COGNITOR Consultancy, R&D and Training Ltd

# Table 6 of IEC 61439-1: Questions to CERTIFIERS & TESTING LABORATORIES:

- Responsibility of approving or certifying LV switchgear: **what temperature rise limits to use?**
- Less labs can do the test using the "new" test method: **test has become more complex, or the confusing text is not well understood …. and that's why the labs say they can't do it?** .
- If IEC60439 method was not good, **should old designs be re-tested by IEC 61439-1 ?.**

- Certifiers & labs use the limit values in Table 6 to be able to approve or certify. Limits for connections, the hotspot, are not written and **allow for very different interpretations. (60K to 105 K)**
- The phrase "**According to the requirements of the component standard or the manufacturer's is not an objective or verifiable statement"** (ISO9000). Connection limits depend only on the materials.
- **Insurers and Liabilities:** e.g., if fire or loss due to accelerated aging occurs, due to use of temperature rise limits above technically recognized limits, who is responsible, from the point of view of insurers?
- **Temperature rise limit of a connection is the lower value of the 2 parts:** if you join a circuit breaker (85K) and a busbar (60/75K), by sound engineering rules, the limit is the lower of the two values – and not the breaker/component value (IEC60943). The concept of note (b) for terminals should also apply here.
- **Mention of 105 K leads to wrong thinking** that this is the limit for connections: possibly, in the past, the term "temperature (40+75=115K) was confused with "temperature rise" and it became the "truth".
- **Test reports without "pass/fail" conclusion are not safe** for users: impossible to know if passed or not.
- **Easy SOLUTION: replace the confusing Table 6 IEC 61439-1 by the transparent Table 14 of IEC62271-1.**

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Suggestion for **C I G R È A3+B3** impacting WG: ***EVALUATE HOW MUCH TEMPERATURE RISE LIMITS USED IN IEC STANDARDS CAN BE INCREASED*** *enabling real savings of Planet resources.*

Keywords: AIS, GIS, TRIAX, Low Cost Substations, Brochure Cigrè 740,, Substations, New Technologies, Innovation, Optimization, Power Transformers, Reactors, Switchgear, Design, Reduction of costs, validation, High Power, Testing, Laboratory, Simulations, Calculations, IEC Standards, Busbar, Busway, Switchboard, Internal Arcs, Overpressures, Temperature rise, Electrodynamical stresses, Short time currents, Magnetic Fields, Electric Fields, IEC 60076, IEC 62271, IEC 61439, Testing Laboratory

## 1. TEMPERATURE RISE: TEXT OF IEC61439-1 IS A BARRIER TO LIGHTER AND MORE EFFICIENT DESIGNS

The text of IEC 61439-1 has two impacting deficiencies that impact on the world market of low voltage switchgear. I alert about this for more than 10 years. Nothing changed in 2022 revision 2022 .

The first one and more important is the poorly written text in Table 6 on temperature rise limits. It mixes up concepts (temperature X temperature rise) and induce to errors. These limits are the key factor in defining project costs, directly affecting the weight and efficiency of the product. Higher temperature rise limits means less use of copper or aluminum. Potential to lead to legal issues in bids.

The second deficiency is the change in the temperature rise test method of section 10.10 of IEC 61439-1 (2022) . In IEC 60439-1 (TTA/PTTA) was allowed the use of 1 current source plus some resistors. IEC 61439-1 is different and required, without significant or proved technical advantages, the use of , at least, two current sources plus resistors . Was there really an intentional change to create a much more difficult test or did the bad writing mislead labs into thinking it's a much more complex test?

The fact is that the change has increased the cost and duration of testing and decreased the number of test labs that can perform it. To exemplify, Brazilian laboratories that could perform the IEC 60439 test now say they cannot perform it by IEC61439-1. I think that most do not understand the confusing text describing the test method and temperature rise limits. I prepared an explanatory figure later in this text. This figure is my interpretation of what is written there.

This change created an obvious barrier for manufacturers trying to develop more efficient designs. If changing the method was really necessary it should be included in IEC61439-1 a statement to specify that, *"for new products derived from old designs already tested (original product & derived) it is necessary to re-test using the new method in IEC61439-1".* This would demonstrate coherence.

There is a paragraph in section 10.1 stating that ***" If the tests were made by IEC 60439, before the publication of the product standard of series IEC 61439 and the results met the requirements of IEC 61439 tests need not be repeated."*** Reading this sentence, as the test method changed, previous temperature rise test should be done again. It is obvious that this was not the intention.

To correct this error, IEC61439-1 should - at the very least - include a statement specifying that the "new" test method is preferred, but the old one can be used alternatively. In addition, it must include an explanatory figure, as shown below, making it clear what the IEC61439-1 temperature rise test is. Reading this figure, possibly some laboratories will realize that they can perform the test.

***This article aims***, mainly, to ask certifiers and testing laboratories what criteria they use to approve or certify low voltage electrical panels in terms of temperature rise. The article also aims to understand whether testing laboratories and certifiers consider ethically correct to issue an official test report – third party – without an "approved/failed" conclusion. I imagine they know how the report can be used, especially in countries with few testing laboratories like Brazil. I explain the differences between the test methods and present a suggestion to Cigrè to assess if the temperature rise limits currently used in IEC standards can be increased. This would bring a considerable saving of copper and aluminum all over the World. It is a way of transforming beautiful environmental speeches in short-term objective actions.

## 2. HOW TESTING LABORATORIES & CERTIFIERS PROCEED USING TABLE 6

I have been publishing articles and posts on LinkedIn in the hope that some of the 27,000+ followers in the electrical industry will comment on the questions above. I never received detailed comments from these colleagues. Earlier I had written to the IEC experts asking the same questions, but I did not receive an enlightening response. There are posts about the matter in the link linkedin.com/in/SergioFeitozaCosta

The background of these issues is that the low voltage switchgear market, currently valued at around $100 billion, is expected to grow by 35% by 2030, according to this "Facts & Factors" report. A technical standard that allows for different interpretations, which imply different production costs, has a direct impact on bidding processes and may even involve legal responsibilities.

https://finance.yahoo.com/news/unveiling-potential-low-voltage-switchgear-210100847.html#:~:text=NEW%20YORK%2C%20June%2022%2C%202023,5.1%25%20from%202023%20to%202030.

***Why different interpretations of Table 6 affect bids?***

In the temperature rise test, passing or failing depends on the limits specified in the standard table. Temperature rise is the main factor that defines project weights and costs. To pass the test, with a temperature rise of 105K (temperature 40 +105=145 ºC) the panel can be designed using much thinner copper bars than if you make a design not to exceed a temperature rise of 75K. (silvered) or 60K (bare). The manufacturer that designs and tests for 105K will have a clear advantage over the one that designs for 60K or 75K.

It is not fair that the manufacturer who made the technically correct connections (60K/75K) is at a disadvantage in terms of price. Laboratories and certifiers should consider this when preparing reports that will arrive to buyers.

In this table you can understand the orders of magnitude for natural ventilation (180 $cm^2$)

| Temperature rise Limit (K) | Power dissipation of main circuit breaker 3ϕ (Watts) | | |
|---|---|---|---|
| | **150W** | **300W** | **600W** |
| **60K** (bare) | **1 x 160x10** (50%) | **2 x 160x10** (100%) | **2 x 250x10** (156%) |
| **75K** (silvered / recommended) | **2 x 120x10** (75%) | **2 x 140x10** (87%) | **2 x 160x10** (100% weight) |
| **85K** (if erroneously you consider the CB limit) | **1 x 150x10** (47%) | **2 x 80x10** (50%) | **2 x 120 x 10** (75%) |
| **105K** ( understood by some people reading table6 of IEC61439-1) | **1 x 100x10** (31%) | **1 x 110x10** (34%) | **2 x 80 x 10** (50%) |

***Working above limits = much higher aging:***
There is a serious aspect related to durability. According to the IEC TR 60943 document, connections in the 105K design will age at least twice as fast as if designed for 60 or 75K.
Read calculation on pages 112 to 117 of this book. https://www.cognitor.com.br/Book_SE_SW_2013_ENG.pdf .
Less aging of materials means less use of materials and effects on the environment.

I think that approving or certifying equipment that will be sold to the market involves responsibilities for those who elaborate the technical standards and for the labs and certifiers that use them and, indirectly, confirm the text of the technical standard. Those responsible for purchasing LV electric panels in the oil, chemical, mining, and large building industries are often making a lot of purchases. They could help us commenting on how they approach this subject, even if they never noticed the problem.

Many people think that technical standards are perfect and unquestionable. I learned, coordinating, and participating in IEC and ABNT working groups that are not even close to this. Standards are the possible compromise between those who participate in their elaboration. Those who do not participate and vote remotely rarely have a full understanding of the text.

The text of technical standards is the possible compromise between the companies that elaborate them. In the case of electrical panels, most working groups (WG) participants are the large international manufacturers that license and sell their products all over the Planet. The focus of discussions at WG meetings is on short-term technical issues. *The IEC and IEEE standards do not attach any importance to encouraging or inducing the economy of the Planet's resources*. If who prepares the text has no interest in it changing, for some reason, the bad text is perpetuated.

My experience of 25 years doing tests and deploying and managing large testing laboratories tells me that when a 3rd party laboratory issues a test report without including the statement (passed / failed) it may be giving the false impression that the equipment has passed the test, even if it did not pass.

In Brazil, where I live, it is more common to find test reports without statements "passed / failed".
Very possibly, most of them are used for commercialization. I think that some buyers accept them because they don't understand what's behind the tables and numbers or because they consider that having a document in hand is enough to exempt themselves from the responsibilities.

If even laboratory experts cannot understand the temperature rise limits set in Table 6 of IEC61439-1, imagine a purchasing user who may have small technical knowledge. I always recommend to my consultancy services clients not to use testing laboratories that do not include those statements.

Sometimes I read in test reports phrases saying that that report is valid only for the tested sample and other things that aim to exempt the laboratory from any responsibility for the future use of the test report. Who writes this kind of statement ignore that the only reason most customers do pay a lot of money to do expensive tests is to have a test report in hands to use for commercial purposes. My intuition tells me that these phrases do not exempt from responsibility.

The most frequent doubt of my consultancy customers for whom I do calculations, in countries around the world, is: **"What is the temperature rise allowed, in the test, for the connection between the circuit breaker terminals and the busbar that feeds the breaker".** The hottest, critical spot for passing the test in general is over there. This defines how much copper or aluminum will be spent in the construction.

The recommendation I give to my consultancy clients is to "do the right thing" because a day the confusions caused by Table 6 of IEC61439-1 will be corrected. Until that happens, I recommend using the IEC62271-1 table, which is transparent and leaves no room for doubts.
Medium or low voltage panels use the same conductive and insulating materials and have the same functions. Why would the requirements for low voltage switchgear be different from those appearing in almost all other IEC standards?

Incidentally, by the rules of common sense, all IEC standards could reference a single temperature rise table. The best candidate to be this table would be the one in the document.
IEC TR 60943 - GUIDANCE CONCERNING THE PERMISSIBLE TEMPERATURE RISE FOR PARTS OF ELECTRICAL EQUIPMENT, IN PARTICULAR FOR TERMINALS. It is like the table in IEC 62271-1 (HV/MV switchgear).

The IEC TR 60943 is little known. I came across it, almost by chance, when it was published for the first time by the Technical Committee 32 of the IEC – FUSES, when I chaired that committee. IEC TR 60943 explains the fundaments of temperature rise limit values and even teaches how to calculate accelerated aging caused by using temperatures above material limits. Look on pages 112 to 117 of this my book used in the trainings I apply https://www.cognitor.com.br/Book_SE_SW_2013_ENG.pdf

As an example of the calculations shown on these pages, using a temperature rise in the connections 10K above the temperature rise limit allowed in the standard table, implies an aging that would reduce the lifetime to about 33% (1/3). To understand better, if they were components with an expected useful life of 10 years, using 10K above the standard limit you would have to buy 3 instead of 1 in that 10-year period.

Returning to the recommendations I give my customers, if they want to use the undefined table 6 of IEC61439-1 I explain that if the silver bus connection has a 75K limit (or 60 K in bare bars) and the circuit breaker terminal supports 85K, the limit of the connection to say whether or not it passed the test, it is the smaller of the two values (75K/60K) . It is the same concept of Note b of table 6 of the standard that mention terminals to connect to external cables but do not mention the internal connections.

For those who want to risk using limits higher than 60/75K I comment that many buyers will accept it and others not, but certainly one day the confusing text will be corrected and then they may have to repeat tests or redo the design.

Check Annex A to understand the main differences between tables and the confusing points of IEC61439-1

## 3. SOLVING THE PROBLEM and PRESENTING A SUGGESTION TO CIGRE INTERNATIONAL on ASSESSING HOW MUCH TEMPERATURE RISE LIMITS USED IN IEC STANDARDS CAN BE INCREASED

Temperature rise of 105K means a temperature of 40 + 105 = 145°C. From the point of view of temperature rise, low and high voltage switchgear are the same and have the same functionalities and materials. For silver coated connections, IEC62271-1 accepts a maximum temperature rise 75K which corresponds to a maximum temperature of 75+40= 115°C.

The problem is that, reading Table 6 of IEC61439-1 the average reader may interpret the text as accepting maximum temperature rise 75K, in a silvered connection. This means a temperature 105+40= 145°C. There is no technical reason for the difference and one of the standards seems wrong or poorly written. Looking at IEC TR 60943, the world's most comprehensive document on temperature rise, it is easy to see that IEC 62271-1 is the best table to use.

The cause of potential problems in tenders is that a well-designed switchgear for a 115K connection will have a production cost of about 75% of the cost of one designed for 75K. This is because it will use much less copper or aluminum. In summary, a 105K device has a lower production cost and shorter connection time life compared to a device designed for 75K.

<u>HOW TO SOLVE THE PROBLEM in table 6 of IEC61439-1 IN THE SHORT TERM</u>

If the experts that prepare the standard maintenance recognize that the table is not well written the solution is simple. The only thing to do is to REPLACE TABLE 6 of IEC 61439-1 BY TABLE OF IEC62271-1 or IEC TR 60943.

<u>IF THERE ARE NO PROBLEMS, FOR DECADES, COULD THE TEMPERATURE RISE LIMITS INCREASE BY 10 to 15K?</u>

First, we must investigate if an equipment that is designed above 75K has given problems. It is rare to see well-founded technical publications about problems with low voltage panels, due to high temperatures in the connections. In Linkedin posts sometimes we see photos of thermography that indicate problems. However, these are quick posts, and it is not possible to get consistent technical information in many cases.

It may also be that few problems of this type occur in panels because the temperature rise limits for panels and busbars could be higher than the values shown in the IEC 62271-1 Table. I think this is a real fact. Many standards have stricter requirements than necessary because they were made in the old times of the fat cows and after that almost nobody invests in R&D to be able to change something. Try to find in the web.

Being able to increase the limits would be an important "innovation". The Brazilian agency ANEEL could even put the topic on its list of preferred R&D projects. If the temperature rises limits of the IEC and IEEE standards could be increased by 10K to 15K, equipment could use much less copper/aluminium than it does today. This would be good to save the planet's resources.

Historically, the maximum temperatures acceptable for materials, which imply the limits described in the standards, are values obtained from experience over time, to avoid accelerated aging (IEC TR60943). As the laboratory tests can be carried out at any ambient temperature, the parameter measured and indicated in the tables is the temperature rise and not the temperature. If the equipment is going to be used in a place with a predominant ambient temperature higher than 40ºC, for example 45ºC , the limits of the IEC table must be reduced by 45ºC-40ºC = 5ºC.

In these cases, manufacturers may recommend using lower currents (derating) so that the maximum temperatures acceptable for the materials are not exceeded.

SUGGESTION TO CIGRE INTERNATIONAL: EVALUATE HOW MUCH TEMPERATURE RISE LIMITS USED IN IEC STANDARDS CAN BE INCREATED

Cigrè is the more competent institution to carry out a worldwide consultation with its partners and R&D to review the current temperature limits for connections and electrical contacts. Most likely the experience of the last 5 decades will indicate that at least 10 to 15K can be increased. The consequence of this would be lower consumption of copper and aluminum by the electrical industry. The Planet will thank you.

Another competent “Green Books” could even be born. By the way, these books did not receive this name due to commitments to the environment and saving resources on the Planet, but the term would fit well as a positive example for the electrical industry.

The most experienced professionals in this subject are those who are well acquainted with the details of the tables of temperature rise limits of IEC 62271-1 (SC32A) and IEC TR 60943 (TC32), which would be the basis of this work.

**Read here a draft Term of Reference (TOR) in the format Cigrè.**

CIGRE Study Committee B3 - **PROPOSAL FOR THE CREATION OF A NEW WORKING GROUP**

| WG N° B3.xxx | Written by: Sergio Feitoza Costa<br>E-mail sergiofeitozacosta@gmail.com |
|---|---|

**Title of the Group: TEMPERATURE RISE LIMITS INCREASE (for lighter products)**

**Background :** According to the World Economic Forum 2022 a main issue is the "failure to mitigate climate change". Also, in the top5 is the "natural resources crisis". Both are behind the Energy Transition efforts. Cigrè and IEC are the main world voices, of the electric power industry. Their visibility facilitates to expose objective practical examples in the direction of saving natural resources. Technical standards do not yet signalize or encourage the use of fewer materials such as copper, aluminum, and other materials. For products fabrication and use, standards are still focused, as 50 years ago, in being approved in severe tests. Specifications are rarely associated to a useful life of less than 40 years.

The "Temperature rise test" is decisive to define the weight of conductors materials used in the products design. The easier items to see this are switchgear of any voltage (e.g., IEC 61271 series). However, this applies also to from big transformers to single substations busbars. From ultra-high voltage to low voltages, all of them use the same materials. Mostly, the "hot spots" that define if the product will pass or not in the temperature rise test are the connections between busbars and to other components like circuit breakers and disconnectors. The temperature rise limits of hot spots depend on the materials and not on the type of product. This is easier to see in Table 14 of IEC62271-1 which define values like 60K (bare connections) or 75K (silver or nickel-coated). As the design and objectives are not to go above limits, if you have higher limits, you can use less weight of conductors materials. If limits used today could be increased in only some 10 to 15K, this would mean a weight reduction around 25 to 35%. It is difficult to find bibliography to understand how the limits were stablished in the past and if the knowledge available today would enable their desirable increase. A key to define limits is to associate them to a time life, like 50 years. Was this approach used in the past? IEC TR 60943 enables to calculate aging when equipment is used above the limits but do not give parameters to know if limits could be increased. Some of these aspects were touched in Cigrè brochures 830 (2021 – simulation of temperature rise), Brochure 830 (2021 – low-cost substations) and 602 (2014 – simulations internal arc). To achieve WG goals, testing simulations would enable to do in a fast and easy way the needed design verifications.

**Scope :** The objective of the WG work is to assess if the temperature rise limits used in IEC standards – for connections and contacts (only) could be increased and by how much. The steps would be:

- Raise the history that led to the limits used today (consultations to experts and documentation). Clarify the duration of useful life they were associated with.
- Survey the R&D activities that have been carried out recently and that can bring evidence to propose raising the current limits (worldwide questionnaire and consultation with experts IEC, IEEE, etc...)
- Survey of the existence or not of systematic problems with aspects of temperature rise. Focus in switchgear. If there are few problems possibly limits can be increased (questionnaire)
- To write a brochure including the conclusions of the work. In the results, to indicate the positive and negative impacts of increasing the temperature rise limits by 10K or 15K or 20K or more.

**Deliverables :**

Technical brochure, summary in Electra and other publications, Tutorial

**Time Schedule**: start: November 2023 **Final report**: Late 2025

# Relevant literature

A3 - Brochure Cigrè 602 ( 2014 ) - Tools for simulation of the internal arc effects in HV and MV switchgear

A3 – Brochure Cigrè 830 (2021) - Application and Benchmark of Multiphysics Simulation Tools for Temperature Rise Calculations

B3 – Brochure Cigrè 740 - Contemporary design of low-cost substations in developing countries

IEC TR 60943 - 1998 - Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals..

## 4. UNDERSTANDING THE CHANGE OF TEMPERATURE RISE TEST METHOD

Several colleagues from different testing laboratories told me that their lab could do the temperature rise tests in a LV switchboard according to IEC 60439 but could not do it according to IEC 61439-1.

The doubt was about the necessary number of current sources. Before, in IEC60430 (TTA/PTTA) the concept was to use one source to test the main circuit. The additional smaller circuits would be represented by resistors with would represent the same value of Watts produced in the busbars, connections, and contacts. It is easy to demonstrate with tests and simulation software that this works sufficiently well.

In IEC61439-1 the test method changed. The text written in the standard is so confusing that is almost impossible to understand what we need to do. I imagine that the reasoning is to be near to represent all the loads as in normal use. This is not reasonable because would need excessive resources in terms of current sources.

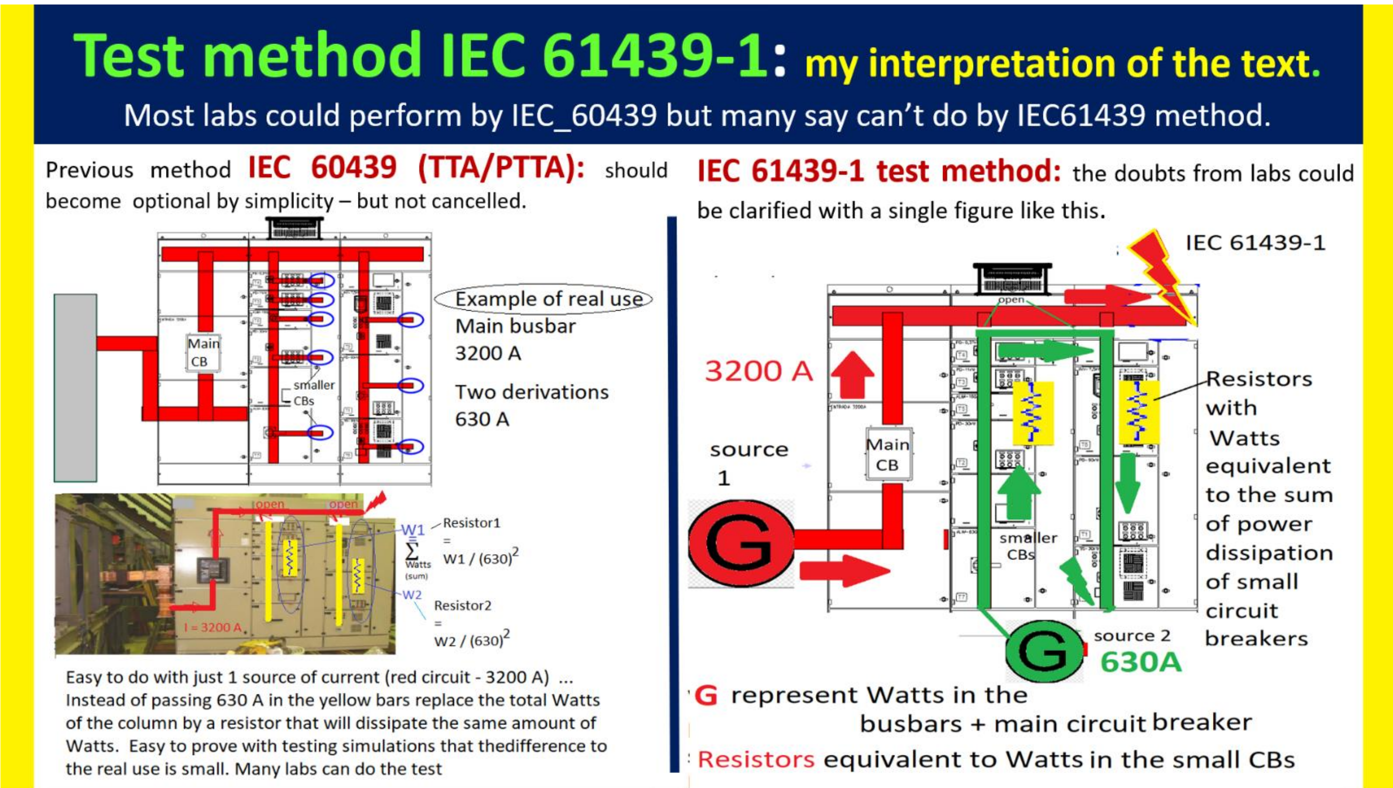
More than the technical difficulties, the need of several additional current sources means that less laboratories would be able to do the test. Also, the test price and duration would become much higher.
I do not believe that renowned experts, from the world's largest companies, who prepare this standard (link) would fail to see something so important. This IEC page show the maintenance team
https://www.iec.ch/dyn/www/f?p=103:14:300005418930343::::FSP_ORG_ID:10644

Having this in mind, weeks ago, I went to read once more the text of section 10.10 of IEC61439-1 (Temperature Rise) but under the vision that the intention of the change of method was not to be drastic. but that the text was simply poorly worded.

After reading, my_interpretation is that the main objective was to improve the method to use more current sources but not many, as I show in the following Figure.
If the standard had a simple figure like this, it would be easier for testing labs to understand how to do the test. Many of them would stop to say that cannot do the test.

It would be great if someone from MT2 commented on whether this figure represents the intention and, if not represent, MT2 could present a figure understandable by the laboratory teams.
Do not confuse this figure with those in Annex E2 (diversity factor). Those figures do not represent the test method.

The fact is that I identified that the mentioned laboratories could carry out the test using my figure, but they were interpreting that they should use many more current sources.




## 5. FINAL COMMENTS

Imagine the situation of a manufacturer who lost a bid because designed a LV switchgear for a temperature rise limit of 75K (correct but uses more copper). Imagine that you lost out to someone else who might offer a lower price because interpreted the standard's limit as 105K. In large bids, this would possibly generate resources that justify having to repeat the bid.

I do not see testing laboratories and certification companies using uniform criteria when interpreting table 6 of the technical standard IEC 61439-1. What is the interpretation do they give to the confusing table? Do they consider reasonable to issue a test report without a statement "approved / not approved"?

IEC management could investigate this problem. It is not just a technical issue. It involves consequences on the world market for low voltage switchgear.

IEC Technical Standards are far from perfect texts and improve with time and use. However, it is not common to keep an unclear text for so long, generating an obvious confusion in the market. What is the reason?

Making changes in testing methods that make more expensive something that has been working well for a long time is uncommon in IEC practices. It reduces the number of testing laboratories that can perform it. This change of method should be optional because makes testing more expensive for small and medium manufacturers. The text shall be improved to avoid the misunderstandings mentioned before.

A new CIGRÈ working group (A3 + B3) could carry out a worldwide consultation with its partners and R&D to review the current temperature rise limits for connections and electrical contacts. The experience gained in the last 5 decades will indicate that at least 10 to 15K can be increased. The consequence of this would be lower consumption of copper and aluminum by the electrical industry. The Planet will thank you.

Institutions that promote R&D projects focused on the electricity sector, such as the Brazilian agency ANEEL, could include this theme in their list of desirable projects.

We shall remember that it is time to open an explicit door for the use of validated testing simulations. The concept is to simulate the old test comparing simulation results with test results and then applying the same simulation method to the new product. This is technically more complete that using only IEC 60890 for air temperature rise extrapolations.

**Table 6 of IEC 61439-1 (temperature rise limits)** is confusing and allows for misinterpretation. The opposite of what a global normative text should be.

Most people do not understand but accepts without questioning as in the Christian Andersen's fable "The Emperor's New Clothes".

Read article in the link above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# REFERENCES:

[1] C.V: https://www.cognitor.com.br/Curriculum.html

[2] Things I helped to do: https://www.cognitor.com.br/HelpedToDo.pdf

[3] Free Book *"Switchgear, Busways, Isolators - Substations & Lines"* *(available also in Spanish and Portuguese)*

https://www.cognitor.com.br/Book_SE_SW_2013_ENG.pdf

Link for this article:
English: http://www.cognitor.com.br/IEC614391Table6.pdf

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Just to register, this revision of the article was posted in Linkedin by Sergio Feitoza Costa on July, 30 - 2023

LINKEDIN by Sergio with many technical posts : https://www.linkedin.com/in/sergiofeitozacosta/

**Annex A: HIGHLIGHTING AND COMMENTING** (with SFC ) **CONFUSING PARTS OF TABLE 6 OF IEC 61439-1 ( LV switchgear) an comparison with the table in IEC 62271-1 ( HV switchgear)**

## Table 6 of IEC61439-1 (2022) Low voltage switchgear

**Table 6 – Temperature-rise limits (9.2)**

| Parts of assemblies | Temperature-rise K |
|---|---|
| Built-in components [a] | In accordance with the relevant product standard requirements for the individual components or, in accordance with the component manufacturer's instructions[f], taking into consideration the temperature in the assembly |
| Terminals for external insulated conductors | 70[b] |
| Busbars and conductors | Limited by[f]:<br>– mechanical strength of conducting material[g];<br>– possible effect on adjacent equipment;<br>– permissible temperature limit of the insulating materials in contact with the conductor;<br>– effect of the temperature of the conductor on the apparatus connected to it;<br>– for plug-in contacts, nature and surface treatment of the contact material |
| Manual operating means:<br>– of metal<br>– of insulating material | <br>15[c,h]<br>25[c,h] |
| Accessible external enclosures and covers:<br>– metal surfaces<br>– insulating surfaces | <br>30[d,h]<br>40[d,h] |
| Discrete arrangements of plug and socket-type connections | Determined by the limit for those components of the related equipment of which they form part[e] |
| The temperature-rise limits given in this table apply for a daily average ambient air temperature up to 35 °C under service conditions (see 7.1). During verification a different ambient air temperature is permissible (see 10.10.2.3.4). | |
| [a] The term "built-in components" means: | |

SFC: Leads to error. The limits depend only on the materials used. If informed by the manufacturer to the laboratory before the test, it must be included in the test report. With this, the laboratory can approve or disapprove.

ERROR: should mention the word "connection" but mention "terminals"

Solution: Replace the complete table and its notes by the good and clear table of IEC62271-1

SFC: Error because goes against ISO9000 fundamentals on "Unmeasurable and unverifiable requirements

# Notes of the table 6 of IEC 61439-1

The temperature-rise limits given in this table apply for a daily average ambient air temperature up to 35 °C under service conditions (see 7.1). During verification a different ambient air temperature is permissible (see 10.10.2.3.4).

[a] The term "built-in components" means:

- conventional switchgear and controlgear;
- electronic sub-assemblies (e.g. rectifier bridge, printed circuit);
- parts of the equipment (e.g. regulator, stabilized power supply unit, operational amplifier).

[b] The temperature-rise limit of 70 K is a value based on the conventional test of 10.10. An assembly used or tested under installation conditions may have connections, the type, nature and disposition of which will not be the same as those adopted for the test, and a different temperature-rise of terminals may result and may be required or accepted. Where the terminals of the built-in component are also the terminals for external insulated conductors, the lower of the corresponding temperature-rise limits shall be applied. The temperature-rise limit is the lower of the maximum temperature-rise specified by the component manufacturer and 70 K. In the absence of manufacturer's instructions, it is the limit specified by the built-in component product standard but not exceeding 70 K. For terminals of the built-in component that are terminals for external insulated conductors, the thermocouple for the temperature-rise test shall not be placed on the test conductor insulation.

[c] Manual operating means within assemblies which are only accessible after the assembly has been opened, for example draw-out handles which are not operated while the assembly is in normal service, are permitted to sustain a 25 K increase on these temperature-rise limits.

[d] Unless otherwise specified, in the case of covers and enclosures, which are accessible but need not be touched during normal operation, a 10 K increase on these temperature-rise limits is permissible. External surfaces and parts over 2 m from the base of the assembly are considered inaccessible.

[e] This allows a degree of flexibility in respect of equipment (e.g. electronic devices) which is subject to temperature-rise limits different from those normally associated with switchgear and controlgear.

[f] For temperature-rise tests according to 10.10, the temperature-rise limits have to be specified by the original manufacturer. It is the responsibility of the original manufacturer to take into account any additional measuring points and limits imposed by the component manufacturer.

[g] Assuming all other criteria listed are met, a maximum temperature-rise of 105 K for copper busbars and conductors shall not be exceeded. The 105 K relates to the temperature above which annealing of copper is likely to occur. In the absence of a declaration from the original manufacturer, regarding the reliability and stability of the ageing behaviour of the electrical contact or joint, a maximum temperature-rise of 55 K for bare (uncoated) aluminium busbars and conductors is applicable.

[h] Where an assembly is installed in an ambient air temperature exceeding a daily average of 35 °C, a higher absolute temperature (°C) may be permitted. Temperature-rise (K) shall not exceed the values given in this table. See also 9.2. In such a case warning label according to ISO 7010 W017 shall be provided.

SFC:

Confusing mix of concepts about annealing (conductors) and withstandability (connections and contacts). . Because item (g) does not differentiate bars from connections in the text, it induces the reader to think that the permitted elevation in connections is 105K (and not 60 or 75K). Connections are almost always the critical point in testing.

# Table 14 of IEC62271-1 (2021) Medium / high voltage switchgear page 66



**Table 14 – Limits of temperature and temperature rise for various parts, materials and dielectrics of high-voltage switchgear and controlgear**

| Nature of the part, of the material and of the dielectric (Refer to points 1, 2 and 3 in 7.5.6.2) (Refer to NOTE 1) | Maximum value | |
|---|---|---|
| | Temperature<br>°C | Temperature rise at ambient air temperature not exceeding 40 °C (NOTE 2)<br>K |
| 1 Contacts (refer to point 4) | | |
| Bare-copper or bare-copper alloy | | |
| – in OG (refer to point 5) | 75 | 35 |
| – in NOG (refer to point 5) | 115 | 75 |
| – in oil | 80 | 40 |
| Silver-coated or nickel-coated (refer to point 6) | | |
| – in OG (refer to point 5) | 115 | 75 |
| – in NOG (refer to point 5) | 115 | 75 |
| – in oil | 90 | 50 |
| Tin-coated (refer to point 6) | | |
| – in OG (refer to point 5) | 90 | 50 |
| – in NOG (refer to point 5) | 90 | 50 |
| – in oil | 90 | 50 |
| 2 Connection, bolted or the equivalent (refer to point 4) | | |
| Bare-copper, bare-copper alloy or bare-aluminium alloy | | |
| – in OG (refer to point 5) | 100 | 60 |
| – in NOG (refer to point 5) | 115 | 75 |
| – in oil | 100 | 60 |
| Silver-coated or nickel-coated (refer to point 6) | | |
| – in OG (refer to point 5) | 115 | 75 |
| – in NOG (refer to point 5) | 115 | 75 |
| – in oil | 100 | 60 |
| Tin-coated | | |
| – in OG (refer to point 5) | 105 | 65 |
| – in NOG (refer to point 5) | 105 | 65 |
| – in oil | 100 | 60 |
| 3 All other contacts or connections made of bare metals or coated with other materials | (Refer to point 7) | (Refer to point 7) |
| 4 Terminals for the connection to external conductors by screws or bolts (refer to points 8 and 14) | | |
| – bare | 100 | 60 |
| – silver or nickel coated | 115 | 75 |
| – tin-coated | 105 | 65 |
| – other coatings | (Refer to point 7) | (Refer to point 7) |
| 5 Oil for oil switching devices (refer to points 9 and 10) | 90 | 50 |
| 6 Metal parts acting as springs | (Refer to point 11) | (Refer to point 11) |

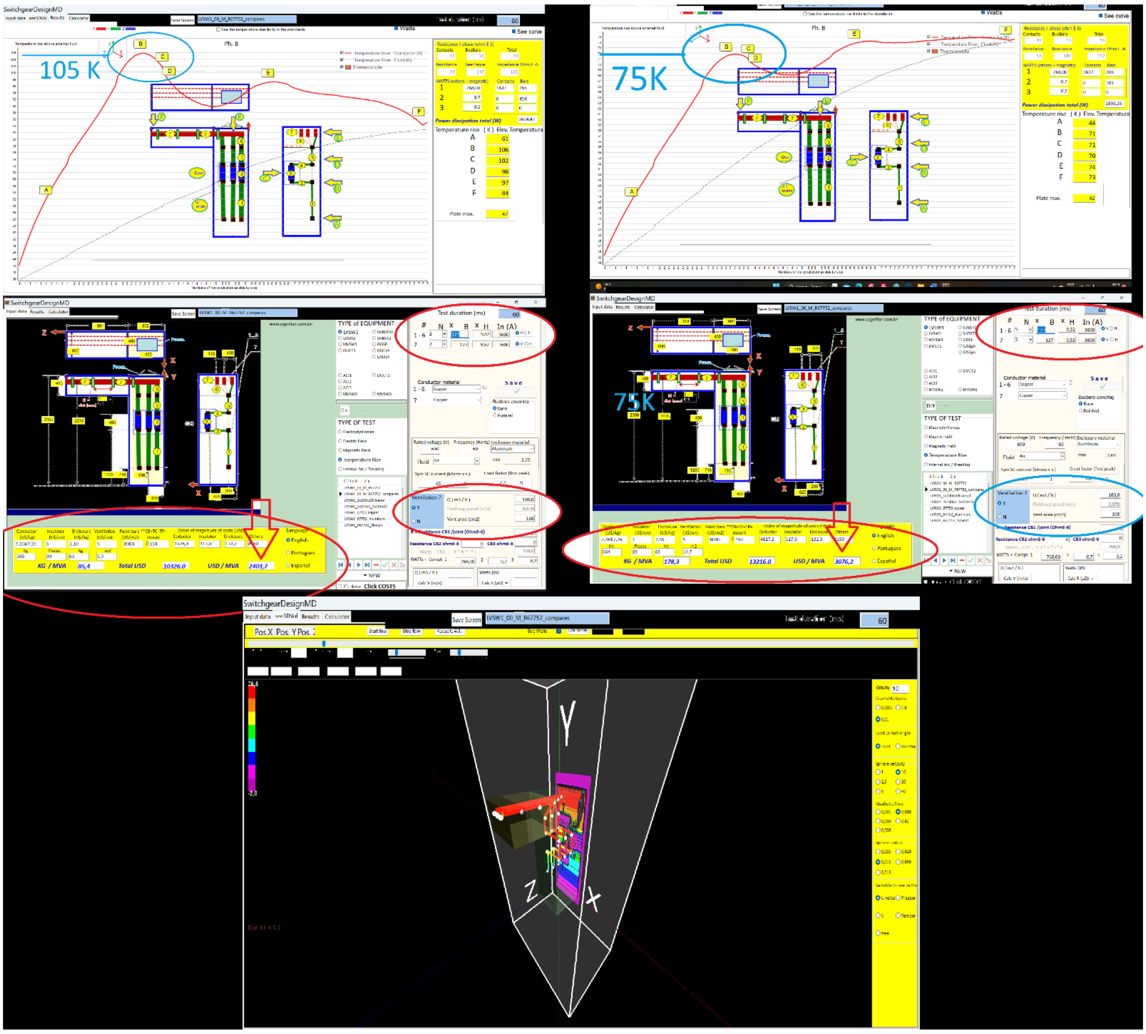
## Table 14 of IEC62271-1 (2021) Medium / high voltage switchgear page 67

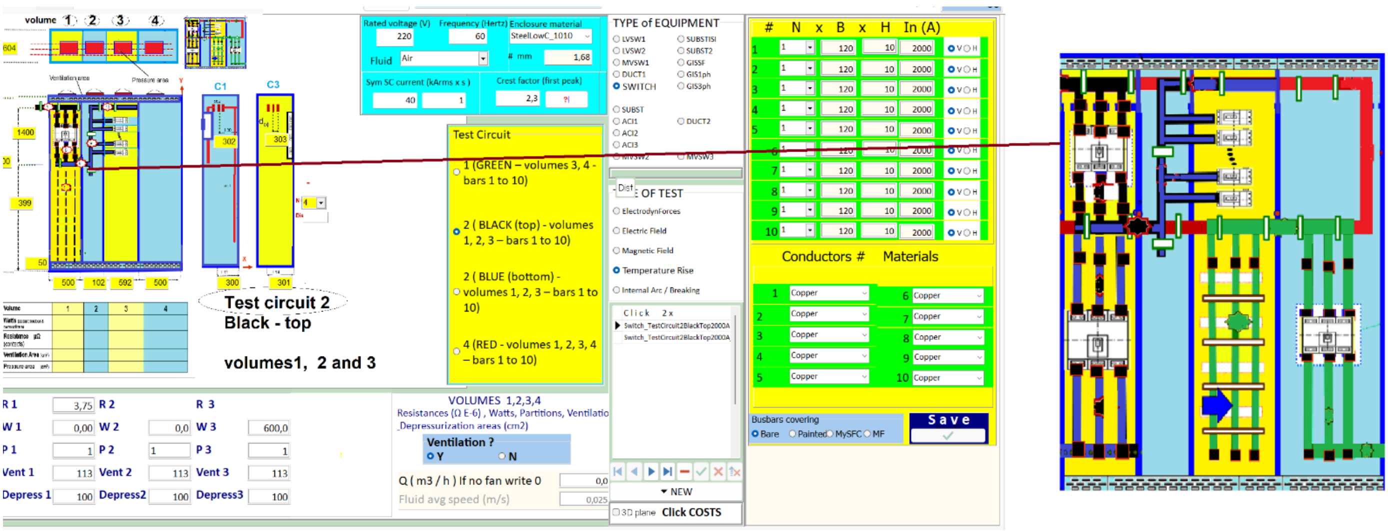
| Nature of the part, of the material and of the dielectric (Refer to points 1, 2 and 3 in 7.5.6.2) (Refer to NOTE 1) | Maximum value | |
|---|---|---|
| | Temperature<br>°C | Temperature rise at ambient air temperature not exceeding 40 °C (NOTE 2)<br>K |
| 7 Materials used as insulation and metal parts in contact with insulation of the following classes (refer to point 12) | | |
| – Y | 90 | 50 |
| – A | 105 | 65 |
| – E | 120 | 80 |
| – B | 130 | 90 |
| – F | 155 | 115 |
| – Enamel: oil base | 100 | 60 |
| synthetic | 120 | 80 |
| – H | 180 | 140 |
| – C other insulating material | (Refer to point 13) | (Refer to point 13) |
| 8 Any part of metal or of insulating material in contact with oil, except contacts | 100 | 60 |
| 9 Accessible surfaces | (Refer to point 15) | (Refer to point 15) |
| Surfaces of manual control components to be touched in normal operation: | | |
| – Uncoated metal | 55 | 15 |
| – Coated metal | 55 | 15 |
| – Non metal | 65 | 25 |
| Other surfaces to be touched in normal operation but not to be held continuously in the hand: | | |
| – Uncoated metal | 65 | 25 |
| – Coated metal | 70 | 30 |
| – Non metal | 80 | 40 |
| Surfaces not to be touched in normal operation: | | |
| – Uncoated metal | 80 | 40 |
| – Coated metal | 80 | 40 |
| – Non metal | 90 | 50 |

NOTE 1 The points referred to in this table are those in 7.5.6.2.

NOTE 2 For switchgear and controlgear with special service conditions including a maximum temperature different from 40 °C, the maximum values of temperature applies and the maximum values of temperature rise are calculated accordingly.

## ANNEX C: COMPARISON OF A PROJECT FOR 75K and for 105K (temperature rise and costs) . Made using SwitchgearDesign software.

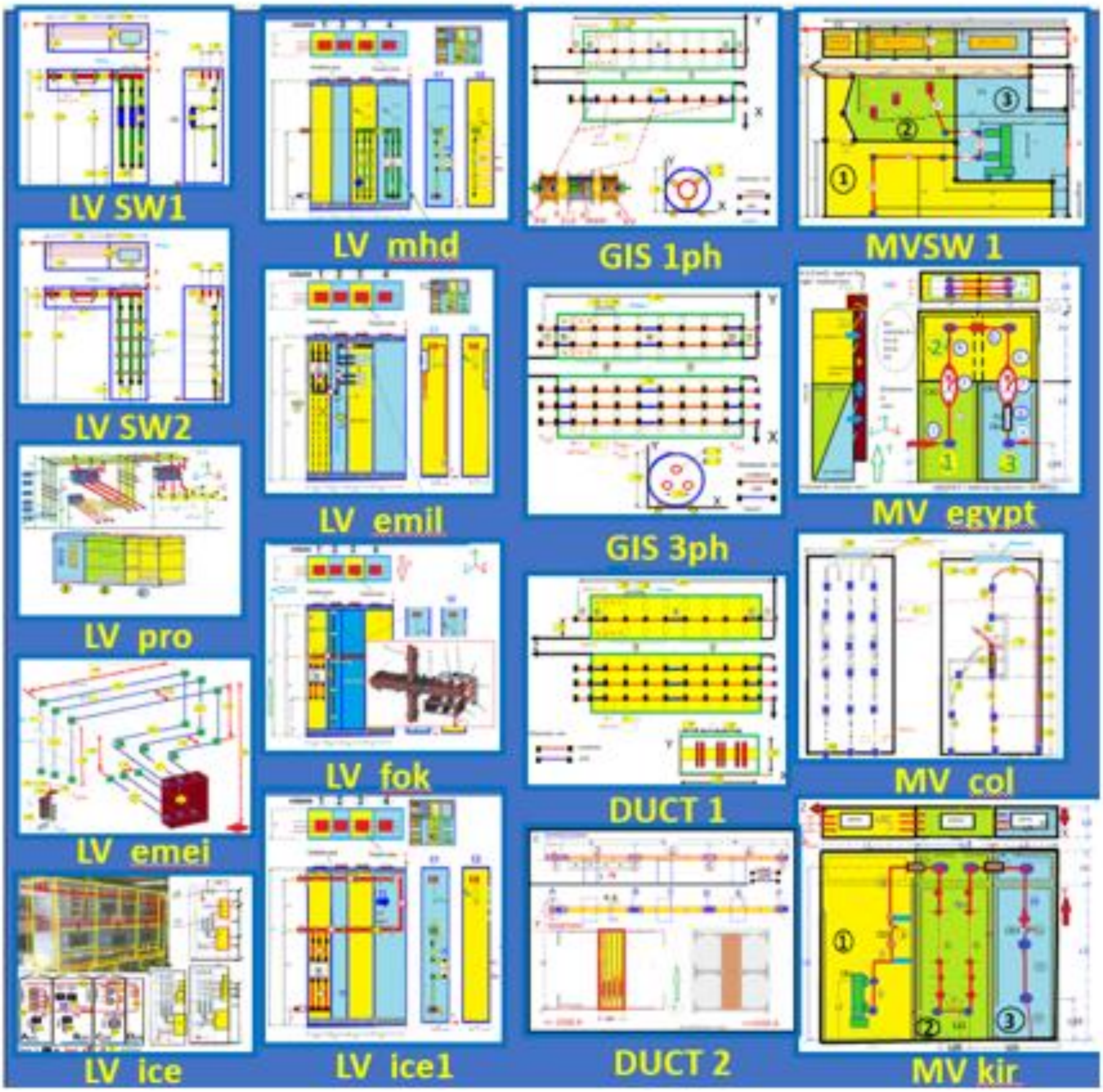


# Project types that can be simulated with SwitchgearDesign.

## High-power tests simulation software.

**Internal arc tests, short circuit forces test, temperature rise tests & more.** Check what will happen during the test and, if needed correct your design. Developed by a test engineer.



**ANNEX D - PART OF THE TEXT SENT TO CIGRE COLLEAGES IN A3 and B3 on July, 6 -2023**

I hope you are well and in good health. There is a long time we met at the event in Manilla. That Cigrè brochure 740 (2018) on low-cost substations has become a reference reading for many people I know. Below is a new article I wrote and posted on Linkedin yesterday.

It includes a suggestion to CIGRÈ for a new working group, possibly in B3 and A3.
I have learned over a long time designing and testing substation equipment how temperature rise limits presented in technical standards are the main factor impacting the amount of copper / aluminum is used in electrical products from LV to HV.
It is something little or not noticed by the specialists who elaborate the standards. They only do a copy-paste in the tables not questioning if after 50years, something could be improved. I only see a focus on the short-term stuff linked to specs and testing. The brochure I mention above would be a good read for them.

I've written provocative articles mentioning that it's time to open the mind to things that bring less material use and resource savings in the electrical industry.

It is curious to note that even now, the times of beautiful green speeches, the IEC, IEEE and national technical standards do not give any importance to encouraging, rewarding or inducing the economy of resources and greater efficiency in the manufacturing. This is not that difficult to do. The work I suggest in the article is an example that can be impactful.

When I started to write, the focus of the article was only a confusing and poorly written text in IEC 61439-1 for temperature rise limits. However, due to this bad text I realized that the temperature rise limits applicable to LV to HV products possibly can be improved. Limits need to be associated with a realistic life expectancy. I do not think that this was considered more than 50 years ago.

LINKS to the article including a suggestion for a CIGRÈ WORKING GROUP to study RAISING THE TEMPERATURE RISE LIMITS USED IN IEC STANDARDS by 10 to 15K (time life 30 years). This would cause a considerable reduction of copper and aluminum use. In line with the goals for environment and reduction of wasting Earth resources.
LINK for article: http://www.cognitor.com.br/IEC61439Table6.pdf

Post in Linkedin https://www.linkedin.com/posts/sergiofeitozacosta_cigre-iec-switchgear-activity-7082356756219072512-Wac5?utm_source=share&utm_medium=member_desktop

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