

TRAINING on LV / MV Switchgear (IEC 61439, IEC 62271, IEEE)

Using software SwitchgearDesign to be approved in the tests (Internal arc, temperature rise, short circuit strength, seismic & dielectric tests)

1. GET MORE COMPETITIVE & LOWER COST DESIGN, BY PREDICTING TEST RESULTS with SwitchgearDesign

In the trainings and consultancy work, I give to switchgear manufacturers and certifiers, all over the world, I hear, from designers, good ideas, innovations, and design improvements that are easy to implement, but have never been tried just because a lab test would be necessary.

Tests in labs are expensive because testing labs are frequently expensive installations. More than this, nowadays few manufacturers have at least a small laboratory in the factory to do fast verifications. However, this is no longer a problem because software tools such as SwitchgearDesign exists, are easy to obtain, are validated, and need 2 to 3 days of learning time.

The cost to implement a training and tool is like the cost of 1 day of use of high-power testing lab. The user will save expenses with testing labs for the rest of life.

A tool like this enables simulating the most expensive tests, giving the same results as laboratory tests. Along the last 15 years, investments in training made by manufacturers and large users of electrical products have dropped to unbelievable levels. That's why many companies don't even know that these tools exist.

Tools like SwitchgearDesign are easier to use than the old tables in engineering manuals. That tables are useful only to get an initial order of magnitude of the busbars to use. As these tables do not consider the main hotspot resistances like circuit breakers, fuses and switches they are a source of errors of over dimensioning or under dimensioning. The few companies that generate innovations and patents are exactly the ones that invest some resources in training.

The focus of this training and software is to enable designers and other product developers, in just about 15-20 hours, to better understand the key engineering concepts needed to design a switchgear panel to be approved on major tests, without oversizing but using the smallest possible number of materials.

This means a commercially more competitive lower cost product.

We cover from low to high voltage power equipment used in substations and industries in general. Our training starts with this text so read it with attention. The training program is detailed in Section 4 below.

2. TRAINING LECTURER

Sergio Feitoza Costa (me) is the author of the tool SwitchgearDesign. I worked for 25 years designing, operating, and coordinating the CEPEL's Brazilian testing laboratories (High Power, High Voltage, EMC, Ex & others). I am co-author of IEC TR62271-307 and IEC 60282-2. In the late 1980s, was Chair of the IEC Technical Committee 32 (Fuses). I am co-author of the brochure CIGRE 602/2014-Simulation of Internal Arc Effects and the document "Proposal of IEC Guidelines for the Use of Simulations and Calculations to Replace Testing in IEC Standards", referred to in this brochure. I am also coauthor of the brochures Cigrè 740 (2018) Solutions for low-cost substations and Cigrè 830 (2021) Simulations for calculating temperature rise. Recently I registered a patent for the use of metallic foams in switchgear, switchboards, and busbar systems. Please check the details in the links.

- CV: <http://www.cognitor.com.br/Curriculum.html>
- THINGS I HELPED TO DO: <https://www.cognitor.com.br/HelpedToDo.pdf>
- Downloads area on the website (free articles and books) www.cognitor.com.br

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3. ABOUT TESTING SIMULATIONS TO AVOID EXPENSIVE DEVELOPMENT TESTS

A medium (MV) or low voltage (LV) panel column costs something like \$20,000 to \$45,000 US dollars. A single day of high-power testing in a laboratory costs 2000 to 6000 US dollars, not including transport to the lab and cost of the prototype. To succeed in this competitive field, it is necessary to invest in training and tools. You need to know, at least, the main design concepts for **temperature rise aspects, internal arc a, short circuit forces, dielectric aspects and even things like seismic tests**. Even to do a web search you need to know the right terms and words.

The 3 most expensive requirements in the design of LV and MV switchgear like cubicles, panels and busducts are:

- **the temperatures** which shall not be over passed during normal operation to avoid premature ageing,
- The supportability to the **overpressures caused by internal arcs** with risks to persons and installations.
- The supportability to the **forces on insulators and conductors** produced by short circuit currents.

The designer goal is to find the optimum point considering the objectives to reach (cheaper, safer, specific requirements of buyer etc...). To do it with real tests is very expensive but, to do it with the software SwitchgearDesign, is a question of few hours, for trained designers.

To find the optimal design, several technical and economic variables shall be considered. When manufacturers develop a product, they know that, at least at the end of the process, they will need to do onerous high-power tests at a testing laboratory. Manufacturers frequently oversize the design to avoid the risk of failures in the tests. This can be easily avoided with SwitchgearDesign.

Laboratory type testing, as specified in product standards, is the traditional way to verify if a certain product attends the technical standards specifications. IEC and IEEE standards – unfortunately and ignoring that it is necessary to save the planet's resources - do not include any advantage to products that use or less materials . Unfortunately, if you produce switchgear that - for the same voltage / rated current / short circuit ratings, use 80 kg or 300 kG , if they pass on the tests, their value is the same . Here is a fantastic opportunity for small and medium-size manufacturers. You manufacture a more efficient and lower cost product and do marketing to make the big buyers to know this (Article in the end). Testing simulation techniques can predict results of main type tests and enable us to obtain more complete information than the information obtained in a real laboratory test.

Simulations are used in situations like:

- to avoid switchgear tests in equipment with characteristics near to another one already tested (IEC62271-307 and partially in IEC61439)
- to extrapolate the results of an already done
- laboratory test to others, with similarities, untested equipment.
- To avoid duplication of testing on product certification processes when small changes are made to an already certified product.
- To replace SF6 with air in internal arc tests.
- To convert projects that use copper bars to use aluminum bars.
- To convince (skilled) clients that some specific tests – in some situations- can be replaced by testing simulations.

The idea is to type the main design data like geometries, currents, voltages, ventilation, materials, busbar covering, etc...(INPUT DATA SCREEN) .

After you click a button to see the results and compare the technical standards limits (RESULTS SCREEN).

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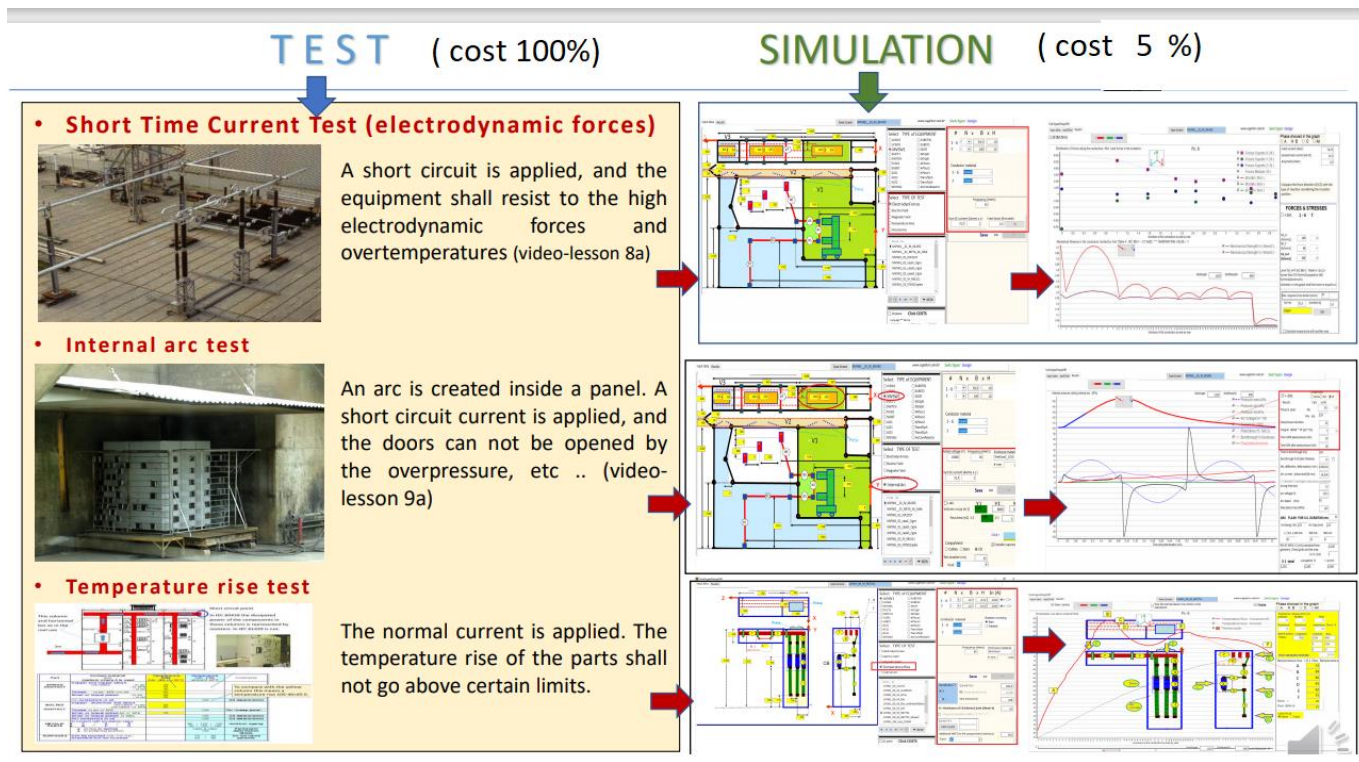
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If the results indicate that you will not pass the test you change the input data and recalculate in minutes. Easy like this . Check the final part of this video to understand <https://youtu.be/3expB4wHiCM>

TYPES OF TESTS FOR WHICH RESULTS CAN BE SIMULATED / PREDICTED:

The user can simulate the tests and adjust the design, reducing the probability of not passing to almost zero:

- Short-time and crest withstand currents test, the short-circuit electrodynamic and thermal stresses in insulators and conductors are calculated by comparing them with the limits of materials and insulators. presented in IEC TR61117
- Temperature rise test. The rises of the conductive and insulating parts are calculated and will be compared to the maximum limits allowed in table 12 of IEC 62271-1 and Table 6 of IEC61439-1
- Internal Arc Test: Calculate overpressures and other arc effects and compare against the acceptable limits for the maximum overpressure peak and integral of the curve of overpressure x time.
- Mapping of electric and magnetic fields inside equipment and in complete substations.



TYPES OF EQUIPMENT THAT CAN BE SIMULATED (this figure may not be updated):

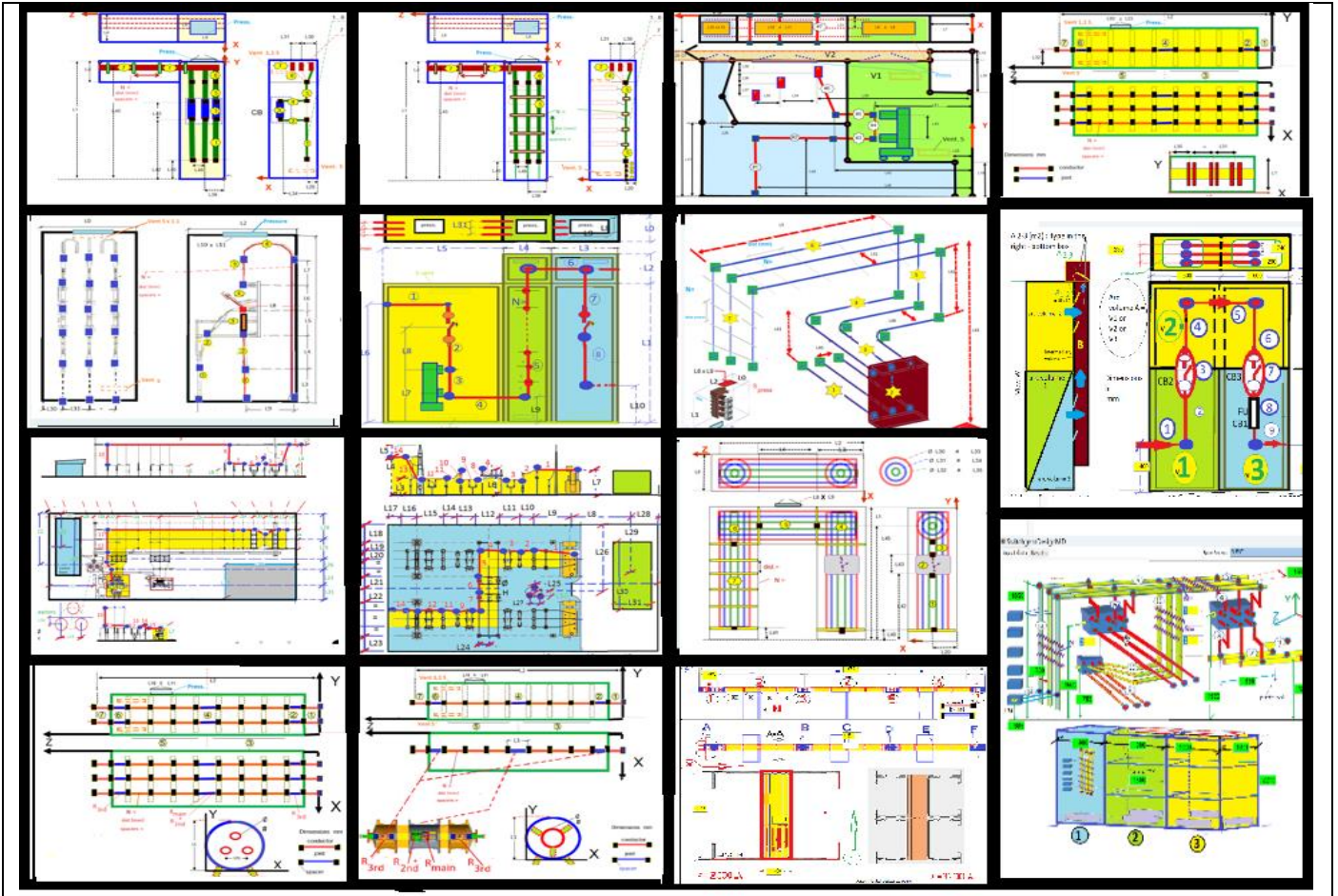
The types are shown in Figure 1. In Figure 2 there is an input data screen for one of them (ACI2). The names in the central part of the screen are:

- LVSW_1 and LVSW2 -: Low voltage panel with circuit breaker, switches, and drawer compartments
- MVSW_1; Medium Voltage Panel - AIS
- DUCT_1: GIS_1ph, GIS_3ph - Ducts
- SubstISI, Subst_2 – Substation Arrangements
- ACI_1 and ACI_2 - Medium voltage panel; ACI_3 (low voltage) and ACI4 (medium voltage)

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Figure 1 (may be not updated)



A frequent question is “What to do if my equipment does not fit these pictures well?”.

The figures have evolved over 15+ years to cover the cases most needed by more than a hundred of our clients. Having been trained in the engineering concepts, it is possible to fit your situation into one of these figures.

If necessary, for a specific reason, Sergio Feitoza Costa can create a new custom model, – provided that – the customer already has a report of temperature rise tests usable to validate the model.

The result of the simulations shall be close to the real test, and it is only possible to confirm this by comparing - once - the result of a real test with a simulation. The creation of a new model takes 15 to 30 working days and is not covered by the price of the training.

Figure 2 next page

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4. TRAINING PROGRAM (main training + additional)

The idea is that you learn or review the concepts behind each of the high power / high voltage tests and specifications of the technical standards. Knowing these concepts means to be well above the average designers knowledge. Learning this, your mind will be more open for challenging tasks like developing innovations and new solutions. An important point is that you may choose the points which will be given more emphasis and points that are not of your immediate interest. In the “standard” training the focus is on which we call “main training” below. If the participant sends questions in advance, the time use is much better. **The training includes:**

- (a) 2 days composed of 4 presential sessions of 3.5 hours with Sergio Feitoza presenting
- (b) access to videos with durations from 20 to 50 minutes and
- (c) receiving the installer of the “computer version” of the SwitchgearDesign software.

Table 1 –MAIN TRAINING

	VIDEO	PDF
(Video 3)	Introduction of training (public) Complete video: https://youtu.be/3expB4wHiCM Reduced 5 min video https://youtu.be/qPSRTf1bCus	----
(Video 7)	TEMPERATURE RISE – Design concepts and tests. (IEC61439 + IEC 62271) Complete video (private) : [REDACTED] Reduced 5 min.s free video https://youtu.be/R28GXw1V9ZY	(private) [REDACTED]
(video 8)	SHORT CIRCUIT ELECTRODYNAMIC FORCES: Concepts, IEC 61117, IEC TR 60865. Complete version (private) : [REDACTED] Reduced video https://youtu.be/CRPopRlyjPc PDF (private) : [REDACTED]	
(video 9)	INTERNAL ARC TESTS - Concepts, IEC 62271-200 e 307 (medium voltage), IEC TR 61641 (low voltage). Some (free) minutes of the complete video https://youtu.be/mTpPBkCBAQ8 Complete version (private) : [REDACTED] PDF (private) : [REDACTED]	

COMPLEMENTARY TRAINING

The “Main Training” covers the most direct points of interest for using SwitchgearDesign software (temperature rise, internal arc, and short circuit forces tests).For those who need a more complete training information there is an

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additional set of contents available. It is covered by the lecturer if previously asked by the company. In any case the material is available for the participant to study alone. If the participant wants to clarify doubts about these additional topics, write and send doubts in advance. In this case the lecturer will cover the requested points within the duration of the main training.

Table 2 – Complementary training i

	Participant watches this video
(videos 5 and 6)	<p>Video 5 – Specification of Currents and Voltages in New Substations.</p> <p>Video [REDACTED]</p> <p>PDF (private) : [REDACTED]</p> <p>Video 6 - Overvoltages and Insulation Coordination</p> <p>Video [REDACTED]</p> <p>PDF (private) : [REDACTED]</p>
(videos 10 and 11)	<p>Video 10 - Magnetic and Electric Fields and Their Effects (Concepts and Mapping)</p> <p>Video [REDACTED]</p> <p>PDF (private) : [REDACTED]</p> <p>Video 11 - Technical Specifications and Tests ("Bids" of Circuit Breakers, Disconnectors, Arresters).</p> <p>Video [REDACTED]</p> <p>PDF (private) : [REDACTED]</p>
(videos 12, 13 and 14)	<p>Video 12 - IEC STANDARDS for Low Voltage Switchgear (IEC 61439 and IEC TR 61641)</p> <p>Video [REDACTED]</p> <p>PDF (private) : [REDACTED]</p> <p>Video 13 – IEC STANDARDS for medium voltage switchgear (IEC 62271-200) and IEC 62271-307</p> <p>Video [REDACTED]</p> <p>PDF (private) : [REDACTED]</p> <p>Video 14 - IEC 890 and IEC 62208: ENCLOSURE FOR PANELS</p> <p>Video [REDACTED]</p> <p>PDF (private) : [REDACTED]</p>

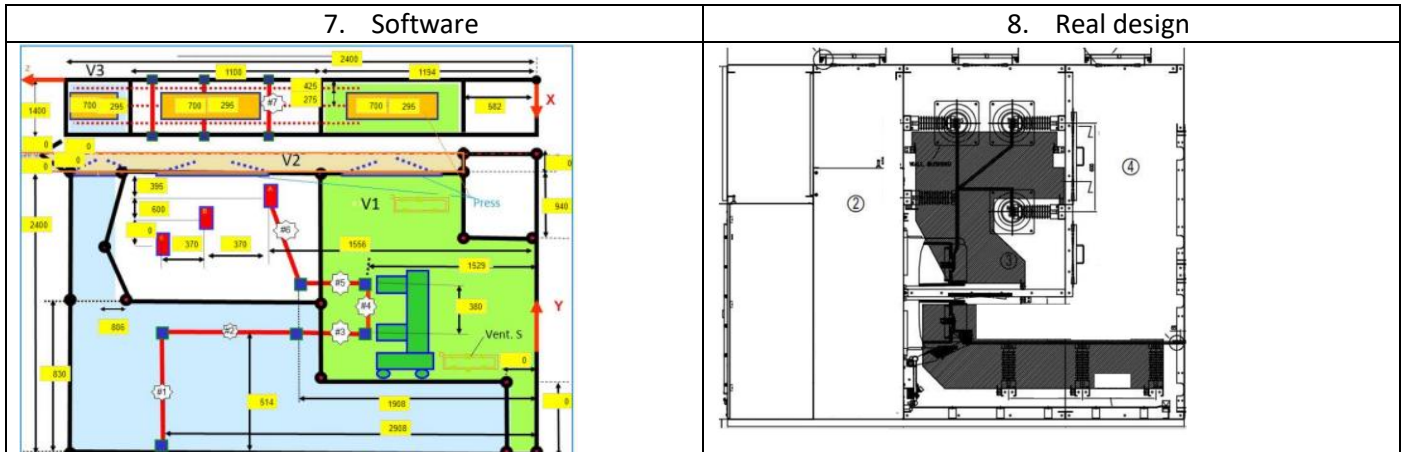
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5. COMMON DOUBTS FOR SWITCHGEARDESIGN BEGINNERS.

QUESTION 1) WHAT TO DO IF THE SOFTWARE FIGURES ARE NOT EXACTLY SAME AS YOUR EQUIPMENT

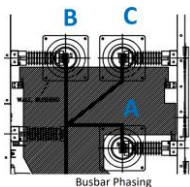
The software has geometric arrangements of some types of equipment that are most frequently used. In the following example, a user mentioned that the figure does not adequately represent the circuit breakers they use.



ANSWER 1) In the last 15 years, I have created around 50 different models of panels and busbars, for dozens of clients. After simulations followed by real tests, I learned that several design factors I considered in these many models had little impact on the results. I've learned from use that the fewer dimensions we put into the model, the easier it is to identify the importance of what really matters. This led to simplifications of the figures below to show just what is influencing the results. The results are very close to real tests. There are in the order of 15 models as presented in Figure 1 above.

In the case above, from the figure shown by the user, using the dimensions of the MVSW1 model, the simulation can be done properly. In the free web version, there are only the most frequent models, including this one. Check here <https://www.cognitor.com.br/SwitchgearDesign.html>

QUESTION 2) HOW TO ENTER THE BUS PHASING INTO THE SOFTWARE?



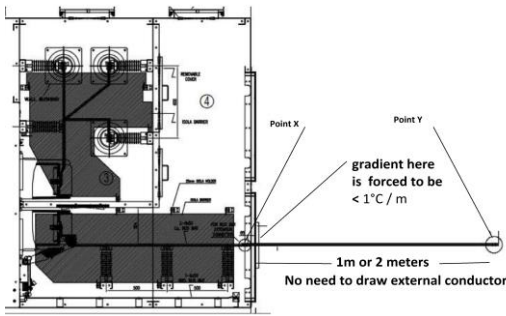
ANSWER 2)

Place a focus - only - to put phase B (center) in the correct position among the 3 alternatives. For the calculations done here, it's okay if you change A to C or C to A

QUESTION 3) THE BUS END OF OUR MEDIUM VOLTAGE PANEL EXTENDS 2 METERS OUTSIDE THE PANEL CABINET AND IS SHORT. HOW TO CONSIDER IT?

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ANSWER 3) This comment is valid for temperature rise tests and is not relevant for others. The reason for the 2 meters outside is to ensure that heat is not injected or removed from the equipment under test. The rule in the technical standard is that the difference between the internal (initial) point and the external point at 1 or 2 meters must not be greater than 1°C . Instead of drawing an external conductor, we simply insert the boundary condition into the equation that the temperature gradient over the distance is less than $1^\circ\text{C}/\text{m}$

QUESTION 4) IN FIGURE, ARE THE LINE AND LOAD SIDES OF THE CIRCUIT BREAKER SHORT-CIRCUITED?



ANSWER 4) The representation only serves to give an idea of the current path, in the case of calculating electrodynamic forces. If it increases or decreases, say, about 100mm the impact is very low in forces. Enter the approximate distances assuming current flows inside (and not across) the circuit breaker. Incidentally, there may also be a fuse or a switch in this position. Related to temperature rise tests, the software calculates the total Watts dissipated in conductors, connections, and contacts. The main impact factor of the project is the "resistance seen from the terminals" by phase, the size of the ventilation openings (net area knocking down barriers), bare or painted bars and fans, if any.

QUESTION 5) ONLY THE "BARE" AND "PAINTED" OPTIONS ARE AVAILABLE FOR BUS COVERING. HOW TO CONSIDER MEDIUM VOLTAGE BUS THERMOPLASTIC INSULATION.

Busbars covering

Bare

Painted

ANSWER 5) : Use the "PAINTED" option

QUESTION 6) HOW TO ENTER THE ENCLOSURE THICKNESS? OUR PANEL HAS VARIOUS VALUES. CABINET BODY - 2.3 MM BACK COVER - 3.0 MM BACK COVER 1.6 MM PRESSURE RELIEF COVER

#	N	B	H	IN (A)
1 - 6	2	50	6	1250
7	2	50	6	1250

Conductor material

1 - 6 Copper

7 Copper

Busbars covering

Bare

Painted

mm 2.30

Frequency (Hz) 60

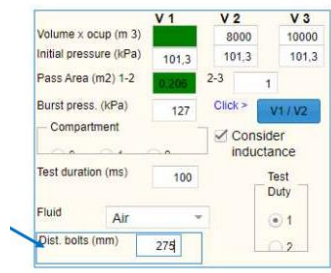
Enclosure material Steel, LdrC

ANSWER 6) The only reason to include the plate thickness in the input data is for some calculations related to the supportability of the plates for overpressures. These calculations are complex to explain here. The concept is that when overpressure occurs, if you exceed a certain mechanical stress limit, you get a permanent deformation that cannot exceed a certain value, for example 100 mm. Therefore, forget about the thickness of the depressurization plates and ONLY consider the minimum thickness value of the main doors and walls. In the case above I would use the value of the casing body (2.3mm). Also read the answer to question 7

QUESTION 7) DISTANCE FROM WHICH SCREWS? THE BACK COVER? SIDE COVER SCREWS ?.

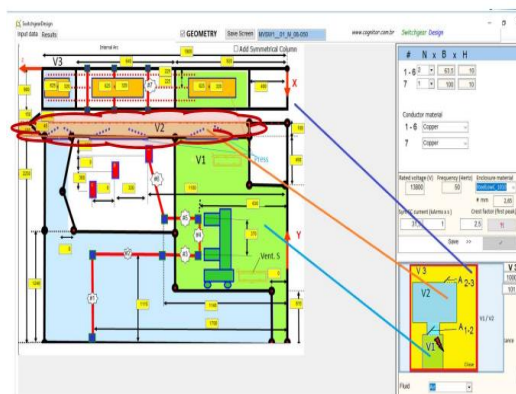
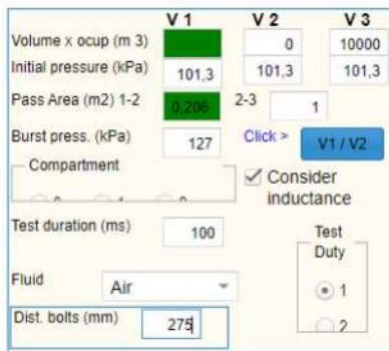
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ANSWER 7) The distance between screws is intended to estimate the supportability of the plates for overpressures. If the space between screws is large, it allows gases to escape (test failed). An approximate value for “side cover screws” on air insulated panels (MVSW1) is 20 cm. The most reliable parameter to consider is the overpressure peak. The second is the integral of the overpressure curve over time. When we wrote the brochure CIGRE 602/2014 - Simulation of Internal Arc Effects in Switchgear T&D (I am a co-author) I proposed to include my values but the WG understood that they weren't mature enough. Read the "Proposed IEC Guidelines for the Use of Simulations and Calculations to Replace some Tests Specified in International Standards" at <https://www.cognitor.com.br/Downloads1.html>

QUESTION 8). ABOUT INTERNAL ARC. THE PANEL DOES NOT HAVE VOLUME 2. ENTERING THE VALUE 0 IN V2 WILL RESULT IN AN ERROR MESSAGE IN THE SOFTWARE. WHY ?

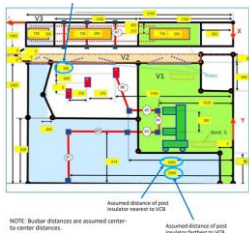


ANSWER 8) As I explain in detail in training, whenever you wish, use only volumes 1 and 2.

Put a large value on volume 2 (the free space) such as 10,000m3. On volume 3 repeat the same value as volume 2. Thus, volume 3 will be like an extension of volume 2

QUESTION 9). DISTANCE FROM THE PHASE OF THE BUS NEAREST TO THE TOP COVER (PHASE B AND C).

ANSWER 9) With the 3 vertical dimensions and the 3 horizontal dimensions, you can make many combinations. As explained in question 2, fix the first phase B (middle) and choose any name for A and C. Using the figure, do your best to represent your panel.



In these more than 15 years using these models, I haven't identified any problems with this. If your design experience says something is wrong, try another approach. The designer's experience is more important than any software.

6. SOFTWARE INSTALLATION INSTRUCTIONS (VERSION “DESKTOP”)

Step 0) Download the installer in the link informed by Cognitor.

Step 1) Before installing the “desktop” version of SwitchgearDesign you must have the MySQL database manager on your computer. If you don't have MySQL you can download the free version of “MYSQL COMMUNITY” which is on the following link.

If the computer you are using already has MySQL, this installation will not be necessary.

The database will keep current data and future data that may be included by the user.

Link to download the free version of MySQL Community: <https://dev.mysql.com/downloads/>

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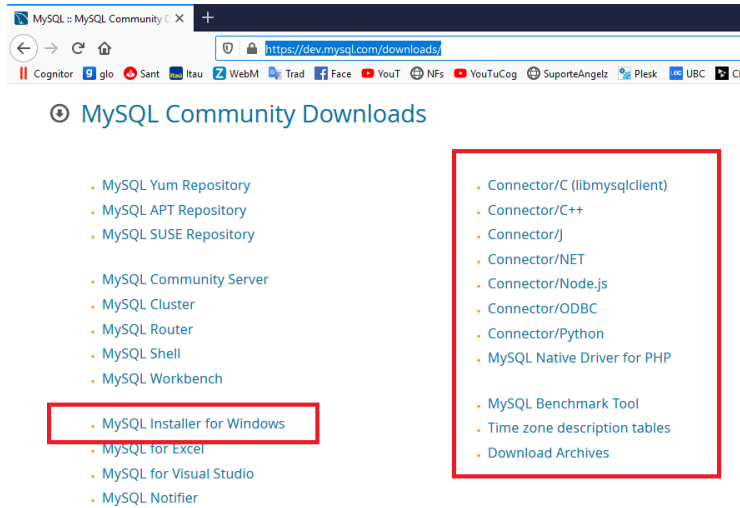
If installing MySQL for the first time use the following settings if prompted at installation

Host >>>> 127.0.0.1

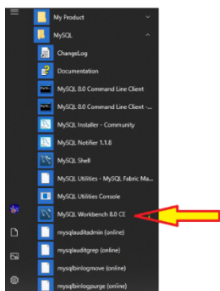
User >>>> root

Password >>>> AVPsf39ab7sfca

Screen to download MySQL Community



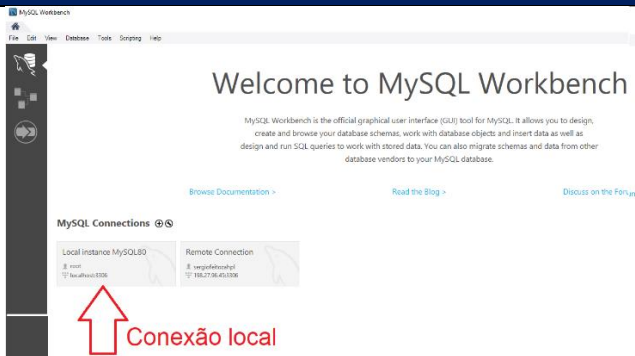
- To test if MySQL was well installed open MySql Workbench



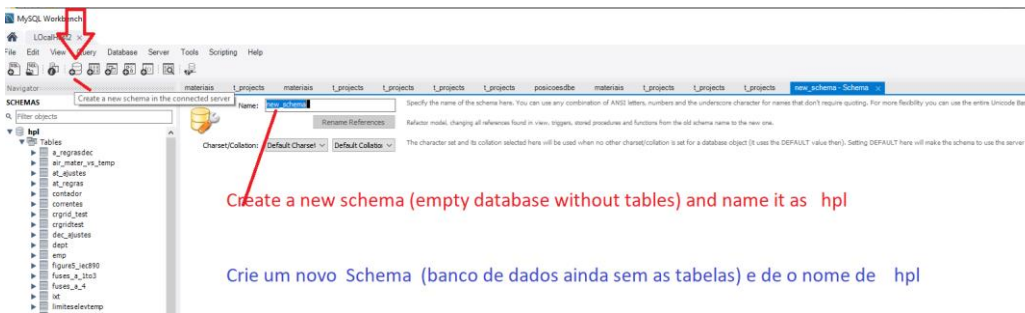
- **Now you will import a database into MySql which will be the SwitchgearDesign database**
 - Inside the file RAR or ZIP of the installer there is the **hpl.sql** file. .
 - Create a directory named C:\SwitchgearDesignMD and keep a copy of this file there
 - Open MySql Workbench where you created a local connection when installing
 - Click on local connection

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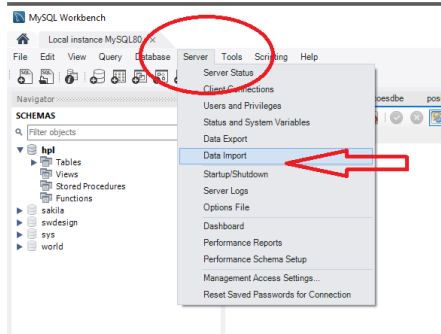
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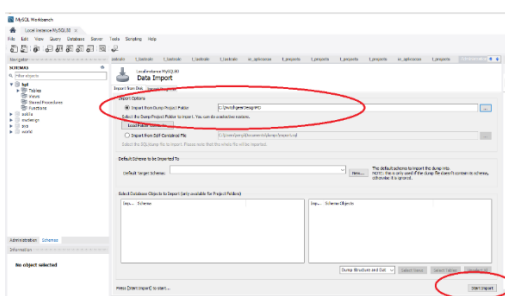
- Click in the right button to create a new “schema”.
- Schema is a new empty database without the tables. Give the name to this schema as **hpl**



- Select the schema **hpl** putting the mouse over it and go to **SERVER > DataImport** and click there



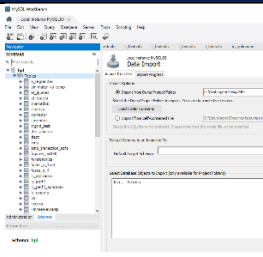
- The schema **HPL** will be your **DEFAULT TARGET SCHEMA**
- When opening the screen, select the directory where the **hpl.sql** file is located and click the button **Start import**. If everything works fine, the **hpl** directory will appear on the left side.



- Click on it and click on **Tables** to see the database tables

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STEP 2) Now you can use the SwitchgearDesign installer on the same computer by following the INSTALLATION INSTRUCTIONS below:

The terms of use are "USE IS AT YOUR OWN RISK". The author of the software and Cognitor are not responsible for any results or use made of the results.

In the "Publications" section of the Cognitor website there are many free documents including software validation cases. **IF YOU HAVE NO TRAINING, IT IS BETTER NOT TO USE IT.**

- After downloading or copying the SetUpSwitchgearDesignpor.RAR installation file (about 13MB in size), save it to a directory on your computer.
- To install, unzip the file and right-click the unzipped file, then left-click "Run as administrator" .
- OK everything and, when prompted, enter the installer password ***** sent to you by e-mail.
- After installation, a software icon will be created on the "desktop" and in the program list of the START button. If not created automatically, you can create a desktop shortcut to the file C:\SwitchgearDesignMD\SwitchgearDesignMD.exe)
- ONLY a directory called C:\SwitchgearDesignMD will be created in the computer with all the necessary files.
- The SwitchgearDesignMD.exe file (or the other name of its version) and all other files will be installed in this directory and its subdirectories. Nothing will be installed outside of this directory.
- This is an installer designed to allow the software to work well on all computers and operating systems.
- Although we have already installed it on many different computers, sometimes when installed on another PC it may (rarely) need to add some auxiliary file.
- Therefore, if there is an error in the installation, note the error message or print a PrintScreen on the screen, and send me to sergiofeitozacosta@gmail.com
- A typical message is ... "This file is missing."

The software is for the exclusive use of your company and may not be passed on to third parties without written permission from Cognitor.

1) **BIBLIOGRAPHY ABOUT OR MENTIONING TESTING SIMULATIONS** (Sergio Feitoza Costa is author or coauthor of these documents)

[1] BROCHURE CIGRE 602(2014): TOOLS FOR SIMULATION OF EFFECTS OF THE INTERNAL ARC IN T&D SWITCHGEAR.

[2] GUIDE" FOR THE USE OF CALCULATIONS AND SIMULATION OF LABORATORY TESTS (referred in the brochure Cigrè 602/2014)" http://www.cognitor.com.br/GUIDE_Simulations_v0_October2010.pdf

To understand the context read also: http://www.cognitor.com.br/Article_Competitivity_Eng_04102011.pdf

[3] BROCHURE CIGRÈ 740 (2018) - CONTEMPORARY SOLUTIONS FOR LOW-COST SUBSTATIONS. (Check Cigrè site)

[4] BROCHURE CIGRÈ 830 (2021) - SIMULATIONS FOR TEMPERATURE RISE CALCULATION. (Check Cigrè site)

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Using software SwitchgearDesign to be approved in the tests (Internal arc, temperature rise, short circuit strength, seismic & dielectric tests)

[5] IEC TR 62271-307 (2015) - GUIDANCE FOR THE EXTENSION OF VALIDITY OF TYPE TESTS of AC metal and solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV (IEC site)

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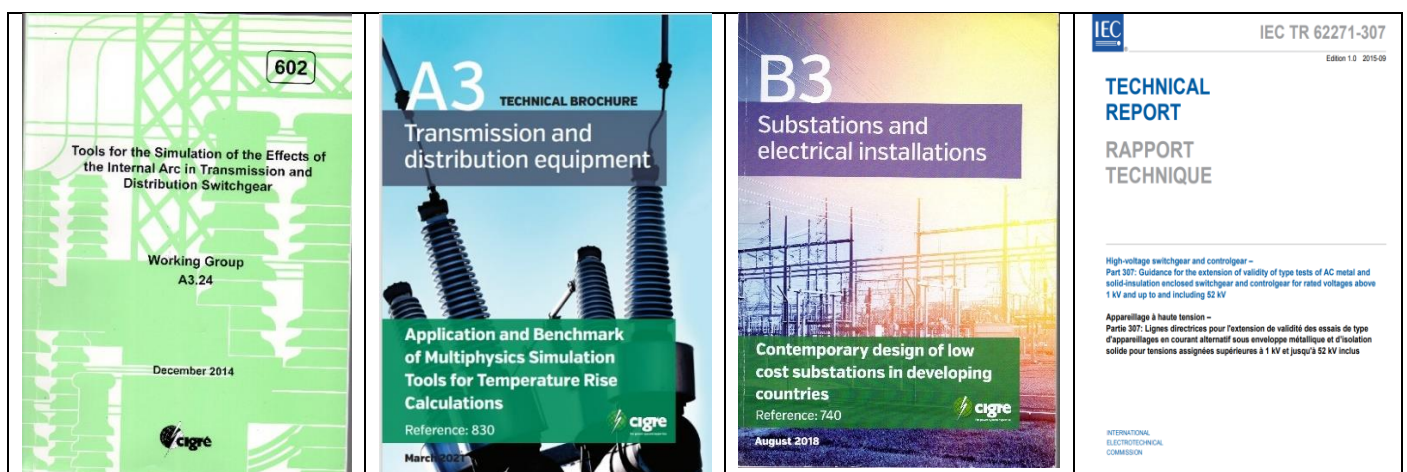
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To better understand the context read this article <https://www.cognitor.com.br/transformersfireexplosions.pdf>

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TRAINING on LV / MV Switchgear (IEC 61439, IEC 62271, IEEE)

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CV of Sergio Feitoza Costa; <https://www.cognitor.com.br/Curriculum.html>

<https://www.cognitor.com.br/cvenglishplus.pdf>

Publications by Sergio Feitoza:

<https://www.cognitor.com.br/Downloads1.html>

Patent by Sergio Feitoza Costa

Article and movie in <http://www.cognitor.com.br/SwitchgearMetalFoam.pdf>

MORE ABOUT THIS TRAINING

YouTube 35 min. video 3: <https://www.youtube.com/watch?v=3expB4wHiCM>

5min. video <https://youtu.be/qPSRTf1bCus>

Additional information (Heritage): <https://www.cognitor.com.br/heritage.html>