Fuse standards
Present state and development

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***Abstract*—Standards are always changing and being added as the industry and the user develop new products or new applications of fuse technology. Social requirements like energy efficiency and ecological needs have to be addressed. The existing standards IEC 60269 series have to be maintained due to new applications and requirements. IEC 60269-3 (household fuses) [3], IEC 60269-5 (guide for the use of fuses) [5] and IEC 60269-6 [6] are presently under maintenance. A new standard for battery fuses is being developed and is expected for 2022. Maintenance for IEC 60269-1 (General requirements) [1], -2 (Industrial fuses) [2] and -4 (Semiconductor protection) [4] will be started very soon.**

***Keywords*—low voltage fuse, standardization, battery fuse, ecology, energy efficiency**

I. INTRODUCTION

Fuse standardization in IEC is made under the umbrella committee of TC 32 (Fuses). It is made up of 3 subcommittees SC 32A (High voltage fuses), SC 32B (Low Voltage fuses) and SC 32C (Miniature fuses). TC 32 was under big pressure from IEC Central Office in the years 2016 to 2018. The description of the work in TC 32 and SC 32B and its reasons, output and planned future developments are described below

II. LOW VOLTAGE FUSE (SC 32B)

A. Changes in the IEC 60269 series since 2015

Since the last ICEFA meeting Part 2, Part 3 and Part 4 have been maintained.

The **amendment 1 of Part 2** [7] was published in August 2016 and had following major changes resp. additions

- Class T fuse added in "gD" and "gN" characteristics
- NH system , contact surfaces require silver plating (otherwise manufacturer must define combinations)
- Test voltage changed for 690V~ rated to 1,1 x U_n / √3 for I^2t test
- NF cylindrical rated voltages 1000V and 1500V DC added, dimensions added, tolerance of 38 changed to 38+0,9/-0,6

The **amendment 2 of Part 3** [8] was published in June 2019 and had following major changes resp. additions

- Rated current 40A added, measuring points for power dissipation definition improved, in D0-system
- Dimension 38+/-0,6 changed to 38+0,9/-0,6 in NF cylindrical system
- Editorial improvements on drawings and in text, also in BS cylindrical and BS plug top

The **amendment 2 of Part 4** [9] was published in August 2016 and had following major changes resp. additions

- Normative references dates taken out
- For VSI fuses di/dt may be used instead of time constant
- Test or rated breaking capacity for VSI fuses explained
- Cross sectional area for tests for fuses with ratings up to and above 4000A added (Table 107)

- Test voltage changed for 690V~ rated to (100% +10%/-0%) of U_n for breaking tests, for all other voltage to (110% +2%/-3%) of U_n
- Annex CC "Preferred voltage rating" was replaced by "Typical voltage rating a.c" and "Preferred current rating" was put into all tables and the remark "For d.c. and VSI rated voltages" contact the manufacturer

B. Present Work in the IEC 60269 series

Presently the Working groups are working on the projects of maintenance for Part 5 and Part 6 and a new standard for battery fuses called Part 7.

Part 5, Ed 2.0 "Guidance for the **application** of low-voltage fuses" [5] is maintained by Maintenance Team 8 (MT8) and should be the amendment 1 to this standard. The maintenance started in January 2018 and two Committee drafts(CD) [10], [11] have already been commented by national committees. Presently the document is in preparation of the Draft Technical Report (DTR). It is expected to be published in 2020.

The following **major changes** resp. additions are contained in this document at the moment

- For the NH system the use of smaller bodies for low rated current values is explained
- Reference made to current carrying capacity and insulation coordination for different altitudes
- Improved description in the table for fuse switch combination units (difference of double breaking and multiple opening)
- Correction of non-fusing current of gS fuses
- New chapter for VSI fuses with description of purpose and location of the fuse, specific characteristics for fuse selection, conditions for quick fuse selection, voltage across the capacitor, current carrying capacity, voltage considerations and breaking range.

Part 6, Ed 1.0 "Supplementary requirements for fuse-links for the protection of solar **photovoltaic** energy systems" [6] is maintained by Maintenance Team 9 (MT9) and should amendment 1 of the standard. The maintenance started in December 2016 and one CD [12] and a Committee Draft for Vote (CDV) [13] have already been commented resp. voted positive by national committees. The discussion on Table 101 of the standard was extensive and presently there is still a discussion of dimensional systems of fuses, including their rated voltages and current

Presently the document is in preparation of the FDIS. It is expected to be published in 2021.

The following **major changes** resp. additions are contained in this document at the moment

- Table 101 is changed to meet market demands
- Verification of rated current, I_{nf} and I_f simplified
- Time constant for I_5 changed to ≤ 1ms
- Equotation changed in Annex: $I_{n,Fuse} \geq 1{,}5 \times I_{SC}$
- Major editorial clean up

Table 101 - Conventional times and currents for "gPV" fuse-links

Rated current A	Conventional time h	Conventional current Type "gPV" I_{nf}	I_f	Fuse type
$I_n \leq 63$	1	1,05	-	String fuse-link
	2	-	1,35[1)]	
$63 < I_n \leq 160$	2	1,13*	1,45*	Subarray or Array fuse-link
$160 < I_n \leq 400$	3			
$400 < I_n$	4			

Note [1)]: For $I_f = 1{,}35\ I_n$ the operating time is 2 h (The thermal withstand capability of a PV module under reverse current is qualified during a 2 h test specified in module safety test from IEC 61730 and is specified on the module as the "maximum overcurrent protection" value).

Table 1: Conventional currents "gPV"

The **new standard IEC 60269-7** for **battery fuses** is currently developed by PT 60269-7. The project started in February 2017 and two CD's [14], [15], have already been commented by national committees. A third CD is expected in late 2019. The standard should be published in 2022.

The following **content** is contained in this document at the moment

- Scope is the protection of batteries and battery systems for circuits up to 1500V DC
- Scope is to establish the characteristics so that the fuse-links can be replaced, provided that the dimensions are identical
- Rated breaking capacity, minimum 30 kA
- Test voltage for breaking test (100+5/-0) % of rated voltage
- Power dissipation and temperature rise according manufacturer
- Guidance for selection as Annex BB
- Minimum Breaking Current for aBat fuses 10 x I_n

Table 3 – Values for breaking-capacity tests on "gBat" fuse-links

	Tests according to 8.5.5.1		
	No. 1	No. 2	No. 5
Mean val ue of recovery voltage [a]	100% -0 +5 % of the rated voltage [b]		
Prospective test current	I_1	I_2	$I_5 = 2\ I_n$
Tolerance on current	0 +10%	Not applicable	0 +20%
Time constant	1-3 ms		<=1ms

I_1 current which is used in the designation of the rated breaking capacity (see 5.7).
I_2 current which shall be chosen in such a manner that the test is made under conditions which approximate those giving maximum arc energy.
NOTE This condition may be deemed to be satisfied if the current, at the beginning of arcing, has reached a value between 0,5 and 0,8 times the prospective current.
I_5 test current deemed to verify that the fuse is able to operate satisfactorily in the range of small over-currents.

a) This tolerance includes ripple.
b) The upper limit may be exceeded with the manufacturer's consent.
c) In some practical applications, time-constant values may be found which are shorter than those indicated in the tests and which may result in a more favourable fuse performance.

C. Summary and Outlook

The **present standard situation and the work** ongoing in the maintenance teams MT8 and MT9, as well as in the Project team PT 60269-7 are shown in Table 1. The present work has been described above. It should be mentioned, that the Working Groups are working very hard, but input and taking of a work load from other parties would be very welcomed.

Part	Title	valid	date	stability	Work
1	General requirements	Ed 4.1	2009-07	2021	----
2	Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) - Examples of standardized systems of fuses A to K	Ed 5.1	2016-08	2020	----
3	Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar application) - Examples of standardized systems of fuses A to F	Ed 4.2	2019-06	2020	----
4	Supplementary requirements for fuse-links for the protection of semiconductor devices	Ed 5.2	2016-08	2020	----
5	Guidance for the application of low-voltage fuses	Ed 2.0	2014-03	2019	AMD1 ED2 / MT 8
6	Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems	Ed 1.0	2010-09	2019	AMD1 ED1/ MT 9
7	Fuse links for the protection of batteries	----	----	----	Ed 1.0 / PT 60269-7

Table 4 – Present situation of IEC 60269 series

For the future there are presently **discussions** within SC 32B to **restructure** the entire IEC 60269 series due to new requirements

- Ensure, that data is only mentioned once in the series (to avoid different data for the same thing in various parts)
- Separate dimension requirements from electrical requirements
- Improve the consistency between IEC and UL (have real NA fuses in the standard)
- Ensure that test voltages are consistent with the series
- Take the requirements for characteristic gG and aM/gM out of Part 1 (only real general requirements stay)
- Ease the standardization of future systems (automotive, railway)

An idea to have the new organization is presented in Table 5

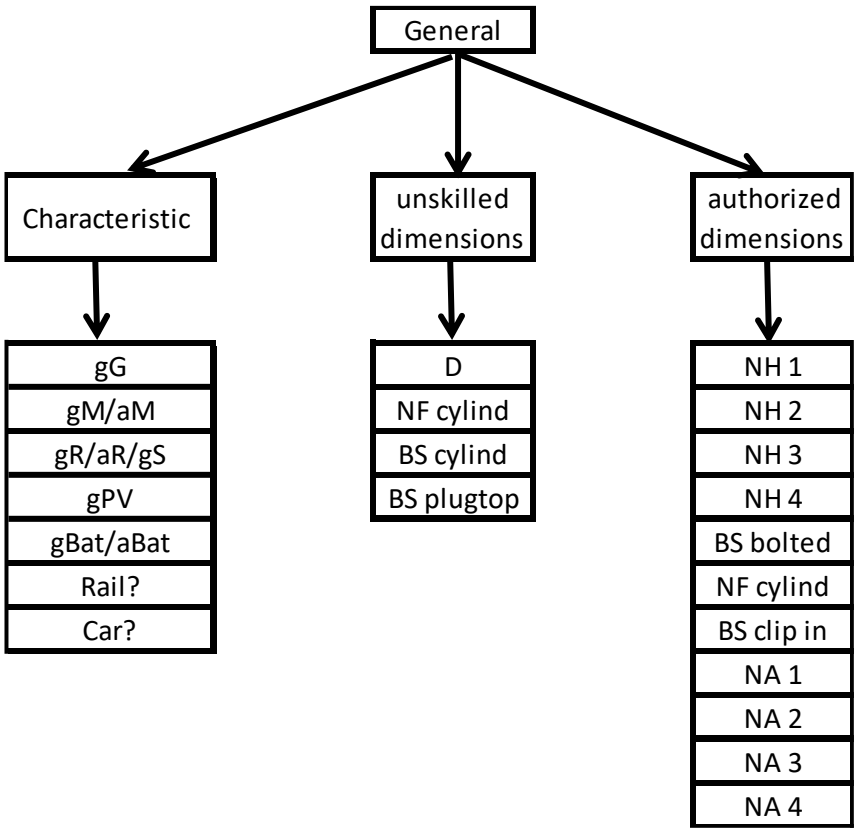

Table 5 – Idea for restructuring IEC 60269 series

III. FUSES GENERAL – TECHNICAL COMMITTEE TC 32

TC 32 is the umbrella committee for Fuses. The last meeting of TC 32 was in October 2016. In 2017 the Central Office stated in an document, that they would like to have TC 32 cancelled and gave the officers the task to reorganize TC 32 and its subcommittees. With a number of discussions, letters, information and suggested work program, it was finally agreed by the SMB to leave TC 32 as an umbrella committee. The officers of TC 32 and its subcommittees had made suggestions for projects of TC 32 as follows

- Maintain IEC TR 60643
- Make a standard concerning environmental issues of fuses

- Make a standard concerning enery efficiency issues of fuses
- Make a standard concerning fuses of more than 1kV a.c. (LV-technology)
- To revise the scopes of TC and its subcommittees to have a clearer understanding and clarifying overlapping issues
- To revise the International Electrotechnical Vocabulary (IEV) IEC 60050, Chapter 441
- Make a standard concerning definition of Product Data

This program submitted to SMB was definitely very important to ensure the continuation of TC 32.

A. Present Action

Today there are 2 AD HOC Groups (AHG) existing, responsible for the review of scopes and presentation of the result to the next TC 32 meeting. Maintenance Team (MT2) is responsible for the maintenance of IEC TR 60643 and MT3 for the revision of IEC 60050, Chapter 441. Working Group (WG1) should make the standard for fuses of more than 1kV a.c. (LV-technology)

Unfortunately up to now, there has been very little action concerning this subject. Similar IEC committees TC 121 (LV switchgear and assemblies), SC 121A (LV switchgear), SC 23E (Miniature Circuit Breakers) and other are actively developing standards regarding product data, environment and energy efficiency. Therefore if the fuse community does not want to be left behind, they must develop a lot more activities in these subjects.

B. Resume

Presently there are only very few persons active in work for TC 32. This explains why the needed action is far behind schedule. No drafts for all the projects mentioned to ensure the further life of TC 32 have been presented. There is the big danger, that the fuse will loose to against other products by not meeting demands of society evolution (environment, product data, etc.). I am asking you and your companies and the entire fuse community to give active participation and the needed funds to further develop fuse standards and to ensure a proper representation within IEC.

REFERENCES

Standards:

[1] IEC 60269-1, Ed 4.1, 2009-07: Low-voltage fuses – Part1: General requirements
[2] IEC 60269-2, Ed 5.1, 2016-08: Low-voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K
[3] IEC 60269-3, Ed 4.2, 2019-06: Low-voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar application) – Examples of standardized systems of fuses A to F
[4] IEC 60269-4, Ed 5.2, 2016-08: Low-voltage fuses – Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices
[5] IEC TR 60269-5, Ed 2.0, 2014-03: Low-voltage fuses – Part 5: General requirements
[6] IEC 60269-6, Ed 1.0, 2016-08: Low-voltage fuses – Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems
[7] IEC 60269-2, Amendment 1, 2016-08 to Ed 5.0: Low-voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K
[8] IEC 60269-3, Amendment 2 to Ed 4.0, 2019-06: Low-voltage fuses – Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar application) – Examples of standardized systems of fuses A to F
[9] IEC 60269-4, Amendment 2 to Ed 5.0, 2016-08: Low-voltage fuses – Part 4: Supplementary requirements for fuse-links for the protection of semiconductor devices
[10] IEC 32B/677/CD (Low-voltage fuses - Part 5: Guidance for the application of low-voltage fuses) circulated 2018-02-02
[11] IEC 32B/685/CD (Low-voltage fuses - Part 5: Guidance for the application of low-voltage fuses) circulated 2016-12-21
[12] IEC 32B/669/CD (Low-voltage fuses-Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems) circulated 2016-12-15
[13] IEC 32B/673/CDV (Low-voltage fuses - Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems) circulated 2018-01-19
[14] IEC 32B/675/CD (Low-voltage fuses-Part 7: Fuse links for the protection of batteries) circulated 2017-12-15
[15] IEC 32B/684/CD (Low-voltage fuses-Part 7: Fuse links for the protection of batteries) circulated 2018-12-21