PRIZE for PATENTS & INNOVATIONS. in power T&D products.

for saving Planet resources giving good ESG examples.

By Sergio Feitoza Costa

ABSTRACT

Imagine if **ABB, Schneider, Hitachi, Siemens, Eaton, and other global titans of the electrical industry banded together to improve their image as guardians of the environment**. They would hold a competition to disseminate ideas and concepts that could cut the amount of materials used in the electrical sector and boost energy efficiency by lowering power losses. The goal would be to develop more effective substitutes for the designs that have been commercialized globally for decades, since the time when taking care of the environment and saving the Earth's resources was not a priority. The terms "Temperature Rise Limits and IEC / IEEE technical standards" are the key, but it is missing an efficiency indicator like the kg/MVA transmitted of products to demonstrate that a design is better than others. It is unbelievable that these standards, at no time, encourage or mention that using fewer materials is good for the Planet. **In this article**, we present a suggestion for a technical standard. The central idea on how to organize the "PRIZE" is presented. We hope that this text will draw the attention of the senior management of these companies to the need to do the right thing in this difficult moment, as they did competently in the past. It would be great to see this text arriving to funds to support sustainable development and climate action.

Link for the article http://www.cognitor.com.br/demo1certificate.pdf

1. SAVING EARTH RESOURCES VIA ELECTRIC POWER INDUSTRY ACTORS

To facilitate the understanding, I will use as examples the low voltage (LV) and high voltage (HV) products like the electric panels of IEC62271 and IEC61439 standards series. They are a very visible part of the world-wide industry.

They consume a huge amount of materials such as copper, aluminum, insulating materials, steel. Their design and projects involve highly prepared specialists who, however, are rarely concerned with producing more efficient equipment that uses fewer materials. There is a reason for this. Commercialized products must meet the requirements of international technical standards like IEC and IEEE that, at no time, encourage or mention that using fewer materials is good for the Planet. These standards, with rare exceptions, are prepared and managed by specialists from these large companies. Only them, have the strength to make changes in the old paradigms.

Large global manufacturers like ABB, Eaton, GE, Hitachi, Schneider, and Siemens were the catalysts of the evolution of the electric industry from some 60 years ago. They invested in knowledge, people education & training, R&D centers and in big testing laboratories. It was due to their merits and the vision of countries close to them that the electrical industry grew with creative solutions for the time, but which today could be much more efficient using less materials. This happened at a time when environmental concerns were at the bottom of the list of priorities.

In despite of their beautiful environmental speech, the big manufacturers have difficulty leaving the comfort zone of commercializing old projects which are less efficient than would be possible today. It is similar to have the technology to build the modern, energy-efficient electric cars but continuing to produce and sale the cars of the 60's causing far more air pollution.

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It is this thinking and perception that needs to change, creating a new focus in which they can continue making their money and sharing the market, but acting at a higher level of environmental awareness. Working on large green energy projects is very welcome, but providing good examples that serve to educate their designers and users, all over the world, would give much more visible and sustainable results.

It is in this context that the idea of an "Environmental Efficiency Certificate for Electrical Products" comes into play.

A starting point to serve as a catalyst could be something never done before like an international "PRIZE FOR PATENTS & INNOVATIONS IN POWER T&D PRODUCTS". The best forums to discuss and promote an idea like this would be CIGRÈ and IEC because that's where these companies sit together to talk about technical things.

In the current scenario of irresponsible wars, the electrical industry can help to create a counterpoint to the enormous loss of credibility on the efforts to save the Planet, caused by wars. How can the common citizen be expected to believe the efforts to save the Planet are serious when rich countries make billions of dollars selling weapons of destruction?

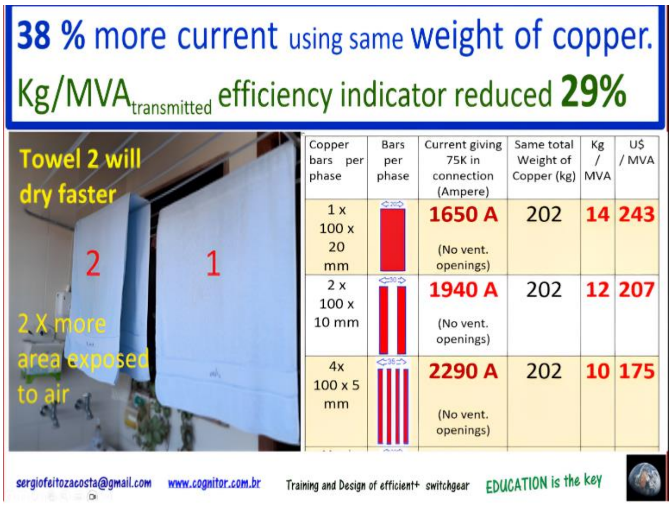
2. EASY TECHNOLOGIES AND A INDICATOR TO BE MORE EFFICIENT AND WASTE LESS RESOURCES

The big manufacturers already know how to produce more efficient solutions. If nowadays even individuals can easily create products with lower wight and resources (less kg/MVA), think how easy it would be for their competent R&D teams. Furthermore, the main players in the IEC are these manufacturers. If they present and defend more efficient products, everyone will follow their good examples.

They are who dictate what will be included in the IEC and IEEE standards. It would be easy and quick for them to put statements in IEC and IEEE standards encouraging the use of fewer materials and resources. This was done in the 80s in relation to EMC when all IEC product standards should include a statement about EMC. I saw this happen up close because at that time I chaired IEC's Technical Committee 32.

The IEC is not an independent neutral entity floating in the air. The IEC is the big manufacturers and a few big users. The common consumer, the citizen who pays taxes, is not represented in the development of international technical standards.

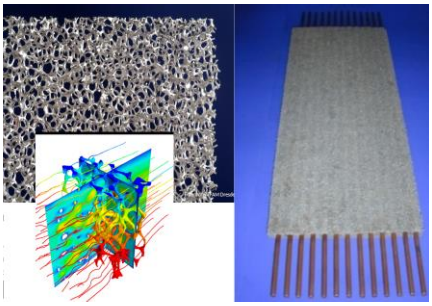
Figure 1 shows an example of how outdated designs might be modified to be more efficient while utilizing less copper. Consider an outdated project that, with a 1x100x20 mm copper bar, can conduct 1650A and pass the temperature rise test. By switching to a 2x100x10mm design, you may conduct 1940 A passing the same test. Better yet, if you utilize 4x100x5 mm as you pass the same test even though your weight remains the same at 2290 A. Implies a 39% greater current. **The efficiency indicator kg /MVA transmitted** is good to estimate the saving of materials with different designs, as in the table. Can be used to demonstrate, for marketing purposes, that a product is more "ESG" than others. ISO documents could use it.

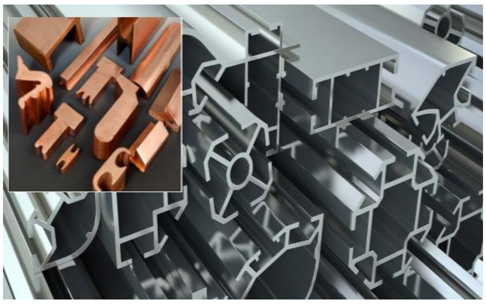


Other examples are,

(a) the use of metal foams in ceilings of enclosures and even in busbar electric conductor (higher heat dissipation)

(b) the use of extruded profiles in busbar electric conductors .





3. HOW TO ORGANIZE THE "PRIZE" FOCUSED IN A "ENVIRONMENTAL EFFICIENCY CERTIFICATE OF ELECTRIC PRODUCTS"

The "Prize" would be focused in showing that there is the intention to change something for better in direction to accessible technologies more efficient than the outdated ones. The PRIZE would be the proper moment to disseminate the idea of a new ISO or IEC document about a new type of certificate to be used in the market, to differentiate products.

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 will be clear enough to facilitate products buyers to select suppliers committed with higher efficiency. As explained after, declarations about the relevancy of a lower kg/MVA in product technical standards would accelerate the process.

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.

AS A SUGGESTION, THE ORGANIZATION OF THE PRIZE MAY FOLLOW THESE PREMISSES.

a) WHAT IS "THE PRIZE"

The PRIZE is a worldwide competition within the theme of "PATENTS & INNOVATIONS IN POWER T&D PRODUCTS for saving Planet resources". Each candidate project eligible to the PRIZE shall follow the SUBMISSION rules"). The prizes to be awarded are:

- 1st Prize of US$ 35 000,00 (Thirty-Five Thousand United States Dollars);
- 2nd Prize of US$ 20 000,00 (Twenty Thousand United States Dollars); and
- 3rd Prize of US$ 10 000,00 (Ten Thousand United States Dollars).

b) ELIGIBILITY OF PROJECTS AND COMPARISON PERFORMANCE INDICATOR

Each project shall auto-declare the phase of development like one of these alternatives:
** Registered Patent (stage from non-developed to near commercialization)
** Designed project in R&D phase needing to test a prototype
** Designed project with a prototype ready for tests
** Commercialized product trying to reach the market

The candidate project shall have, from the technical point of view (but not necessarily from the economical point of view) an expected performance better than the commonly commercialized products in the market. The term "better" here means having a lower weight per transmitted power (kG/MVA). Transmitted power, for example for an electric panel, is the product of the rated voltage by the rated normal current (multiplied by √3 if 3-phase). In the description of the project the candidate shall be skilled enough to give and order of magnitude of the kG/MVA of the proposed project and the kG/MVA products in the market). In other words, the candidate shall understand what is being improved.

There is no fee to register a candidate project for the PRIZE. Project authors may register either individually or as a group of co-authors. On registration, the contact author shall be clearly identified (individuals, institution or company, public e-mail, and clear contact information). The author will be the person with whom the organizers shall communicate in respect of all matters concerning the PRIZE. A 10 lines CV shall be included.

Authors and participating institutions may be from any country in the world and submit more than one project. All authors or co-authors must be living individuals and 18 years of age or older. Each winning submission shall receive only one award regardless of the number of co-authors.

c) HOW TO SUBMIT AND DESCRIBE A CANDIDATE PROJECT

The submission shall be made according to the instructions of the organizers presented in the link below. The project description is free and shall have no more than 4 pages, including figures photos. Being able to do a proper description is part of the aspects to consider in the project analysis. So, the description shall have focus on measurable results, advantages, and disadvantages. Avoid using formulas and descriptions not easily understandable by non-technical people.

As above, a candidate project shall have, from the technical point of view (but not necessarily from the economical point of view) an expected performance better than the commonly commercialized products in the market under the focus kG/MVA. Test reports and test simulation results may be used to demonstrate results. A key information is to include a comparison of the kG/MVA of the proposed project and the kG/MVA products in the market.

d) JUDGING AND AWARD CERIMONY

Submissions complying with the above rules will be reviewed by the PRIZE Advisory Council. More information about the methods are in the link at the end. The judges' decisions will be communicated directly to the winners and during the award ceremony as informed in the link below.

4. WHAT IS THE "ENVIRONMENTAL EFFICIENCY CERTIFICATE FOR ELECTRICAL PRODUCTS"?

More than the possibility of encouraging or exposing innovative ideas in efficiency, via designs, the PRIZE would be the proper moment to disseminate the idea of a new ISO or IEC document about a new type of certificate to be used in the market, to differentiate products that are better to the environment and use less Earth resources. Possibly as soon as become well understood it will possibly call the attention of funds to support sustainable development and climate action.

The "Environmental Efficiency Certificate for Electrical Products" is a document aimed at creating a difference that shows that a certified product with lower kg/MVA is better for the environment and saving the Earth's resources than another that is not certified. The draft rules to get the CERTIFICATE are explained below.

An important way to speed up the implementation of the certificate and its use in marketing strategies would be to include a mandatory statement in all IEC / IEEE product standards indicating that using less copper, aluminum, and insulators is good for the environment and that IEC standards encourage this. This "mandatory statement" could be more or less like:

> Products covered by this IEC / IEEE standard use significant amounts of copper, aluminum, insulators, and metals. Material savings are desirable for the Climate Change and Energy Transition initiatives. Products with designs that passes on the type tests and achieve lower values of weight by transmitted power (kg/MVA) are encouraged and considered environmentally better.

The implementation of the statement is like was done by IEC in the 80's to promote the importance of EMC (electromagnetic compatibility). It became mandatory that IEC technical standards should have a clause talking about the susceptibility or not of that product with EMC. Possibly behind that idea were concerns about future cyber-attacks and things of the same nature. Implementation was immediate.

Regarding the Certificate's commercial application, we assume that it will range from straightforward marketing applications to more intricate uses like "credits of higher environmental efficiency", similar to the idea of carbon credits. It is possible to imagine an association of values for this type of credits due to the simple economic difference in kg/MVA of less or more efficient projects.

A typical marketing strategy is manufacturing products with lower kG/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 kG/MVA values. Possibly, the first ones to obtain the Certificate would do campaigns to disclose who buys and who does not buy more efficient products.

THE BASIC RULES

This Certificate attests that the product 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). Weight per power is an indicator that can be associated with production cost divided by the transmitted power ($/MVA) . Looking at the example presented in Figure 1, the weight of copper is the same in the 3 cases but from the point of view of efficiency , the last line design of the table is much better.

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 design rules in 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.

> ISO Guide or IEC document draft? a key aspect is that to be accepted by people and buyers, *the rules must be written in an international standardization document*. A complete draft text prepared by me is presented in the Annex.

The written verification methods shall enable to compare the KG/MVA of different design alternatives. After a certain time and experience, the world values of these indicators will become well-known by users and manufacturers. It will become more evident that designs can become more efficient with simple existing techniques. The test reports issued by the qualified bodies to issue the Certificates must explicitly indicate whether the equipment has passed the tests or not and to write and demonstrate the KG/MVA indicators.

5. FINAL COMMENTS AND DRAFT TEXT OF THE GUIDE OR TECHNICAL STANDARD

Here is a suggestion and a concept for the major global manufacturers, such as Eaton, Siemens, ABB, Hitachi, Schneider, and others, to enhance their reputation as environmental stewards. They alone possess the strength to change the prevalent rationale in the modern electrical business, which ignores the need to utilize less resources and materials is good for the Planet. This omission is very visible in IEC/IEEE standards, which do not address the importance of "environmental efficiency" and instead concentrate solely on rigorous testing.

For example, about electric cars and green hydrogen, the evolution and good examples are already in the market. However, from domestic sockets, switches and electric showers to large substations, there are almost no good efficiency examples to follow. The waste of materials is enormous as old projects from 60 years ago prevail. Design could be much better now with known easy design techniques. That old designs were created in a moment when climate change and ESG where not a priority.

Any help in getting this message across to large manufacturers and those who promote actions to reduce the effects of climate change is welcome. The many global funds have resources for serious projects and ideas that attack the root of our problems.

There is a fantastic market for products with a “Certificate of Environmental Efficiency of Electric Products” . Rare electric products meet these requirements from low to very high voltages. Most of them can be improved to use less materials and still being approved in tests like temperature rise, internal arc, and short circuit strength.

From the commercial point of view, a good marketing strategy is building electric power products with lower 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.

In the Annex there is draft text of a guide / technical standard to support the issuance of the CERTIFICATE in the format of IEC and ISO documents. This text may be used freely for any person or institution which want to use it. Manufacturers, big electric products users, 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.

The electrical industry is very visible and can produce good examples to be followed.

ANNEX: BASE TEXT IN THE FORMAT OF ISO / IEC for

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 products that goes beyond the quality assured by prescribed type tests . The focus is on highlighting designs and construction actions on electrical power products that lead to lower weight per transmitted power (KG/MVA). This is directly associated with saving Earth materials and climate change. The indicator (KG/MVA) aims to characterize higher efficiency and lower use of materials. It can be used to improve 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, calculations, and simulations may be used.

Laboratory type testing, as specified in product standards, is the most used way to verify if a certain product attends the specifications. However, it is necessary to recognize that tests are expensive and a barrier for new developments. Nowadays there are lower cost alternatives of design verification like testing simulations.

Using the design parameters showed in the tables of IEC TR 62271-307 for Extension of Validity of Test Reports make easier to verify the higher efficiency of designs. Testing simulation techniques can predict results of most type tests. They enable to compare – at a low cost - different designs to see which one is more efficient (lower kG/MVA).

Let's use as an example a simple reference electrical busbar made of copper busbar 1x100x10 mm. The connection between bars is bare. Suppose you do a testing simulation increasing the value of electric current up to the level that the temperature rise of the hot spot is equal to the temperature rise limit prescribed in the technical standard (60K for bare connections). Then you will now do the same simulation for another electrical busbar equal but having 2x100x5mm busbars. The weight of both is the same but the second simulation will show that it is more to pass more current than the first test , reaching the same 60K. This means that the second design has the same weight but a lower kG/MVA than the first one. So, it is more efficient to save materials.

The main concern related to the use of testing simulations instead of real type tests is to be sure that their results are equal to the results of a real laboratory, within an acceptable tolerance. This Guide exemplify tolerances values and give guidelines to validate the methods. Temperature rise tests are the main test to define the weight of equipment busbars. The validation of the simulation method is simple because you just compare the temperature rise measured in the test with the simulation results.

The key aspect for analyzing if a certain design is more efficient than others, is to define an indicator reference values for the comparisons. To define initial reference values, world-wide queries can be made, initially only, for switchgear , switchboards, and busways (IEC 62271 and IEC 61439 series). You need only to know the weight of the equipment and the transmitted power of a product in the limit of passing in the test. So, you have the kg/MVA of that design. This Guide present some initial reference values of KG / MVA for typical commercial products.

GUIDELINES FOR THE IMPLEMENTATION 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 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 use less materials that is to have a lower KG / MVA.

The 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 to a lower use of copper, aluminum, insulating supports, materials etc. This is a measurable objective using an indicator like the weight per transmitted power (KG/MVA) of the product .

To facilitate the understanding lets consider switchgear produces according to IEC61439 or IEC62271 series. A simple example is that with a single copper bar 100x10 mm you may transmit a certain value of electric current attending a specified temperature rise limit. However, if you use 2x100x5mm (same weight) , for the same temperature rise value, you can transmit quite more current. Higher current means higher MVA and so the indicator KG/MVA is lower in the second case.

A key aspect is that this kind of verification, as in the example above, can be done using real laboratory tests or, faster and cheaper, using validated test simulations. By this reason this Guide give orientation on how to validate test simulations.

The main aspect behind the Certificate is that the product has passed all relevant type tests. The temperature rise test is of particular importance because the weight of busbar conductors is directly associated with the temperature rise limits specified in technical standards. Equipment is composed by conductors; busbar supports and enclosures. Usually, the biggest influence in the kG/MVA of a product is the weight of the busbars.

The Certificate shall be issued by third parties under the concepts in these Guidelines. The verifications and results that lead to the kG/MVA indicator shall be transparent, auditable, and reproducible. The design parameters presented in the tables of IEC TR 62271-307 shall be used.

The data to support the Certificate can be obtained from test reports or from validated testing simulations, considering the design parameters of the tables and concepts IEC TR 62271-307. This IEC document allows, if certain rules are met, to extend the validity of test reports of tests carried out on a certain product representative of a family, to demonstrates that if the tested one passed the tests, other similar non-tested ones would also pass. It is based on sound technical principles.

The extension of the validity of test reports seeks to avoid unnecessary repetition of tests of IEC 62271-200/201 standards. It can be used to extend type tests performed on one sample with a defined set of ratings for another product of the same family with a different set of ratings or different arrangements.

A relevant aspect in IEC62271-307 is the explicit mention to the use of testing simulations used in a comparative sense. If the testing simulations done in the tested equipment give the same results as the real test, they can 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.

It is expected that, after some time of application of this Guide, the world values of the kG/MVA indicator become well known, unlike today. The consequence will be creating a higher step of design efficiencies with less use of materials and lower weight.

The verification reports issued by the qualified certifiers shall indicate in clear words that the equipment has passed the tests and demonstrate KG/MVA indicators. It is particularly relevant the performance in temperature rise tests (weight of conductors), short circuit tests (higher electrodynamic forces means higher amount and weight of supports) and internal arc tests (weight of enclosures).

Some verifications are possible only when certain specific measurements are presented in the laboratory test report. So, the test reports shall include measurements and photographic registers that make the test to be reproducible .

It is not an objective of this Guide to present calculation methods. It is considered that a model or method is acceptable when it produces validated results within acceptable tolerances if compared with the real test results and this can be demonstrated in a transparent way.

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
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 comparing to laboratory test results

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 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 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 FOR CERTIFICATES

5.1 Steps of the assessment

The usual sequence to obtain the certificate is:

- Test a head of family product using the related product technical standard. Define the electric current (I) that will imply in reaching the permitted temperature rise limit in the hot spot. Register the total weight of the equipment The kG/MVA will be equal to the weight divided by 1.732 x I x rated voltage of the equipment. Simple like this.
- Search for a certification company able to analyze the data and to verify the correctness of the KG/MVA calculated values.
- This entity will issue the CERTIFICATE explaining the details transparently and making statements based on the values of kG/MVA currently practiced in the market.

The initial procedure is to collect data and test reports results of an already (approved) tested design. If testing simulations are used, they should use transparent and validated verifiable tools and methods.

The relevant design parameters to be considered in the tests or test 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 the 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

Text to be prepared, based on data below.

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

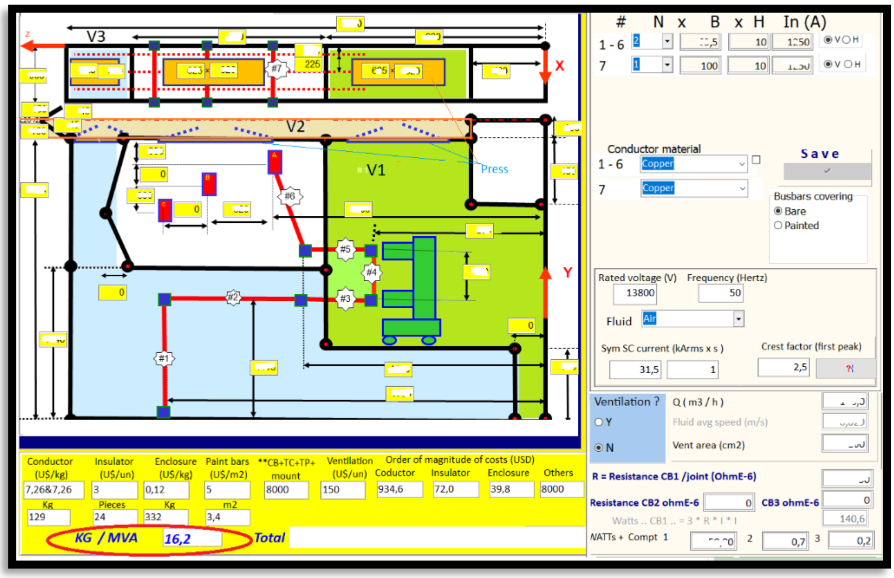
Table 4 – Internal arc test and simulation results (K).

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 – 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



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4 Recommended statements in IEC products standards.

IEC STANDARDS STATEMENT about SAVING MATERIALS (as was done with EMC in 1980s):
Reduced use of copper, aluminum & insulators is beneficial for the environment. All product standards should add this clause: "PRODUCTS COVERED BY THIS STANDARD use significant amounts of copper, aluminum, insulators, and metals. Material savings are desirable for the Climate Change and Energy Transition initiatives. IEC promotes designs and methods that lower the kg/MVA" designs.

REFERENCES

[1] IEC TR 60943:1998 - Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals. Issued by IEC Technical Committee TC 32.

[2] CIGRÈ BROCHURE 830 (2021) – "SIMULATIONS FOR TEMPERATURE RISE CALCULATION".

[3] Cigrè Brochure 740 (2018) Contemporary design of low-cost substations in developing countries.

[4]_**CIGRÈ BROCHURE 602 (2014)** Tools for Simulation of The Effects of the Internal Arc in T&D Switchgear,

[5] IEC62271-307 (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.

END OF THE DRAFT STANDARD

OTHER REFERENCES

[6] Article "TEMPERATURE RISE LIMITS OF IEC 61439-1 : unclear values distort the LV switchgear market. (May,12, 2023) - http://www.cognitor.com.br/IEC614391Table6.pdf

[7] Article "METAL FOAM in SWITCHGEAR, switchboards & bus ducts
http://www.cognitor.com.br/switchgearmetalfoam.pdf

[8] SUBSTATIONS & LINES INNOVATIVE PRODUCTS. SMALL R&D CENTRES + TESTING LABORATORY
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