The comparison of thermal properties of test rig, fuse-holder and switch-disconnector-fuse

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Abstract

The paper presents results of verification of conventional non-fusing current and fusing current performed with the usage of the test rig according to IEC 60269-3, fuse-bases with fuse-carriers and switch-disconnector-fuse. The results show that the test rig according to IEC 60269-3 is not a thermal equivalent apparatus to the fuse-holders. Furthermore, the switch-disconnector-fuse has even worse cooling conditions of the fuse-link than fuse-holders.

Keywords: fuse-link test, D-type fuse-link, test rig, conventional time, conventional current.

1. Introduction

The inspiration to start with a comparative tests were negative results of size D fuse-links tested in testing laboratory at conventional fusing current (I_f) in the test rig according to IEC 60269-3 [1]. The fuse-links tested did not operate within conventional time. It can be assumed from this results that the differences in fuse-link cooling between test rig and fuse-holders have an influence on the results of the tests i.e. operate time at conventional fusing current.

According to the IEC 60269-3 standard the verification of conventional non-fusing (I_{nf}) and fusing (I_f) currents of D and DO type fuse-links shall be performed with the usage of the special test rig while in earlier CEE 16 [2] and IEC 60269-3A:1978 [3] standards this tests were performed with the usage of typical fuse-holders consisting of fuse-base and fuse-carrier. The reason for introduction of this test rig to the IEC 60269-3-1 [4] in 1994 was to eliminate the influence of fuse-base and fuse-carrier types on test results. However, the construction of this test rig is an “open” construction while the fuse-holder (fuse-base with fuse-carrier) is a “closed” construction. This change caused a better fuse-link cooling in the case of test in the test rig than in the case of test in the fuse-holder. Also in the last years the disconnector-fuses and switch-disconnector-fuses are becoming popular. These apparatus have even worse cooling conditions than fuse-holders.

That is why the comparative tests of verification of conventional non-fusing current and fusing current were performed with the usage of the test rig according to IEC 60269-3, fuse-holders (fuse-bases with fuse-carriers) and switch-disconnector-fuse.

2. The objects to be tested

- Test rig according to Fig. 105 and 106 of IEC 60269-3. Test rig is presented on Fig. 1. The contact force was adjusted to 80 N.

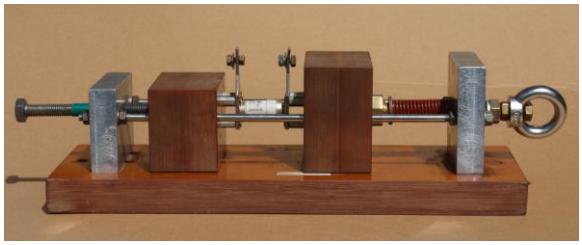

Fig. 1: Test rig according to Fig. 105 of IEC 60269-3.

- Typical size D02 fuse-holders consist of fuse-bases and fuse-carriers. The fuse-holder is presented on Fig. 2.

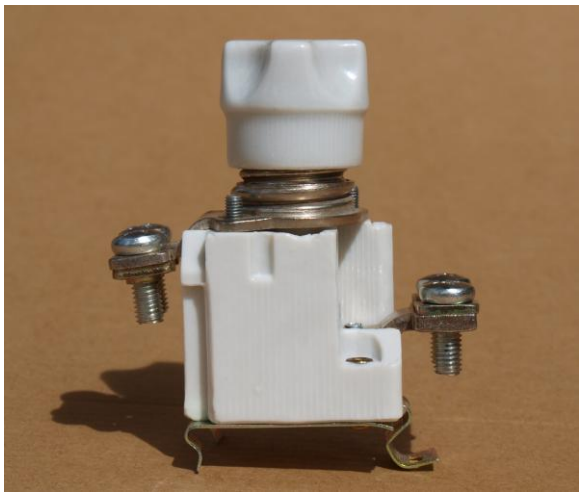

Fig. 2: Size D02 fuse-holder used in tests.

- 1-pole switch-disconnector-fuse type STV D02-1 for rated current of 63 A and rated voltage of 400 V AC made by ETI. This apparatus is presented on Fig. 3.
- Typical size D02 gG fuse-links for rated current of 63 A and rated voltage of 400 V AC. The fuse-links tested belong to the same manufacturing batch.

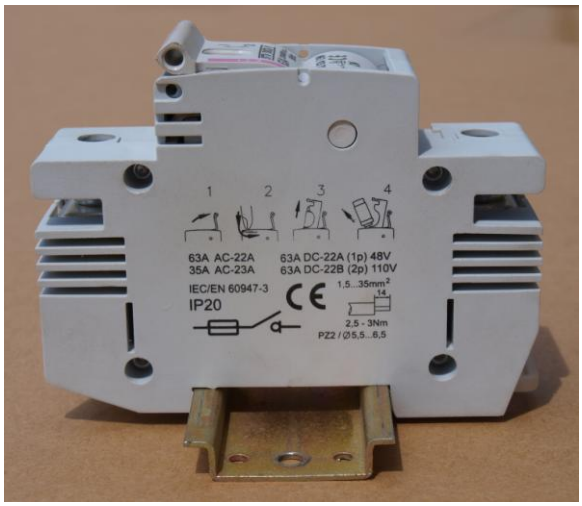

Fig. 3: Switch-disconnector-fuse type STV D02-1.

3. Preliminary tests of the fuse-links

Before the tests at I_{nf} and I_f currents the internal resistance of 15 fuse-links tested were measured with a measuring current of 6 A. The resistance of fuse-links varied from 0,872 Ω to 0,937 Ω. After this the fuse-links were divided into three groups of similar distribution of resistance.

The next test is verification of temperature rise and power dissipation of all fuse-links that performed in fuse-holders. The temperature rise not exceed 50,1 K and the power dissipation of fuse-links varied from 4,60 W to 4,93 W.

4. Comparative tests and test results analysis

According to IEC 60269-1 [5] the tests at non-fusing and fusing currents should be performed on the same fuse-links. Each of the groups of fuse-links were tested in one type of apparatus. The cross-section area of copper conductors was 16 mm^2. The conductors were insulated with PVC. The ambient air temperature during the tests was between 23,5°C and 26,5°C. After the tests at non-fusing current the fuse-links and tested apparatus were cooled down to ambient air temperature. No one of the tested fuse-links operated within 1 h conventional time. The times measured at fusing current are presented in Table 1. One of the fuse-link tested in test rig operated in time which exceed the conventional time. Also in Table 1 the results of statistical analysis are presented.

Small significance level of 0,0002 indicate that averages of times for test rig, fuse-holders and switch-disconnector-fuse differ significantly. In other words, a significant difference exists among the averages for test rig, fuse-holders and switch-disconnector-fuse. This mean that the test rig isn't thermal equivalent to fuse-holders and switch-disconnector-fuses.

Table 1: Comparative test results and statistical analysis.

	Test rig	**Fuse-holder**	**Switch-disconnector-fuse**
Times at I_f [s]	1897 1915 2625 2836 3934	1030 1061 1176 1288 1721	640 662 679 855 913
Average [s]	2641	1255	750
Standard deviation [s]	835	280	125
Variance	697685	78187	15619

5. Conclusions

- The tests results show that the test rig according to IEC 60269-3 is not a thermal equivalent apparatus to the fuse-holders. This cause the differences in the operate times of the fuse-links tested in test rig and fuse-holder. In extreme cases fuse-links tested at fusing current in the test rig may have fusing times exceeding conventional time (negative result) while tested in the fuse-holder have fusing times not exceeding conventional time (positive result). That's why the construction of the test rig according to IEC 60269-3 should be modified. The second way is resignation from the test rig and test the fuse-links in typical fuse-holders.
- The switch-disconnector-fuse have even worse cooling conditions of the fuse-link than fuse-holders and test rig. This means that the fuse-links used in switch-disconnector-fuse have very short operate times. It was confirmed during the tests.

References

[1] IEC 60269-3:2006 Low-voltage fuses. Part 3: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications). Examples of standardized systems of fuses A to F.
[2] CEE 16 Specification for D-type fuses for domestic and similar general purposes. *International Commission on rules for the approval of electrical equipment, February 1970.*
[3] IEC 60269-3A:1978 First supplement: Appendix A: Examples of standardized fuses for domestic and similar applications.
[4] IEC 60269-3-1:1994 Low-voltage fuses. Part 3-1: Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications). Sections I to IV.
[5] IEC 60269-1:2006 Low-voltage fuses. Part 1: General requirements.

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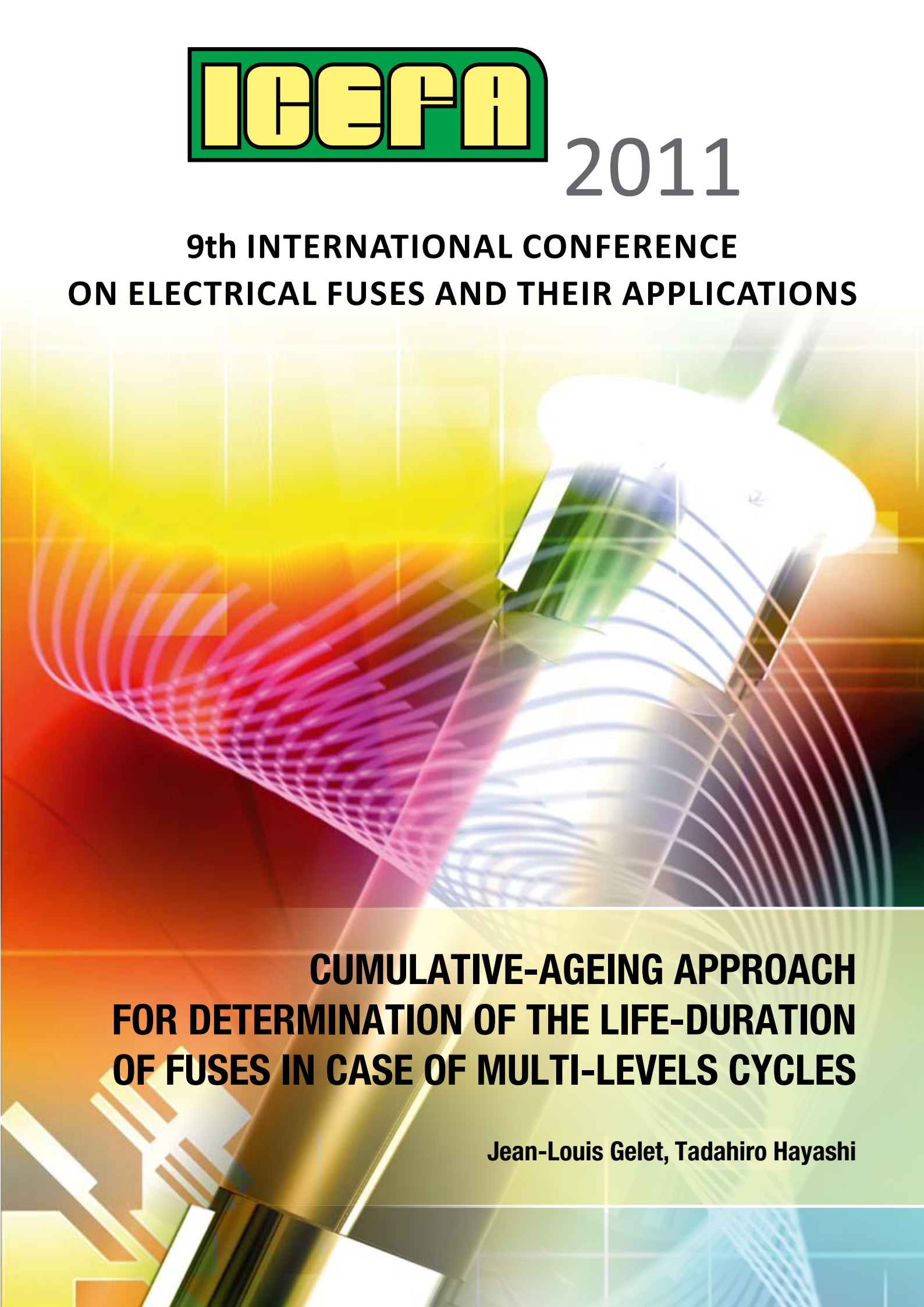

CUMULATIVE-AGEING APPROACH FOR DETERMINATION OF THE LIFE-DURATION OF FUSES IN CASE OF MULTI-LEVELS CYCLES

Jean-Louis Gelet, Tadahiro Hayashi