawal against the necessary high contact pressures. This is a problem with conventional British fuseholders and foreign fuse-bases where a compromise has to be made on contact pressure. The new fuseholder overcomes this problem with a simple cam and lever action giving a mechanical advantage to remove the fuse carrier with a low application of force whilst maintaining a high contact pressure. This cam action enables safe withdrawal and insertion of the fuse carrier which is independent of the users skill. It also enables the design to have high contact pressures to give enhanced reliability and performance.

The main requirement regarding cable connection for British Standard fuseholders is to fit the stripped cable end directly into the fuseholder terminals, and is generally referred to as "front connected". Normally these fuseholders have tunnel type terminals machined or extruded in brass with a grub screw for fastening. Special measures are required to give effective clamping for all sizes of cable for a reliable connection without damaging the conductors. The new fuseholder has a saddle type connection and the main electrical contact is made directly onto the high conductivity top plate (Fig. 1). This in turn is an integral part of the double sided fuse base contacts.

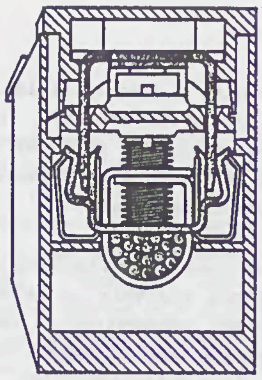


Fig. 1 Saddle Type Terminal

The use of stainless steel saddles and hardened terminal screws coupled with profiling of the cable contact enables high tightening torques to be achieved. This is particularly important in applications where undersized cables are inadvertently used which could result in excessive temperatures in this terminal zone. The design permits the saddle to "breathe" during normal expansion and contraction of cables during normal load variations, maintaining a constant clamping pressure. This obviates the need for re-tightening as is often required in conventional arrangements. In addition to the requirements of IEC 269 the terminals have been tested to the requirements of the new Low Voltage Switchgear and Controlgear Standard IEC 947-Part 1, which require tests for:-

Mechanical strength
Damage and accidental loosening of cable
Pull out force

The terminal designs gave values well in excess of these modern requirements

Fuseholders generally have the cable clamping screws firmly screwed home, and they have to be released (often forcibly) before the cable can be inserted. The new fuseholder has these screws "backed-out" leaving the cable aperture open, thus saving installation time.

The cam action well covers the attribute of "simple and swift facility for safe fuselink replacement" and in addition, hinged captive screws are a feature of the fuse carrier, particularly important for the busy electrician (Fig. 2). Often the fuselink

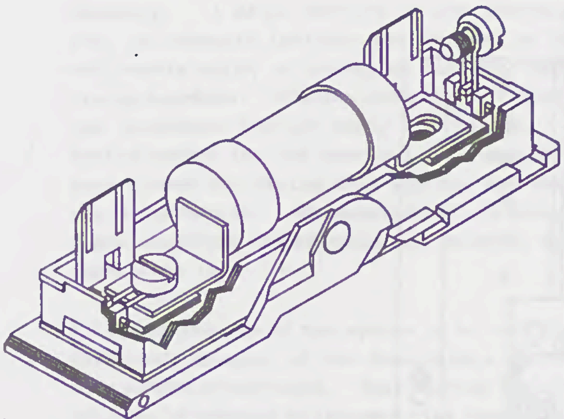


Fig. 2 Hinged Captive Screws

has to be replaced in difficult situations and in traditional products it is easy to loose the screw and they are often difficult to locate.

In the British system, the fuse carrier is an integral part of the fuse; this is an advantage over the "DIN system" with a replaceable handle which may be lost and unsafe improvisation may be attempted.

Non-interchangeability with different levels of rated current at 20, 32 and 63A and beyond, are achieved in British fuseholders through dimensional constraints on the fuselinks. The bulk of the market requirement for final distribution circuits in industrial and commerical application is up to 63A. The new fuseholder is, however, available up to 100A, using modern compact bolted fuselinks. For higher current ratings the modern cost effective approach is to use fuse combination switches, switch fuses or fuse switches.

An optional optical indicator is available as an accessory to be fitted into the fuse carrier meeting another of the desirable attributes. This means the fuselink is not complicated with the provision of an indicator, sometimes of questionable reliability.

Rail mounting is a feature of modern equipment and the new fuseholder offers DIN rail mounting - the modern approach - and bolted panel mounting, the conventional approach, as standard thus obviating the need for stocking the individual types. The DIN rail mounting facility for each of the sizes are designed to have equal height and depth above the DIN rail, thus giving a functional and aesthetic appeal to installations of mixed ratings.

There is a requirement for the electrical connections to be made through back studs for example, on surface panel mounted applications for control circuits on distriution switchgear. The new fuseholder can be readily converted to a single or double back stud version with a conversion kit and the aid of a screwdriver. Traditional products cannot be converted and are factory assembled. Availability of these back stud versions with inherent lower demand is, therefore, greatly enhanced and stockholding can be minimised at appropriate points down the distribution chain.

3.3 New Distribution Fuseboard

In the United Kingdom up to the 1970's fuseboards with semi-enclosed or rewireable fuses were popular in final distribution circuits. The large potential market to supersede these old technology devices has largely been taken by mcb boards, mainly due to their ease of installation and competitiveness. Similar progress has been made by mcbs throughout the world in applications where their breaking capacity meet the installation requirements.

The features of modern mcb boards were examined and a fuseboard developed incorporating the desirable features of such a system and giving the added advantages afforded by modern cartridge fuses. A survey showed that the vast majority of requirements are covered by fuse ratings of 63A or less and of these the bulk are below 32A

It was decided to use fuselinks to BS88 part 6 with blade contacts, removing the need for a special tool (screwdriver) to put the fuselinks into the fuse carrier. The desirable features of the fuseholder with the cam action was incorporated with a common modular envelope size for the 32 and 63A ratings. These include non-interchangeable features in the fuse-base and carrier so that the 32A fuse carrier cannot be "over-fused" and the 63A fuse carrier will not fit into the 32A fusebase. This modular design overcomes one of the problems of British fuseboards in that if only one outgoing circuit requires a 63A size fuselink then a multiway board with 63A fuses has to be used in all circuits.

The new fuseboard takes a similar form to the mcb board and for ease of installation a pan assembly is used incorporating protected vertical 200A bus-bars (Fig. 3). The appropriate fuseholders for a specific application are assembled onto the pan assembly. The fuseholders are fitted with stab connectors at the bus-bar end which are orientated for the phases (Fig. 4) and simply docked into the rising bus-bars and secured into position by means of a captive screw on the pan

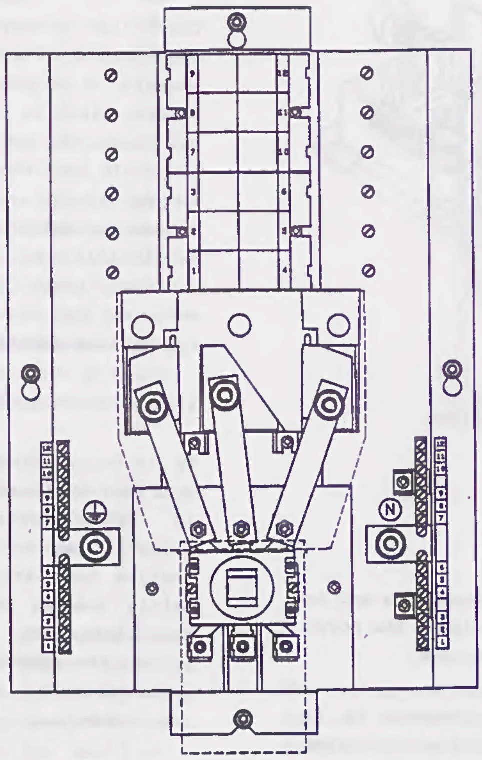


Fig. 3 Pan Assembly with Integral Isolator

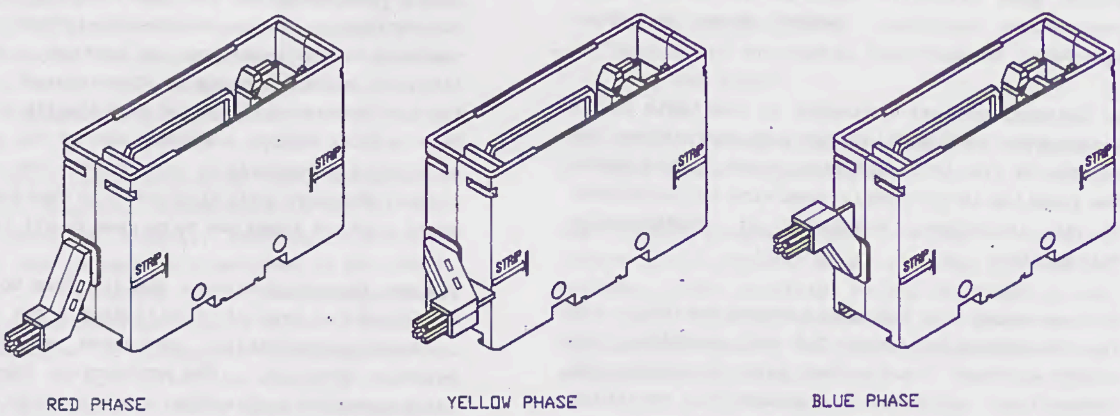


Fig. 4 Stab Connectors

assembly. A major feature of the fuseboard is that an integral isolator can be used as in the mcb boards which is connected directly onto the rising bus-bars. The pan assembly is fitted into the enclosure and is ready for wiring. The configuration for the vertical arrangement gives good access for wiring in a similar and familiar way to mcb boards. The addition of the Escutcheon plate completes the assembly and gives an elegant appearance (Fig. 5).

A further feature of the system is to have two and three pole ganging of the fuseholders by the use of standard accessories. This enables the correct poles to be removed at the same time thus providing improved safety to the isolation of 2 and 3 pole circuits. Prominent circuit identification labels are also provided on the fuse carrier and bus-bar covers.

The new fuseboard forms part of a range of fusegear, bus-bar chambers, fuse combination switches, isolators etc. to give an integrated system with all the technical advantages of fuse protection in a modern and economic way with an emphasis on ease of installation.

4. Conclusions

The longstanding advantages, versatility, simplicity of selection and well proven experience of high breaking capacity fuselinks, coupled with the evolution of new compact products, are strong factors for the longevity of fuse protection in final distribution circuits.

These desirable features of the fuselink cannot be fully exploited without considering its integration into the associated fusegear to give a complete system. Innovations in fusegear, such as fuseholders and distribution boards as illustrated in this paper, are of paramount importance. Advances in ease of installation, availability, aesthetics, safety and cost effectiveness can be achieved to enable fuse protection to play a dominant role in protecting electrical circuits in the future.

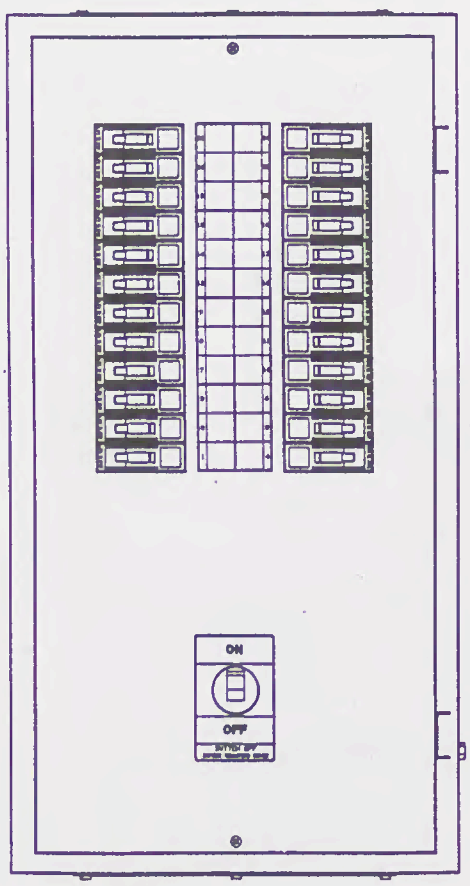


Fig. 5 New Distribution Fuseboard (door removed)

OVERLOAD TESTS FOR FUSES IN ROLLING-MILLS

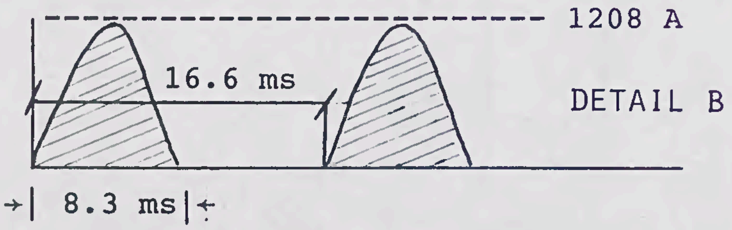
PAPER TO BE PRESENTED AT THE ICEFA 91 - CONFERENCE

SESSION 1

CORRIGENDUM:

A) FIGURE 1 - REPLACE DETAIL B

FROM:



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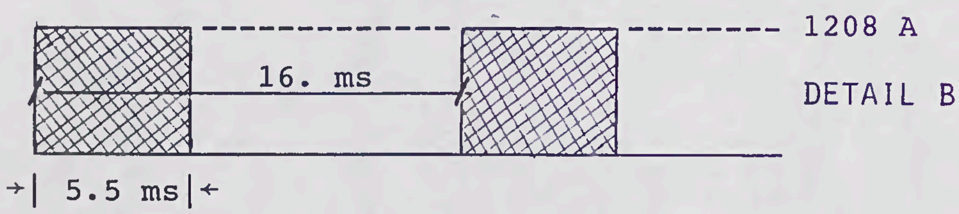

B) FIGURE 2 - REPLACE IN THE FIGURE THE SYMBOL  BY 

C) FIGURE 7 - REPLACE "T = 186S" BY "T = 180S"

D) ITEM 4 - PAGE 5 - LEFT COLUMN:

D.1) 1ST LINE:
REPLACE "TEXT" BY "TEST"

D.2) 3RD LINE AFTER THE TITLE OF FIGURE 7
REPLACE "27.6×10^6" BY "26.5×10^7"

D.3) 7TH LINE AFTER THE TITLE OF FIGURE 7
REPLACE "27×10^6" BY "26.5×10^7"

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