PERFORMANCE CRITERIA FOR COMPACT INDUSTRIAL FUSELINKS

by H W Turner, C Turner and D J A Williams

Summary

The International Electrotechnical Commission are seeking to harmonise a type of low-voltage, high breaking-capacity fuse which is suitable for use world-wide as a normal standard preferred item. A compact industrial fuse system with rated currents up to 125 A has been developed in the United Kingdom which achieves the criteria proposed by the IEC and has proved its effectiveness in practical use in a large number of industrial installations. Limitation of the rated voltage to 415 V has allowed significant reductions in power dissipation and size. This system is a most suitable choice for international harmonisation as the preferred system for the harmonised system voltage of 230/400 volts.

1. Introduction

During the last quarter century there have been many attempts to secure an internationally harmonised system of low-voltage fuses. The idea has many theoretical attractions. A manufacturer of equipment could make provision for the fuses within that equipment without having to make special provision for the exchange of fuse-bases to accommodate the various designs which have become established in different countries during this century. There are types which are bolted into position, others with blade contacts, ferrule contacts, and in medium and low current ratings there are types which are placed within the fuse holder and secured in position by a screw-down cap, and another type with a fuselink constructed like a plug with two contact pins between which the enclosed fuse element is connected. The latter is inserted into a fuse-base in the form of a socket. How much simpler it would be if there was only one design for each current and voltage rating. The equipment designer could provide for it in the knowledge that anywhere in the world there would be an exact replacement readily obtainable. The replacement would also be certified to the IEC standard and have identical characteristics to the item being replaced, giving no problems with respect to discrimination etc. So goes the theoretical argument.

In practice the aim of harmonisation is not so easy to achieve as would appear from the theoretical argument. There are many practical difficulties.

Billions of fuses are already installed in apparatus throughout the world and require replacement fuselinks for "Blown" fuses. Enthusiasm in a given country for a harmonised system rapidly dies if the fuselinks do not fit in the available fuse-bases with the same degree of protection. A completely new harmonised system is therefore universally unpopular because it is seen everywhere as just an additional system, which would need to have exceptional economical and technical advantages before its use would even be considered.

It appears therefore that any International harmonisation needs to be based on existing systems. These are continuously being improved by normal technical evolutionary development, and IEC SC32B and its working groups are constantly assessing the new types as they become established in use, with a view to identifying a type or types most suitable as preferred designs in any future harmonisation, reducing proliferation and ensuring good reproducible performance.

In spite of the practical difficulties there has been considerable progress in the last few years toward the achievement of these aims, particularly in achieving common characteristics and performance standards. These achievements are summarised below together with details of the schemes being proposed for the "Neutral" evaluation of the various available types, and an examples of the application of the proposed evaluation criteria which identifies the British compact industrial fuselink as the most suitable for harmonisation within its range.

2. Progress to Date

The process of harmonisation has been considerably advanced in recent years, as is evidenced in the latest edition of IEC 269 "Low-voltage fuses", every part of which has been or is being revised in accordance with these aims. IEC 269-1 "General Requirements" and IEC 269-2 "Supplementary requirements for fuses for use by authorised persons (fuses mainly for industrial application)" have both been published and incorporated in national standards.

It was early realised that before any thought of dimensional standardisation could be attempted, it was necessary to proceed towards standardisation of characteristics and performance. A survey carried out on behalf of IEC 32B/WG8 at the commencement of this work revealed that at that time the fuses in use throughout the world differed by as much as 5 to 1 in certain characteristics. It was appreciated that although special characteristics might be needed for certain specialised applications, the bulk of the applications of fuselinks were of a general purpose type where it was desirable to have similar characteristics when replacing a fuselink by one of similar dimensions and rating but of different manufacture. Designers of equipment specifying the use of "100 A general purpose fuse to IEC 269", for example, should also be able to get the same protection whatever the national system.

The achievement of 32B can be recognised in IEC 269-1 and IEC 269-2 where a general purpose fuse is defined within specified gates of time/current and I^2t which ensure discrimination between fuses of 1.6 to 1 in current rating. Fig 1 is an example of how this has been achieved for fuselinks to the British Standard BS 88, bur similar time/current zones are obtained if the values are taken from the German Standard, the French Standard, or any other National Standard complying with IEC 269-1 and IEC 269-2. More detail of the various national types complying with all sub-clauses of IEC 269-1 and IEC 269-2 is given in IEC 269-2-1 "Supplementary requirements for fuses for use by authorised persons (fuses mainly for industrial application) Sections I to III" in which special features and dimensions of the various systems are recorded.

The only variation still existing is in fuses to the American national standards which are still classified according to a historical philosophy of fuse current rating, but at the same time of writing a special working group with a US convener is actively proceeding with supplementary requirements which should enable the American system to be added to IEC 269-2-1.

The other essential performance factors of the fuses are harmonised in IEC 269. In particular the breaking capacity of fuses up to a rated voltage of 660 V, mainly for industrial applications has been set at a minimum level of 50 kA. The criteria for establishing rated current and rated voltage, the temperature rise of contacts and terminals, interpretation of oscillograms, the number of samples to be tested, and the methods of test for power dissipation, protection against electric shock etc, are also all specified so as to ensure equal conditions of high safety and reliability in application to all systems which comply with the standard.

All new refinements to the standard under consideration are now applied universally to all systems included in IEC 269-2-1.

It could justifiably be claimed that the framework for world-wide harmonisation of low-voltage fuses on the basis of performance and characteristics has been attained in IEC 269-1 and IEC 269-2.

3. Future Tasks and Philosophy

Because of the evolutionary nature of fuse development and use, established systems need to be considered when selecting a particular fuse system as a preferred system for international harmonisation. However, because of the strength of local preference for each national system it is difficult to make an objective analysis on a world-wide basis. However, 32B/WG13 has been given the task of attempting this analysis, and has proposed that a "Neutral" system of assessment be used to compare the advantages and disadvantages of the different fuses within the national systems, to select the best fuse for harmonisation. The philosophy of the proposed system of comparison is outlined below and appears to be a very fair one. However, it must be said at the outset that early study shows that the result of any comparison is dependent upon the specific application of the fuse and the geographical area in which it is used. This is a major drawback to the philosophy, but it still produced interesting results, as is shown in Section 4 where the philosophy is applied to the British compact industrial fuselink compared with other types with similar performance.

The philosophy developed by IEC 23B/WG13 starts by assembling a list of desirable attributes of a Fuse System. This list is based on a collation of attributes obtained by the circulation of questionnaire to all the National Committees of the IEC asking them to proposed such desirable attributes. The list of attributes proposed is as follows:-

1 High breaking-capacity
2 Optimum number of ratings based on the R10 series
3 Good cycling withstand ability
4 Defined total I^2t values
5 Electrical shock protection
6 Fuse-link easy to replace
7 Low power dissipation
8 Compact physical size
9 Indicator system
10 Low cost
11 Non-"repairable" design
12 Contact pressure independent of user's skill
13 Non-interchangeable by voltage rating
14 Non-interchangeable by current rating
15 Safe replacement under load conditions
16 Provision for safe replacement without danger in a high prospective fault area
17 Non-interchangeable with other systems of different specification
18 Easy mounting of fuse holder
19 DIN rail mounting option
20 Modular design
21 Access for voltage tester
22 Fuse handle an integral part of the fuse
23 I_6 test duty
24 Defined dc rating.

These attributes are all desirable in a fuse system, and the intention is that a panel of experts would examine each competing system and allow a percentage "score" representing the extent to which the system achieves each parameter. However, before these "scores" can be used to provide the yardstick to measure the relative advantages of one system above any other, it is necessary to establish an agreed order of importance of the attributes. It is proposed that this be accomplished by considering each attribute in comparison one at a time with each of the others, and thus establish an order of importance, with the least important at the bottom of the list and the most important at the top. A simple tabular method has been devised for this purpose. The position in the table will then determine the weighting to be applied to each attribute. The scores will then each be multiplied by the appropriate rating and added up. The optimum system will be that with the highest total.

In theory this appears to be a completely "Neutral" system but in practice it is again fraught with difficulty. Even assuming that a panel of completely independent experts could be found, their assessment of relative importance experts could be found, their assessment of relative importance of the attributes would differ, depending on their country of origin. These differences of opinion are not chauvinistic but represent significant differences in the conventional wisdom in different countries. To take one example: the fuse indicator. In some European countries it is usual to fit an indicator to each fuse-link to identify a fuse which has blown. It is generally accepted by the users in those countries that this feature is of significant value, and that its advantages outweigh the disadvantage that indicators are not 100% reliable. In the UK this matter was studied at BSI many years ago, and the reverse conclusion was reached. Early fuselinks to BS 88 were fitted with such indicators, but in later editions of BS 88, they were removed because it was decided that the occasional maloperation of an indicator could have safety implications which far outweighed the convenience of the indication. Furthermore, the removal of the indicators reduces manufacturing cost, and thus gives a better score to item (10). Item (10) is of primary importance to many users.

The last point brings out a further difference in the voting of experts. In attempts already made to make this assessment in one country with a large number of respondents, it was found that if the respondents were divided into two groups, users and manufacturers, there was good consistency in the opinions within each group, but the conclusions of each group were very different.

Finally there is the question of establishing what basis we should establish for the ultimate use of the fuse system. A lot of the views which have been expressed in these discussions have tended to seek a fuse system which would be usable in every possible application up to 690 volt systems. Item (24) suggests that the same system should also be usable on dc, whereas the number of dc installations and the number of 660 volt installations is small compared with ac installations up to 415 volts. A "universal" fuse could be regarded as over-engineered, and the inefficient compared with a fuse designed to be restricted to the lower ac voltage used in the majority of applications. The latter fuse could contain the same electrical performance at the lower voltage within smaller dimensions, saving material cost, and more importantly saving expensive space. The lower voltage rating enables a fuse to be made with a lower power loss, which reduces the heat dissipated within the enclosure, and also saves energy - an environmental bonus when we consider the enormous number of current-carrying fuses in service.

Thus we see that there is a philosophical basis which colours the judgement in assessing the relative merits of different fuse systems, and that it is unlikely that any system would have over-riding superiority above all others. However it is clear that in restricted circumstances one type can be superior, as we can illustrate with the British compact industrial fuse.

4. Application of the Philisophy to the Compact Industrial Fuse

The basis of the argument is contained in the penultimate paragraph of the last section. This fuse meets all the requirements of IEC 269-2 and IEC 269-1, and thus it achieves all that is at present required of it in parameters (1), (2), (3), (4) and (5), and proposed improvements to these specifications. It is restricted to 415 volts ac use. This enables it to score high marks on all these items. Now the other attributes of the fuse can be compared with other fuses to the same standard. (6) Fuselink easy to replace: With their offset blade construction (see Fig 2) a blown fuse is easily lifted out and replaced. (7) Low power dissipation: due to the restriction to a maximum of 415 volts, these fuselinks have a significantly lower power dissipation than other BS 88 fuses with the same rated current. (8) Compact physical size: this is a special feature of these fuses (see Fig 2). (10) Low cost: these fuses use less materials than other comparable types and also occupy less expensive space. There are thus significant cost savings. There is a further on-going cost saving in the reduced power dissipation. (11) Non-"repairable" design: Yes (12). Contact pressure independent of user's skill: Yes. (13) Non interchangeable by voltage rating: Yes, these fuselinks are of unique designs and of dimensions which provide non-interchangeability. (14) Non-interchangeability by current rating: Non-interchangeability is specified in four current bands with maxima at 20 A, 32 A, 63 A and 125 A. This has proved sufficient in wide experience of use of these fuses, and although the system is capable of additional keying features to give complete non-interchangeability, this was judged unnecessary. (15) safe replacement under load conditions: this is provided by attribute (22). (16) provision for safe replacement without danger in a high prospective fault area: It is arguable that replacement without isolation in such an area cannot be without hazard, although feature (22) reduces such hazard. (17) Non-interchangeable with other systems of different specification: Yes, this is a unique type of fuse. (18) Easy mounting of fuse holder: Yes (19).

DIN rail mounting option: Yes. (20) Modular design: Yes. (22) Fuse handle an integral part of the fuse: Yes. Two aspects are yet to be decided, ie: (21) Access for voltage tester, which could readily be provided, and (23) I_6 test duty which is not required in IEC 269 although experience with these fuses in practice indicates that there should be no difficulty in successfully passing any additional breaking capacity test in the specified range. We see that this system will score high marks on all these attributes, and therefore, whatever the order of importance assigned, it is sure to be outstanding in its assessment.

There were two attributes to which answers could not be provided: (9) Indicator system and (24) defined dc rating. However it was explained that the British national committee had decided that indicators should be separated from the fuselinks and thus (9) was a separate matter, and with respect to (24) these fuselinks are restricted to ac use.

It is seen therefore that a fuse system can have considerable advantages above other systems if restrictions are applied to its use. There is no hazard introduced, provided the fuses are non-interchangeable with other types. Such a case is illustrated above.

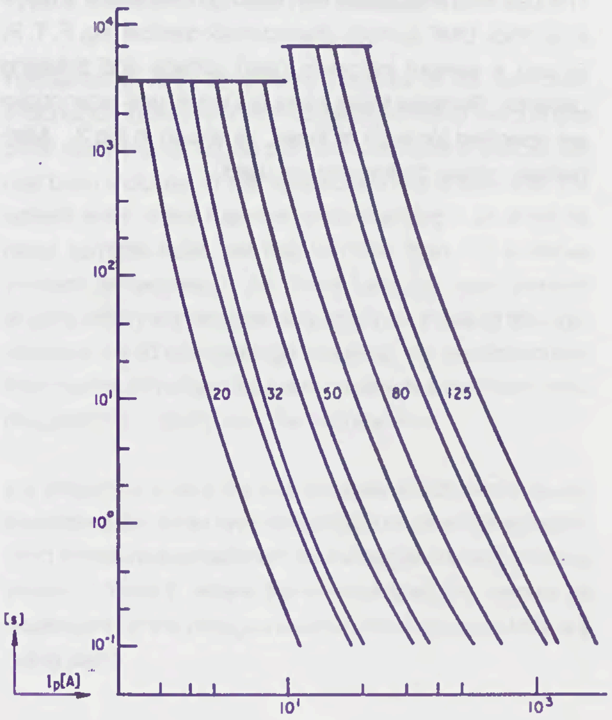

Fig.1 Time/examples of current characteristics specified in BS88

5. Conclusions

1 Considerable progress has been made in international harmonisation of requirements for performance and characteristics of fuselinks to IEC 269-1 and IEC 269-2.

2 Progress in harmonisation of dimensions is slow, due to a variety of practical considerations.

3 A new attempt is being made to assess existing systems on the basis of agreed desirable attributes of the fuse, to select the best preferred types and reduce proliferation.

4 Although a "Neutral" method of assessment has been devised, practical and theoretical difficulties exist in establishing an order of importance of the attributes.

5 In spite of the difficulties, it is clear that certain fuses will stand out from the others by their many advantages, provided their range of use is limited.

6 An example of such a fuse is the British compact industrial fuse.

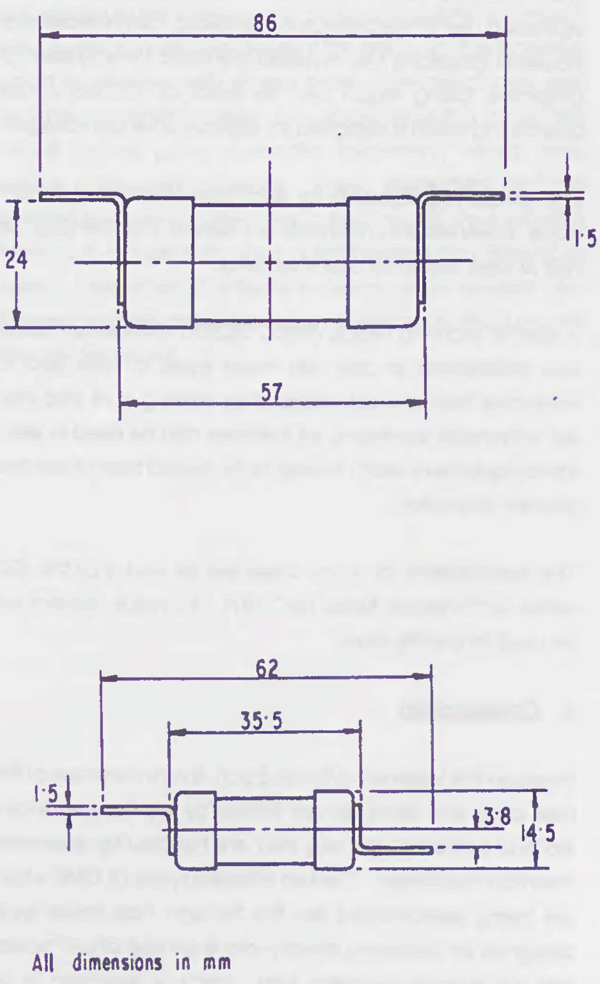

Fig.2 Comparison of the dimensions of the British compact industrial fuselink (below) with the conventional design of industrial fuselink (above)