

STATE OF THE ART OF IEC WORK WITH RESPECT TO FUSES

G.J. Deelman, G.R. Hoekema, B. Noordhuis

INTRODUCTION

In present-day electrical installations the current-limiting fuse forms an integral component, with an excellent price-performance ratio. As a result, the International Electrotechnical Commission pays wide and active attention to the various aspects of fuses. In this paper a review is given of the present situation of the IEC-standardization work concerning high-voltage fuses, low-voltage fuses and miniature fuses. For each group of these fuses, first will be summarized which standards are available now and which will be available shortly. Further will be reported on the main items which, in the near future, will probably lead to amendments to the standards. Thirdly, some information is given concerning the future activities of the relevant Working Groups.

COMMITTEES

Within the IEC, electrical fuses are considered by the Technical Committee 32. This TC has three Sub-Committees:

- SC 32A: High-voltage fuses
- SC 32B: Low-voltage fuses, and
- SC 32C: Miniature fuses.

Each SC is assisted by one or more Working Groups, composed of specialists from various countries.

Since 1980 the Technical Committee and its Sub-Committees have met three times: in Montreux, Tokyo, Brussels (32A and C) and Orlando (32B). For SC 32C the next meeting is scheduled in Prague in 1987. Usually the Working Groups meet twice a year.

HIGH-VOLTAGE FUSES

Available IEC Publications.

The main document for high-voltage fuses is IEC Publication 282. This standard consists of three parts:

- 282-1 (1985): Current limiting fuses.
Applies to all types of high-voltage current limiting fuses.
The third edition issued in 1985 is based on the edition of 1974 and a number of amendments issued since.
- 282-2 (1970): Expulsion and similar fuses.
Applies to high-voltage fuses in which the arc is extinguished by the expulsion effect of the gases produced by the arc.
The first edition of 1970 is still valid. In 1978 one amendment has been issued, dealing with revised requirements for the insulation level. On this subject no further work has been undertaken since by the IEC.
- 282-3 (1976): Determination of short-circuit power factor for testing current-limiting fuses and expulsion and similar fuses.
IEC sub-committee 32A decided that, in order to harmonize the determination of power factors in test laboratories, some guidance is required. This matter was not considered by other Technical Committees and as a consequence this document was issued under responsibility of SC 32A.

For specific applications of high-voltage fuses three more standards have been issued:

- 549 (1976) : High-voltage fuses for the external protection of shunt power capacitors.
The document gives some requirements with respect to the performance of fuses for this application and it specifies the type tests to be carried out.
- 644 (1979) : Specification for high-voltage fuse-links for motor circuit applications.
This standard mentions limits for the pre-arcing time-current characteristics. It also defines an overload factor K to which a fuse-link may repeatedly be subjected to without deterioration, due to the specific behaviour of high-voltage motors.
It further specifies withstand tests and it gives guidance with respect to proper selection of fuse-links.

G.J. Deelman - Electrical Engineering Consultant, Eindhoven, The Netherlands
G.R. Hoekema - KEMA, Arnhem, The Netherlands
B. Noordhuis - Holec, Hengelo, The Netherlands

- 787 (1983) : Application Guide for the selection of fuse-links of high-voltage fuses for transformer circuit applications.
Apart from some considerations of the fuse-link's time-current characteristics, the document elucidates on the co-ordination of fuse-links on the primary side of a transformer and the protective devices at the load side.
An amendment to this standard requires that the manufacturer of this type of fuse-links makes available recommendations for ratings of fuse-links for given kVA ratings of transformers.

Documents in final stage

In april 1986 a number of documents under the Six Months' Rule have been issued.

- 32A (Central Office) 80 deals with testing of strikers. An improved method of the operation tests is described.
These tests are intended to demonstrate that the action of the striker in every service situation is sufficiently rapid to ensure correct operations of striker tripped fuse-switch combinations.
(IEC Publication 420).
- 32A (CO) 81 proposes an amendment to the Application Guide for fuses in a three-phase isolated neutral or resonant earthed system. It refers to IEC Publication 265-1: "High-Voltage switches" for tests in earth fault conditions.
- 32A (CO) 82 concerns another addition to the Application Guide of Publication 282-1, namely to the paragraph where it is stated that fuse-links should be handled very carefully. If fuse-links during normal installation and service are subject to severe mechanical stresses, it should be verified that the fuse-links can withstand such stresses without damage or deterioration.
- 32A (CO) 83 gives an alternative test method for test duty 3:
Verification of operation with low overcurrents.
This method is particularly of interest if has to be proved that the fuse operates correctly if the pre-arcing time is longer than one hour. It permits the melting of all main fuse elements in a low-voltage circuit, before the high-voltage circuit is switched on.
This method is considered to be more severe than the existing method in which the switch-over has to take place during the arcing period.
- 32A (CO) 84 describes the waterproof test.
In IEC Publication 282-1 the list of special tests did not mention a test with respect to ingress of moisture for fuses intended to be used outdoors. As the dryness of the arc-quenching medium is an important condition for correct operation, this requirement had to be added.
- 32A (CO) 85 proposes an enhanced limit for the switching voltage for fuse-links with a low rated current, intended for protection of for example voltage transformers. For this kind of fuses the switching voltage may exceed the limits mentioned in the existing standard, however, only during less than 0.2 ms and up to a level which averages 1.4 times the actual limit.
- 32A (CO) 86 proposes the introduction of another appendix to the standard, giving technical information for test laboratories how to calculate circuit data in case the test method using two power factors is used for test duty 3.

Work under consideration

For preparation of draft documents Sub Committee 32A is assisted by one Working Group (WG 3) with a general scope.

At the moment the following items are under consideration:

Classification and designation of current-limiting fuse-links.

For high-voltage fuses two classes have been recognized in Publication 282-1, according to the range in which they can be used: "back-up" fuses and "general-purpose" fuses. Actually a third category of fuse-links is on the market: so called "full range" fuses. One of the Secretariat Documents prepared by WG 3 proposes to delete the known classes from the standard, however, to retain the terms in the Application Guide and to determine the fuses by their minimum breaking currents.

Simplification of the rules for homogeneous series of fuse-links.

At present these rules in Publication 282-1 are complex and lengthy. The aim of the Working Group is to reassess these rules and to combine the experience of manufacturers and testing authorities to arrive at simple, however, correct requirements.

Additional test duty for fuse-links which depend for their breaking performance on more than one arc quenching principle.

In the region of the so called take-over current, where one arc interruption system takes over from the other, additional tests are now under consideration.

For the near future IEC Sub Committee 32A may consider further standardization work on new developments such as SF₆ fuses and vacuum fuses. Another type of equipment for which no standard exists are the hybrid overcurrent protection system consisting of a fast explosion actuated zero-voltage disconnecter in parallel with a current-limiting fuse.

LOW-VOLTAGE FUSES

Available IEC-Publications:

For low-voltage fuses following IEC publications are available:

- 241 (1968) : Fuses for domestic and similar purposes.(Report)
Applies to non-interchangeable fuses of ceramic material with cartridge fuse-links for domestic and similar general purposes, with a rated voltage not exceeding 500 V and a rated current not exceeding 200 A, intended for the protection of wiring, provided that the prospective breaking current is within limits indicated in the specification.

The main document for low-voltage fuses is IEC publication 269, applying to:
Fuses intended for protecting power-frequency a.c. circuits of nominal voltages not exceeding 1000 V or d.c. circuits of nominal voltages not exceeding 1500 V.
This standard consists of several subsequent parts.

- 269-1 (1986): General requirements.
Establishes the characteristics of fuses or parts of fuses in such a way that they can be replaced by other fuses or parts thereof having the same characteristics provided that they are interchangeable as far as their dimensions are concerned.
- 269-2 (1986): Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application).
Specifies, in addition to Part 1, the characteristics of these fuses.
- 269-2A(1975): First supplement to Part 2: Appendix A(with amendment no. 1.)
Examples of standardized fuses for industrial application.
Contains data sheets for fuses with blade contacts, for fuses with bolted connections and fuses having cylindrical contact caps.
- 269-3 (1973): Supplementary requirements for fuses for domestic and similar applications.
(With amendment no. 1).
Specifies in addition to Part 1: rated voltages, maximum power losses, time/current characteristics and conventional currents, rated breaking capacities, markings, standard conditions for construction, and tests.
- 269-3A(1978): First supplement to Part 3: Appendix A.
Examples of standardized fuses for domestic and similar applications.
Contains data sheets for screw type fuses, cylindrical fuse-links and pin type fuses.
- 269-4 (1980): Supplementary requirements for fuse-links for the protection of semiconductor devices.
Establishes characteristics of semiconductor fuse-links in such a way that they can be replaced by other fuse-links having the same characteristics provided that their dimensions are identical. Defines standard conditions for operation in service, characteristics of fuses, markings, standard conditions for construction, and tests.

Documents in final stage

The revision of the Publications 269-2A, 269-3 and 269-3A is in the final stage.

- The new draft of Publication 269-2A is printed now and issued as publication 269-2-1.
- The revision of Publication 269-3 is also finished and issued as Publication 269-3-1987.
- The revision of Publication 269-3A is in the final stage of considering under the Six Months' Rule. At issue it will be numbered 269-3-1.

Work under consideration

IEC sub-committee 32B has set up a number of Working Groups:

WG 7 was formed to prepare supplementary requirements for semiconductor fuses.

WG 8 has the general task to prepare the documents concerning the various items for further discussion in the National Committees. Special work within WG 8 is done at present in three ad hoc groups.

- Ad hoc group "non-deterioration of contacts".
A German proposal for inclusion of non-deterioration tests in Publication 269-2-1 has been sent to the National Committees. The necessity of such tests for domestic fuses is also under consideration.
- Ad hoc group "IEC-UL characteristics".
This group has made a reconnaissance concerning the possibilities first and will in due course make proposals for integration of the UL time delay fuse class J in IEC Publication 269-1 and 269-2.
- Ad hoc group "co-ordination between contactors and fuses"
By the end of 1985 this group was set up to study the problems which arise concerning the co-ordination between contactors with their relays and fuses. These problems mainly occur due to the large spread of the operating time of the fuses in the region of 15-30 times the rated current of the contactors. In the second meeting of the group it was decided to collect more details of the contactors and relays involved.
This work has to be done in conjunction with WG2 of sub-committee 17B.

In february 1986 an administrative circular has been sent to all National Committees to notify the set up of Working Group 13 to study "The feasibility of achieving a world-wide low-voltage fuse". This WG has to define the problems, to consider the conditions and to propose ways for feasible solutions. Furthermore a time schedule has to be made. The WG has to report about its results at the next Sub-Committee meeting. The SC will decide then whether and how the work will be continued. In the meantime WG 13 started its work and has met two times.

MINIATURE FUSES

Available IEC-Publications

For miniature fuses there are two main IEC documents:
Publication 127 for the fuse-links and Publication 257 for the fuse-holders:

- 127 (1974) : Cartridge fuse-links for miniature fuses.
This publication relates to miniature fuse-links for the protection of electric appliances, electronic equipment and components thereof.
It establishes requirements and defines performances and tests.
The Publication contains four Standard Sheets:

No. 1	covers fuses	5	x 20 mm,	characteristics	F, HBC
No. 2	"	5	x 20 mm,	"	F, LBC
No. 3	"	5	x 20 mm,	"	T, LBC
No. 4	"	6.3	x 32 mm,	"	F, LBC

F stands for fast-acting, T for time-delay, HBC and LBC for high-breaking and low-breaking capacity respectively.

- 127A (1980): First Supplement: Colour Coding.
Gives requirements for colour coding as an additional identification for current ratings and the time-current characteristics.
- 127-3 (1984): Sub-miniature fuse-links.
This Publication also specifies four Standard Sheets:
Nos 1 and 2 for fuses with radial and axial leads respectively, having fast acting characteristics, mainly in accordance with UL.
Nos 3 and 4 for fuses with radial leads, characteristics F and T respectively, mainly in accordance with the IEC gates 1.5-2.1.
- 127-B (1985): Second supplement.
This supplement contains (among other matters) tables in the Standard Sheets which are provided with an extra column giving requirements for safe dissipation values.
- 257 (1968): Fuse holders for miniature cartridge fuse-links.
Applies to fuse-holders with a maximum rated current of 16 A and a maximum rated voltage of 1000 V a.c. and d.c.
In 1980 was added amendment no. 1, applying to a definition and requirements for accepted power of a fuse-holder.

It is envisaged to publish in the near future all documents related to miniature fuse-links and fuse-holders in one standard: IEC Publication 127, which will be subdivided in 7 parts, covering different parts and subjects of miniature fuses.

Documents in final Stage

Survey of recent Central Office documents, related to the main topics.

- 32C (CO) 39 (Mar. 1984): Maximum sustained dissipation values.
- 32C (CO) 42 (Dec. 1985): Standard Sheet 5, fuse-links 5 x 20 mm, Char. T, HBC.
- 32C (CO) 43 (Dec. 1985): Warning note regarding the use of miniature fuses.
- 32C (CO) 44 (Feb. 1986): Part 5: Quality assessment of miniature fuses.
- 32C (CO) 45 (Feb. 1986): Fuse-holders for miniature fuses.
- 32C (CO) 46 (Apr. 1986): Part 1: General requirements.
- 32C (CO) 47 (Apr. 1986): Part 2: Cartridge fuse-links for miniature fuses.
- 32C (CO) 49 (May 1986): Part 3: Sub-miniature fuses.

Work under consideration

Within sub-committee 32C five Working Groups are active:

WG 1 drafts a new scope for Publication 257, inclusive of test holders. In WG 4 the policy and philosophy for miniature fuse specifications are developed. WG 5 studies possibilities of introducing homogeneous series into Publication 127, in order to simplify the test procedures.

WG 6 has to prepare a document on Universal Modular Fuses (UMF), based on 32C (secretariat)57 from July 1983 and the comments received since. The scope of WG 7 is the quality assessment of miniature fuse-links. It has to prepare a proposal for a standard on acceptance-tests and (a second step) to prepare a document on reliability tests.

Future work in Sub-Committee 32C and its Working Groups will probably concentrate on the following items:

- Marking the breaking capacity on miniature fuses.
 - Preparing a final solution for the gates for the UMF series based either on the values 1.25-1.7 or 1.5-2.1
 - Total revision of Publication 127 with respect to the gates for all 5 x 20 mm and 6.3 x 32 mm fuses gate 1.5-2.1.
 - Study of possible model protection for the UMF version in connection with gates 1.25-1.7.
 - I²t gates especially for time delay fuses.
 - Solution of the controversy between IEC SC-32C and UL 198. This controversy has been caused by equipment manufacturers who, when exporting their products to both USA oriented countries and Europe, were forced to use miniature fuses with size 6.3 x 32 mm in order to comply with the USA requirements. However, in Europe smaller (5 x 20 mm) fuses with IEC characteristics were available for many years. Wishing to provide 5 x 20 mm fuses acceptable for listing by UL, fuse makers manufactured such fuses and the UL organisation granted listing (approval) of such fuses. However, when equipment, provided with UL 5 x 20 mm fuses, needs replacement of fuses in Europa (where only such fuses with IEC characteristics are available), the consequences can be very serious due to the totally different characteristics. Such a substitution involves a serious risk of damage or even fire due to overheating and/or electric failure.
- The above pictured case of trespassing international standardization philosophy might even result in law suits questioning whom should be held responsible for the damages.

CONCLUSION

Standardization is a continuous process to keep up with new technical developments and improved understanding of physical phenomena. In this respect it is likely that existing standards will regularly be subject to amendments. In IEC, experts of many countries are member of the Technical Committee 32 and its Sub-Committees and Working Groups in order to draft standards for all kinds of electrical fuses.

For both low-voltage fuses and miniature fuses there is a trend to specify world-wide acceptable fuse systems, although this will not be an easy task.

Anyway, the IEC TC 32 activities are directed towards improvement of certification of electric fuses, for safer and more reliable electrical equipment and installations.

Closing Address