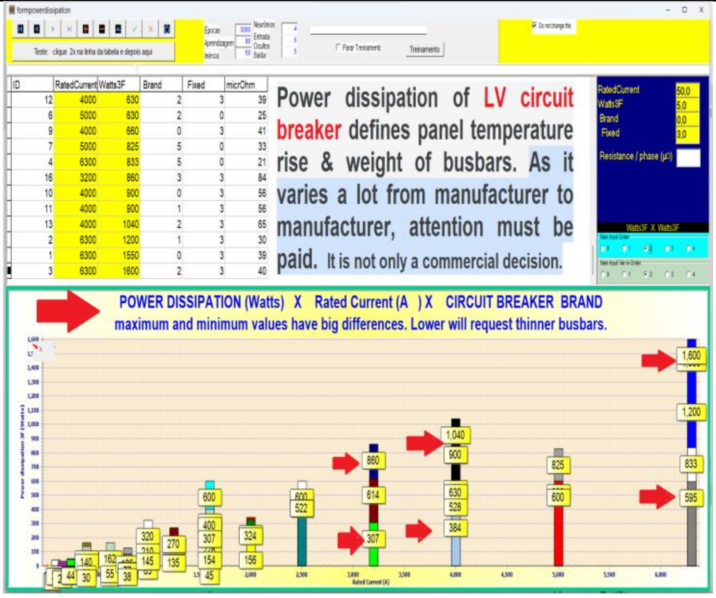
LV CIRCUIT BREAKER POWER DISSIPATION : defines LV switchgear cost. Choosing a brand, based only in the commercial aspects can be a gross mistake.



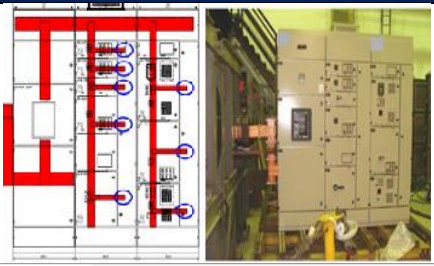


Table 1 – Cross-section of main busbar needed to be approved in temperature rise test. Versus temperature rise lit X power dissipation – Current 2500 A – dimensions mm				
Temperature rise ΔT (K)	Circuit breaker power dissipation 3ϕ = 3 x R x I ^{2} (Watts)			natural ventilation net area (cm2)
	150W	300W	600W	
60K (bare)	1 x 160x10 (50%)	2 x 160x10 (100%)	2 x 250x10 (156%)	180 cm2 bottom 180 cm2 top
75K (silvered / recommended)	2 x 120x10 (75%)	2 x 140x10 (87%)	2 x 160x10 (100% peso)	180 cm2 bottom 180 cm2 top
85K: if considered (wrongly) only the circuit breaker	1 x 150x10 (47%)	2 x 80x10 (50%)	2 x 120 x 10 (75%)	180 cm2 bottom 180 cm2 top
105K: value understood by some from the bad text of Table 6 of IEC61439-1	1 x 100x10 (31%)	1 x 110x10 (34%)	2 x 80 x 10 (50%)	180 cm2 bottom 180 cm2 top

Contact: e-mail: sergiofeitozacosta@gmail.com Site: www.cognitor.com.br Article: http://www.cognitor.com.br/LVcircuitBreakerResistance.pdf

keywords: #iecstandards, #cigre #busbar #testinglaboratory #internalarc # overpressure #temperaturerise #electrodynamic #stresses #shorttimecurrent # emc #magneticfields #electricfield #certification #qualitysystem #newtechnologies #design #costsreduction #validation #calculation #busway #sergiofeitoza #switchgeardesign #highpower #r&d #simulation #highpowertest #testing #shortcircuit #cpri #jstc #pehla #sats #stlna #zku #intertek #sgs #bureauveritas #switchgear #switchboards #asefa #paineis #barras #esef #tablero #consultant #iec62271 #veiki #iec61439 #substation #lowcost #kema #keri #lactec #cesi #stl #cepel #powertech #sgs #sergiofeitozacosta #aelp #chptl #icmet #fg #sabsnetf.

1. IMPACTS OF POWER DISSIPATION OF DIFFERENT BRANDS versus TEMPERATURE RISE LIMITS

http://www.cognitor.com.br/LVcircuitBreakerResistance.pdf

If a manufacturer of low voltage (LV) products wants to make an impactful innovation, a great opportunity is to develop circuit breakers (CB) with low power dissipation for rated currents from 1250 A to 5000 A. It is not that difficult to design. After successful, some big international manufacturer will possibly want to buy your factory or technology.

It is easy to demonstrate through simulations of temperature rise tests that CB resistances are the determining factor of the hottest spots that are noticed in the tests. In general, these spots are busbar connections to circuit breakers, fuses, or switches. For those who want to understand, start by reading the document IEC TR 60943 – "Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals". Another good publication is the Cigrè Brochure 830 (2021) – "Simulations for Temperature Rise Calculation". I am coauthor of this great Cigrè brochure. The 1st edition of IEC 6043 was published in 1989 when I was chair of IEC Technical Committee 32 (Fuses).

To understand the impact of power dissipation, and of the temperature rise limits on the temperature rise test results, read Table 1 below and the article "Table 6 of IEC 61439-1: Question to certifiers & testing laboratories: What temperature rise limits, in bar/breaker connections, to use when approving or certifying low voltage switchgear? The link is at the end.

In that article I show the problems caused by changing the IEC 61439-1 temperature rise test method. I show also the problems caused by the badly written Table 6 of IEC 61439-1. IEC top management should investigate this matter as it is a source of commercial problems. Imagine the situation of a manufacturer who lost a bid because they designed a LV switchgear to a 75K temperature rise limit (correct but uses more copper). It lost out to another company that might offer a lower price because it interpreted the limit as 105K. In large bids this could generate claims that would justify the repetition of the bid. I also included a suggestion to Cigrè to assess how much the temperature rise limits used in IEC standards can be increased. For connections, around 10-15K, means using much less copper and aluminum.

The results of the temperature rise test are the main aspect that defines the production cost of a switchgear. They depend mostly on the power dissipation of the main circuit breaker.

If you manage to design an equipment that is slightly below the limits, you get the most competitive project. Having this in mind, check in Table 1 the size of the bus bar that need to use to be approved in the test. This depends on the temperature rise limits of the standard and the power dissipation of the main circuit breakers. A manufacturer that designs the product to have a 75K elevation will possibly lose the bid to another that designed it for 85K or 105K.

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Temperature rise ΔT (K)	Circuit breaker power dissipation 3ϕ = 3 x R x I ^{2} (Watts)			natural ventilation net area (cm2)
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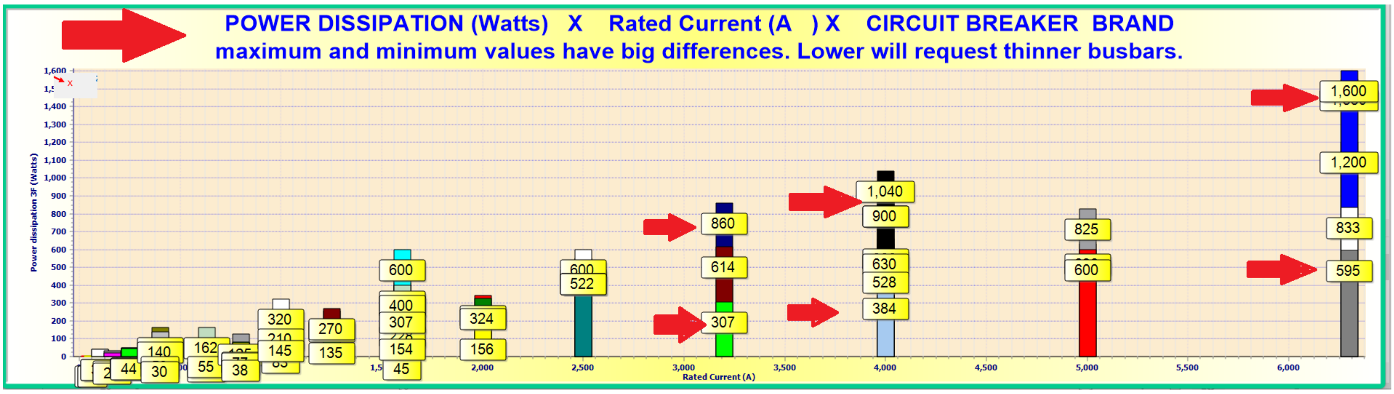

I have always seen panel manufacturers very concerned about choosing the CB's brands. In almost 100% of the times, the choice was from a commercial point of view for license agreements between the panel builder and the CB manufacturer. I have never seen a panel manufacturer selecting this or that brand because it would lead to a more economical design using less copper and aluminum.

About the performance, the quality of LV circuit breakers made by the more known manufacturers like WEG, SCHNEIDER, ABB, SIEMENS, EATON, GE, and many others is not considerably different. All of them have to attend the same IEC standards specifications and tests. To maintain market competitivity they will not have very sensible differences. World changed and. nowadays, most buyers are more concerned about having a tested product at a lower price than having quality add-ons that are difficult to verify.

2. THE IMPACT OF THE CB POWER DISSIPATION IN THE RESULTS OF TEMPERATURE RISE TEST AND COST OF PRODUCTION OF THE SWITCHGEAR

Doing design calculations and tests I learned that the resistance of the CB as seen from the terminals, is the more important factor in defining the cost of producing a panel with CBs. The reason is that, in general, in the temperature rise test, the hottest point that will make or fail the test is the connection of the bars to the circuit breaker.

Depending on the coating of the connection, the limit value of the IEC standard is 60K to 75K of temperature rise. If the CB has lower resistance, the connections heat up less and you can use thinner bars to meet the temperature rise allowed in the technical standard.
Other design issues like short circuit forces, dielectric aspects and internal arc are easy to solve.

The best documents to understand the impacting factors in temperature rise are the already mentioned IEC 60943 and IEC 62271-307 (I am coauthor). The concepts are very well explained there. In general, the higher the resistance is , closer to the temperature rise limits you will be. A long-term lab testing experience showed me that when installing the circuit breaker inside a switchgear / controlgear the hottest point is usually in the connections from the circuit breaker to the busbar. There is some additional information in Annex A.

The demonstration that the power dissipation of the LV circuit breaker defines the costs and temperature rise of the panel and the weight of the copper is shown in the graph at the beginning of this article and in Table 1. To obtain them, I performed simulations of temperature rise tests using the SwitchgearDesign software. There are articles, books and validations in the link below.

Observing the graph above, the power dissipation of circuit breakers of different brands varies from manufacturer to manufacturer, reaching twice or 3X more. The temperature rise will be greater for circuit breakers with higher power dissipation. In these cases, more weight of copper or aluminum must be used to meet the same temperature rise limit.

Thus, the competitiveness of a given LV switchgear will be mainly defined when you choose the circuit breaker to use. Read Table 1 carefully and think through the possibilities.

As mentioned, an impactful innovation is to develop circuit breakers (CB) with low power dissipation for rated currents from 1250 A to 5000 A. It is not that difficult to design.

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The author of this article is Eng. Sergio Feitoza Costa. Sergio is an electrical engineer, M.Sc. in power systems and director of COGNITOR. It has 40+ years of experience in the design, operation and management of high power, high voltage, and other testing laboratories. After leaving CEPEL's testing labs, Sergio gained considerable experience using test simulations to support manufacturers and certification companies in substation equipment projects. He is co-author of several IEC standards and Cigrè brochures. Sergio is the author of SwitchgearDesign simulation software and DECIDIX.

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- Article "Table 6 of IEC 61439-1: Question to certifiers & testing laboratories: What temperature rise limits, in bar/breaker connections, to use when approving or certifying low voltage switchgear? http://www.cognitor.com.br/IEC61439Table6.pdf
- Free publications and books about the matter, including the "Temperature rise: a guide to learning to design MV/ LV switchgear" : https://www.cognitor.com.br/downloads1.html

Training: https://www.cognitor.com.br/trainingeng.pdf
CV https://www.cognitor.com.br/Curriculum.html

Things Sergio helped to create: https://www.cognitor.com.br/HelpedToDo.pdf

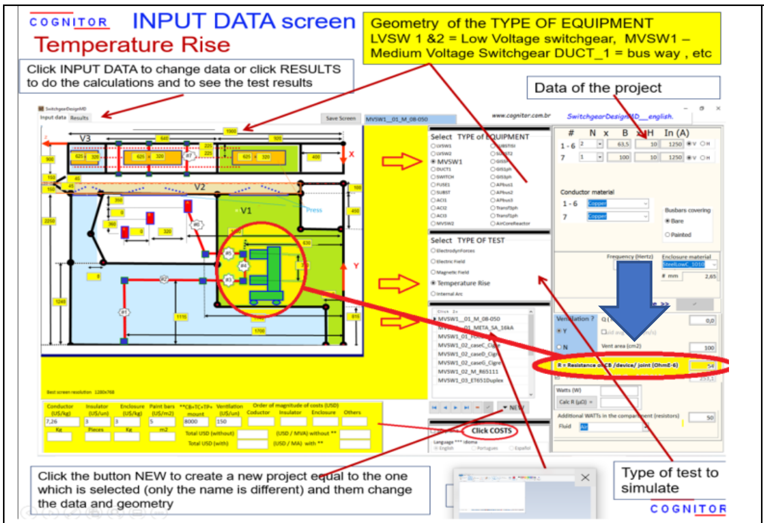
ANNEX

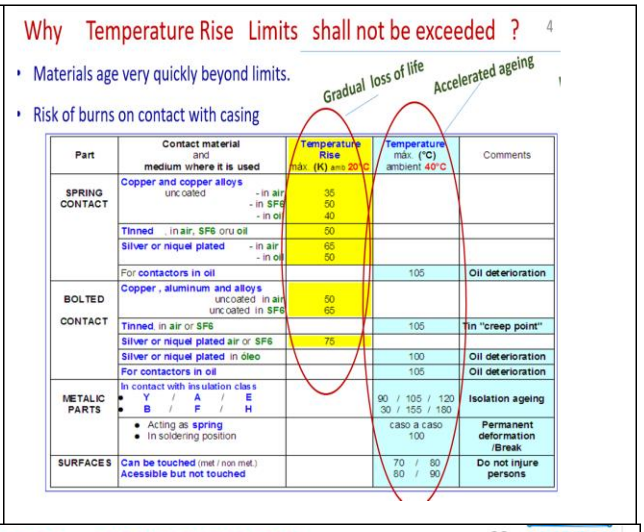
ABOUT THE DIFICULTIES TO FIND THE MICROOHMS (µΩ) VALUES

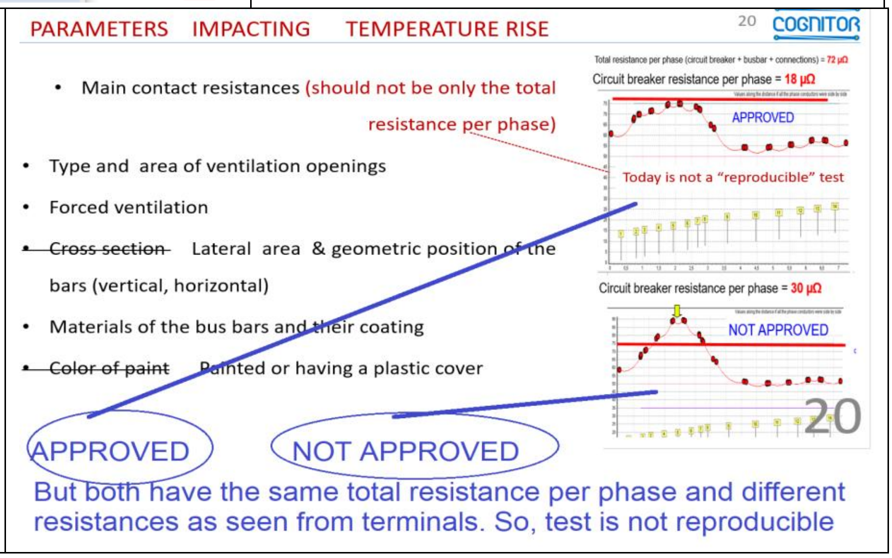
When doing a design review for a manufacturer, the resistance values of MV/HV/LV circuit breakers are necessary. However, it is frequently difficult to find them explicitly in the manufacturer's catalogues. When you call the manufacturer, the salespeople must consult the "engineering" because have no idea of the importance of this data or where to find it. This has happened to me dozens of times.

Seems that even the manufacturers have difficulties to understand their importance. Still today IEC standard request in the temperature rise test to measure the total circuit resistance per phase and not (also) the CB resistance. Without doing this the test is not reproducible.

Another reason for having this information is that after receiving the supplied the circuit breaker, the resistance will be the main reference to follow up on predictive maintenance. I got experience with this because the testing staff of the high-power labs I worked and managed were responsible for the maintenance of the testing equipment. In a high-power testing lab, the maintenance is a key factor because the equipment operates with very high frequency at extreme conditions. The "artificial intelligence" knowledge rules used for predictive maintenance system need always use this data. If you have difficulties to obtain the resistance values ask for the manufacturer, report of temperature rise test of the circuit breaker alone.



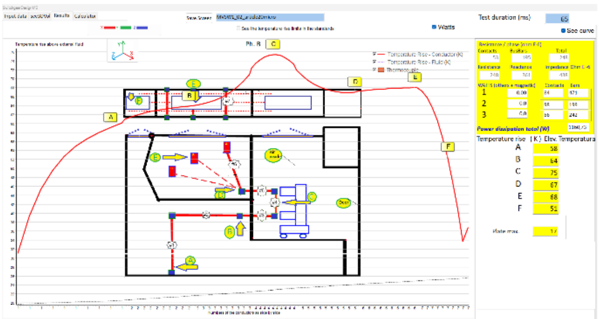


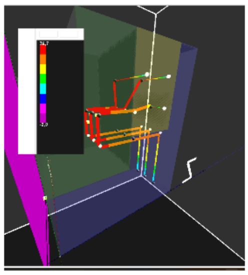


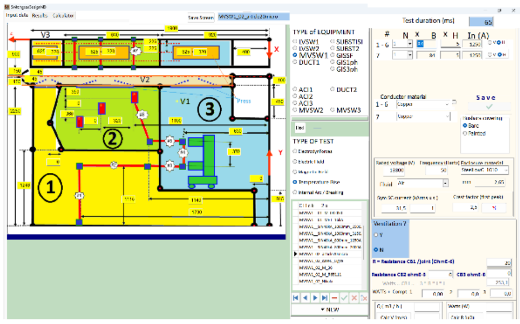
EXAMPLE OF IMPACT OF THE RESISTANCE OF THE CIRCUIT BREAKER IN THE BUSBARS THAT FEED IT Panel 1250 A – 1 bar per phase – temperature rise limit 75K – Copper bare bars

In MV circuit breakers it was easy to see that if you use a CB with a "tighter" setting in the temperature rise tests you will have a lower temperature rise in the test because the resistance is lower than in the normal use. For this reason, it should be mandatory in the temperature rise tests to measure both the total resistance of the circuit and that of the circuit breaker alone. For the same total resistance value, you can pass or fail the test, depending on the setting. In other words, temperature-rise tests are not reproducible without the two measurements.

Resistance of the circuit breaker per phase (microOhms)	Cross section of the busbar to reach 75K in the connection	**Weight of copper %**
20 µΩ	84 x 5mm	**100 %**
50 µΩ	114 x 5 mm	**135 %**
80 µΩ	163 x 5 mm	**184 %**







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