IEC 60947-2: HOW and why TO DEVELOP a LOW-VOLTAGE CIRCUIT BREAKER WITH LOWER POWER DISSIPATION (for IEC61439-1/2)

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1. WHY a CB WITH LOWER POWER DISSIPATION CAN LOWER the SWITCHGEAR FABRICATION COST

It is easy to demonstrate by tests or simulations of temperature rise tests that CB resistances are the determining factor of the hottest spots that are registered in the tests.

They are the key to pass or not in the test. In general, these spots are busbar connections to circuit breakers, fuses, or switches. For those who want to understand, start by reading References [1] to [3] below.

To pass in the tests is the focus. If you manage to design a competitive switchgear using less copper or aluminum the way is to achieve in the final type tests temperature rises below the temperature rise limits permitted in the relevant IEC standard.

Just to give an idea of the impact of the circuit breakers suppose that you have a switchgear like the left side of this figure. You have in the left column a 1600 A CB and in the right side 6 CBs of 250 Watts each

Suppose you have in the first case CBs with the brand of higher power dissipation. In the second case we will have the CBs with the brand with lower power dissipation

First case:
400 W (1600 A)
400W means 52 μΩ per phase
and
6x75 W = 450W (250 A)

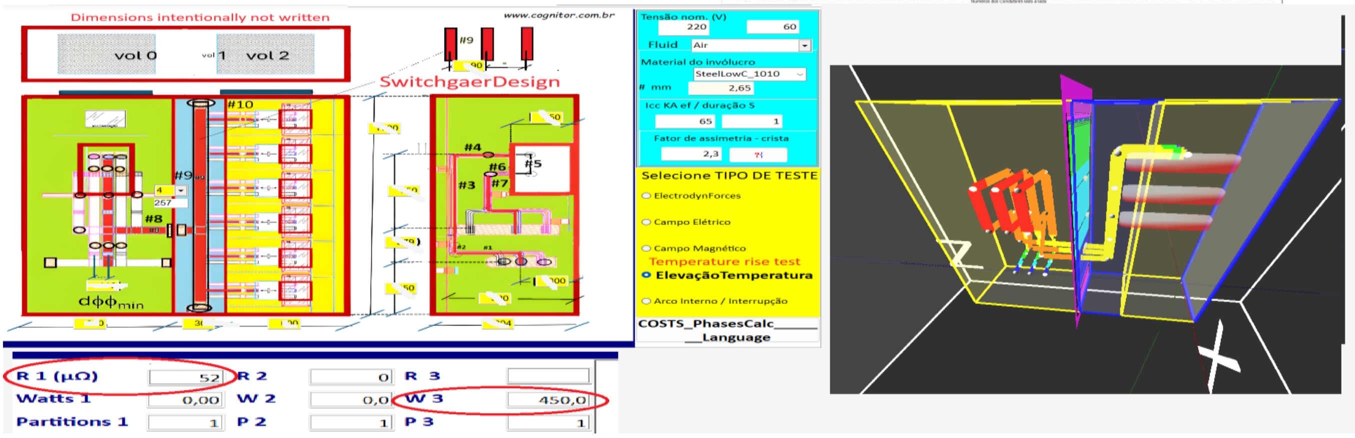
Second case:
307 W (1600 A)
307W means 40 μΩ per phase
and
6x49,2 W = 295W (250 A)

CB 1600 A	Watts	Manufacturer
1600	45	A
1600	117,	A
1600	400	A
1600	423	A
1600	600	B
1600	310	C
1600	400	D
1600	168	D
1600	228	E
1600	307	F
1600	154	F

CB :250 A	Watts	Manufacturer
250	49,2	A
250	52,8	B
250	48	C
250	48	C
250	75,	D
250	54,	D
250	44	F
250	44	F

When you simulate properly the two tests, to follow you will notice that the difference of temperature rise is 8K. This innocent 8K, when translated to a proper design to pass in the test means more than 20% of savings in the weight of copper. In a market with so many manufacturers competing this makes the difference.
Read the article in reference [1]

Temperature rise max. 94 K	Temperature rise max. 86 K
	



2. **THE STEPS TO DEVEOP a CB WITH LOWER POWER DISSIPATION**

The types of knowledge which are necessary can be resumed – more or less - in the following

a) Good reference drawings:	Get well dimensioned drawings of some successful (tested) design preferably of a medium or low power dissipation product. Identify clearly the differences and distances in the positions closed and opened. Improve your understanding of mechanical devices for quick opening of circuit breakers.
b) Processes to interruption x distances	Start reading about the necessary conditions for a safe breaking and making operation under short circuit and repetitive operations at lower currents. Start from the basics of Paschen's law (breakdown voltages, discharges, gap length). Initial focus only in "air". Identify some tool that enable you to calculate the electric fields when the contacts are moving to open.
c) Processes to interruption electrical modelling	Read about the "transient recovery voltages" which appear during the breaking operations. Understand their relationship with the inductances, resistances and capacitances of the circuit protected by the CB. Try to model basic transient operations using tools like ATP ? ATPDRAW. What you need was made by someone before, and you will find the model ready for use.
d) Processes to interruption and arc modelling including overpressures	Create a calculation model for a "temperature rise test" but that consider high currents that will make the conductors to melt and after to vaporize. Calculate the overpressure that will occur within the breaking chamber

e) Tools to simulate temperature rise tests, electrodynamic forces and overpressures of the internal arc	You will need a tool to do simulations because checking the effects of the several geometrical and materials variables would be extremely expensive with real tests
f) THE KEY: How to reduce the power dissipation of contacts and connections ?	Start reading the reference[3] IEC TR 60943. There you will find what you need about contacts processes, materials and aging. After this do searches to find about methods used for high-current contacts. Your focus will be on how to reduce the contact resistances. This is not so easy as it seems. A good starting point is in the https://ieee-holm.org/ International Conference on Electrical Contacts. Find previous proceedings and find the names of best books. Try defining two or three basic designs to do some tests.
g) Tests	After you define the basic designs, you will need to do tests in testing laboratories to check the performance. This kind of test is not replaceable by testing simulations.

These are the steps to follow. If you are courageous and innovative you have a good chance of success. The big manufacturers will keep an eye on you and maybe down the line they will get in touch to discuss some kind of partnership

If you decide to follow these steps I can help you with my experience.
Good luck, by Sergio Feitoza Costa

-- END OF THE ARTICLE --

REFERENCES AND ABOUT THE AUTHOR

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, software DECIDIX and a patent about the use of metal-foams in switchgear.

REFERENCES

[1] Article "… a way for a lower-cost switchgear is the selection of the circuit-breakers brand …" https://www.cognitor.com.br/LVcircuitBreakerDevelopment.pdf

[2] 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

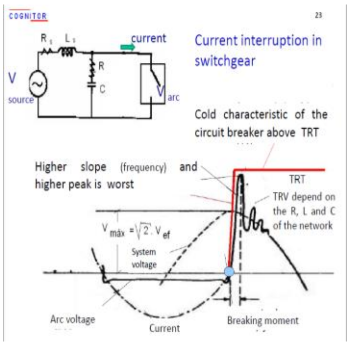
[3] IEC TR 60943 – "Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals".

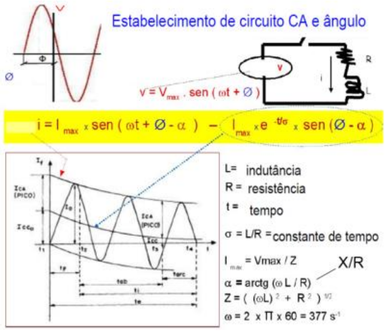
[4] Free publications and books about the matter, including the "Temperature rise: a guide to learning to design MV/ LV switchgear" : https://www.cognitor.com.br/downloads1.html

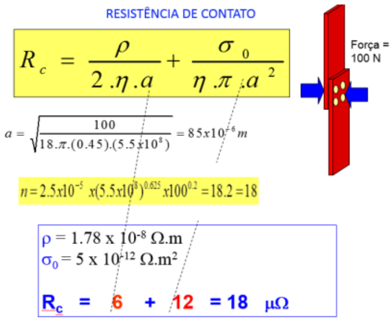
[5] Training: https://www.cognitor.com.br/trainingeng.pdf

[6] CV https://www.cognitor.com.br/Curriculum.html

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


Current interruption in switchgear
current
source
arc
Cold characteristic of the circuit breaker above TRT
Higher slope (frequency) and higher peak is worst
TRT
TRV depend on the R, L and C of the network
System voltage
Arc voltage
Current
Breaking moment


Estabelecimento de circuito CA e ângulo
L= indutância
R = resistência
t = tempo
σ = L/R = constante de tempo
X/R
ω = 2 x Π x 60 = 377 s-1


RESISTÊNCIA DE CONTATO
Força = 100 N
ρ = 1.78 x 10-8 Ω.m
σ0 = 5 x 10-12 Ω.m2
Rc = 6 + 12 = 18 μΩ