Demo Project 1: **Environmental efficiency certificate of electrical products (kG/MVA): technical standard & demo projects.**

Brazil could implement initial steps of this idea!!!

By Sergio Feitoza Costa

Technical Standards: instead of encouraging less waste of resources are **focused in preserving old low-efficient designs.**

1. SAVING EARTH RESOURCES VIA ELECTRIC POWER INDUSTRY

In 1992, RIO_92 (or ECO_92) took place in Rio de Janeiro, few km from my home. I witnessed that Brazil got a lot of money to clean up the Guanabara Bay and little was done. Even today it is not possible to bath in the sea because the water is dirty. I believe the money was used for other less noble purposes. Things like this happens all over the World. Many good ideas arise but are blocked. The results are clearly insufficient. We are already paying the bill much faster than were the expectations. Droughts, floods, and big fires are there for everyone to see. I do not believe that countries that earn so much money selling the weapons that fuel wars are concerned about the environment, reducing hunger, and reducing inequalities between the G7 countries and developing countries.

> There are some easy actions to take, to demonstrate that long-term intentions are serious. An example is to shift the focus of the international technical standards (IEC, ANSI, IEEE, and other nationals). Instead of focusing only on expensive tests, technical standards should encourage the creation of more efficient products (lower kg/MVA). I think that nowadays the focus of technical standards is only to preserve, for the large international manufacturers, the market of inefficient products, designed 40 years ago. It would be easy to all of them to design more efficient products. If it is easy for an individual like me to design products with lower kg/MVA, imagine for their competent R&D teams. Would be great to read in the agenda of future COPs, the implementation of this idea. Sure, this needs to come from a level higher than the world-wide technical standards associations because users and governments are not adequately represented in the development of technical standards. In theory they are, but in practice they are not. Just look at the attendance list for working group meetings.

The "kG /MVA: Research Centre on Environmental Efficiency of Electric Products" is a concept under implementation. The initial goal is to finance and carry out 7 short-duration demonstration projects to show to the world that designing higher efficiency equipment using less materials is easy and depend more on serious attitudes and intelligence than of significant investments. Brazil could implement the initial steps of this idea

Saving the Planet's resources is a global goal and should be reflected in international technical standards such as IEC, IEEE, and others. However, the institutions that prepare and sell them do not transform their beautiful environmental discourses into objective actions.

That is why the equipment produced today, like electrical panels, busways, etc., developed some 50 years ago, in the days of the fat cows, use much more materials than would be possible. The focus of our current technical

standards, usually prepared and managed by engineers only focused on short-term technical things, is only to pass severe and onerous tests. I know this because I have been participating in several of them in IEC work.

> Severe and expensive testing is a barrier to new manufacturers and ideas coming to market. The technical standards never mention that more efficiency and less use of materials is something desirable for the Planet.

Regarding the activities of this non-profit research center, we are in the process of seeking sponsors for the demonstration projects. In the case of Brazil this could start in the Ministry of Energy. We anticipate that some of the main sponsors will possibly be large companies that, due to their activities potentially conflicting with environmental preservation issues, want to improve their environmental image by supporting initiatives that objectively contribute to the preservation of the planet's resources.

Most of these companies are in the fields of oil and gas, chemicals, mining, and large agribusiness. They have in common that they are large users of electricity. In countries, the electrical industry is generally the most visible and organized. The idea is to demonstrate that it is simple to improve current electrical products on the world market to spend at least 30% less materials than today. To achieve verifiable results and stay focused, we would use products that are widely used in electrical energy transmission and distribution (T&D) systems.

An initial condition is to have sponsors to provide funding for the demo projects listed in Table 1. After attending this condition, an operating mode would be stablished to enable the development of the demo projects. The results obtained would be monitored by a "Council of Sponsors", which would decide the next steps to follow.

Table 1 – The 7 demonstration projects scope

Demonstration project (Details in the links)	Name	Scope and monitoring of results
#1 http://www.cognitor.com.br/demo1certificate.pdf	Environmental efficiency certificate of electrical products (kG/MVA): technical standard & demo projects management	To disseminate the idea, to monitor the level of interest through the number of Linkedin followers, to create the guidelines for the implementation and to act within major technical standards organizations to discuss and prepare the standard.
#2 http://www.cognitor.com.br/demo2Lab.pdf	High Power (small size): Testing Laboratory with R&D services focused on lower kG/MVA products	Design and implementation of 3 units in) in three regions like South America (possibly Brazil), Africa and Asia (possibly in Malaysia ou Singapore or Thailand).
#3 http://www.cognitor.com.br/demo3SwitchgearEfficiency.pdf	Examples of more efficient switchgear (30% less kg/MVA) using thinner bars, small ventilation, and different materials Cu / Al profiles and coatings	Design, testing results & comparisons of kg/MVA between traditional techniques and (a) using several thin bars, per phase, (b) small (auto) ventilation resources , (c) different coatings of the busbar connections and (d) parts of components using metal foam
#4 http://www.cognitor.com.br/demo4HighRiseBuildings.pdf	Designing triaxial busways for high rise buildings (lower kg/MVA & impedance for IEC62271 – IEC 61439)	Design and testing comparing the traditional busways with a triaxial busway with higher rated and short circuit current ratings (lower kg/MVA) using proved concepts used in measuring coaxial cables
#5 http://www.cognitor.com.br/demo5SuperEnclosures.pdf	A Super Enclosure for high current switchgear and controlgear (IEC62271 – IEC 61439)	To be disclosed soon
#6 http://www.cognitor.com.br/demo6EconoCosts.pdf	Decidix for kg/MVA – a tool to assess the efficiency of high electric power products	A tool for technical-economic evaluations easy to use by equipment developers with little knowledge of cost calculations. Allows you to compare the attractiveness of projects of different natures
#7 http://www.cognitor.com.br/demo7MHD.pdf	MHD for a water transportation vessel based on electrodynamic forces and coaxial structures	To be disclosed soon

2. USING THE MARKET COMPETITION AS A CATALYZER TO REDUCE THE WASTE OF MATERIALS IN THE FABRICATION OF ELECTRIC POWER PRODUCTS (the role of the market, manufacturers, and technical-standards makers).

I witnessed, participating directly in IEC working groups, that most technical standards are made by engineers, without any political or environmental vision. The only goal is to specify equipment that will pass for type tests. To be more efficient and using less materials and resources of Earth is simply disregarded. The standards texts do not have statements saying that this is a goal to be achieved or even that it is desirable

This thinking is well reflected in the technical standards marketed by IEC, ANSI/IEEE. The documents do not signalize that the equipment will be more efficient having a lower weight/MVA. If we can't even do this, how can we convince the world population that 10% energetic efficiency gains are very good?

This "Environmental Efficiency Certificate for Electrical Products" is an action to signalize that higher efficiency via a lower kg/MVA is good for the environment. The rules to get the CERTIFICATE are explained in the next lines.

A typical marketing strategy is manufacturing products with lower kG/MVA and $/MVA and making the market to know this. Big buyers that need to take care of the environmental image, would prefer to buy products with lower values. The first ones to obtain the Certificate would possibly do campaigns to disclose who buys and who does not buy more efficient products. Declarations about the relevancy of a lower kg/MVA in product technical standards would accelerate the process.

3. **THE FUNDAMENTS OF THE CERTIFICATE**

This Certificate attests that the project was designed and constructed to meet the requirements of the tests prescribed in the product standard but, *much beyond this*, was designed for the minimum necessary use of copper, aluminum, insulating supports, materials etc. This is a measurable objective using indicators like the weight per transmitted power (KG/MVA) or the order of magnitude of the production cost divided by the transmitted power ($/MVA) . An easy example is that, within a switchgear panel, with a 2x100x5mm copper bar you can transmit 19% more current, for the same temperature rise, than using a 1x100x10mm bar. The weight of copper is the same in both cases. So, the indicators KG/MVA and $/MVA are lower in the first case. You used less materials and this means higher use of materials efficiency better for the Planet.

Figure 1 – 19% more current with same weight of copper
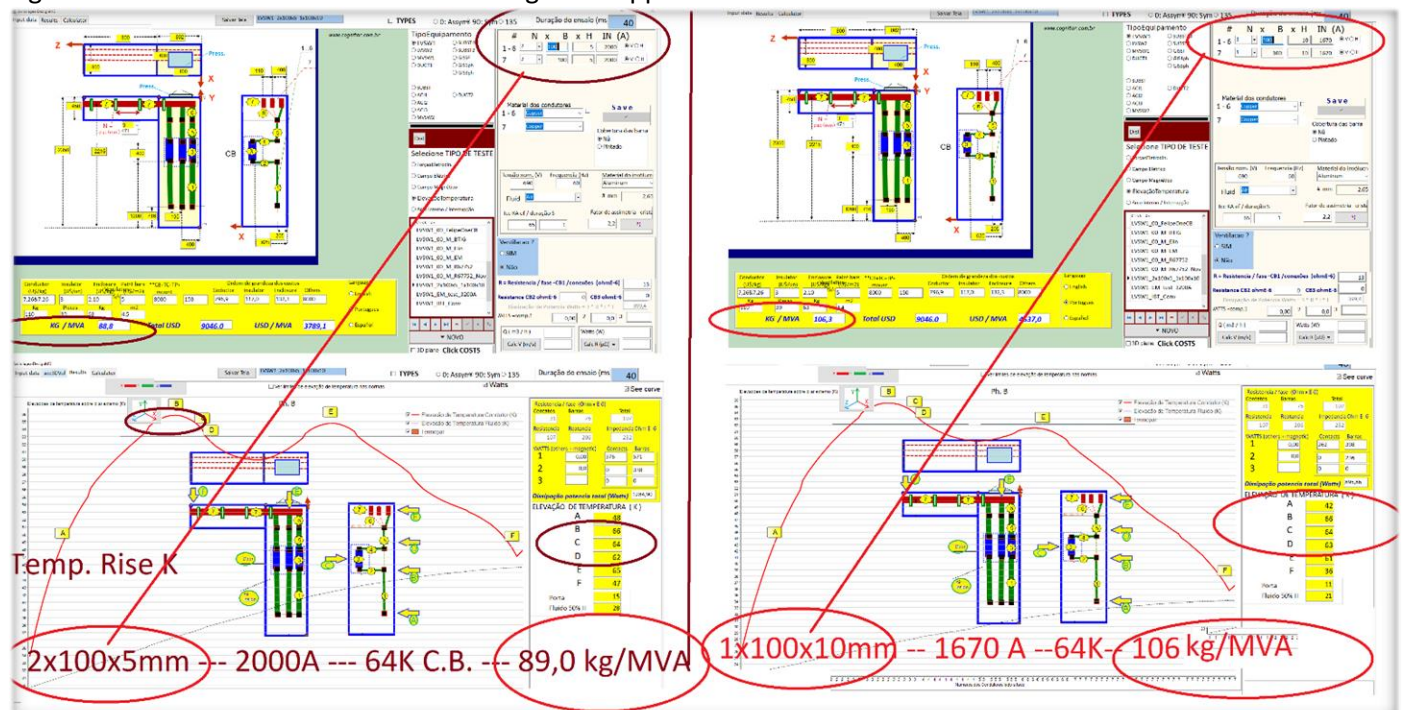
The Certificate shall be issued by third parties and based in an international technical standard explaining the concepts and rules. The results shall be transparent, auditable, reproducible and easy to understand by the common public. It shall demonstrate that the minimum material usage requirements have been met or tried. This is not difficult to do and to verify using the tables of the IEC TR 62271-307.

The assessment results to support the Certificate may be obtained by real tests or - *much cheaper and faster* - using testing simulations plus the concepts of IEC TR 62271-307. In this important IEC document issued by the first time in 2015, the basis is a "head of the family" product already tested in the testing laboratory. Suppose you test a product and simulate that test already done getting the same results. Now, suppose that you have another design of the same nature as the tested one, but with some differences. If you do the same simulations on the untested piece, using the same tool and a qualified method, there is no reason to question that the new simulation represents what would happen in a real test. Then you can avoid the higher cost of real laboratory tests.

> **Draft of a technical standard:** A key aspect is that, for this to be accepted by people and buyers who are not qualified or skilled in engineering, *the rules must be written in an international technical standard*. A complete draft text prepared by me is presented below. Any help to make this article and ideas to arrive to reach ISO, IEC, IEEE, ANSI and other national standards associations is very welcome and the Planet thanks you in advance.

Using these methods, it is possible to compare the KG/MVA and $/MVA of different design alternatives. After a certain time and experience, the world values of these indicators will become well-known. Then, the electric industry will see how the current old designs, marketed around the world, can become more efficient with simple existing techniques. Universities and technical schools could give importance to this theme in their teaching programs.

The test reports issued by the qualified laboratories or others actor qualified to issue the Certificates must explicitly indicate whether the equipment has passed the tests or not and to write and demonstrate the $/MVA and KG/MVA indicators.

This is a fantastic market because, in 2023, rare substations equipment meets these requirements. Most of them can be improved to use less materials, considering - mainly - the performance for temperature rises tests, internal arc, and short circuit tests (electrodynamic forces). From the commercial point of view, a good marketing strategy is building electric power products with lower $/MVA & kG/MVA , and, to make the World to know this. The big companies that need to take care of the environmental image, will prefer to buy products with lower KG/MVA.

4. FINAL COMMENTS AND DRAFT TEXT OF THE TECHNICAL STANDARD

Complete examples of what is to do a more efficient electric product, with lower $/MVA & kG/MVA are presented in the articles related to the demo projects 3 and 4 (links in Table 1 above). You may find the fundaments for these articles in previous articles freely downloadable in the link https://www.cognitor.com.br/Downloads1.html

In Section 5 the reader may find the draft text of a technical standard to support the issuance of the ENVIRONMENTAL EFFICIENCY CERTIFICATE of electric products, more or less in the format of IEC and ISO documents. This text may be used freely for any person or institution which want to use it. Opinion makers, research centers, the universities and the academic World have here an opportunity to do something effective in the direction of preserving Earth resources.

5. THE BASE TEXT OF THE TECHNICAL STANDARD IN THE FORMAT OF ISO / IEC

See next page.

GUIDE (Edition 1.0):

Guidelines for the use of the "ENVIRONMENTAL EFFICIENCY CERTIFICATE of electric products"

CONTENTS

FOREWORD

This "Environmental Efficiency Certificate for Electrical Products" aims to induce the electric industry to produce items that goes beyond the quality assured by prescribed type tests . The focus is on award and highlight design and construction actions on electrical power products that lead to weight per transmitted power (KG/MVA) or estimated lower cost per transmitted power ($/ MVA). These indicators are used to characterize higher efficiency and lower use of materials. It is particularly relevant to users that take care of the environmental image.

To obtain the Certificate, it is necessary to pass design verifications that are specified to meet specific requirements and tests. To evaluate these characteristics, real tests, and test calculations or simulations can be used.

Laboratory type testing, as specified in product standards, is – currently - the most efficient way to verify if a certain product attends the specifications. However, it is necessary to recognize that high power tests to verify temperature rise (aging), internal arc (safety of persons and installations) and short circuit forces are expensive. By this reason, other lower cost alternatives of verification are necessary.

The main alternative is the use of testing simulations associated with the principles of the Extension of Validity of Test Reports presented in IEC TR 62271-307 . Testing simulation techniques are used to predict results of most type tests. They enable to obtain more detailed information than the information which could be obtained in a real laboratory testing.

Simulations can be applied in situations like: (a) to avoid switchgear tests in equipment with characteristics near to another one already tested or (b) to facilitate the certification process of products that pass for design modifications after type tested or (c) to replace SF_6 by air in some tests.

The main concern related to the use of testing simulations methods is to be sure that their results, well represent the results of a real laboratory, within an acceptable tolerance. This Guide show rules for achieving this, exemplify tolerances values and give guidelines to validate the methods.

For analyzing if a certain design is more efficient than others, it is necessary to define reference values for the comparisons. . The starting point are values practiced in current designs. To define initial reference values, world-wide queries were made, initially only, for switchgear , switchboards, and busways (IEC 62271 and IEC 61439 series). The weight and the transmitted power of a product is an easy to obtain characteristic. This Guide present some initial reference values of KG / MVA for typical commercial products

GUIDELINES FOR THE USE OF THE
"ENVIRONMENTAL EFFICIENCY CERTIFICATE   OF ELECTRIC PRODUCTS

1 Scope

This Guide presents guidelines for the systematization of the use of the environmental efficiency Certificate of electric products. The use of this "Certificate" is an action to motivate the electric industry to design and manufacture more efficient electric power products with lower $/MVA & kG/MVA. The concept is that , as the Certificate become known in the world market, companies, especially the ones that need to take care of the environmental image, will prefer to buy products with lower USD / MVA and KG / MVA . This means less of use of materials.

This Certificate attests that the project was made to meet the requirements of the tests prescribed in the product standard but, much beyond this, was designed with the minimum necessary use of copper, aluminum, insulating supports, materials etc. This is a measurable objective using indicators like the production cost divided by the transmitted power ($/MVA) or the weight per transmitted power (KG/MVA) .

An easy example is that with a single copper bar 100x10 mm you may transmit a certain value of current having a certain temperature rise (like in a test) . However, if you use 2x100x5mm (same weight) , for the same temperature rise value, you can transmit quite more current. So, the indicators $/MVA and KG/MVA are lower in the second case because less materials are used, and this is better for the Planet.

The Certificate shall be issued by third parties following the concepts in these Guidelines. The tests, verifications and results shall be transparent, auditable and reproducible. It shall demonstrate that the minimum material usage requirements have been met.

Whenever applicable, the design parameters presented in the tables of IEC TR 62271-307 shall be used.

IN GENERAL, THE SEQUENCE TO OBTAIN THE CERTIFICATE IS THE FOLLOWING:

- Test a head of family product using the related product technical standard

- After being approved the data of these tests may be used to extend the validity of that tests reports to other products of similar characteristics but that have similarities within the concepts of IEC 62271-307

- If it is necessary to use testing simulations to demonstrate any of the IEC62271-307 assertions this can be provided by the manufacturer or be done by the entity issuing the Certificate.

- Search for a 3rd part testing laboratory or certification company that will analyze the data, calculate the $/MVA and KG/MVA indicators.

- This entity will issue the CERTIFICATE explaining the details and , in the conclusions of the report, make statements based on the values currently practiced and showed in Table 1 of these guidelines

Considering this expected sequence, statements in the product standards related to recommend informing , in the type test report, the values of   the indicators $/MVA and KG/MVA are useful for future Certificates. This is the same type of procedure that was implemented 30 years ago goe Electromagnetic Compatibility (EMC).

The results of the assessment to support the Certificate can be obtained from test reports or from testing simulations based on the use of the tables and concepts IEC TR 62271-307. In this IEC TR the origin of the process is a "head of the family" product already tested in a testing laboratory. The testing simulations are used in a comparative sense. The principle is that, if the testing simulations done in the tested equipment give the same results as the real test, they are able to predict what will be the performance of other non-tested samples.

In other words, suppose you test a product and simulate that test getting the same results. Suppose you now have another design of the same nature as the tested one, but with some differences. If you simulate the tests of the new equipment, using the same tool and a qualified method, there is no reason to question that the new simulation represents what would happen in a real test. However, for this to be accepted by people and buyers who are skilled in engineering, the rules must be transparent. This is the aim of this Guide.

Using validated simulation tools and methods, it is quick and simple to compare the $/MVA and KG/MVA of different projects. It is expected that, after some time of application of this Guide, the world values of these indicators become known, unlike today. The consequence will be the economy of materials and resources of the Planet.

To implement the process of certification is necessary to stablish sound references to validate the testing simulation methods. This is explained in the definitions of Section 3. The principles follow the same concepts and design parameters detailed in IEC 62271-307. Examples of input data and results which can be used to demonstrate that a certain simulation model is acceptable are presented in Section 3.

The verification reports issued by the qualified laboratories and certifiers shall indicate in clear words whether the equipment has passed the tests or not and to write and demonstrate the $/MVA and KG/MVA indicators. For this purpose, it is particularly relevant the performance in temperature rise tests, internal arc and short circuit tests (electrodynamic forces).

The use of simulations to replace tests is possible only when certain specific measurements and registers are specified in the relevant product standards and are presented in the laboratory test report. In Section 3 are listed the minimum measurements and photographic registers that shall be informed in test reports, specified in product standards. These measurements make the test to be reproducible and usable for future simulations. This data also help users to identify if a commercialized product is similar to the laboratory tested one.

It is not an objective of this Guide to present calculation methods for testing simulation. It is considered that a model or method is acceptable when it produces validated simulation results within acceptable tolerances if compared with the real test results and this can be demonstrated in a transparent way. In principle, the key design factors are based only in the geometry and materials properties of the conductors, insulation and fluids.

2 Normative references

The following referenced documents may be used for the application of this Guide, where relevant. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

a) ISO/IEC Directives, Part 2:2004, Rules for the structure and drafting of International Standards
b) IEC TR 62271-307:2015 : High-voltage switchgear and controlgear - Part 307: Guidance for the extension of validity of type tests of AC metal and solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

c) IEC TR 60943: Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals.

d) IEC TR 60890: A Method of Temperature-rise Verification Assessment by Extrapolation for Partially Type-Tested Assemblies (PTTA) of Low-Voltage Switchgear and Controlgear Assemblies by calculation.

e) IEC 61117: Method for assessing the short-circuit withstand strength of partially type-tested assemblies (PTTA)

f) IEC 60865-1: Short-circuit currents – calculation of effects – Part 1: Definitions and calculation

g) IEC 60865-2: Short-circuit currents – calculation of effects – Part 2: Examples of calculation

h) IEC 60112: Method for the determination of the proof and the comparative tracking indices of solid insulating materials

i) IEC 60071 1: 2010 Insulation co-ordination - Part 1: Definitions, principles and rules

j) Brochure CIGRE 602 / 2014 Tools for the Simulation of The Effects of the Internal Arc in T&D Switchgear

k) Brochure CIGRE 740 (2018) Contemporary Solutions for Low-Cost Substations.

l) Brochure CIGRE 830 (2021):Application and Benchmark of Multiphysics Simulation Tools for Temperature Rise Calculations

3 Definitions

For the purposes of this Guide, the following definitions apply.

3.1 – kG/MVA (weight divided by transmitted power) of an electric product

The aim of the Certificate is to attest that the product was made to meet the requirements of the tests prescribed in the product standard but, much beyond this, was designed with the minimum necessary use of copper, aluminum, insulating supports, materials etc. To measure this objective the indicator to be used is the weight per transmitted power (KG/MVA) . For example, a single copper bar 100x10 mm can transmit 20% less current than using 2x100x5mm (same weight) , for the same temperature rise. So, the indicator KG/MVA is lower in the second case. Less materials were used, and a higher efficiency was obtained. This is better for the Planet resources.

3.2 - Simulation or calculation to replace a test and acceptable tolerances

A calculation method used to predict, within a certain specified tolerance, the results which would occur in a laboratory test as specified in the relevant product standard. Here are typical values of acceptable tolerances of the results to be obtained in the simulations if compared to the real laboratory test results:

Table 1

Type of test	Parameter to compare	Typical values of acceptable tolerance for the calculated values
Temperature rise test	Temperature rise in solid and fluid parts	1% to 5%
Internal arc test	Overpressure in the enclosure above the atmospheric pressure (crest value and integral of the pressure curve)	5% to 10%
Short time withstand current, and peak withstand current tests	Electrodynamical forces and mechanical stresses	5% to 15%
Other applicable tests	The ones listed in IEC 62271-307.	(*)

(*): Values of tolerances to be defined

3.3 - Product publication

Publication covering a specific product or group of related products

34 - Reproducibility of a simulation or calculation method

The capability of to obtain, for a specified set of input data the same test results or the same simulation results in two or more different occasions or two different test laboratories.

3.5 - Validation of a simulation or calculation method or a laboratory test
A method of comparison between the results showed in a well-documented test report issued at a test laboratory and the results of a simulation method. A simulation method is generally acceptable, from the point of view of users, when it is reproducible and gives a difference between simulation and laboratory results not higher than a certain acceptable tolerance.

3.6 - Minimum input data to be registered in a temperature rise laboratory test report.
Temperature rise is the main parameter which defines the kG/MVA of a product. Equipment is approved during a test if the final measured temperature rises of the parts do not go beyond certain limits dictated by the properties of the insulating and conductive parts. These limits are showed in the relevant product standard. IEC TR 60943 and IEC 60890 explain the concepts involved.

The data affecting the test and the simulations results are the ones explained in the relevant table of IEC 62271-307 . The main ones are:
- the circulating electric current,
- the total power dissipation inside the fluid compartment
- the materials used in the conductor and insulating parts
- the contact resistances and its coatings (total per phase and also the ones of the individual parts like circuit breakers, fuses , isolators)
- the ambient gas or liquid fluid temperature (for example at the bottom , the top and at 50% of the height of the enclosure),
- the fluid velocity
- the geometry and spatial position of the conductors
- the volume of fluid inside the compartments
- The input and output areas for ventilation
- The number of horizontal partitions inside the enclosure if applicable
- The relative position of the equipment in relation to walls, ceiling and neighbor equipment (as presented in IEC 60890)

For the sake of reproducibility, the measurement of the total per phase and partial electrical contacts resistances, before and after the test, shall be registered in laboratory test report.

The values of the data mentioned above shall be clearly registered in the test report trough drawings and photos,

3.7 - Minimum input data to be registered in internal arc tests laboratory test reports

Equipment is approved during a test if the effects of the overpressures arising during the arc do not cause potential risks to persons in the neighborhood of the equipment. The relevant aspects to consider are showed in the relevant product standard. IEC 62271-200 and IEC TR 61641 explain the concepts involved.

The curve overpressure x time is the main parameter to predict a good or bad test result.

The data affecting the test and the simulations results are the ones explained in the relevant table of IEC 62271-307 . They are explained in the reference Brochure CIGRE 602 / 2014.   The main ones are

- the circulating electric current,
- the materials used in the conductor and insulating parts
- the geometry and spatial position of the conductors
- the volume of fluid inside the compartments
- The input and output areas for ventilation and devices to close it during the arc
- The areas for pressure relief after the arc
- The relative position of the equipment in relation to walls and ceiling

For the sake of reproducibility, the measurement of the internal overpressure along the test shall be registered in the laboratory test report. The values of the data mentioned above shall be clearly registered in the test report trough drawings and photos,

3.8 - Minimum input data to be registered in short-time withstand current and peak withstand current test report

The objective of the test is to verify the supportability to the effects of electrodynamical forces on insulators and conductors occurring during a short circuit without arc. The verification is done by visual inspection and measurement of the resistances per phase.

The data affecting the test and the simulations results are the ones explained in the relevant table of IEC 62271-307 . They are explained in the references IEC 61117, IEC 60865-1 and IEC 60865-2. The main ones are:
- The circulating electric current,
- The materials used in the conductor and insulating parts.
- The mechanical resistances of the insulators to compression, traction and flexion
- The geometry and spatial position of the conductors

For the sake of reproducibility, the measurement of the total per phase and partial electrical contacts resistances, before and after the test, shall be registered in laboratory test report.

The values of the data mentioned above shall be clearly registered in the test report trough drawings and photos,

If visible permanent deformations are identified after the test, they shall be registered by photos and an estimate of the maximum permanent sag after the test.

4   Working procedures

4.1   General
When dealing with subjects relating to the use of simulations or calculations to replace real laboratory tests, in product standards, committees shall follow the provisions of this Guide, which is to be used in conjunction with the ISO/IEC Directives.
The status of the simulation or calculation methods, as well as the acceptable values of tolerances, shall be re-evaluated during the maintenance process.

4.2   Product publications
Committees developing product publications, involving subjects covered by this Guide, shall incorporate this Guide into their own publication by reference. If necessary, they may specify, in their own publications, additional details relevant to their product area

5   QUALIFYING AND EXTENDING THE VALIDITY OF TESTS AND CERTIFICATES USING TESTING SIMULATIONS

5.1 Steps of the assessment

The initial procedure is to collect data and test reports results of an already (approved) tested design. Using transparent verifiable tools and methods the tests already done are to be simulated. The results of the simulations are compared with the test results to verify if they are within the acceptable tolerances presented in section 3.2.

The same testing simulations will be done in the untested sample to verify if an expected approval would occur, within the same requirements of the product standard.

The relevant design parameters considered in the simulations are the ones described in the relevant table of IEC TR 62271-307 . In addition to those parameters, data related to the weight of conductor materials, insulating materials and enclosures will be registered. The final objective is to calculate an indicator KG/MVA as defined in section 3.1.

The Certificate shall inform if the untested sample would be expected to be approved in the type tests and also the KG/MVA indicator. The relevant data shall be presented in a single figure like in the example in Section 5.2.

5.2 An example of a typical assessment

This example intend to facilitate the understanding of the concepts and how to register and compare test and test simulation results with the purposes of:

a) To validate a simulation model
b) To assess a specific design.
c) To register transparently the data supporting the emission of a Certificate

This example can be used as a reference for data to be included in test reports required by product standards, useful to support the preparation of future Certificates. It relates to typical medium voltage switchgear. The input data is showed in the Figure 2 and Table 2.

Typical comparisons between test and simulation results are presented for temperature rise tests (Table 3), internal arc tests (table 4) and short time withstand current, and peak withstand current tests (table 5). The data marked with (*) in Table 1 was intentionally omitted.

Table 2 – Input data for the simulation of temperature rise test, internal arc tests and short time current peak withstand tests

Rating	Value
Rated voltage (U_r) and number of phases	15,0 kV - 3Φ
Rated frequency (f_r)	60 Hz
Rated normal current (I_r)	(*) A rms
Rated short-time withstand current (I_k) and duration (s)	31,5 or 40,0 kA $_{rms}$ – 1s
Rated peak withstand current (I_p)	79 or 100 kA $_{cr}$
IAC (Internal Arc Classification)	IAC AFLR - 31,5 or 40,0 kA - 1,0s
Busbar dimensions and material	XX copper bars (*) x (*) mm per phase
Circuit breaker contacts resistance	<=45 Ohms E-6
Total resistance per phase	<= 112 Ohms E-6
Inlet and outlet free ventilation area (cm2)	(*) cm2 x (*) cm2
Forced ventilation rated if any (m3/h)	No
Pressure relief free area (cm2)	(*) cm2
Absorbers or parts like grids working as absorbers	Yes with a free area (*) cm2
Weight of conductor materials (Kg)	
Weight of insulating materials (Kg)	
Weight of enclosure and others (Kg)	

Table 3 – Temperature rise test and simulation results (K).

Point of the measurement	Test result (K)	Simulation result (K)
Connection at conductor # 1 (short circuit point)	47	42
Connection at the end of conductor # 3 (circuit breaker - low)	57	54
Connection at the end of conductor # 4 (circuit breaker-low)	64	66
Connection at the end of conductor # 5 (circuit breaker-high)	64	65
Connection at the end of conductor # 6 (circuit breaker-high)	52	53
Connection at end of conductor # 7 (top horizontal)	32	28
Enclosure door circuit breaker	5	
Fluid 50% height - cables compartment	not measured	13
Fluid 50% height - circuit breaker compartment	not measured	9
Fluid 50% height – bus-bars compartment	15	15

Table 4 – Internal arc test and simulation results (K).

Parameters	Test result	Simulation result
Symmetric or Asymmetric current	Asymmetric	
Arc voltage (V rms)	530	567
Maximum overpressure above 1 bar ΔP (%)	52	52
Overpressure duration (ms)	42	45
Integral Pressure curve along the time (bar*s*1000)	(*)	13
Time to 100% of overpressure peak ΔP (ms)	18	21
Time to 50% of overpressure peak ΔP (ms)	24~26	36

Table 5 – Short-time withstand current, and peak withstand current test and simulation results

	Test result	Simulation result
Max. Mechanical stress σ_H (N/mm2)	Not measured	94
Max. Mechanical stress σ_T (N/mm2)	(*)	18
Max. mechanical stress $\sigma_H + \sigma_T$ (N/mm2)	(*)	111
Max. Force on the insulator in compression or tension (N)	(*)	8918
Max. Force on the insulator in flexion (N)	(*)	5711

Figure 2 in next page.

Figure 2 – Input data to be used in the assessment of designs according to the parameters in the Tables of IEC 62271-307. The numbers of the conductors are the same used in Tables 2 to 5

SOME BOOKS WRITTEN BY SERGIO FEITOZA COSTA COVERING THE PLANET'S ENVIRONMENTAL ISSUES . Links to read the free book.

"Renewable Energy + Environmental Education to try to save the Planet (About Energy Transition, H2 Green, Hydrogen and how to ride this wave)"
http://www.cognitor.com.br/educationfortheplanet.pdf
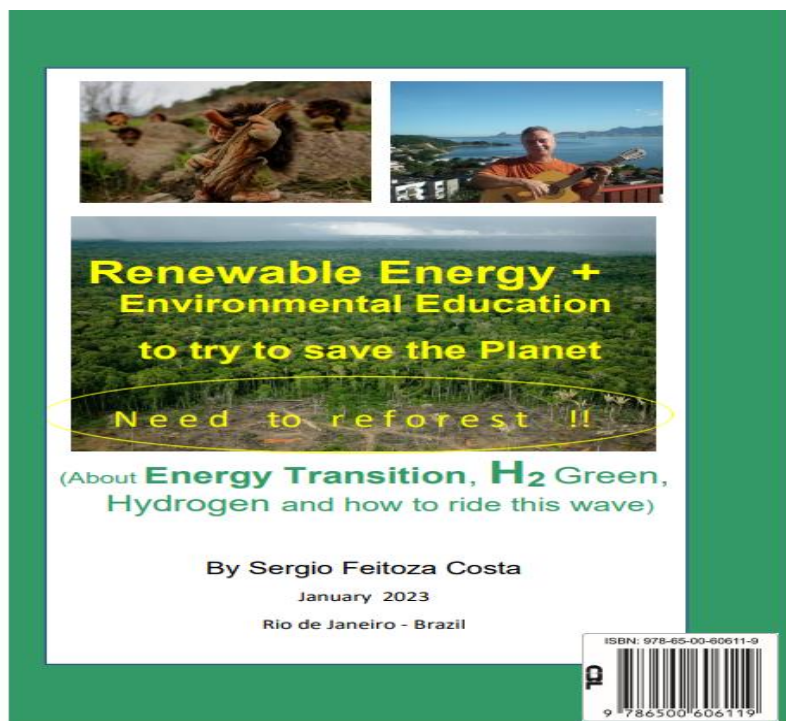
Project "Save Rio in 10 years" (the size of a mustard seed)
https://www.cognitor.com.br/saverioENG.pdf

The Cosmic Engineers in the Country of the TransAmazon Highway
https://www.cognitor.com.br/TheCosmicEngineers.pdf