STUDY OF RELIABILITY AND EFFICIENCY OF AUTOMOTIVE FUSES SAMPLES

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ABSTRACT: The paper inhere summarizes results from testing of automotive fuses samples, performed in the Specialized Research Lab "Electrotest", situated at the department "Basic Principles of Electrical and Power Engineering" at the Technical University of Gabrovo and also in collaboration with colleagues from the University „Constantin Brâncuşi" in Targu Jiu, Romania. All studies and test procedures have been performed in compliance with the international standards ISO 8820 and SAE - J1284.

KEY WORDS: *electromotive fuses, blade type, time-current characteristics, cold resistance, voltage drop.*

INTRODUCTION

Automotive fuses are a class of fuses used to protect the wiring and electrical equipment of vehicles. They are generally rated for circuits no higher than 32 volts direct current, but some types are rated for 42-volt electrical systems. Automotive fuses are typically housed inside one or more fuse boxes (also called an integrated power module (IPM)) within the vehicle, typically on one side of the engine compartment and/or under the dash near the steering wheel [1].

Being one of the most important protective devices in vehicles' wiring against current overloads and short circuits, they have to meet lots of requirements as stated in the specific international standards ISO 8820 and SAE - J1284 [2, 3]. Related test procedures are also described in [8, 9 and 10].

The rated voltage (U_N) of a fuse link has to be at least equal or higher than the operating voltage of the device or assembly unit which is to be protected with the fuse link. If the operating voltage is very low, the fuse link's natural resistance (voltage drop) must possibly be taken into consideration.

The voltage drop (ΔU) is measured according to standards e.g. ISO, SAE etc.

The rated current (I_{rat}) of a fuse link should approximately correspond to the operating current of the device or assembly unit which is to be protected (in accordance with the ambient temperature and rated current-definition, which means the permitted continuous currents).

Table 1

T_{amb}, °C	%	F_T	T_{amb}, °C	%	F_T
-25	14	0,877	23	0	1,000
-20	13	0,885	30	-2	1,020
-15	12	0,893	35	-4	1,042
-10	11	0,901	40	-6	1,064
-5	10	0,909	45	-8	1,087
0	9	0,917	50	-10	1,111
5	8	0,926	55	-13	1,149
10	6	0,943	60	-16	1,190
15	4	0,962	65	-19	1,235
20	2	0,980	70	-22	1,282

Higher ambient temperatures (T_{amb}) mean additional load for the fuse links. The heating conditions of the maximum occurring ambient temperature have to be checked, in particular

with high rated currents of the fuses, and a strong thermal radiation of components nearby. For such applications, the fuse should be derated with factor F_T in accordance with *Table 1*.

$$I'_{rat} = I_{rat} \cdot F_T \quad (1)$$

Due to different specifications of rated current the recommended continuous current of the fuse links is max. 80% of their rated current (with an ambient temperature of 23°C).

The pre-arcing time limits indicate the relation of fusing time to current. (They are presented as an envelope curve for all mentioned rated currents.)

The melting integral (I^2t) results from the squared melting current and the corresponding melting time. At excess current with melting times < 5 ms the melting integral remains constant. The melting integral is an index for the time-current characteristic and informs about the pulse consistency of a fuse link.

The breaking capacity (I_B) should be sufficient for any operating and error conditions. The short-circuit current (maximum fault current) to be interrupted by the fuse links at the rated voltage under default conditions must not be higher than the current corresponding to the breaking capacity of the fuse link.

The maximum power dissipation (P_V) is determined at a load with rated current, after having obtained temperature equilibrium. In operation, these values can occur for some time [4].

Also relevant questions that have to be considered discusses problems with insulation aging of fuses materials [5] and the parameters of electromagnetic compatibility, especially for implementations in hybrid or electric vehicles [6, 7].

INSPECTION OF AUTOMOTIVE FUSES SAMPLES. TEST RESULTS

The performed inspection and test procedures are performed for a sample consisting 10 pieces of fuse blister packs, each of which contains 10 pieces of blade fuses, described as follows: 5A - 1 pc.; 7.5A - 1 pc.; 10A - 2 pcs .; 15A – 2 pcs .; 20A - 2 pcs.; 25A - 1 pc .; 30A – 1 pc.

In the process and for the purpos of the tests, all provided samples were destroyed.

All tests of the provided samples were performed on the basis of the requirements of the international standards ISO 8820 and SAE - J1284.

Shape and dimensions check of the provided samples of automotive blade type fuses.

According to the cited standards [2, 3], the dimensions and the shape of the provided samples must meet the requirements according to Fig. 1.

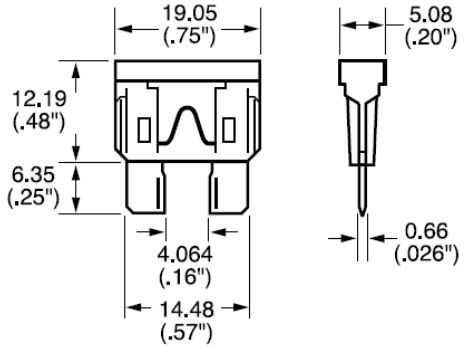

Figure.1. Standard dimensions of blade type automotive fuses.

It has been verified that the provided samples at all rated currents correspond to the standard shape and dimensions, as stated in Fig. 1.

Color marking check

According to ISO 8820, the following standard housing colors (color marking) are used for blade type automotive fuses in dependence on their rated current:
5A - orange; 7.5A - brown; 10A - red; 15A - blue; 20A - yellow; 25A - transparent; 30A - green.

It has been verified that the provided sample of automotive fuses have a color marking corresponding to the standard.

Fuse housing's insulation thermal resistance test

The operating temperature of standard blade type automotive fuses must be in the range from +40 °C to +105 °C according to the standards.

In this relation, an experiment has been performed in which two samples of each type

of fuses were tested in a thermal chamber and the results are presented in Table 2.

Table 2

Test temperature	Test duration	Result after the experiment
105 °C	1 hour	There are no changes in the shape, structure and appearance of the fuse housing
125 °C	1 hour	There are no changes in the shape, structure and appearance of the fuse housing
150 °C	1 hour	The shape of the case remains unchanged. There is a slight softening of the insulating housing
200 °C	1 hour	The fuse housing is melted down

As a result of the performed experiment (Table 2) it has been concluded that at the specified by the standards operating temperature range between +40 and +105 °C *the insulation of the tested fuses (housing) is thermally stable and consistent.*

Voltage drop and cold resistance tests

Measurement data is provided in regard with measured and averaged values of the following technical parameters related to the safe operation of automotive fuses:

- ✓ Resistance in cold condition under rated current (Cold resistance) R[mΩ], Table 3;
- ✓ Voltage drop ΔU[mV] and fuse filament temperature under rated current, Table 4.

Table 3

Rated current, Irat[A]	Cold resistance, R[mΩ]
5A	12.72 mΩ
7.5A	12.2 mΩ
10A	8.18 mΩ
15A	4.26 mΩ
20A	3.22 mΩ
25A	2.56 mΩ
30A	2.24 mΩ

Cold resistance measurement have been performed using a Watson's bridge.

The measurements of the voltage drop and the fuse filament temperature are performed at rated current and after reaching a thermal equilibrium. All tests are made at an ambient temperature in the range (23 - 25) °C.

Table 4

Rated current, Irat[A]	Voltage drop at rated current, ΔU[mV]	Fuse filament temperature at rated current, [°C]
5A	68 mV	38 ° C
7.5A	88 mV	43 ° C
10A	92 mV	48 ° C
15A	88 mV	53.8 ° C
20A	76 mV	61.2 ° C
25A	80 mV	62.5 ° C
30A	110 mV	87.5 ° C

Time-current protective characteristics measurments.

According to the requirements of the standards ISO 8820 and SAE - J1284, the protective time-current characteristics for tripping of standard automotive blade type fuses must correspond to the data from Table. 4.

Table 4

Applied current as percentage of the fuse current rating, [%]	Tripping time MIN / MAX, [sec]	
	Minimum allowable	Maximum allowable
110 %	100 h	not defined
135 %	750 ms	1800 s
200 %	150 ms	5 s
350 %	40 ms	500 ms
600 %	20 ms	200 ms

The time-current characteristics were taken experimentally for the provided samples and the results are presented in Table 5.

Table 5

Rated fuse current I_{rat} [A]	Tripping time, [ms]				
	110% I_{rat}	135% I_{rat}	200% I_{rat}	350% I_{rat}	600% I_{rat}
5A	-	125 s	2380 ms	245 ms	53 ms
7.5A	-	98 s	1840 ms	135 ms	80 ms
10A	-	115 s	2270 ms	195 ms	36 ms
15A	-	95 s	1560 ms	180 ms	60 ms
20A	-	136 s	2010 ms	190 ms	40 ms
25A	-	166 s	1400 ms	345 ms	55 ms
30A	-	82 s	1020 ms	143 ms	35 ms

CONCLUSIONS

Based on the above tests and regulatory requirements, it has been verified that all tested samples of automotive fuses meet the requirements for safe operation in electrical automotive installations for DC rated voltage up to 32 V, providing the necessary electrical protection without risks for health and safety of people or property damage.

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