kG/MVA : Research Centre on Environmental Efficiency of Electric Products

180+ posts for the Electric Power industry (seeding R&D ideas)

100 LinkedIn posts for the **electric power industry** R&D

Read, share & use: About design, testing & specification of substations equipment .

ISBN 978-65-00-47301-8 .

Most posts in English. Few in Portuguese

Link for the FREE book above
http://www.cognitor.com.br/180posts.pdf

sergiofeitozacosta@gmail.com www.cognitor.com.br

- Here writes Sergio Feitoza Costa, 67 y.o. , Brazilian and very concerned about what is happening in the Amazon region of Brazil. Greed, omission and deforestation would kill us, all, in this beautiful Blue Planet.
- I write **free posts, articles & books** to show key points of designing and specifying more efficient equipment, using less copper, aluminum, insulating materials and other Earth resources.
- **Companies, especially the world-wide manufacturers**, could do better by reducing commercializing old projects that, nowadays, could be much more efficient. They know how to do this. **Technical standards disregard efficiency but it is easy to improve them .** Speech and texts do not match
- **Researchers & institutions** selling web articles and knowledge, to make small profits, should think about share them free.

100 LinkedIn posts for the **electric power industry** R&D

Free book “180+ POSTS FOR THE ELECTRIC POWER INDUSTRY”.

Download http://www.cognitor.com.br/180posts.pdf

The intention is to help professionals with low access to technical knowledge.

The “Research Center on Environmental Efficiency of Electrical Products” is becoming real. I need to reach 100K followers on LinkedIn (22K now) to demonstrate that is serious and to get funding for some R&D projects. There are several companies already interested but waiting for this demonstration. Resume, free articles and more at www.cognitor.com.br

It is about design, specification, tests and standards for substations and their equipment such as transformers, switchgear (HV, MV, LV), busbar systems, CBs, disconnectors and fuses. Focused on IEC62271, IEC61439, IEC60282-2 and IEC60076 products

100 LinkedIn posts for the electric power industry R&D

Contents

- **How to design more efficient power equipment**
- **Temperature Rise** – Design concepts and Tests. (IEC61439 + IEC 62271)
- **Short circuit electrodynamic forces**: concepts, IEC 61117, IEC TR 60865.
- **Internal arc tests** - concepts, IEC 62271-200 e 307 (MV), IEC TR 61641 (LV)
- **Breaking tests in circuit breakers & expulsion fuses**
- **Specification of Currents and Voltages in New** (lower-cost) **Substations**.
- **Overvoltages & Insulation Coordination**
- **Magnetic & Electric Fields & their Effects** (concepts & mapping)
- **Technical Specifications & Tests for Bids:** Circuit Breakers, Disconnectors, Arresters, Transformers.
- **Technical standards for switchgear, switchboards, fuses, ...(**IEC 61439, IEC TR 61641, IEC 62271-200, IEC 62271-307. IEC60282-2, IEC 890 and IEC 62208) & more

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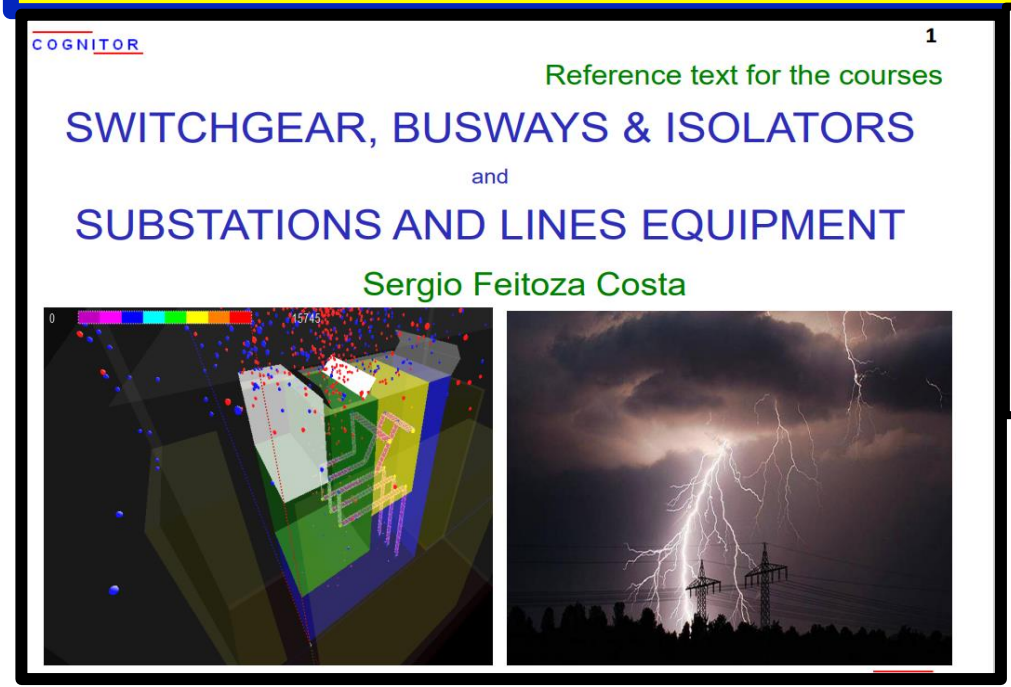
More reading materials

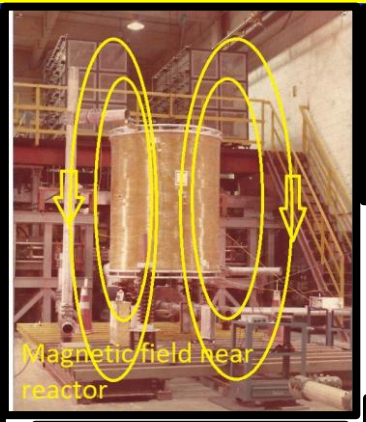
- In the downloads area of my site www.cognitor.com.br there are unique free articles about the post's themes.
- Just access here . No registering is necessary.
- https://www.cognitor.com.br/Downloads1.html
- Start with the free book *"Switchgear, Busways, Isolators - Substations & Lines"* .

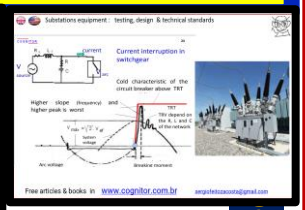
Training in https://www.cognitor.com.br/trainingENG.pdf

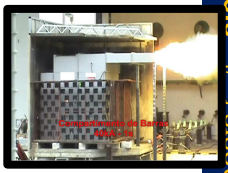
Switchgear / switchboards (training IEC 62271 / IEC 61439 / IEC60282-2 & more)

Another **Substations free book**









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Available in English, Portuguese and Spanish

HOW TO DESIGN MORE EFFICIENT POWER EQUIPMENT

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- Focus on **temperature rise design** (rated currents)
- If you do a good job here, **short-circuit & internal arc** things will be easy to solve

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CHANGE TEMPERATURE RISE LIMIT OF SILVERED/TINNED BOLTED CONNECTIONS FROM 75K to 85K?

- In the past, the limit on bare connections was 50K and has been increased to 60K. Nothing bad happened. We've known for decades that 75K doesn't cause problems in silvered / tinned.
- Is there evidence against? where are they written? If not, it's time to dust off the old paradigm that prevent products from having a lower cost.

I suggest to IEC TC32 (in cooperation with TC17) to update IEC TR60943 (2008)

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by Sergio Feitoza Costa ** June 2022

COGNITOR

EFFECT OF CURRENTS AND VOLTAGES

Lower or equak the rated permanent values → **Aging "normal"** (as 20 years)

Long duration overcurrents (as 1,5 IN during 120 seconds → **Moderated temperature rises:** + aging

Short duration overcurrents (as 20,0 IN during 1s → **High temperatures like 180ºC for copper:** annealing, bending,

→ **Electrodynamical effects:** forces (tons) and mechanical stresses damaging insultators and busbar

Overvoltages

- Long duration (dozen of seconds)
- Short duration(micro- seconds)

→ **Imediate failure or isolation aging**

$I^2t \sim V^2t$?

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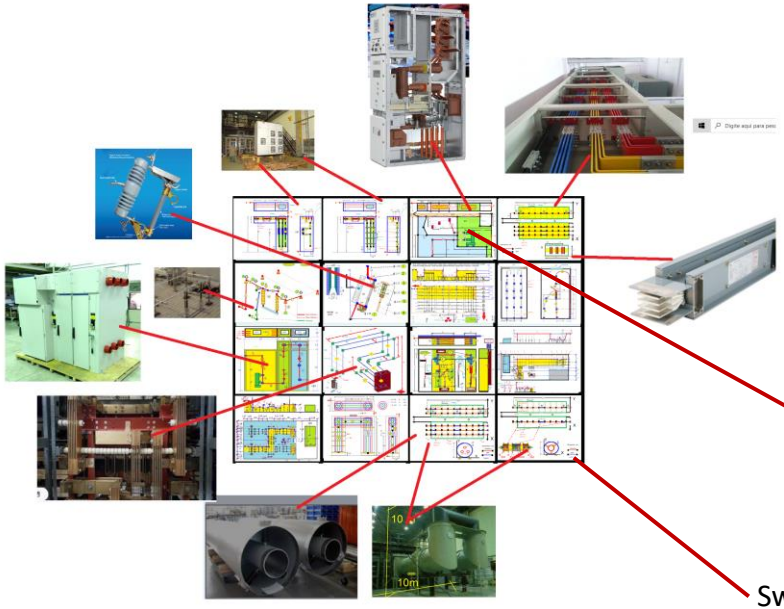
If you cannot pay for expensive lab tests use *testing simulations*



SwitchgearDesign was developed by Sergio Feitoza, a high-power testing lab expert.

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Seeding R&D ideas
for innovative manufacturers

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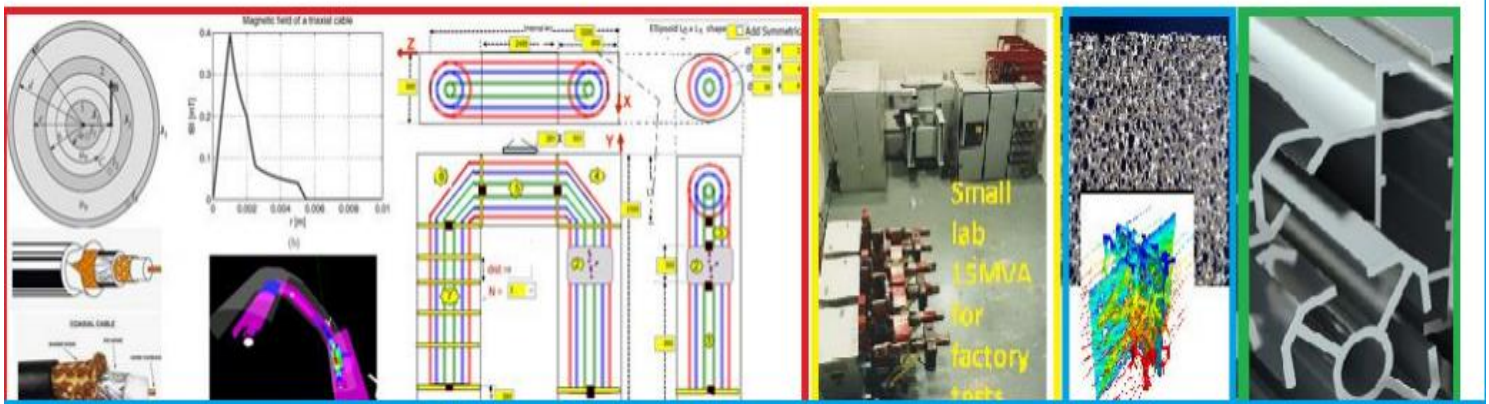
Read the article (link above)



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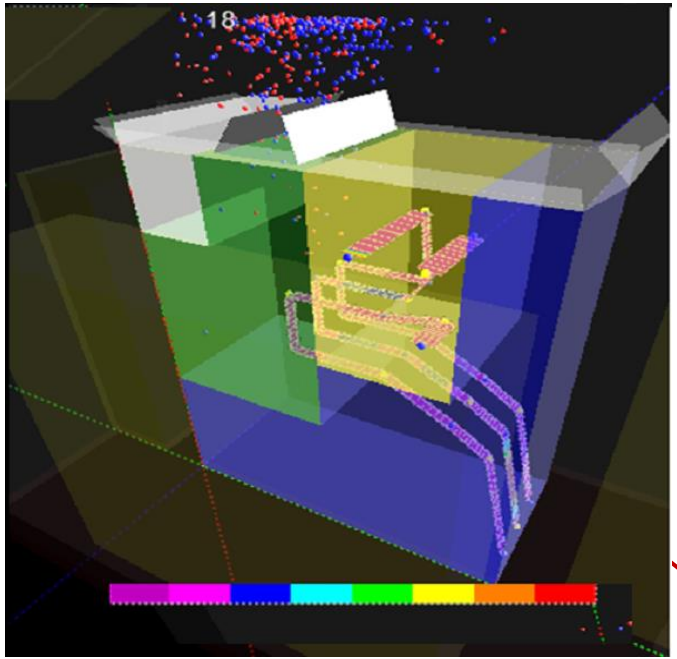
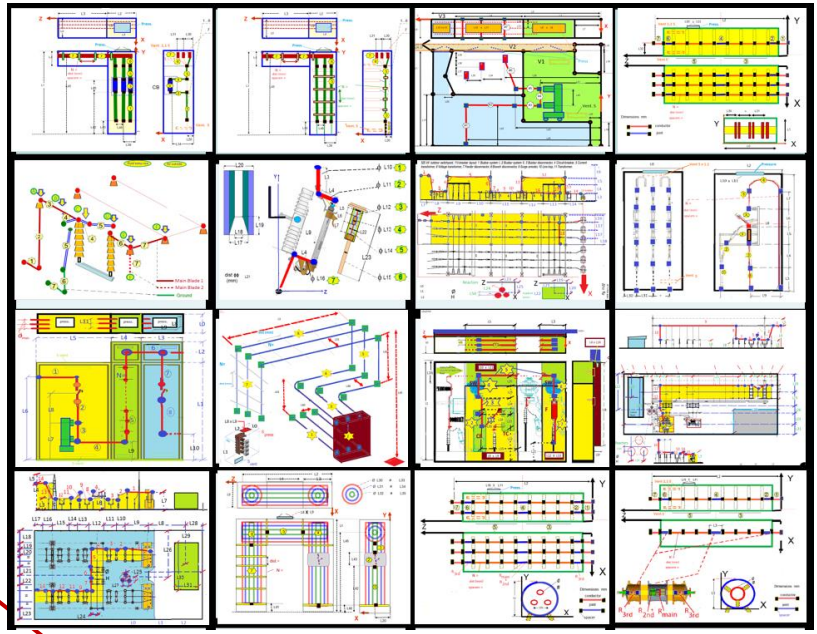
High-Power Testing simulations

are a low-cost alternative for developments





SwitchgearDesign was developed by Sergio Feitoza, a high-power testing lab expert

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TEMPERATURE RISE

Design concepts & Tests.

(IEC61439 + IEC 62271)

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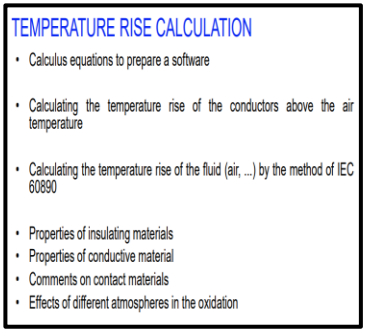
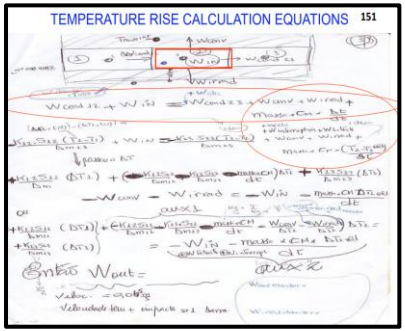
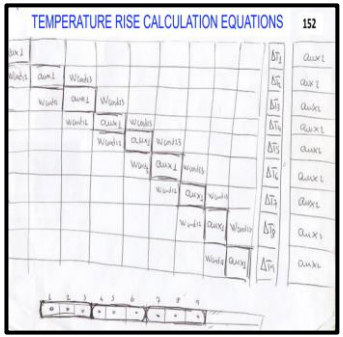
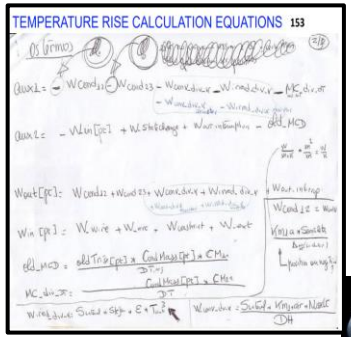
If you want to create a software to calculate temperature rise in switchgear, read pages 150 to 155 of my book (link above) with SwitchgearDesign equations.

I wrote them 22 years ago. #sergiofeitozacosta









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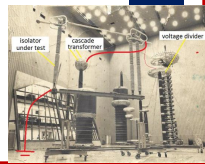
Want to predict the result of the temperature rise test before going to the testing lab for the expensive test ?



Use SwitchgearDesign testing simulations

(also for internal arc & short circuit forces).

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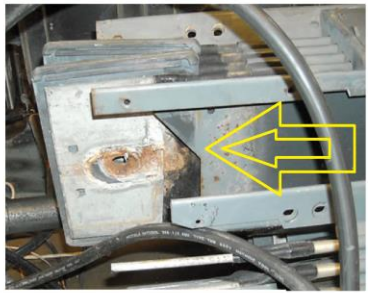

IEC 61439 – Temperature rise test: question to maintenance team or "committee of testing laboratories (CTL)".

I did a test in a 4000 A busway (could be a switchboard). The temperature of the air in the lab was 22°C. I measured 101°C in a copper silvered connection and measure . So, **the temperature rise was 101-22= 79K.**

Question is: By table 6 of IEC 61439-1 the equipment was APPROVED OR NOT approved ? Would not pass by IEC 62271-1 table

In Table 6 for "Busbars and Conductors" it is written that the temperature rise permitted is limited by (a) mechanical strength of conducting material (b) possible effect on adjacent equipment (c) permissible temperature limit of the insulating materials in contact with the conductor; (e) effect of the temperature of the conductor on the apparatus connected to it; (f) for plug-in contacts, nature and surface treatment of the contact material

This is not – obviously - a text usable by neutral testing laboratories or certificators because the values are not known by the lab. Why not using a clear table with clear values as in the IEC 62271-1 ? **TWO BAD CONSEQUENCES** : (a) most of the test reports do not have a statement "passed or not" (b) Unfair competition between manufacturers who consider the value of 75K and manufacturers who - from the bad text - use much higher values like 105K

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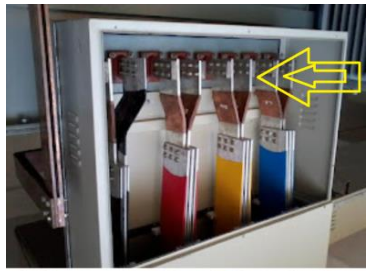
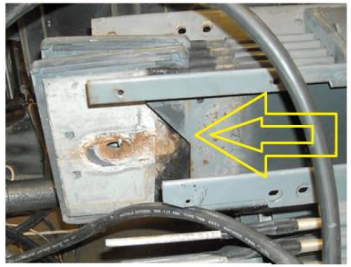
IEC 61439 – Teste de elevação de temperatura: Pergunta ao time IEC de manutenção da norma ou o "Comitê de Laboratórios de Testes (CTL)".





Fiz teste em barramento blindado 4000 A . Temperatura do ar externo no laboratório era 22°C. Coloquei termopar em conexão de cobre prateada e medi 101°C. Então, a elevação de temperatura foi **101 -22 = 79K.**

PERGUNTA: Pela tabela 6 da IEC 61439-1 o equipamento foi **APROVADO OU NÃO APROVADO?** Pela IEC 62271-1 seria reprovado, pois lá o limite é 75K

Na Tabela "Barramentos e Condutores" está escrito que a elevação de temperatura permitida é limitada por (a) resistência mecânica do material condutor (b) possível efeito em equipamentos adjacentes (c) limite de temperatura permitido dos materiais isolantes em contato com o condutor; (e) efeito da temperatura do condutor sobre os aparelhos a ele conectados; (f) para contatos plug-in, natureza e tratamento de superfície do material de contato . Este texto não é – obviamente - utilizável por laboratórios de teste neutros ou certificação porque os valores não são conhecidos pelo laboratório. Por que não usar uma tabela com valores claros como na IEC 62271-1? . DUAS CONSEQUÊNCIAS RUINS PARA O MERCADO: (a) a maioria dos relatórios de teste não diz se o equipamento "passou ou não" (b) Concorrência desleal entre fabricantes que consideram o valor de 75K e fabricantes que são induzidos pelo texto ruim a usar valores muito mais altos como 105K

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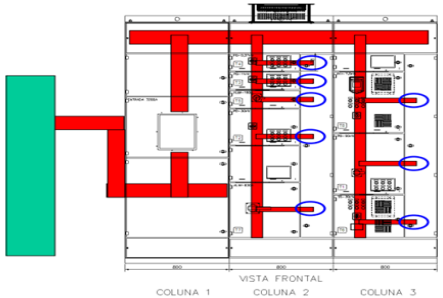
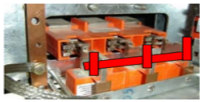
TEMPERATURE RISE: A GUIDE to LEARNING to DESIGN MV SWITCHGEAR (IEC62271), LV SWITCHBOARDS (IEC61439) & BUSWAYS

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

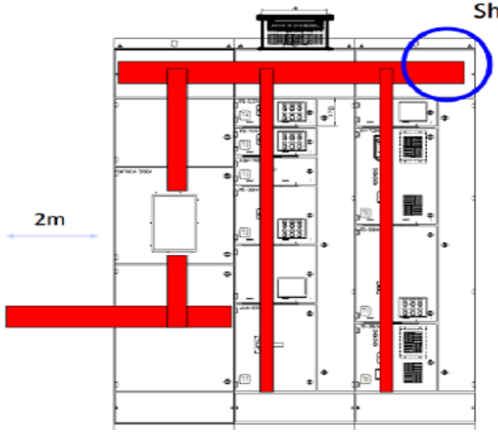
Summary: Understand the path of stones for whom wants to learn the temperature rise concepts used in design, specification and testing. The 2 usual ways to learn are (a) studying alone but using the right technical references. Right means, documents that really teach how to solve daily problems, and not academic papers , and (b) taking training or classes with someone already experienced in the subject, who already knows the shortest paths. In general, more experienced professionals prefer the 2nd option, because of the shorter learning time. Younger people and beginners, in general prefer the 1st , to start studying alone. In this case, almost everyone I met, after spending a lot of time reading the materials, decided to seek training from someone experienced. It is the cheap that is expensive. I will base this guide text on documents, which are the best I know about the theme. I will summarize their content. Read my CV and trust what I am saying. I have a lot of experience in this topic. Good learning !





Short circuit point 65kA – 380V – 60Hz

Short circuit point



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Switchgear / switchboards (training IEC 62271 / IEC 61439)

BARE CONNECTIONS: limits of IEC62271-1 raised from 50 to 60K.

Would it be possible to do the same for silvered connections (75 to 85K) and tinned (65 to 75K).?

Read the article – link above

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Switchgear / switchboards (training IEC 62271 / IEC 61439)

I am doing **R&D work to identify economical methods to silver or tin plate the ends of copper bars**

Where can I find articles ? Are there faster methods than electrolytic processes.

Do you know machines to do this quickly for small thicknesses?

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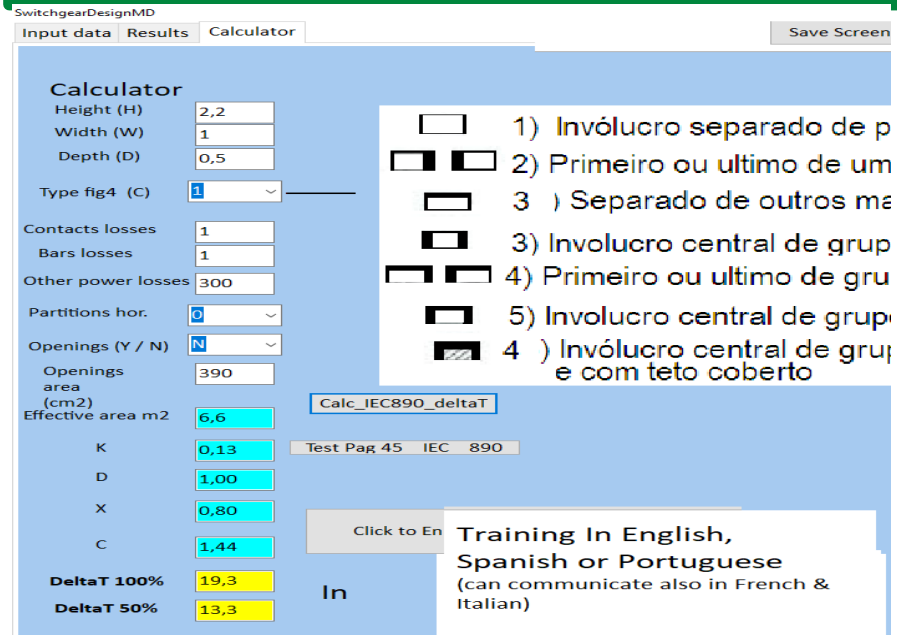
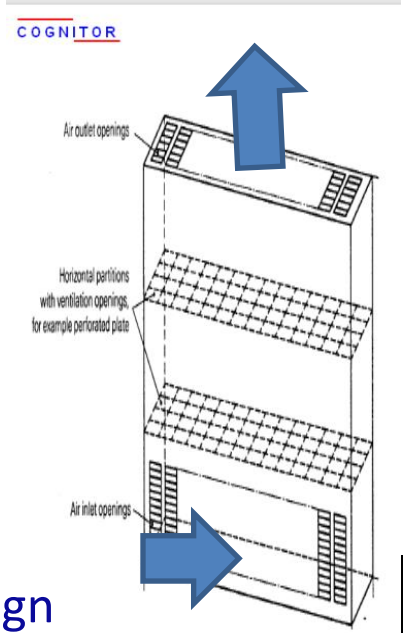
Para conexões nuas, os limites da IEC62271-1 subiram de 50 para 60K. Seria possível fazer o mesmo em conexões prateadas (75 a 85K) e estanhadas (65 a 75K).?

Flashes of the Web training (link above) – Improved IEC 60890 method to calculate temp. rise of the fluid but extended by me to cover also forced ventilation





Using SwitchgearDesign

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Assessing the aging of switchgear, switchnoards and busways connections by IEC 60943

$$K = 2^{\frac{(\Delta T_{i1} - \Delta T_{i2})}{\Delta i} + \frac{(T_{e1} - T_{e2})}{\Delta_e}}$$

- Copper electrical contact initially with temperature rise equal to 35K
- Apply overload so that the temperature rise above ambient becomes 45K
- Constant $\Delta_i = 6K$ for $\Delta T_{i1} = 35K$ (Figure B)

$$K = 2^{\frac{(35-45)}{6}} = 0.315$$

Life expectancy in the conditions of standard (suppose 10 years) will be multiplied by a factor of 0,31

You need to buy 3 contacts in 10 years instead of just one

IEC 62271-1: temperature rise permitted for a copper silvered connection, as busbar to circuit breaker is 75K. It is the critical point in most tests. Having only 10K above the limit means you have a loss of life of 1/3 . **THE QUESTION IS: what is the temperature rise permitted in IEC 61439 series? Check what is written in your test report.**

IEC 62271-1: temperature rise permitted for a copper silvered connection, as busbar to circuit breaker is 75K. It is the critical point in most tests. Having only 10K above the limit means you have a loss of life of 1/3 . **THE QUESTION IS: what is the temperature rise permitted in IEC 61439 series? Check what is written in your test report.** The ELECTRIC POWER INDUSTRY need an ENVIRONMENTAL EFFICIENCY CERTIFICATE FOR POWER PRODUCTS. Only , HITACHI, EATON, SIEMENS, ABB, SCHNEIDER, GE have force to propose this to ISO / IEC. It is to attest that the product was designed with the minimum necessary use of copper, aluminum, insulating supports, materials etc. This is a fantastic not-explored market . Read the chapter "City of Environmental Education and Energy" of the FREE book in this link https://lnkd.in/dDVDPTT

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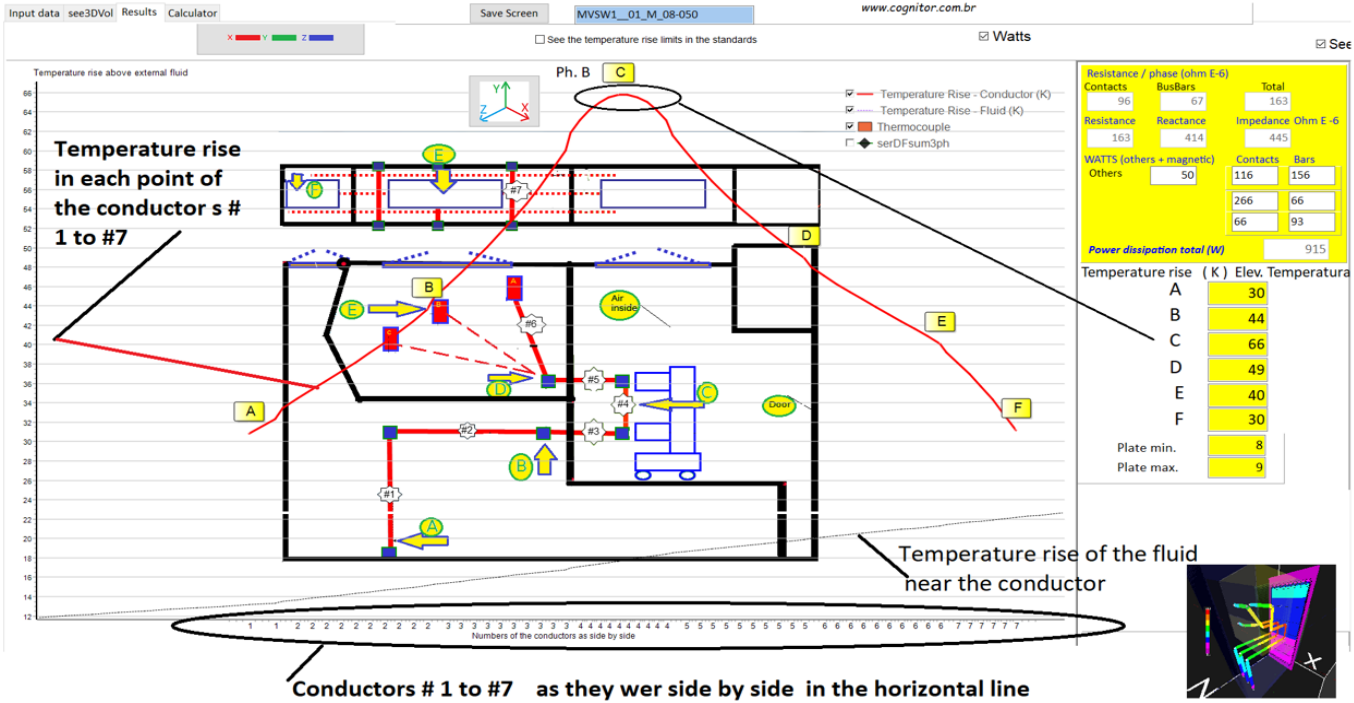
Switchgear Web training (link above)

Vertical axis = Temperature rise
Horizontal: conductors 1 to 7 side by side



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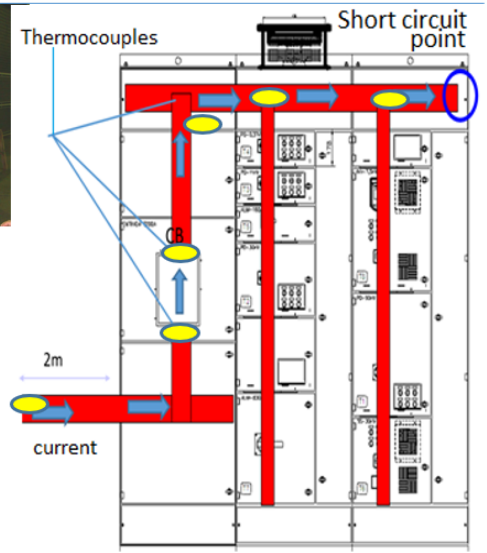
Switchgear Web training (link above)

What is the Temperature Rise test ?

- Mount the equipment as in normal use
- Room without air drafts
- Apply the rated current
- Wait the stabilization of the temperatures (like 4 hours)



- Measure in points specified in the technical standard
- **Temperatures (T)** and **air external Temperature (T_{amb}).**
- **Temperature rise** $\Delta T = T - T_{amb}$

- **Approved if** "temperature rise" is lower or equal to standard permitted limits.

- **AVOID to accept Test Reports which do not state " Approved" .** Need to be skilled to check

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Can I mix materials in connections ?

Higher " bi-metallic voltage" = more oxidation (acceptable < 0.5 V)

IEC 60943

Copper

Copper
X
Aluminum
=
0, 58 V
=
NO

Aluminum

TABLE III

Voltages in 10^{-2} V developed on bi-metallic contacts

Anode (−) / Cathode (+)	Silver	Nickel	Monel (30% Cu)	Cupro-nickel (70-30)	Copper	Silver solder	Bronzes*	Red bronze	Brasses*	Stainless steels*	Tin	Tin-lead solder	Tin-silver solder	Lead	Cast-iron	Steels	Aluminium alloys*	Aluminium	Cadmium	Galvanized iron or steel	Zinc alloys*	Zinc	Magnesium alloy*
Silver	0	15	17	19	19	21	23	25	26	33	47	48	51	56	71	72	77	77	[illegible]	109	110	111	159
Nickel		0	02	04	04	06	08	10	11	16	32	33	36	41	53	57	62	62	[illegible]	94	95	96	144
Monel (30% Cu)			0	02	02	04	06	08	09	16	30	31	34	39	54	55	[illegible]	60	62	[illegible]	93	94	142
Cupro-nickel (70-30)				0	0	02	04	06	07	14	28	29	32	37	52	53	58	58	60	90	91	92	140
Copper					0	02	04	06	07	14	28	29	32	37	52	53	58	58	60	90	91	92	140
Silver solder						0	02	04	05	12	26	27	30	35	50	51	56	56	58	88	89	90	138
Bronzes*							0	02	03	10	24	25	28	33	48	49	54	54	56	86	87	88	136
Red bronze								0	01	06	22	23	26	31	46	47	[illegible]	52	54	[illegible]	85	86	134
Brasses*									0	07	21	22	25	30	45	46	51	[illegible]	[illegible]	83	84	85	133
Stainless steels*										0	14	15	18	23	38	39	44	44	46	76	77	78	128
Tin											0	01	04	09	24	25	30	30	32	62	63	64	112
Tin-lead solder												0	03	08	23	24	29	29	31	61	62	63	111
Tin-silver solder													0	05	20	21	26	26	28	58	59	60	108
Lead														0	15	16	21	21	23	53	54	55	103
Cast-iron															0	01	06	06	08	38	39	40	88
Steels																0	05	05	07	37	38	39	87
Aluminium alloys*																	0	0	02	32	33	34	82
Aluminium																		0	02	32	33	34	82
Cadmium																			0	30	31	32	80
Galvanized iron or steel																				0	01	02	50
Zinc alloys*																					0	01	49
Zinc																						0	45
Magnesium alloy*																							0

*Characteristic values.

Flashes of the Web training (link above)

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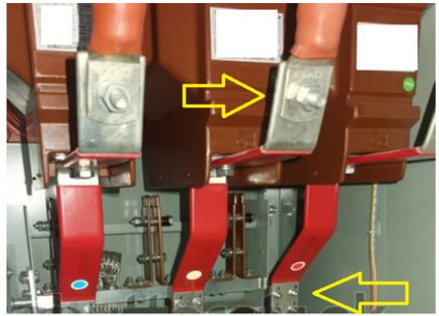
Design of IEC62271 & IEC61439 products: (training)

It is more economic to use **Silvered or Tinned** than **bare connections**!

Author Sergio Feitoza Costa COGNITOR – Consultancy, Research and Training Ltd. **Please help me to share**

Keywords: Substations, Optimization, Switchgear, design, reduction of costs, validation, High Power , Testing, Laboratory, Simulations, Calculations, IEC Standards, Busbar systems, Internal Arcs, Overpressures, Temperature rise, Electrodynamical stresses, short time currents, Magnetic Fields

Temperature rises in the connection (K)	Busbar dimensions per phase	Weight of copper (kg) and % of 50Kvalue	Total kg/MVA
50K	100x10 mm	110 (100%)	142
60K	83,5x10 mm	92 (84%)	130
65K	77,5x10 mm	85 (77%)	125
75K	67,8x10 mm	74 (67%)	118



READ THE ARTICLE IN THE LINK ABOVE

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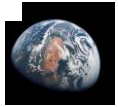
calculated with SwitchgearDesign



IEC 62271 / IEC61439 training (*) : **Forced ventilation** is good.

Can reduce weight of equipment in 1/3

Ventilation openings X increase the busbar cross-section:

Temperature rise - IEC 62271 & IEC 61439

If you block the ventilation area of the domestic cable TV modem it will burn out much faster. Ventilation openings avoid this. If you accept this in your home, why do you think it is not reliable to put forced ventilation in panels?

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Build products with lower $$ / MVA and KG / MVA and use this as marketing to reach companies that give importance to the environmental image.

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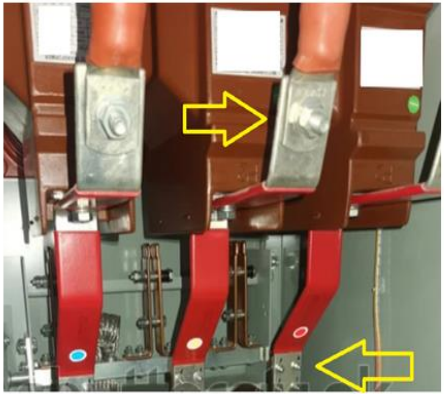
Projeto e testes de painéis e barramentos de produtos IEC62271 & IEC61439: (treinamento)

É mais econômico usar **conexões prateadas** ou **estanhadas** que **conexões nuas**

Autor Sergio Feitoza Costa *** COGNITOR – Consultancy, Research and Training Ltd. *** Por favor compartilhe

Keywords: Substations, Optimization, Switchgear, design, reduction of costs, validation, High Power , Testing, Laboratory, Simulations, Calculations, IEC Standards, Busbar systems, Internal Arcs, Overpressures, Temperature rise, Electrodynamical stresses, short time currents, Magnetic Fields

ELEVAÇÃO DE TEMPERATURA NA CONEXÃO (K)	BDIMENSÕES DA BARRA mm (por fase)	PESO DO COBRE (kg) e % do valor 50K	Total kg/MVA
50K	100x10 mm	110 (100%)	142
60K	83,5x10 mm	92 (84%)	130
65K	77,5x10 mm	85 (77%)	125
75K	67,8x10 mm	74 (67%)	118



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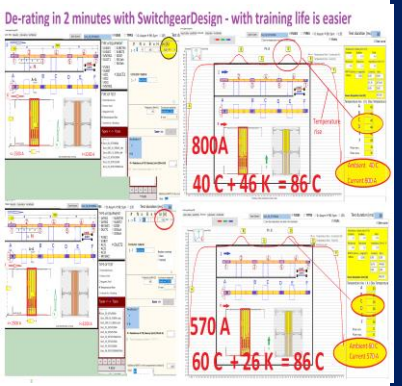
calculated with SwitchgearDesign

IEC 62271 / IEC61439 training (*) : Do you know what Amperes derating is ?

Suppose a maximum permitted temperature rise in the IEC standard is 46K, with 800 A. Air outside is 40°C. This means a maximum permitted temperature of the connection material 46K + 40°C= 86°C



Derating: To use in an air temperature 60°C **recalculate the current which will produce** the same **86°C = 26K + 60°C. Here is 570A.**

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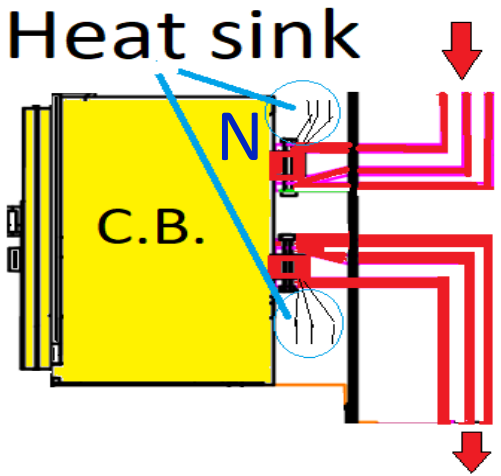
Calculate with SwitchgearDesign

Switchgear / switchboards

(hotspot = circuit breaker terminals)

** calculated with SwitchgearDesign



N	Temperature rise ** (K)
0	75
2	71
7	???

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IEC 60943: Contact resistance representation

- **N** small contacts

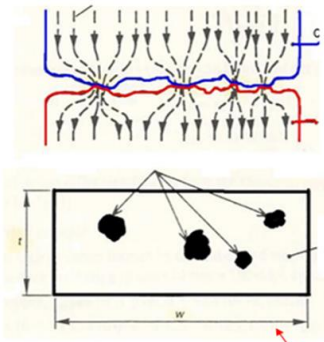
$$n = n_k . H^{0.625} F^{0.2}$$

$$n_k \approx 2.5x10^{-5} (SI)$$

- with radius **a**

$$a = \sqrt{\frac{F}{\eta . \pi . \xi . H}}$$

- F = force in the contact
- H = hardness of the material
- ξ = roughness coefficient ~ 0.3 a 0.6



Virtual contact with **N** elements in paralel with a radius **a**

IEC 60943: calculating contact resistances

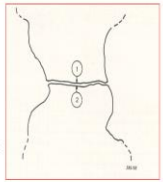
$$R_c = \frac{\rho}{2 . \eta . a} + \frac{\sigma_0}{\eta . \pi . a^2}$$

Constriction resistance (geometry)

Resistance due to the oxide layer in the interface of the contacts

σ_0 = surface resistivity (function of the thickness of the oxide layer)

ρ = material resistivity
a = radius of each small virtual contact
n = number of virtual contacts



High temperatures accelerated the oxidization in the interface surface

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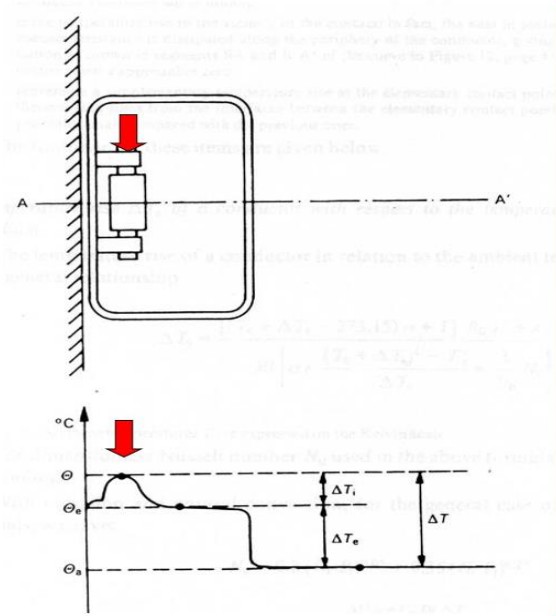
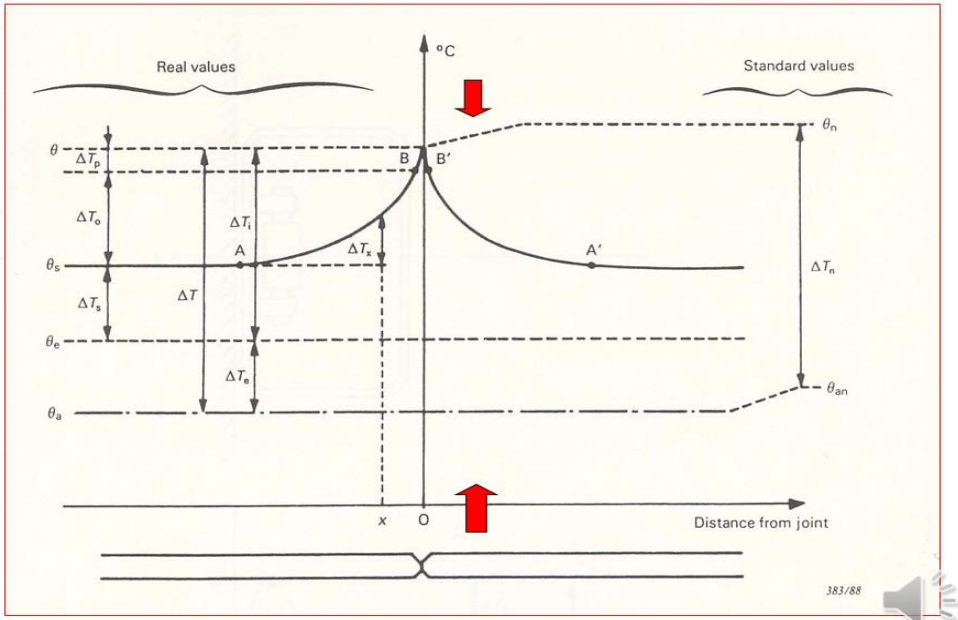
IEC 60943: Contact resistances are the main source of heat





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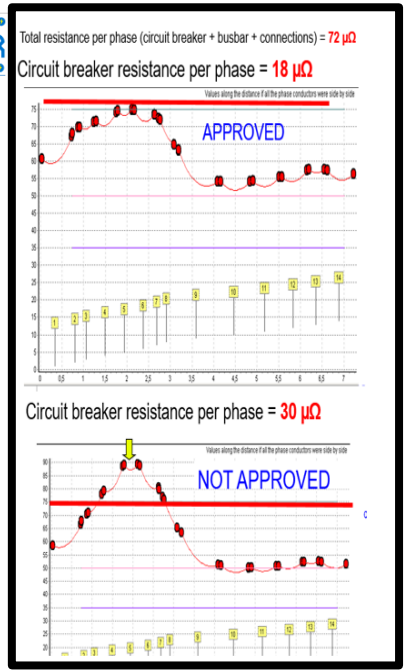
Temperature rise limits: IEC 62271-1, IEC 61439 & IEC 62271-200

If limits are exceeded parts may have accelerated aging or even be destroyed in a small time

Part	Contact material and medium where it is used	Temperature Rise máx. (K) amb 20°C	Temperature máx. (°C) ambient 40°C	Comments
SPRING CONTACT	Copper and copper alloys uncoated - in air - in SF6 - in oil	35 50 40		
	Tinned , in air, SF6 oru oil	50		
	Silver or niquel plated - in air - in oil	65 50		
	For contactors in oil		105	Oil deterioration
BOLTED CONTACT	Copper , aluminum and alloys uncoated in air uncoated in SF6	50 65		
	Tinned, in air or SF6		105	Tin "creep point"
	Silver or niquel plated air or SF6	75		
	Silver or niquel plated in óleo		100	Oil deterioration
	For contactors in oil		105	Oil deterioration
METALIC PARTS	In contact with insulation class • Y / A / E • B / F / H		90 / 105 / 120 30 / 155 / 180	Isolation ageing
	• Acting as spring • In soldering position		caso a caso 100	Permanent deformation /Break
SURFACES	Can be touched (met / non met.) Acessible but not touched		70 / 80 80 / 90	Do not injure persons

To compare with the yellow column this means a temperature rise 105-40=65 K



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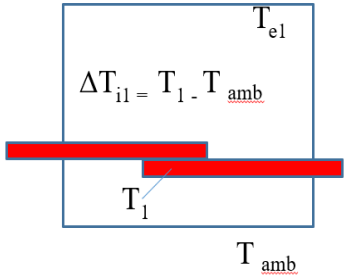
IEC 60943: Loss of life

Influence of the temperature (T_{e1} e T_{e2}) and temperature rise (ΔT_{i1} and ΔT_{i2}) in the aging

$$K = 2^{\frac{(\Delta T_{i1} - \Delta T_{i2})}{\Delta i} + \frac{(T_{e1} - T_{e2})}{\Delta_e}}$$



1 hour of operation in the condition 1

=

K x 1 hour of operation in the condition 2

Δ_e and Δ_i are functions of ΔT_i

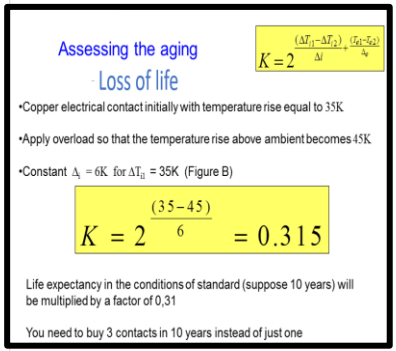
T_{e1} = Ambient temperature inside box

T_{amb} = Ambient temperature outside

T_1 = contact temperature

ΔT_{i1} = temperature rise of the contact related to external temperature

Condition 1: lower temperature
Condition 2: higher temperature



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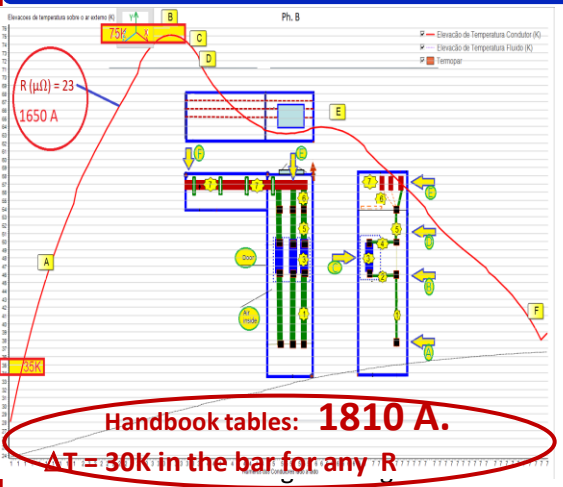
Switchgear / switchboards (training)

Article link above

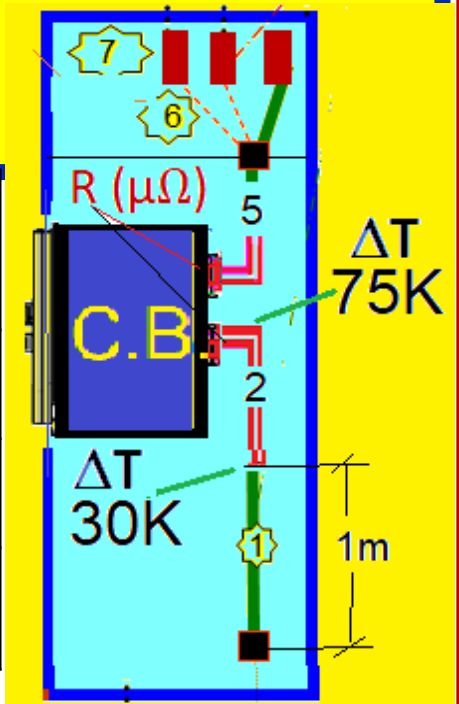
Still using that old tables to design busbars ?



Handbook tables: 1810 A.

ΔT = 30K in the bar for any R

μΩ	Amperes for 75K in C.B. connection
R = 0	1950 A
R =10	1850 A
R= 23	1650 A



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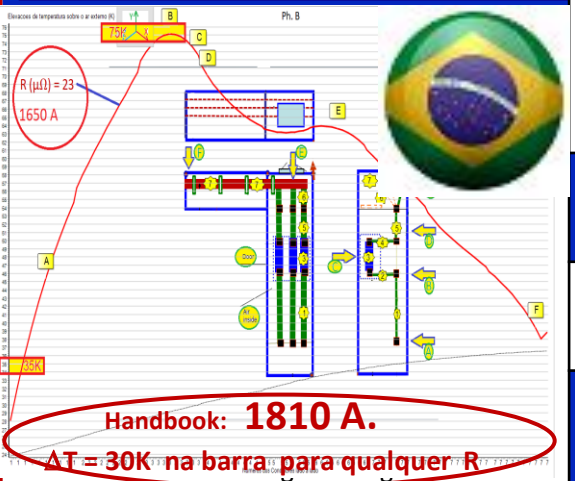
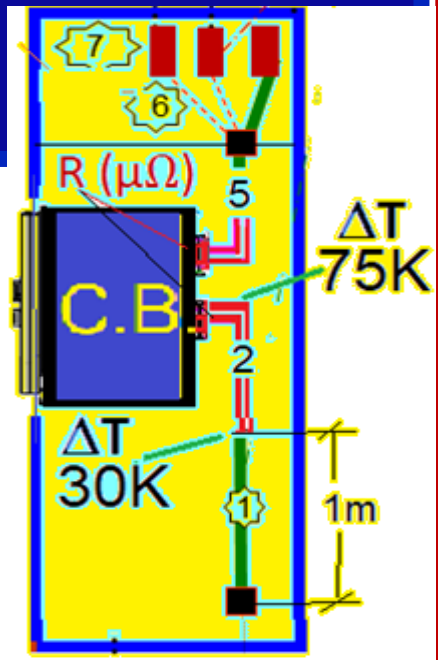
Painéis e dutos blindados (treinamento)

Artigo no link acima

Ainda usa velhas tabelas para calcular a corrente das barras ?



μΩ	Amperes p/ 75K no disjuntor
R = 0	1950 A
R =10	1850 A
R= 23	1650 A



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Page 103 of my free book (link above)

CONTACT RESISTANCE

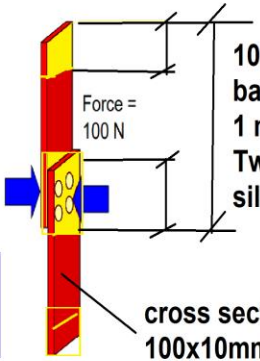
$$R_c = \frac{\rho}{2.\eta.a} + \frac{\sigma_0}{\eta.\pi.a^2}$$

$$a = \sqrt{\frac{100}{18.\pi.(0.45).(5.5x10^8)}} = 85x10^{-6} m$$

$$n = 2.5x10^{-5} \cdot x(5.5x10^8)^{0.625} \cdot x100^{0.2} = 18.2 = 18$$

$\rho = 1.78 \times 10^{-8}\ \Omega.m$
$\sigma_0 = 5 \times 10^{-12}\ \Omega.m^2$

R_c = 6 + 12 = 18 μΩ



100 copper bars with 1 meter each Two ends of 0,1 m silvered

cross section 100x10mm (0,1x0,01m)

Total silvered are in each end is approximately
2 x 0,1 x 0,1 + 2 x 0,1 x 0,01 =

0,022 m²

The silvered area for 100 pieces of 1m with 2 ends is 2x100x0,022 = 4,4m²

If we have a covering with a thickness 5μm the mass of silver needed is around 4,4 m² x 5 x 10-6 m x 10500 (kg/m3 - silver density) = 0,23 kG

Just as an order of magnitude this means a materials cost of USD 710x0,23 = USD 163,00

So, we are speaking about (not including work): USD 163,00 /4,4 m2 = 37 USD/m2 or USD 1,63 / piece of bar . What I need to know is a more precise value of USD/m2 but also considering the work time.

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Switchgear / Switchboards (training) Learn how to save Earth resources

Same weight of copper but rated current 33% higher

Easy to do and to calculate

with SwitchgearDesign

Copper bars per phase	Bars per phase	Current giving 75K in connection (Ampere)	Same total Weight of Copper (kg)	Kg / MVA	U$ / MVA
1 x 100 x 20 mm		1650 A (No vent. openings)	202	14	243
2 x 100 x 10 mm		1940 A (No vent. openings)	202	12	207
4x 100 x 5 mm		2290 A (No vent. openings)	202	10	175

14

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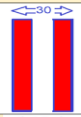
Painéis Elétricos (treinamento)

Mesmo peso de cobre porém corrente nominal 30% maior

Fácil de fazer e calcular

com o SwitchgearDesign

Copper bars per phase	Bars per phase	Current giving 75K in connection (Ampere)	Same total Weight of Copper (kg)	Kg / MVA	U$ / MVA
1 x 100 x 20 mm		**1650 A** (No vent. openings)	202	**14**	**243**
2 x 100 x 10 mm		**1940 A** (No vent. openings)	202	**12**	**207**
4x 100 x 5 mm		**2290 A** (No vent. openings)	202	**10**	**175**

14

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IEC 61439-1: Answer to a NIAZ QUESTION about TABLE 6 - (Limits of temperature rise)

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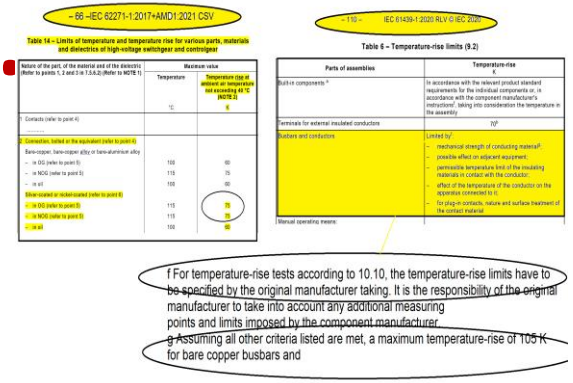
Question: “Table 6 (note g), states a maximum **temperature rise limit of 105K for busbars …**

Why ?

Read my answer in the new 2 pages article (link above)



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Painéis elétricos de média e baixa tensões (curso CWB)

Pergunta: Temperaturas maiores que limites das normas reduzem muito a vida útil das conexões e componentes.

Quais 2 fatores + fáceis na reforma de um painel antigo, para reduzir as temperaturas ?

a) A resistência do disjuntor (mudar de extraível para fixo)
b) O perímetro das barras (área exposta a ventilação). P.ex. usar por fase 2x100x5 ao invés de 1x100x10mm
c) O tamanho das aberturas de ventilação (aumentar)
d) A seção transversal dos barramentos (aumentar)

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Switchgear / switchboards (training)

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THERMAL LOSSES: CONVECTION, RADIATION & CONDUCTION)

TEMPERATURE RISE CALCULATION ΔT_s
over the temperature of the surrounding air Te

Joule effect — Sun light if applicable — Eddy currents

$$\Delta T_s = \frac{[(T_e + \Delta T_s - 273.15)\,\alpha + 1]\; R_0\, I^2 + r\,\varphi_s\, S_r}{Bl\left[\sigma\,\varepsilon\,\frac{(T_e + \Delta T_s)^4 - T_e^4}{\Delta T_s} + \frac{\lambda}{D_h}\,N_u\right]} + W_{edy}$$

Lateral area — Radiation losses — Convection losses

dy currents= $W_{eddy} = K_1 * B^2 * \omega^2 * e^2 * \rho *$ volume $_{enclosure}$

K_1 = adjustment
$\omega = 2*\pi*f$
e = plate thickness

B = magnetic field
ρ = plate resistivity

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Improve the design of your switchgear / controlgear (MV,LV)

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Reduce the final cost with small changes in busbars geometry, intelligent use of ventilation

If you want to learn to do it alone I can train you in knowing the relevant engineering concepts and to use SwitchgearDesign

If you want that a 3rd part do it for you, I can do it in few days

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Please help me:

MV Circuit breakers: Resistance as seen from the terminals

I need to fill this table for simulations of Temperature Rise Tests. The resistance rarely appear in the catalogues . Please send values to e-mail below

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
TAVIDA 17,5 kV	18 μΩ	
ABB VD4 40kA and 50 kA	????????????????	????????????????

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Melhore o Projeto de seu Painel ou duto (média ou baixa tensão)

Reduza o custo final com pequenas alterações no uso inteligente da ventilação, geometria de barramentos e mais .

Se você quiser aprender a fazer sozinho posso treiná-lo para conhecer conceitos de engenharia e usar o SwitchgearDesign

Se você quiser que eu faça os melhoramentos por você, faço rápido.

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Ventilation (using intelligence to reduce copper and aluminum waste)

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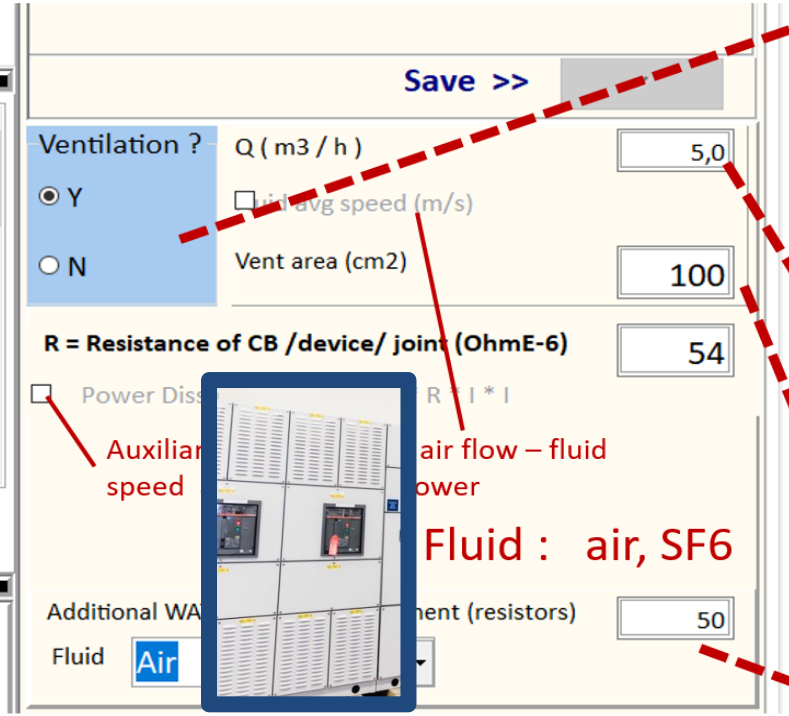

N = completely sealed

Y = there is a window with open area (S) in the bottom and another in the top

Air flow (forced ventilation by fans, exhausters)

S = net area after filters

Additional Watts like lamps and resistors

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The Input Data and Results Screens

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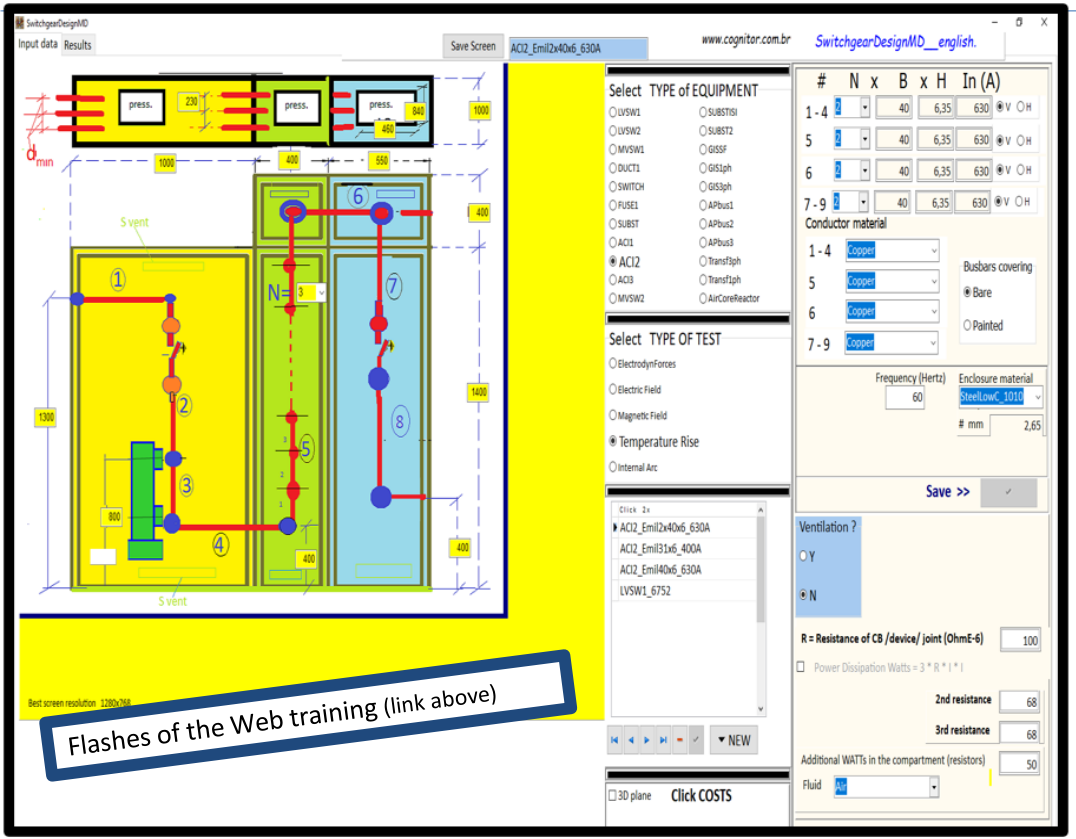

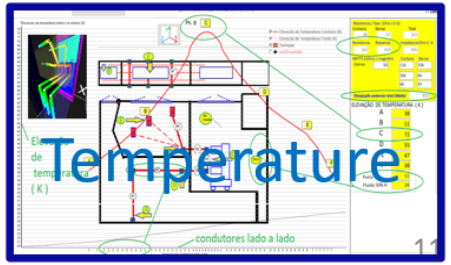

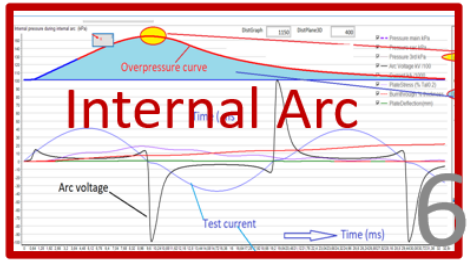

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SHORT CIRCUIT ELECTRODYNAMIC FORCES:

concepts, IEC 61117, IEC TR 60865.

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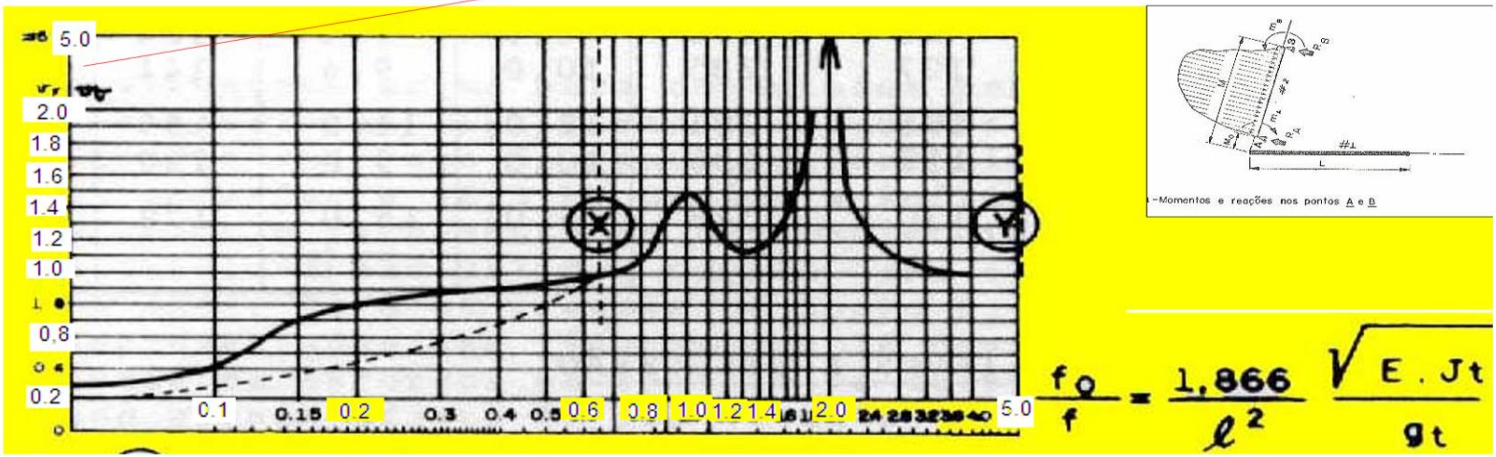
Flashes of the Web training (link above): Calculating **electrodynamic forces** considering only parallel conductors do not enable to **reduce the number of supports in a switchgear**

STEP 2) CONVERT "STATIC FORCES" to "DYNAMIC FORCES"

$F_{dynamical} = F_{static} \times$ Y value factor (function of fo / f in X axis)



$$\frac{f_o}{f} = \frac{1,866}{\ell^2} \frac{\sqrt{E \cdot Jt}}{gt}$$

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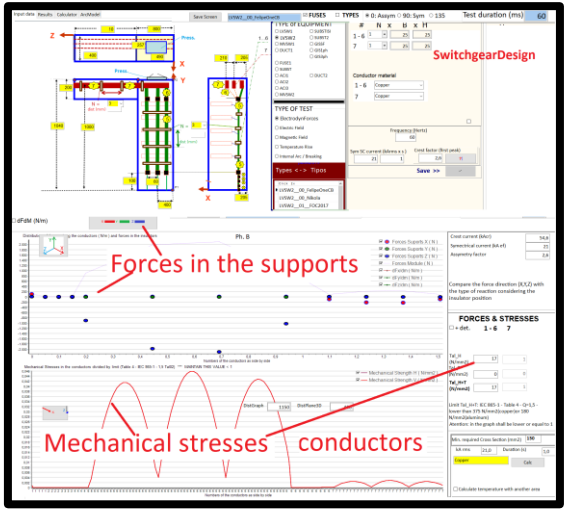
REDUCING THE AMOUNT OF SUPPORTS FOR SHORT CIRCUIT FORCES.

Currents up to 100 kA rms are becoming common and the focus in reducing equipment size provoke much higher forces. It is possible to – easily - calculate the forces accurately to use a minimum of supports.



The ENVIRONMENTAL EFFICIENCY CERTIFICATE FOR POWER PRODUCTS IS COMING

Reducing the use of materials will become a strong factor for the company's environmental image

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Short circuit forces & stresses

COGNITOR 127

STEP 1) CALCULATING DISTRIBUTIONS OF FORCES

(Sergio's M.Sc. thesis)

$$\frac{\partial F_x}{\partial m} = (\psi_0 I_1 I_2/4\pi).\text{sen}^2\alpha.m\left\{\left[1/\sqrt{m^2-2L_0\cos\alpha\ m+L_0^2+S^2}\ (\sqrt{m^2-2L_0\cos\alpha m+L_0^2+S^2}+\right.\right.$$

$$\left.\left.+L_0-m\cos\alpha)\right]-\left[1/\sqrt{m^2-2L\cos\alpha\ m+L^2+S^2}\ (\sqrt{m^2-2L\cos\alpha m+L^2+S^2}+L-m\cos\alpha)\right]\right\} \quad (3.1)$$

$$\frac{\partial F_y}{\partial m} = -(\psi_0 I_1 I_2/4\pi).\cos\alpha.S\left\{\left[1/\sqrt{m^2-2L_0\cos\alpha m+L_0^2+S^2}\ (\sqrt{m^2-2L_0\cos\alpha m+L_0^2+S^2}+\right.\right.$$

$$\left.\left.+L_0-m\cos\alpha)\right]-\left[1/\sqrt{m^2-2L\cos\alpha m+L^2+S^2}\ (\sqrt{m^2-2L\cos\alpha+L^2+S^2}+L-m\cos\alpha)\right]\right\} \quad (3.2)$$

$$\frac{\partial F_z}{\partial m} = -(\psi_0 I_1 I_2/4\pi).\cos\alpha.\text{sen}\alpha.m\left\{\left[1/\sqrt{m^2-2L_0\cos\alpha m+L_0^2+S^2}\ .\right.\right.$$

$$.(\sqrt{m^2-2L_0\cos\alpha m+L_0^2+S^2}+L_0-m\cos\alpha)\Big]-\left[1/\sqrt{m^2-2L\cos\alpha m+L^2+S^2}\ .\right.$$

$$\left.\left.(\sqrt{m^2-2L\cos\alpha+L^2+S^2}+L-m\cos\alpha)\right]\right\} \quad (3.3)$$

Neighbor conductors

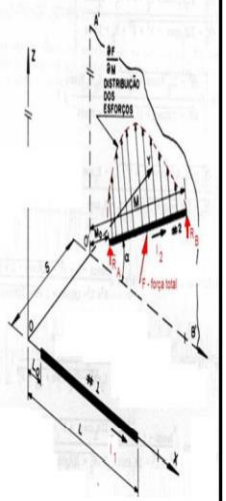
Current I_1 in conductor #1 produce magnetic field B1

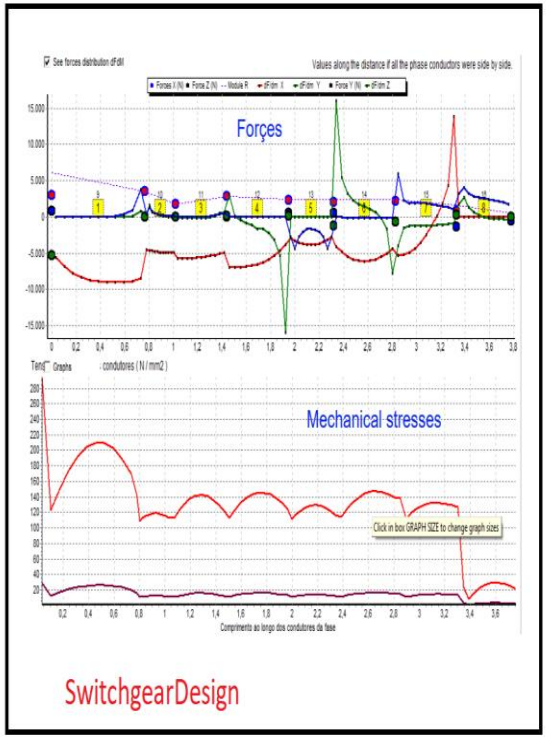
Field B1 interact with current I_2 in conductor # 2 producing a force

$$dF_2 = I_2.dl \times B_1$$

Forces bend the conductor and are transmited to the insulators

$$dF/dm = dFx/dm\ (x) + dFy/dm\ (y) + dFz/dm\ (z)$$





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What does the term "Short Circuit Power" mean?

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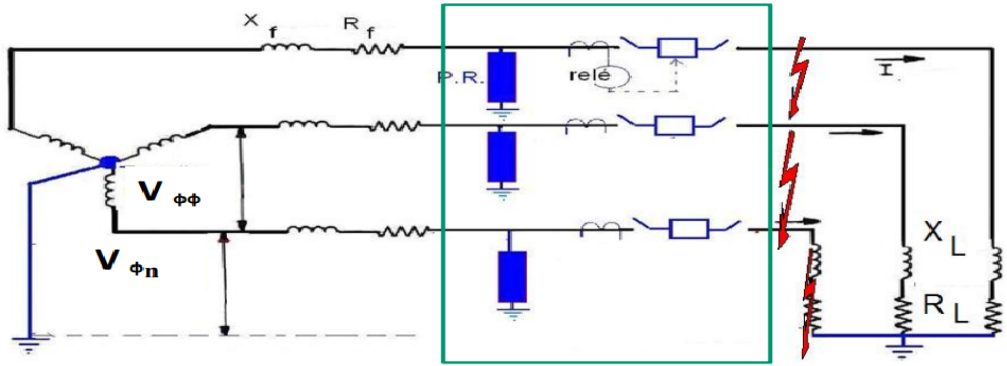
$X_F << X_L$ $R_F << R_L$



$V_{\Phi\Phi} = 145\ kV > V_{\Phi n} = 83,7\ kV$

$I_{sc} = 25\ kA_{rms}$

$P_{sc} = 1,732 \times 145\ kV \times 25\ kA = 6280\ MVA$

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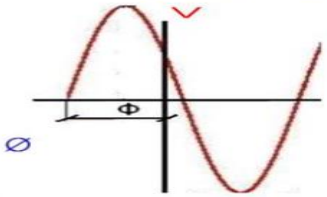
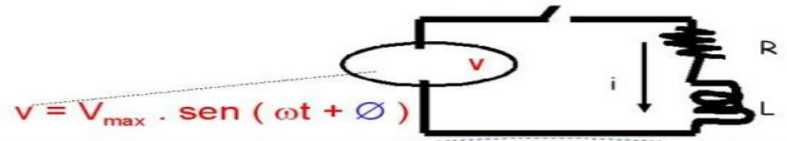
CLOSING AN AC CIRCUIT AND CURRENT ASSYMETRY

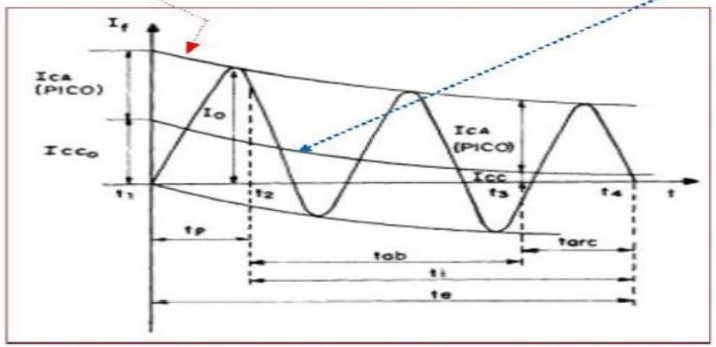


Closing a circuit breaker under a short circuit condition



$v = V_{max} \cdot \text{sen}\,(\omega t + \varnothing)$

$$i = I_{max} \times \text{sen}\,(\omega t + \varnothing - \alpha) - I_{max} \times e^{-t/\sigma} \times \text{sen}\,(\varnothing - \alpha)$$



L= inductance ωL = reactance

R = resistance

t = time

$\sigma = L/R$ = time constant

$I_{max} = Vmax / Z$

$\alpha = \text{arctg}\,(\omega L / R)$

$Z = ((\omega L)^2 + R^2)^{1/2}$

$\omega = 2 \times \Pi \times 60 = 377\ s^{-1}$

X/R

To specify substations equipment you need to know well the meaning

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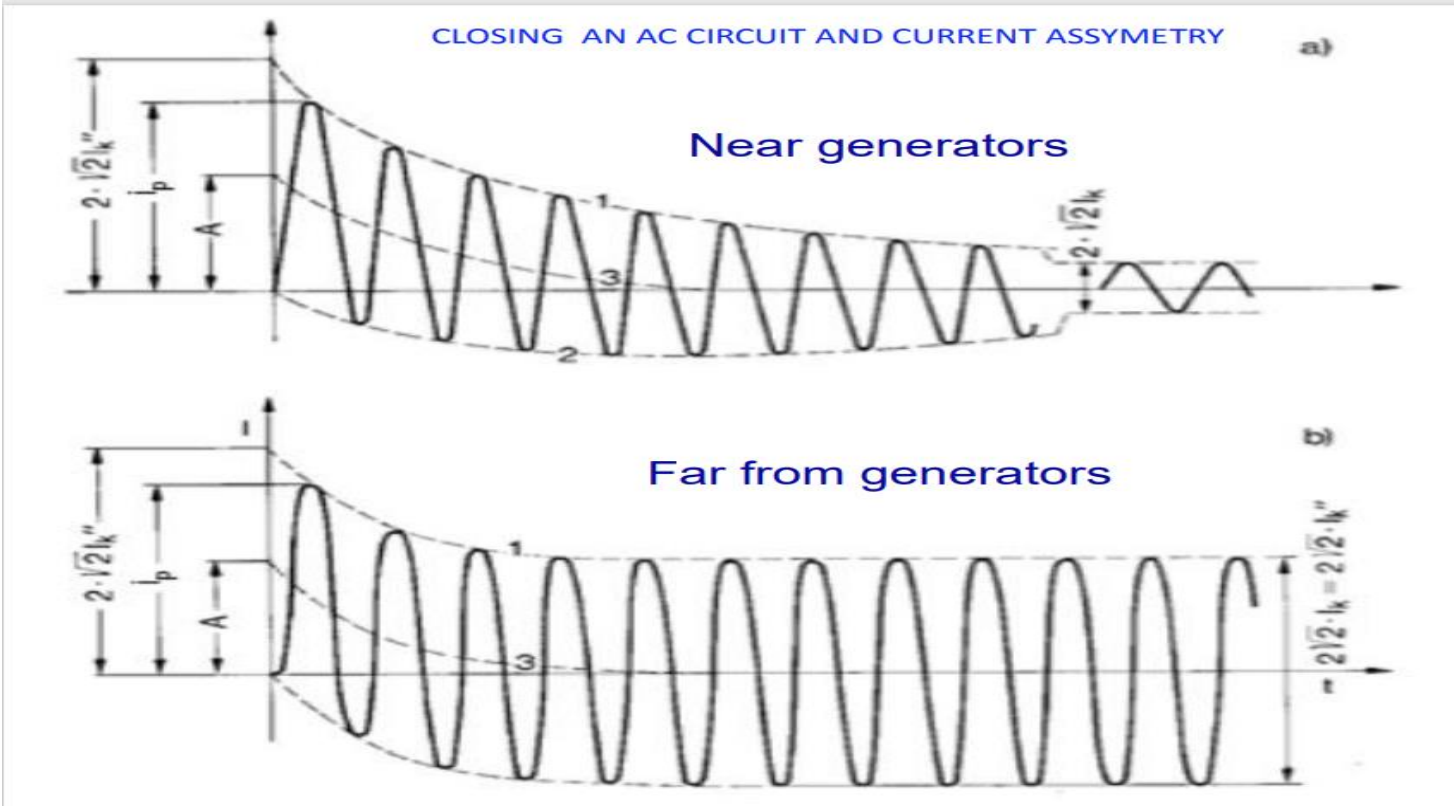

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INTERNAL ARC TESTS

concepts, IEC 62271-200 and 307 (MV), IEC TR 61641 (LV)

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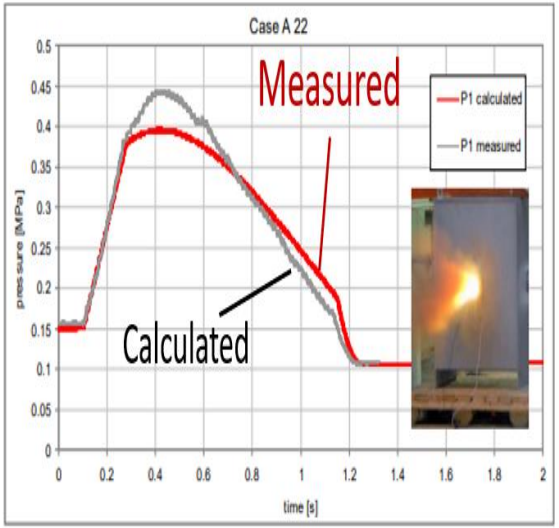
INTERNAL ARC OVERPRESSURES

Brochure Cigrè 602 (2014): Although it is easy to measure and it's the most important factor, IEC / IEEE standards do not request a pressure measurement in the arc compartment during testing

* I am co-author

.. a proper identification of the equipment and relief areas will enable the extension o validity of test reports by IEC 62271-307 .

Prefer labs that measure overpressure



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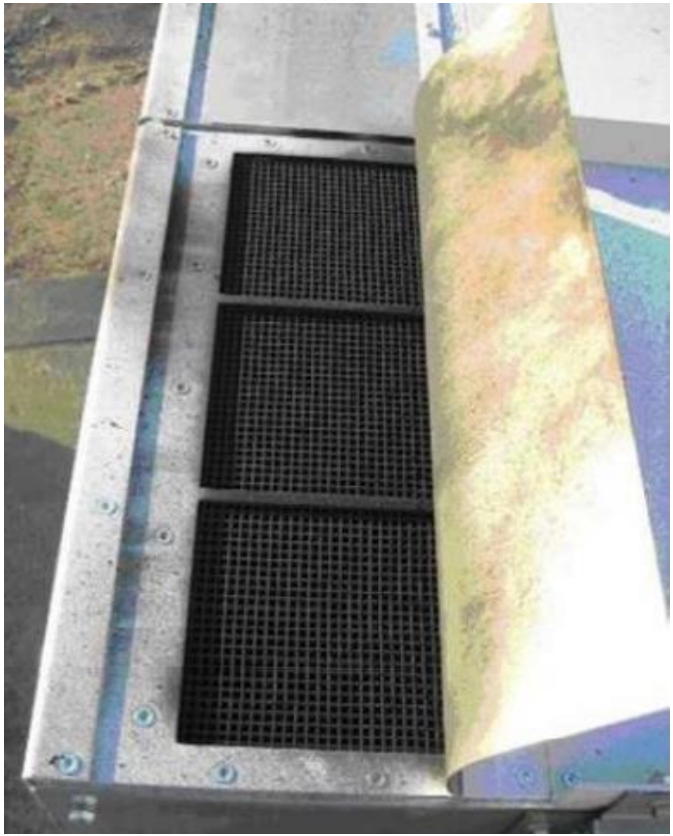

INTERNAL ARC

Use only high-power labs that measure overpressure to avoid future tests using IEC 62271-307 .

Distance to the room ceiling is the main reason of failures due to burning cotton indicators IEC60271-200 was improved.

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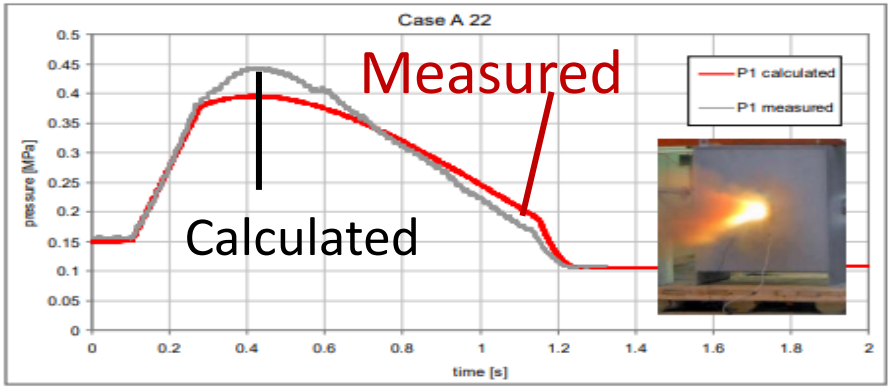
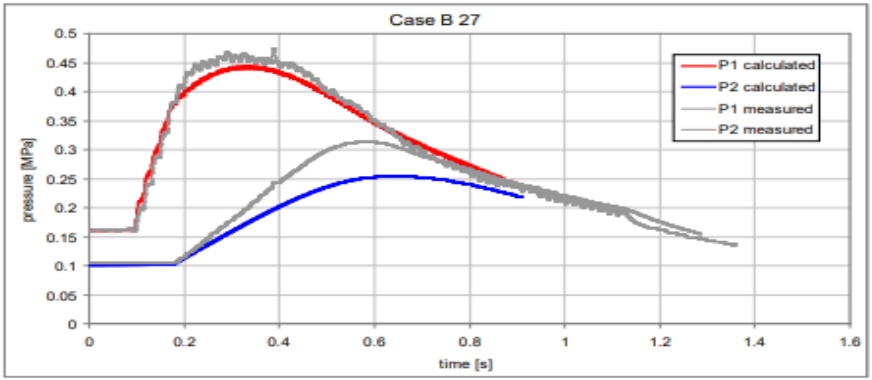


INTERNAL ARC TEST

SIMULATION



Prefer testing labs that measure the overpressure.

It is a sign that they know what is important and understand what is written in technical standards

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OIL PLATFORMS, REFINERIES & MINES (power panels, busways, switchgear)

Great care with Ex equipment & certification. Very high short circuit levels (near big generators). KG/MVA is very important in offshore platforms.

(a) Which additional requirements for **internal arc** (IEC62271 / IEC 61641) **?**

(a) **KG/MVA** of power equipment taken into account in the **BIDs?**

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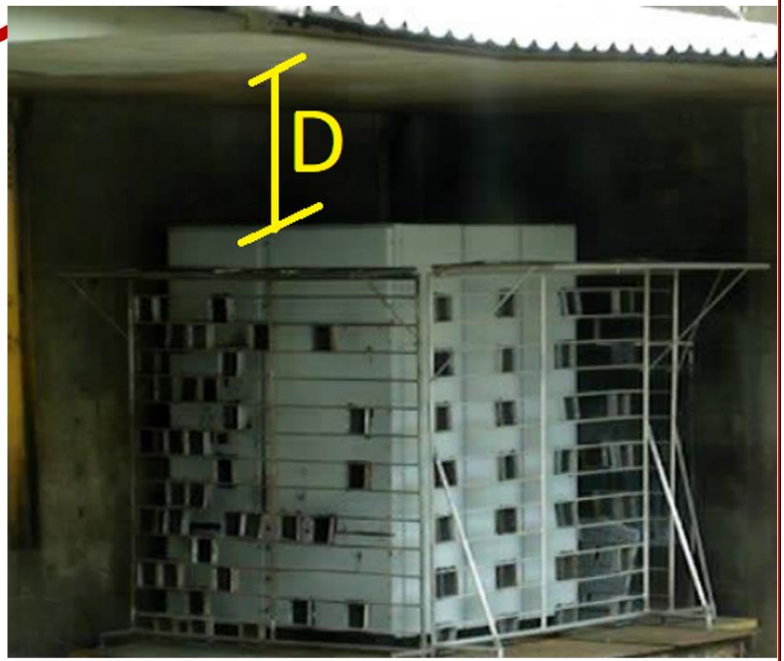
Substations equipment : testing, design & technical standards

INTERNAL ARC

distance from top to ceiling is the key



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Selecting right values avoid failures & bring extension of validity

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BREAKING TESTS of CIRCUIT BREAKERS & EXPULSION FUSES

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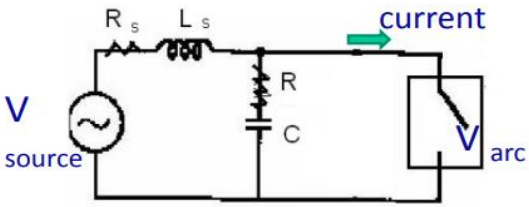
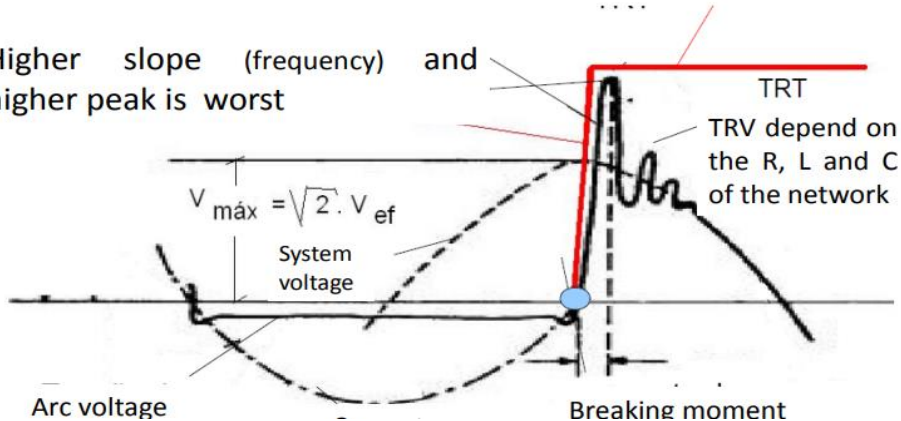


Current interruption in switchgear

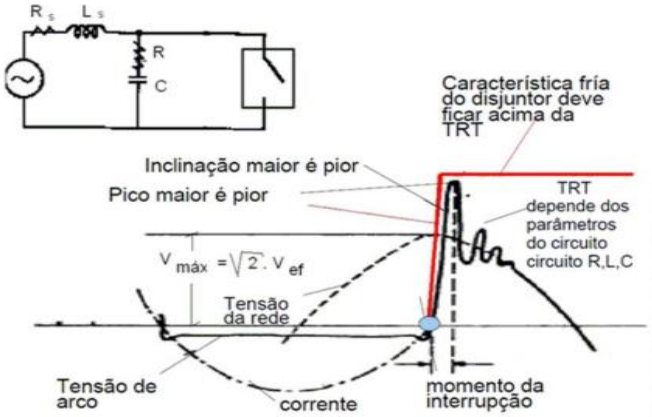
Cold characteristic of the circuit breaker above TRT

Higher slope (frequency) and higher peak is worst



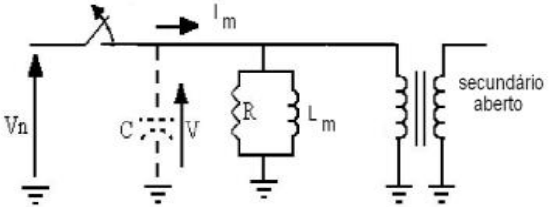
INTERRUPTION OF INDUCTIVE CURRENTS

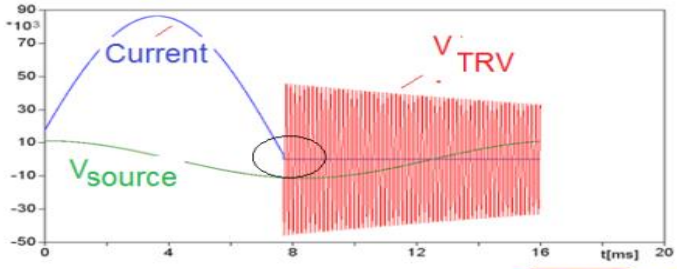
From IN to several IN



Small inductive currents in transformers

- I_m : 0,5 a 5% de I_n





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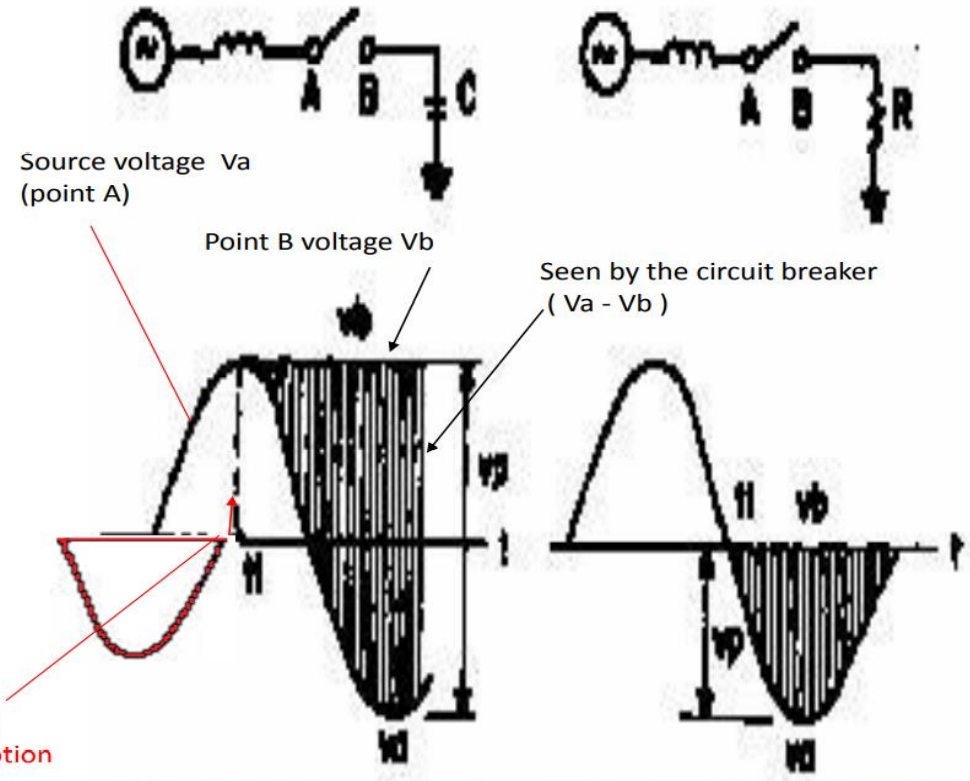
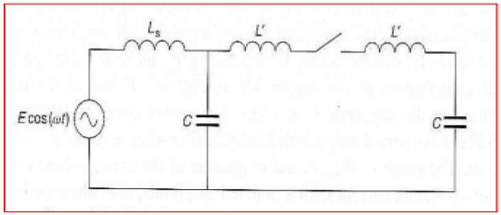
INTERRUPTION OF CAPACITIVE LOADS (cables, capacitors, ..)

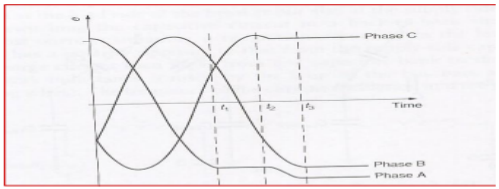
- TRV grows slowly making easier the interruption but V_{peak} = 2pu may cause reignition of the arc because there is not sufficient separation of the contacts

- If a new interruption happens, the voltage may be duplicated again to 4 pu

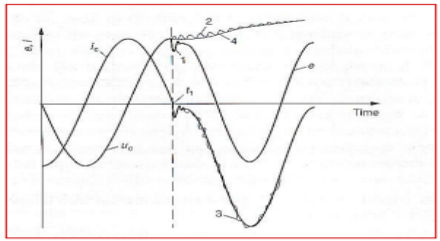


"Back-to-back" capacitors

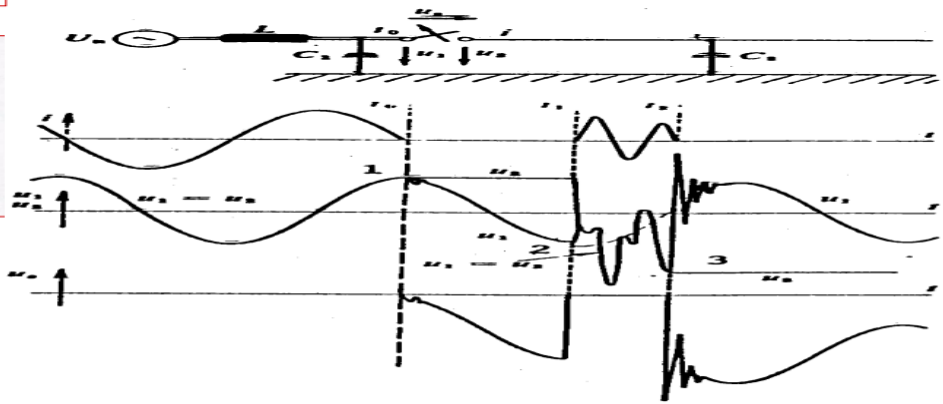




No-load lines



Reginition



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SHORT LINE FAULTS

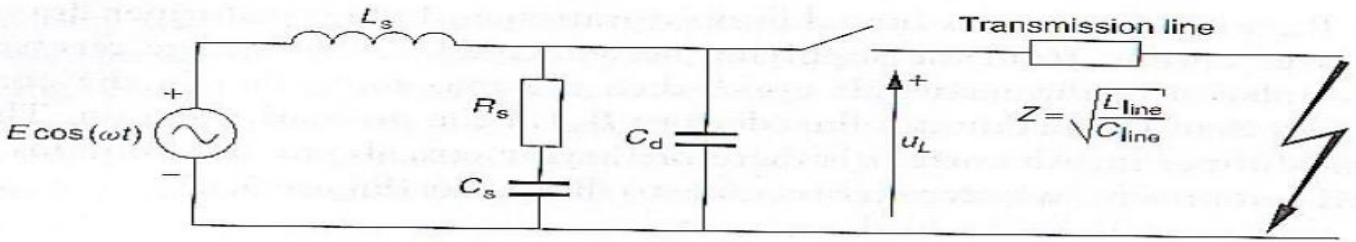
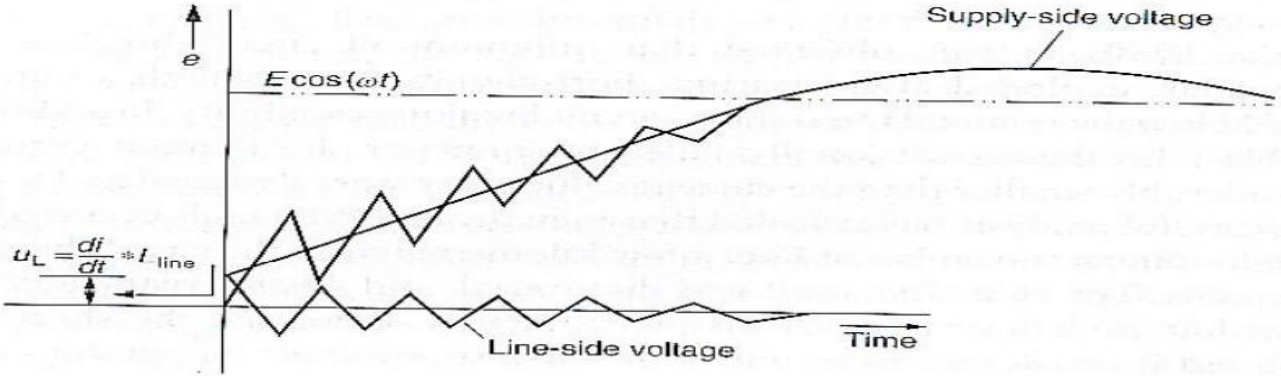
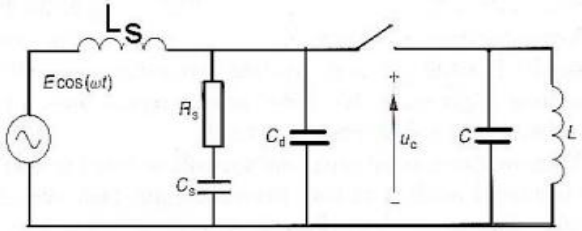


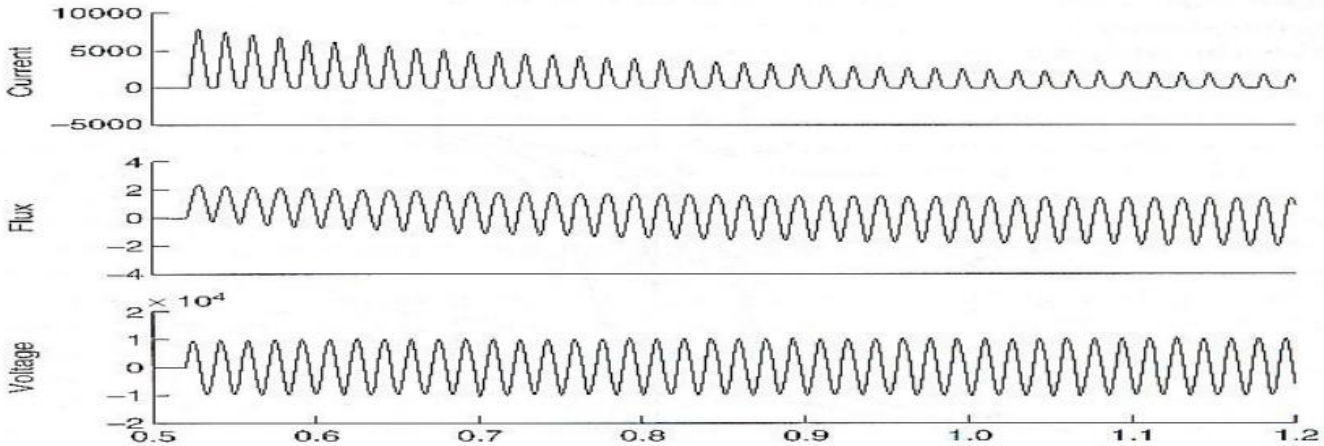
Figure 5.13 The short-line fault



"INRUSH" CURRENTS IN POWER TRANSFORMERS

- Currents may reach 4 IN
- Depend on closing moment and remaining magnetic flux





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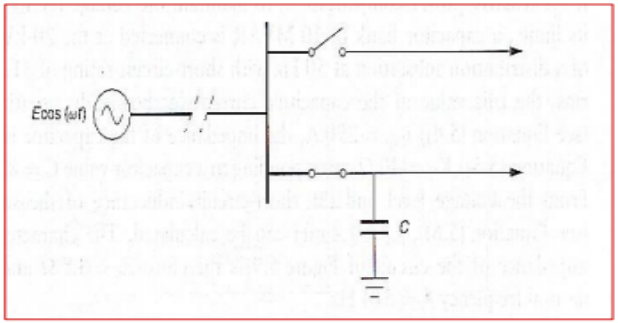
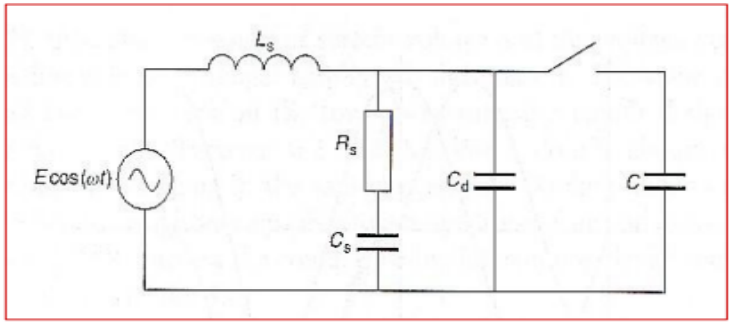
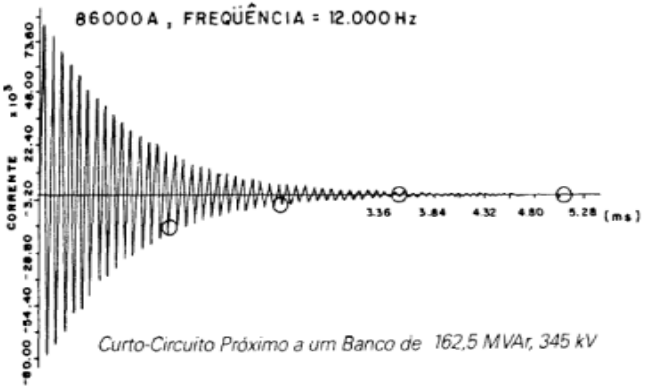
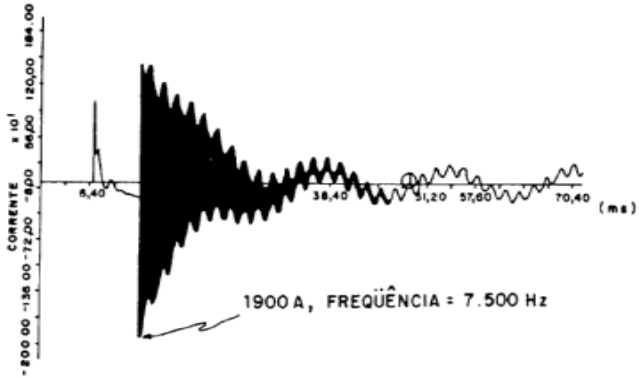
"INRUSH" CAPACITIVE CURRENTS





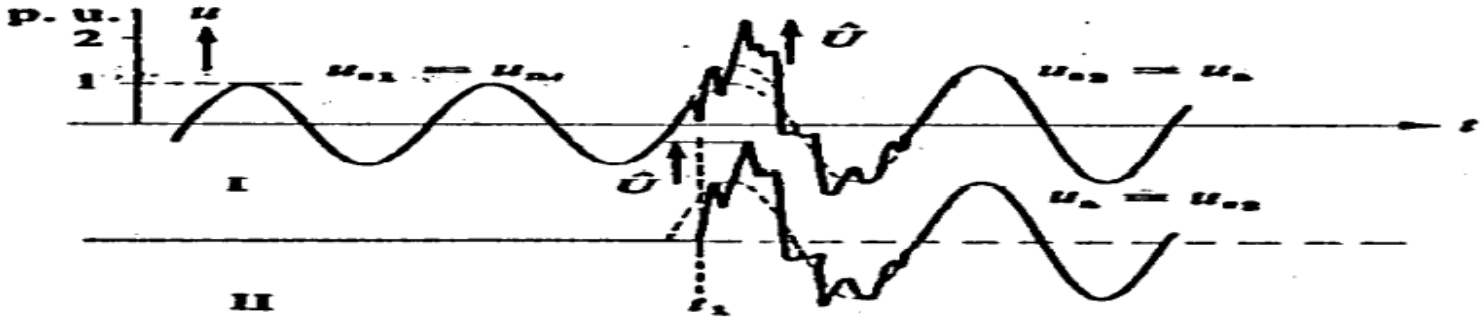


Curto-Circuito Próximo a um Banco de 162,5 MVAr, 345 kV



Corrente de Energização, "Back-to-Back"(*) 125 MVAr, 138 kV

SWITCHING OF-LOAD LINES



Transients frequency

Transformers connection	1 kHz
Ressonance (iron)	1 kHz
Connection of lines	20 KHz
TRV for terminal faults	20 KHz
TRV for short line faults	100 KHz
Atmospheric impulses	3000 KHz
GIS switching isolators	50.000 KHz

Fequency depend on L and C which depend from geometry and distances

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{L.C} - \left(\frac{R}{2L}\right)^2}$$

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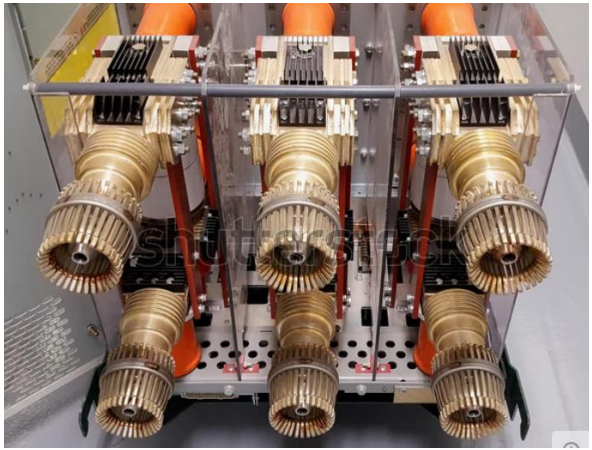
Remembering fundaments



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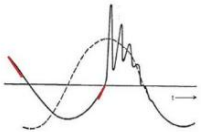
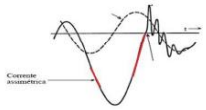
TRANSIENT RECOVERY VOLTAGE (TRV)

Symmetric current: high frequency component sum to max value of system voltage



Asymmetric:: high frequency sum to lower value



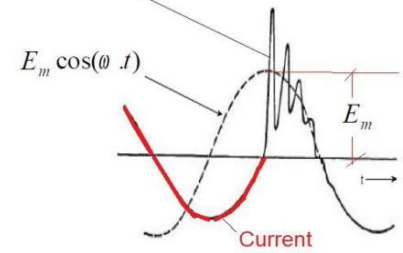
$$U(t) = E_m\left[\cos(\omega\, t) - \frac{1}{\sqrt{1-\alpha^2}}\, e^{-\alpha\,\omega_0 t}\cos(\omega_0\sqrt{1-\alpha^2}\, t + \tan^{-1}\left(\frac{\alpha}{\sqrt{1-\alpha^2}}\right)\right]$$

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{L.C} - \left(\frac{R}{2L}\right)^2}$$

$\omega = 2\pi f$

$\alpha = \frac{R}{2\sqrt{L/C}}$

$\omega_o = \frac{1}{\sqrt{LC}}$



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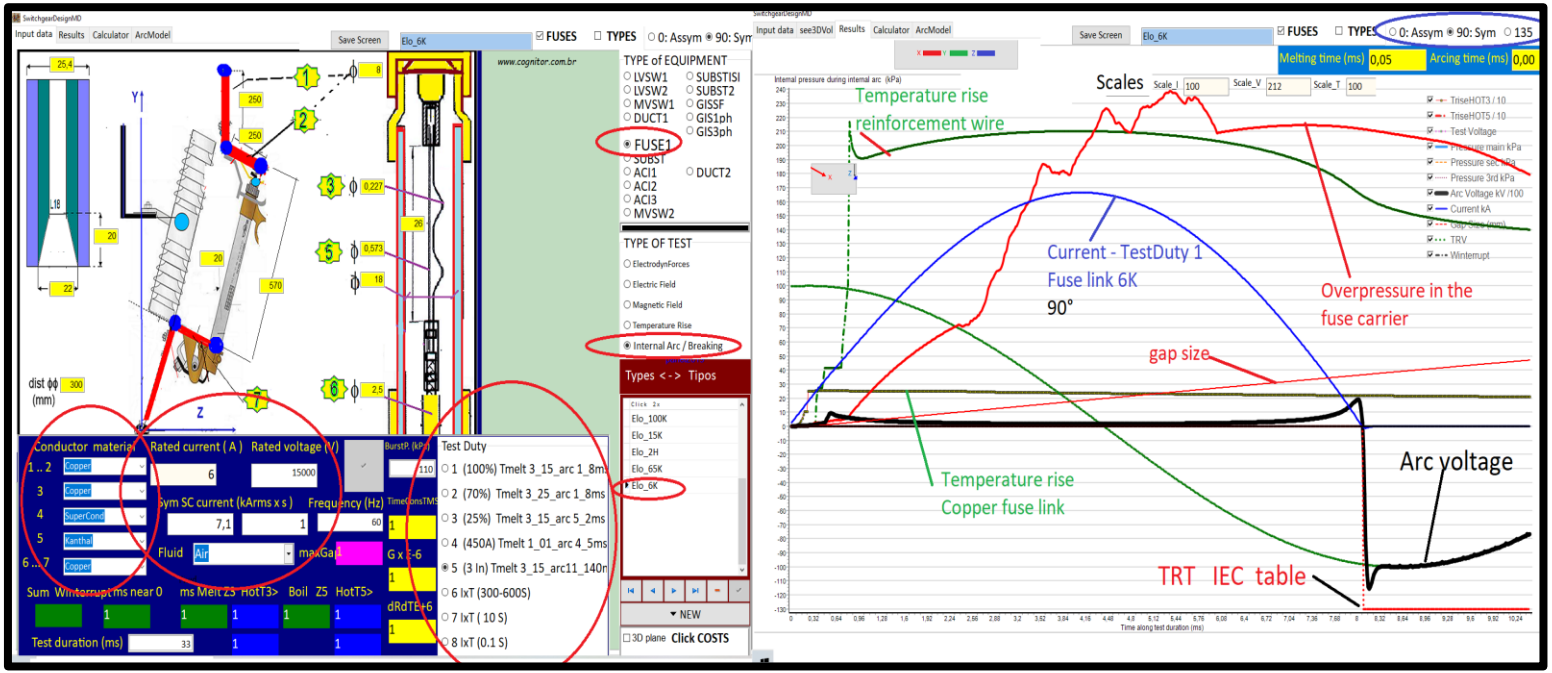
Breaking Tests of Expulsion Fuses & C.Bs



It is possible to simulate the short-circuit breaking behavior of test duties 1 to 5 of expulsion fuses

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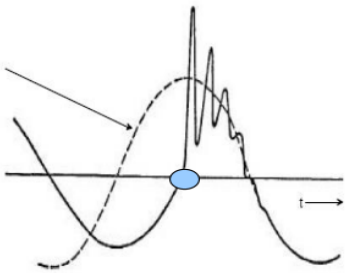
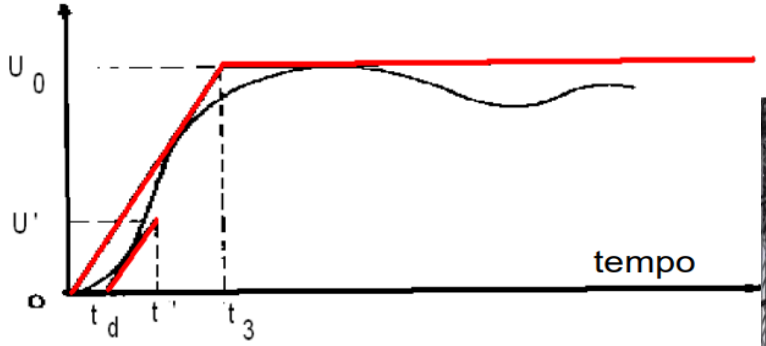
TRV by two parameters





	Tensão Nominal U_r (kV)	Tipo da interrupção	Fator de primeiro polo k_{pp} (p.u.)	Fator de amplitude k_{af} (p.u.)	Valor de pico da TRT u_c (kV)	Tempo t_3 (µs)	Tempo de retardo t_d (µs)	Tensão u' (kV)	Tempo t' (µs)	TCTR[b] ** u_c / t_3 (kV/µs)
	4,76 [c]	Falta terminal	1,5	1,4	8,2	51	8	2,7	24	0,16
		Discordância de fases	2,5	1,25	12,1	101	15	4,0	48	0,12
	72,5 [a]	Falta terminal	1,5	1,4	124	165	8	41	63	0,75
		Falta quilométrica	1	1,4	83	166	8	28	64	0,50
		Discordância de fases	2,5	1,25	185	336	50	62	163	0,55

Validating breaking testing simulations of C.B.s & FUSES

If you know that test results are very near simulations results you save time & money doing cheaply, at your computer, what you could not pay in high-power testing labs.

You will need materials technical information about :

- **Fuse Carriers**: physical & thermal properties of vulcanized fiber or synthetic material. Values of heat of vaporization of internal tube enable to **estimate maximum number of shots** possible before replacing it.
- **Test Reports of breaking tests**, for Test Duty 5 (3 x In)

Read the article about proposals to revise IEC 60282-2

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IEC 60282-2 & IEEE C37.41

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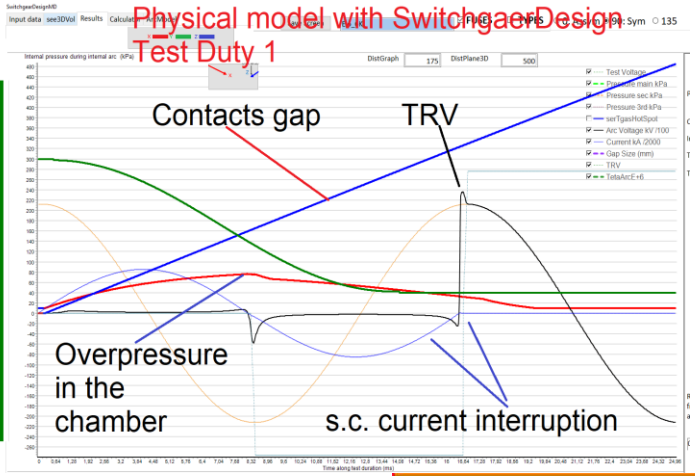

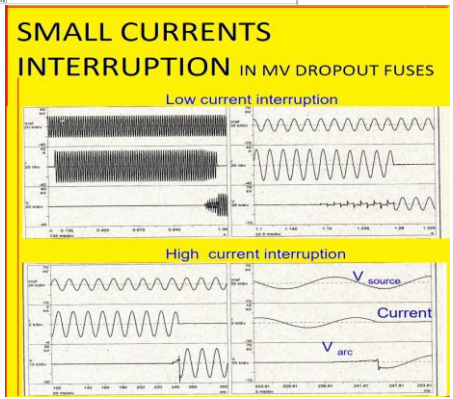

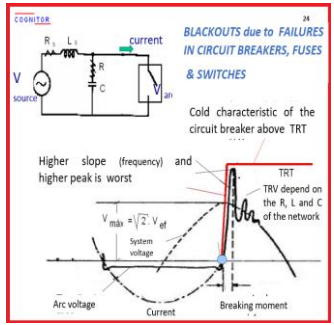

With a **physical arc-model** you can develop fuses, switches, disconnectors, reclosers & C.Bs

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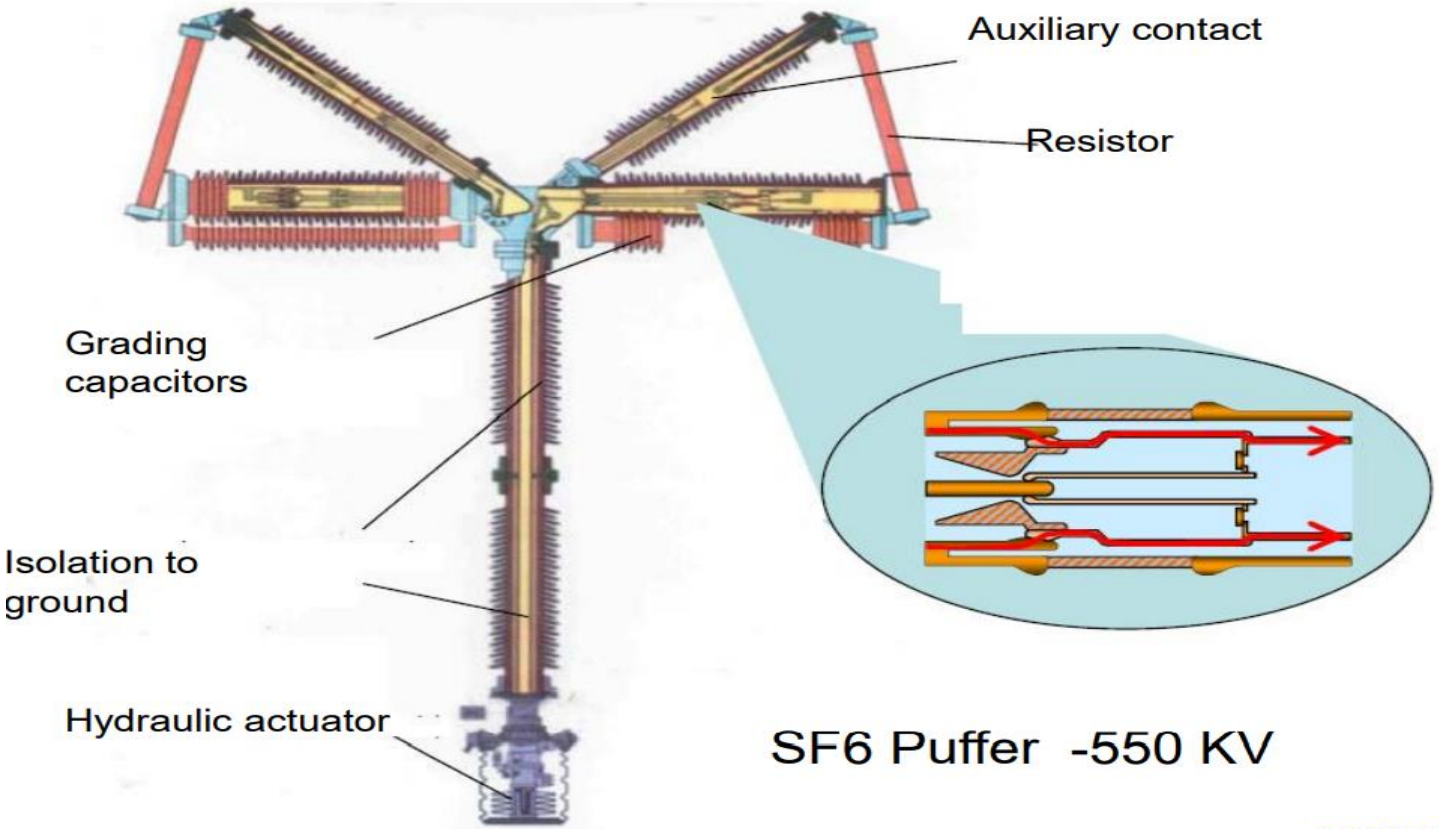

SF6 Puffer -550 KV

Specification of Currents & Voltages in New (low-cost) Substations.

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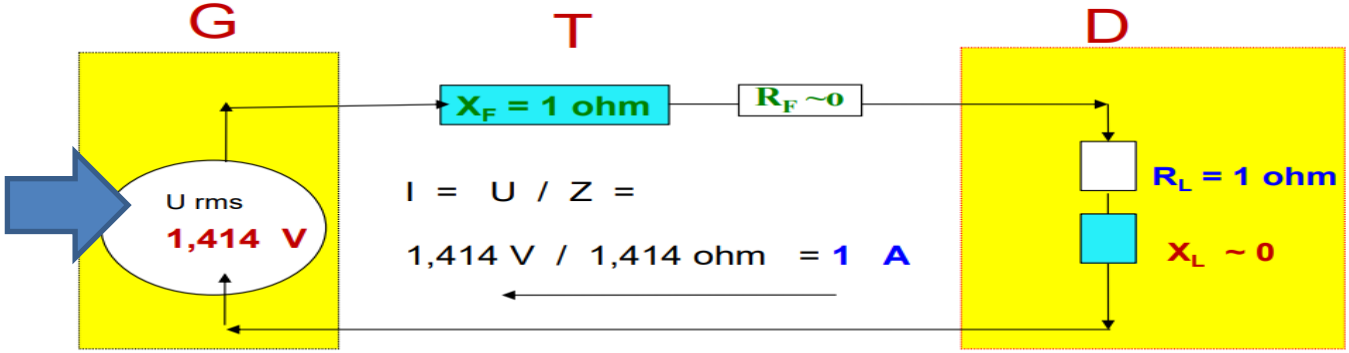
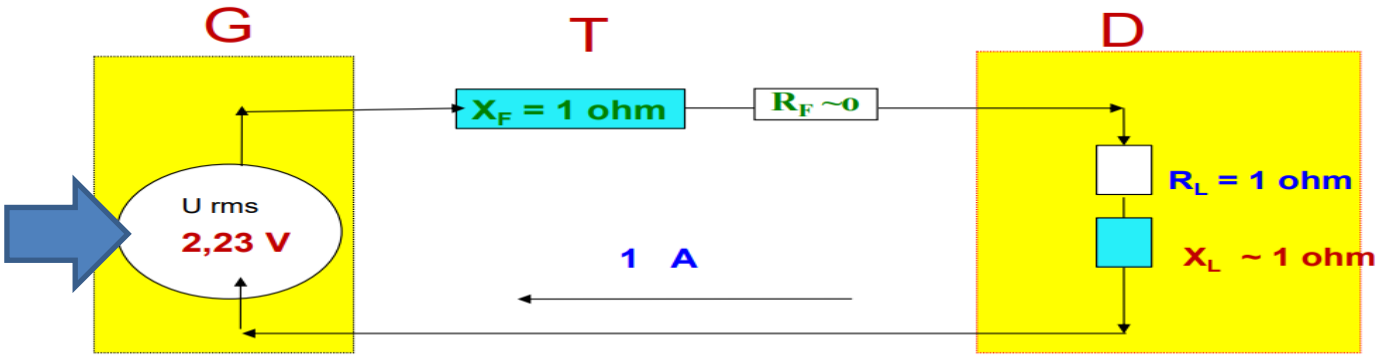


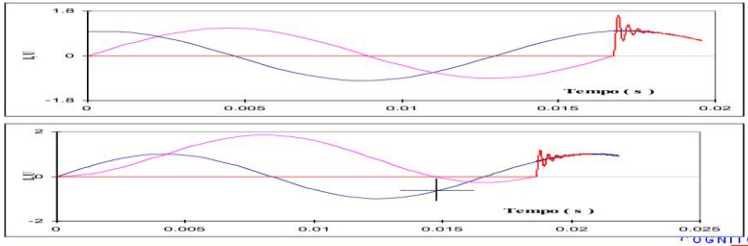
The compensation of power factor enable lower investments in the generation system.



BREAKING TESTS

- ✓ Fault type to represent (voltage, current and power factor)
- ✓ % asymmetry in the current interruption
- ✓ Transient recovery voltage (TRV)
- ✓ First pole to clear factor

- ✓ **Terminal faults**
- ✓ 10%, 30%, 60%, 100% symmetrical e 100% asymmetrical Icc



Technical data		Requirement
	Other specifications like the isolator	
Short circuit	Rated breaking capacity Component AC (kArms) Component CC (%) Rated Duration (s)	 40 kArms 50% 3 s
Interruptions	Number of interruptions without maintenance	
TRV for terminal faults	Representation: 2 or 4 parameters First pole to clear factor First reference voltage U1 Time T1 related to voltage U1 Second reference voltage Uc Time T2 related to voltage Uc Delay time Td Voltage U' Time T' Rate of rise U1/T1	4 1,5 296 kVcr 148 µS 415 kVcr 444 µS 2 µS 148 kVcr 76 µS 2 kV/ µS
Operating cycle		O - 0,3s – CO - 3min - C

- ✓ Short line fault: 90%, 75% e 60% I_{cc}

- Out of phase switching
  - Interconnection circuit breakers I_1 = 20 to 40% I_{disc}
  - I_2 =100 to 110% I_{disc} - voltage 2 to 2,5 U ØN

- Capacitive currents switching :
  - No-load lines
  - No-load cables;
  - Back to back capacitor banks
  - Capacitor banks.

- Small inductive currents switching.

Technical data		
Line Characteristics	Surge i Rated c Rate of	
TRV for terminal faults	Repres First re Time T Second Time T Delay time Td Voltage U' Time T' Rate of rise U1/T1	 2 µS 98,8 kVcr 51,5 µS 2 kV/ µS
	Rated breaking time	3 cycles
No load line	Rated breaking current (Arms) Surge factor at line closing Number of operations without maintenance	125 A rms 1,4

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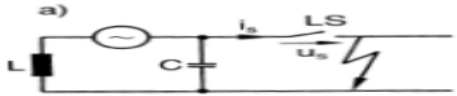
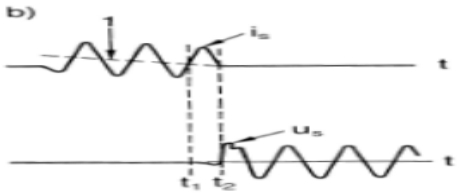
Terminal faults interruption

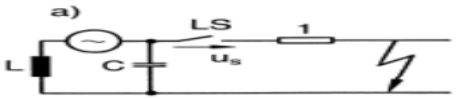
Terminal fault (asymmetrical short-circuit current), Fig. 10-13

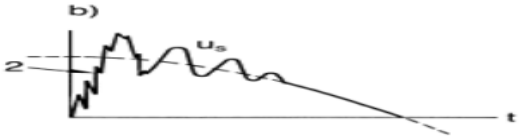




Short line faults interruption

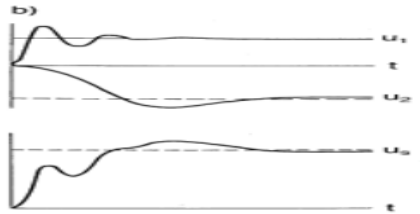
Short-line fault, Fig. 10-14





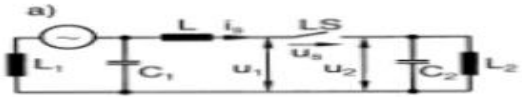
Out of phase interruption

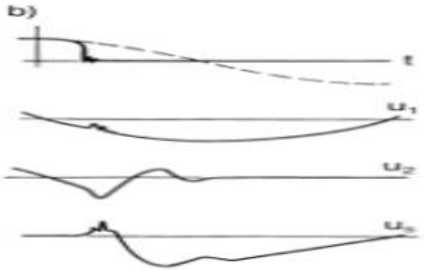
Switching under out-of-phase conditions (phase opposition)



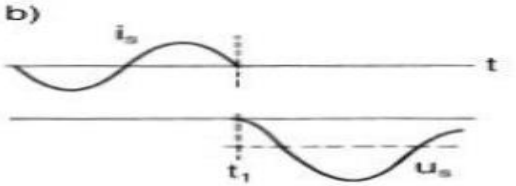
Switching under out-of-phase conditions.
a) simplified equivalent circuit.
b) voltage stress on circuit-breaker

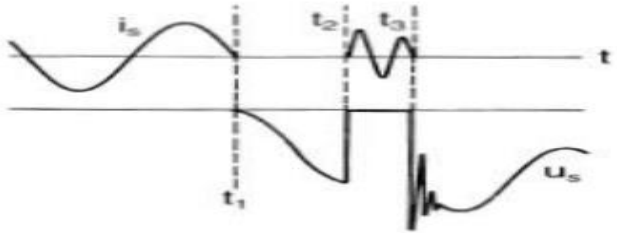
Small inductive currents interruption





Out of load lines and cables





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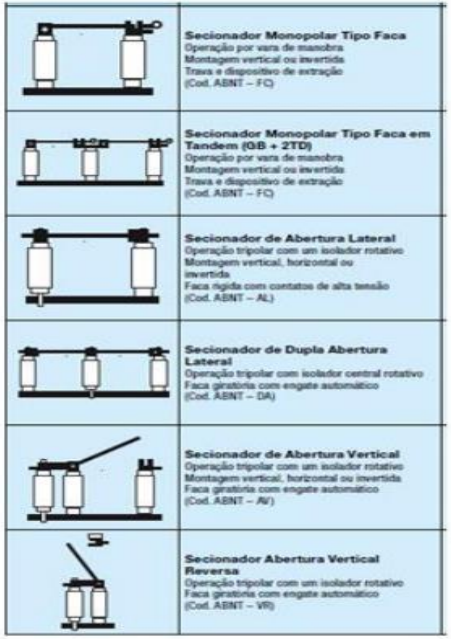
SPECIFICATION OF HIGH VOLTAGE ISOLATORS / DISCONNECTORS



Secionador Monopolar Tipo Faca
Operação por vara de manobra
Montagem vertical ou invertida
Trava e dispositivo de extração
(Cod. ABNT – FC)

Secionador Monopolar Tipo Faca em Tandem (GB + 2TD)
Operação por vara de manobra
Montagem vertical ou invertida
Trava e dispositivo de extração
(Cod. ABNT – FC)

Secionador de Abertura Lateral
Operação tripolar com um isolador rotativo
Montagem vertical, horizontal ou invertida
Faca rígida com contatos de alta tensão
(Cod. ABNT – AL)

Secionador de Dupla Abertura Lateral
Operação tripolar com isolador central rotativo
Faca giratória com engate automático
(Cod. ABNT – DA)

Secionador de Abertura Vertical
Operação tripolar com um isolador rotativo
Montagem vertical, horizontal ou invertida
Faca giratória com engate automático
(Cod. ABNT – AV)

Secionador Abertura Vertical Reversa
Operação tripolar com um isolador rotativo
Faca giratória com engate automático
(Cod. ABNT – VR)

Secionador Semi-Pantográfico Horizontal
Operação tripolar com um isolador rotativo
Faca articulada
(Cod. ABNT – SPH)

Secionador Semi-Pantográfico Vertical
Operação tripolar com um isolador rotativo
Faca articulada
(Cod. ABNT – SSP)

Secionador de Abertura Central
Operação tripolar com isoladores rotativos
Articulações com contatos deslizantes
(Cod. ABNT – AC)

Secionador de Aterramento
Operação monopolar ou tripolar
Montagem individual ou acoplado ao seccionador
(Cod. ABNT – TE)

Secionador de Aterramento
Operação monopolar ou tripolar
Montagem individual ou acoplada ao seccionador
Dispositivo de retenção e extração
(Cod. ABNT – TE)

Secionador de Aterramento Rápido
Operação monopolar ou tripolar
Montagem horizontal ou vertical
Disparo através de dispositivo eletromagnético
(Cod. ABNT – AR)

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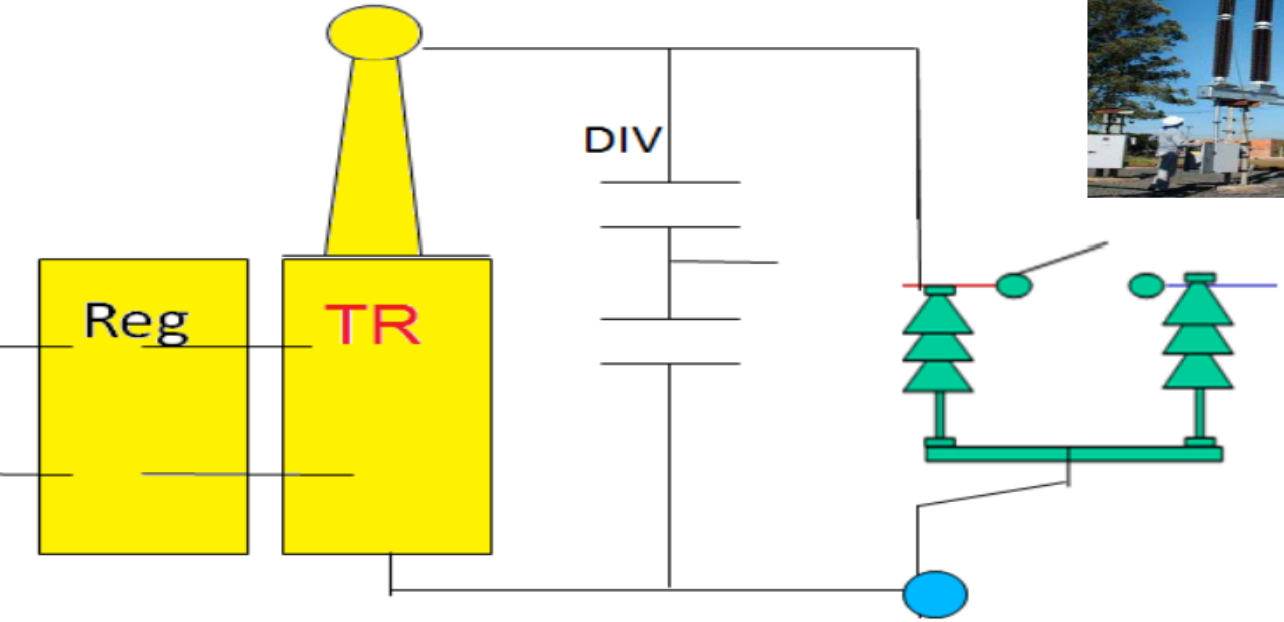
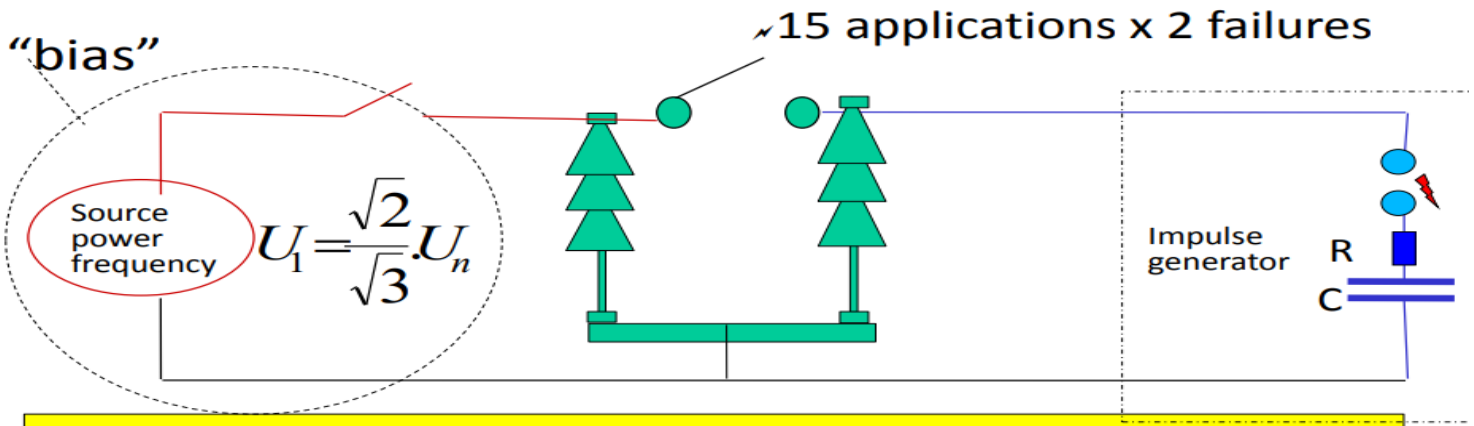
SPECIFICATION OF HIGH VOLTAGE ISOLATORS / DISCONNECTORS

Technical data		Requirement
Rated voltage	Rated voltage (phase to phase)	230 KV rms
	Maximum continuous operating voltage (ph-ph)	242 KV rms
Frequency	Rated frequency	60 Hz
Insulation levels	Power Frequency withstand voltage	Closed to ground 395 kV Open contacts: 460kV
	Lightning Impulse withstand voltage	Closed to ground 950 kVcr Open contacts: 950 kVcr + 140kV 1min – 60Hz
	Power Frequency withstand voltage (auxiliary and control circuits)	3 kV
Number of poles		3
Rated current	Rated current	2000 Arms
Short circuit	Short time withstand and crest	40 kArms during 3s / 100 kAcr
RIV	Radio interference voltage	500 µV
Corona	Extinction and start minimum voltage	154 KVrms

SHORT-DURATION POWER-FREQUENCY WITHSTAND VOLTAGE TESTS



IMPULSE TEST



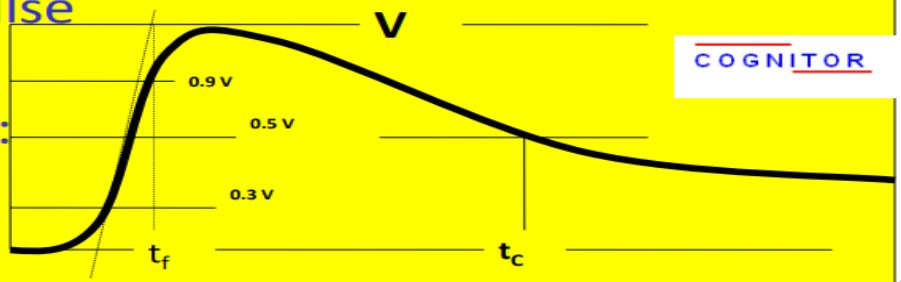
Atmospheric impulse

tf = 1,2 µs; tc = 50 µs

Switching impulse:

tf = 250 µs; tc = 2500 µs

Positive and negative polarities



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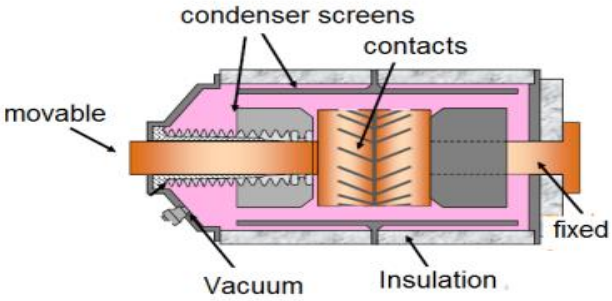
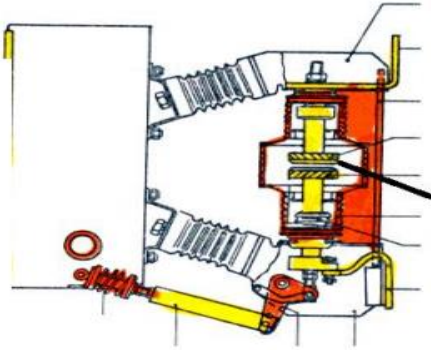
VACUUM CIRCUIT BREAKER

Arc formed between contacts unlike other types of circuit breaker, being held by ions coming from the metallic material vaporized contacts.

At current zero the space between the contacts is rapidly deionized (condensation of metal vapors in the electrodes)





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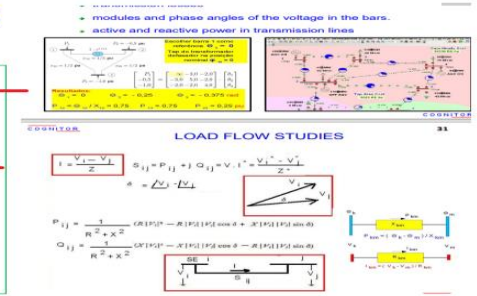
SPECIFICATION OF VOLTAGES AND CURRENT VALUES IN A NEW SUBSTATION:

- Load flow studies
- Short-circuit studies
- Standardized values in technical standards
- To avoid exaggerated specifications reduce costs without any loss of quality.



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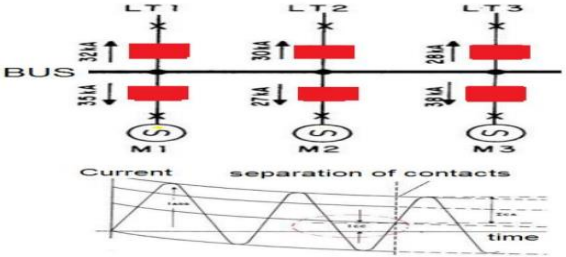
33

SHORT CIRCUIT STUDIES:

to specify the short time and peak currents and switchgear breaking capacities

- Determine X / R circuit (and L/ R time constant);
- Calculate short chains, the crest and maximum durations.
- Adjust to the standard values of IEC standard
- Find the values of DC / AC components in the separation of contacts



Circuit	Calculated current (kA rms)	Standard value (kA rms)
LT1	32	40,0
LT2	30	31,5
LT3	28	31,5
M1	35	40,0
M2	27	31,5
M3	38	40,0

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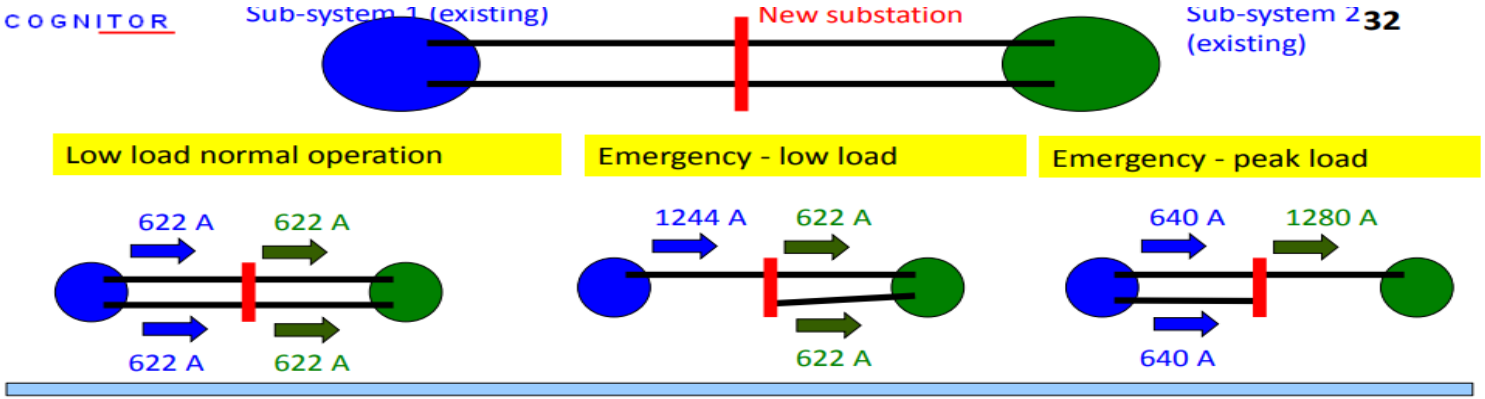

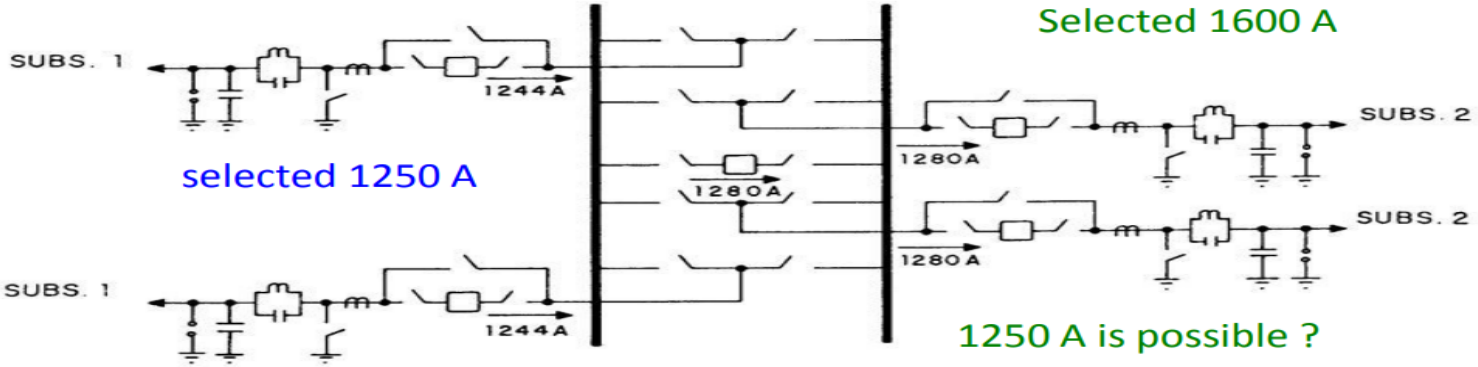

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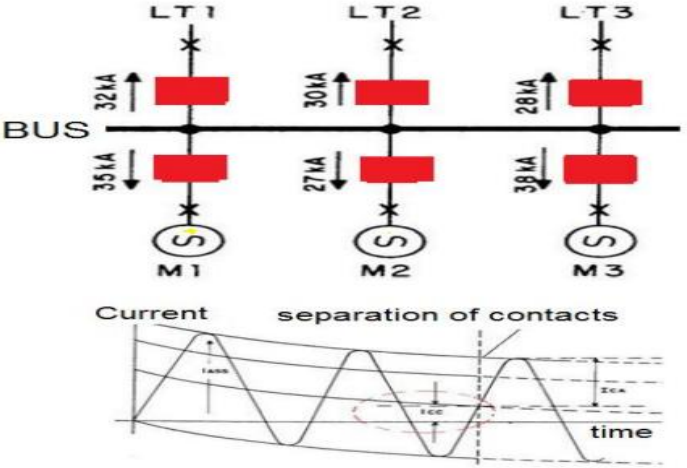

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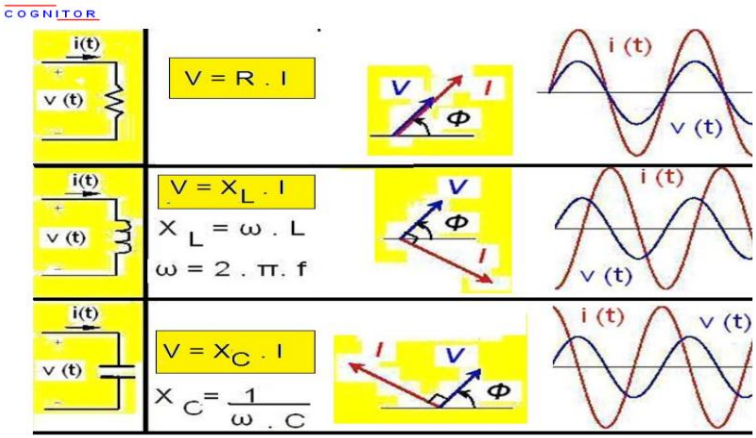
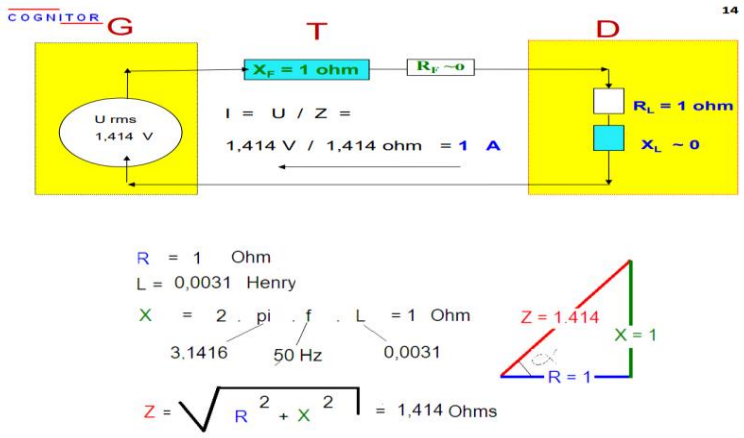
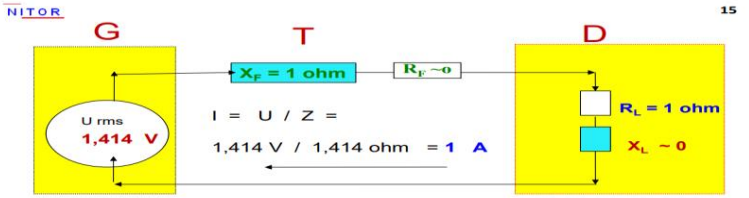
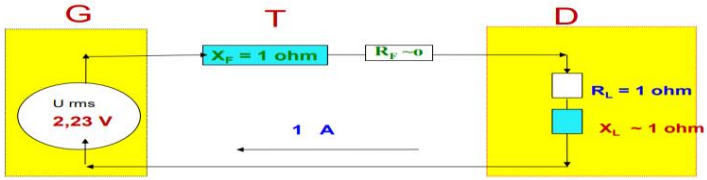
M3	38	40,0









WHY CONTROL LOAD POWER FACTOR IN T&D NETWORKS?

a) To reduce energy utility costs?.

b) To reduce transmission losses ?.

c) To reduce energy generation costs?

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OVERLOADS IN POWER TRANSFORMERS
(previous)

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Loading	P < = 100 MVA	P > 100 MVA
Normal condition	150%	130%
Emergency (long duration)	150%	130%
Emergency (short duration)	150%	140%

Loading	Temperature at top oil		Temperature hot spot	
	tr.55°C	tr.65°C	tr.55°C	tr.65°C
Normal condition	95°C	105°C	105°C	120°C
Emergency (long duration)	105°C	110°C	120°C	130°C
Emergency (short duration)	105°C	110°C	130°C	140°C

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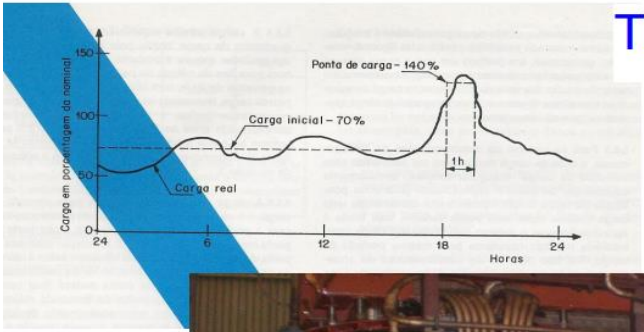

TRANSIENT LOADING

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Overvoltages

and

Insulation Coordination

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OVERVOLTAGES CONTROL

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PRE-INSERTION RESISTORS

- To reduce overvoltages in the switching operations for energization or reclosing of lines (closing)
- To reduce TRV during the opening operation
- Function of resistance and insertion duration (over price)

LIGHTNING ARRESTERS : to reduce overvoltages to a level lower than the one supported by the protected equipment.

CAPACITORS in the terminals of circuit breakers to reduce TRV kV / µS.

SHIELDING OF SUBSTATIONS AND LINES AGAINST LIGHTNING (ground wires, protection rods) to avoid direct incidence in the conductors or busbars.

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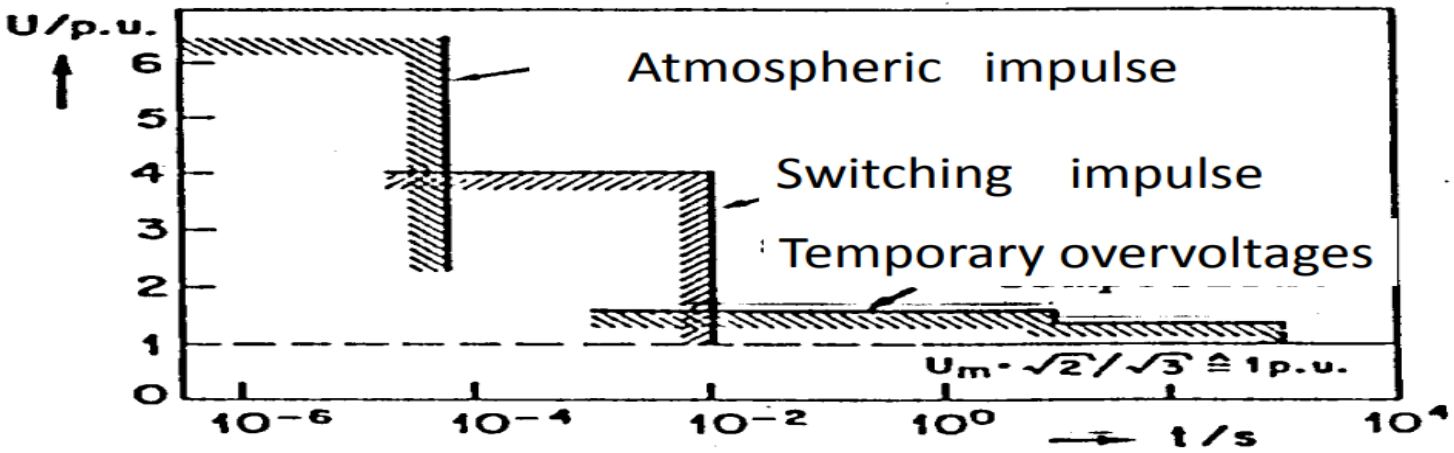
OVERVOLTAGES CLASSIFICATION

- Atmospheric
- Switching – connection and disconnection of elements , initiation or interruption of faults
  - Temporary: power frequency or harmonics and sustained or poorly damped
  - Switching: short and damped



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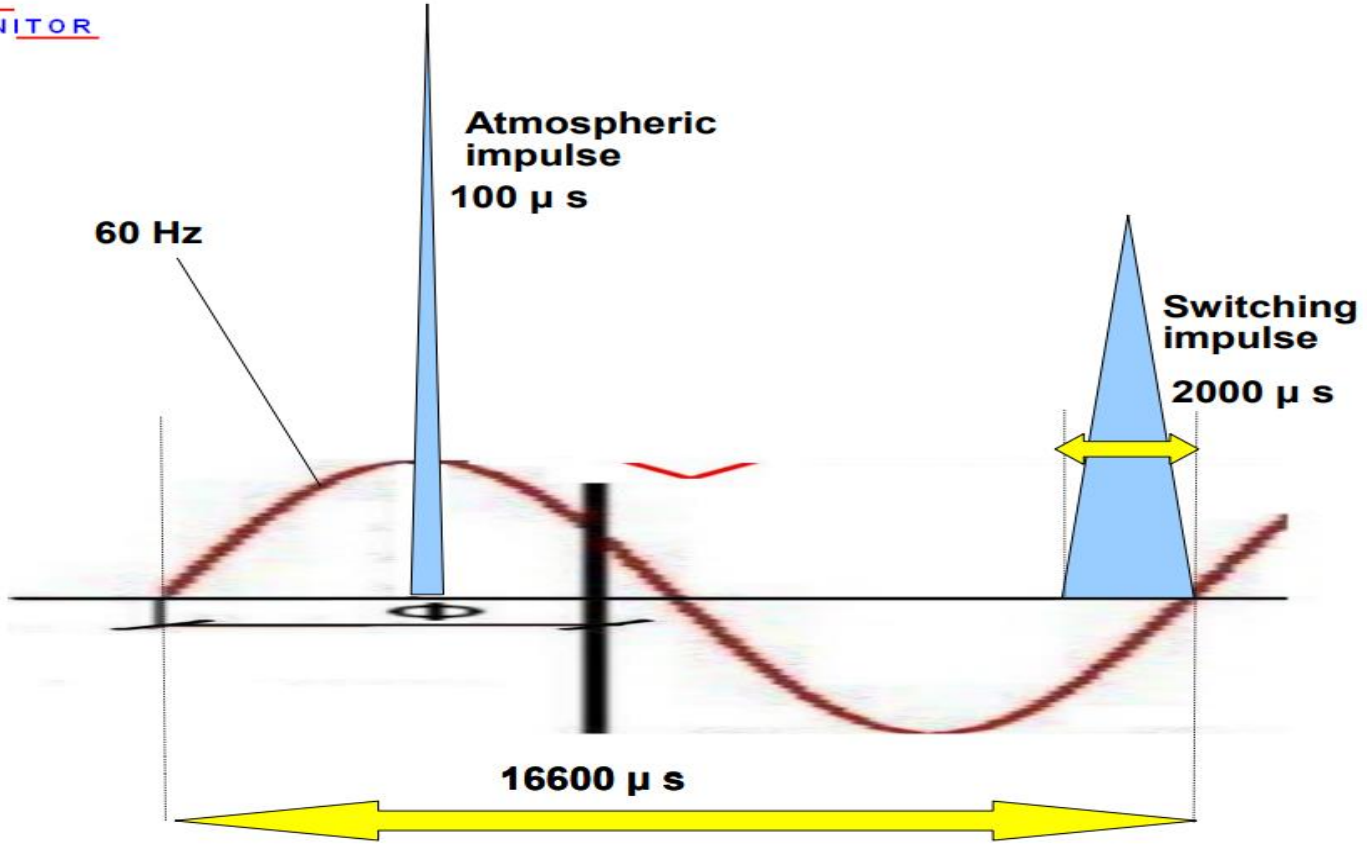

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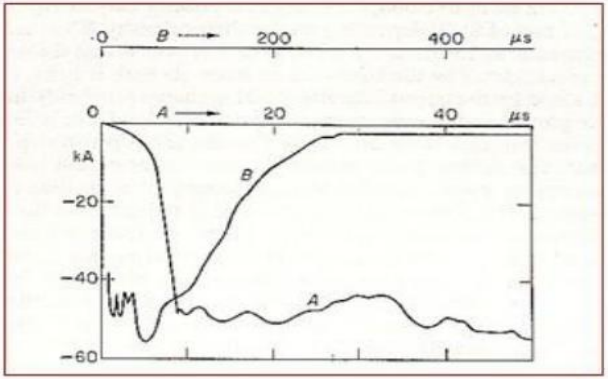
IMPULSES (actual and laboratory)

Atmospheric



Switching

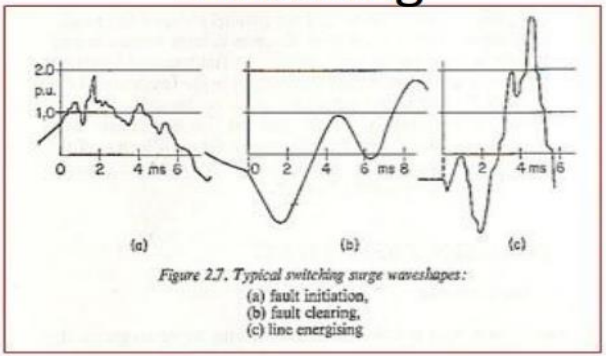
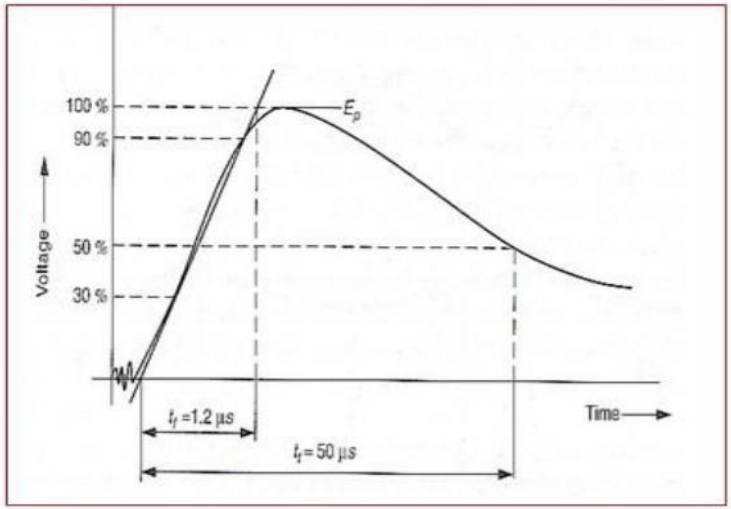


Figure 2.7. Typical switching surge waveshapes:
(a) fault initiation,
(b) fault clearing,
(c) line energising

Laboratory test

t_1 = 1,2 μs t_2 = 50 μs



t_1 = 250 μs t_2 = 2500 μs

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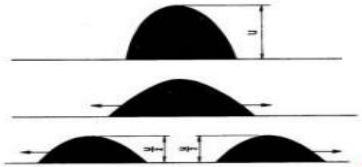
IMPULSES PROPAGATION

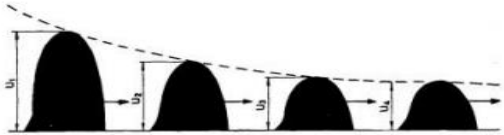
- Direct impact in the cable of phase: U = (I / 2) x Z
- Impact in the guard cable: "back-flashover.

$$Z = \sqrt{L/C}$$

$$v = 1 / \sqrt{L*C}$$



$$i_1 = i_2 = \frac{u}{2Z}$$

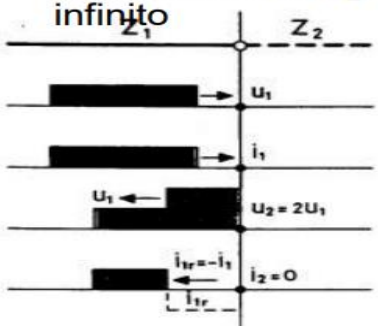


Changing the wave impedance medium

$$u_2 = u_1 \frac{2Z_2}{Z_1 + Z_2}$$

$$u_{1r} = u_1 \frac{Z_2 - Z_1}{Z_1 + Z_2}$$

transformador: Z_2 infinito



TEMPORARY OVERVOLTAGES

- Power frequency or harmonics sustained or poorly damped
- Range <1.5 P.U.
- Duration: few seconds depending on the type of system voltage control (even more if the intervention is manual)

✓Some of the causes

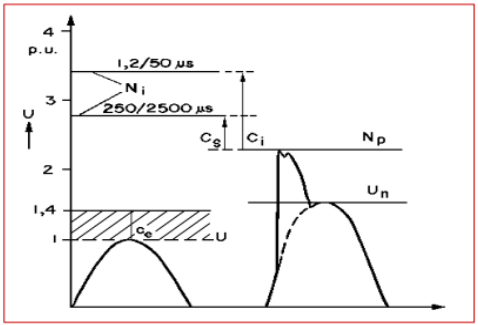
- ✓Sudden loss of load
- ✓Unbalanced faults to earth
- ✓Disconnection of inductive loads
- ✓Connection of capacitive loads
- ✓Connection of no-load lines

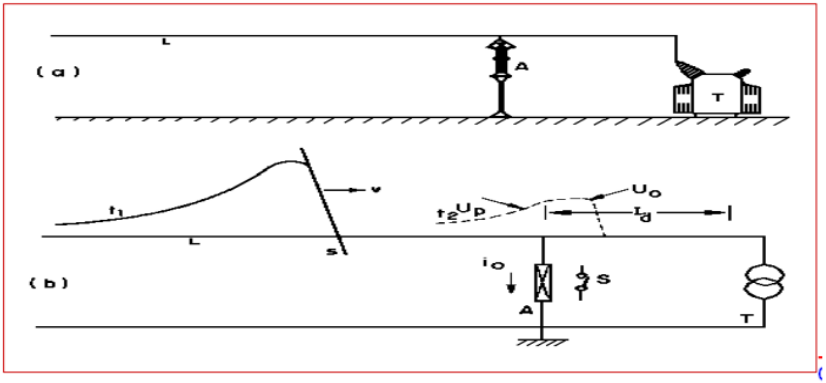
COGNITOR

SURGE ARRESTERS

Divert surges to the ground preventing them from being applied to the protected equipment.

Overvoltages: power frequency, switching and atmospheric impulses





ZnO SURGE ARRESTER SPECIFICATION

1. Manufacturer model:	
System rated voltage (phase to phase; kVef)	230
Rated frequency (Hz):	60
System maximum continuous operation voltage (phase to phase; kVef)	242
Maximum continuous operation voltage(phase - neutral kVef):	160
Surge arrester rated voltage(kVef):	228

Residual voltage for wave front (max kVcr):	590
Residual voltage for atmospheric impulse (max kVcr):	__?
Residual voltage for switching (max kVcr):	480
Residual voltage for rated discharge current (max kVcr):	600
Rated discharge current (A crista):	20.000A
Long duration discharge class (IEC 99-4) KA	4 kA
Pressure relief withstand current	
1) Component AC of the high intensity current (kArms):	40 kArms
2) Maximum peak current (kAcr):	100 kAcr
3) Low intensity current (Arms)	800 Arms
Minimum withstand temporary overvoltage post-discharge by (kVef): for the durations 10 s -------1 s -------0,1s	216 kV during 10 s
Leakage current at the rated voltage and frequency. (mA):	

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INSULATION COORDINATION

- Determination of the overvoltages: magnitude, duration and probability of occurrence (ATP, TNA, ...)
- Selection of the insulation levels
  - **Conventional method:** higher overvoltages + safety margin ((as 25%)
  - **Statistic method:** select a certain risk of failure taking
- Dielectric tests
  - Power frequency
  - Switching impulse (250 x 2500 μ S)
  - Atmospheric impulse (1,2 x 50 μ S)
- Use of protection devices to reduce the overvoltages

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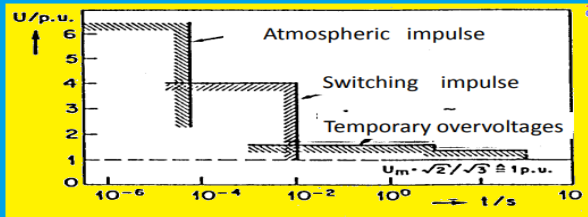
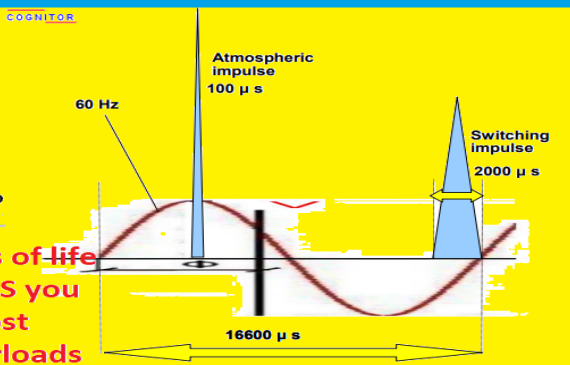
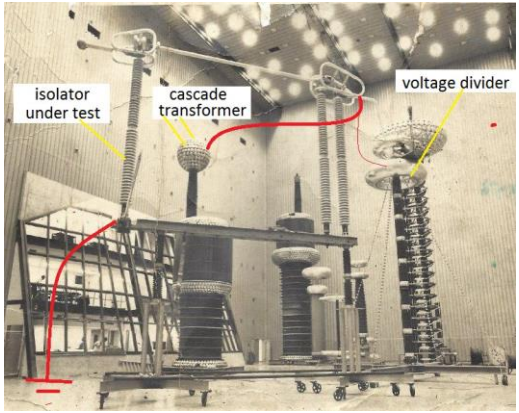




If you know how to calculate the loss of life of equipment due to OVERVOLTAGES you will find solutions to achieve "low-cost substations" . Loss of life due to overloads is easy to calculate (IEC 60943)

Train your team to improve your company results

Dielectric tests require high voltage testing labs with impulse generators , cascade transformers, etc...



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Magnetic and Electric Fields and Their Effects (concepts & mapping)

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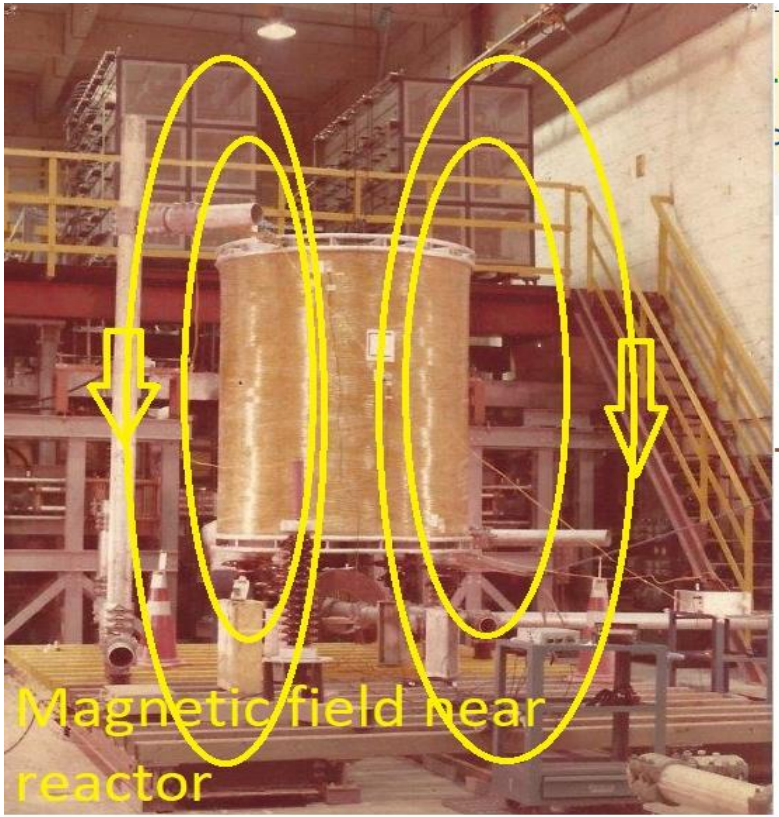

Small-size High Power Testing Labs & Low-Cost Substations

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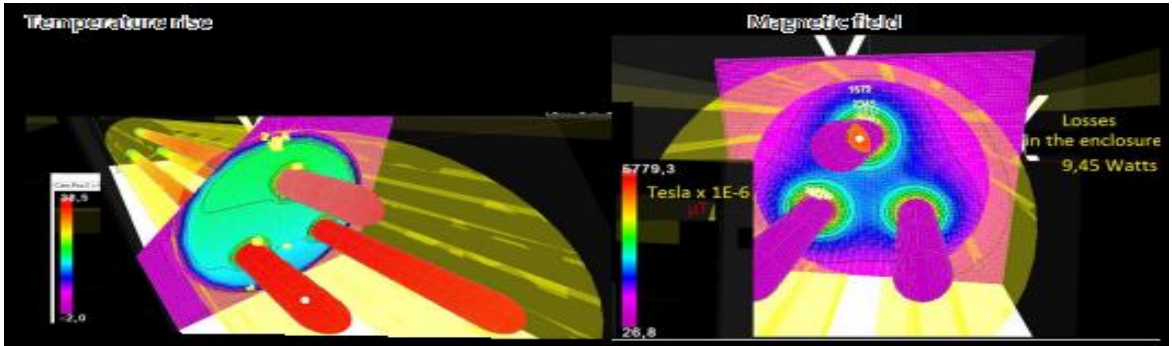

Measuring point	Test temperature rise (K)	Simulation AIR (K)	Simulation SF6 (K)
A - Terminals for the connection to external conductors		25	24
B – Conductor # 2		31	29
C – Conductor #3		34	31
D – Conductor #4 (** connection)		38	35
E – Conductor # 6		31	29
F – #7 – Short circuit point		22	22
Side of the enclosure		8	8 (***)
Internal air (50% H)		16	16 (***)

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Technical Specifications and Tests for Bids (Circuit Breakers, Disconnectors, Arresters, Power transformers).

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IEC 61936 - Power installations exceeding 1 kV AC – Part 1: Common rules

Table 1 – Minimum clearances in air – Voltage range I (1 kV < U_m ≤ 245 kV)

Related to temporary overvoltages

Related to the impulse overvoltages

Voltage range	Nominal voltage of system	Highest voltage for equipment	Rated short-duration power-frequency withstand voltage	Rated lightning impulse withstand voltage [a]	Minimum phase-to-earth and phase-to-phase clearance, N [c]	
	U_n r.m.s.	U_m r.m.s.	r.m.s.	1,2/50 µs (peak value)	Indoor installations	Outdoor installations
	kV	kV	kV	kV	mm	mm
I	3	3,6	10	20	60	120
				40	60	120
	6	7,2	20	40	60	120
				60	90	120
	10	12	28	60	90	150
				75	120	150
				95	160	160
	15	17,5	38	75	120	160
				95	160	160
	20	24	50	95	160	
				125	220	
				145	270	
	30	36	70	145	270	
				170	320	
	45	52	95	250	480	
	66	72,5	140	325	630	
	110	123	185 [b]	450	900	
			230	550	1 100	
	132	145	185 [b]	450 [b]	900	
			230	550	1 100	
			275	650	1 300	
	150	170	230 [b]	550 [b]	1 100	
			275	650	1 300	
			325	750	1 500	
	220	245	275 [b]	650 [b]	1 300	
			325 [b]	750 [b]	1 500	
			360	850	1 700	
			395	950	1 900	
			460	1 050	2 100	

Values applied in the tests

In equipment can be lower

Switchgear / switchboards (training IEC 62271 / IEC 61439 / IEC60282-2)

"What is tested should be equal to what is sold but IEC standards do not request enough to be sure about this.". Write, in test reports, the data needed to identify what was tested.

Example 1: **Resistance of circuit breakers** define temperature rise test results of switchgear. Measurement not requested (only total per phase)

Example 2: **Fuse holders of expulsion fuses for transformers should support 3 shots** before replacement. The thickness & material of the internal tube define the result but is not mentioned

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Read the article – link above

Painéis, dutos blindados e chaves fusíveis (**IEC 62271 / IEC 61439 / IEC60282-2**)

O que é testado deveria ser igual ao que é vendido mas não dá para afirmar.

Escreva em relatórios de teste, os dados necessários para identificar o que foi testado.

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Exemplo 1: **Resistência dos disjuntores** define resultados a elevação de temperatura de painéis . Medição não pedida (somente pedido o total por fase)

Exemplo 2: **Porta-fusíveis de fusíveis de expulsão para transformadores** devem suportar 3 disparos antes da substituição. Espessura e material do tubo interno definem o sucesso na interrupção. Deveria ser obrigatório constar no relatório.

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Leia o artigo no link acima

FUSIVEIS EXPULSÃO da IEC 60282-2

Sugestões ao SC32A da IEC para próxima revisão

baseadas na norma brasileira NBR7282

(DEC e o FEC mostram pouco onde impostos são excessivos e mal utilizados)

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Tabela 1 – INDICADORES DE QUALIDADE E CUSTOS (ORDENS DE GRANDEZA)

Em caso de dúvidas leia o artigo original em inglês aqui https://www.cognitor.com.br/IEC602822sugestionstosc32afrombrazil.pdf

País	DEC SAIDI (minutos)	FEC SAIFI	Qualidade do fornecimento de eletricidade (Indice World Bank GovData360)	Preço ao consumidor residencial (*)(USD / MWh)	(USD / MWh) dividido por salário-mínimo mensal no país
EUA/Canada	> 92 (2019) IEA	1,25 (2016) IEA	6,2 -6,6	140 - 170	0,12
França	48,0 (2002) 70,0 (2016) CEER metodologia	0,11 (2002) 0,22 (2002) CEER metodologia	6,7	267	0,13
Holanda	31,5 (2012) 27,3 (2016) CEER metodologia	0,33 (2012) 0,32 (2016) CEER metodologia	6,8	259 - 316	0,14
Australia			5,7	176	0,14
Turquia			4,4	77	0,23
Filipinas			4,2	150	0,50
África do Sul			3,9	208-230	0,70
BRASIL	26 (1996) 16 (2016) DEC - GESEL	22 (1996) 8 (2016) FEC - GESEL	4,5	280-314 (*)	0,85

A conta + difícil de pagar

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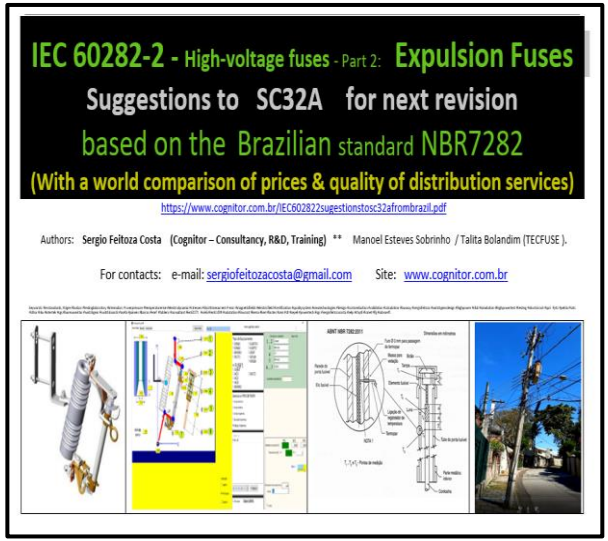
IEC 60282-2 & IEEE C37.41 *** Expulsion Fuses

Read a new article with proposals to improve the quality of expulsion fuses very much used in developing countries

Table 1 - ELECTRICITY QUALITY & COSTS indicators: ORDER of MAGNITUDE

Country	SAIDI (minutes)	SAIFI	Quality of electricity supply Index (World Bank GovData360)	Price (*) of residential consumer bill (USD / MWh)	(USD / MWh) divided by minimum month wage in the country
USA/Canada	> 92 (2019) IEA	1,25 (2016) IEA	6,2 -6,6	140 - 170	0,12
France	48,0 (2002) 70,0 (2016) CEER methodology	0,11 (2002) 0,22 (2002) CEER methodology	6,7	267	0,13
Netherlands	31,5 (2012) 27,3 (2016) CEER methodology	0,33 (2012) 0,32 (2016) CEER methodology	6,8	259 - 316	0,14
Australia			5,7	176	0,14
Turkey			4,4	77	0,23
Philippines			4,2	150	0,50
South Africa			3,9	208-230	0,70
BRAZIL	26 (1996) 16 (2016) DEC - GESEL	22 (1996) 8 (2016) FEC - GESEL	4,5	280-314 (*)	0,85



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TECHNICAL STANDARDS for switchgear, switchboards, fuses,

(IEC 61439, IEC TR 61641, IEC 62271-200, IEC 62271-307. IEC60282-2, IEC 890 and IEC 62208)

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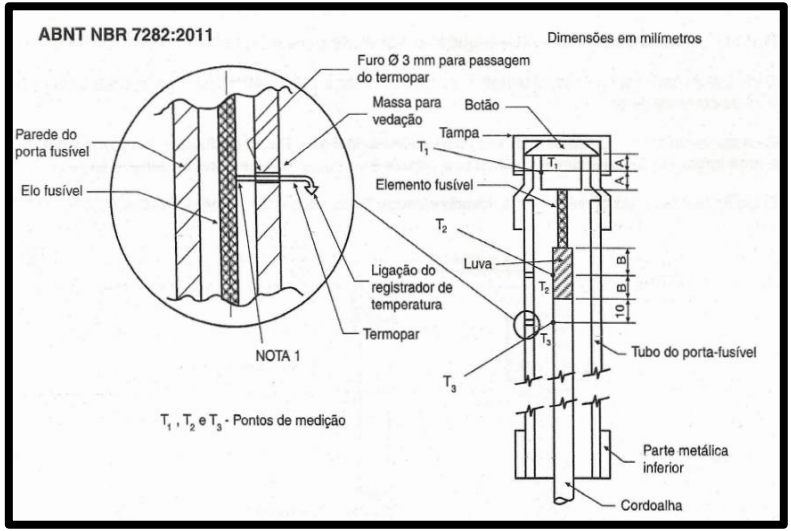
IEC 60282-2 should specify clearly the points to measure in the temperature rise test,

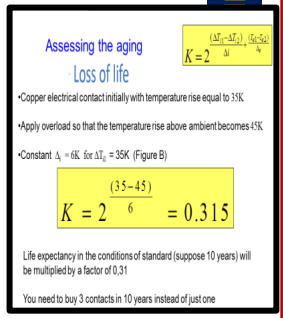
as done in the Brazilian standard NBR 7282

Premature aging of expulsion fuses working above temperature rise limits is disregarded by the IEC standard

Read the new article with proposals to SC32A of IEC to improve the quality of expulsion fuses very much used in developing countries



In posts for the electric



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IEC 60282-2 should include a "Time x Current test after aging cycle" as done in the Brazilian standard NBR 7282

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Premature aging of expulsion fuses working above temperature rise limits is disregarded by the IEC standard

Read the new article with proposals to SC32A of IEC to improve the quality of expulsion fuses very much used in developing countries

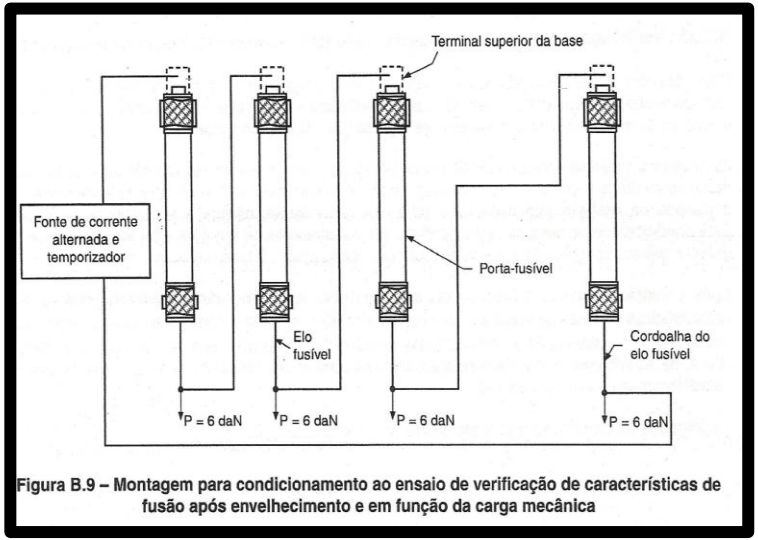
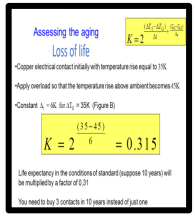


Figura B.9 – Montagem para condicionamento ao ensaio de verificação de características de fusão após envelhecimento e em função da carga mecânica



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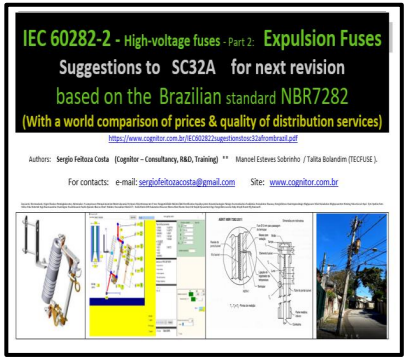
IEC 60282-2 & IEEE C37.41 *** Expulsion Fuses

Read the new article with proposals to SC32A of IEC to improve the quality of expulsion fuses very much used in developing countries



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A designer is changing the project of an old busway to be used in a building of 50 floors. The objective is to increase the short circuit capacity from 20 to 25 kA. What are the two more economic options to reduce or maintain the short circuit forces in insulators and bending of conductor?

a) Increase distance between phases.in some 25%
b) Reduce the distance between phases in 10%
c) Increase distance between supports of the same phase by some 10%
d) Reduce distance between supports of the same phase by some 25%
e) Increase the moment of resistance of the busbar
f) It is necessary to do a comparative costs calculation between options

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An alternative global technical standards organization focused in undeveloped and developing countries is missing !

The requirements of developed countries are much higher and the IEC technical standards for substations equipment are specified for them being more expensive than necessary for developing countries (should have 2 levels of severity)

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Avoiding tests using the concepts of "extension of the validity" (IEC 62271-307) requires more competent test reports than those issued today.

Even reference labs only include the information explicitly requested in the product standard. They understand that it is not their responsibility to ensure that the test is reproducible. I've seen a temperature rise test report attesting that the equipment was approved, but without including the dimensions and material of the bar. Therefore, while IEC 62271-307 is little known, manufacturers themselves should ask to include the information, for their own future benefit.

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Painéis e dutos de media e baixa tensões

Você gosta de repetir testes em equipamento que já foi aprovado ?

Você fabricou um painel de 4000A e foi aprovado nos testes de tipo em um laboratório reconhecido. Outros clientes querem o mesmo projeto, mas para 5000A. Você pode atender com poucas modificações, mas precisa provar ao cliente que funcionará bem. Você só pode fazer isso usando simulações de teste porque será difícil investir de novo 50 mil dólares em testes. O cliente aceitará o relatório que comprova o desempenho em 5000A se você demonstrar que o método de cálculo é confiável e se o relatório for emitido por alguém de credibilidade comprovada. É fácil explicar isso para compradores de empresas com equipes técnicas bem-preparadas.

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Switchgear / Switchboards / Busways

Do you like to repeat tests in equipment already approved ?

You manufactured a 4000A panel which was approved in the type-tests in a recognized testing lab. Other customers want the same design but for 5000A. You can attend with few modifications but need to prove to the client that works well. You can do it using test simulations because is difficult to reinvest 50K Euros testing. The customer will accept the 5000A design review report if you demonstrate that the calculation method is reliable, and the report is issued by someone of proven credibility.

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It is easy to explain this to buyers of companies with well-prepared technical teams

Need assistance to design a high-power testing laboratory ?

I have experience to do it from the feasibility study to the final staff training. Check the CV

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IEC 62271-307 Design Verification Report 100/ 2022

TITLE	**Verification of compliance with the rules of** **IEC 62271-307** **for the extension of validity of reports of type tests performed in a tested and approved equipment, to another, untested , of the same family.**
And approved EFERENCE STANDARDS	IEC TR 62271-307: High-voltage switchgear and controlgear - Part 307: Guidance for the extension of validity of type tests of AC metal-enclosed switchgear &controlgear for rated voltages > 1 kV & < 52 kV IEC 62271-200 (High voltage switchgear and controlgear - Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
PREPARED BY	Sergio Feitoza Costa

Contact: Sergio Feitoza Costa - Electrical Engineer- M.Sc. ... co-author of IEC 62271-307 (2015)
C.V.: https://www.cognitor.com.br/Curriculum.html

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Revisions	Date	Pages	Description
0	[redacted]	-	First version

3.6 - IEC 62271-307: Extension criteria for INTERNAL ARC TESTS (the equipment)

Item	Design parameter	Acceptance criterion	Condition	The criteria were attended?
1	Clearance between phases	≤		
2	Clearance to earth		here the arc is	
3	Net volume			
4	Rated			
5				
8	E			
9	Exh area			
10	Exhaust pressure			
11	Mechanical st elements to let the relief device (fla			
12	Mechanical strength of the enclosure and compartment			
13	Thickness of the enclosure walls	≥		
14	Mechanical strength of the doors and covers	≥		
15	Degree of protection (IP-code) of enclosure	≥	Where relevant for indicator ignition criterion	

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Free Switchgear / switchboards (training)

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Temperatures over limits of IEC standards cause fast aging.

Refurbishing

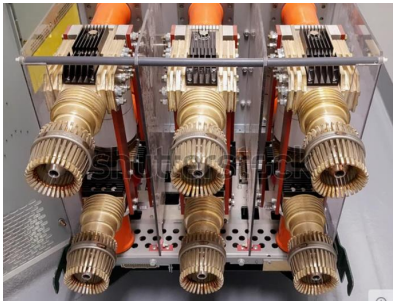
Question: Tell 2 easier ways to reduce temperature rise inside ?

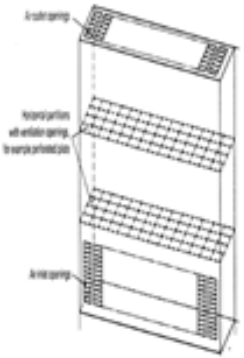
a) CIRCUIT BREAKER RESISTANCE (change from withdrawable to fixed circuit breaker)

b) PERIMETER OF BUSBAR (use 2x100x5 per phase instead of 1x100x10mm)

c) VENTILATION OPENINGS: create or increase

d) CROSS SECTION OF BUSBARS: increase





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IEC 62271-307 Verification Report 100/ 2022

TITLE	**Verification of compliance with the rules of IEC 62271-307 for extension of validity of type tests performed in a (tested) equipment, to another, untested, of the same family**
REFERENCE STANDARDS	IEC TR 62271-307: High-voltage switchgear and controlgear - Part 307: Guidance for the extension of validity of type tests of AC metal-enclosed switchgear &controlgear for rated voltages > 1 kV & < 52 kV IEC 62271-200 (High voltage switchgear and controlgear - Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

Read the 3 initial pages of an "extension of the validity" by IEC-62271-307

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Check guide in downloads area

An IEC standard is missing to give guidance on how to simulate the main high-power tests... to achieve less expensive products. Check downloads area

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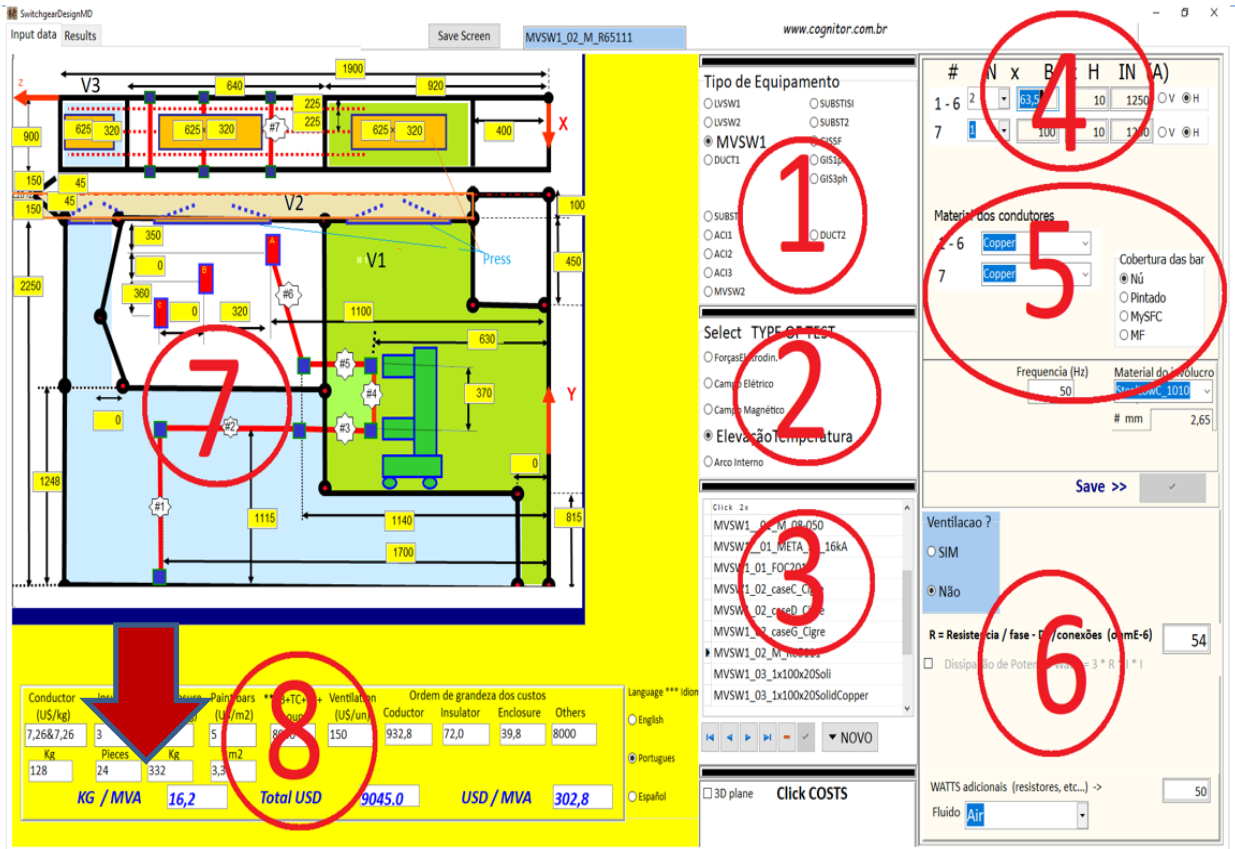
Screen of the Input Data to simulate the test



1 - Type of equipment
2- Type of calculation
3 – Project name

4 - Dimension of bars, rated current, vertical / horizontal

5 – Materials and coating
6 – Ventilation and contact resistance
7 – Geometry
8 - Costs

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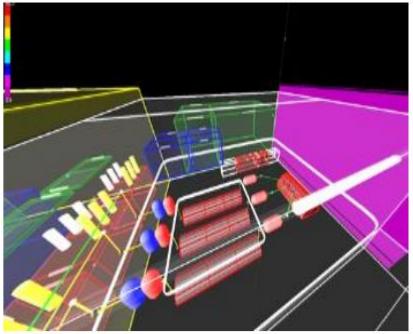
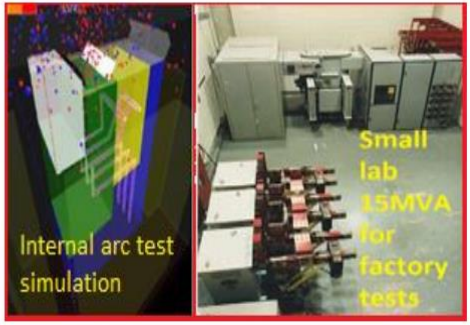
2022: CREATING DEVELOPMENT, EMPLOYMENT & INCOME IN developing COUNTRIES via ELECTRIC INDUSTRY (a real case example)

By Sergio Feitoza Costa





1. A REAL CASE OCURRED IN A DEVELOPING COUNTRY AROUND THE 80'S

Developing a growing medium-size electrical industry in undeveloped countries is not difficult and produces impacting results in development, employment & income. I am not saying this by saying or because I have heard somewhere. Actually, I had a rare opportunity to witness and to participated intensively in an entire process like this, occurred in Brazil, which started in the 70's. What I saw there , nowadays, could be done better and faster in many undeveloped regions all over the World. The results in Brazil were quite good, visible and can be checked via web. You need only to compare the size and profile of the electric industry in the beginning of the 70's and now.

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… I sent to ….IEC, ANSI / IEEE …. a suggestion on how to signalize that equipment should be more efficient having smaller weight/MVA to save Earth resources. ….

Current technical standards are concerned only with creating products that pass the tests, without considering whether they are constructed with less materials.

… To become mandatory to include, in all products standards, a statement about having a lower KG / MVA

Something like this was successfully done, in IEC, in the late 80's , for electromagnetic compatibility (EMC)

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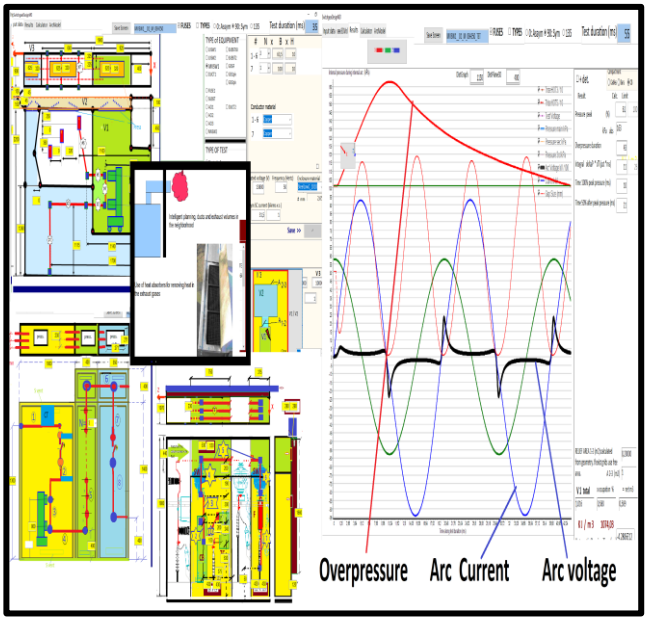
INTERNAL ARC DESIGN: planning of installations X heavier electric panels



Higher currents bring dangerous arc effects. Deaths & accidents are avoidable with installation planning by ducts, etc. However, planning is rare in most developing countries.

They prefer to make electric panels & switchgear more resistant and to alleviate the overpressures. The overpressure curve, is used to predict the behavior in the expensive high-power tests.

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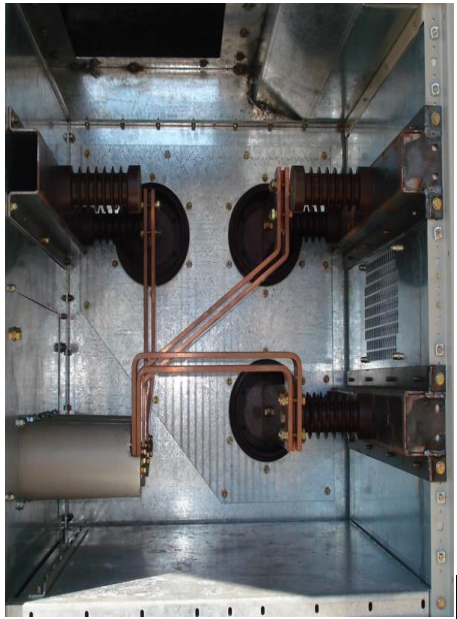
Serviço Help-desk para dúvidas de normas IEC quando você estiver com problemas no laboratório de testes ???



As dúvidas surgem durante os testes porque o texto da norma não está claro ou porque o laboratório dá uma interpretação com a qual você não concorda ou mesmo porque o teste está sendo feito de forma mais severa do que deveria. Nesse momento você precisa de uma opinião qualificada para discutir com a equipe do laboratório. Já vi algumas vezes fabricantes perdendo dinheiro, por causa disto.

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Aging by overloads & overvoltages

OVERLOADS: calculate by IEC 60943 to assess economics of different solutions to increase lifetime of transformers & switchgear

OVERVOLTAGES: no method to estimate aging by temporary and short duration overvoltages. Savings are possible with solutions considered expensive because a complete analysis was not done

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2025: "Environmental Efficiency Certificate" of electric products

… to save resources of the Planet, ….. for an electric product to be commercialized, it is mandatory to have the certificate, assuring that it was designed for minimum use of copper, aluminium, insulating supports, materials, etc.

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

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RESUMES / CVs of EXPERTS in SWITCHGEAR, SWITCHBOARDS, BUSWAYS (DESIGN, TESTING & CERTIFICATION)

In the comments of this Linkedin post, you may post your resumes. The 22.000+ followers may be interested in your expertise. Most are manufacturers, testing labs and certifiers of the electric power industry.

"Likes" do not enable companies to see your knowledge. **Try to write short technical comments to the technical posts if the matter is within your expertise** Good Luck

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ENERGY GENERATION and COSTS OF ENERGY

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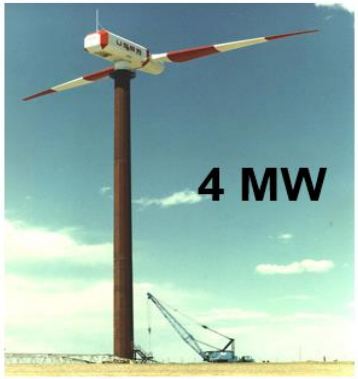
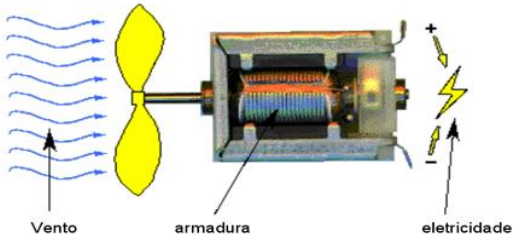
COGNITOR





The key is having a local legislation focused in the environmental benefits and not in the profits of power utilities

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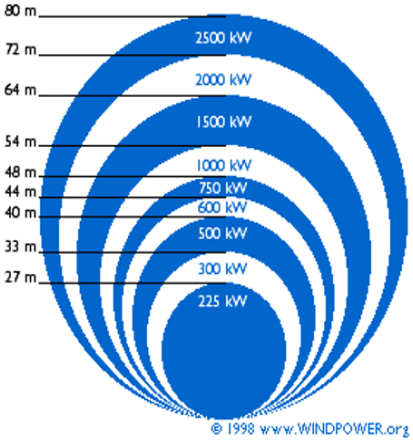
COGNITOR

Wind Energy

concepts



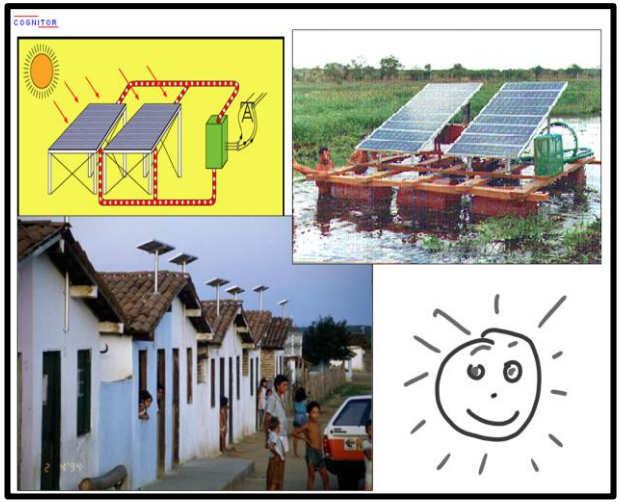
Example

•Wind power in a circular area $P_0 = 1/2 \cdot \rho \cdot v^3 \cdot \pi \cdot r^2$

•Wind speed 16 m/s Radius = 27 / 2 m $\rho_{ar} = 1{,}225\ kg/m^3$ (1 atm - 15°C)

•$P_0 = 1/2 \cdot 1{,}225 \cdot (16)^3 \cdot \pi \cdot (13{,}5)^2 =$ **1436 kW**

• With wind 8,6 m/s is 225 kW



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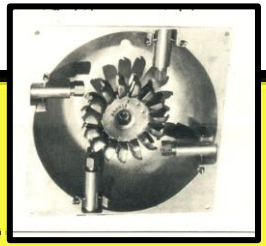

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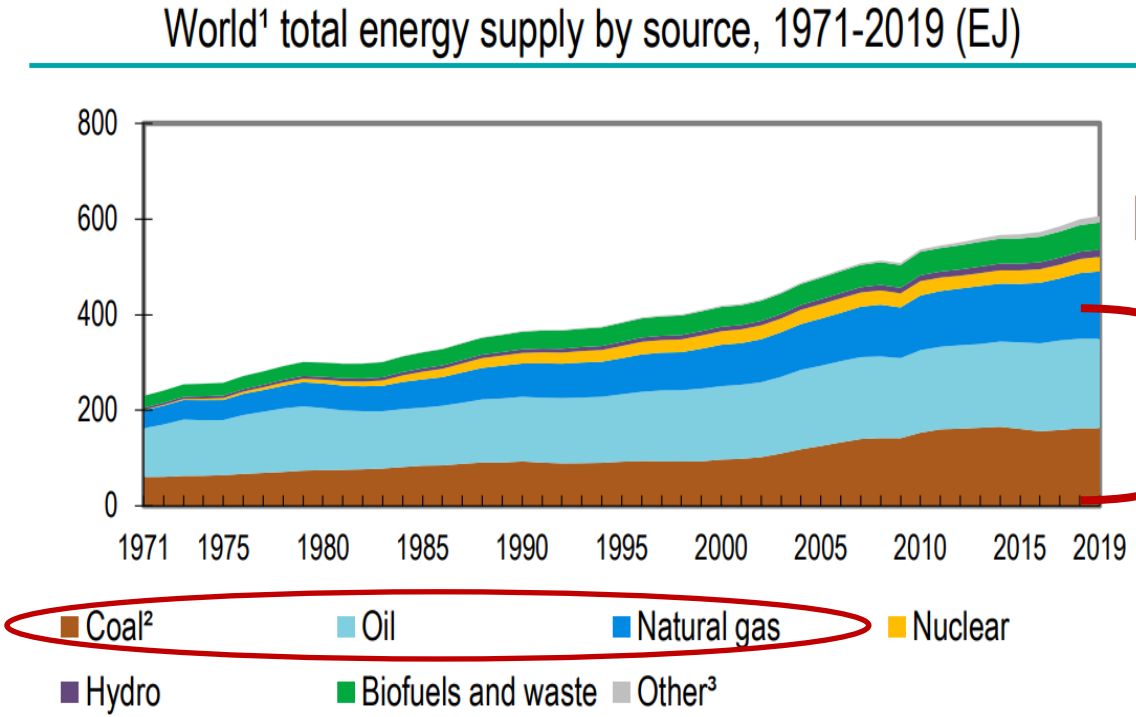
Key World Energy Statistics 2021 - IEA link above



Non-renewables

& low level of Education are killing Earth.

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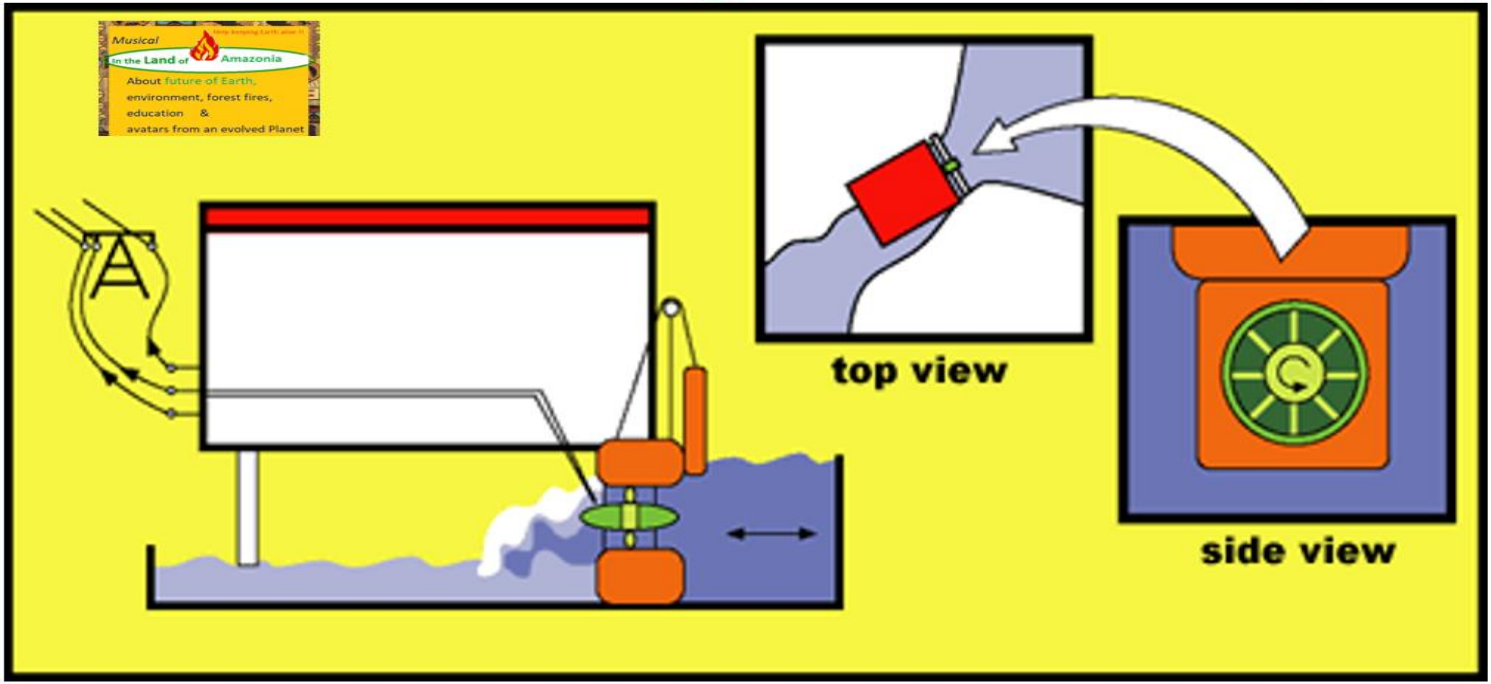
Electric power generation with the strength of the tides ("tidal")



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Fuels combustion (ex. methane)

$$CH_4 + 2(O_2 + 3{,}76N_2) \Rightarrow CO_2 + 2H_2O + 7{,}52N_2 + Heat$$

Air

Balanced ($CO_2 + H_2O$);

With air excess ($CO_2 + H_2O + O_2$)

With low air ($CO_2 + H_2O + CO$)

The real fuel has "impurities" and there is also formation of CO, SOx, NO_X...

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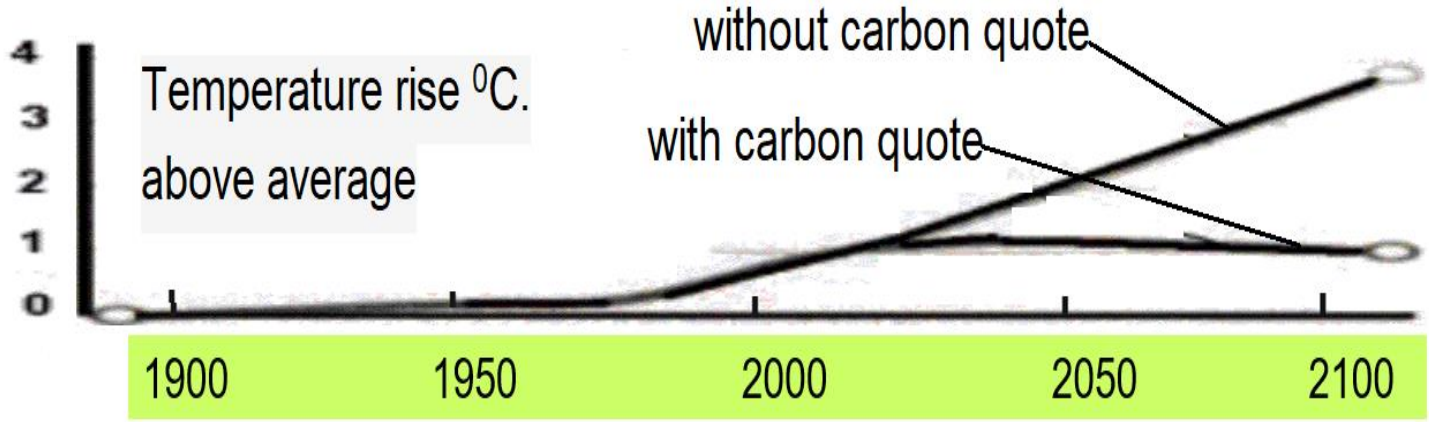

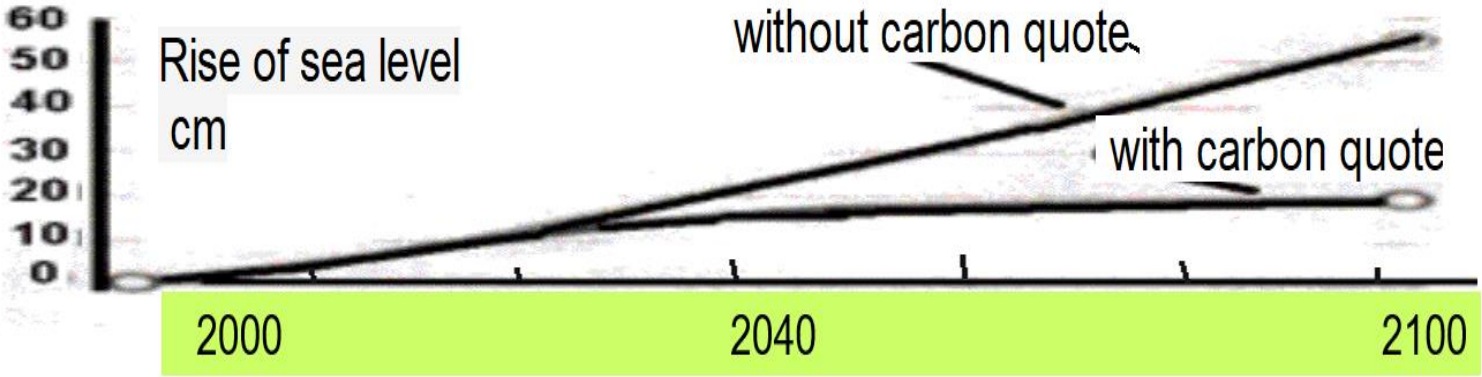

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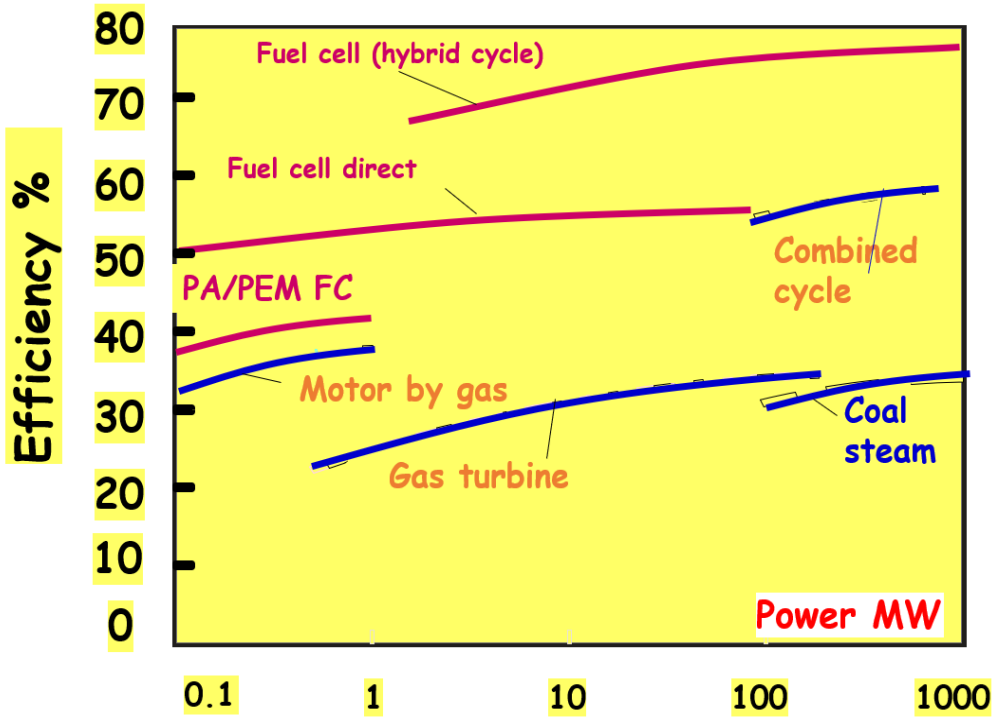

Replacing non-renewable fuels of existing plants by “biomass”.

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Check the Brazilian experience Pro-Alcohol

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Type of plant X emissions

Emissions (gr/kwh) (*) without dessulfurization or Nox reduction				
Fuel	CO_2	CH_4	SO_2	NO_x
Coal	955	2.92	11.82	4.34
Oil	818	0.17	14.16	3.98
Natural gas (combined cycle)	446	0.27	0	0.49
Nuclear	4	0.01	0.05	0.02

ECONOMICS of G, T & D PROJECTS

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Examples of technical-economic analysis of T&D + G projects (A)

Case A: **TO PERFORM VLF PREDICTIVE DIAGNOSTICS** (very low frequency - 01Hz - diagnostics of partial discharges) on underground cables.

Just after to perform scheduled repairs in moments of low load like weekends

O R

TO WAIT FOR A FAILURE TO OCCUR and to make the repair on a high load moment when defects often occur

CIRCUIT WITH 760 M OF CABLE 50KV INSTALLED IN A BRIDGE PROBLEM: 4 failures per year

Alternative solutions: Replacing the Cable or Diagnosis + Repair

ASSUMPTIONS FOR REPLACEMENT

Cable replacement: $ 286,000.00
Average Repair Duration: = 6h
Cost $ per failure = $ 14400.00 / 2.5 (average of 4 to 1)
Failures / year reduced from 4 to 1 due to new cable

ASSUMPTIONS FOR PREDICTIVE DIAGNOSTICS

Average Repair Duration: = 6h is reduced to 3h
Fixed & M = diagnostics = $ 7200.00
Replace 9m of cable: $ 14,400.00 per point of possible future failure

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Free Decidix Link above:
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Examples of technical-economic analysis of T&D + G projects (B)

Case B

PREDICTIVE MAINTENANCE PHILOSOPHY based on ARTIFICIAL INTELIGENCY TECHIQUES (define procedures and train teams to use small diagnostics and tests performed regularly to predict the moment of doing maintenance)

OR

MAINTENANCE BASED ON TIME (scheduled maintenance at a fixed time of the year whether or not there is a need to)

105 CIRCUITS WITH TOTAL LENGTH OF 152000 M OF CABLES 10 KV PILC

PROBLEM: stablishing a power utility philosophy between using regular predictive diagnostics or maintenance based on time

ASSUMPTIONS FOR PREDICTIVE DIAGNOSTICS:

(a) tests: $ 237,000.00

(b) repairs of 29 problems at $ 3000.00 / problem: $ 87,000.00

ASSUMPTIONS FOR "BASED ON TIME":

(e) localization at U $ 2000 / failure: $ 58,000.00

(f) Repair $ 6,000.00 / failure: $ 174,000.00

(g) Customer losses at U $ 8000.00 / failure: $ 232000,00

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Typical examples of technical-economic analysis in the T&D + G (C)

Case C) **TO INSTALL SURGE ARRESTERS TO IMPROVE TRANSMISSION LINE PERFORMANCE – LESS SHUTDOWNS** (with or without guard wire) considering the lightning / surges occurrence level

- 69kV line with a 10 MW active power
- Line 9.5 km and 48 structures.
- Isoceraunic level = 40 and 15 discharges- year
- Cost of energy not supplied at U $ 0.95 / kwh
- Installation cost = cost of material; man-hour assembly; line de-energized during assembly, personnel for cable-guard installation = $ 1,200.00 / h
- Avg. installation time: 0.5 km / h.
- staff for surge arrester installation = U $ 300.00 / h.
- Avg. installation time: 1 hour for 3 arresters, 45 minutes for 2 arresters and 30 minutes for one.
- Time with energy not supplied: 5 min. for lines with automatic reclosing, and 6 h for permanent faults.

OR

DOING NOTHING (maintain as it is)

FAILURE INDEXES (%)

- Without guard wire 99.0 With guard wire 39,0
- Installing 1 arrester per structure 39.0
- installing 2 arresters per structure 10.0
- installing 3 arresters per structure 0 (one in each phase)

EXISTING LINE

- Installation costs (materials) (U $ / km): 0
- Installation costs (man hour & others (U $ / km): 0
- Cost of energy not supplied (U $): 96,091.00

LINE WITH GUARD WIRE

- Installation costs (materials) (U $ / km): 720,50
- Installation costs (man-hour & others (U$ / km): 19.974,72
- Cost of energy not supplied (U $): 37513,13

LINE WITH 1 ARRESTER PER STRUCTURE

- Installation costs (materials) (U $ / km): 3134,94
- Installation costs (man hour & others (U $ / km): 12.388,08
- Cost of energy not supplied (U $): 37513,13

LINE WITH 2 ARRESTERS PER STRUCTURE

- Installation costs (materials) (U $ / km): 6269,88
- Installation costs (man hour & others (U $ / km): 18582,11
- Cost of energy not supplied (U $): 9618,75

LINE WITH 3 ARRESTERS PER STRUCTURE (one per phase)

- Installation costs (materials) (U $ / km): 9396,40
- Installation costs (man hour & others (U $ / km): 24726,15
- Cost of energy not supplied (U $): 0

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Typical examples of technical-economic analysis in the T&D + G

(D)

Case D **To use FUSE-LINKS (IEC 60282-2) OF BETTER QUALITY (more expensive)**
OR CHEAPER FUSE-LINKS

-- 15 km urban feeder with cable 336/400 A 3500 consumers.
Fuse-link of lower quality costs $ 1.40 / unit and the higher quality costs $ 2.4 / unit
-- The system has 90 fuses and 390 links (including spare) protecting 100 distribution transformers that cost U $ XX each.
-- Transformers have annual failure rates of 3% and this could be lowered to 2%

The cheaper fuse-link operates more times than it should (premature ageing) and sometimes does not work well.
It is less expensive but on the other hand, more money is spent with inspections and repairs of transformers.

The mean replacement time is: TMR = 2h30 ' R $ xx / consumer billing

Cost of each "failure" $ 35 / failure
U $ 500 / repair of transformer or U $ 500/3 per loop operation

Best strategy to change fuse- link (all at once or only the melted one) ?

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Part 3 of 5 of the course on ASSESSMENT OF THE FEASIBILITY OF ENERGY PROJECTS: generation, cogeneration and transmission and distribution)

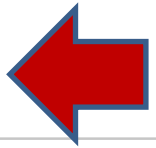
METHODOLOGY for the TECHNICAL - ECONOMIC ANALYSIS of the FEASIBILITY OF ENERGY PROJECTS

(using the software Decidix)

HOW TO GET A COMPLETE AND FREE COPY OF THE DECIDIX SOFTWARE

Click here to read in English

http://www.cognitor.com.br/c_Feasibily_Analysis.htm



Teaching to save Earth resourcesprojects

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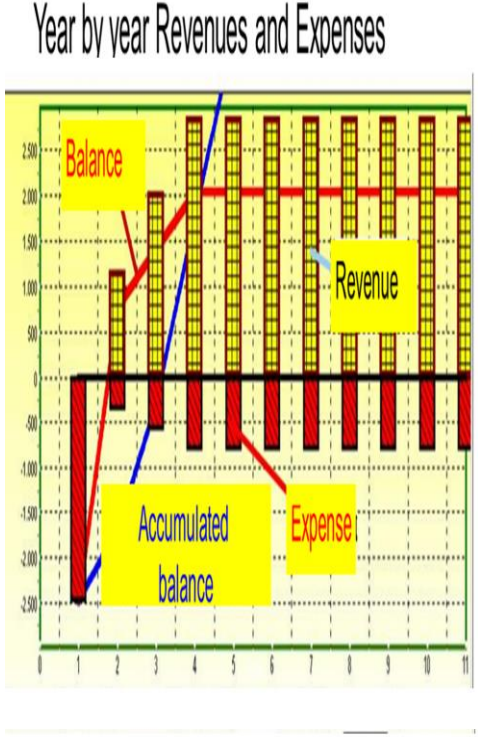
Technical-economical assessment of power projects

(for switchgear designers)



Free software Decidix

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Typical examples of technical-economic analysis in the T&D + G

(E)

Case E **TO USE CIRCUIT BREAKER SYNCHRONIZERS (point one wave dispositives) FOR POWER SYSTEM RATED VOLTAGES AS LOW AS 145KV OR 69 KV**

Synchronizers or point on wave switches are devices used with circuit breakers to minimize or eliminate switching transients by closing the circuit breaker contacts at a convenient point of the wave. The main use is during energization of no-load lines, energization of capacitive loads and to avoid inrush currents. The reduction of time life of components associated to overloads and consequent over temperatures is a common calculation. The same methods used for power transformers loading are employed. However, it is easy to find, even estimates of the loss of life caused by temporary overvoltages.

For a 345kV system the price of a synchronizer (~ USD35.000) is relatively small in front of the price of a SF6 circuit breaker (~ USD220.000) . However, for a 138kV circuit breaker costing around USD70.000 many utilities understand that it is not a good cost option. The reason is that the $ benefits of the avoided overvoltages has not been calculated

That's why people use synchronizers mostly over 230 kV. However, if you do a more serious analysis and consider, instead of only the initial investment, the book life, O&M and the whole system it is different.

In this example we consider that 20 operations per year (like the ones at left side) are done provoking a reduction of the useful time life of only 10% . As a reference point, calculations in IEC60943 enable to estimate that for each 6.5 K above the IEC standards for temperature rise a reduction of 66% of time life duration is expected.

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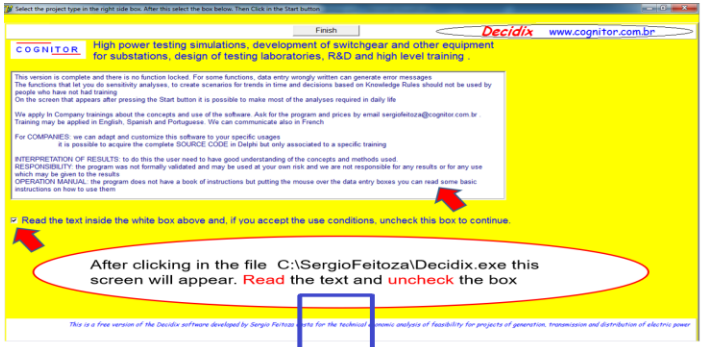
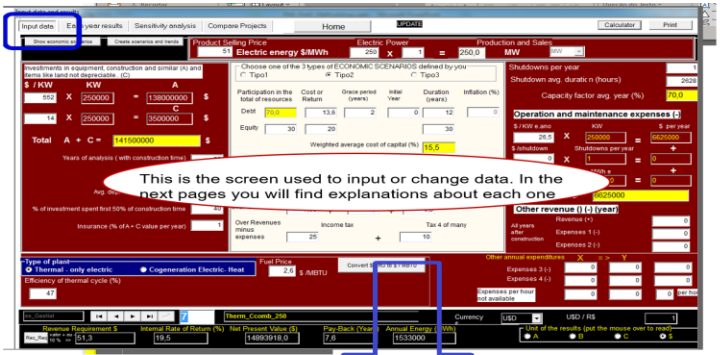
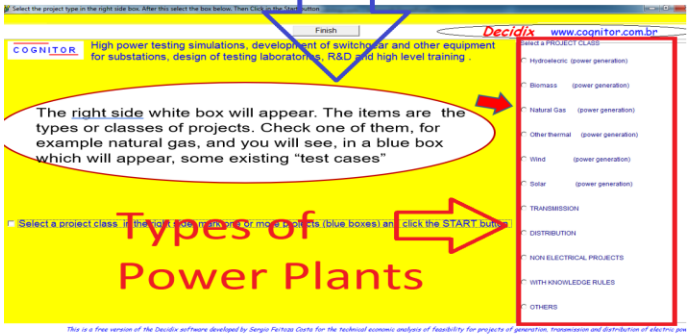
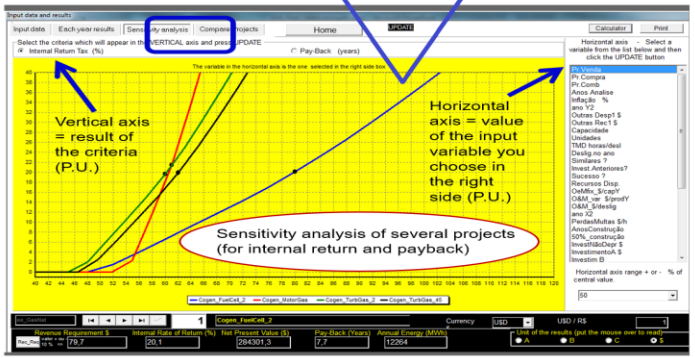
kG/MVA : Research Centre on Environmental Efficiency of Electric Products









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Technical- economical assessment of power projects

With free software Decidix

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Legislation that looks for environment and the benefit of society. The consumer generates more than own use and sell surplus to the power utility . All the ceiling area is used.

Legislação olha o beneficio da sociedade e meio ambiente. O consumidor gerar mais que seu consumo próprio e vende excedente para a concessionaria. Toda área do teto é usada.

Brazil: Legislation that first meets the interest of the power utility and do not pay for the surplus.
The consumer only generate the sufficient to own use (lost opportunity)

Brasil: Legislação que primeiro atende a interesse da concessionária de energia e não pagar pelo excedente.
O consumidor só gera o suficiente para uso próprio (outra oportunidade perdida)

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Implantation of R&D Centers, Testing Labs & Training

Need a visiting researcher to make the company fly higher?

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Themes for M.Sc. Thesis (Electrical Engineering)

Electrical engineers have been writing me asking for suggestions for themes.

If I was young and had to do a choice I would think about:

- **Removing old paradigms** in the electric industry (e.g. forced ventilation in switchgear X waste of copper / aluminum)
- **Metal foams** in power equipment
- **Wireless power** T&D - 1 kW
- **Superconductivity** in switchgear
- **M H D** applications in ...
  - Environmental efficiency certification for substations equipment
  - Technical standards with two levels of severity

100 LinkedIn posts for the **electric power industry** R&D

Read link above

Switchgear, Controlgear, Switchboards & Busways

Substations design& testing - Web Training

(2 X 3,5 h of "live" sessions + videos + software)

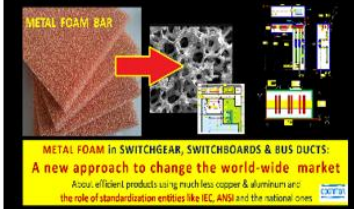
Training in Manilla - Asia – Cigrè events

Consultancy work for equipment design & tests

Training in Angola Africa -

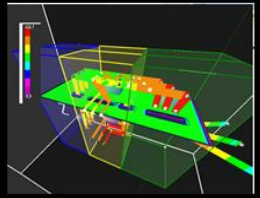
Trainings in Colombia, Argentina, Guatemala

Trainings in China, North America, Europe



Patent by Sergio – Metal Foam in switchgear

Environmental Efficiency of Electric products



Implantation of testing simulation scheme

Design of High Power Testing laboratories

Startup of research centers & R&D (visiting researcher)

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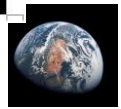

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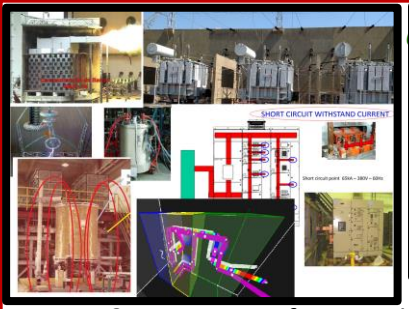
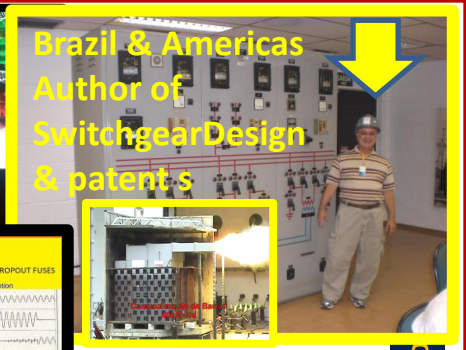
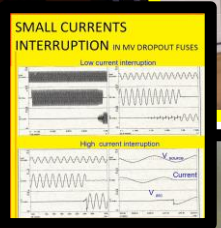


Design & operation of testing labs





I trained hundreds all over the World !!!

變電站設備。

需要提高設計師的知識？

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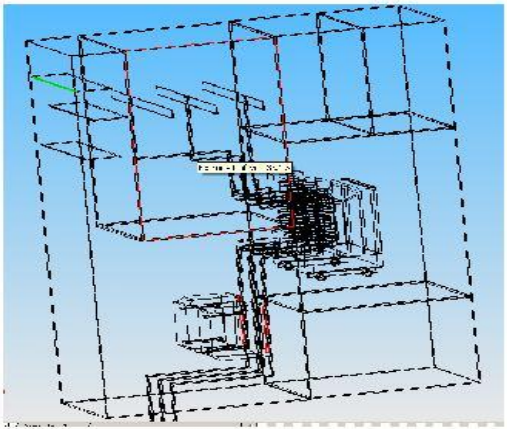
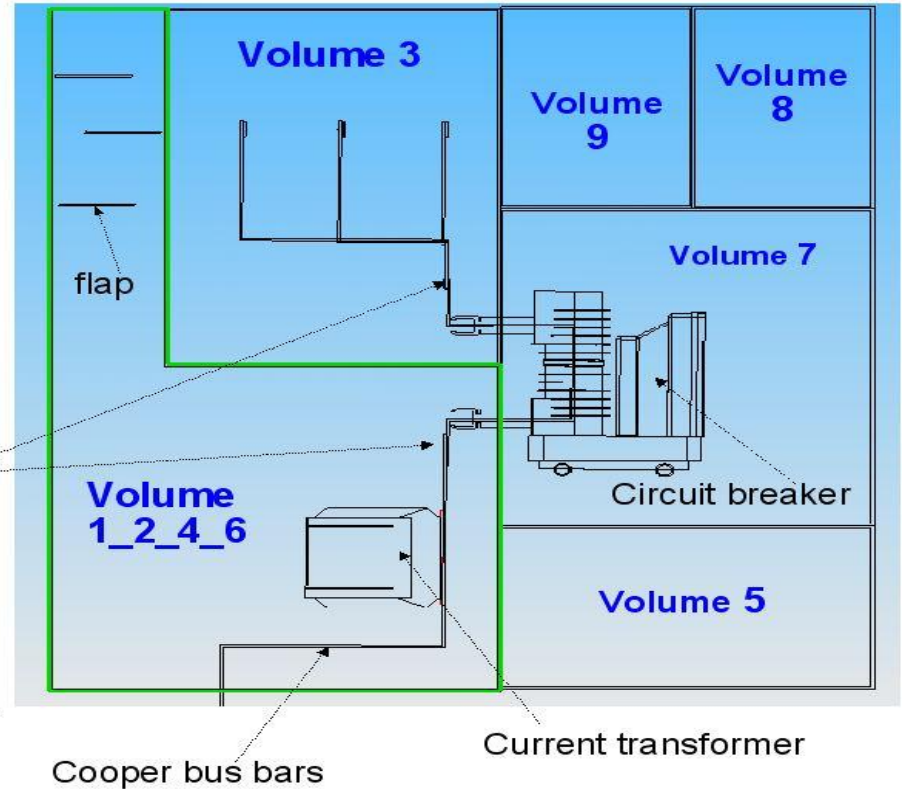
file **Panel_1_to_8_Full.sldasm**



Top opening with the same size as the flaps



50 x 25 x2 mm metallic bars with a created material in such a way that Resistance = resistivity x length / area is equal to a known contact resistance, for example 60 microOhms (yellow in the drawings) The "contact resistance bar" touch the bus bars externally at the point and we inject a current in it in such a way that heat will be produced

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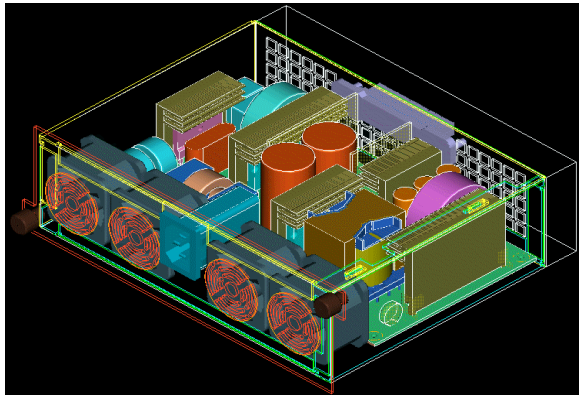
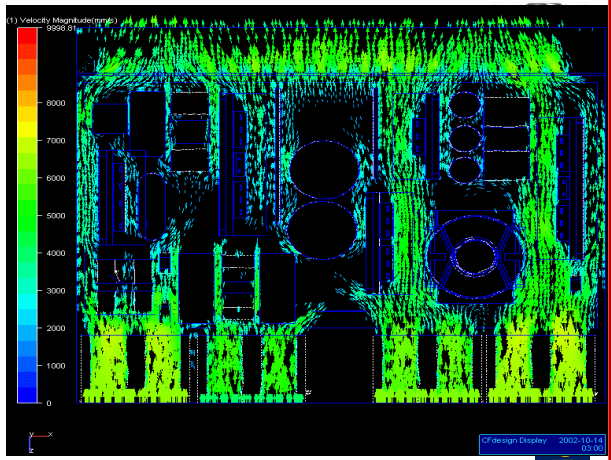
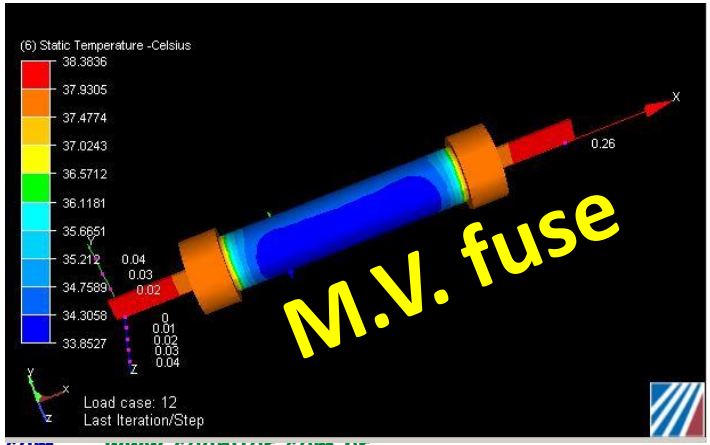
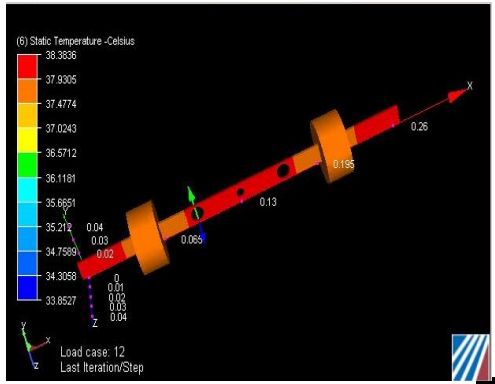
Temperature rise:

what is the most difficult to design ?



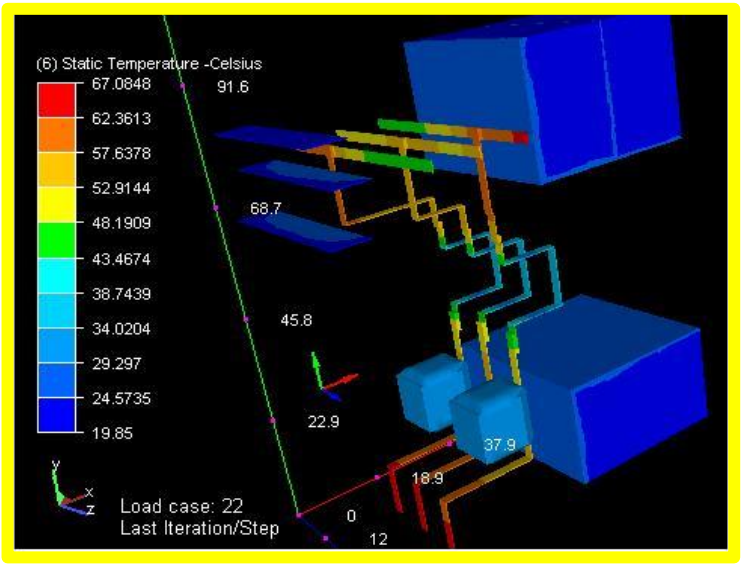


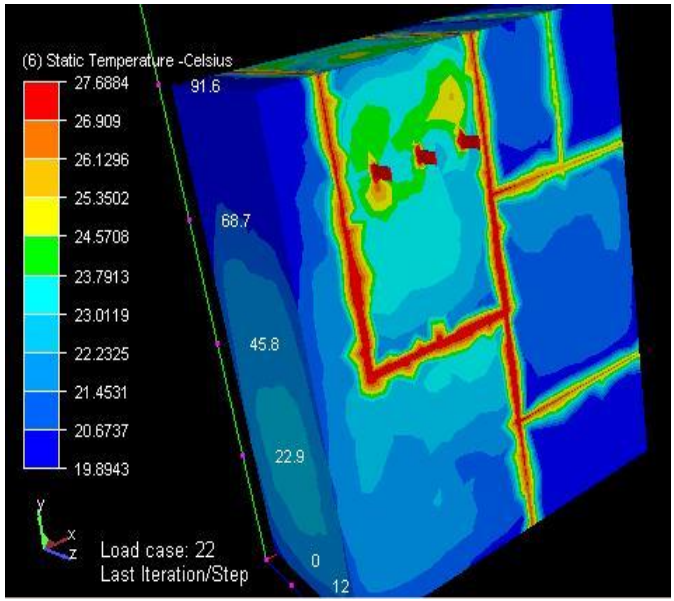




100 LinkedIn posts for the el

Temperature rise: what is the most difficult to simulate ?





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- Implementation of Research Centers & large R&D projects
- Design / implementation of electrical testing laboratories
- Planning of regional renewable energy programs.
- & orientation of M.Sc. thesis

Visiting researcher:

Temporary. Partially presential / partially remote. **Only outside Brazil,** in a place known to be pleasant & safe . I can communicate in English, Spanish, French, Portuguese & Italian

100 LinkedIn posts for the **electric power industry** R&D

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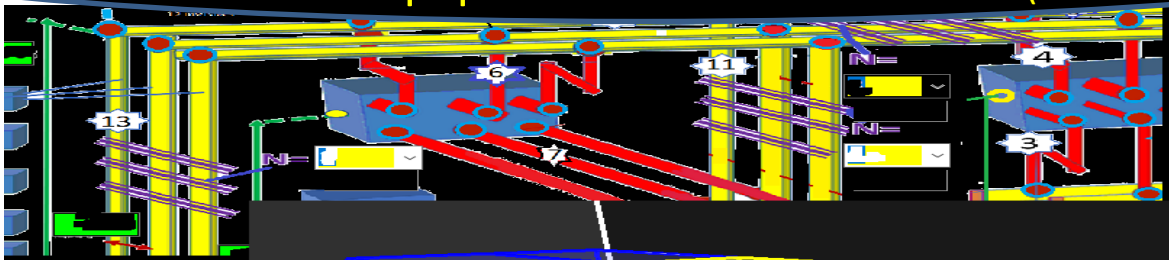
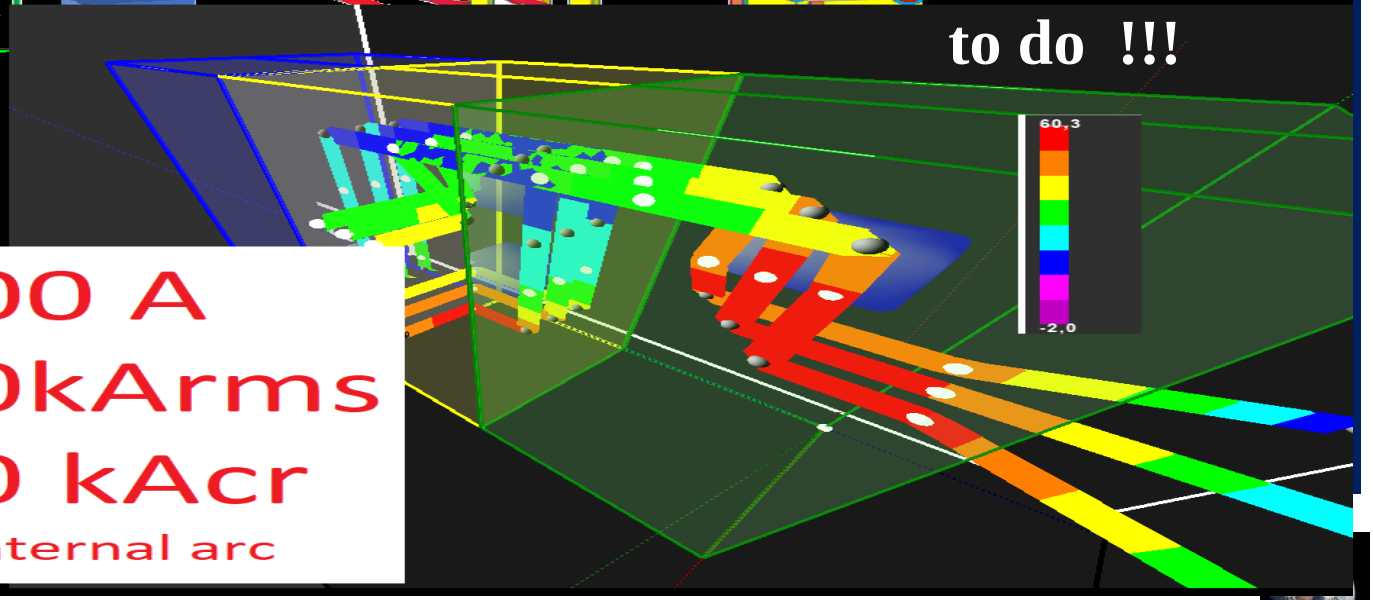
Design, testing and specification of substations equipment : Web TRAINING (link above)



ΔT < 75K
as it is correct to do !!!



5000 A
110kArms
230 kAcr
with internal arc

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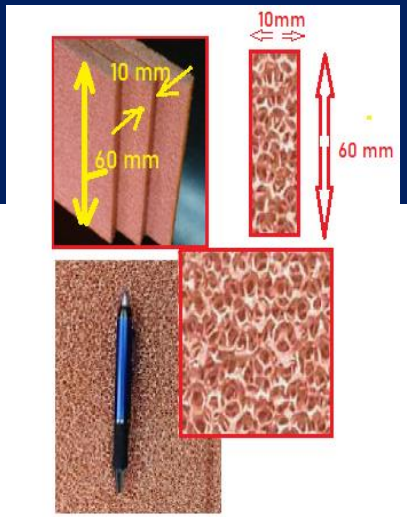
ANEEL P&D: Falta projeto sobre uso elétrico de espuma metálica

Leia o artigo



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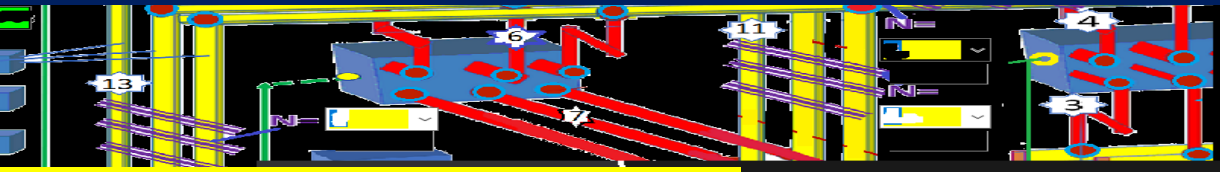
Design, testing & specification of substations equipment :

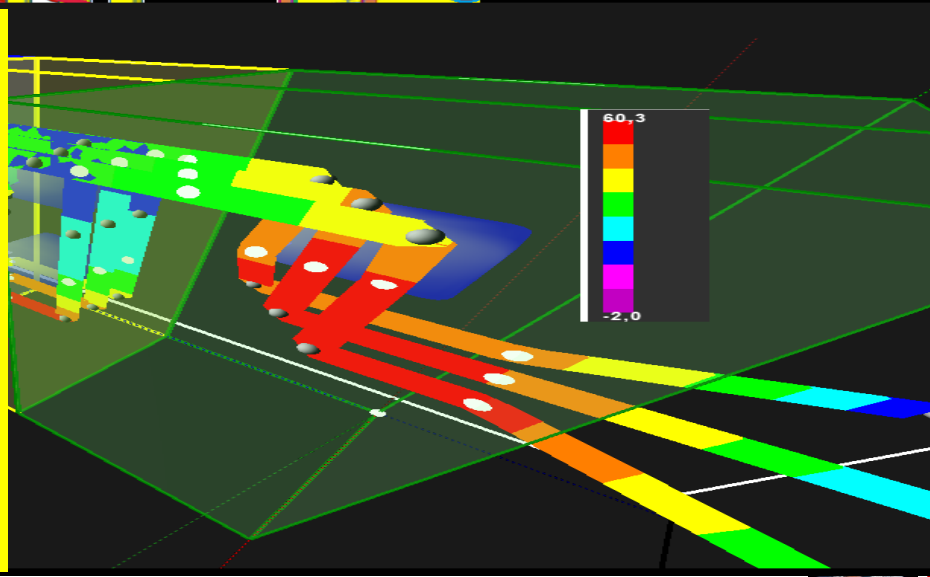
Learn concepts using SwitchgearDesign



2 days Presential training:

SINGAPORE

March 2023



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Testes de Elevação de Temperatura, Arco Interno, Correntes de Curta Duração (forças de curto-circuito)

Precisa analisar o projeto do painel elétrico para saber se vai passar nos testes ?

Quer evitar gastar com testes de painéis de media tensão com análise da IEC 62271-307 ?

Precisa treinar sua equipe de engenharia?

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ELECTRIC POWER INDUSTRY: We do not need new technologies ...only to increase the efficiency of existing ones. However the focus of the major switchgear & controlgear manufacturers (IEC 62271 / IEC 61439) is to license old designs to less developed countries

An idea to SIEMENS, ABB, SCHNEIDER, GE, HITACH is to propose to **ISO / IEC, an ENVIRONMENTAL EFFICIENCY CERTIFICATE FOR POWER PRODUCTS** attesting that the product was designed with the minimum necessary use of copper, aluminum, insulating supports, materials etc. As a marketing strategy would bring better results than reducing the volumes of the small SF6 chambers or GIS. This is a fantastic not-explored market.

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Read the chapter “City of Environmental Education and Energy” of the book

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SINGAPORE - March 2023 : 2-day presential course:

Design, testing & specification of substation equipment:

Understand concepts using SwitchgearDesign. Target: electric power manufacturers and concessionaires.

1	**Definitions and concepts of substation equipment. How to use SwitchgearDesign software**
2	• TEMPERATURE RISE – Design &Tests. (IEC61439 + IEC 62271 + IEC60943 + IEC60890)
3	• ELECTRODYNAMIC FORCES of short circuit: Concepts of IEC 61117, IEC TR 60865.)
4	• INTERNAL ARC - IEC 62271-200 /IEC 62271-307 (medium voltage), IEC TR 61641 (L.V;)
5	• How to define Currents and Voltages in New Substations. • Overvoltages and Insulation Coordination (and related dielectric tests)
6	• Technical Specifications and Purchase Tests ("Bids"):Circuit Breakers, Disconnectors, Arresters.
7	• Technical standards for low voltage switchboards (IEC 61439 and IEC TR 61641) • Magnetic and Electric Fields and their Effects (Concepts and Mapping) • Technical standards for medium voltage switchgear (IEC 62271-200) and IEC 62271-307 (extension of validity of test reports) . Technical standard IEC 60282-2 for HV expulsion fuses

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ENVIRONMENTAL EFFICIENCY CERTIFICATE of electric products . (kG / MVA)

The draft of a world-wide technical standard

using design concepts of IEC TR 62271-307 .

An idea by Sergio Feitoza Costa

Article : http://www.cognitor.com.br/EnvironmentalEfficiencyCertificate.pdf

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Good moments applying trainings abroad

China very competent team & company

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Size: Another old paradigm to overcome

I learned, designing, that a lighter switchgear / switchboard is better in offshore oil platforms. There, each kG matters.

Lower volume means greater overpressures (& internal arc do not extinguish), short-circuit forces & temperatures. Lower volume but higher KG/MVA.

What is the difference of having a group of panels 800mm wide instead of 600 mm in a room of more than 10 meters ? Like in 100 kArms.

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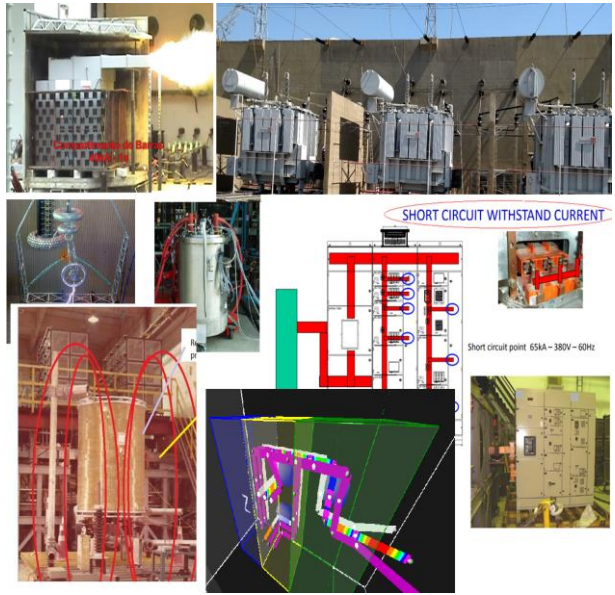
Need to design better switchgear, switchboards , busways ?

I can teach you.

But if you prefer, I can do it for you



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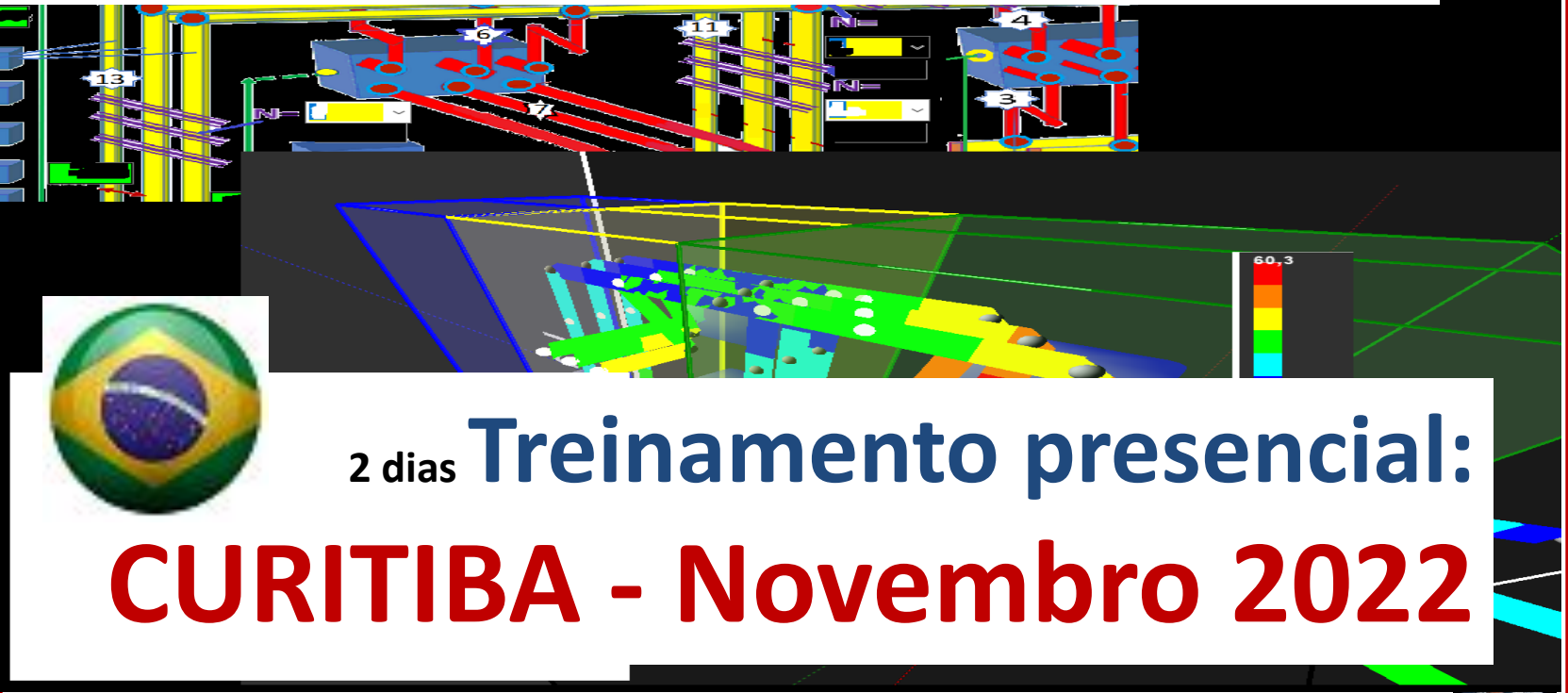
Curso: **Projeto, testes e especificação de equipamentos de subestações** : Entenda com o SwitchgearDesign



2 dias **Treinamento presencial:**

CURITIBA - Novembro 2022

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IEC TR 62271-307 : design review studies for the extension of the validity of test reports to avoid expenses with tests in H.V. / M.V switchgear.

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Sergio Feitoza Costa is coauthor of this IEC T.R.

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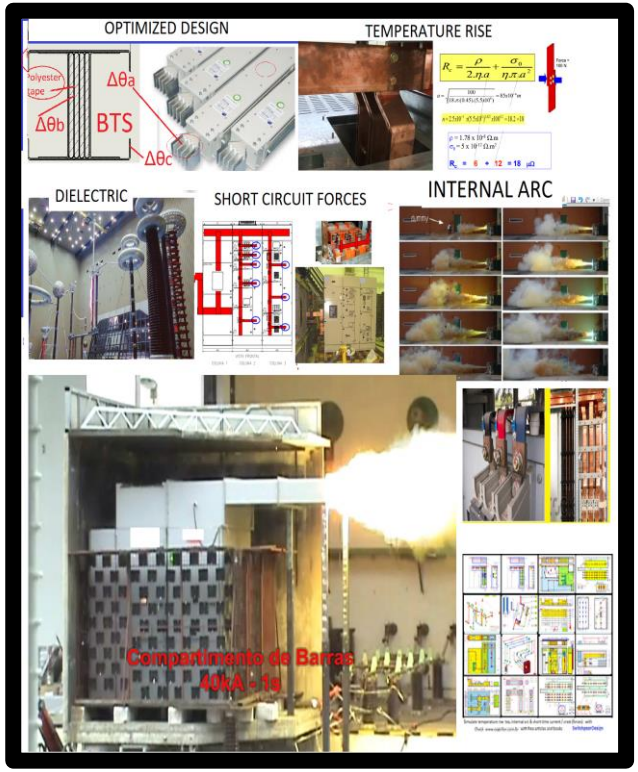
kG/MVA : Research Centre on Environmental Efficiency of Electric Products



Switchgear / Switchboards

(Medium /Low voltages)

2 x 3,5h

Web training

100 LinkedIn posts for the electric power industry • R&D

Prepared for manufacturers, certifiers, testing labs & big users

Can be applied in English or Spanish or Portuguese

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kG/MVA : Research Centre on Environmental Efficiency of Electric Products

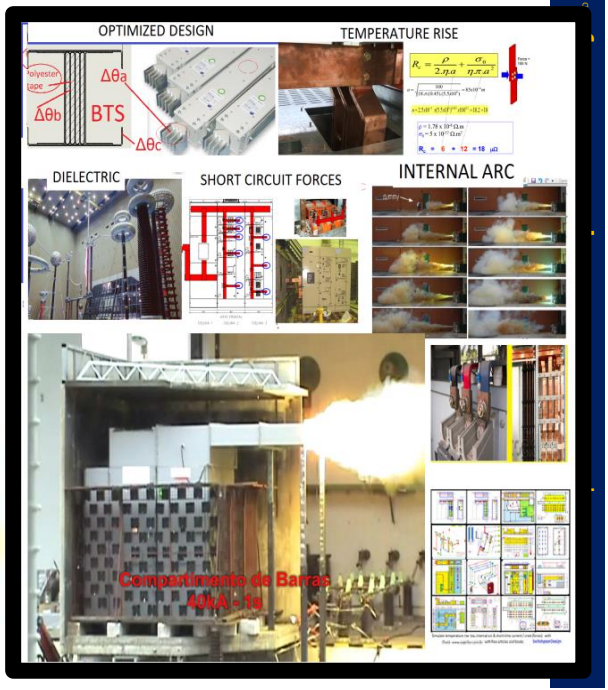
Painéis Elétricos

(Média e Baixa Tensões)

e dutos de barras:

2 x 3,5h

Treinamento Web



Para fabricantes, grandes usuário, projetistas e certificadoras

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CURITIBA – novembro 2022: CURSO PRESENCIAL 2 dias:

Projeto, testes, especificação de equipamentos de subestações

Entenda conceitos usando o SwitchgearDesign. Alvo: fabricantes e concessionarias de energia elétrica.

1	**Conceitos de equipamentos de subestações. Como usar o software SwitchgearDesign**
2	ELEVAÇÃO DE TEMPERATURA – Projeto /Ensaios (IEC61439 * IEC 62271 *IEC60943 * IEC60890)
3	FORÇAS ELETRODINÂMICAS de curto-circuito: Conceitos, IEC 61117, IEC TR 60865.)
4	ARCO INTERNO - IEC 62271-200 e 307 (média tensão), IEC TR 61641 (baixa tensão).
5	Como são definidas as Correntes e Tensões em Novas Subestações e Sobretensões e Coordenação do Isolamento
6	• Especificações Técnicas e Ensaios de Compra de Disjuntores, Secionadores, Pará rios • Campos Magnéticos e Elétricos e Seus Efeitos em subestações
7	• Normas técnicas de painéis de baixa tensão (IEC 61439 e IEC TR 61641) • Normas técnicas de painéis de média tensão (IEC 62271-200) e IEC 62271-307(extensão da validade dos relatórios de ensaio) . • Norma IEC 60282-2 e NBR 7282 (fusíveis expulsão)

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R&D + INVENTIONS

by Sergio Feitoza

100 LinkedIn posts for the electric power industry - R&D

Read, share and use this free book to help in the design, testing & specification of substations equipment

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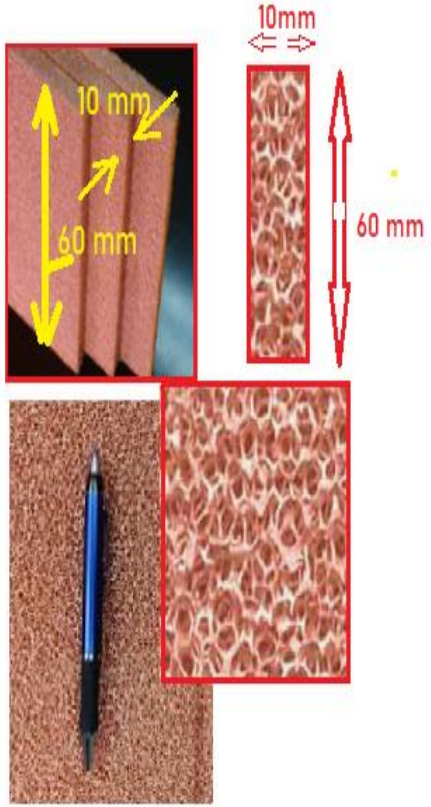
IEC 62271 & IEC 61439 products

Metal foam technology



Read article (link above) and do a test in your factory

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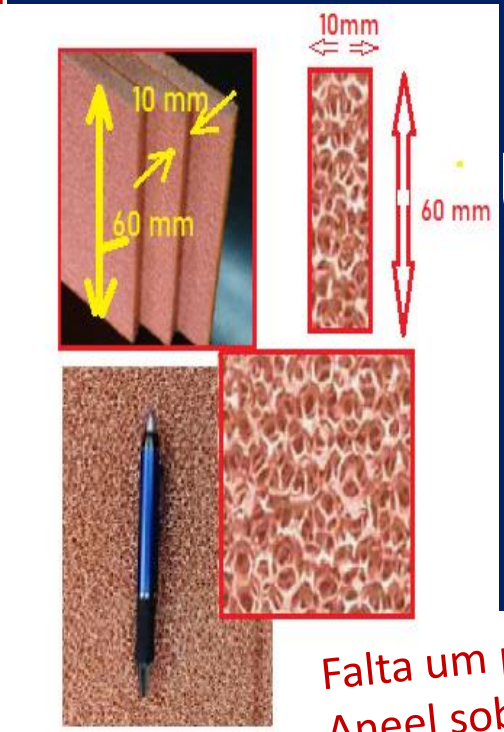
NBR IEC 62271 & 61439



Use espuma metálica

Leia o artigo e faça o teste na fábrica

Falta um projeto P&D Aneel sobre isto

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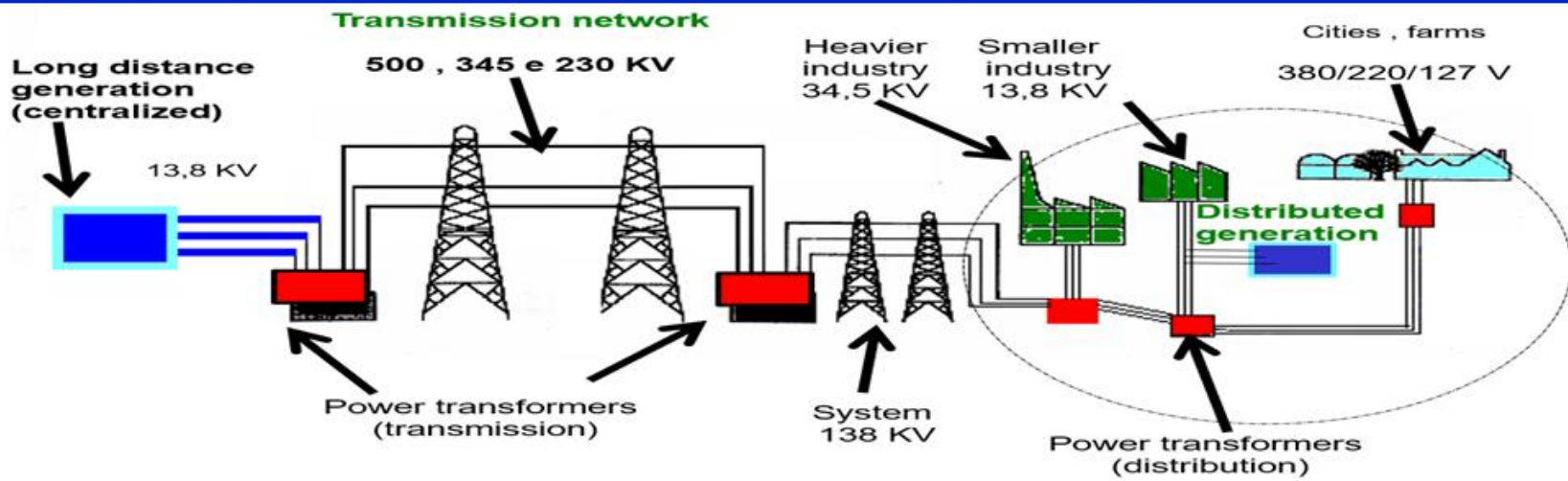
Next technologies



G Lower losses, new fluids, small renewable plants, low-cost superconductivity

T Dynamic Line Rating, D.C, . **Underground + Triaxial**, Aesthetics., Low-Cost substations

D Underground + Triaxial, Aesthetics, Metal Foams + " **Labelling for Environmental Efficiency of electric products**" , IEC standards looking also to developing countries

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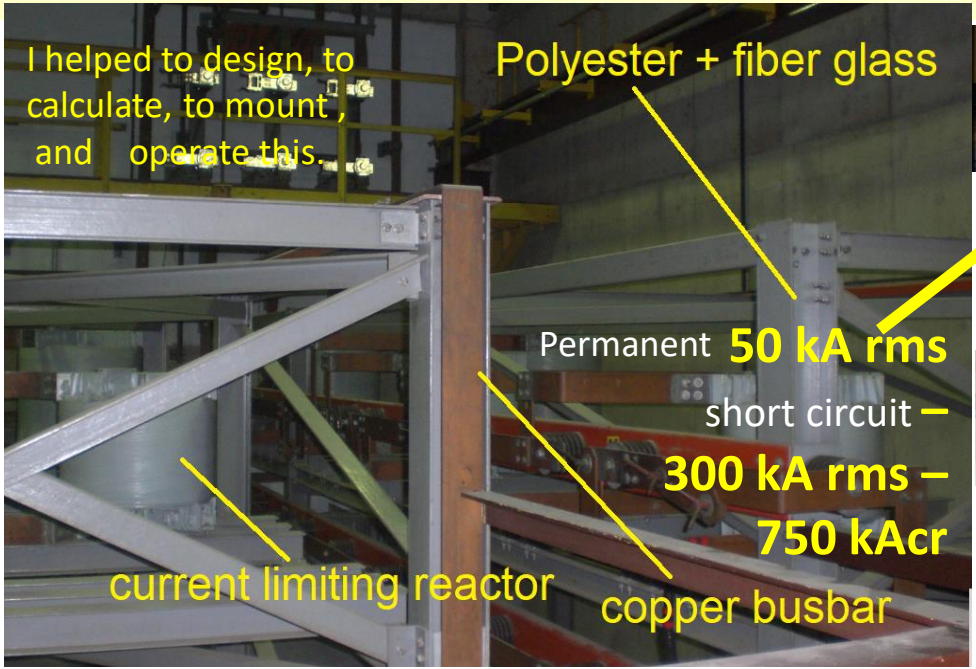
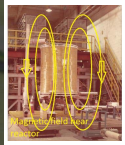
100 Lin

Polyester reinforced with fiberglass profiles in switchgear





The possibilities are enormous, for currents > 4000 A (magnetic heating) . In the Brazilian high power labs we calculated and used it in all the structures.

It is there still working. Practically no maintenance is needed. Attention to the material of the bolts and structure calculations.

Need a design ?

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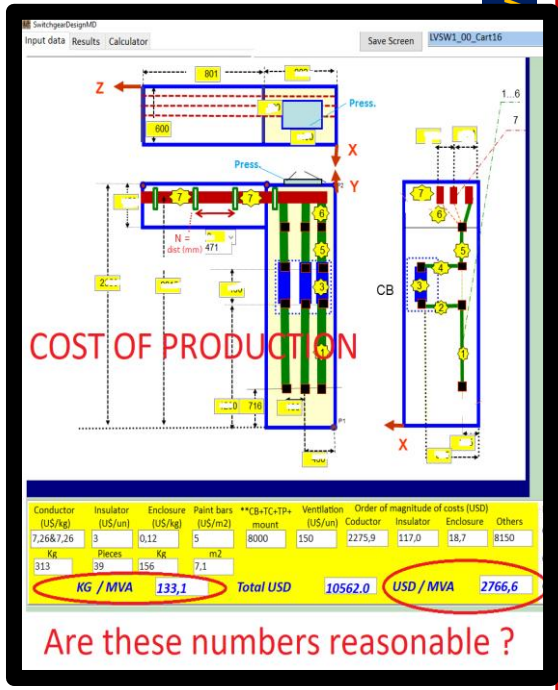
Costs of production estimate (and kg/MVA)

When calculating the performance for rated and short circuit currents the tool show also an order of magnitude of production costs. This is to compare, for example the benefits of using 2x100x5mm copper bars instead of 1 x100x10mm per phase



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21 SMALL-SIZED COMPANIES with REMARKABLE RESULTS IN INNOVATIONS

13

r industry

Short description of product (Main innovation)	Manufacturer or developer name	Order of magnitude of construction cost without taxes(USD/MVA)	Weight by MVA transmitted kg/MVA	RORC /nr. employees (order of magnitude per year)	Nr. patents issued from 2012
Triaxial busbar system for very high rise (30+) buildings (very low impedance but very high short circuits withstandability)	Company A				2
Medium Voltage 4000A / 50KA panel with forced ventilation and IAC AFLR (forced ventilation + internal arc synchronized)	Company B				1
Low Voltage Switchboard 5000A / 65 kA using metal foams in busbars + internal arc (Extra light weight)	Company C				3

RORC= return on research capital , or RORC, (proportion of profits that are generated from R&D spending in previous period of 10 years) https://www.investopedia.com/terms/r/return-on-research-capital.asp

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Research Center on Environmental Efficiency of Electric Products

- Create a “technical standardization association” committed to environmental efficiency.
- Design techniques for less kg/MVA (demos & technical support services)
- Making companies to understand the opening market
- Testing laboratory & certification body . Focus on **kg/MVA**

FUNDING: companies with a good environmental image.

100 LinkedIn posts for the **electric power industry** R&D

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Visiting researcher: I stay in your company 3 to 4 months to start up - challenging only - R&D projects & training of implantation teams.

Examples:

a) Implantation of research centers / testing labs or R&D development

b) Planning / implementation of regional sustainable development. and orientation of M.Sc. thesis

Requirements: Temporary. Partially presential / partially remote. **Abroad Brazil only**, in a place known to be pleasant & safe . I can communicate in English, Spanish, French, Portuguese & Italian,

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Build electric power products with lower **$/MVA** & **kG/MVA:** use this as marketing to reach companies that take care of the environmental image.

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Read the "The draft technical standard for the **CERTIFICATE OF ENVIRONMENTAL EFFICIENCY FOR ELECTRICAL PRODUCTS**"

IEC 62271
IEC 61439
IEC 60282-2

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"Environmental Efficiency Certificate" of

electric products: assuring that it was designed for minimum use of copper, aluminum, insulating supports, materials, etc. **The new market**

Make your product with less materials and tell this to the world. Companies that care for the **environmental image** will prefer to buy from you.

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A marketing strategy for manufacturers is designing / manufacturing products with lower kG/MVA and $/MVA and making the World to know this.

Big buyers needing a good environmental image, like the ones which provoke big accidents, will prefer to buy your products. The market will disclose who buys and who does not buy more efficient products.

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GUIDE (Edition 1.0):

Guidelines for the use of the "ENVIRONMENTAL EFFICIENCY CERTIFICATE of electric products"

CONTENTS

1 Scope
2 Normative references
3 Definitions
4 Working procedures
5 An example of CERTIFICATE and the process to obtain it.

Read & share.
Downloads area

FOREWORD

This "Environmental Efficiency Certificate for Electrical Products" aims to induce the electric industry to produce items that goes beyond the quality assured by prescribed type tests . The focus is on award and highlight design and construction actions on electrical power products that lead to weight per transmitted power (KG/MVA) or estimated lower cost per transmitted power ($/ MVA). These indicators are used to characterize higher efficiency and lower use of materials. It is particularly relevant to users that take care of 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, and test calculations or simulations can be used.

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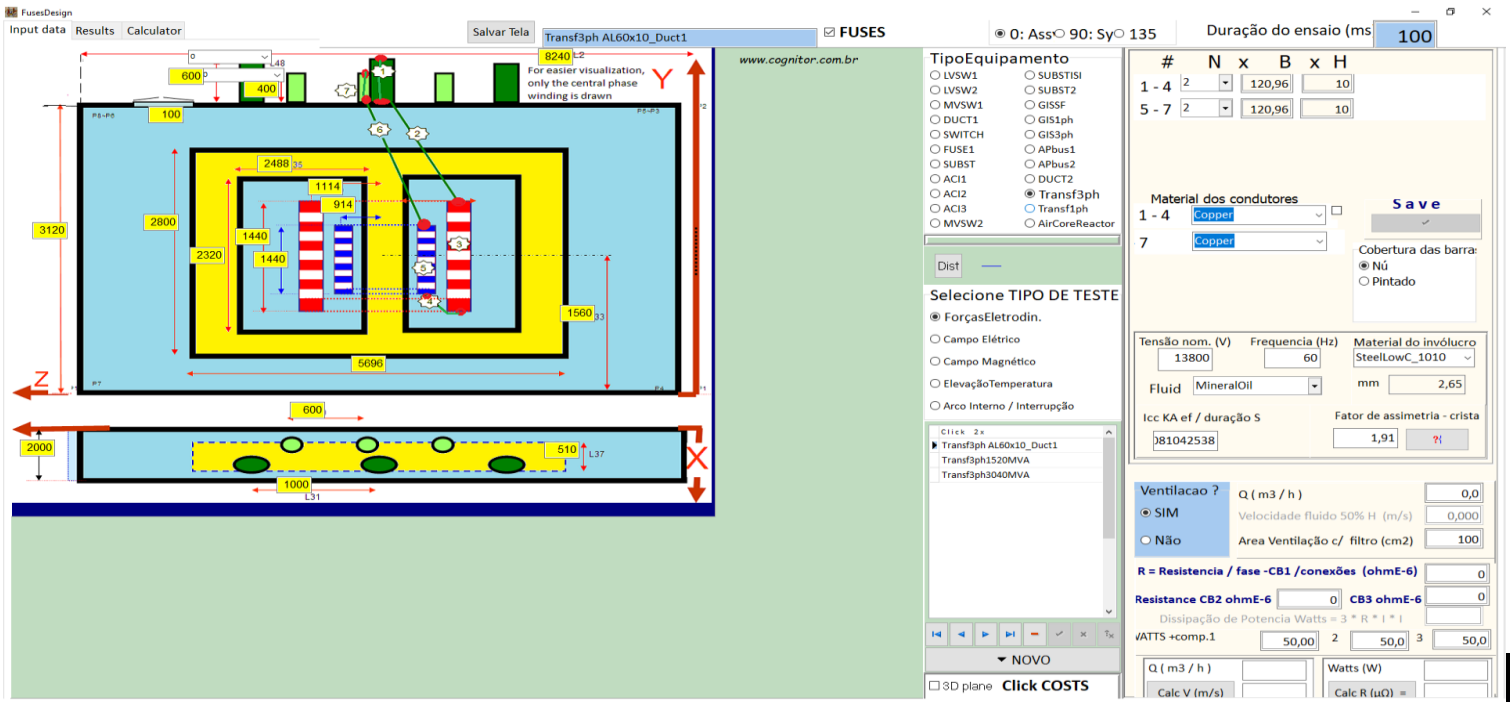
POWER TRANSFORMERS & REACTORS: TESTING SIMULATIONS OF ELECTROMECHANICAL FORCES & STRESSES, TEMPERATURE RISE and OVERPRESSURES OF INTERNAL ARC.



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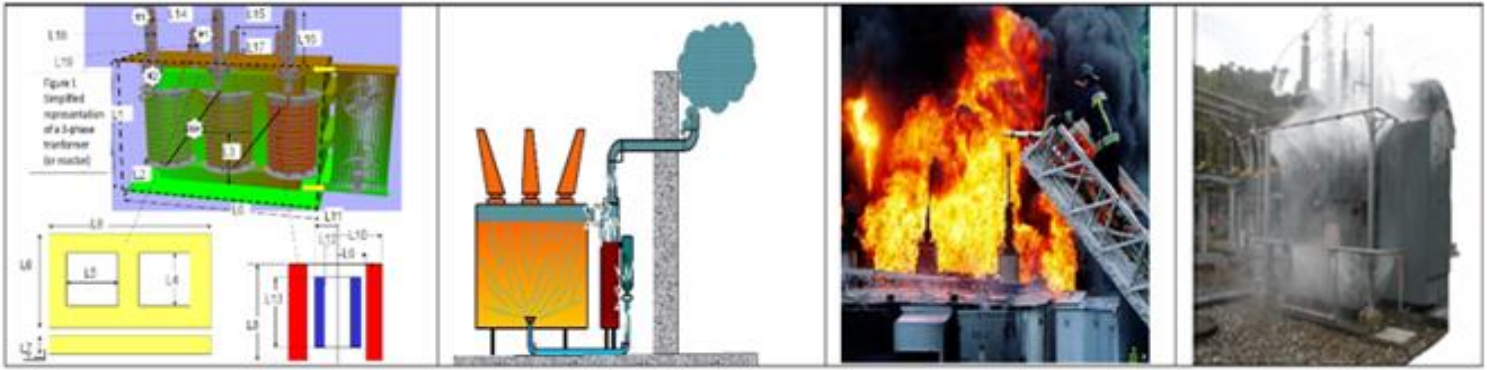
Read the article

kG/MVA : Research Centre on Environmental Efficiency of Electric Products

AVOIDING EXPLOSIONS & FIRES in POWER TRANSFORMERS & REACTORS

Why the only worldwide technical standard with a test for internal arc faults and depressurization systems, the Brazilian NBR_8222 (2005) - Protection systems by depressurization ……. was canceled in 2014 ?

An improved text of an **INTERNAL ARC TEST** with depressurization, for IEC



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Read the article and a complete draft of an IEC standard

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The **remaining big testing labs will not survive thinking that "everything must be tested"** .

They were created to grow the electric industry of entire countries and not to make small short-term profits because are a low R.O.I. to investors.

Could give support to manufacturers of + efficient products. This do not conflict with being 3rd part.

Check this video of years ago. It is more update than before (link above).

100 LinkedIn posts for the **electric power industry** R&D

sergiofeitozacosta@gmail.com www.cognitor.com.br By Sergio Feitoza Costa

Here is the end of the technical posts.
In the site www.cognitor.com.br there is more material including songs and fiction books written by me.
To be an engineer is much easier than to work with non-technical things .

Thank you and hope it is useful to you

By Sergio Feitoza Costa

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"AUTOMATION", "VP" and "MANAGER" are not GOOD FISHING BAITS

- Nowadays, to demonstrate competence, professionals use these words in profiles. Seems there are only managers & directors in the market
- I am 67 y.o. and learned that the only way for the professional success is to know the concepts of what you do and to work hard.
- 45 years ago, as a young high-power testing engineer, I helped to replace the measuring system coaxial cables by optical fibers in the labs. Was one of the first and after, we automated some things. I think, after 4 decades that creativity & knowledge of the teams went backwards.
- **So, young friends, forget titles. Just show that you are a serious dedicated worker . Recruiters are smart and value this much more.**

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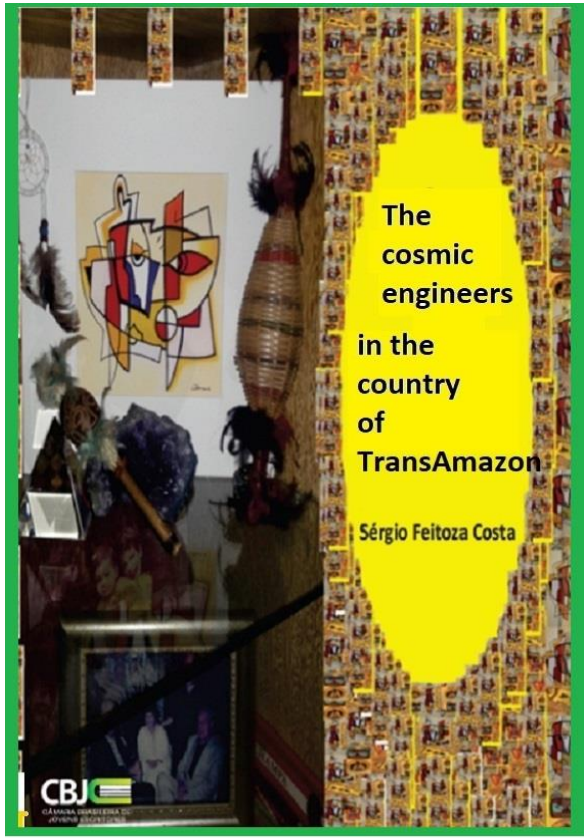

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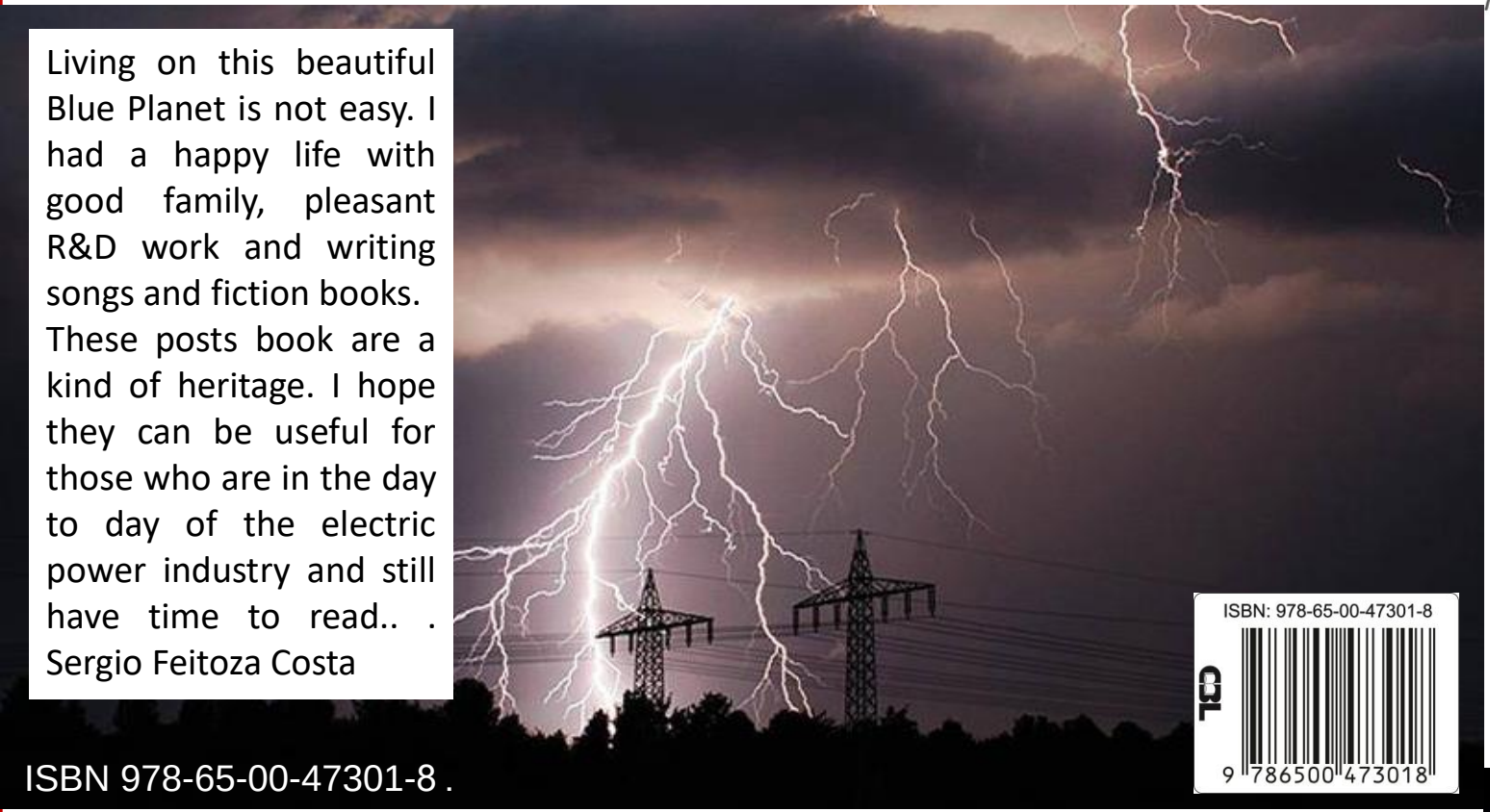

Living on this beautiful Blue Planet is not easy. I had a happy life with good family, pleasant R&D work and writing songs and fiction books.
These posts book are a kind of heritage. I hope they can be useful for those who are in the day to day of the electric power industry and still have time to read.. .
Sergio Feitoza Costa

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