CIRCUIT BREAKER RESISTANCE: IMPACTS ON AMOUNT OF COPPER / ALUMINUM USED IN THE M.V. PANEL / SWITCHGEAR ..... DIFFERENT BRANDS = DIFFERENT VALUES

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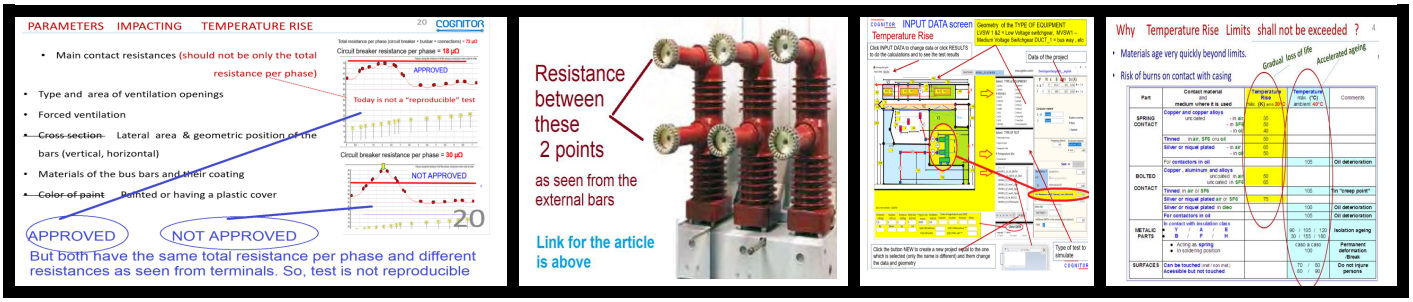


1. ABOUT IMPACTS AND DIFFERENT BRANDS

I have 40+ years of experience using medium voltage (CB) circuit breakers and designing switchgear like panels of IEC62271-200. As a user I got experience from operating and maintaining CBs in the high-power test labs I worked and managed for 25 years. CBs in testing labs are much more operated than the average. As a designer I have calculated and reviewed the design of MV and LV switchgear for dozens of manufacturers around the world. Since I couldn't afford experiments in test labs, I developed a software to simulate tests (temperature rise tests, internal arcing and short-circuit forces). The tool is fully validated and allows me to simulate tests and adjust the design before going to the lab to type test and obtain a test report to use in marketing the product. Check documents and articles in the end.

I have always seen panel manufacturers very concerned about choosing breaker brands. In 100% of the times, it 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 circuit breakers made by the more known manufacturers like **SCHNEIDER, ABB, SIEMENS, EATON, GE, TAVIDRA, MITSUBISHI, ALSTOM**, 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. Nowadays, most CB buyers are more concerned about having a tested product at a lower price than having quality add-ons that are difficult to verify.

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.

Let's use as an example circuit breaker rated 15kV, 1250A permanent, 31.5kArms of breaking capacity.

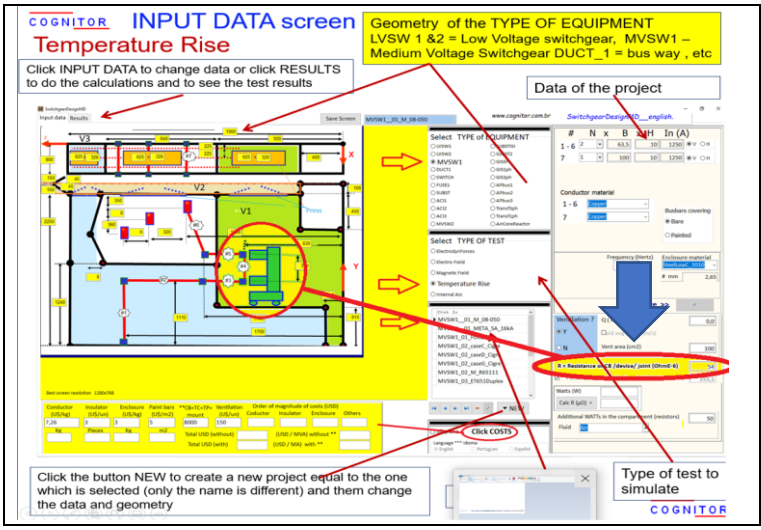
If you have time and patience to ask to the manufacturers the resistance values, usually not included in the catalogues, you will see that the resistances per phase, may be very different depending on the manufacturer brand and type (fixed or withdrawable).

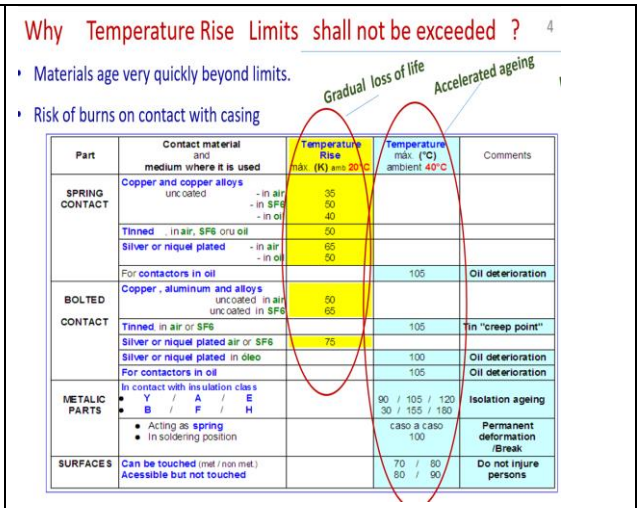
These resistances typical values vary from about 18 to 90 microOhms. The variations are big and have big impact on the busbars to be used in the panel construction, to pass the temperature rise test.

2. ABOUT THE DIFICULTIES TO FIND THE MICROOHMS (μΩ) VALUES

When doing a design review for a manufacturer, the resistance values of MV/HV/LV breakers are necessary. However it is always very 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. I do not understand why manufacturers have difficulty in informing and the IEC technical standards themselves don't seem 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 important 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, the report of temperature rise test of the circuit breaker alone. As written above, the typical values vary from about 18 to 90 microOhms





3. THE IMPACT OF THE CIRCUIT BREAKER RESISTACE IN THE RESULTS OF TEMPERATURE RISE TEST

If you wish to understand the impacting factors start reading IEC 62271-307 (I am coauthor). They are very well explained there. In general, the higher the resistance is , closer to the temperature rise limits of the IEC62271-100 (circuit-breaker) you will be. When installing the circuit breaker inside a switchgear / controlgear (IEC 62271-200) the hottest point is usually in the connections from the circuit breaker to the busbar.

IF you use a breaker 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. Do the right thing and do not do it, although the IEC standard is omisse in this point. The reason is because, this will not correspond to the regulation recommended by the manufacturer to be used in everyday life. If, on a daily basis, you use a tighter adjustment than recommended by the manufacturer, you will quickly have to redo the maintenance adjustments.

> For this reason, it should be mandatory in the IEC 62271-1 temperature rise test 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, the temperature-rise test of IEC 62271-1 is not reproducible without the two measurements.

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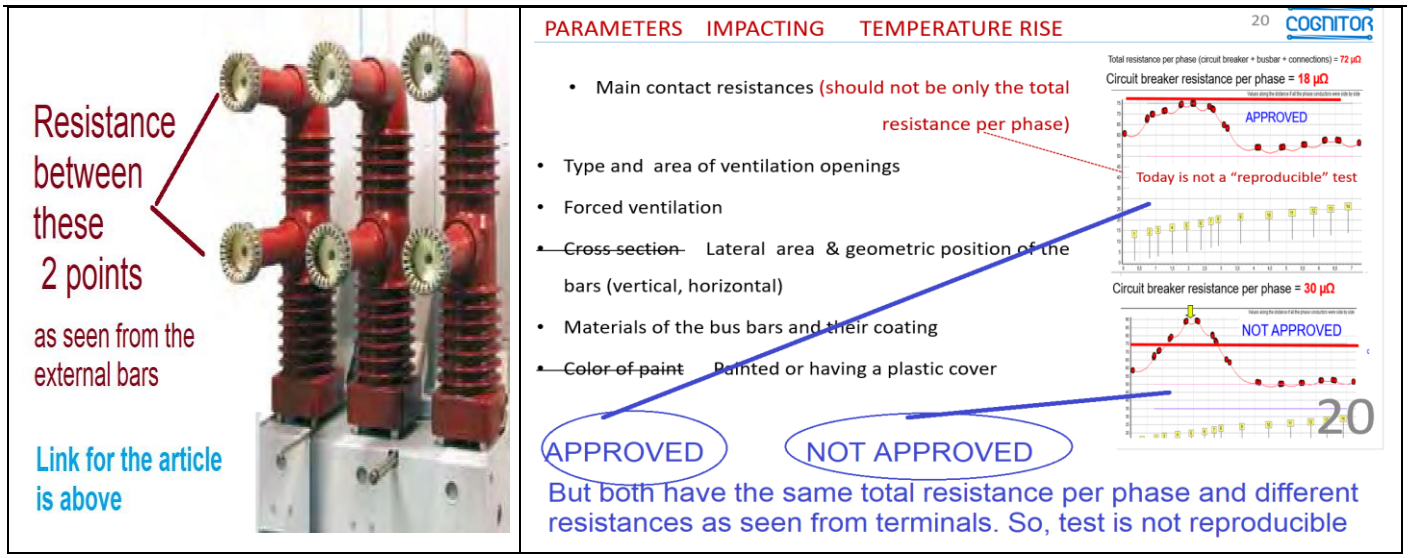
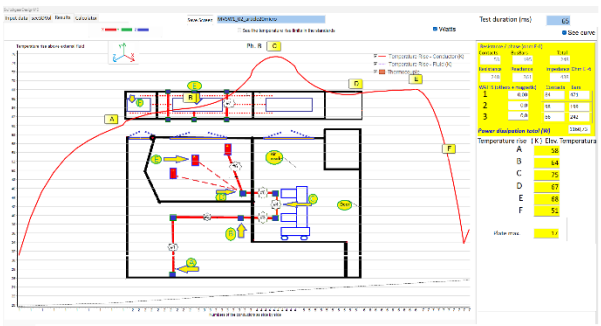
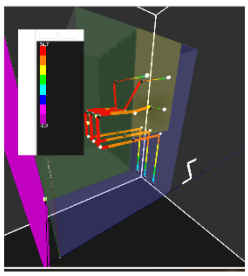


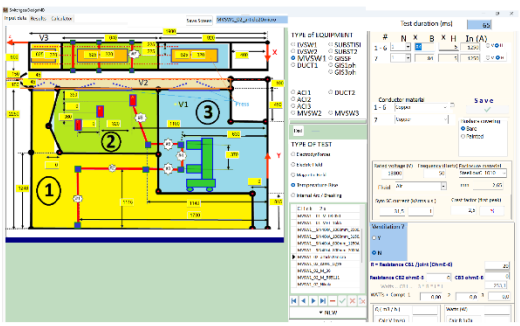
4. EXAMPLE OF IMPACT OF THE RESISTANCE OF THE CIRCUIT BREAKER IN THE BUSBARS THAT FEED IT

Panel 1250 A – 1 bar per phase – temperature rise limit 75K – Copper bare bars

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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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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CAN ANYONE HELP ME TO FIND DATA TO FILL or CORRECT THIS TABLE ?

Test reports of the temperature rise test of the circuit breaker are also welcome but not essential . If you send me the report it will not be disclosed in any way.

NON-CONFIRMED VALUES INCLUDED ONLY TO EXEMPLIFY, AS ORDERS OF MAGNITUDE

Manufacturer of circuit breaker / Rated voltage / Rated current	Resistance as seen from the terminals of the circuit breaker (as seen from external bars) μΩ	
	Installation Fixed	Extractable (Plug In)
Schneider Evolis 17,5 KV * 185/145 mm	35 μΩ	68 μΩ
Schneider Evolis 17,5 KV * 240 mm	18 μΩ	30 μΩ
AREVA VAA (vacuum) 36 kV	42 μΩ	90 μΩ
AREVA HVX (vacuum) 17-30-20E	19 μΩ	25 μΩ
TAVRIDA 17,5 kV	18 μΩ	
ABB VD4 40kA and 50 kA	??? 70 μΩ ?????	??? 70 μΩ ?????
EATON		
SIEMENS		
GE		
.....		

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