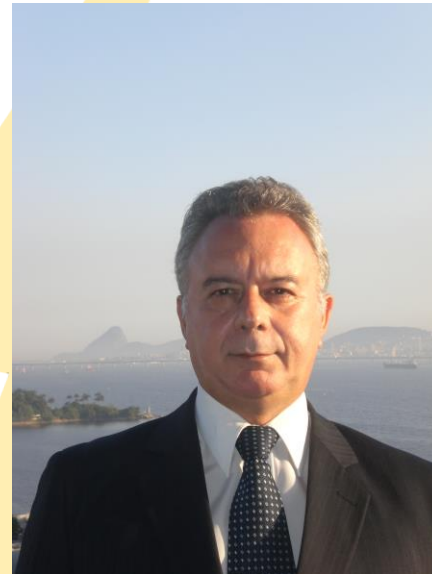


# DESIGN CONCEPTS + software SwitchgearDesign for SWITCHGEAR, SWITCHBOARDS, BUSDUCTS & SUBSTATIONS"



Item 1:

Contents of the  
complete training  
&  
CV of the lecturer



- Design & management of testing laboratories: high power, high voltage, temperature rise & other
  - 25 years: designer, test engineer, researcher and general manager of 14 CEPEL testing laboratories
  - Consultant for implantation of the new Brazilian testing labs under construction in 2016 at Itajubá - MG (ISI – CEDIIEE, SENAI, FIEMG – MG). High Power 2500 MVA , High Voltage 500/765 KV class
- 16 years: Design of medium and low voltage switchboards, switchgear, busways(attending > 30 companies)
- WG A3.24 CIGRÉ International - Simulations and Engineering Tools for Internal Arc Tests (member)
  - Coauthor brochure CIGRE 602 / 2014 Simulation of The Effects Of the Internal Arc in T&D Switchgear.
- WG A3.36 CIGRÉ International - Simulations & Engineering Tools for Temperature Rise Calculation (member)
- IEC SC 17 C / WG31: coauthor of IEC 62271-307 (2015): : Guidance for the extension of validity of type tests of ac metal-enclosed switchgear and controlgear
- Chairman (1990-1994) Technical Committee 32 - IEC - International Electrotechnical Commission ( Fuses).
- Coordinator of Forum LinkedIn Switchgear, Substations & Superconductivity



**e**nergia  
INGENIERIA ENERGÉTICA Y MEDIOAMBIENTAL  
No. 220 - ENERO/FEBRERO 2010 - AÑO XXXVI  
SEGURFOC 381  
El más seguro y flexible en caso de incendio.  
General Cable

**Simulação de ensaios em painéis e barramentos: metodologia e validação**  
Este artigo apresenta uma técnica de simulação de ensaios de arco interno... Engenharia Sergio Feitoza Costa, da Cognitor

**Celdas, cuadros, canalizaciones y conexiones eléctricas**  
Algo falta en las normas IEC y en las especificaciones de usuarios  
calidad eléctrica

**602**  
Tools for the Simulation of the Effects of the Internal Arc in Transmission and Distribution Switchgear  
Working Group A3.24  
December 2014  
cigre

**o setor elétrico**  
Mercados de T&D faturam, cada um, mais de R\$ 300 milhões por ano... Qualidade de energia

**Painéis, cuadros, barramentos e seus componentes: falta algo nas normas IEC**  
Estudo sugere que normalização permita que técnicos de simulação sejam utilizados como ferramenta auxiliar para a verificação de resultados

**EM ELETRICIDADE MODERNA**  
OS AVANÇOS E AS TENDÊNCIAS DA TECNOLOGIA ELETOELETRÔNICA  
December 2014  
cigre





# In this video

- Topics of the complete course (parts may be obtained separately).
- Focus on:
  - manufacturers of equipment for high / low voltage substations
  - experts working in certification and testing laboratories.
  - engineering concepts required for a good design.
  - How to use the software SwitchgearDesign



## SPECIFICATION OF CURRENTS AND VOLTAGES IN NEW SUBSTATIONS

- Load flow studies
- Short circuit studies
- Software ATP / ATPDRAW

(definition of normal currents).  
 ( short circuit currents and durations)  
 (concepts)

The screenshot shows the ATPDRAW interface with a circuit diagram. A 13.8 kV source is connected to a series RLC circuit. The circuit includes a capacitor (Capac), a resistor (R), and an inductor (L). A disjunct (breaker) is placed in the line. A 5 MVar capacitor is connected to ground. Data tables are visible for component parameters:

DATA	VALUE
R	0.1
L	0.1992
C	0

DATA	VALUE
R	0
L	38.088
C	0

Another table shows breaker parameters:

DATA	VALUE
T-cl	0
T-op	0.001
Imar	10

The circuit diagram is labeled with '13,8 kV', '1 Xeq', '2', 'Disjunt', and '5 MVar'. A small plot at the bottom right shows a current waveform.

C:\0\_CD\_Conceitos\Curso\_2012\_SW\_SE\CD\_ATP\_CBUE\ Exercicios\Abertura\_Reator\Project\reator.adp

The plot shows a multi-frequency waveform over a 30 ms interval. The y-axis ranges from -200 to 300. The plot title is 'MC's PlotXY plot'. The x-axis is labeled '[ms]'.

C:\0\_CD\_Conceitos\Curso\_2012\_SW\_SE\CD\_ATP\_CBUE\ Exercicios\Abertura\_Reator\Project\trt.ADP

DATA	VALUE
R	0.1
L	1
C	0

DATA	VALUE
T-cl	
T-op	
Imar	

The diagram shows a power network with several buses and lines. Power flows are indicated by arrows. Key data points include:

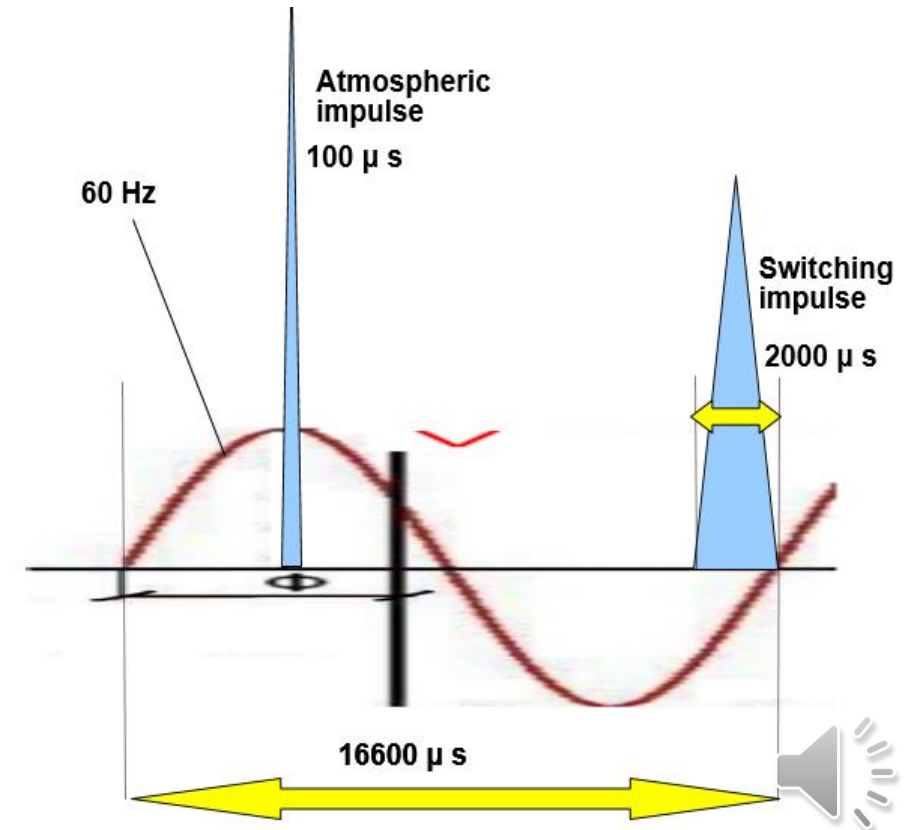
- 106 MW AGC ON
- 110 MW 40 Mvar
- 80 MW 30 Mvar
- 94 MW AGC ON
- 130 MW 40 Mvar
- 200 MW 0 Mvar
- 108 MW OFF AGC
- 100 MW 0 Mvar

Costs are also shown:

- Case Hourly Cost: 16930 R\$/hr
- Top Area Cost: 8026 R\$/hr

## OVERVOLTAGES AND INSULATION COORDINATION

- Transients and insulation coordination.
- Techniques to reduce over voltages (synchronizers, resistors, surge arresters)
- Selection of levels of withstand voltages (industrial frequency & impulse )
- Dielectric tests (impulse, AC, corona, RIV, ...)
- Electric fields and distances in installations

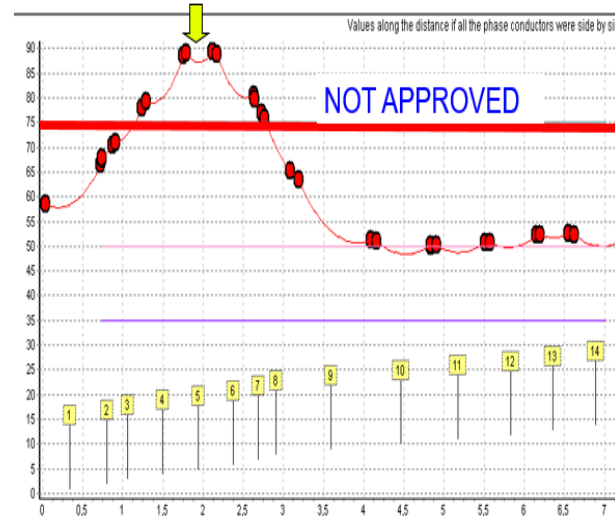


# SHORT CIRCUITS, OVERLOADS AND AMPACITIES

- Electrical contacts and temperature rise
- Reduction of lifetime, supportability of materials to temperatures
- Ventilation and contact resistances
- Overloads in power transformers
- Temperature rise tests

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: 35 - in SF6: 50 - in oil: 40		
	Tinned in air, SF6 or oil	50		
	Silver or niquel plated	- in air: 65 - in oil: 50		
	For contactors in oil		105	Oil deterioration
BOLTED CONTACT	Copper, aluminum and alloys uncoated	in air: 50 in SF6: 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		90 / 105 / 120 30 / 155 / 180	Isolation ageing
	<ul style="list-style-type: none"> <li>• Y / A / E</li> <li>• B / F / H</li> <li>• Acting as spring</li> <li>• In soldering position</li> </ul>		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

Total resistance per phase (circuit breaker + busbar + connections) = 72 μΩ  
Circuit breaker resistance per phase = 30 μΩ



CONTACT RESISTANCE

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

Force = 100 N

$$a = \sqrt{\frac{100}{18 \cdot \pi \cdot (0.45) \cdot (5.5 \times 10^8)}} = 8.5 \times 10^{-6} \text{ m}$$

$$n = 2.5 \times 10^{-5} \times (5.5 \times 10^8)^{0.625} \times 100^{0.2} = 18.2 = 18$$

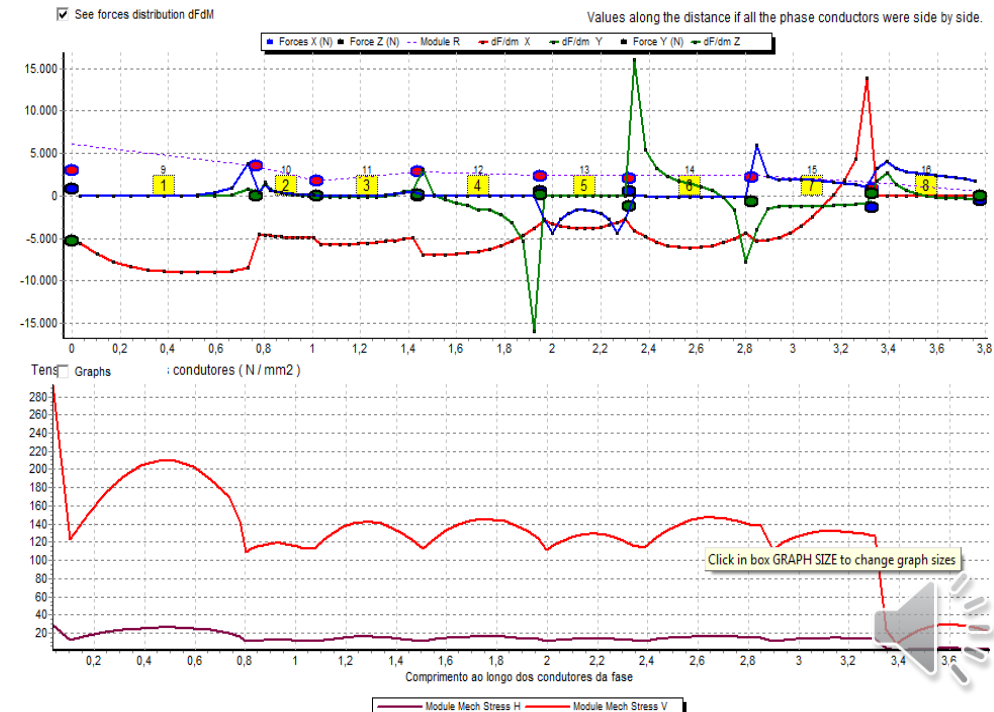
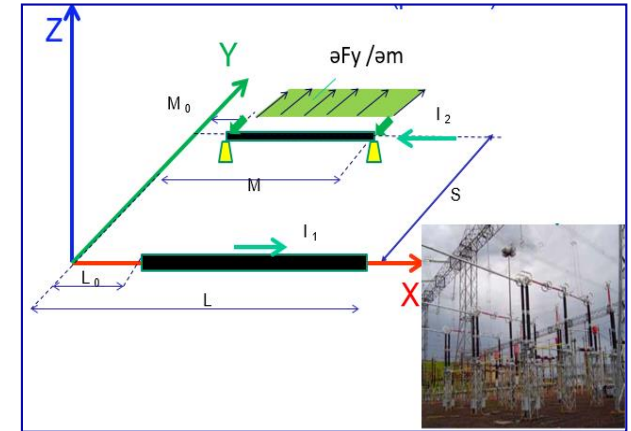
$$\rho = 1.78 \times 10^{-8} \text{ } \Omega \cdot \text{m}$$

$$\sigma_0 = 5 \times 10^{-12} \text{ } \Omega \cdot \text{m}^2$$

$$R_c = 6 + 12 = 18 \text{ } \mu\Omega$$

# SHORT CIRCUITS, OVERLOADS AND AMPACITIES

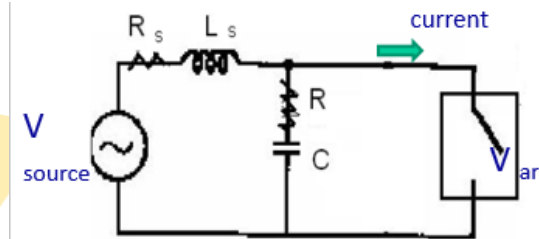
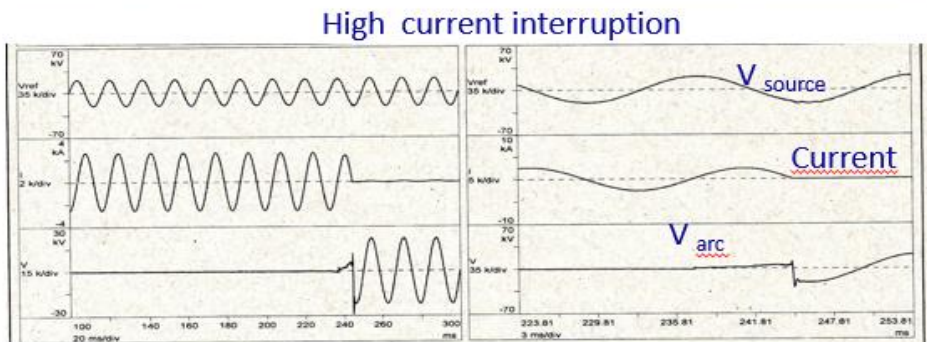
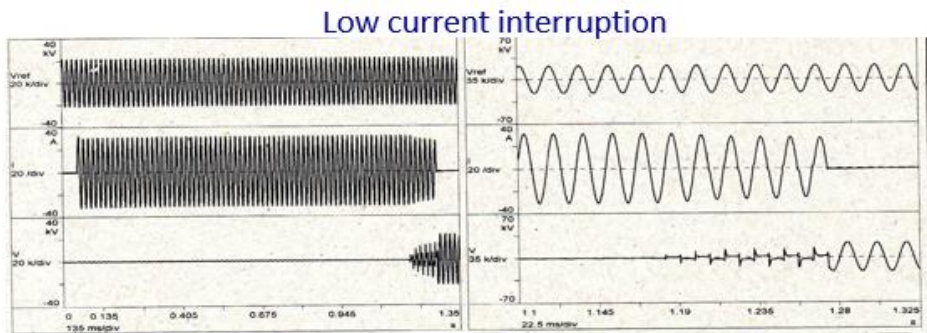
- Electrodynamical forces and mechanical stresses during short circuits
- Calculating and assessing supportability.
- Limit values for insulators and conductors.
- Short-time withstand & peak currents test
- Magnetic induction





# TRANSIENT RECOVERY VOLTAGES AND SWITCHING PROCESSES

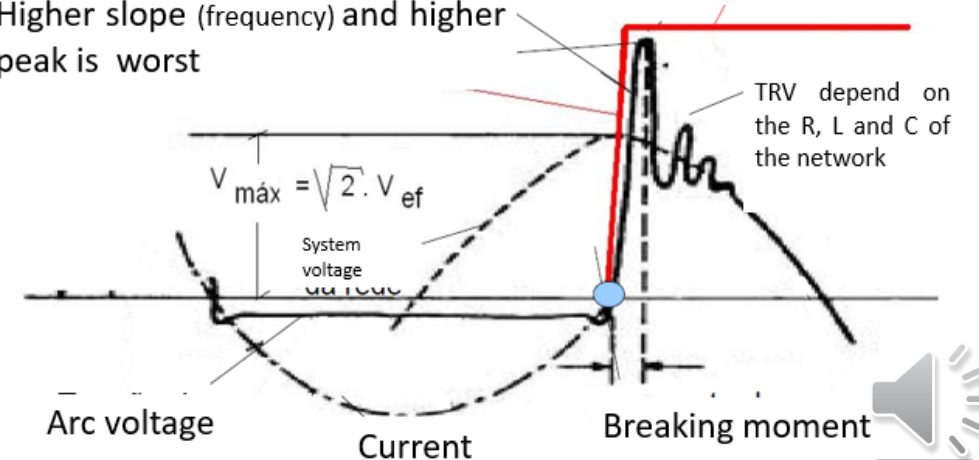
- Technologies: circuit breakers, switches, fuses (current limiting and expulsion)
- Breaking Tests



CURRENT INTERRUPTION IN  
CIRCUIT BREAKERS, FUSES  
AND SWITCHES

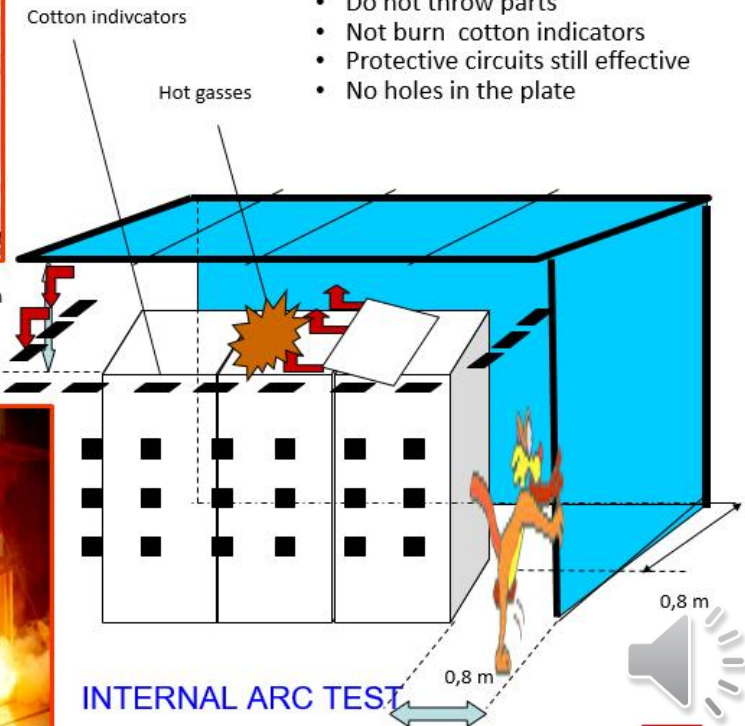
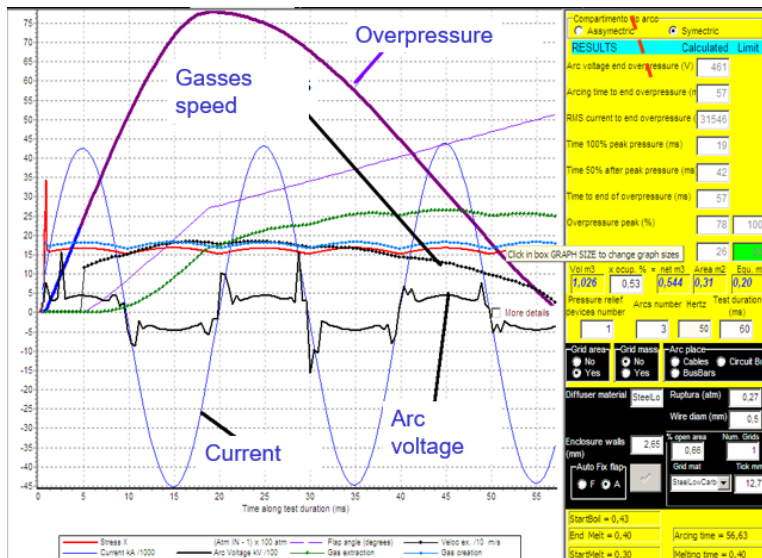
Cold characteristic of the  
circuit breaker above  
TRT

Higher slope (frequency) and higher  
peak is worst



## POWER ARCS AND SAFETY OF PERSONS AND INSTALATIONS

- Internal arc in switchgear (medium and low voltage).
- Technologies to control the effects of arc , overpressure curve, supportability
- Aspects of explosions and fires in transformers.
- Arcs in insulators strings and tests



- Doors should not open
- Do not throw parts
- Not burn cotton indicators
- Protective circuits still effective
- No holes in the plate

## SWITCHGEAR AND CONTROLGEAR TECHNICAL STANDARDS (HV)

- IEC 62271-200 (medium voltage)
- IEC 62271-307 - Parte 307: extension of the validity of type test reports (standard in preparation – Sergio is member of the IEC working group preparing the standard)
- IEC 62271-1 (common clauses), IEC 62271-100 (circuit breakers),
- Others: IEC 60282-2 (expulsion type fuses), IEC 60076 (Power transformers).

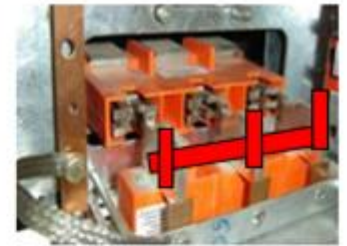
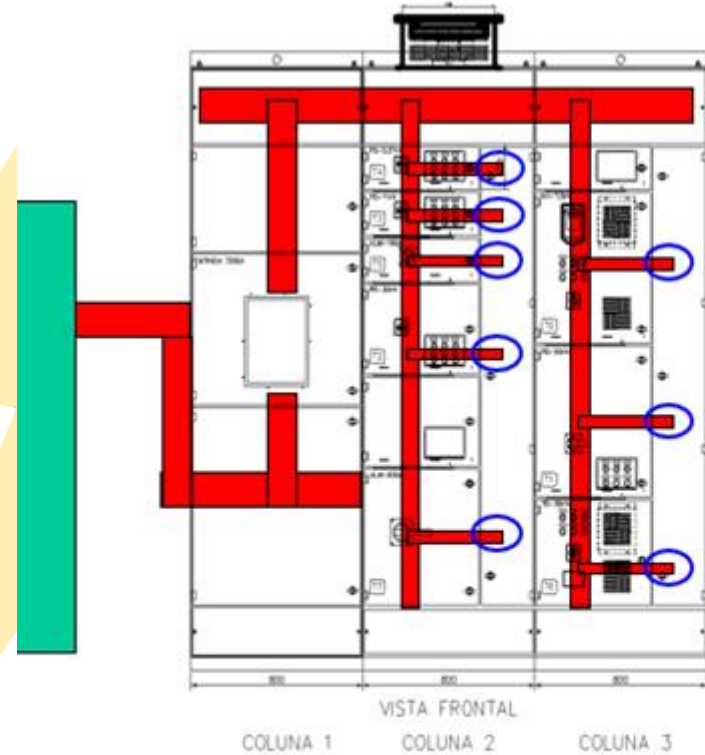




# SWITCHGEAR AND CONTROLGEAR TECHNICAL STANDARDS (LV)

IEC 61439 (low voltage)

- Planning the use of the design rules of IEC 61439.



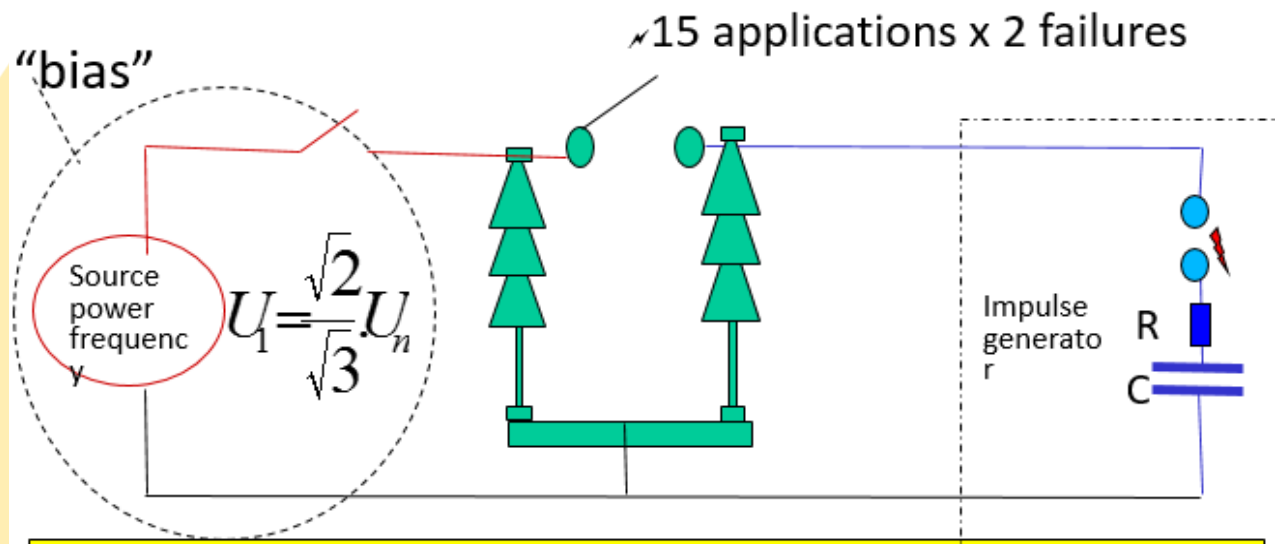
65kA – 380V – 60Hz



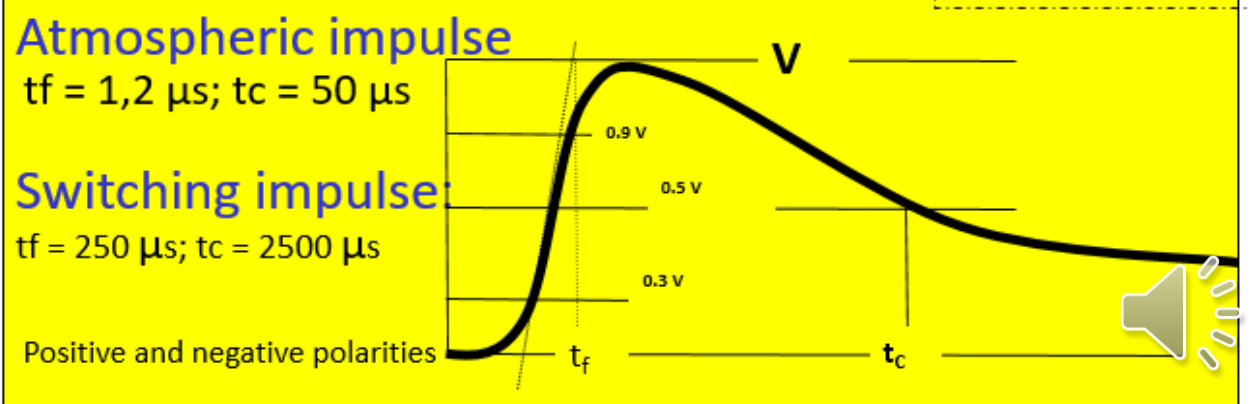


# TECHNICAL SPECIFICATIONS OF T&D EQUIPMENT

- The most efficient specification is the IEC Standard
- High voltage switches and isolators
- Circuit - breakers
- Surge arresters
- Power transformers and reactors

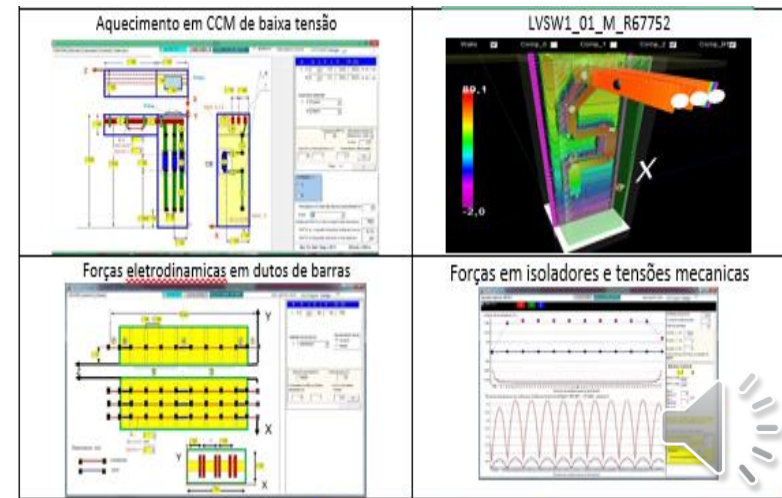
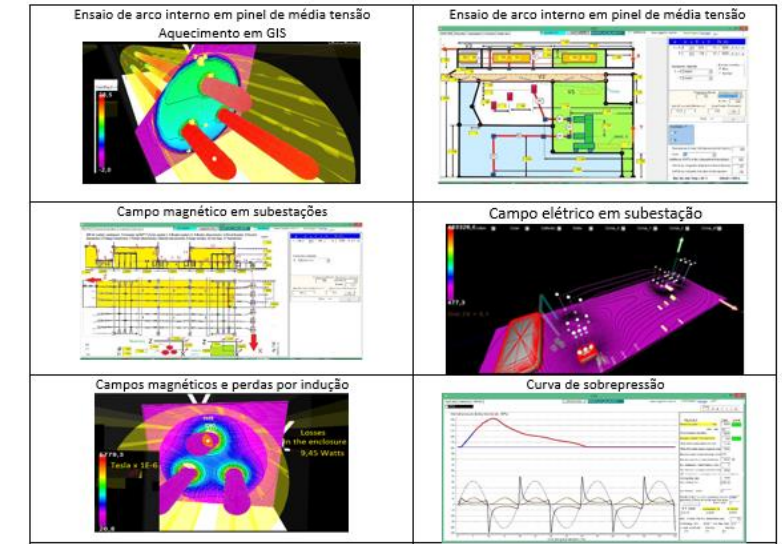


Dados técnicos		Requisito
Tensão nominal	Tensão nominal (fase-fase)	230 KV rms
	Maxima tensão de operação contínua (F-F)	242 KV rms
Frequencia	Tensão nominal	60 Hz
Níveis de isolamento	Tensão suportável à frequência nominal	Fechada à terra 395 kV Contatos abertos: 460kV
	Tensão suportável de impulso	Fechada à terra 950 kVcr Contatos abertos: 950 kVcr + 140kV 1min – 60Hz
	Tensão suportável frequência nominal (circuitos controle)	3 kV
Numero de polos		3
Corrente nominal	Corrente nominal	2000 Arms
Curto circuito	Corrente suportável de curta duração e de crista	40 kArms durante 3s / 100 kAcr
RIV	Tensão de rádio interferencia	500 µV
Corona	Mínima tensão de inicio e de extinção	154 KVrms



# Software SWITCHGEAR\_DESIGN (use and case studies / benchmark)

- State of the art of the use of simulations to replace tests
- Simulation of short-time withstand current and peak tests (electro dynamical forces, mechanical stresses )
- Simulation of temperature rise / heating tests (calculations and how to optimize the design)
- Simulation of internal arc tests (overpressures, burn-through and supportability)
- Case studies with the software ( LV and MV switchgear)
- Mapping of magnetic & electric fields



End