AUTOMATIC TESTING OF MINIATURE FUSES

P.J. van Rietschoten, H.J. van Altena, Littelfuse Tracor B.V., Utrecht, The Netherlands

ABSTRACT

Miniature fuses involve very large production quantities and in connection herewith very large quantities of fuses have to be tested. Instead of 100% testing, samples are taken to check the quality level of the whole lot. This sample testing still involves large quantities, so it is obvious that automatic testing is considered to be able to guarantee a certain quality level. However, some problems have to be overcome to bring automatic testing into reality. These problems are related with requirements in the relevant IEC 127 standards. In the next paragraphs these problems will be discussed.

1. THE NEED FOR AUTOMATIC TESTING

The newly proposed part 5 of IEC publication 127 (Quality assessement of miniature fuse links) specifies requirements for lot-by-lot inspection. These requirements are divided into two categories, viz :

* Primary characteristics, that means non-destructive testing on marking, mechanical parameters (length, diameter, alignment, cap adherence, cracked insulation tube) and cold resistance.
* Time-current characteristics, that means destructive testing at $1.5I_n$, $2.1I_n$, $2.75I_n$, $4I_n$ and $10I_n$.

For each category inspection levels according to IEC 410 have been specified, as well as AQL-figures. For primary characteristics, inspection level II has been specified. This means that, as an average, appr. 1% of all fuses produced should be tested. So per million fuses produced, 10.000 pieces should be tested. (Production of one million fuses per week is not a very large production volume for this kind of fuses.) Doing the required inspection by hand and one by one should required more than 10 people per million fuses per week. For the time-current characteristics, inspection level S4 has been specified. This means that, as an average, appr. 0.1% of all produced fuses should be tested. This is 1000 fuses per million fuses produced. The requirement is that 40% of these fuses must be tested at $2.1I_n$. The blowing time at this current value may be up till 30 minutes. Assuming an average testing time of 15 minutes and the test will be done by hand and one by one, then only the $2.1I_n$ test requires 100 hours per million fuses.

From the above it might be clear that in an automatic production facility, the inspection by hand involves a number of people which is comparable with those producing the fuses. So the gain may get lost by introducing IEC 127, part 5. Therefore, automatic testing is a need. It should be kept in mind that the IEC requirements are directed to final inspection, all sorts of in-process inspection, patrol inspection and the like, are not taken into account.

2. PROBLEMS FOR AUTOMATIC TESTING AS ORIGINATING FROM IEC 127

Electrical continuity (cold resistance) as well as the time-current characteristic have to be checked using the test fuse holder as specified in IEC 127. (see fig. 1)

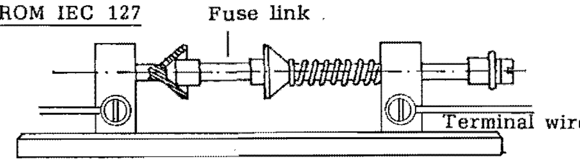

Fig. 1 Test fuse holder according to IEC 127.

Apart from the fact that it is rather difficult to make a reliable mechanism for automatic loading with fuses of such a fuse holder, an even more important factor is that this type of fuse holder requires much maintainance to keep contact pressure and contact resistance within specified limits. The same is valid for the cap adherence test: the requirements and equipment as specified make it not easy to automate such a testing process. In addition to this, cap adherence is to a large extend determined by the process parameters during production. If production is well under control and a good patrol inspection during production takes place, it is questionable why such large quantities should be subjected to an adherence test during final inspection.

Another problem for automatic testing, originating from IEC 127, is that fuse links should be sujected to a so-called modified endurance test. This means: passing a current of 1.5 times rated current through the fuse during one hour and measuring the voltage drop before and after this one hour test. (The voltage drop values of one particular fuse may not change by more than 10%) The voltage drop measurement must be carried out after thermal equilibrium, taking appr. 5 minutes for each measurement. So the total modified endurance test of one fuse takes appr. 1.25 hours. It is specified that 10% of the destructive test category should be subjected to this test. This means that approximately 100 fuses per million fuses produced should be tested. It takes 125 hours when they are tested one by one. Automation cannot reduce this testing time because the testing time is determined by the test requirements. Simultaneous testing can solve this problem only partly.

When there is a production of one million fuses per week but devided over 25 different fuse types and current ratings, then in the average only 4 fuses per fuse type should be subjected to the modified endurance test per million fuses per week. So in this situation the minimum testing time with one equipment suitable for testing 4 or more fuses simultaneously, is in the average $\frac{125}{4} \approx 31$ hours per million fuses per week.

A final problem we like to mention is the fact the determination of the time-current characteristic should be carried out using a DC-source, whereas, according to IEC 127, for the continuity test AC should be used. This condition makes it more difficult to use the same equipment for full electrical testing in one automatic test cycle.

POSSIBILITIES FOR AUTOMATIC TESTING

In the rest of this paper we will not discuss testing of mechanical parameters, we confine ourselves to electrical testing. From the preliminary it became evident that many fuses should be tested simultaneously in order to keep track of production volumes. This is especially true for the more time-consuming tests to determine the time-current characteristic. In principle two possibilities exist for simultaneous testing, viz :

* Parallel testing (see fig. 2) which requires as much current sources as there are fuses to be tested.

* Testing a number of fuses connected in series (see fig. 3) requiring the short-circuiting of each fuse at the instant that the particular fuse blows.

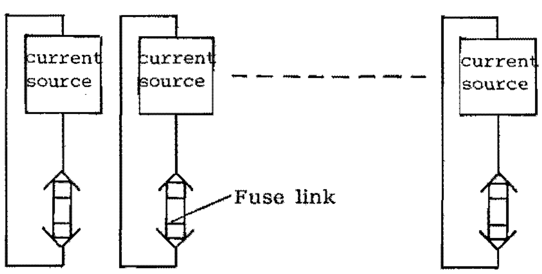

Fig. 2 Parallel testing of fuse links.

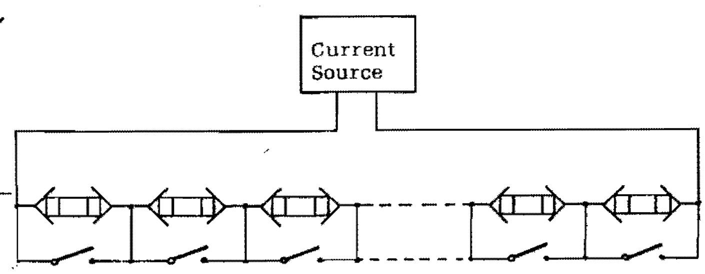

Fig. 3 Serial tesing of fuse links.

In our laboratory we designed and built an automatic testing machine with which a combination of serial testing and one by one testing is realised. Serial testing is carried out for those tests which take a long testing time. (especially the modified endurance test and the $2.1I_n$ test.) Testing times at the remaining current values for the determination of the time-current characteristic are much shorter. (down to max. 20ms at $10I_n$) So one by one testing, but testing a number of fuses in an automatic sequence, is in this case more pratical. Fig. 4 shows the basic concept of the testing machine.

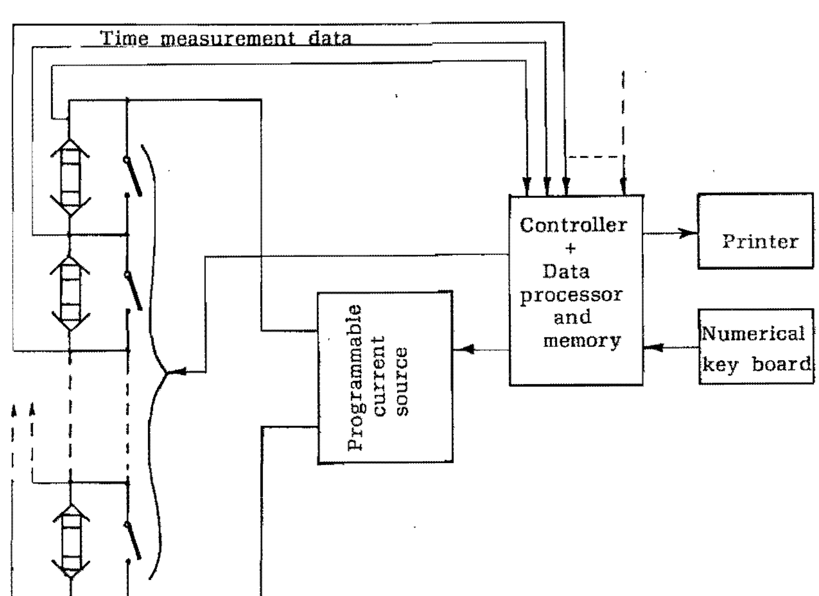

Fig. 4 Basic lay-out automatic testing machine.

In the case of serial tests all fuses connected in series must be monitored constanly. When a fuse blows, the blowing time of that fuse has to be recorded and this particular fuse must be short-circuited, in order to restore current flowing in the rest of the circuit. This short-circuiting should be performed in a very short time (in the order of 0.1 ms) in order not to influence test results by the fuse interruption. (see fig. 5)
Care should be taken not to introduce transient overvoltages (spikes) in the test circuit, which may arise from switching actions while short-circuiting blows fuses.

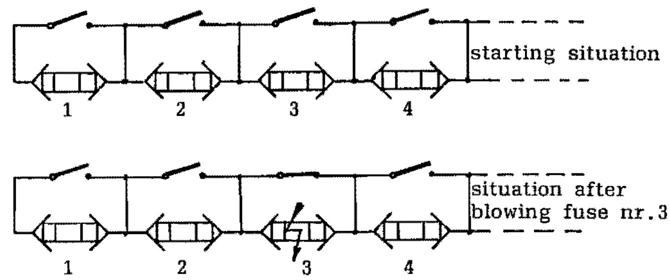

Fig. 5 : Serial testing

The basic idea of sequential one by one testing, in use for the higher current set values, is illustrated in fig. 6.

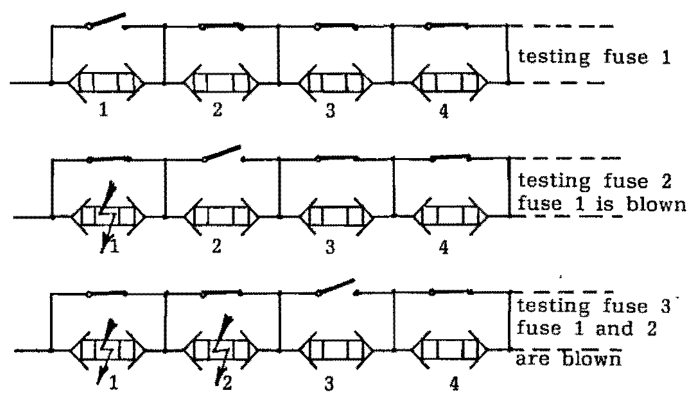

Fig. 6 : Sequential one-by-one testing

The above described functions have been realised in the automatic testing machine. The basic design is shown chematically in fig. 4. With such an equipment it is of course also easily possible to manipulate the test data, for instance determining mean values, standards deviations, etc. per batch.

4. CONCLUSIONS

From the preliminary it may be clear that full automatic testing, following the test duties as specified in IEC 127, part 5, is not simple, due to test requirements as specified in IEC 127, part 1 and 2. A testing machine as described above can, in pratical situations, only be used for final inspection and not for in-process inspection. This is mainly due to testing times which are too long to give an adequate feed-back in the production process.

Quality has to be built-in during the production process and cannot be "tested-in" afterwards. So testing in accordance with IEC 127, part 5 is an additional testing, giving only a final proof of the quality. Testing in this way has no value at all for obtaining a good quality level. The automatic testing machine cannot replace any testing or quality inspection during the production process. The only advantage may be that better reliability figures per batch of finished fuses can be provided.