SWITCHGEAR , BUSBAR SYSTEMS and ITS BUILT-IN COMPONENTS:

SOMETHING IS MISSING IN IEC and IEEE STANDARDS

Author name: Affiliation:
Sergio Feitoza Costa COGNITOR – Consultancy, Research and Training Ltd.

Email: sergiofeitoza@cognitor.com.br Site : www.cognitor.com.br

Keywords: IEC Standards, Switchgear, Bus-bar systems Testing simulation, Laboratory, High Power, Internal Arcs, Overpressure, Temperature rise, Electrodynamic stresses, Short time currents, Switchgear.

1) Introduction:

Electrical equipment users request that the equipment they buy have a test certificate or report issued by a recognized laboratory. This is a regular practice in developed countries but only in the last 25 years it increased in countries like Brazil, China, India and other emerging ones

Laboratory testing, especially in high power labs, is expensive and necessary. Before arriving to an approved design the manufacturer needs to repeat tests some times. Nowadays there are few high power testing laboratories in the world. Most of them were constructed in the 60´s to 80´s under a strategic view to enable the countries electric industry to develop. The need to use testing laboratories is a barrier for small and medium size manufacturers because testing costs are high and the cue for having a vacancy can arrive to one year.

Most of the multinational manufacturers are big today because, in the past, they had a view for the future and constructed their own laboratories for developing equipment. They use the 3rd party laboratories mostly to get recognized test reports or certificates. When you have a laboratory you do not need to do many complicated calculations to develop a new product. Using the previous experience and some test trials you can arrive to a competitive design.

IEC – International Electrotechnical Commission Standards are very competent, used all over the World and are the basis for national standards. All the countries can participate in their preparation. Most of these standards were originally done many decades ago under the vision "everything shall be tested". IEC standards are regularly reviewed but the old concept of "test everything" remains there and need to be reconsidered.

Electrical equipment testing simulation techniques can be used to foreseen testing results at low cost. Joining some testing laboratory and technical standards use experience the author of this paper could develop a home-made tool which permits to simulate internal arc tests and its overpressures, short circuit electrodynamical forces and temperature rise tests. The tool is useful to manufacturers to improve the design reducing the risk of not being approved in the expensive laboratory tests.

Within certain limits, testing simulation can be used to extrapolate the results of an already done laboratory test to other similar, but not equal, equipment. An existing example of the role of calculations and simulations in testing replacement is in IEC 60439-1 - Low Voltage Switchgear and Controlgear (Type tested - TTA and partially tested assemblies -PTTA).
The concept of the conversion of TTA to PTTA projects for low voltage switchgear replace the idea of "test everything" by the acceptable use of tools plus common sense and written rules.

The barrier for a wider use of simulation in the context of real tests replacement is the lack of written rules and guidelines on how to do it. IEC and IEEE may have an important role in the systematization and dissemination of the proper use of simulations in, this context. The idea is not to replace tests by simulations anytime but, instead, to indicate the proper way to use simulation when the common sense show it is reasonable to do it. This can bring benefits so different as to avoid switchgear tests which can put SF6 in the atmosphere or to enable certification of products in countries with low testing laboratories availability.

A suggestion, from the author of this paper, for a strategy on "How to establish some rules, in IEC or IEEE standards, to enable simulation techniques to be used as an auxiliary tool for the verification of some testing results."

The idea is to extend some concepts used in IEC 60439-1 to other low and high voltage IEC standards. The practical way to do this is to include in the general management rules for IEC standards (and not in specific individual standards) some written guidelines like:

> "Extrapolation of the results of tests already done in certain equipment may be used to estimate the performance of untested equipment within the limits indicated in the new IEC Technical Report XYZ: Reference examples and rules to extrapolate results of tests already done in a certain equipment to estimate the performance of untested equipment".

This kind of standards management procedure was implemented in IEC in the 90's for electromagnetic compatibility (EMC). From then on all IEC product standard shall have a statement about EMC. The key point is, if the concept of some tests replacement is acceptable for low voltage switchgear (and for some cases in extra high voltages where there are no labs available for certain tests) why not to extend it to all products?

The aim of this paper is, in addition to expose the idea above, to suggest to IEC / IEEE Technical Committees and Sub Committees to call the attention for an omission in several technical standards when they do not request:

a) a proper identification , in the test reports, of the equipment which was tested.

b) some ohmic resistance measurements which would make some tests to be reproducible in the future.

By lack of guidelines in our main technical standards, test reports issued by laboratories are very poor from the point of view of photos and drawings not permitting a reliable comparison between the equipment which was tested and the equipment which is commercialized.

An example is when we try to compare, for medium or low voltage switchgear, test reports containing the results of temperature rise tests (where openings for air flow are welcome) and internal arc tests (where the air openings are usually unacceptable). It is difficult to check if the same equipment design was used in both tests.

There are several details about the validation of simulations of high power tests in the paper *"Validation of simulations of electrodynamical forces, temperature-rise and internal arc tests in switchgear (and main parts of a code to do them)",* of the same author, available at **www.cognitor.com.br**

2) WHAT IS MISSING IN OUR MAIN TECHNICAL STANDARDS ?.

The 3 more expensive tests to be performed are:

- Internal arc tests.
- Short-time withstand current and peak withstand current
- Temperature rise test.

There is a design “conflict” between the performances of switchgear in these 3 tests. The requirements by users about the supportability to internal arcs are increasing each day. For medium voltage switchgear the internal arc test is a type test and usually requested. For low voltage switchgear it is a not a type test but several big users, knowing about the risks for arcs above 10 kA, are including the internal arc test as mandatory in their specifications.

Most of the low voltage switchgear in the market is not tested for internal arc. The requirements at IEC TR 61641 (Guide for Testing under Conditions of Arcing due to Internal Fault) for low voltage and at IEC 62271-200 (medium voltage switchgear) should be unified because the “problem to solve” is the same.

For bus-bar systems the IEC standard does not cover directly the internal arc test but should do it. For example suppose you have at an offshore platform a short circuit level of 50 kA rms. Suppose that you have an untested bus-bar system connecting two sets of type tested medium voltage switchgear. Or the investment done in the switchgear internal arc tests was not necessary or, by coherence, you should also have tested the bus-bar system.

In the design of switchgear and bus-bar systems the 3 requirements to attend are:

a) the temperatures which shall not be over passed during normal operation (aging of materials)

b) the supportability to the effects of the overpressures arising during internal arcs and the risks to persons in the neighborhood

c) The supportability to the effects of electrodynamical forces (insulators and conductors) occurring during a short circuit without arc

These effects are more severe for smaller dimensions (volume) and with higher currents. To attend the requirements of the temperature rise test it is good if you have more ventilation (openings). To attend the requirements of the internal arc tests you shall avoid the ventilation openings. The IEC standards do not focus in this relationship.

The way to assure that the equipment tested for temperature rise in a certain laboratory is the same equipment which was tested for internal arc in another laboratory is very easy. A sentence shall be written somewhere in the IEC standard requesting the good identification of the tested apparatus by drawings and photos (geometry), the materials used and the power dissipation inside the switchgear.

Another omission in the technical standards is when they request to measure, before the temperature rise test, only the total electrical resistance per phase. To enable the test to be reproducible, it is necessary also to measure, and to register in the test report, the individual resistance of the circuit breakers and/or isolators inside.

In Figure 1 it is showed a simulation of two temperature rise tests in the same switchgear. In both tests the total resistance per phase is 72 µΩ. In the first the resistance of the circuit breaker is 30µΩ (the catalog value) and in the second it is 18µΩ (a special breaker). Only with the lowest resistance circuit breaker the temperature rises were lower then the standard maximum limits. If, with the same total resistance per phase you may pass or not the test is not reproducible.

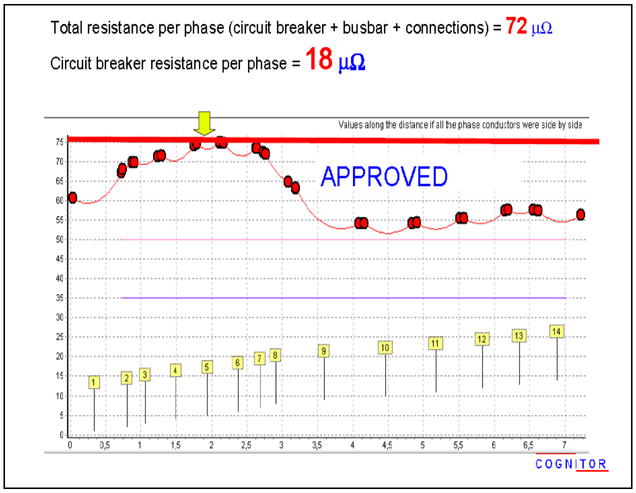

Figure 1A – Total resistance 72 µΩ. and circuit breaker resistance 18 µΩ (approved).

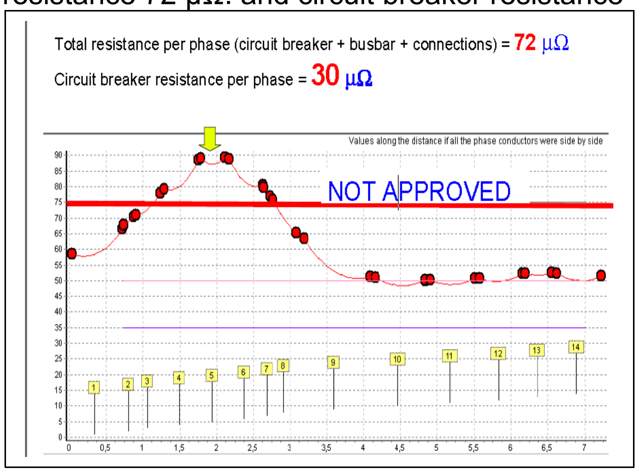

Figure 1B – Total resistance 72 µΩ. and circuit breaker resistance 30 µΩ (not approved).

Another point to mention is that testing laboratories do not include in the test reports what is not explicit in the standards so the Standard shall contain the product identification requirements.
A final remark to users, related to temperature rise tests and short time current tests, is to pay attention to the fact that certain laboratories do the test , measure temperatures and do not include a conclusion – approved or not - in the test report. It is not recommended to use test reports like this for commercialization purposes.

3) FINAL COMMENTS.

The objectives of this paper were:

(a) to present a suggestion on how to formalize the use of simulations as an auxiliary tool in IEC and IEEE standards and,

(b) to present a contribution to the experts involved in technical standardization work showing some points which need to be improved in such so useful and world wide used standards. These points involve:

- To make explicit the need of a good identification, in the test reports, of the type tested products. Only a good identification assure that the commercialized product is equal to the product which was type tested;
- To include the need of the measurement and register in test reports of the circuit breaker or switch electrical resistance (and not only the total resistance per phase)

If, 40 years ago, we could use simulations to reliably send rockets to the Moon we can certainly use nowadays simulations to replace, at least, some temperature rise tests. Unless we do not believe that we landed on the Moon.

The author of this paper is Mr. Sergio Feitoza Costa. Sergio is an electrical engineer, M.Sc in Power Systems and director of COGNITOR. The detailed CV may be read in the link http://www.cognitor.com.br/cv_english.htm

He has a 30 years experience in high power, high voltage and materials testing, R&D services, electrical equipment and power systems specification, simulation and operation. For many years he was the manager of the main high power and high voltage testing laboratories in Brazil.

His experience includes also international technical standardization management (former chairman of IEC Technical Committee 32 - Fuses) and is member of the CIGRÈ International Working-Group CIGRE WG A3. 24 - Tools for Simulating Internal Arc and Current Withstand Testing

He is coordinator of the Brazilian National Standardization Committee for High Voltage Fuses (equivalent to IEC SC32A) and also for the commission related to "Protection against Fire in Electrical Energy Generation, Transmission and Distribution Installations".
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