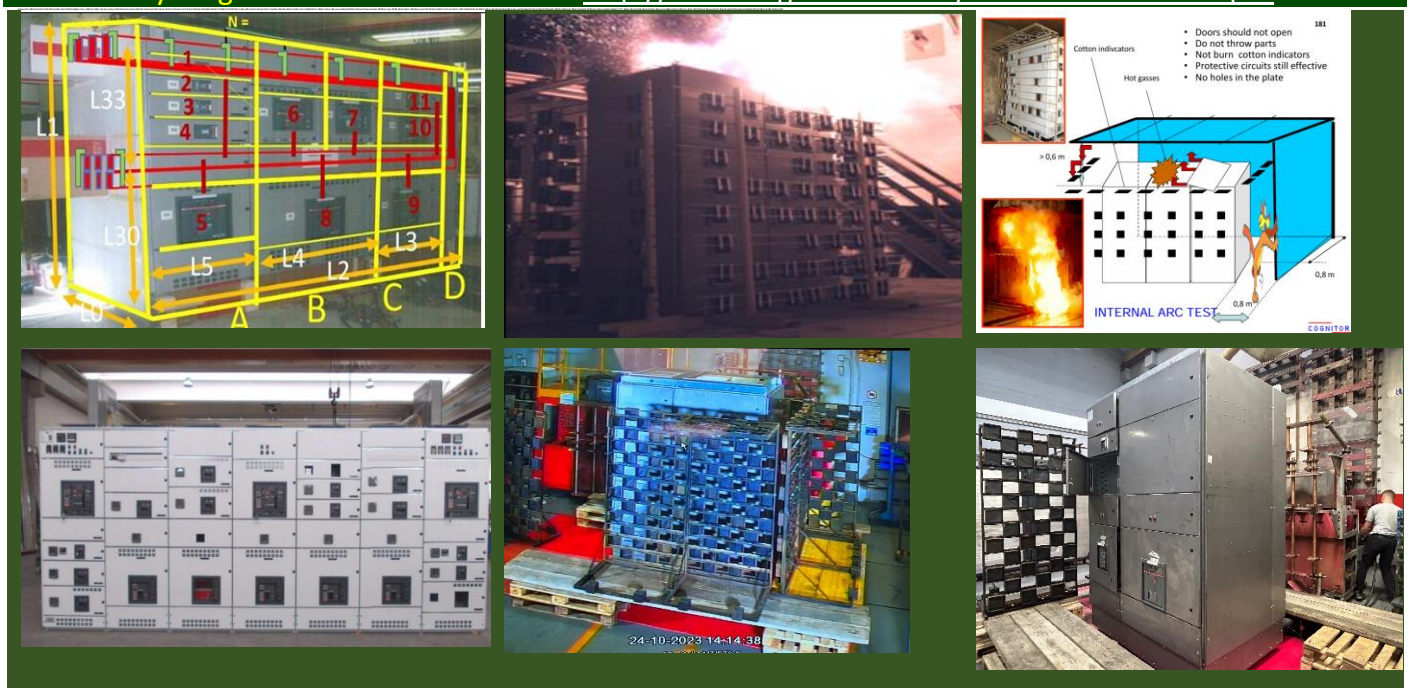
Internal arc in LV switchgear

test of IEC TR 61641 should become type test

with ceiling + indicators for the head of operators (and as IEC62271-307)

By Sergio Feitoza Costa http://www.cognitor.com.br/LVinternalArcGuide.pdf



1. **WHY INTERNAL ARC TESTS IN LV ELECTRIC PANELS HIGHER THAN 20 KArms ARE A DANGEROUS EVENT (an installation guide is missing)**

Low voltage switchgear panels with short circuit currents above 20 kAef can release considerable amounts of energy during the dangerous internal arcing events. When the current level reaches values of the order of 80 to 100 kAef, the energies involved are of the order of magnitude of what occurs in 13.8kV – 16kA systems found in power utilities.

Therefore, installations of this type of LV panels also require care regarding distances and accessibility, as is carefully done in medium voltage in IEC62271-200 and IEC62271-307. In medium voltage installations, distances are well defined in IAC tests and their distances from panels to walls and ceilings. So, when proposing an installation to the future user of the panel, the manufacturer is supported by indications written in an international technical standard.

For low voltage panels the internal arc test follows the same principles, of MV electric panels but the aspects of a proper installation are not adequately covered. The main reason is that is that **the internal arc test prescribed in IEC TR 61641 is done without simulating the control room ceiling and placing horizontal cotto**n indicators that simulate the heads of operators close to the walls.

The burning of the horizontal indicators is the main reason of failures in the internal arc tests of electric panels. This is explained in the CIGRÈ Brochure 602: … Effects of the Internal Arc in T&D Switchgear, mentioned in the References, below. I am coauthor of this document and assure you that is a must for switchgear designers.

These video of successful low voltage internal arc tests that the equipment passed makes it easy to understand the risks involved. https://www.cognitor.com.br/LVinternalarctest.avi

Cell phone. 55-21-9 88874600
E-mail: sergiofeitozacosta@gmail.com Site: http://www.cognitor.com.br

IEC Technical Report 61641 (2014) – "Enclosed low-voltage switchgear and controlgear assemblies - Guide for testing under conditions of arcing due to internal fault "gives guidance on the method of testing of LV switchgear (IEC61439-1/2) under conditions of arcing in air due to an internal fault. The objective is to assess the ability to limit the risk of personal injury, damage of equipment and suitability for further service after an internal arc. It includes aspects like:

- Classes defining different forms of protection provided against arcing faults;
- Differences between (a) personnel protection, (b) damage restricted to part of the switchgear, and (c) switchgear suitability for limited service. After an internal arc;
- Cover two levels of personnel protection; (d) for panels installed in areas where access is restricted to skilled persons, and (e) installation in areas accessible to ordinary persons;
- Accessibility from front, back and sides of an assembly;
- Minimum performance requirements for arc ignition protected zone.

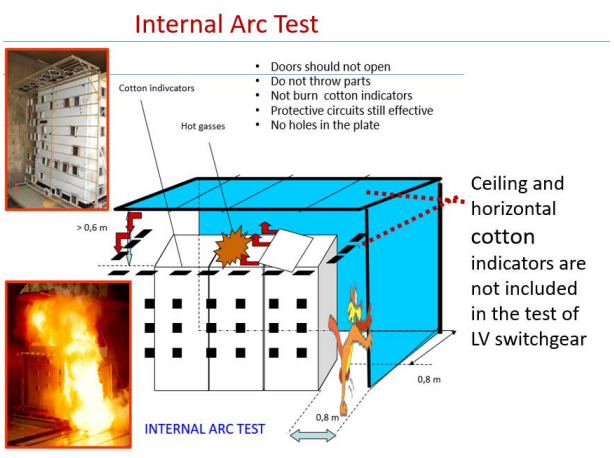
The options for classification are like presented in this table and use the criteria defined in 8.7. of the TR. Notice that classes increase by adding more criteria to attend. Nothing is said about the level of current related to the "Unrestricted access" .

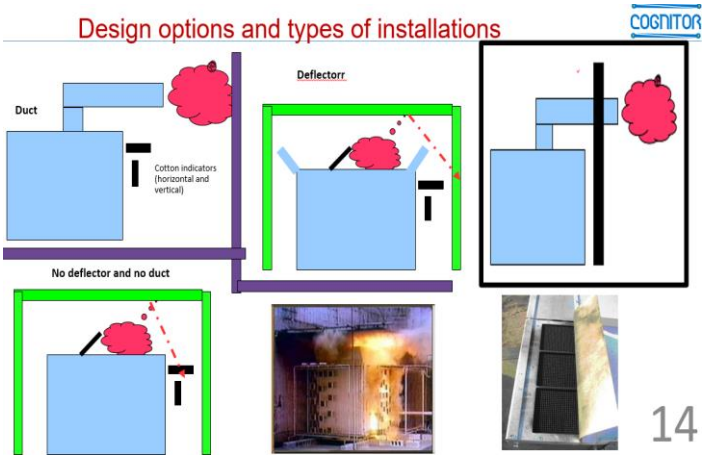
Classes for assemblies tested according to TR61641	**Arcing class A:** personnel protection. (Criteria 1 to 5)	Less or different criteria may apply if there is an agreement between the user and the manufacturer
	Arcing class B: personnel protection plus arcing restricted to a defined area within the ASSEMBLY. (Criteria 1 to 6)	
	Arcing class C: personnel protection plus arcing restricted to a defined area within the ASSEMBLY. Limited operation after the fault is possible. (Criteria 1 to 7)	
	Arcing class I: ASSEMBLY providing protection be means of arc ignition protected zones.	
Access	**Restricted** (default).	Only authorized (skilled) persons have access
	Unrestricted	Accessible to all including ordinary persons

- **CRITERIA 1)** Correctly secured doors and covers do not open and remain effectively in place and provide a minimum level of protection in accordance with the requirements of IP1X of IEC 60529. Deformations are accepted. Some breakage of a limited number of fastenings and hinges is acceptable. Does not need to comply with its IP code after the test. It aims to minimize the risk of severe injury to persons by impact from doors, covers etc. and ensure a minimum level of protection of persons against accidental contact with hazardous live parts.
- **CRITERIA 2)** No parts are ejected which have a mass of more than 60 g except those which are dislodged and fall between the enclosure and the indicators. This minimize the risk of severe injury to persons by impact.
- **CRITERIA 3)** Arcing does not cause holes to develop in the external parts of the enclosure below 2 m, at the sides declared to be accessible as a result of burning. This minimize the risk of severe injury to persons by direct burning.
- **CRITERIA 4)** The indicators – that simulate the skin of a person nearby - do not ignite (indicators ignited as a result of paint or stickers burning are excluded from this assessment);
- **CRITERIA 5)** The protective circuit for accessible part of the enclosure is still effective according to IEC 61439-2.
- **CRITERIA 6)** The assembly is capable of confining the arc to the defined area where it was initiated, and there is no propagation of the arc to other areas within the assembly. Effects of hot gases and sooting to adjacent units other than the unit under test are acceptable, as long as only cleaning is necessary.
- **CRITERIA 7)** After clearing the fault or after isolation or disassembly of the affected functional units in the defined area, emergency operation of the remaining assembly is possible. This is verified by a dielectric test but with a test voltage of 1,5 times the rated operational voltage for 1 min.

2. PRINCIPLES FOR AN INSTALLATION GUIDE FOR LOW VOLTAGE PANELS, IN RESPECT TO THE POSSIBILITIES OF INTERNAL ARC OCURRENCES

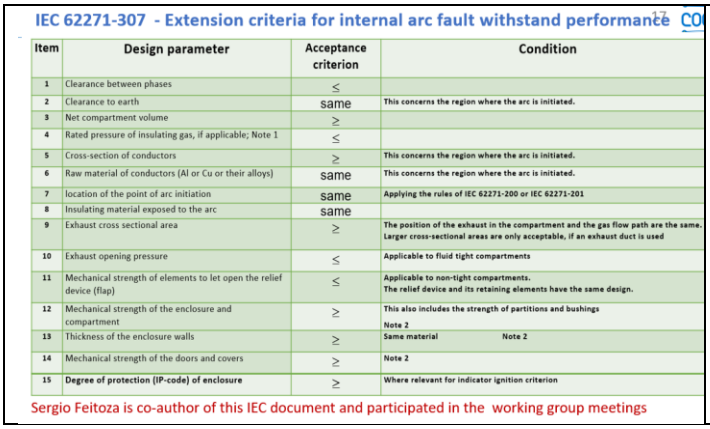
We will refer the reasoning to the figures to follow showing, in the left side, a switchgear and someone near it when an internal arc occurs. In the right side we see the arrangements which are used for MV switchgear.
For medium voltage the use of ducts only is necessary for currents higher than some 35 kAef or when the user of the switchgear was intelligent enough to plan a neighbour gasses scape area at the side of the internal closed switchgear place. For currents lower than some31,5 kA the AIS foldable plates are usually sufficient.

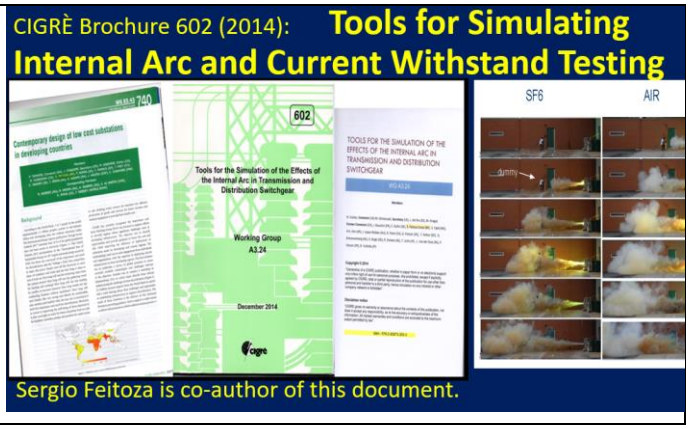




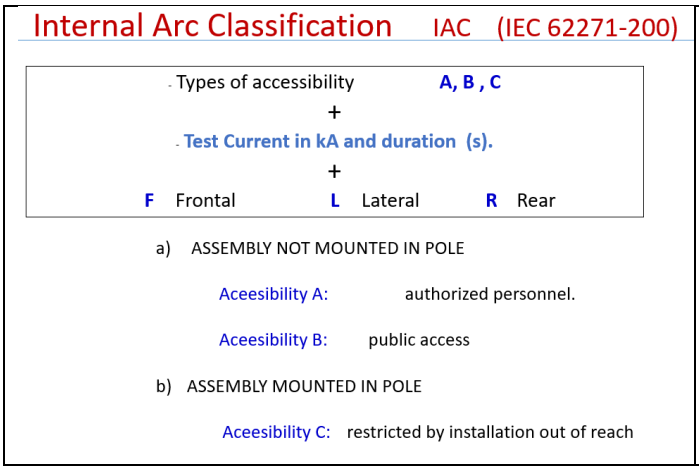
Check these videos showing an operation with these alternatives https://www.cognitor.com.br/internalarc.mp4

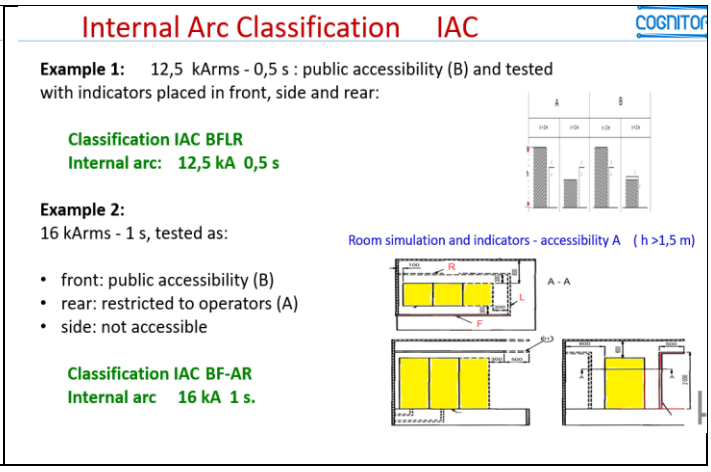
For whom wants to go deeper in the aspects of installation it is recommended to read the Section xxx of the Brochure Cigrè 602 - Simulation of The Effects of the Internal Arc in T&D Switchgear, It is the more complete document in the World. Also read the Section about Internal arc in the IEC62271-307. Check References below.





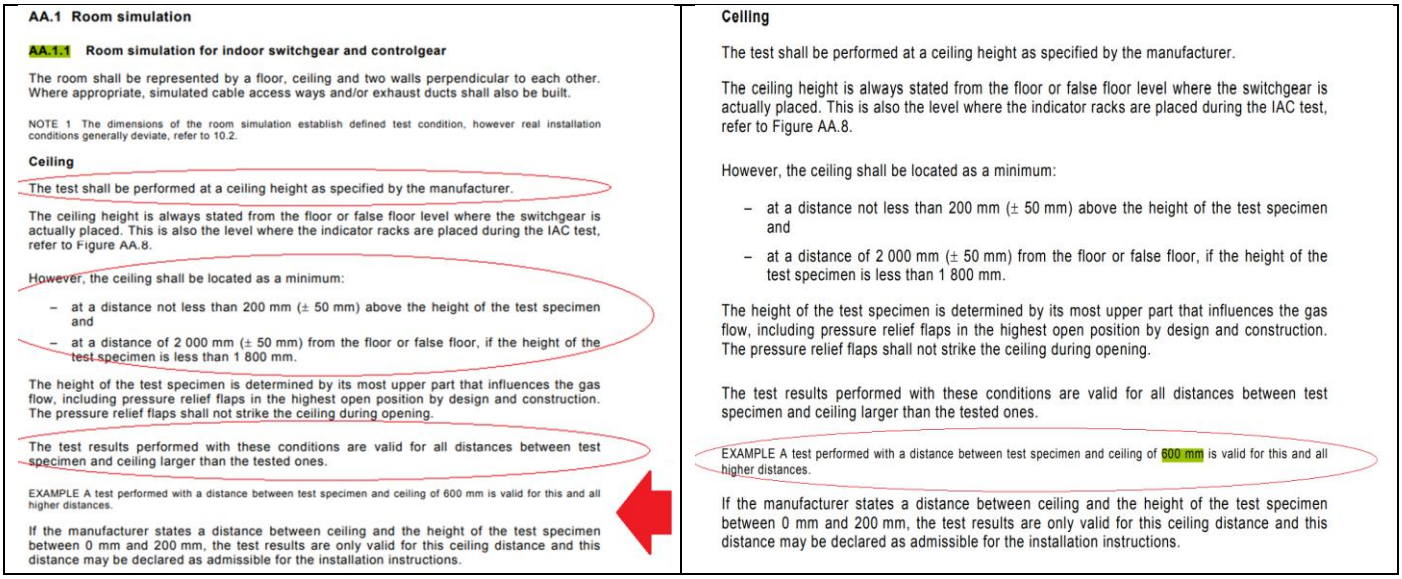
To enable comparisons related to the installation of low voltage switchgear and the distances related to internal arc I suggest using the approaches of IEC62271-200. The arrangements of cotton indicators and the concepts related to distances to ceilings and walls are well detailed there.





I would highlight specially the aspects mentioned in the sections AA.1 of IEC 62271-200

Cell phone. 55-21-9 88874600
E-mail: sergiofeitozacosta@gmail.com Site: http://www.cognitor.com.br



AA.1 Room simulation

AA.1.1 Room simulation for indoor switchgear and controlgear

The room shall be represented by a floor, ceiling and two walls perpendicular to each other. Where appropriate, simulated cable access ways and/or exhaust ducts shall also be built.

NOTE 1 The dimensions of the room simulation establish defined test condition, however real installation conditions generally deviate, refer to 10.2.

Ceiling

The test shall be performed at a ceiling height as specified by the manufacturer.

The ceiling height is always stated from the floor or false floor level where the switchgear is actually placed. This is also the level where the indicator racks are placed during the IAC test, refer to Figure AA.8.

However, the ceiling shall be located as a minimum:

- at a distance not less than 200 mm (± 50 mm) above the height of the test specimen and
- at a distance of 2 000 mm (± 50 mm) from the floor or false floor, if the height of the test specimen is less than 1 800 mm.

The height of the test specimen is determined by its most upper part that influences the gas flow, including pressure relief flaps in the highest open position by design and construction. The pressure relief flaps shall not strike the ceiling during opening.

The test results performed with these conditions are valid for all distances between test specimen and ceiling larger than the tested ones.

EXAMPLE A test performed with a distance between test specimen and ceiling of 600 mm is valid for this and all higher distances.

If the manufacturer states a distance between ceiling and the height of the test specimen between 0 mm and 200 mm, the test results are only valid for this ceiling distance and this distance may be declared as admissible for the installation instructions.

Ceiling

The test shall be performed at a ceiling height as specified by the manufacturer.

The ceiling height is always stated from the floor or false floor level where the switchgear is actually placed. This is also the level where the indicator racks are placed during the IAC test, refer to Figure AA.8.

However, the ceiling shall be located as a minimum:

- at a distance not less than 200 mm (± 50 mm) above the height of the test specimen and
- at a distance of 2 000 mm (± 50 mm) from the floor or false floor, if the height of the test specimen is less than 1 800 mm.

The height of the test specimen is determined by its most upper part that influences the gas flow, including pressure relief flaps in the highest open position by design and construction. The pressure relief flaps shall not strike the ceiling during opening.

The test results performed with these conditions are valid for all distances between test specimen and ceiling larger than the tested ones.

EXAMPLE A test performed with a distance between test specimen and ceiling of 600 mm is valid for this and all higher distances.

If the manufacturer states a distance between ceiling and the height of the test specimen between 0 mm and 200 mm, the test results are only valid for this ceiling distance and this distance may be declared as admissible for the installation instructions.

3. INSTALLATION CONDITIONS INSTRUCTIONS X TEST REPORTS

For the installation conditions it is very important to consider what is written in the test reports. There are test reports that omit many relevant information. If you want to know what is really relevant to register in the test report just check the tables for internal arc test of IEC62271-307. Each one of the rules associated to that IEC Technical Report is based in one or more explicit design and / or installation rues.

The more relevant aspects are like:

a) arrangement and positioning of cotton indicators, ceiling and walls
b) value of the a.c (or dc) current (rms and peak value)
c) applied voltage. For LV switchgear is at least the rated voltage. For MV switchgear may be lower than the rated but sufficient to maintain a sinusoidal current along the test;
d) duration of the test (td) and Joule integral;
e) total burning duration of the arc
f) oscillograms showing currents, voltages and overpressures;
g) If there is ventilation in the switchgear enclosure explain or photo details of the dispositives to block the exit of hot gasses.
h) Assessment of the test results including clear statements in case of indicators burned by hot gasses (and not by glowing particles). To declare that the performance is "satisfactory," require that the condition of "non-inflammation of the indicators due to the effect of hot gases" must be met. Sometimes it can be almost impossible to determine if burning symptoms are the result of blazing particles or hot gasses. The IEC standard states that "hot gases should not cause the indicators to ignite." In the event that they burn during the test, and it is proven that the glowing particles, not the hot gases, triggered the ignition, the evaluation criterion can be deemed satisfactory. The lab shall use images captured by high-speed cameras, video, or other means to determine. In case of doubt or if the laboratory failed in provide this, as I saw before in a test, I understand that shall be considered “passed”. Attention because some labs do not like to recognize errors even if the client is paying a lot of money to do the test.

4. FINAL COMMENTS

If I had to write an installation guide that manufacturers of LV switchgear should provide to users I would specify something like “Do as in the specifications of the IEC62271-200 for the internal arc tests (Annex AA) ”. This would be possible only if the LV internal arc tests was dome using the “head” horizontal cotton indicators and a distance higher or equal the one used in the test.

When I started to write this article, my intention was to write a complete “installation instructions guide for LV switchgear internal arc aspects”. When writing I understood that it would not make sense to repeat something which is already very complete in IEC62271-200 complemented by IEC62271-307.

So, my suggestion for whom wants to write a formal document with this purpose is to make it short referring to these two IEC documents and to the part of IEC TR 61641 related to the classifications.

// END OF THE ARTICLE //////////////////////////////////////

Cell phone. 55-21-9 88874600
E-mail: sergiofeitozacosta@gmail.com Site: http://www.cognitor.com.br

REFERENCES

[1] **CIGRÈ BROCHURE 602 (2014)** Tools for Simulation of The Effects of the Internal Arc in T&D Switchgear,

[2] **CIGRÈ BROCHURE 740 (2018)** Contemporary design of **low-cost** substations in developing countries.

[3] **CIGRÈ BROCHURE 830 (2021)** – "SIMULATIONS FOR TEMPERATURE RISE CALCULATION". (Sergio Feitoza Costa is co-author)

[4] **An article explaining IEC62271-307 (2015)** about extension of the validity of type tests in IEC62271-200 switchgear to avoid tests repetitions. https://www.cognitor.com.br/IEC62271307ENG.pdf

[5] **Free book by Sergio "SWITCHGEAR, BUSWAYS & ISOLATORS & SUBSTATIONS & LINES EQUIPMENT"** https://www.cognitor.com.br/Book_SE_SW_2013_ENG.pdf

[6] **A SUCCESSFUL LPC POWERCENTER SWITCHGEAR DEVELOPMENT – 6300A – 100kArms -690V** (by IEC 61439-1&2 plus internal arc test 100kArms + seismic tests) https://www.cognitor.com.br/ArticleIcel.pdf

[5] **IEC TR 60943:1998** - Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals. Issued by IEC Technical Committee TC 32.

[6] **Article "TEMPERATURE RISE LIMITS OF IEC 61439-1** : unclear values distort the LV switchgear market. (May,12, 2023) - http://www.cognitor.com.br/IEC614391Table6.pdf

OTHER USEFUL REFERENCES

[6] **Article "METAL FOAM in SWITCHGEAR, switchboards & bus ducts**
http://www.cognitor.com.br/switchgearmetalfoam.pdf

[7] **ENVIRONMENTAL EFFICIENCY CERTIFICATE OF ELECTRICAL PRODUCTS (KG/MVA): TECHNICAL STANDARD & DEMO PROJECTS MANAGEMENT)**
http://www.cognitor.com.br/demo1certificate.pdf

[8] **SUBSTATIONS & LINES INNOVATIVE PRODUCTS. SMALL R&D CENTRES + TESTING LABORATORY**
https://www.cognitor.com.br/demo2Lab.pdf

[9] **ENVIRONMENTAL EFFICIENCY CERTIFICATE of electrical products (kg/MVA) . Draft of a technical standard**
http://www.cognitor.com.br/EnvironmentalEfficiencyCertificate.pdf

[11] **IMPROVEMENT OF QUALITY OF ELECTRIC SYSTEM INDEXES:**
https://www.cognitor.com.br/IEC602822sugestionstosc32afrombrazil.pdf

[12] **Free book by Sergio "RENEWABLE ENERGY + ENVIRONMENTAL EDUCATION TO TRY TO SAVE THE PLANET"**
https://www.cognitor.com.br/educationfortheplanet.pdf

[14] **Free book by Sergio" PROJECT SAVE RIO IN 10 YEARS:**
https://www.cognitor.com.br/saverioENG.pdf

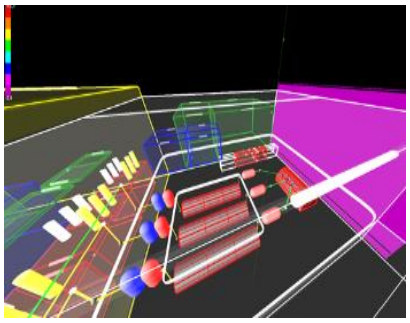
[15] Visiting researcher training: https://www.cognitor.com.br/trainingENG.pdf

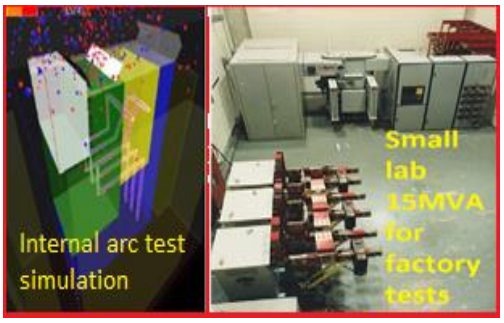
[16] Other reference articles free downloads https://www.cognitor.com.br/Downloads1.html

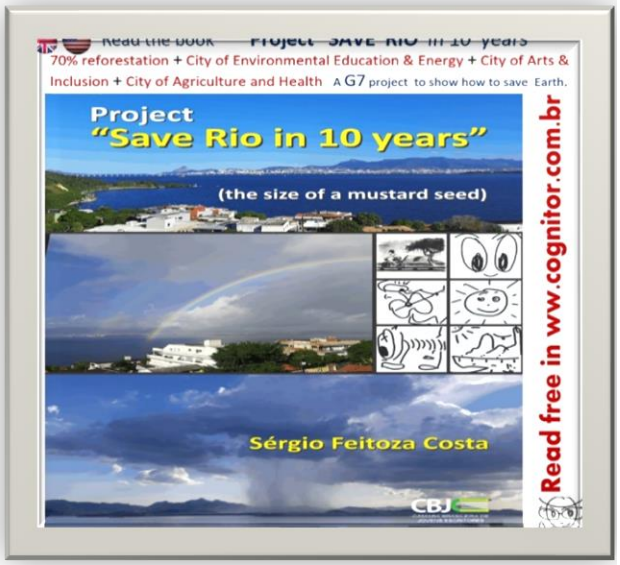
CV Sergio Feitoza Costa https://www.cognitor.com.br/Curriculum.html

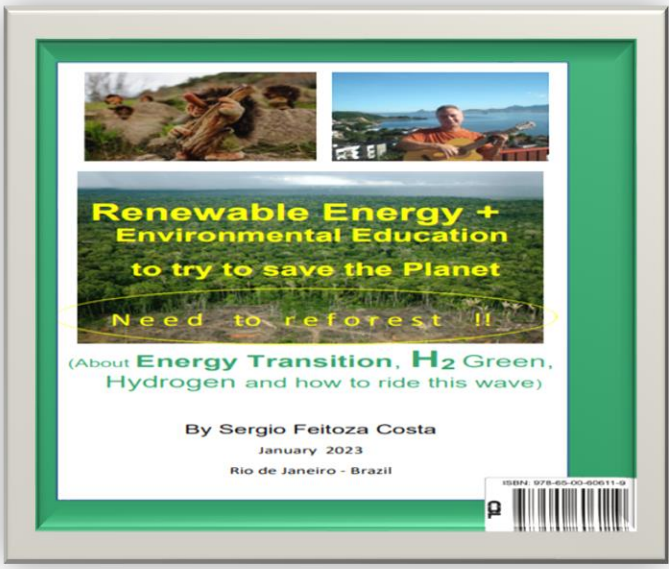
Cell phone. 55-21-9 88874600
E-mail: sergiofeitozacosta@gmail.com Site: http://www.cognitor.com.br

Things Sergio helped to do http://www.cognitor.com.br/HelpedToDo.pdf

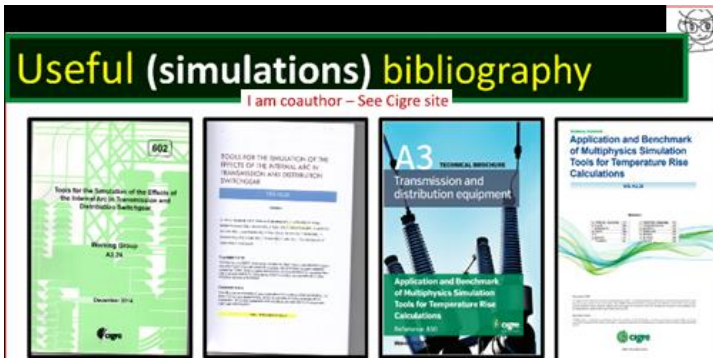


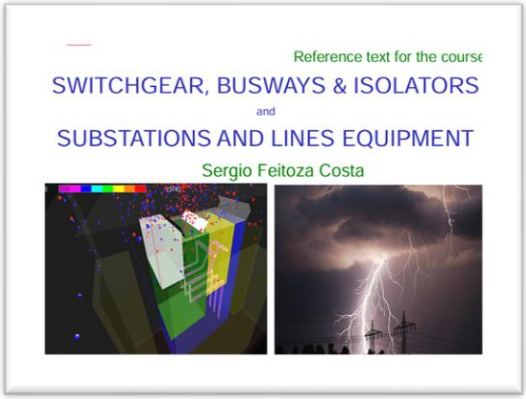




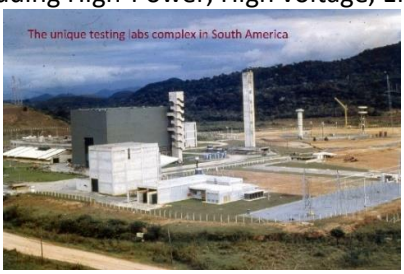


Será publicada em breve um livro ("Brochure Cigré) sobre o tema "Contemporary Solutions for Low Cost Substations in Developing Countries". Sergio escreveu os textos iniciais dos capítulos "Equipment Selection" e " Training and Development"





Cell phone. 55-21-9 88874600
E-mail: sergiofeitozacosta@gmail.com Site: http://www.cognitor.com.br

Sergio Feitoza, author of this article, helped to design, construct operate and to manage this set of 14 testing labs. including High-Power, High voltage, EMC, Ex, …  	Site https://www.cognitor.com.br Contact e-mail: write to sergiofeitozacosta@gmail.com Linkedin profile (31K followers) : linkedin.com/in/sergiofeitozacosta