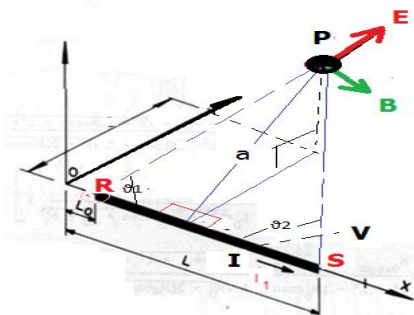


TECHNICAL REPORT 076 / 2016

<http://www.cognitor.com.br/TR076ENGElectroMagFields.pdf>

TITLE	MAGNETIC & ELECTRIC FIELDS IN SUBSTATIONS AND THEIR EQUIPMENT <i>(Mapping for health legislation and to solve EMC problems).</i>
Application	Document for use in the training http://www.cognitor.com.br/Training2015.pdf
Some of the IEC standards mentioned in this report	<ul style="list-style-type: none"> • IEC 62271-1 – High-voltage switchgear and controlgear - Part 1: Common specifications • 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 • <u>Future</u> 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 61439 - Low-voltage switchgear and controlgear assemblies. 
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Revisions	Date	Pages	Description
0	January, 15 , 2016	-	First version

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1. INTRODUCTION

The electromagnetic fields occurring in substations due to the high currents and high voltages produce different effects on people and objects nearby. High levels of permanent magnetic or electric fields have impacts on the health of people exposed to them. These effects depend on the field strength and duration of exposure. There are specific legislations specifying the maximum values that should not be exceeded.

Permanent magnetic fields can also cause effects of magnetic induction and overheating in metal parts near to their source. In addition, transient magnetic fields produced by high currents at rated frequency (short circuit) or higher frequencies like in the switching of capacitive circuits, can induce high voltages in the control circuits and other closed circuits in substations.

The focus of this report is the calculation of the values, which may occur, depending on the geometry of the object under study and the values of currents and voltages involved. The object may be a complete substation or an enclosed metallic equipment. The more frequent objectives of such studies are:

- a) To verify if the values of electromagnetic fields in a substation are lower than the reference levels established in references like ICNIRP “Guidelines for Limiting Exposure to Time-varying Electric and Magnetic Fields (1 Hz to 100 kHz)”. There you may find limits for human exposure to electric and magnetic fields in generation, transmission and distribution of electricity. ICNIRP means International Commission on Non-Ionizing Radiation Protection.
- b) To see if local gradients of voltage / electric field are higher than the values which could produce a dielectric discharge or corona in an energized circuit
- c) To see if the magnetic field acting in a metal plate or part is sufficient to produce overheating by magnetic induction

This report intends to help the users of the software SwitchgearDesign to do validations of their simulations. The software permit to simulate:

- Temperature rise tests
- Short time current and crest tests (electro dynamical forces)
- Internal arc tests.
- Mapping of electric and magnetic fields. This ability enable the user to estimate the results of dielectric tests (impulse and applied AC voltage) as well as to solve EMC (Electromagnetic Compatibility) problems.

Such validations are to prove, transparently, that the simulation results are within an acceptable tolerance from the values of the actual results obtained in the laboratory tests. Table 1 present values of acceptable tolerances considered here. These values as well as a “technical standard” for the use of simulations are in Annex F. An IEC technical standard is missing on this theme and so, this is the best reference in the moment.

Table 1 – Tolerances between test results and simulation results

Type of test	Parameter to compare	Typical values of acceptable tolerance
Temperature rise test	Temperature rise in solid and fluid parts	1% to 5%
Internal arc test	Overpressure in the enclosure above the atmospheric pressure (crest and duration)	5% to 10%
Short-time withstand current and peak withstand current tests	Electrodynamic forces and mechanical stresses	5% to 15%
Magnetic and electrical field mapping	Module and XYZ components of the field at any point	5%

THIS REPORT IS APPLICABLE TO MAGNETIC & ELECTRIC FIELDS MAPPING SIMULATIONS.

In the link, <http://www.cognitor.com.br/download.htm> there are other reports related the other types of tests mentioned above.

These documents were prepared for use in the training courses applied by Cognitor (see http://www.cognitor.com.br/en_home.htm). These trainings for manufacturers of high to low voltage equipment, certification companies and testing laboratories cover topics like:

- Specification and testing of MV and LV switchboards, switchgear, transformers, circuit breakers, isolators, fuses, busways , etc..
- Details and understanding of IEC technical standards 62271-1 / 100 / 200 /307 (MV and HV) and IEC 61439 (low voltage)
- Laboratory tests methods (breaking, short circuit, internal arc, heating, electro dynamical forces, dielectric tests, mechanical tests and others)
- Calculation of electrical and mechanical effects to improve the design.
- Magnetic and electric fields mapping in substations to solve EMC problems
- How to design an equipment using simulations before going to a lab to do the type tests.

Sergio Feitoza Costa developed SwitchgearDesign based in his experience in the design, operation and management of big size testing laboratories, especially high power and high voltage ones. He is member of IEC and Cigré working groups. He was Chairman of IEC Technical Committee 32 (Fuses). He is member of the working group WG 31 of IEC preparing the new IEC 62271-307 and also of the CIGRE WG which published in 2014 the CIGRE brochure "Tools for the simulation of internal arc effects in MV and HV switchgear ". He is also member of the Cigré working group WG A3.36 International - Application and Benchmark of Multi Physic Simulations and Engineering Tools for Temperature Rise Calculation.

Program of the training	http://www.cognitor.com.br/SoftwareEN.htm
In two pages	http://www.cognitor.com.br/Training2015.pdf
Book of the course	http://www.cognitor.com.br/Book SE SW 2013 ENG.pdf
Validation temperature rise, magnetic & electric fields	http://www.cognitor.com.br/TR074ENGValidationTempRise.pdf
Validation of internal arc and electrodynamic forces	http://www.cognitor.com.br/TR075ENGValidationForcesArc.pdf
Some articles by the lecturer	http://www.cognitor.com.br/download.htm
CV of the lecturer	http://www.cognitor.com.br/en_curriculum.htm

This report includes the following information:

- The validation method used and comparison between simulation and test results reports or calculations and acceptance criteria of simulations.
- Standard / guideline for applying simulations to replace some laboratory tests
- User requirements (inputs and outputs for the calculations) and Instructions on how to use the software
- Information about the software design, implementation, programming language, operating technician support, installation and removal

All methods and topics covered in this report came from efforts of Cognitor already registered and published in national and international references.

2. VALIDATION METHOD AND COMPARISON BETWEEN SIMULATION AND TEST RESULTS OR IEC STANDARDS.

In the other reports related to other types of tests mentioned above, we used laboratory test reports and IEC standards to compare with the simulation results. In the case of electric and magnetic fields (unfortunately) we could not find public documents, reliable or not, to compare with the simulation results.

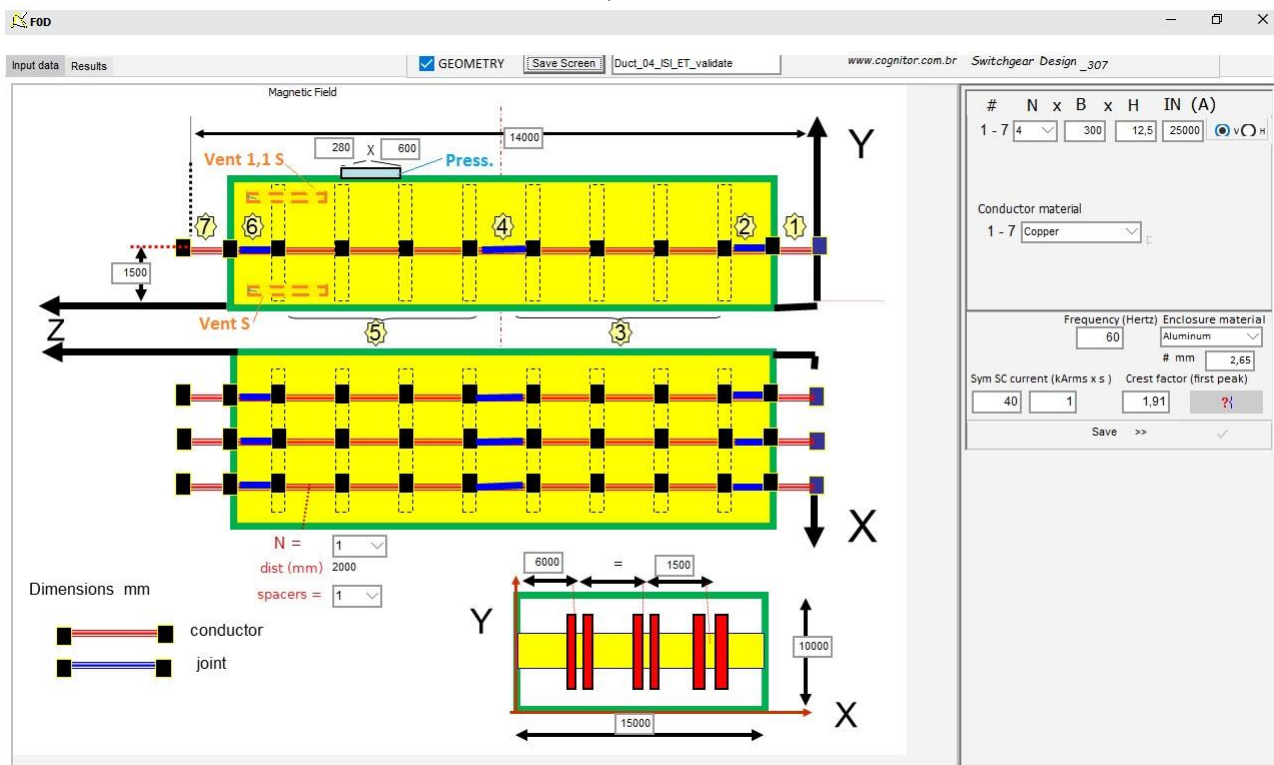
Documents like these and suggestions of new test cases to include here are welcome if accompanied by good test reports or reliable data. Good test reports, in this context, are the ones in which the equipment is properly identified and the test results shown. To know what means good identification of a tested equipment read the document entitled “Guidelines for the use of simulations and calculations to replace some tests specified in international standards” in the link: http://www.cognitor.com.br/GUIDE_Simulations_v0_October2010.pdf. This document is included in the annexes of this report.

In Table 2, there are some test cases used for validation. By lack of test reports and published results we used classical recognized formulas to do handmade calculations to compare with.

Table 2 – Test Cases for validation

	Test	Type of equipment / Case in the software database	Test report	Comments	FIGURES with inputs and results	TABLE Lab Tests x simulation
1	Magnetic field inside a room 14m x 15 m x 10 m (h) due to a busbar 25000A	Duct1 Duct_04_ISI_ET_validate	Calculation using theoretical equation		Figure 1	Table 3
2	Magnetic field LV switchgear	LVSU-1 LVSU1_01_M_R67752			Figure 2	Table 4
3	Magnetic field GIS – 3ph	GIS_3ph GIS3ph_MissingReport_3ph	Enclosure Aluminum or enclosure common steel		Figure 3	Table 5
4	Magnetic field Substation ISI	subSTISI subST_01_ISI			Figure 4	Table 6
5	Electric Field SUBSTISI	subSTISI subST_01_ISI			Figure 5	Table 7
6	Electric Field SUBST	subST subST_01_OneHalfCB			Figure 6	Table 8
7	Electric Field MV switchgear	MVSU_1 MVSU1_02_M_R6511 1			Figure 7	Table 9

Figure 1 **MAGNETIC FIELD MAPPING**
INPUT DATA AND RESULTS Duct_04_ISI_ET_validate
 Values in μT (Tesla $\times 10^{-6}$)



Magnetic field in a central plane at 1,5 m height with 3-phase currents

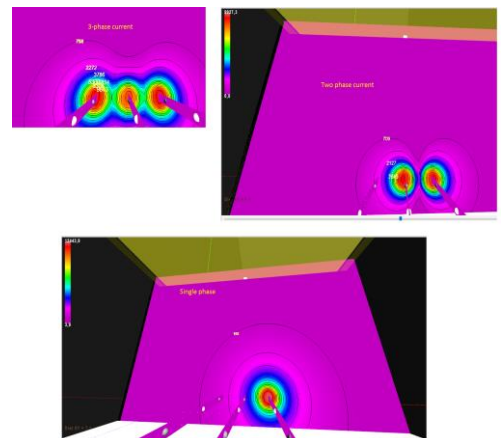
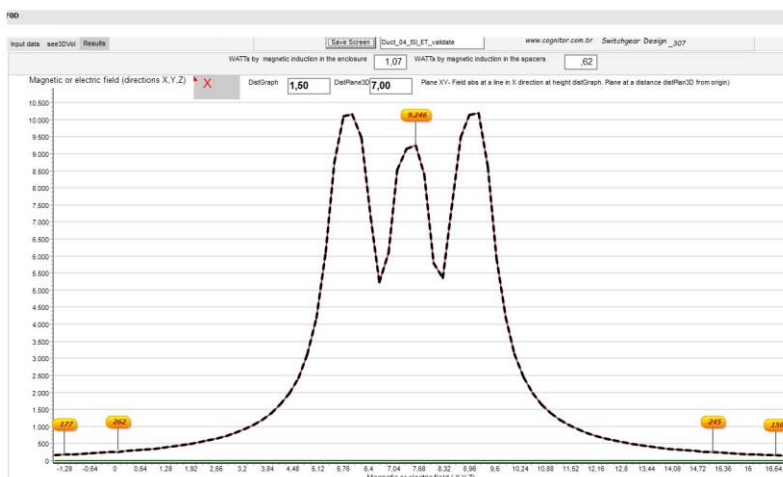
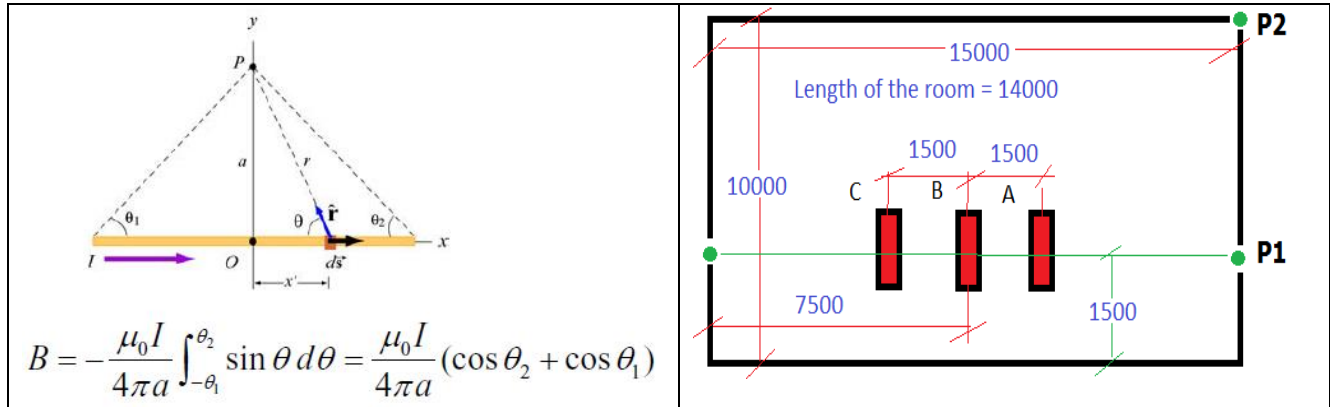


TABLE 3

MAGNETIC FIELD MAPPING

Duct_04_ISI_ET_validate

The value of the magnetic field at a point near a thin, straight wire carrying a current is calculated by the equation below. The direction of the field is the Z-axis.



Calculating the field at point P1, just in the center of the length of the room, for three phase currents at 25000 A we get

Contribution from Phase A : $B = 4 \cdot \pi \cdot 10^{-7} \cdot 25000 \cdot (\cos \vartheta_1 + \cos \vartheta_1) / (4 \cdot \pi \times 6)$
= 621 μ T with angle 0

Where $\tan \vartheta_1 = 6 / 7$ and therefore $\cos \vartheta_1 = 0.7592$

Contribution Phase B : $B = 4 \cdot \pi \cdot 10^{-7} \cdot 25000 \cdot (\cos \vartheta_1 + \cos \vartheta_1) / (4 \cdot \pi \times 7.5)$
= 455 μ T with angle 120°

Where $\tan \vartheta_1 = 7.5 / 7$ and therefore $\cos \vartheta_1 = 0.6823$

Contribution Phase C : $B = 4 \cdot \pi \cdot 10^{-7} \cdot 25000 \cdot (\cos \vartheta_1 + \cos \vartheta_1) / (4 \cdot \pi \times 9)$
= 341 μ T with angle 240°

Where $\tan \vartheta_1 = 9 / 7$ and therefore $\cos \vartheta_1 = 0.613$

Case	Calculation	Calculated Field in point P1	Value obtained in SwitchgearDesign	Difference (%)
Three phase currents (A,B and C)	621 (angle 0) + 455 (angle 120) + 341 (angle 240)	244 μ T	243 μ T	< 5 %
Current in phase A and B	621 (angle 0) + 455 (angle 180) (*)	166 μ T	170 μ T	<5 %
Current only in phase A	621 (angle 0)	621 μ T	605 μ T	< 5 %

(*) In the case of magnetic fields, the current goes inside in phase A (angle 0) and returns through phase B at angle 180. When calculating electric fields, more ahead in this text, the angle in phase B is 120 degrees (open circuit voltage with no current circulation).

Calculating the field at point P2, just in the center of the length of the room, for three phase currents at 25000 A we get

Contribution from Phase A : $B = 4 \cdot \pi \cdot 10^{-7} \cdot 25000 \cdot (\cos \vartheta_1 + \cos \vartheta_1) / (4 \cdot \pi \times 10,4)$
 = **268 μ T with angle 0** (angle XY 54.5°)

Where $\tan \vartheta_1 = 10.4 / 7$ and therefore $\cos \vartheta_1 = 0.558$

Contribution Phase B : $B = 4 \cdot \pi \cdot 10^{-7} \cdot 25000 \cdot (\cos \vartheta_1 + \cos \vartheta_1) / (4 \cdot \pi \times 11.1)$
 = **241 μ T with angle 120°** (angle XY 50.5°)

Where $\tan \vartheta_1 = 11.1 / 7$ and therefore $\cos \vartheta_1 = 0.536$

Contribution Phase C : $B = 4 \cdot \pi \cdot 10^{-7} \cdot 25000 \cdot (\cos \vartheta_1 + \cos \vartheta_1) / (4 \cdot \pi \times 12.2)$
 = **209 μ T with angle 240°** (angle XY 45°)

Where $\tan \vartheta_1 = 12 / 7$ and therefore $\cos \vartheta_1 = 0.503$

Case	Calculation	Calculated Field in point P1	Value obtained in SwitchgearDesign	Difference (%)
Three phase currents (A,B and C)	268 (angle 0) + 241 (angle 120) + 209 (angle 240)	51 μ T	58 μ T	< 15 %
Current in phase A and B	268 (angle 0) + 241 (angle 180) (*)	27 μ T	35 μ T	<20 %
Current only in phase A	268 (angle 0)	268 μ T	256 μ T	< 5 %

(*) In the case of magnetic fields, the current goes inside in phase A (angle 0) and returns through phase B at angle 180. When calculating electric fields, more ahead in this text, the angle in phase B is 120 degrees (open circuit voltage with no current circulation).

Figure 2 MAGNETIC FIELD MAPPING
INPUT DATA AND RESULTS LVSW1_01_M_R67752

Magnetic field inside a low voltage switchgear
(Three phase currents 3200 A and with aluminum enclosure + non-magnetic supports)

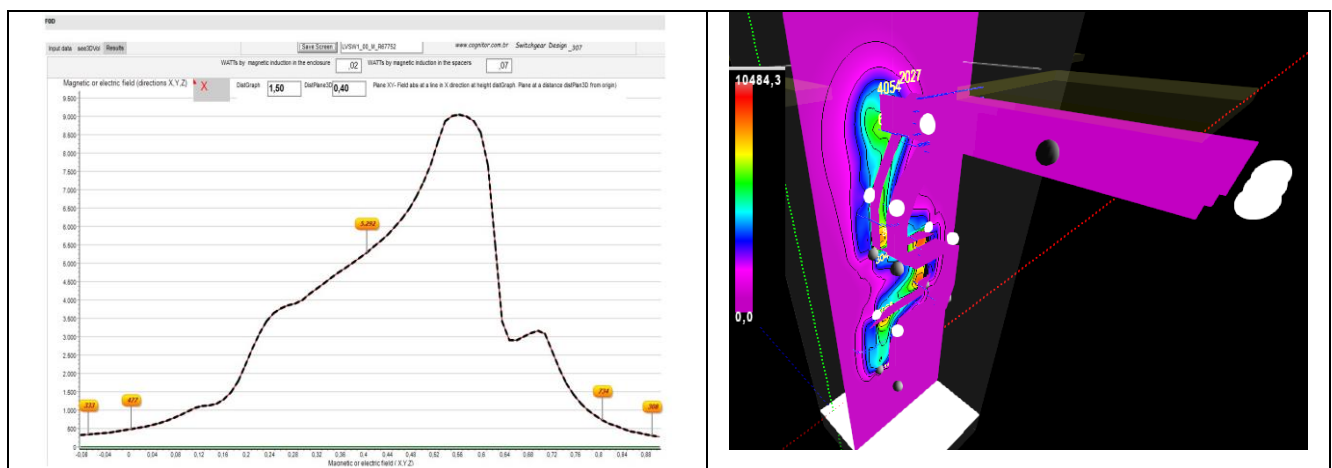
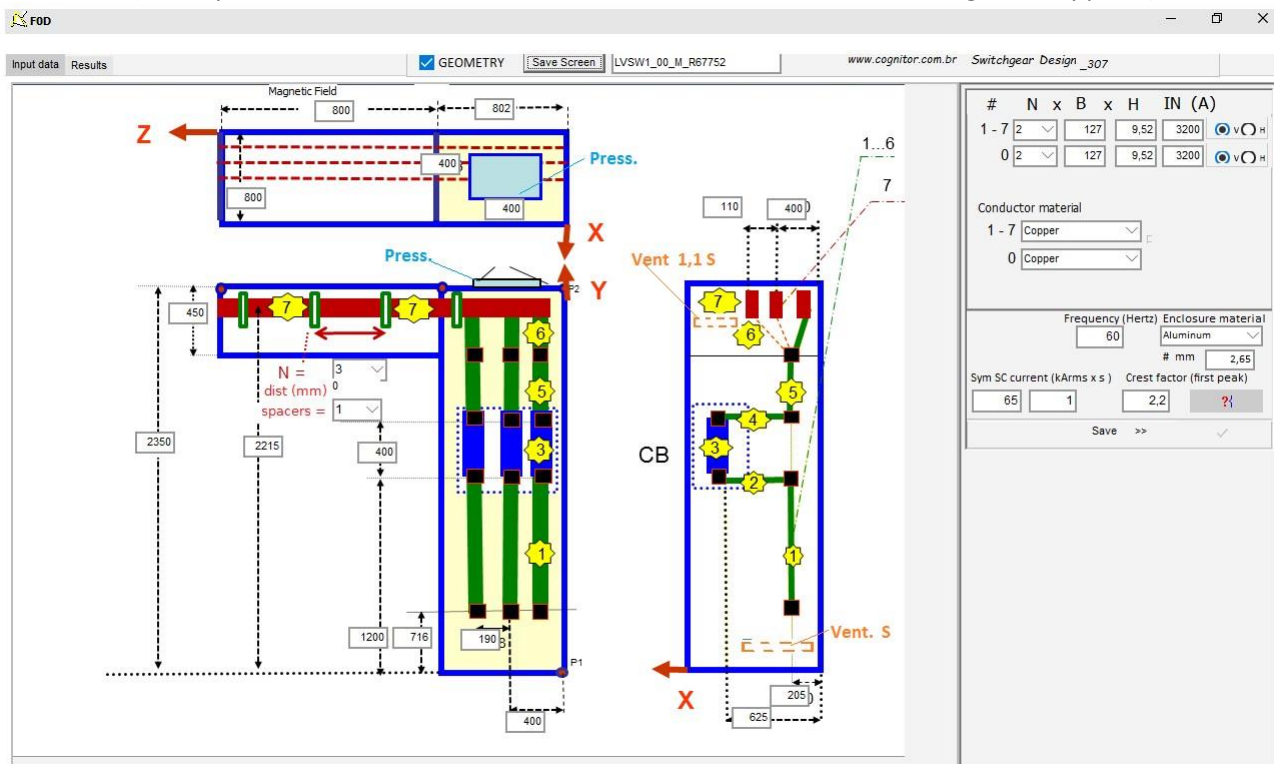
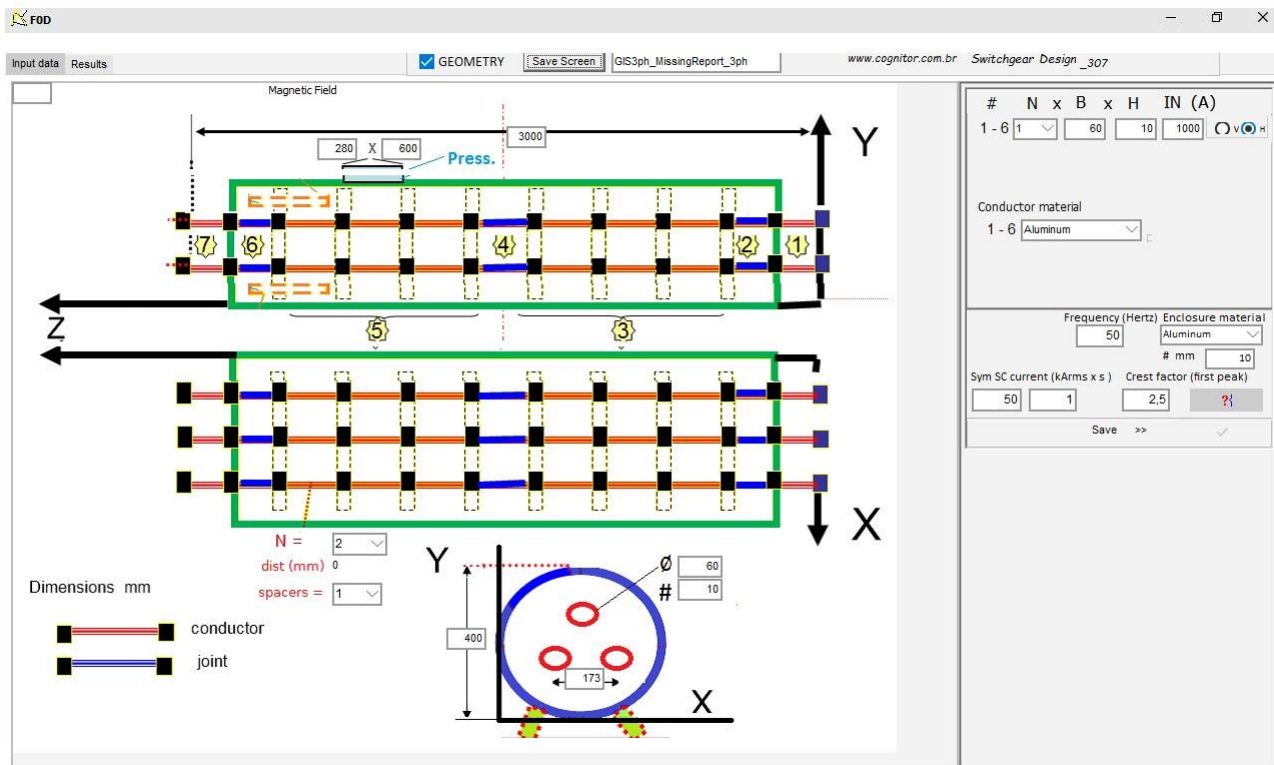


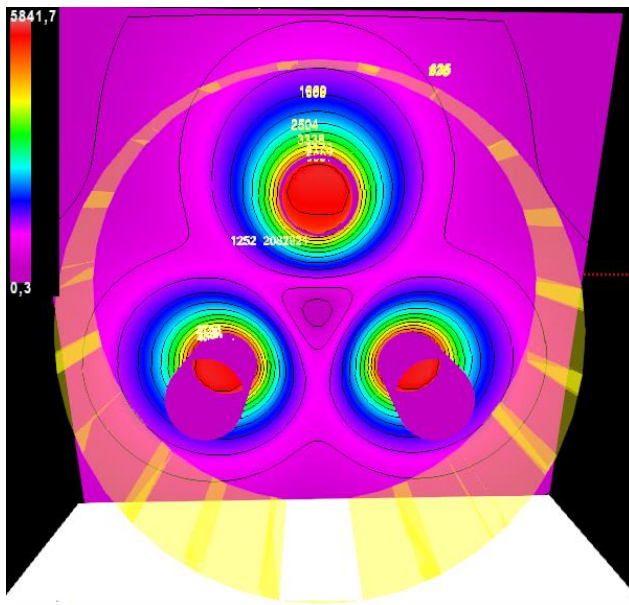
TABLE 4 MAGNETIC FIELD MAPPING LVSW1_01_M_R67752
Waiting for an actual measurement to compare

Figure 3	MAGNETIC FIELD MAPPING
INPUT DATA AND RESULTS	GIS3ph_MissingReport_3ph

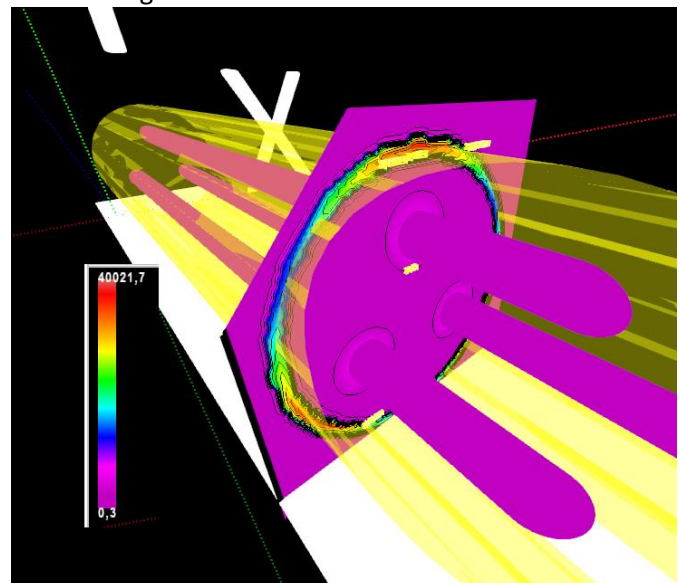
With Aluminum enclosure or Carbon Steel enclosure



Aluminum enclosure
Low fields and losses in the enclosure



Steel lowC enclosure
High fields and losses in the enclosure



Depending of the material of the enclosure or the material of spacer or the material of supports of busbar, for example in cubicles, a considerable power loss is produced by magnetic induction

F0D

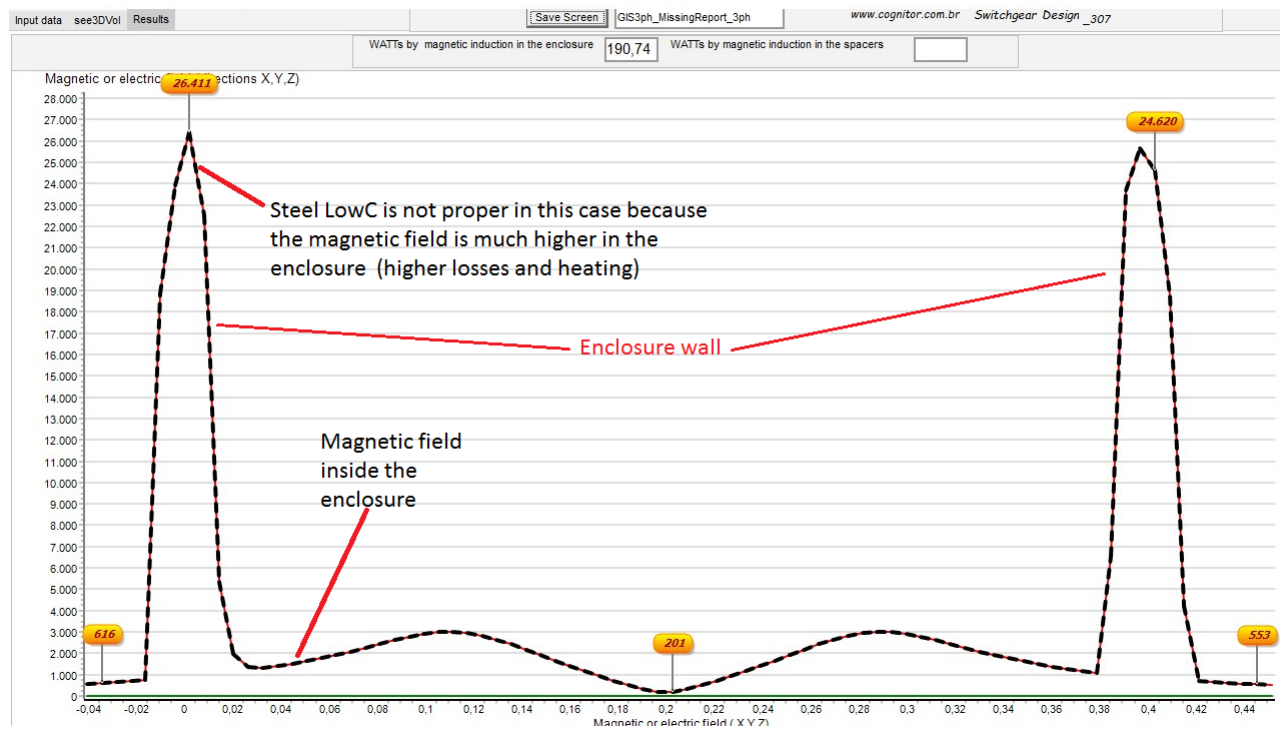


TABLE 5

MAGNETIC FIELD MAPPING

GIS3ph_MissingReport_3ph

To complete after

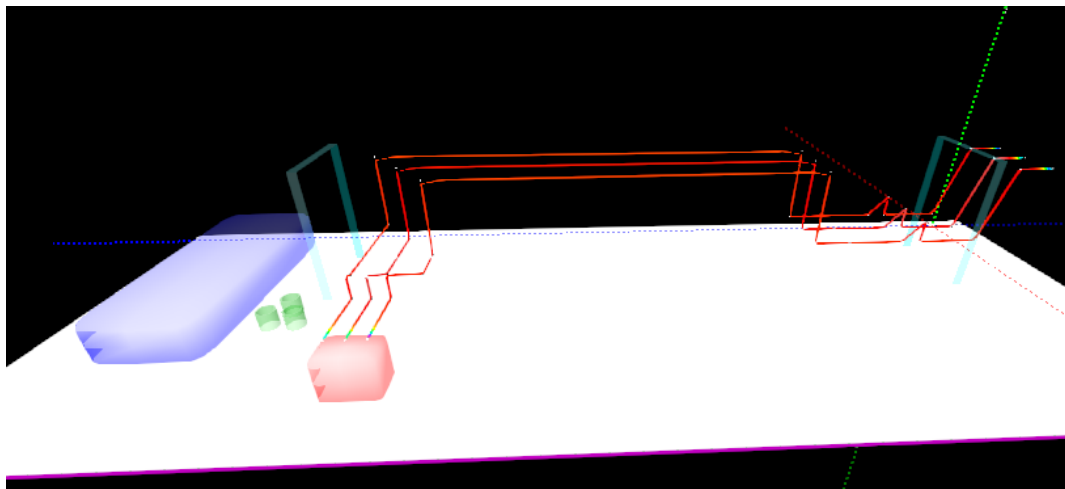
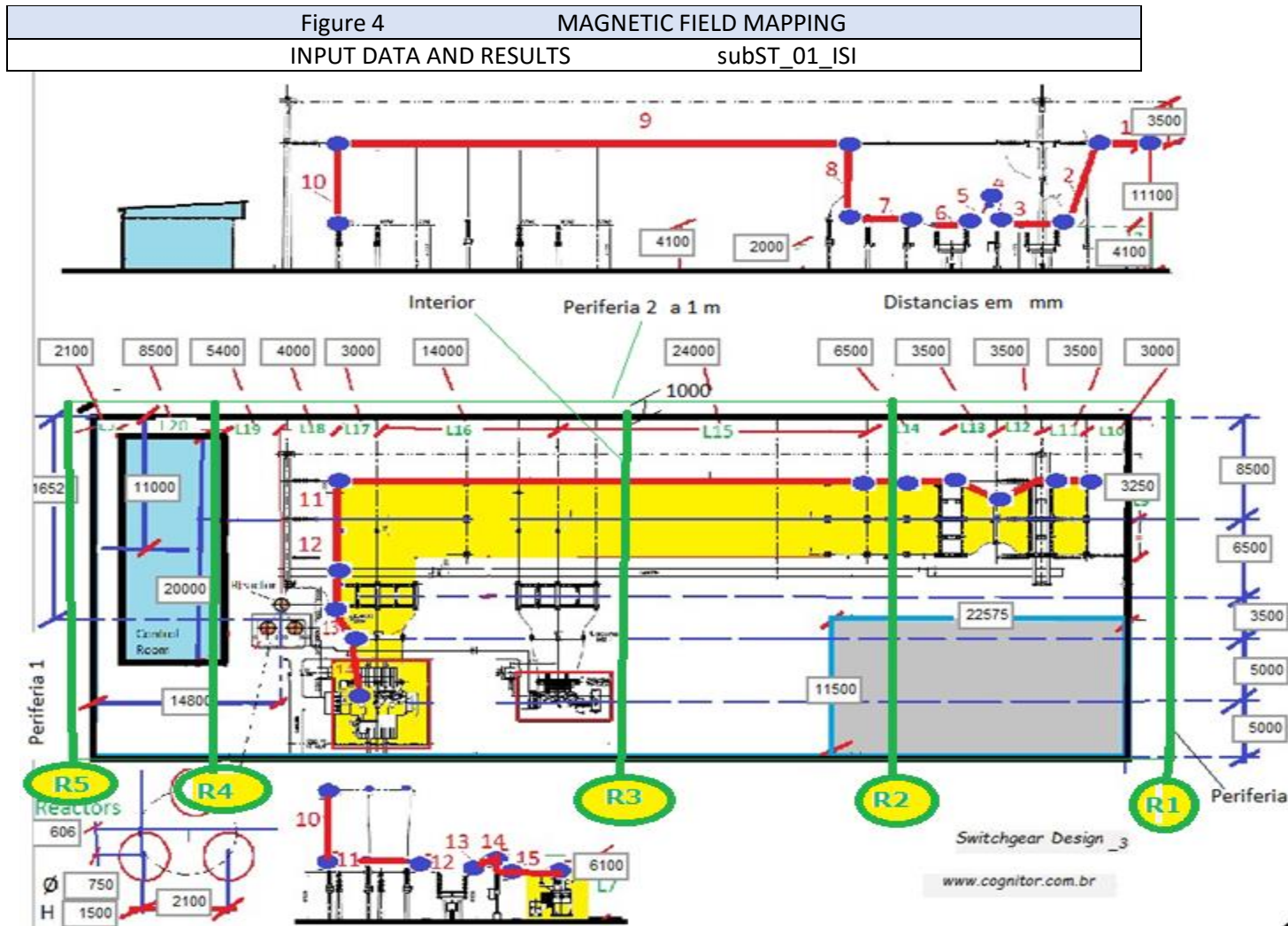


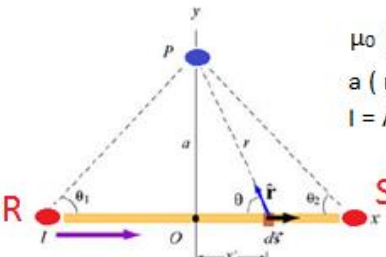
TABLE 6

MAGNETIC FIELD MAPPING

subST_01_ISI

Magnetic field B produced at point P due to the current I circulating between points R and S of the electrical conductor. The direction of the magnetic field is a vector pointing out of the paper (Z axis).

This is the contribution of each of the conductors 1 to 15 showed in the Figure 4



$\mu_0 \text{ (air - SI)} = 4.\pi .10^{-7}$
 $a \text{ (m)}$
 $I = \text{Ampere}$

$$B = -\frac{\mu_0 I}{4\pi a} \int_{-\theta_1}^{\theta_2} \sin \theta d\theta = \frac{\mu_0 I}{4\pi a} (\cos \theta_2 + \cos \theta_1) \text{ Tesla}$$

The substation cable is a CAA 336.4 MCM Linmet with nominal diameter 18,3mm and therefore geometric mean radius of $0.5 \times 18.3 \times 0.7788 = 7.1$ mm. There are more details in http://www.alubar.net.br/downloads/produtos/cabos_caa_condutores_de_aluminio_com_alma_de_aco.pdf

The currents were considered 510 A. Supposing this current is circulating in conductor 9 in only one of the three phases and that there is a person in the middle of the conductor and under it. To have current in only one phase is not a possible situation, but would generate the largest magnetic field achievable there. Having circulating currents in the three phases the fields of each of the phases are lagged 120° are summed as vectors leading to a much lower value that the single phase case.

With R-S length 41 meters and a point in phase B at a height 1,5 m ($a = 11 - 1.5 = 9.5$ meters) we have angles $\theta_1 = \theta_2 = 24.9^\circ$ and thus $\cos \theta_1 = 0.907$. The value of the field at P due to just one phase would be:

$$B = 4.\pi .10^{-7} . 510 . (0,907 + 0,907) / (4.\pi \times 9,5) = 9,7 \mu\text{T}$$

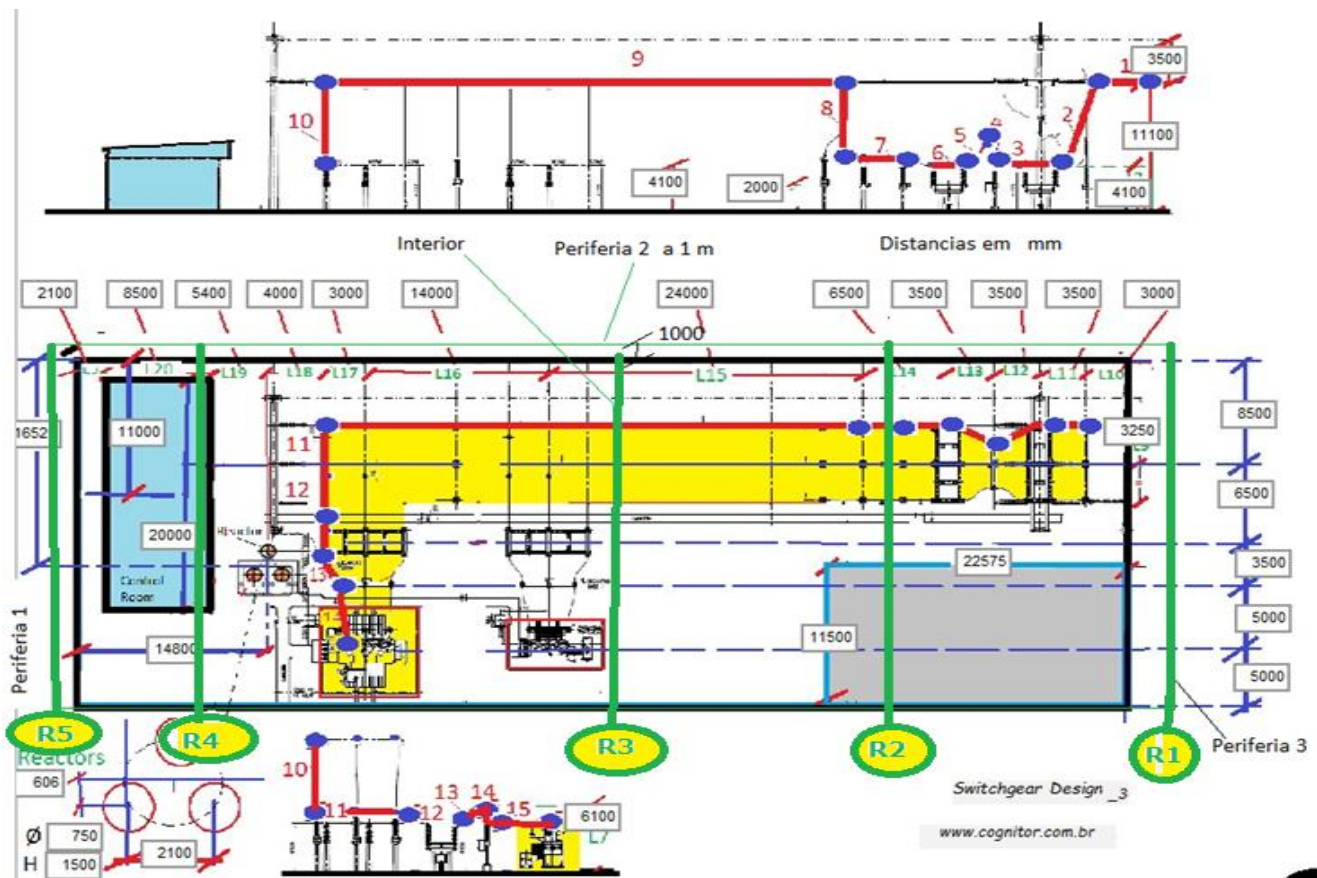
Supposing the person under the length composed by the conductors 3 to 7 and the same 510 A in only one phase. With R-S = 21 meters and $a = 4.1 - 1.5 = 2.6$ m the magnetic field would be:

$$B = 4.\pi .10^{-7} . 510 . (0,970 + 0,970) / (4.\pi \times 2,6) = 38 \mu\text{T}$$

The circuit is permanently used three-phase, so a person under the central phase would be submitted to a field equal to the vectorial sum of the fields produced in phases ABC lagged 120° . In the second situation, the modules are $38 \mu\text{T}$ (closest phase) and $24 \mu\text{T}$ (the other two phases). The vector sum is $14 \mu\text{T}$.

Case (under # 3 to 7)	Calculation	Calculated Field in point P1	Value obtained in SwitchgearDesign	Difference (%)
Three phase currents (A,B and C)	38 (angle 0) + 24 (angle 120) + 24 (angle 240)	$14 \mu\text{T}$	Depending on the region from $12 \mu\text{T}$ to $17 \mu\text{T}$	< 20 %

Figure 5	ELECTRIC FIELD MAPPING
INPUT DATA AND RESULTS	subST_01_ISI



Supposing the 138 kV cables energized, off load, with maximum system operating voltage. This is the condition to calculate the maximum electric field, which can occur in the substation. To assess the values of the largest electric fields, in an extreme situation, we will use a permanent voltage equal to $1.16 \times 138 = 160$ kV rms between phases.

The charges on the conductor between points R and S in the figure will produce at point P a calculable electric field. The expressions shown in the central part and right part of the figure classical expressions are used to calculate the electric field, respectively, coaxial conductors and the coaxial conductors long type and of the type used in overhead transmission lines.

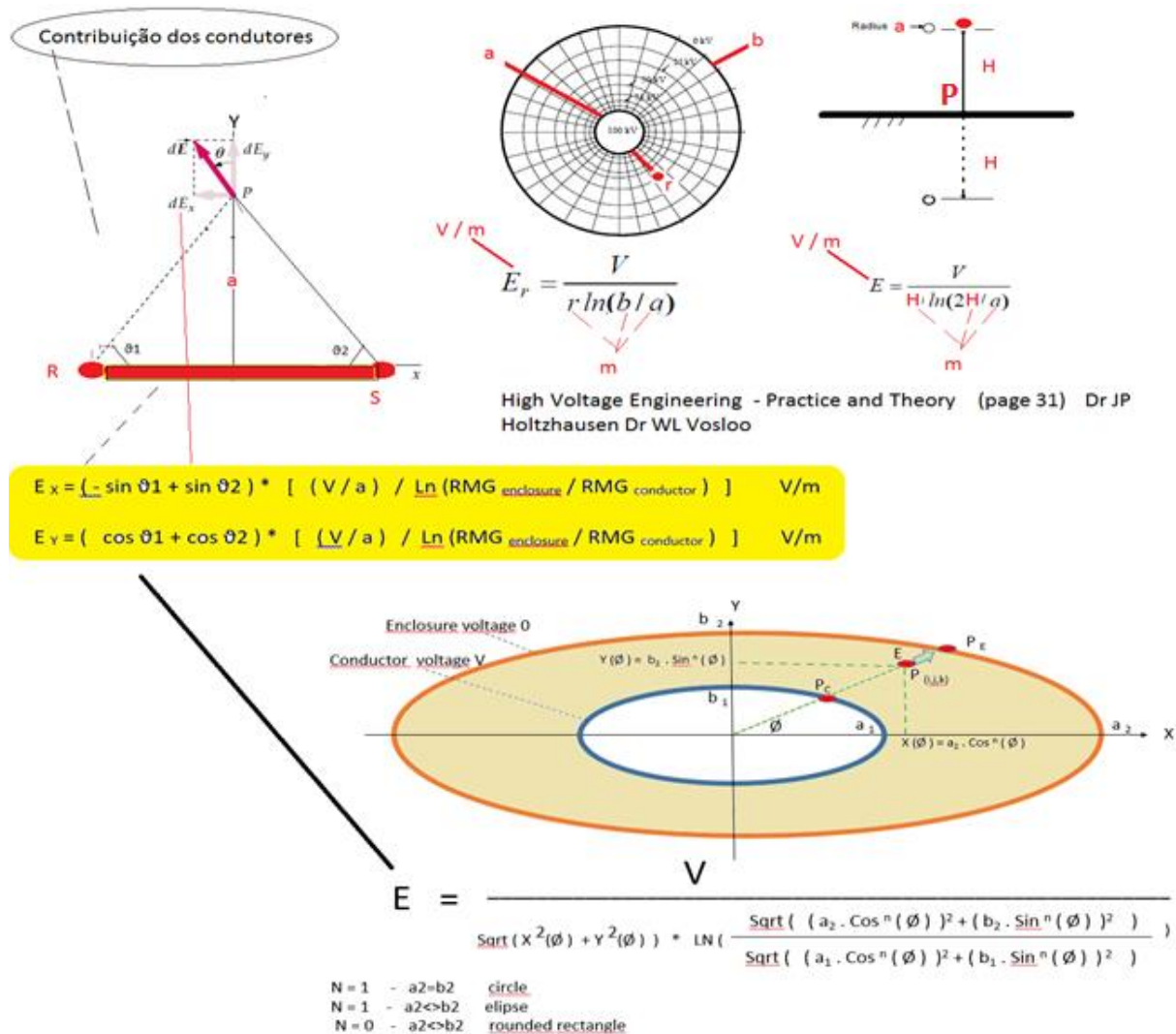
The expression shown in the left part of the figure is used in the software SwitchgearDesign to calculate the contribution of each conductor at the point P. For each conductor we use the phase-ground voltage (phase to phase V / 1732) in volts rms and the value of the distance from the point P to the line R-S in meters obtaining the value of the field in V / m

Note that in the calculation expression appear variables $RMG_{conductor}$ e $RMG_{enclosure}$. The value $RMG_{conductor}$ in the classic formulas, is the geometric mean radius of the cable CAA 336.4 MCM Linmet (7.1 mm) .

The value of $RMG_{enclosure}$ used in the software allows calculations with a broader approach. Use of this parameter makes it possible to calculate the electromagnetic fields both in whole substations (Figure 2), as

well as in small equipment like switchboards or bus ducts. By using the value of $RMG_{enclosure}$, the existence of grounded structures in the neighborhood is taken into account.

$RMG_{enclosure}$, for a metallic switchboard is the geometric mean radius of the enclosure in the same direction of the conductor axis. In the case of the whole substation "rectangle" to obtain the RMG has a height equal to the distance from the ground for cable rays, on top, and a width equal to 4 times the distance between the main distance phase-to-phase. The geometric mean radius of a rectangle of dimensions A x B is equal to $0.223 * (A + B)$. In this substation we use $RMG_{enclosure} = 0.227 * (14.6 + 4 * 3) = 5.93$ m.



Before a detailed calculation using the software, we present the orders of magnitude of the maximum electric fields using only the expression of Figure 4 in direct calculation situations and easy viewing.

Suppose that is applied the phase-ground voltage of $160 / 1,732 = 92,4$ KV in the conductor 9 of Figure 5 only phase B. Suppose also there is a person in the middle of the conductor and under it. To have voltage in just one phase is not a possible situation but would generate the highest achievable electric field there. With R-S length of 41 meters and a point B at a height 1,5 m ($a=11-1.5 = 9.5$ m) we would have angles $\theta_1 = \theta_2 = 24.9^\circ$ and thus $\cos \theta_1 = 0.907$.

Using the software formula, the value of the field at P would be equal to:

$$E = ((0,970 + 0,970) * (92400 / 9,5)) / \ln(5.93 / 7.1E-3) = 2625 \text{ V/m}.$$

Using the classical formula for long-conductor transmission lines a field value of the order of 1200 kV/m, and therefore, the software formula is conservative.

Assuming the situation of a person under conductors 3 to 7 and the same phase to ground voltage in phase B, with the length R-S= 21 m and a height 1,5 m ($a=4.1-1.5 = 2.6$ m) the electric field is:

$$E = ((0,970 + 0,970) * (92400 / 2,6)) / \ln(5.93 / 7.1E-3) = 9572 \text{ V/m}.$$

Using the classical formula for classical long transmission line conductors we would obtain a field value 5400 V / m.

As the circuit is three phase, the field will be the vector sum of the fields produced by phases ABC lagged 120°. In the second situation, these modules would be 9520 V / m (closest phase) and 3400 V/m (two other phases). The sum is about 6100 kV / m. As the point is inside the substation, we may compare this value with values established by health legislation for the occupational population (and not public in general).

Therefore, even before the more elaborate calculation using the software, we estimated that no permanent electrical field, even in the most critical point of the substation (under conductors #3 to #7) will be higher than 6100 V / m.

As a reference, the limits of 4700 V / m (for general public) and 8330 V / m (occupational population) are used in some health legislation related to electromagnetic fields.

In Figures 11 to 15 are shown the values of the electric fields across the substation, inside and in the periphery, at the height of 1.5 m above the ground in the lines R1 to R5 marked in Figure 5, These are the most characteristic points of the substation. The values of the fields are in the vertical axis. The horizontal axis coincides with each of the lines. Figure 16 shows the overall mapping of the electric field to 1.5 m above the ground.

Figure 11 - Line R1 - Electric field at 1.5 m above the ground less than 1 m from the fence.

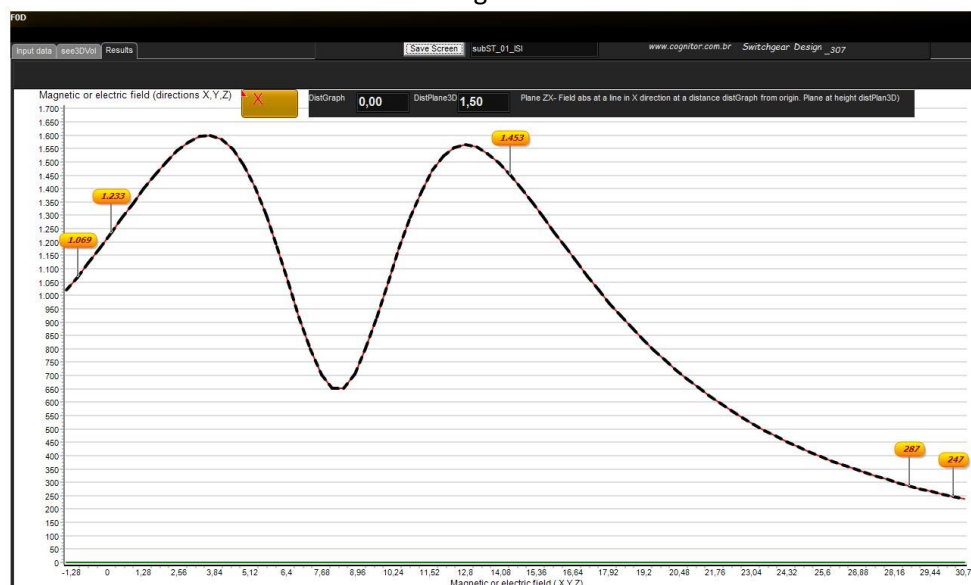


Figure 12 - Line R2 - Electric field at 1.5 m above the ground passing under conductor # 7 (the nearest from ground) at 17 m from origin.

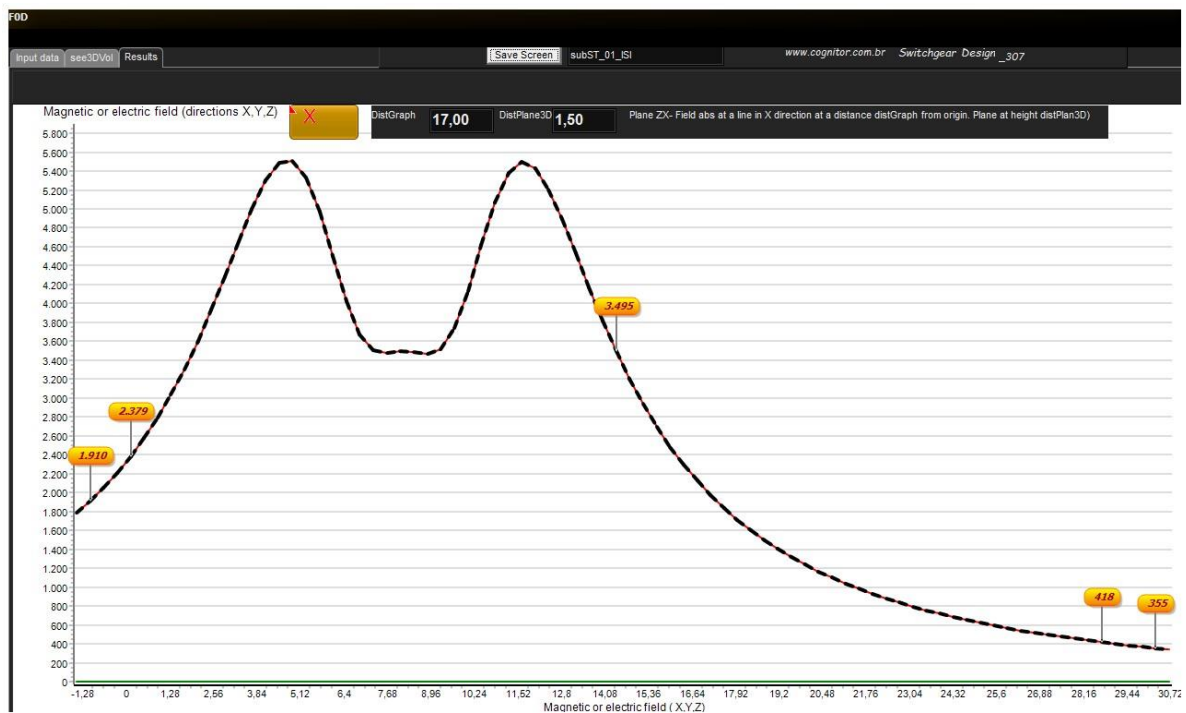


Figure 13 - Line R2 - Electric field at 1.5 m above the ground passing under conductor # 9 (the farthest from ground) at 37 m from origin.

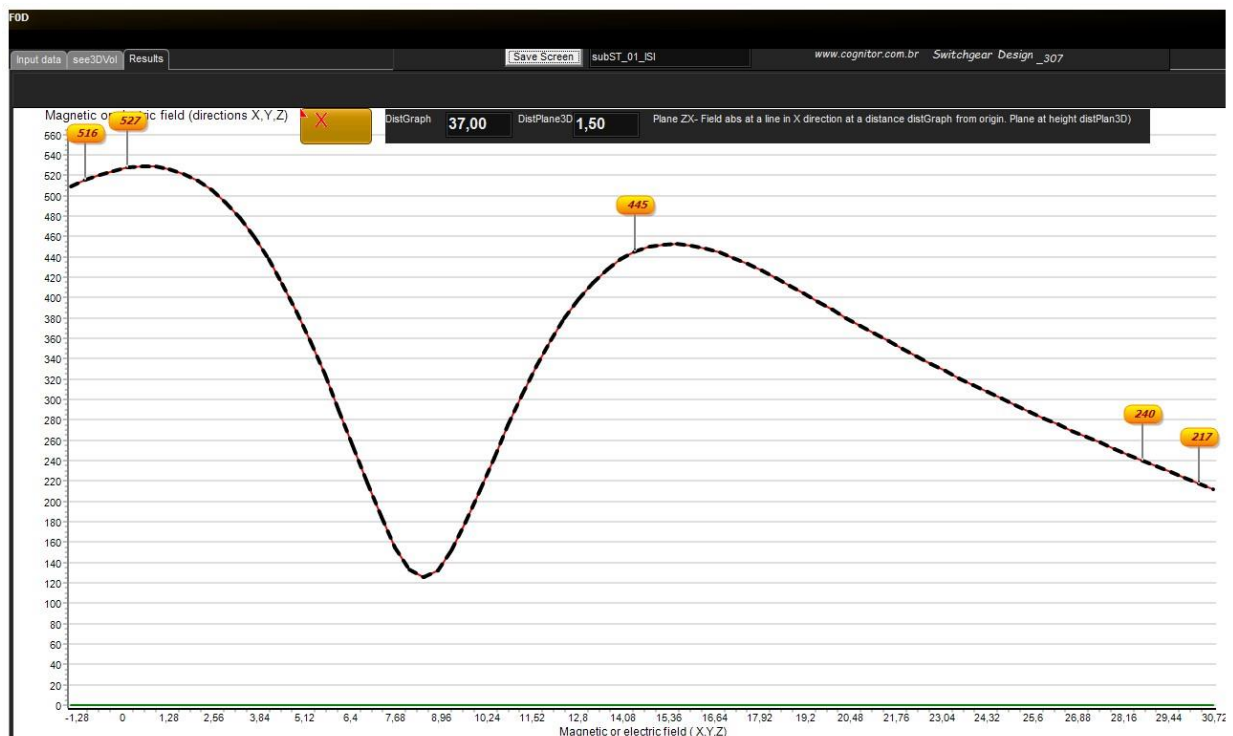


Figure 14 - Line R4 - Electric field at 1.5 m above the ground at the walls of the control room at 70,4 m from origin.

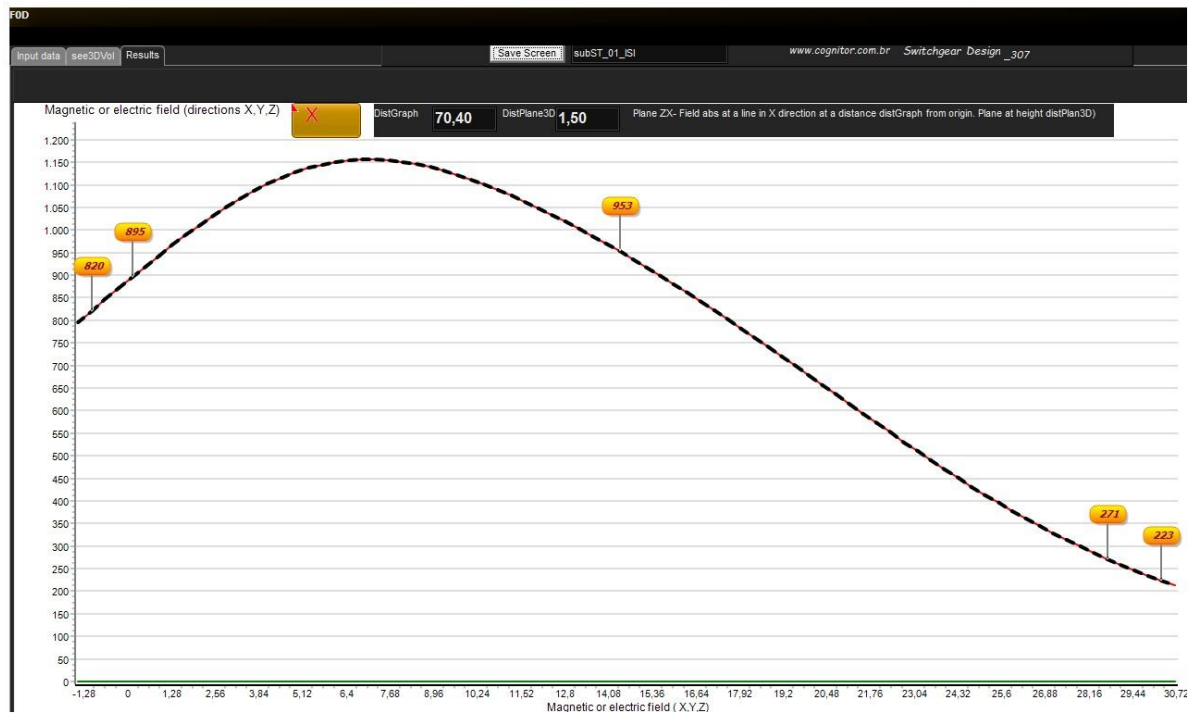


Figure 15 - Line R5 - Electric field at 1.5 m above the ground at the opposite side fence at 80,5 m from origin.

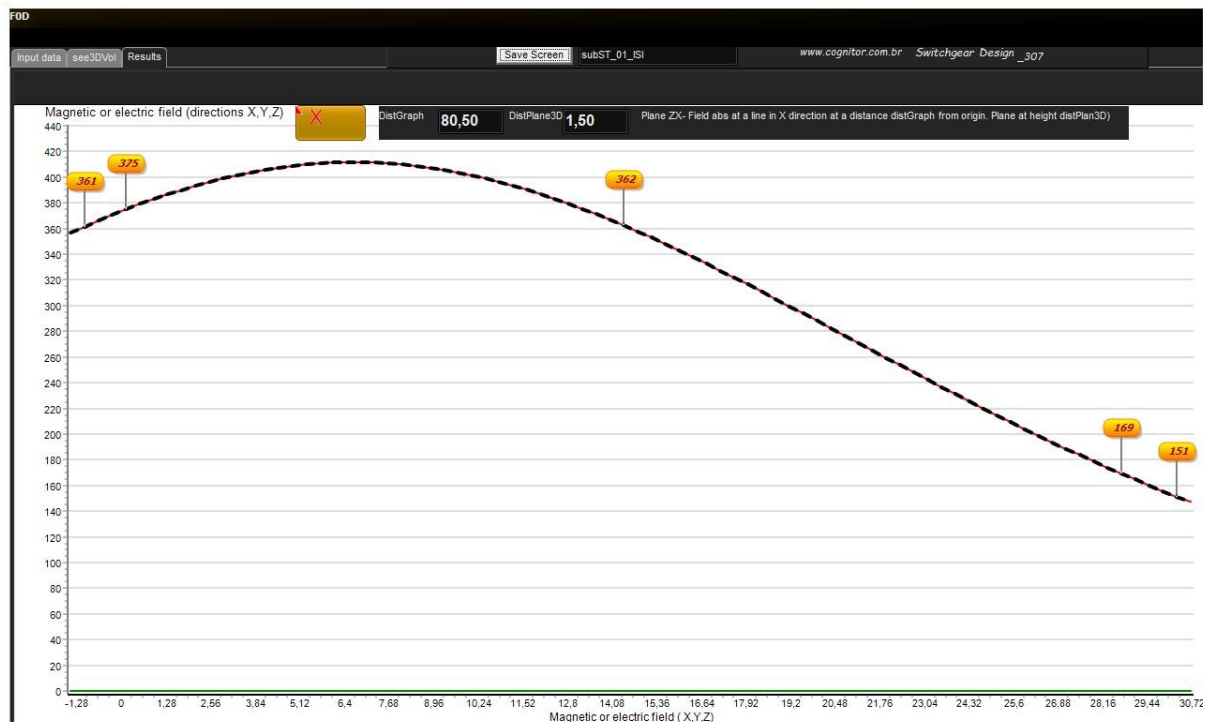


Figure 16 - Mapping of the electric field at 1.5m above the ground

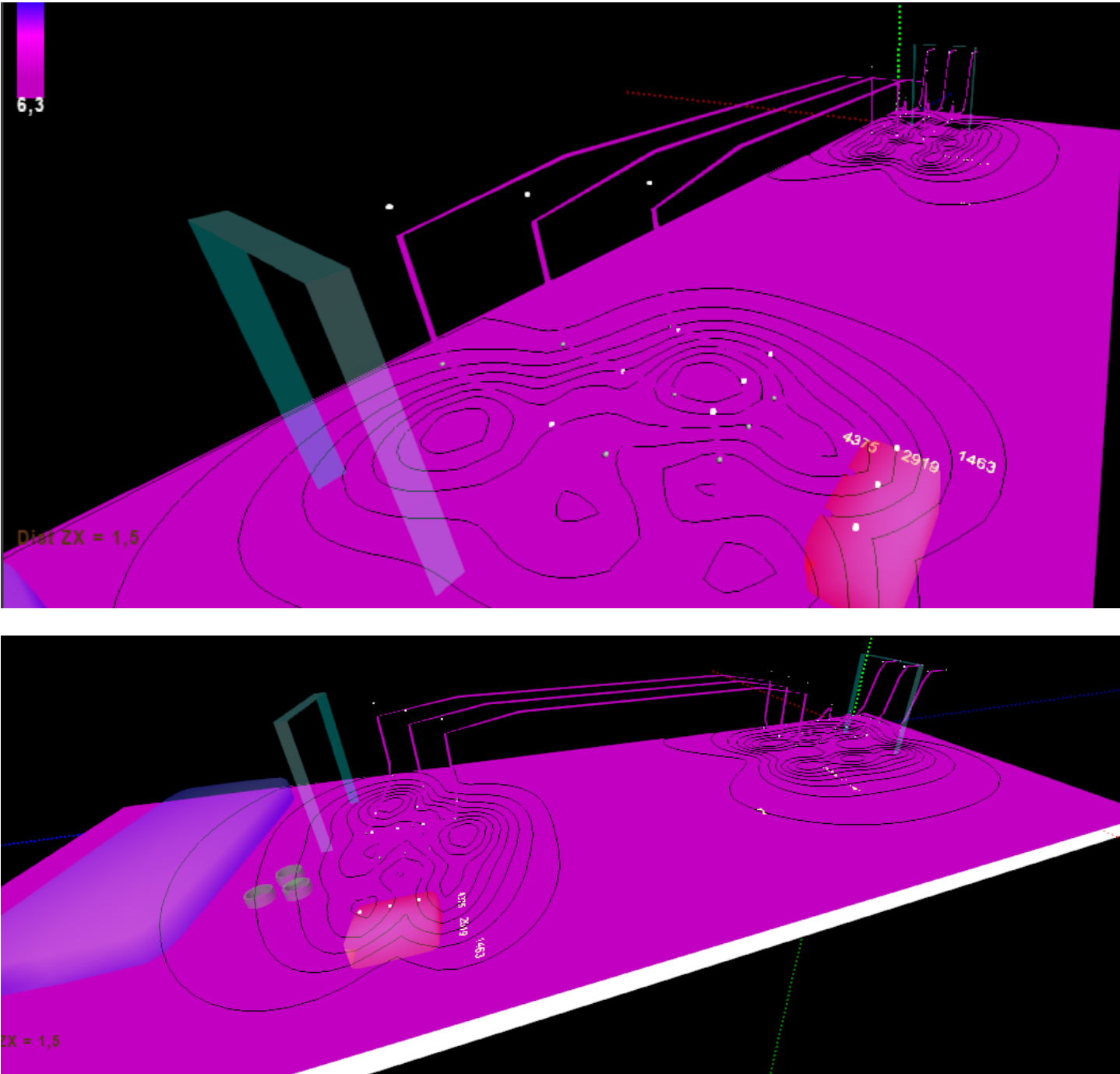


TABLE 7	ELECTRIC FIELD MAPPING	subST_01_ISI
For future use		

Figure 17

ELECTRIC FIELD MAPPING

INPUT DATA AND RESULTS

subST_01_OneHalfCB

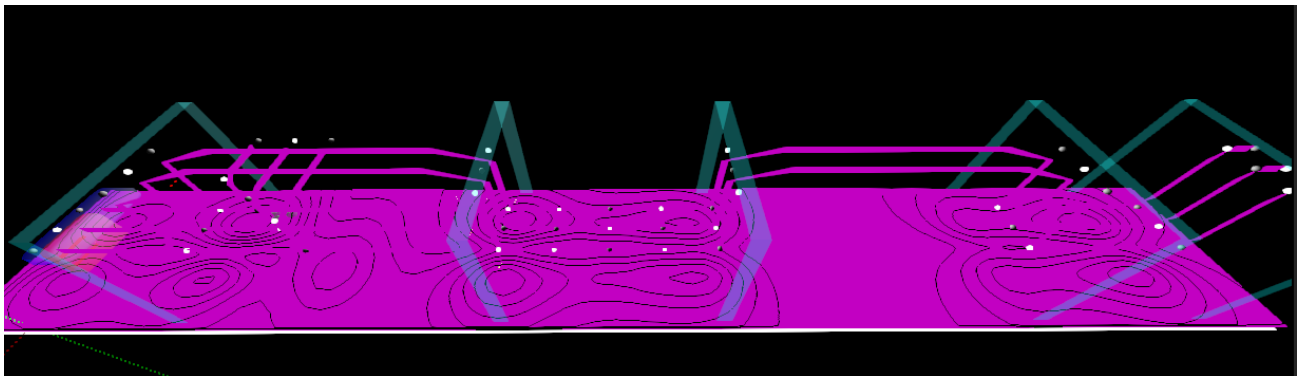
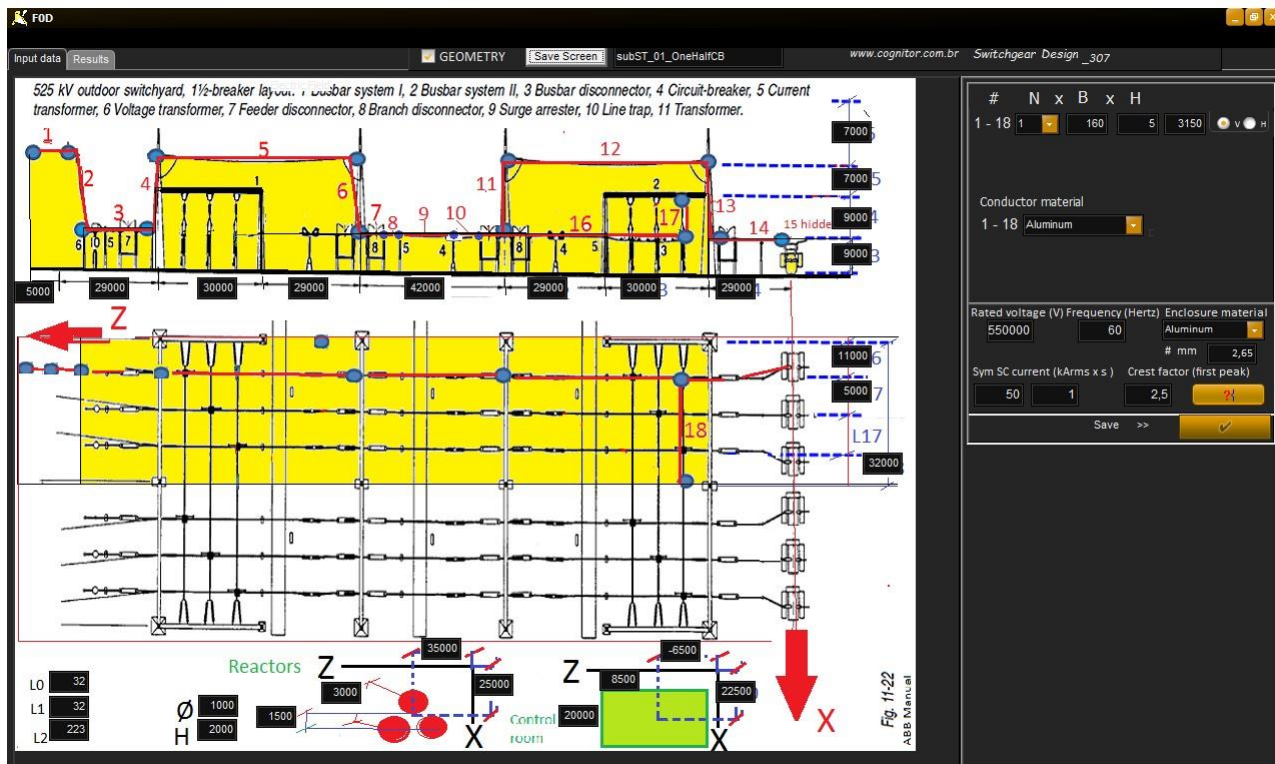


TABLE 8

ELECTRIC FIELD MAPPING

subST_01_OneHalfCB

Figure 7	ELECTRIC FIELD MAPPING
INPUT DATA AND RESULTS	MVSW1_02_M_R65111

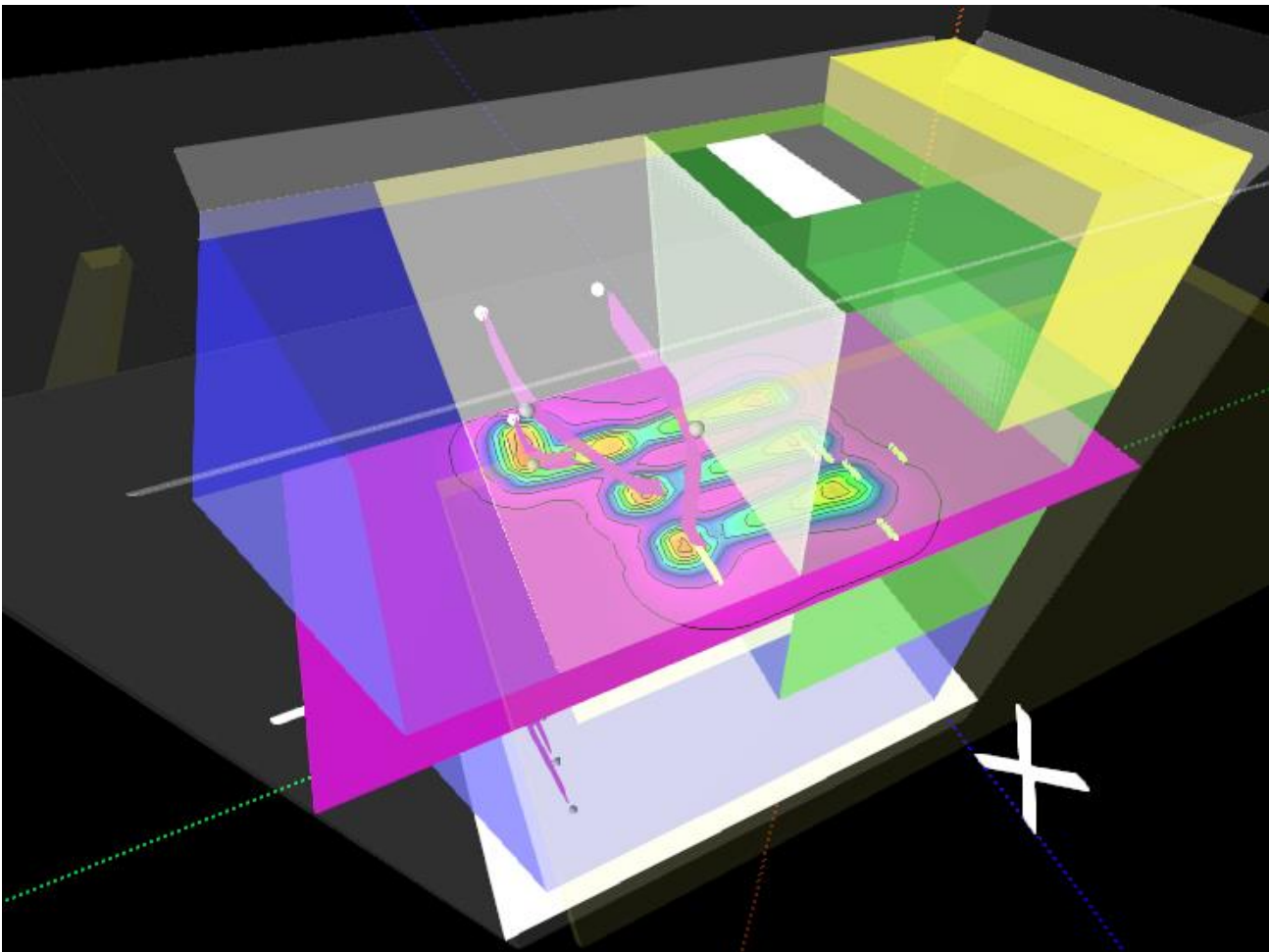


TABLE 9	ELECTRIC FIELD MAPPING	MVSW1_02_M_R65111
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Figure 8	ELECTRIC FIELD MAPPING
INPUT DATA AND RESULTS	Duct_04_ISI_ET_validate

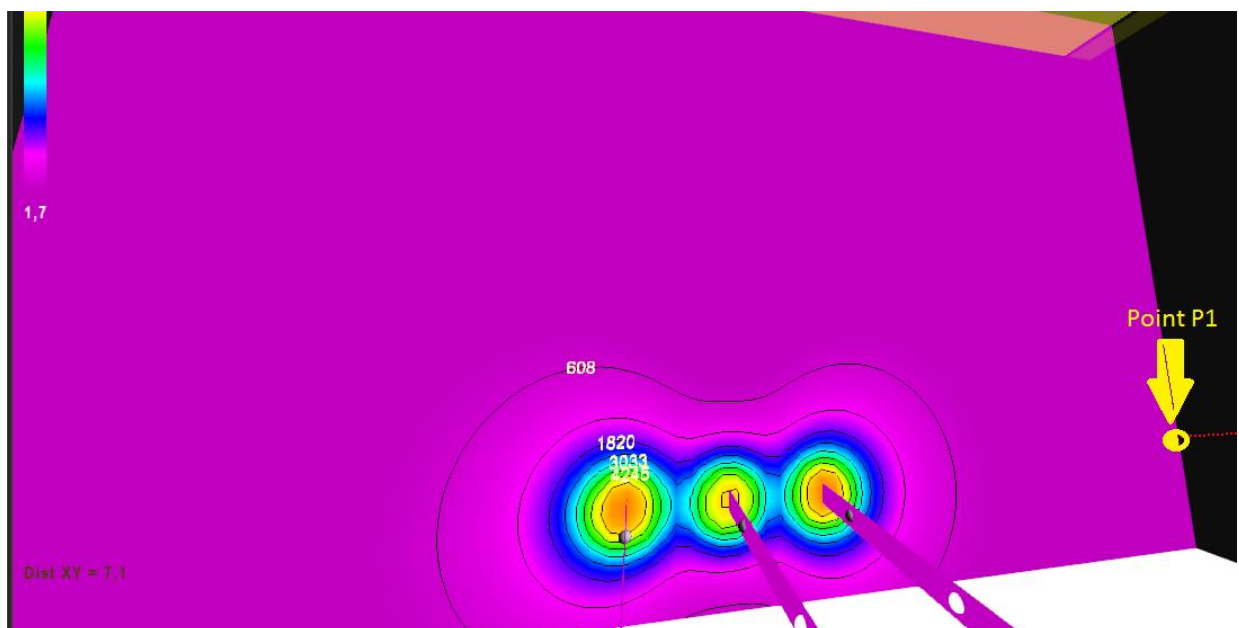
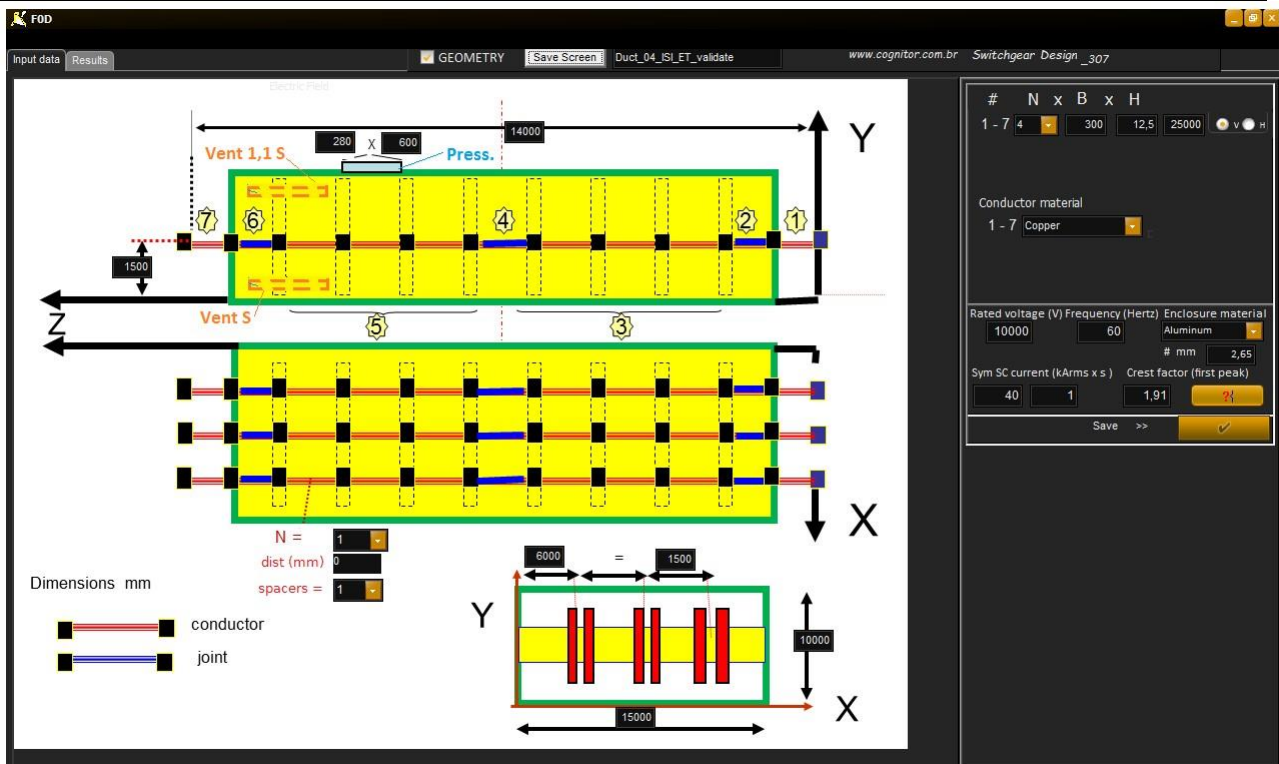
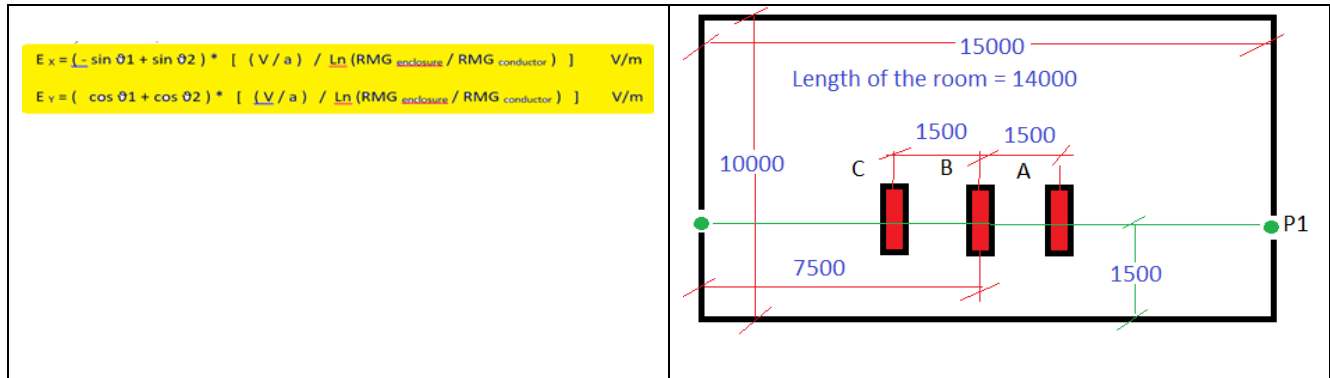


TABLE 10

ELECTRIC FIELD MAPPING

Duct_04_ISI_ET_validate

Doing the same done under Table 3 but using – for each phase - the formula below we calculated the value of the electric field at a point P1 near a straight conductor, with an open phase to phase voltage 10.000 V (divided for 1.732 to ground) by the equation below. This handmade calculation intends only to give an idea of values using this equation to calculate a non-symmetrical situation. The conductors are not in the center of the enclosure. The software takes this into account but the equation alone not. We used a conductor, per phase, 3x 300x12,5mm (RMG = 86,5 mm) and RMG enclosure = 0.227 * (10 + 15) = 5,67 m



Case	Calculation	Calculated Field in point P1	Value obtained in SwitchgearDesign
Three phase open circuit with 10.000 V phase to phase (A,B and C)	230 (angle 0) + 184 (angle 120) + 153 (angle 240)	67 V/m	135 V/m
Two phase open circuit with 10.000 V phase to phase (A and B)	230 (angle 0) + 184 (angle 120)	210 V/m	299 V/m
Single phase open circuit with 10.000 V /1,732phase A to ground	230 (angle 0)	230V/m	335V/m

3. CRITERIA FOR ACCEPTANCE OF SIMULATION RESULTS.

See reference criteria in Annex F.

4. REQUIREMENTS OF THE OPERATING SYSTEM

There are no special requirements for computers. Throughout the several courses already applied, the software worked properly.

5. PROGRAMMING LANGUAGE

The software was developed originally in Delphi 7 (formerly Borland and now Embarcadero) and the most recent version is compiled in Delphi 10

6. INSTRUCTIONS FOR INSTALATION AND USE.

The conditions of use are “usage is at your own risk”. The author of the software and Cognitor are not responsible for any result or use given to the results.

After downloading or copying the file SetUp_SwitchgearDesignEN.zip installation (size of 4.2 MB) save it to some directory on your computer.

To install SwitchgearDesign_307 unzip the file and then click the right mouse button on the uncompressed file and then click with the left button on “Run as Administrator”.

Give OK on everything and when prompted for the password during the installation type para150413kalo

After installation, a SwitchgearDesign icon will be created on the “desktop” and in the list of programs start button.

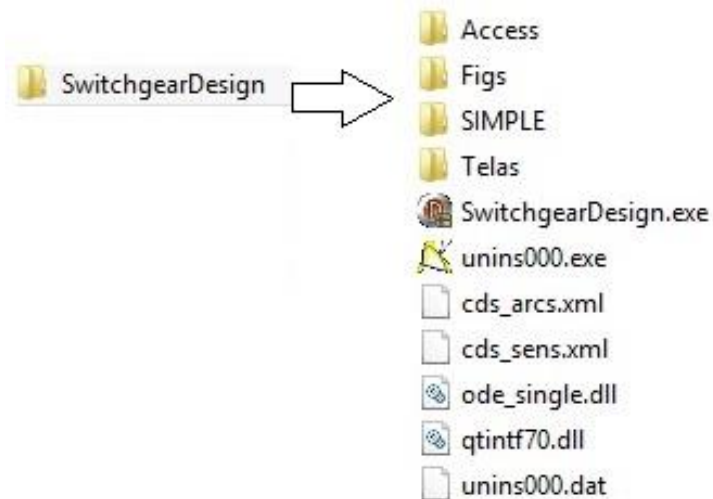
On your computer a single directory c:\SwitchgearDesign will be created where the all the necessary files will be installed.

If it is not automatically created, you may create a desktop shortcut to the file

C: \ SwitchgearDesign \SwitchgearDesign.exe

The SwitchgearDesign.exe file, the tables of the database and all other files will be installed in this directory and its subdirectories. Nothing more will be installed outside this directory.

Here is what you will see:



This installer was designed intending to enable the software to work fine on all computers and operating systems. Although we already have it installed on, many different computers sometimes when installed on, another PC may be necessary to add files. A typical error message is ... “This file is missing.”

Therefore, if an error occurs in the installation note the error message and send an email sergiofeitoza@cognitor.com.br.

This software, as provided in the training program is for use only within the participant’s company who received the installer. Passing on copies to others without written authorization from Cognitor is not permitted.

7. [Annex A – REFERENCES \(ARTICLES AUTHORED OR CO-AUTHORED BY SERGIO FEITOZA COSTA\)](#)

Check the complete list here <http://www.cognitor.com.br/download.htm>

[0] Co-author of the brochure CIGRE 602 / 2014 TOOLS FOR THE SIMULATION OF THE EFFECTS OF THE INTERNAL ARC IN TRANSMISSION AND DISTRIBUTION SWITCHGEAR

http://www.e-cigre.org/Publications/ru_pu.asp

[1] Report 074/2014 VALIDATION OF MAGNETIC & ELECTRIC FIELDS MAPPING & TEMPERATURE RISE TESTS SIMULATIONS.

<http://www.cognitor.com.br/TR074ENGValidationTempRise.pdf>

[2] Report 071/2014: VALIDATION OF SOFTWARE SWITCHGEARDESIGN_307 FOR SIMULATION OF HIGH POWER TESTS (TEMPERATURE RISE, SHORT TIME AND CREST CURRENT TESTS – ELECTRO DYNAMICAL FORCES / STRESSES AND OVERPRESSURES FROM INTERNAL ARC)

http://www.cognitor.com.br/TR_071_ENG_ValidationSwitchgear.pdf

[3] Book “Reference text for the courses SWITCHGEAR, BUSWAYS & ISOLATORS and SUBSTATIONS AND LINES EQUIPMENT” (available also in Spanish and Portuguese in the site)

http://www.cognitor.com.br/Book_SE_SW_2013_ENG.pdf

[4] A "GUIDE" FOR THE USE OF CALCULATIONS AND SIMULATION OF LABORATORY TESTS FOR INCREASING THE COMPETITIVENESS OF THE ELECTRIC INDUSTRY

http://www.cognitor.com.br/Article_Competitvity_Eng_04102011.pdf

[5] “VALIDATION OF SIMULATIONS OF ELECTRODYNAMICAL FORCES, TEMPERATURE-RISE AND INTERNAL ARC TESTS IN SWITCHGEAR (& main parts of a code) (2010)

Presented at the CIGRE Technical Seminar "Modeling and Testing of Transmission and Distribution Switchgear" March 24, 2010 Brisbane – Australia

Download: http://www.cognitor.com.br/Validation_Simulations_English.pdf

[6] “SIMULATION, IEC STANDARDS AND TESTING LABORATORIES: JOINING THE PIECES FOR HIGHER QUALITY HV EQUIPMENT”.

Paper published PS1-06 in the CIGRÈ International Technical Colloquium - Rio de Janeiro - September

2007 http://www.cognitor.com.br/Artigo_Cigre_SergioFeitozaCosta_Cognitor.pdf

Published also in in Energy Pulse weekly, September, 28 , 2010

http://wwwenergypulse.net/centers/article/article_display.cfm?a_id=2338

[7] “SIMULATIONS AND CALCULATIONS AS VERIFICATION TOOLS FOR DESIGN AND PERFORMANCE OF HIGH-VOLTAGE EQUIPMENT”

Co-authors: M. Kriegel, X. Zhu, M. Glinkowski, A. Grund, H.K. Kim, P. Robin-Jouan, L. Van der Sluis, R.P.P. Smeets, T. Uchii, H. Digard, D. Yoshida, S. Feitoza Costa

CIGRE WG A3-20 publication A3-210 (2008) - Presented at Congress Cigre - Paris 2008

http://www.cognitor.com.br/Cigre_Paris_A3_210_2008.pdf

[8] SIGNIFICANT PARAMETERS IN INTERNAL ARC SIMULATION AND TESTING,

CIGRE WG A3.24, CIGRE A3 SESSION, 2009

Co-authors: M. Kriegel, R. Smeets, N. Uzelac, R. Pater, M. Glinkowski, P. Vinson, S. Feitoza Costa, G. Pietsch, E. Dullni, Th. Reiher, L. van der Sluis, D. Yoshida, H.K. Kim, K. Y. Kweon, E. Fjeld,

[9] Paper FINDING THE OPTIMAL SWITCHGEAR DESIGN: A comparison between aluminum and copper and an idea of new concept.

Co-authors: Sergio Feitoza Costa & Marlon Campos

Also published in Portuguese in January 2014 in Magazine Revista O SETOR ELÉTRICO “as ALUMINIO X COBRE EN PROYECTOS DE LOS PANELES ELÉCTRICOS (PÁGINA 136)

In English : <http://www.cognitor.com.br/DesignOptimization.pdf>

[10] HOW CAN IEC STANDARDS HELP TO REDUCE THE GAP BETWEEN DEVELOPED COUNTRIES AND OTHER COUNTRIES?

<http://www.cognitor.com.br/ProposalToIEC.pdf>

[11] VALIDATION OF TEST REPORTS ISSUED BY RECOGNIZED TESTING LABORATORIES

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

[12] SWITCHGEAR , BUSBAR SYSTEMS and ITS BUILT-IN COMPONENTS: SOMETHING IS MISSING IN IEC and IEEE STANDARDS

Published in Energy Pulse weekly, September, 28 , 2010

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

http://www.energypulse.net/centers/article/article_display.cfm?a_id=2338

[16] Free Software DECIDIX SOFTWARE FOR THE TECHNICAL ECONOMICAL ASSESSMENT OF ENERGY PROJECTS

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

17) INDUCING AND ASSESSING NEW TECHNOLOGIES FOR THE ELECTRIC INDUSTRY OF DEVELOPING COUNTRIES

<http://www.cognitor.com.br/InducingNewTechnologiesSubstationEN.pdf>

In Spanish and In Portuguese:

See and download in <http://www.cognitor.com.br/download.htm>

8. Annex B - TECHNICAL STANDARDS OF REFERENCE

- [1] IEC 62271-200 Ed. 2.0 b:2011 : 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
- [2] IEC TR 60890: A Method of Temperature-rise Assessment by Extrapolation for Partially Type-Tested Assemblies (PTTA) of Low-Voltage Switchgear and Controlgear
- [3] IEC 61117: Method for assessing the short-circuit withstand strength of partially type-tested assemblies (PTTA)
- [4] IEC 60865-1: Short-circuit currents – calculation of effects – Part 1: Definitions and calculation
- [5] IEC 60865-2: Short-circuit currents – calculation of effects – Part 2: Examples of calculation
- [6] IEC TR 60943: Guidance concerning the permissible temperature rise for parts of electrical equipment, in particular for terminals
- [7] CIGRE Brochure No. xxx, 2014, “Tools for the simulation of effects of the internal arc in MV and HV switchgear”
- [8] IEC 61439-1 Ed. 2.0 (2011) – Low-voltage switchgear and controlgear assemblies - Part 1: General rules
- [9] IEC 61439-2 Ed. 2.0 (2011) – Low-voltage switchgear and controlgear assemblies - Part 2: Power switchgear and controlgear assemblies
- [10] IEC TR 61641(2008) – Enclosed Low Voltage Switchgear Assemblies – Guide for testing under Conditions of Arcing due to Internal Fault.
- [11] ABB Switchgear Manual - ABB Pocket Book - Switchgear Manual - 10th revised edition
Edited by ABB Calor Emag Schaltanlagen AG Mannheim and ABB Calor Emag
Mittelspannung GmbH Ratingen - Previous editions: (published till 1987 by BBC Brown Boveri, since 1988 by ABB) - First edition 1948 - <http://pt.scribd.com/doc/23692182/ABB-Switchgear-Manual-11th-Ed-2006>
- [12] Sergio Feitoza Costa's M.Sc. thesis on Electrodynamic Forces at
<http://www.cognitor.com.br/electrodynamic.pdf> COPPE / UFRJ – Janeiro - 1981

9. [Annex C – COMPARISON WITH IEC STANDARD](#)

Not applicable

Blank space

10. [Annex D – COMPARISON WITH LAB TEST REPORTS.](#)

Not available

Blank space

11. [Annex E - TYPES OF CALCULATION WHICH ARE POSSIBLE WITH SWITCHGEAR DESIGN AND TYPES OF EQUIPMENT](#)

LVSW_1 : Low voltage switchgear - compartment with circuit breaker

LVSW_2: Low voltage switchgear - drawers bars

MVSW_1; medium voltage AIS

DUCT_1: Bus duct LV or MV

SWITCH: isolator FUSE_1: MV or LV fuse

SubST, SubstISI, Subst_2 - substation arrangements

ACI_1 and ACI_2 - MV voltage switchgear

ACI_3 and ACI_4 - LV voltage switchgear

GIS_1ph - GIS SF6 single bar and GIS_3ph - GIS SF6 Three phase

12. [Annex F - TECHNICAL STANDARD \(GUIDE\) FOR THE APPLICATION OF SIMULATION TO REPLACE SOME LABORATORY TESTS](#)

1.1 – Introduction

This text was prepared in 2010 by Sergio Feitoza Costa, as a formal proposal for IEC and to the Brazilian National Standardization Committee to be the basis of a new Standard. Although the proposal had the support of around 25 relevant companies, the BNSC decided not to do the standardization work. Now, 5 years later, the concepts showed in this text are now referred or used in Cigré publications and in IEC standards as IEC 62271-307 .

The old concept that "everything must be laboratory tested" was replaced by the low-cost computing capabilities. Today the concept of "test everything" is defended only by a few who understand that they would lose with the widespread use of simulations. It is a short-term thinking. For example, electrical testing laboratories and certification companies can add to their experience in testing the great potential of simulations to produce profitable and useful services.

A testing laboratory that can demonstrate by comparison (validation) that simulations provide approximately the same results as the tests can add a good source of funds doing, in addition to testing, services using simulations. To build a large laboratory cost more than fifty hundred million dollars and that is why the tests are expensive. As a private business is not always an attractive investment and due to this reason there are few laboratories in the world.

Some of the major worldwide manufacturers have testing laboratories in their countries of origin. This is their differential to develop own products using many simulations combined with tests. They have well-prepared development technical teams. Outside their countries of origin, they do not develop nearly anything new. Only mount equipment without adding technology. The use of simulations allows medium and small manufacturers to become more competitive and they are really becoming better.

Using simulations of electrical testing is a realistic solution increasingly well accepted. To replace tests by calculations or simulations is not new idea. It is applied for decades in technical standards such as IEC 60076 - Power Transformers (short tests), IEC 61439 (low voltage switchgear) and the previous IEC 60439.

For example, IEC 61439 is possibly the most advanced world standard in the use of innovative concepts. It allows the substitution of certain tests by the use of simulations and, more than this, by the so called "design rules". The concept is that if an equipment is similar to another one already tested in laboratory and attend to certain rules you do not need to test it.

For medium voltage, switchgear there is a very important work, of the same nature, in progress in IEC. The working group WG 31 IEC / SC 17C is preparing new document IEC / TR 62271-307: High-voltage switchgear and controlgear - Part 307: Guidance for the extension of validity of tests of type AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV. Sergio Feitoza is a member of the IEC working group preparing this standard, expected for publication in July 2015.

The way to speed up the systematic use of simulations is through the preparation of an IEC standard roughly with the text presented in the paragraphs to follow. Here we call this "future" standard of [SIMULATIONS APPLICATION GUIDE \(Guide\)](#).

The reader may download the full text prepared by Sergio Feitoza in the site http://www.cognitor.com.br/GUIDE_Simulations_v0_October2010.pdf .

Since this guide does not yet exist as a formal standard, an interesting action for many countries is to establish a commission in their National Standards Association to implement it. An example of action of this nature is in Colombia where it was implemented a government regulation that allows, under certain conditions, the use of calculations and simulations.

12.2) FOREWORD (of the Application Guide for Simulations)

Laboratory type testing, as specified in product standards, is the most efficient way to verify if a certain product attends the technical standard specification. High power tests as the internal arc tests, temperature rise test and short time withstand current test are onerous and time consuming. There are relatively few laboratories in the World with capacity to do them.

Testing simulation techniques may predict results of several type tests. In many cases, they enable to obtain more complete information than the information obtained in a real laboratory testing. Simulations are useful in situations like:

- (a) to avoid switchgear tests in equipment with characteristics near to another one already tested
- (b) To avoid duplication of testing on product certification processes, when doing small changes in an already certified product.
- (c) To replace SF6 by air in internal arc tests.

Within certain limits, testing simulation may be used to extrapolate the results of an already done laboratory test to other, with similarities, untested equipment. This can be done in an easier or more complex way depending on the type of test.

For temperature rise tests, the simulation to replace a test is relatively simple to perform and to validate. You need only to compare the results of simulations with measurements of temperature rise shown in the reports of laboratory tests.

For internal arcs tests in switchgear the task is more complex but possible. What is to be checked are the effects of the overpressures arising during the arc and the risks to persons in the neighborhood.

The curve overpressure x time is the decisive agent for the good or bad test result but IEC's standard do not request this easy measurement to be made and recorded in the test report. A lot of useful information in the tests is lost due to this omission in the IEC standard.

The brochure CIGRE WG A3.24 "TOOLS FOR THE SIMULATION OF EFFECTS IN INTERNAL ARC MV AND HV SWITCHGEAR" was published in 2014 after a work started in 2009. There are several case studies supported by laboratory tests allowing the validation of internal arc simulations.

In section B.4 of this important document of CIGRÉ, this SIMULATION APPLICATION GUIDE prepared Sergio appear in the "references"

[Feitoza2010]: S. Feitoza, "Guidelines for the use of simulations and calculations to replace some tests specified in international standards". COGNITOR Guide 2010.

For short-time withstand current and peak withstand current tests the objective is to verify the supportability to the effects of electro dynamical forces on insulators and conductors occurring during a short circuit without arc. To calculate the forces and stresses is not a so complex task but to measure them

is very difficult and onerous. Nevertheless, the calculation methods are used for many decades and well accepted in the technical world.

The main reference for validation, in this case, is the document IEC 61117: Method for Assessing the short-circuit withstand strength of partially type-tested assemblies (PTTA). There is no known way to do validation of simulations electrodynamic forces through laboratory test reports. By the same reason the IEC 61439 and IEC 62271-307 documents also reference IEC 61117.

The greatest difficulty in validating simulation methods of electrical testing is that some simple measurements are not specified in IEC standards to be made during the laboratory tests. Reliable information for comparison between test results and simulation data is missing. Most of the testing laboratories do not perform measurements not requested in the technical standards, whether simple to do. However, some do it when requested by the customer before.

The purpose of this Guide is to provide guidelines for the systematic use of simulations used to replace some laboratory tests in situations where common sense indicate to be reasonable to do it.

The guide present the parameters that shall be recorded in laboratory tests to allow the future use of simulations in the extrapolation of the test results.

The Guide also indicates the typical values of acceptable tolerances for the values calculated in comparison with the results obtained in the test report.

12.3) SCOPE AND CONTENT (of the Simulations Application Guide)

This Guide presents Guidelines for the systematization of the use of simulations and calculations (from now on named “simulations”) which may be used to replace some laboratory tests in situations where the common sense shows it is reasonable to use it. The most frequent case of such use of simulations is in the extrapolation of real test results done in a certain equipment to predict the results of a test in untested equipment with characteristics close to the tested one.

The use of simulations to replace tests is possible only when certain specific measurements and registers are specified in the relevant product standards and are presented in the laboratory test report. This Guide specifies minimum measurements and photographic registers that shall be done and registered in test reports, during laboratory tests specified in product standards.

These measurements make the test to be reproducible and usable for future simulations. These measurements and registers also help users to identify if a commercialized product is similar to the laboratory-tested one. Currently, there is a lack of data for the validation of simulations results by comparison with real test results. It is expected that with few simple additional measurements and registers here specified, to be used in product standards, the amount of available data will increase significantly, in the short term. This Guide presents some examples of input data and results, which can be used as a calibration to demonstrate that a certain simulation model is acceptable for the extrapolation of the laboratory test results.

It is not an objective of this Guide to present calculation methods for testing simulation.

A model or method is acceptable if produces simulation results within acceptable tolerances, if compared with the real test results and this is demonstrated in a transparent way to the users. The acceptance of simulations results by users is easier when the number of input variables of the simulation model is smaller

and based in the geometry and materials properties of the conductors, insulation and fluids. The reproducibility of the calculation method is the key point.

Although the simulation concepts here presented are valid for any electrical equipment, in the current stage, the simplest visible applications of it are in high and low voltage switchgear, transformers, fuses and bus-bar systems.

12.4) SOME DEFINITIONS (of the Simulations Application Guide)

12.4.1 – Temperature rise test (concept)

The equipment is installed in a place free of air drafts. The rated current is applied for a time sufficient to have the temperature stabilization of the measured points. The measured temperature rise should not go beyond certain limits specified in the technical standard.

The results are influenced by the current flowing, the type of materials, the contact resistances, the temperature of the fluid, the geometry of the conductors, net internal volume of the enclosure and the existence of partitions and ventilation openings. The contact resistance and ventilation areas are key factors in the results. The test is reproducible only if the major resistances are registered. It is necessary to measure not only the total resistance per phase but also the higher resistance like a switch, circuit breaker key or fuse as seen from its terminals

12.4.2 - Short-time withstand current and peak withstand current tests (concept)

These tests check the effect of the forces and high temperatures applied to the isolators and conductors during a short circuit. It is possible to calculate the mechanical forces acting on insulators (compression, tension and bending) and the mechanical stresses on the bus bar conductors using the expressions shown in [5] and references methods in Annex A and Annex B [14, 15, 16, 22 and 23].

The forces must remain below the limits specified by the manufacturer of the insulator otherwise, it can be destroyed. The mechanical stresses in the conductors must remain below certain limits (of the order of 200-250 N / mm² for copper according to the same reference above) otherwise the bars will suffer a permanent and visible deflection.

The results are affected by the short circuit current, the materials, and the geometry of the conductors, distances between phases and the types of insulators.

12.4.3 – Internal arc tests and overpressures (concept)

The idea is to create an arc along a certain time duration. The consequences of the overpressures are observed. Some of the requirements for passing in the test are the evidence that the doors will not open allowing hot gases and the gases expelled out through the pressure relief parties should not burn cotton indicators placed near the accessible parts that simulate the skin of a person in the vicinity. Holes on the outer walls, caused by the arc, are not allowed.

The equipment is approved in testing if the effects of overpressure caused by the arc does not lead to potential risks to people nearby.

Issues to consider and assessment methods are in IEC 62271-200 (medium voltage - Ref. 12) or IEC TR 61641 (low voltage - Ref. 21).

For air, insulated switchgear the main cause of failures during tests is the burning of the horizontal cotton indicators due to reflections of the hot gases in the ceiling.

The main factors that influence the results are the voltage, current, net internal volume, relief area and time of operation of the pressure relief devices. Ventilation openings, good in temperature rise tests are an example of a potential way for the exit of the hot gases, burning cotton indicators.

12.4.4 – Validation of a simulation or calculation method or a laboratory test and tolerances.

A method of comparison between the results showed in a well-documented test report issued at a test laboratory and the results of a simulation method.

A simulation method is generally acceptable, from the point of view of users, when it is reproducible and gives a difference between simulation and laboratory results not higher than a certain acceptable tolerance.

Table 1 – Tolerances between test results and simulation results

Type of test	Parameter to compare	Typical values of acceptable tolerance
Temperature rise test	Temperature rise in solid and fluid parts	1% to 5%
Internal arc test	Overpressure in the enclosure above the atmospheric pressure (crest and duration)	5% to 10%
Short-time withstand current and peak withstand current tests	Electrodynamic forces and mechanical stresses	5% to 15%
Magnetic and electrical field mapping	Module and XYZ components of the field at any point	5%

12.4.5 – Product publication.

Publication covering a specific product or group of related products, for example IEC 62271-200 (medium voltage switchgear) or IEC 61439 (low voltage switchgear).

12.4.6 - Reproducibility of a simulation or calculation method

The capability of to obtain, for a specified set of input data the same test results or the same simulation results in two or more different occasions or two different test laboratories.

12.4.7 - Validation of a simulation or calculation method or a laboratory test.

Method of comparison between the results in a well-documented test report issued by a testing laboratory and the simulation results. The simulation method is acceptable when it is reproducible and shows a difference in relation to the results of laboratory tests unless an acceptable tolerance.

12.4.8 - Minimum input data to be registered in temperature rise laboratory test reports

Equipment is approved during a test if the final measured temperature rises of the parts do not go beyond certain limits dictated by the properties of the insulating and conductive parts. These limits are presented in the relevant product standard.

IEC TR 60943 and IEC 60890 explain the concepts involved.

The data affecting the test and the simulations results are

- The circulating electric current,

- The total power dissipation inside the fluid compartment
- The materials used in the conductor and insulating parts
- The contact resistances and its coatings (total per phase and also the ones of the individual parts like circuit breakers, fuses , isolators)
- The ambient gas or liquid fluid temperature (for example at the bottom , the top and at 50% of the height of the enclosure),
- The fluid velocity
- The geometry and spatial position of the conductors
- The volume of fluid inside the compartments
- The input and output areas for ventilation
- The number of horizontal partitions inside the enclosure if applicable
- The relative position of the equipment in relation to walls, ceiling and neighbor equipment (as presented in IEC 60890)

For the sake of reproducibility, the measurement of the total per phase and partial electrical contacts resistances, before and after the test, shall be registered in laboratory test report. The values of the data above shall be clearly registered in the test report through drawings and photos.

12.4.9 - Minimum input data to be registered in internal arc tests laboratory test reports

Equipment is approved during a test if the effects of the overpressures arising during the arc do not cause potential risks to persons in the neighborhood of the equipment.

The relevant aspects to consider are shown in the relevant product standard. IEC 62271-200 and IEC TR 61641 explain the concepts involved. The curve overpressure x time is the main agent for the good or bad test result.

The data affecting the test and the simulations results are

- The circulating electric current,
- The materials used in the conductor and insulating parts
- The geometry and spatial position of the conductors
- The volume of fluid inside the compartments
- The input and output areas for ventilation and devices to close it during the arc
- The areas for pressure relief after the arc
- The relative position of the equipment in relation to walls and ceiling

For the sake of reproducibility, the measurement of the internal overpressure along the test shall be registered in the laboratory test report.

The values of the data mentioned above shall be clearly registered in the test report through drawings and photos,

12.4.10 - Minimum input data to be registered in short-time withstand current and peak withstand current test report

The objective of the test is to verify the supportability to the effects of electrodynamic forces on insulators and conductors occurring during a short circuit without arc. The verification is verified by visual inspection and measurement of the resistances per phase.

The data affecting the test and the simulations results are

- The circulating electric current,
- The materials used in the conductor and insulating parts.
- The mechanical resistances of the insulators to compression, traction and flexion
- The geometry and spatial position of the conductors

For the sake of reproducibility, the measurement of the total per phase and partial electrical contacts resistances, before and after the test, shall be registered in laboratory test report.

The values of the data mentioned above shall be clearly registered in the test report through drawings and photos,

If visible permanent deformations are identified after the test, photos and an estimate of the maximum permanent sag shall be registered.

12.5) PROCEDURES IN COMMITTEES WHICH PREPARE THE PRODUCT TECHNICAL STANDARDS IN THE NATIONAL STANDARDS ASSOCIATION WHICH IMPLEMENT THE GUIDE

When dealing with subjects relating to the use of simulations or calculations to replace real laboratory tests, in product standards, committees shall follow the provisions of this Guide, which is to be used in conjunction with the ISO/IEC Directives.

The status of the simulation or calculation methods, as well as the acceptable values of tolerances, shall be re-evaluated during the maintenance process.

Committees developing product publications, dealing with subjects covered by this Guide, shall incorporate this Guide into their own publication by reference.

If necessary, they may specify, in their own publications, additional details relevant to their product area.

13. [Annex G - SOFTWARE SwitchgearDesign_307: USER REQUIREMENTS, INPUT and OUTPUT DATA, TRAINING AND CONDITIONS OF USE](#)

The software was created to help to develop equipment for substations (medium and low voltage) mainly panels, cubicles, busways, bus ducts, switches, isolators, and CCMs. It is a unique tool (search Internet and try to find any).

The software SwitchgearDesign_307 applies, to products of IEC 62271, IEC 61439 and IEC 61641 standards and the relevant national standards. For a good use, you must have some experience of electrical design and have understood the concepts shown in the training.

The software allows simulating the following tests:

- Short time and crest withstand current (electrodynamic stress, mechanical stress).
- Internal arc test (calculation of overpressure, burnthrough and supportability)
- Temperature rise tests.
- Mapping of electric and magnetic fields.

The main features are in Table 2.- Characteristics of SwitchgearDesign

Features	
Simulation of temperature rise test	Yes
Simulation of electrodynamic forces	Yes
Simulation of internal arc test	Yes
3D geometry visualization	Yes
Mapping of magnetic and electric field	Yes
Module MVSW1 (medium voltage)	Yes
Modules LVSW1 e LVSW2 (low voltage)	Yes
Module DUCT_1 (busways)	Yes
Module SWITCH (not validated)	Yes
Module GIS_1ph and GIS_3ph	Yes
Database and possibilities to modify, save and create new cases.	Comes with case. User can create as many as needed
Training “In Company”	Yes – Read Section 1

The conditions of use are “usage is at your own risk” The author and Cognitor are not responsible for any result or use given to the results. In this report, there are parts of sheets of test reports made in testing laboratories. There are also pages of other publications useful for validation purposes. Parts covered by black marks are intentionally hidden to avoid identification of names.

[Annex H - Source code of SwitchgearDesign](#)

The link is presented during the “In Company” trainings only.