SIMULATION OF HIGH POWER TESTS FROM 2007 to 2017:
what changed for manufacturers, users, certification companies and testing laboratories?

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1) INTRODUCTION:

In 2007 I wrote the paper PS1-06 “Simulation, IEC Standards & Testing Laboratories” published in the CIGRÈ International Technical Colloquium - Rio de Janeiro. In 2015 I wrote another named “Inducing & Assessing New Technologies & Procedures for The Electric Industry”. These and others may be downloaded in http://www.cognitor.com.br/download.htm .

Between these two moments I have been participating in two CIGRÈ working groups about simulations of internal arc tests (WG A3-24) and temperature rise tests (WG A3-36). The first one prepared and published the Brochure 602 / 2014 (simulation of internal arc) which is the most complete document already published about internal arc. The second one is preparing one about temperature rise tests which certainly will also become a worldwide reference.
As a suggestion to CIGRÈ, in addition to the brochures for internal arc and temperature rise, would be welcome other about simulation of electrodynamic forces (high currents short time current tests) and another about simulation of magnetic and electric fields (simulation of some EMC and dielectric tests).

I also collaborated in the IEC working group (WG 31/17C) which prepared the IEC TR IEC-62271-307 published in 2015. This one presents guidance for the extension of validity of type tests of switchgear (<= 52 kV). This document will have, for MV switchgear, an impact in the market, similar to the IEC 61439 series in the low voltage switchgear market. Both IEC documents create clear openings for a wider use of simulations to replace some expensive laboratory tests.

Equipment manufacturers are using simulations, each time more, to predict laboratory test results. Their focus is to simulate the tests they will do in testing labs to adjust the equipment design to “pass on the laboratory test”. The idea is to reduce the probability of failures in the expensive test. Because the availability of testing laboratories all over the World is small, lab testing is expensive and waiting queues are usual.

Some certification companies already have a perception of the potential of simulations as a business. When you certify a product and a modification of the product is done after the emission of the certificate, some tests should be repeated. Simulations done in a comparative sense with a previously tested equipment are very effective for the purposes of a certification company.

Most of the testing laboratories still consider that “everything should be tested”. Twenty years ago, as a manager of big testing labs I was used to think like this. Today, based on 15 years doing simulations for manufacturers and comparing them with laboratory test results, I am convinced that this is an error of

assessment. Laboratories could think that would lose part of the testing market. However, the business "testing simulations" is a very interesting complementary area for them. The most difficult aspect of the simulations is to validate it by comparison with the test results. For testing labs would be easy to validate whatever they need and so, they are in a privileged situation.

Equipment buyers are each time more receptive to simulations. For them, the missing aspect for a much wider acceptance is the absence of an IEC formal document describing guidelines for the use and validation of simulations to replace some electric tests. A proposal for this exists since 2010 as showed below.

In this article I intend to update the information presented from the occasion of the 2007 paper showing what changed about the use of testing simulations in the last 10 years.

2) WHICH KIND OF SIMULATIONS ARE WE SPEAKING ABOUT?

The key aspects to consider in the use of testing simulations are:

- The objective is to predict the results of IEC tests within an error margin of some 5 to 10%
- To use simulations mostly in the cases in which the tests are significantly expensive or when simulations provide more complete information than the lab tests like in temperature rise tests.
- There are tests in which some aspects of the performance can be well simulated but others not. For example, the overpressures of internal arc tests are "easy" to simulate and to validate but the reach of the hot gasses would be expensive to validate.
- The use of simulations is in upward trajectory but the availability of testing labs is not.

The main type tests necessary when developing equipment like switchgear, switchboards and busways are:

a) Internal arc tests.
b) Short-time withstand current and peak withstand current (short circuit electrodynamic forces)
c) Interruption (making – breaking) tests
d) Temperature rise test.
e) Dielectric and some EMC tests
f) Mechanical tests

High power tests (a) to (c) are the more expensive ones. At 2nd level, a little less expensive,arethe temperature rise tests and the dielectric tests. Mechanical tests cannot be properly simulated and are cheaper. The simulation of Interruption tests is complex. The focus, in this article, will be on (a) internal arc tests, (b) short-time currents (electrodynamic forces) and (c) temperature rise tests. Simulations of dielectric and EMC tests will be covered in a separate article. In Table 1 there is some relevant information.

Table 1 – Simulation and validation of simulations of some tests

Type of test	Representability of the simulations	Complexity of the models used for simulation	Difficulties for validation and input data for it
Short-time withstand current and peak withstand current (electrodynamic forces)	High, if the objective is only to assess the IEC test results (pass or not pass in the test)	Intermediate complexity based on existing IEC documents	Easy to validate by calculations using excellent bibliography in IEC TR 61117 and IEC TR 60865. Difficult to validate by direct testing (to measure transient forces)
Internal arc test	High for the calculation of overpressures. Low for AIS simulation of reach of hot gasses.	Higher complexity for overpressures but achievable - like on the Cigrè Brochure 602/2014. CFD for simulating reach.	Easy to validate for the overpressure curves. Published results in Cigre Brochure 602/2014 & others. No existing reference for reach of hot gasses. Many testing days would be needed for AIS

Type of test	Representability of the simulations	Complexity of the models used for simulation	Difficulties for validation and input data for it
Temperature rise tests	Very high. There are practically no effects that would occur in the test but not in a reasonable complexity simulation (without complex CFD models)	Possible with simpler models as in SwitchgearDesign (5 to 9% of error in the points specified in IEC standards. Possible to achieve lower errors with CFD.	The validation should be very easy because it is needed only a direct comparison between test results and simulation results. Some difficulties to find lab test reports with complete data.
Dielectric and some EMC tests	Intermediate (depending on the case) if using magnetic and electric fields mapping.	Intermediate for fields calculation. More difficult to define the values for "pass or not pass in the test".	Limited bibliography available for equipment different from "long and straight" conductors.

2) WHAT CHANGED IN THE LAST TEN YEARS AND WHAT TO EXPECT FOR THE FUTURE?

Electrical equipment users request that the equipment they buy have a test report issued by a recognized laboratory. Testing, especially in high power labs are expensive and necessary. The number of testing laboratories available all over the World remained more or less the same. Before arriving to an approved type tested product the manufacturers need to repeat tests some times. This is a barrier for small and medium size manufacturers. The history shows that only countries having testing labs availability had a growth in the electric sector activity.

In the last 20 years, very few technologically new products arrived to the electric power market all over the World. On the contrary of what happened in 80´s and 90´s companies prefer now to do high investments in commercial marketing than to invest in technological knowledge. The focus is to emphasize the benefits of "new name" products that do not have anything new. The technical development teams and training in manufacturers companies are each time smaller, when exists. It is impressive how companies lost knowledge and do not know anymore how to do simple engineering calculations.

Cigre Cigrè have working groups preparing and publishing reference brochures about testing simulations.

IEC standards are used all over the World and translated some 3 to 4 years after to become national standards. It would be great if IEC standards were also published in languages different from the languages used in the developed countries. This would reduce inequalities. The participation in IEC working groups is restricted to experts from the big international companies. It is very rare to see experts from medium and small companies participating in these activities because they do not consider this as a priority.

An advance is that the previous approach in IEC standards of "everything shall be tested" is changing and now concepts like the design rules, the extension of validity of test reports and use of simulations are presented in (excellent) documents IEC 62271-307 (MV switchgear) and IEC 61439 series (LV switchgear).

It is still missing an IEC standard with guidelines for the use of simulations to replace some tests. There are no formal proposal being worked in IEC as the one which can be downloaded in http://www.cognitor.com.br/Article_Competitivity_Eng_04102011.pdf . This proposal is one of the references in the Brochure CIGRE 602 / 2014.

Users and buyers of equipment for substations became more receptive to the use of simulations but this will grow consistently only when IEC guidelines exist.

Certification companies evolved in the use of simulations and there are cases in which official country rules were created to permit testing replacements. Testing laboratories still do not consider seriously to involve themselves in the simulations business.

Related to what to expect for the future, it is unavoidable that the use of testing simulations will become each time more intense by all the mentioned actors. The main reason is that the availability of testing laboratories, all over the World, will not grow significantly in the future.

It will not grow because, for private companies, to invest 100 million Euros in a testing lab has a much lower return of investment than other much simpler alternatives of business.

It is reasonable to imagine that some of the world wide existing testing laboratories and certification companies will occupy most of the spaces in the business of testing simulations.

The ones which do not percept and open their minds for this will possibly be out of the market in less than 15 years.

There are testing labs that still nowadays continue to do test circuit calculations using hand calculations instead of using software available since the 70´s like ATP / ATPDraw. It works but takes 10 times more time. These ones possibly will not survive.

The author of this paper is Mr. Sergio Feitoza Costa. Sergio is an electrical engineer, M.Sc in Power Systems and director of COGNITOR. His CV may be seen at http://cognitor.com.br/en_home.htm .

Sergio has 25 years of experience in design, operation and management of high power, high voltage and other testing laboratories. After leaving the activities in testing labs Sergio acquired 16 years of experience in the use of testing simulations in support to manufacturers and certification companies.
Sergio is the author of the simulations software SwitchgearDesign

In these links there are some videos and reference material, inclusive for validation of testing simulations:

(Video) Simulations of temperature rise tests (1)
http://www.cognitor.com.br/Item7b2Eng.mp4

(Video) Simulations of temperature rise tests (2)
http://www.cognitor.com.br/Item7b1Eng.mp4

Details: http://www.cognitor.com.br/ChaptersEN.htm

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