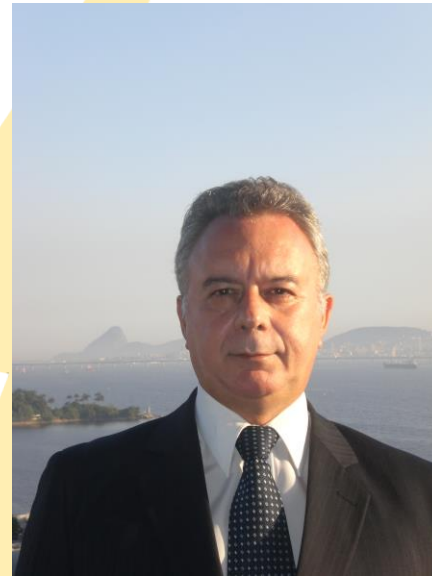


## DESIGN CONCEPTS + software SwitchgearDesign for SWITCHGEAR, SWITCHBOARDS, BUSDUCTS & SUBSTATIONS"



Item 7b1:

Simulations of  
temperature rise  
tests with  
SwitchgearDesign

See also movie in [Item 7b2:](#)



Step by step description on how to use SwitchgearDesign to design switchgear, switchboards, AIS, GIS, busbar systems and substations

in the aspects related to **temperature rise tests**

Test cases validated by laboratory test results and more.

The installer of the software is available in item 4a (complete) and 4b ( only temperature rise) of the list in <http://www.cognitor.com.br/ChaptersEN.htm>



- Review of the main screens and geometry figures
- Main variables
- How to see and analyze the results
- A movie with the sequence is in Item 7b2
  - Creating a new case based on an existing one sent with the installer
  - Changing the data of an existing case of a medium voltage switchgear to the new desired test case
  - Running the case, analyzing the results and viewing 3D.
- Information about validation and validated cases



# Review of the main screens and geometry figures

Project selected

Click here to see the geometry related to the PROJECT TYPE (type of equipment)

Type of test to be simulated

Electric & ventilation data, conductor cross section and enclosure materials

Click INPUT DATA to change the data or click RESULTS to do the calculations and to see the test results

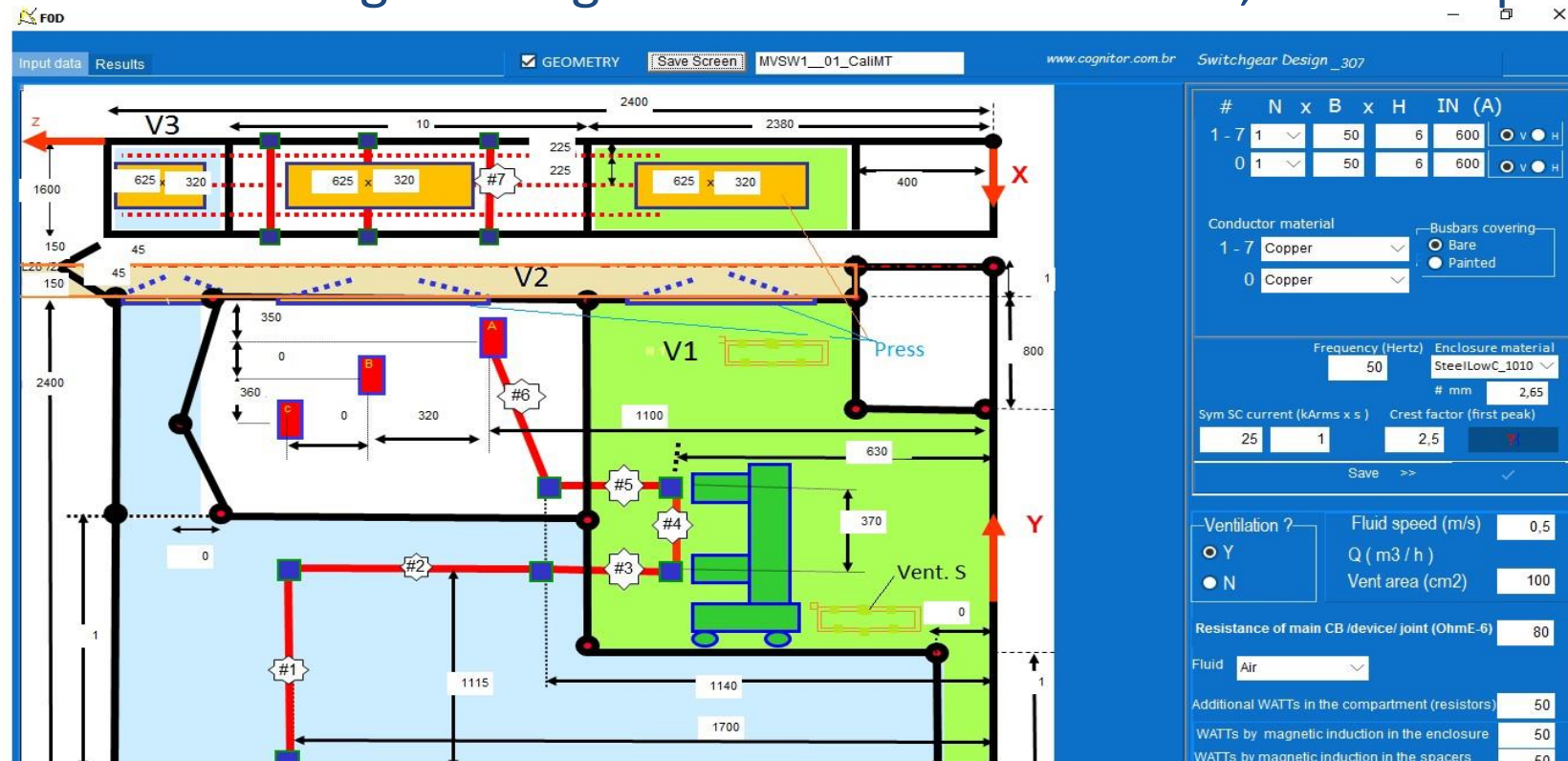
Click the button NEW to create a new project equal to the one which is selected (only the name is different) and then change the data and geometry

Type of equipment project to be simulated (LVSW 1 & 2 = Low Voltage switchgear, MVSW1 – Medium Voltage Switchgear DUCT\_1 = bus way ... ,)

Type of equipment project to be simulated (LVSW 1 & 2 = Low Voltage switchgear, MVSW1 – Medium Voltage Switchgear DUCT\_1 = bus way ... ,)

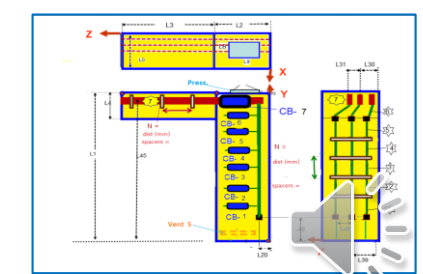
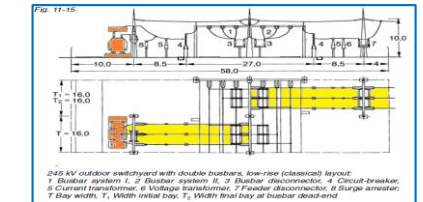
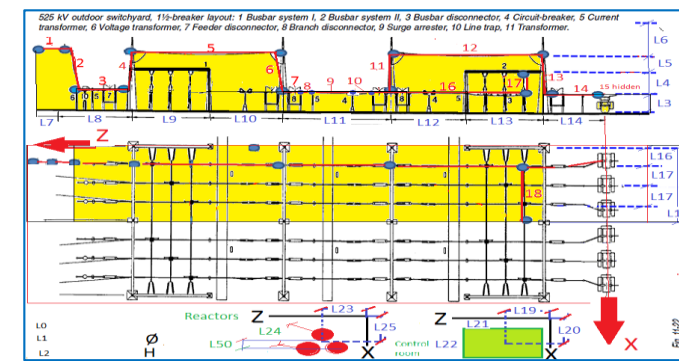
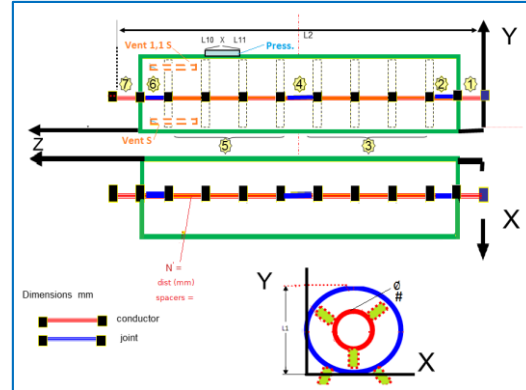
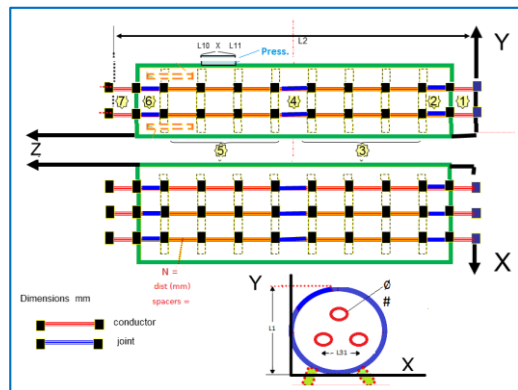
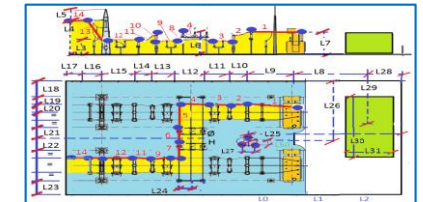
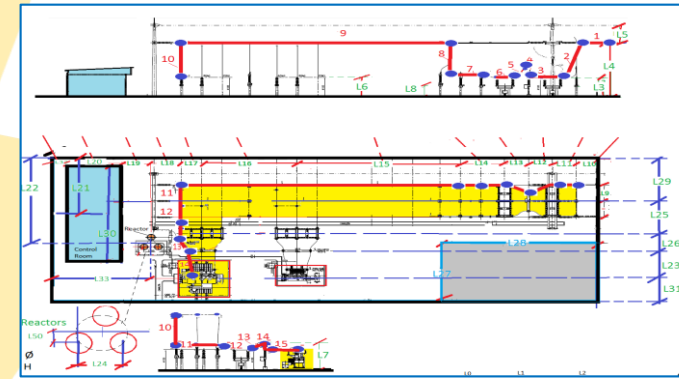
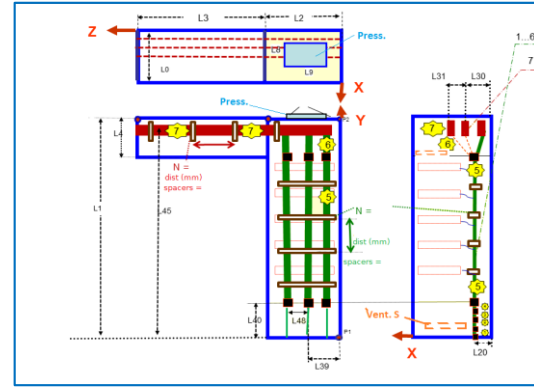
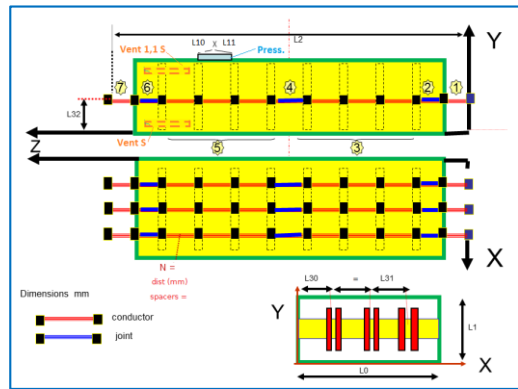
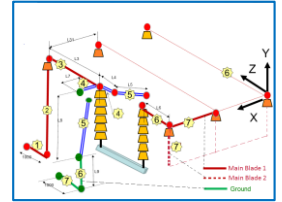
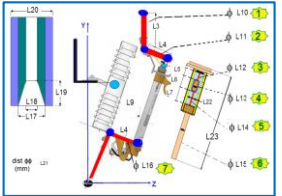
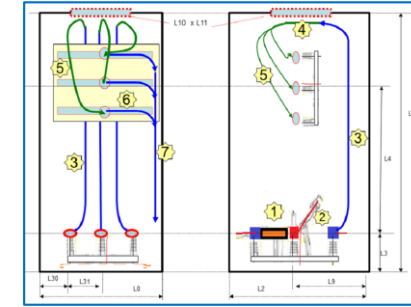
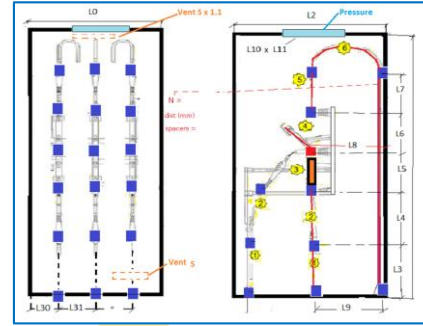
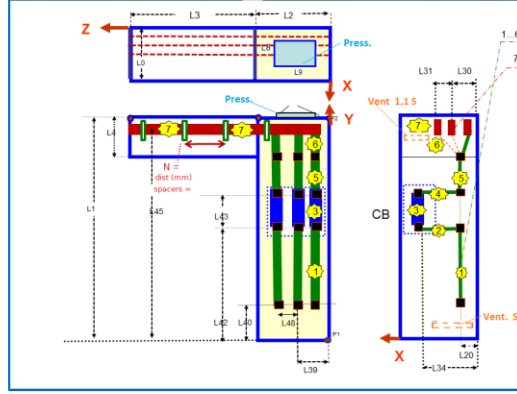
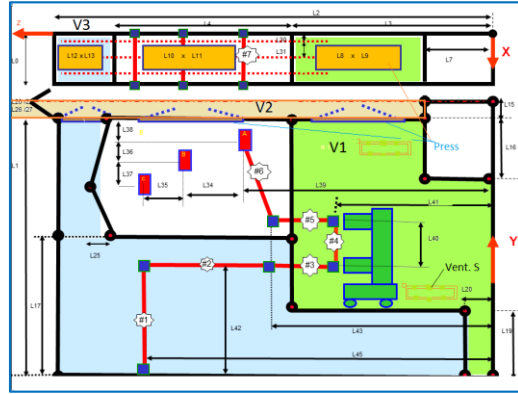
# Geometry figures

- Think “easy” : all types of equipment can be properly analyzed with these “geometry” figures if you are looking for tolerances between rests and simulation results around 5 to 8 %. If you are looking for lower tolerances ask why !!!
- The relevant details are in figure: forget details as rounded bars, colors of painting, etc..





# Other geometry figures



# INPUT DATA

# LOW VOLTAGE SWITCHGEAR

# LVSW\_1

Number of subdivisions in conductor # 7 and corresponding distance between supports (in # 1 to 6 is 1)

The upper line is for conductors # 1 to # 6, in this example 2 bars per phase 127 x 10 mm

The second line is for conductor #7 which in this example 2 bars per phase 127 x 10 mm

Current applied in the temperature rise test (A)

Geometry and dimensions (mm)

The screenshot displays the LVSW\_1 software interface. On the left, a 3D model of a switchgear is shown with dimensions and labels. On the right, a detailed input data form is visible, containing various parameters for the switchgear design.

**Input Data Form:**

#	N	x	B	x	H	IN (A)	Bar in the Horizontal or Vertical position
1 - 6	2		127	9,52	3200		<input type="radio"/> V <input checked="" type="radio"/> H
7	2		127	9,52	3200		<input type="radio"/> V <input checked="" type="radio"/> H

**Conductor material:**  
 1 - 6 Copper  
 7 Copper

**Busbars covering:**  
☐ Bare  
☒ Painted

**Frequency (Hertz):** 60  
**Enclosure material:** Aluminum  
**# mm:** 2,65

**Sym SC current (kArms x s):** 65  
**Crest factor (first peak):** 2,2

**Rated voltage (V):** 176  
**Enclosure material:** Aluminum  
**Fluid (air, SF6, oil ...):** Air  
**Frequency:** 60  
**Short circuit current (kA<sub>rms</sub>), duration (s) and crest factor:** 168

**Resistance of main CB /device/ joint (μhmE-6):** 25  
**Fluid:** Air  
**Additional WATTS in the compartment (resistive):** 783  
**WATTS by magnetic induction in the enclosure:** 783  
**WATTS by magnetic induction in the spacers:** 783

**Ventilation ?**  
☐ Y  
☒ N

**Fluid speed (m/s):** 0,076  
**Q (m3 / h):** 176  
**Vent area (cm2):** 168

**Vent. S**

Bar in the Horizontal or Vertical position

Bar coating: bare, painted

Material: copper, aluminum

Rated voltage (V)  
Enclosure material  
Fluid (air, SF6, oil ...)  
Frequency  
Short circuit current (kA<sub>rms</sub>), duration (s) and crest factor

Circuit Breaker resistance (μΩ)  
Conductor # 2, #3 and #4

Number assigned to each conductor (#1 to # 7) to visualize results

Ventilation area, additional power dissipation (IEC 60890)

## INPUT DATA SCREEN

## BUSWAY

## DUCT\_1

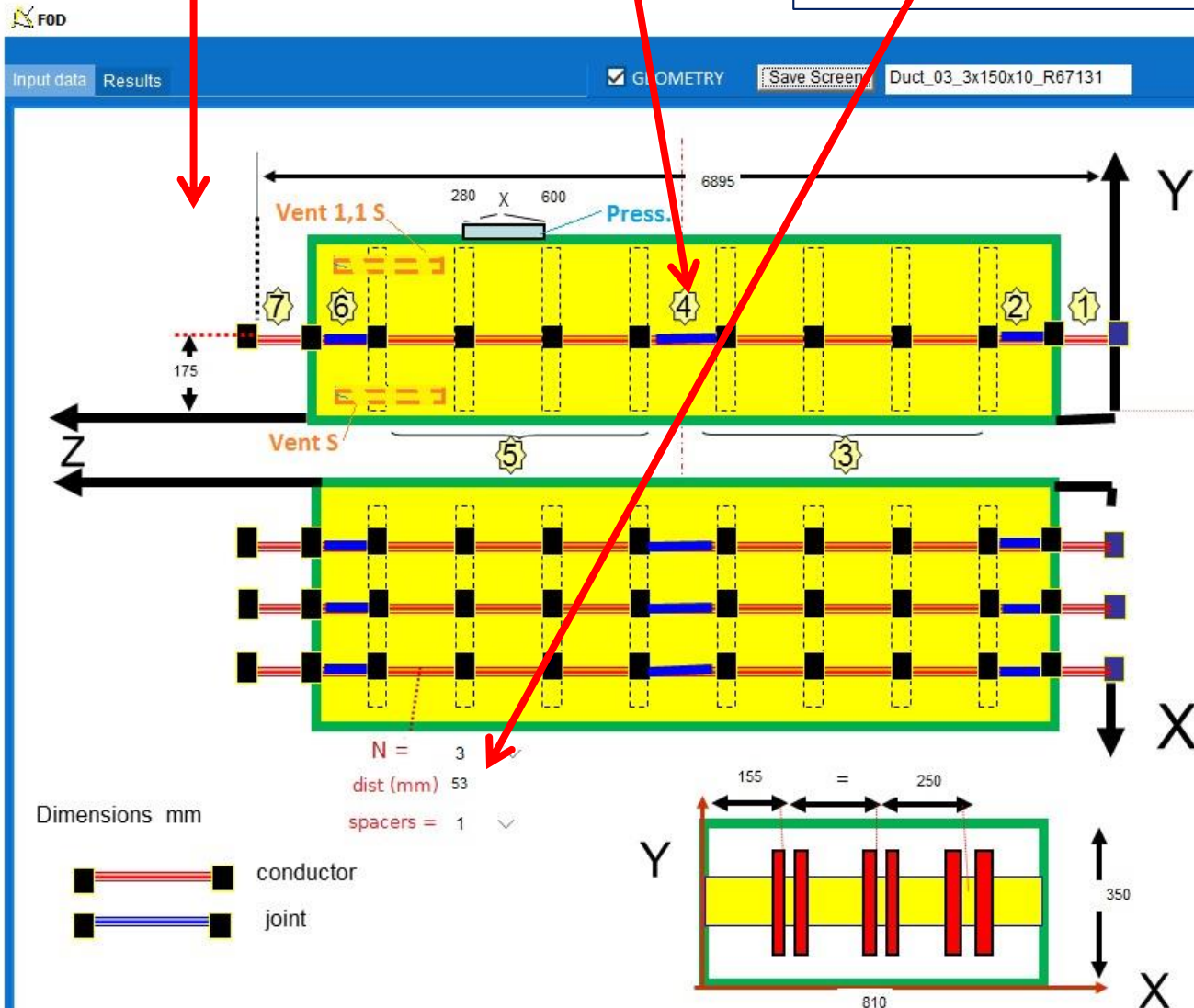
Geometry and dimensions (mm)

Number assigned to each conductor (#1 to # 7) to visualize results

Number of subdivisions in conductors # 3 e 5 and corresponding distance between supports

Conductors # 1 to 7 formed by 3 bars per phase 150x10 mm

Current applied in the temperature rise test (A)



The software interface displays various input parameters for the busway assembly. The parameters are organized into sections:

- General Parameters:**
  - Conductor material: Copper
  - Busbars covering: Bare (selected), Painted
  - Frequency (Hertz): 60
  - Enclosure material: Aluminum
  - # mm: 3
  - Sym SC current (kArms x s): 50, 1
  - Crest factor (first peak): 2,5
- Ventilation ?**
  - Y (selected), N
- Resistance of main CB /device/ joint (OhmE-6):** 7
- Fluid:** Air
- Additional WATts in the compartment (resistors):** 0
- WATts by magnetic induction in the enclosure:** 699868
- WATts by magnetic induction in the spacers:** 653882

Bar in the Horizontal or Vertical position

Material: copper, aluminum

Bar coating: bare, painted

Rated voltage (V)  
Enclosure material  
Fluid (air, SF6, oil ...)  
Frequency  
Short circuit current ( $kA_{rms}$ ), duration (s) and crest factor

Joints resistance ( $\mu\Omega$ )  
Conductors #2,4 e 6

Ventilation openings area (IEC 60890)



# INPUT DATA LOW VOLTAGE SWITCHGEAR LVSW\_2

Geometry and dimensions (mm)

Number assigned to each conductor (#1 to # 7) to visualize results

The upper line is for conductors # 1 to # 6, in this example 1 bar per phase 76,2 x 6,35 mm  
The second line is for conductor #7 in this example 2 bars per phase 127 x 10 mm

Number of subdivisions in conductor # 5 or 7 & corresponding distance between supports ( for others is 1)

Bar in the Horizontal or Vertical position

Current applied in the temperature rise test (A)

Bar coating: bare, painted

Material: copper, aluminum

Rated voltage (V)  
Enclosure material  
Fluid (air, SF6, oil ...)  
Frequency  
Short circuit current ( $kA_{rms}$ ), duration (s) and crest factor

Ventilation area, additional power dissipation (IEC 60890)

The screenshot displays the COGNITOR LVSW\_2 software interface. The top bar includes 'Input data' and 'Results' tabs, a 'GEOMETRY' checkbox, a 'Save Screen' button, and the file name 'LVSW2\_01\_M\_R19901'. The main area is divided into a 3D model on the left and a parameter input panel on the right. The 3D model shows a switchgear layout with conductors numbered 1 through 7. Dimensions like 1600, 800, 400, 800, 450, 2350, 2215, 716, 60, 400, 205, 110, and 280 are visible. The parameter panel on the right contains the following fields:

#	N	x	B	x	H	IN (A)
1 - 6	1	76,2	6,35	800	<input checked="" type="radio"/> H <input type="radio"/> V	
7	2	127	10	3200	<input type="radio"/> V <input checked="" type="radio"/> H	

Below the table, the 'Conductor material' is set to 'Copper' for both groups. 'Busbars covering' options are 'Bare' (selected) and 'Painted'. 'Frequency (Hertz)' is 60. 'Enclosure material' is 'SteelLowC\_1010' with a thickness of 2,65 mm. 'Sym SC current (kArms x s)' is 65 and 1. 'Crest factor (first peak)' is 2,2. A 'Save' button is present. Further down, 'Ventilation ?' has options 'Y' (selected) and 'N'. 'Fluid speed (m/s)' is 0,078. 'Q (m3 / h)' is 0. 'Vent area (cm2)' is 168. 'Resistance of main CB /device/ joint (OhmE-6)' is 0. 'Fluid' is set to 'Air'. 'Additional WATTS in the compartment (resistors)' is 783. 'WATTS by magnetic induction in the enclosure' is 0. 'WATTS by magnetic induction in the spacers' is 0.

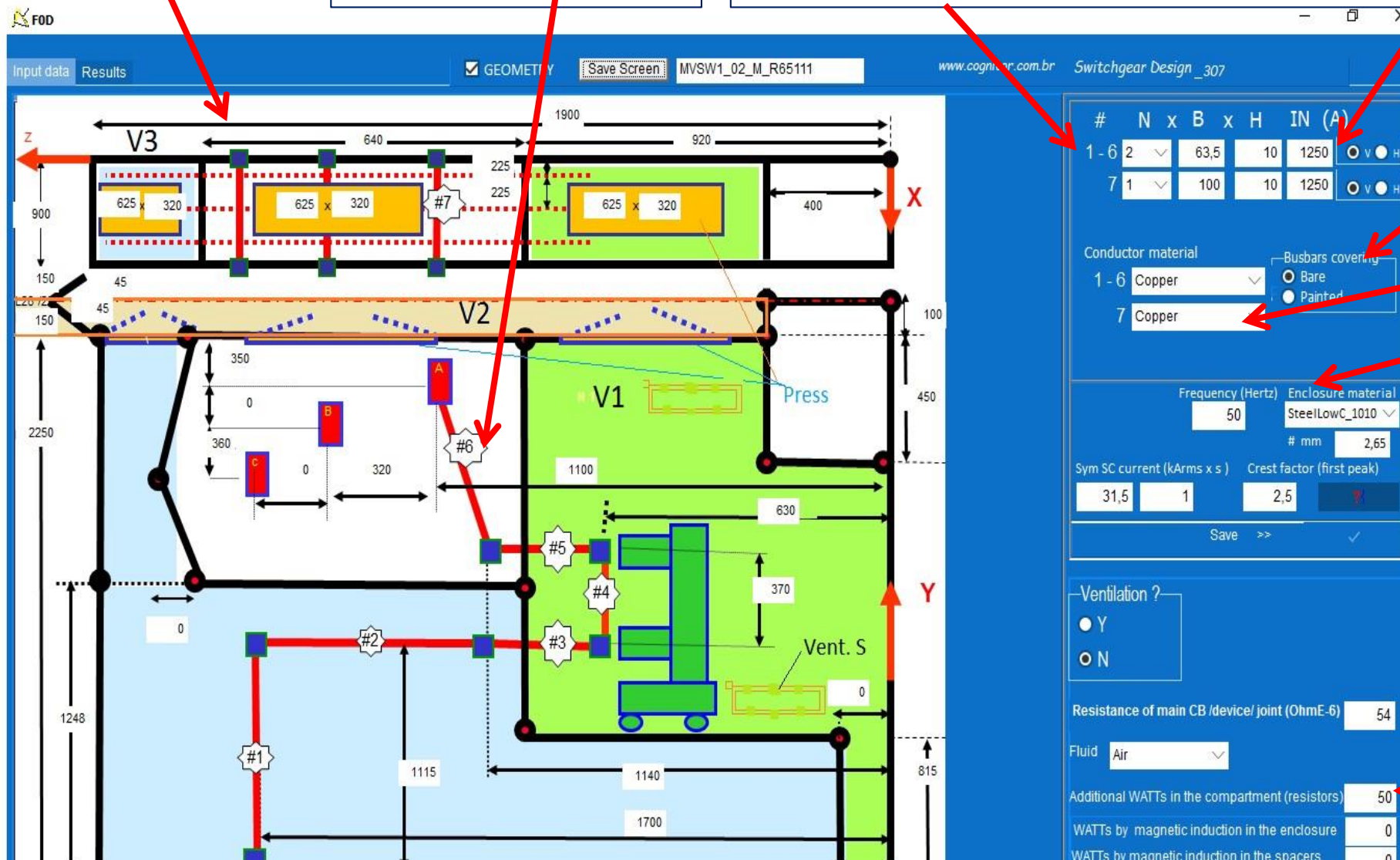
# INPUT DATA MEDIUM VOLTAGE SWITCHGEAR MVSW\_1

Geometry and dimensions (mm)

Number assigned to each conductor (#1 to #7) to visualize results

The upper line refers to conductors # 1 to # 6 , in this example 2 bars of 63,5 x 10 mm. The second line refers to conductor #7 ( here 1x100 x10 mm)

Current applied in the temperature rise test (A)



Bar in the Horizontal position

Bar coating: bare, painted

Material: copper, aluminum

Rated voltage (V)  
Enclosure material  
Fluid (air, SF6, oil ...)  
Frequency  
Short circuit current (kA<sub>rms</sub>),  
duration (s) and crest factor

Circuit breaker (CB)  
resistance ( $\mu\Omega$ ) CB  
represented by conductors  
#4, 5 and 6

Ventilation area, additional  
Watts (IEC 60890)



F0D

Input data Results

☒ GEOMETRY Save Screen GIS3ph\_Fasc9\_3ph www.cognitor.com.br Switchgear Design\_307

280 X 600 Press.

3000

Y

7 6 5 4 3 2 1

5 3

337

R<sub>3rd</sub>

N = 2 dist (mm) 333 spacers = 1

R<sub>main</sub> + R<sub>2nd</sub>

Y

400

173

X

Ø 60 # 10

Dimensions mm

conductor

joint

spacer

#	N	x	B	x	H	IN (A)
1 - 7	1	60	10	1000	<input type="radio"/> V <input checked="" type="radio"/> H	

Conductor material

1 - 7 Aluminum

Frequency (Hertz) 50 Enclosure material Aluminum # mm 10

Sym SC current (kArms x s) 50 1 Crest factor (first peak) 2,5

Save >> ✓

Ventilation ?  
☒ Y ☐ N

Resistance of main CB /device/ joint (OhmE-6)

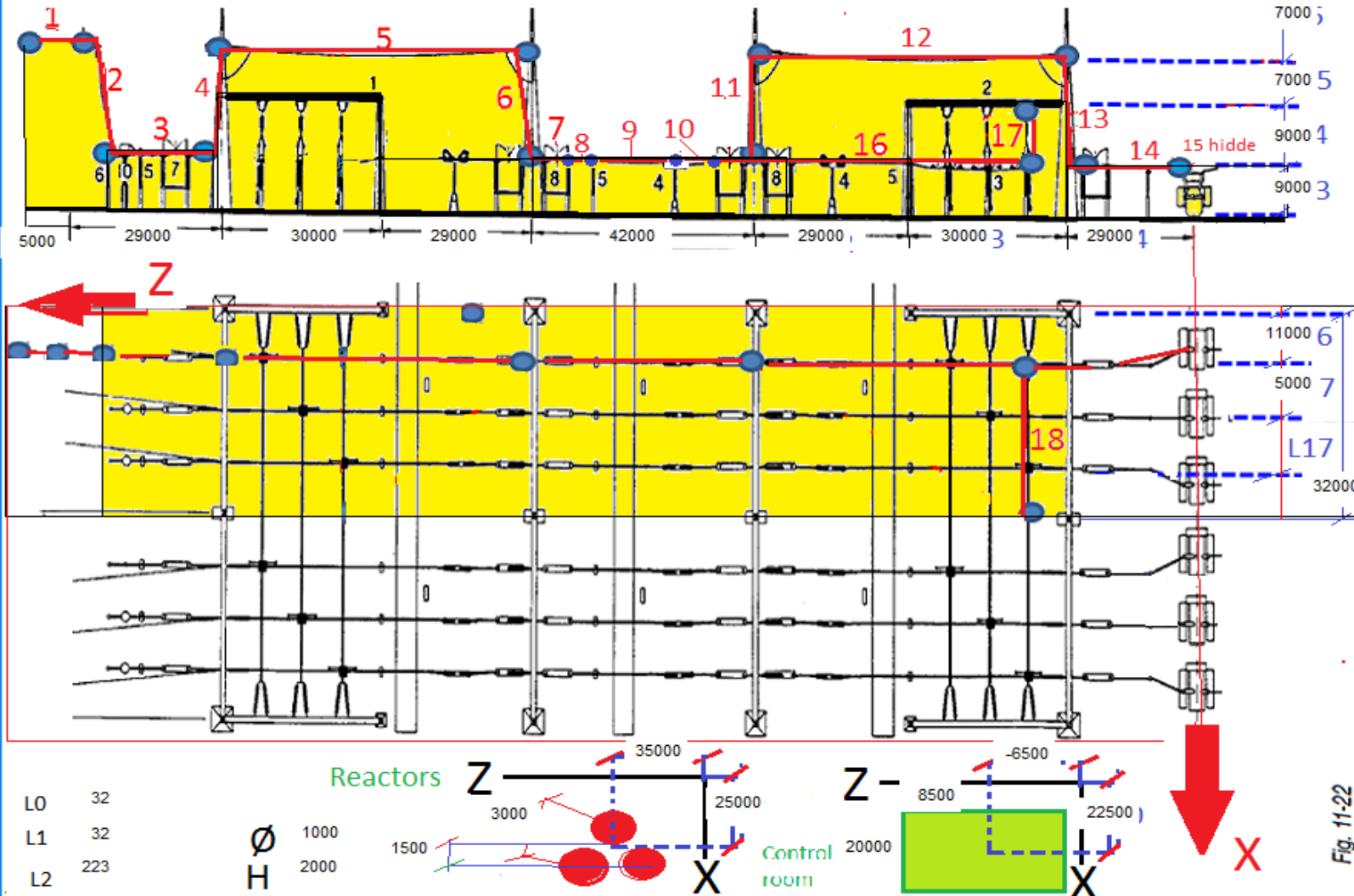
Fluid	2nd resistance	3rd resistance
Air	7	0
	0	0

Additional WATTS in the compartment (resistors) 0

WATTS by magnetic induction in the enclosure 796605

WATTS by magnetic induction in the spacers 0

525 kV outdoor switchyard, 1½-breaker layout, 1 Busbar system I, 2 Busbar system II, 3 Busbar disconnector, 4 Circuit-breaker, 5 Current transformer, 6 Voltage transformer, 7 Feeder disconnector, 8 Branch disconnector, 9 Surge arrester, 10 Line trap, 11 Transformer.



# N x B x H IN (A)  
1 - 18 1 16 16 3150

Conductor material

1 - 18 Aluminum

Busbars covering

Bare

Painted

Frequency (Hertz)

60

Enclosure material

Aluminum

# mm

2,65

Sym SC current (kArms x s)

50

1

Crest factor (first peak)

2,5

?

Save

>>

✓

Ventilation ?

Y

N

Resistance of main CB /device/ joint (OhmE-6)

50

Fluid

Air

Additional WATTS in the compartment (resistors)

0

WATTS by magnetic induction in the enclosure

574005

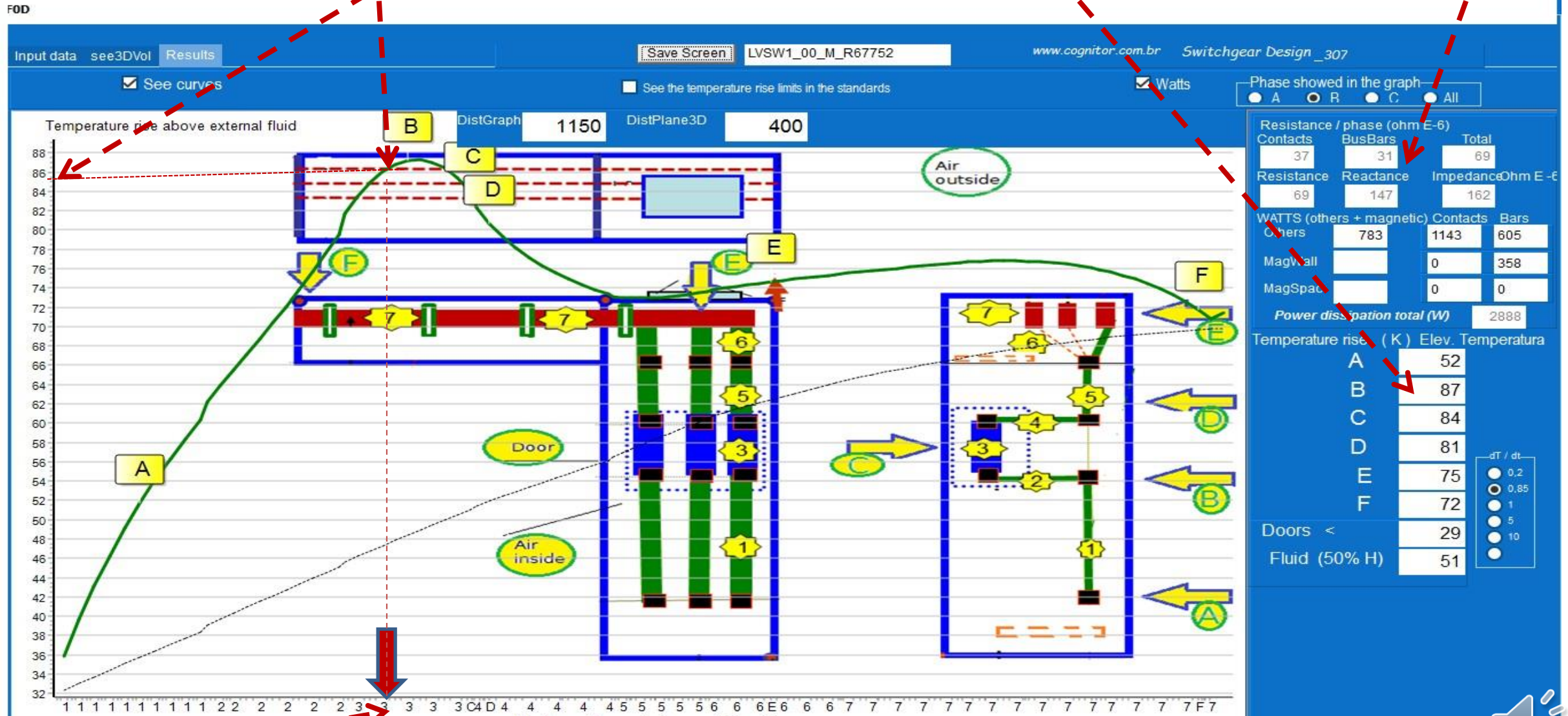
WATTS by magnetic induction in the spacers

0



# How to see and to analyze the results

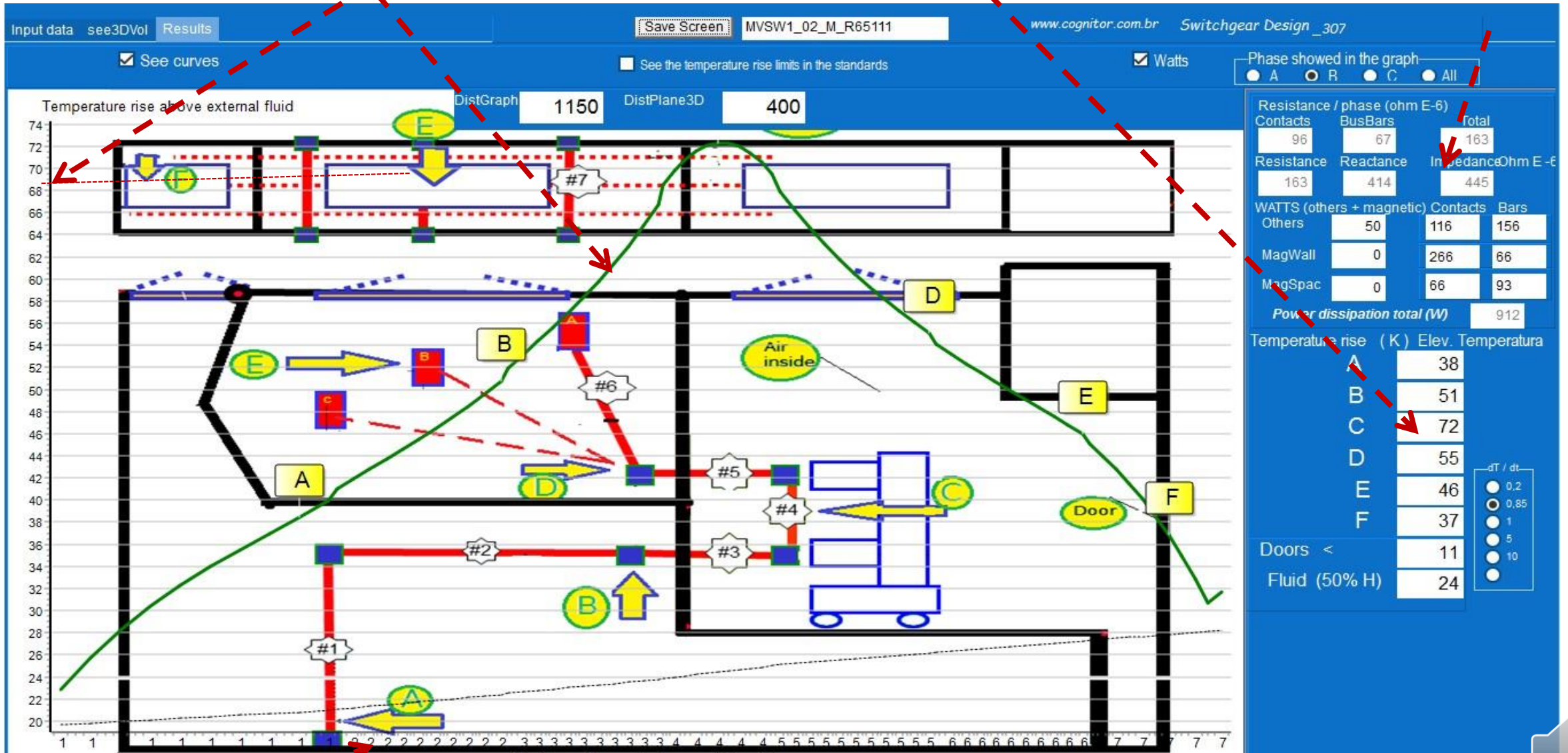
Green curve is the temperature rise (K) above the temperature of the external air ( A, B, ...F are “key” points) Other results



Position of conductors 1 to 7 as they were side by side in a straight line

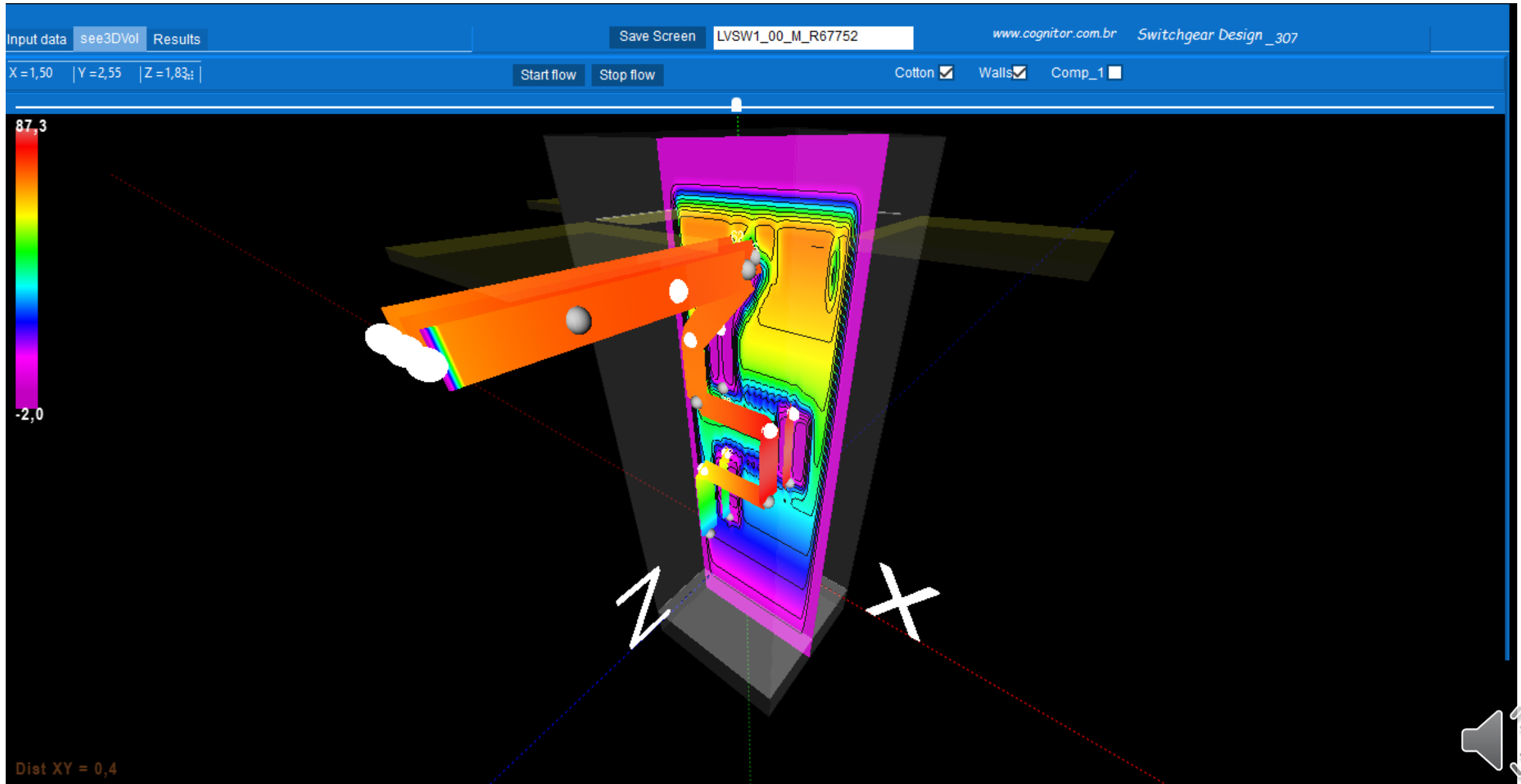
# How to see and to analyze the results

Green curve is the temperature rise (K) above the temperature of the external air ( A, B, ...F are “key” points) Other results



Position of conductors 1 to 7 as they were side by side in a straight line

# Visualization in 3D (good to see if a wrong dimension was typed)





- Install SwitchgearDesign
- Click the icon in the desktop
- Select “ temperature rise” if using the all “**TYPE OF TEST**” version.
- Click the “**TYPE OF EQUIPMENT**” you need, for example MVSW1
- Select an existing desired case, for example MVSW1\_02\_M\_R65111
- Click **GEOMETRY** to see dimensions
- Click the tab “**Results**” (top – left ) for calculating and seeing results
- Click **See3Dvol** to see the geometry in 3D (use the mouse to enlarge or to educe size)
- Click the tab **InputData**.
- Increase rated current changing the value 1250 (top – right) to 2000.
- Confirm with the button “**Save >> V**”
- Click **Results** ( temperature rises are higher now that when it was 1250 A)
- Click “**InputData**”
- To create a new test case based on an existing one, select the case to duplicate clicking twice in the table (left side) . The line becomes blue. Click the button “ **NEW**” and see that a new line was created . The name of the new is equal to the one before but with an added \_ bis MVSW1\_02\_M\_R65111 \_bis.
- Change the name as you wish , for example “MVSW1\_03”
- Change the desired data as dimensions and others, confirm change with “**Save >> V**” and click **Results**

See movie  
in Item 7b2





## Report 074/2014: VALIDATION OF MAGNETIC & ELECTRIC FIELDS MAPPING & TEMPERATURE RISE TESTS SIMULATIONS.

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

COGNITOR Test Simulation Report 074 / 2015 Page 6 of 56

**2. VALIDATION METHOD AND COMPARISON BETWEEN SIMULATION AND TEST RESULTS OR IEC STANDARDS. (TEMPERATURE RISE TESTS)**

To compare test and simulation results we used laboratory test reports. In Table 2, there are test cases and references to the test reports used for comparisons, to the figures with input data used in the simulation and to the tables comparing test and simulation results.

Table 2 – Test Cases used for validation

	Test	Type of equipment (software screen) Case in the software database	Test report	Comments	FIGURES with inputs and simulation results	TABLE with comparison tests x simulation
1	Temperature rise AIS	LVSU-1 LVSU1_01_M_R67752	Test report 67752 (Annex D)	Circuit breaker 25 $\mu\Omega$ 768 w	Figure 1	Table 3
2	Temperature rise AIS	MVSW_1 MVSW1_02_M_R65111	Test report 65111 (Annex D)	Circuit breaker 54 $\mu\Omega$	Figure 2	Table 4
3	Temperature rise AIS	Duct_1 Duct_03_3x150x10_R67131	Test report 67131 (Annex D)	Connection joint 7 $\mu\Omega$	Figure 3	Table 5
4	Temperature rise AIS or GIS	GIS_1ph GIS1ph_MissingReport_1ph AIR and SF6	No test report available	Connection joint 7 $\mu\Omega$	Figure 4	Table 6
5	Temperature rise AIS or GIS	GIS_3ph GIS3ph_MissingReport_3ph AIR and SF6	No test report available	Connection joint 7 $\mu\Omega$	Figure 5	Table 7
6	Temperature rise GIS	GIS_3ph GIS3ph_PaperSF62009 SF6	Article Note 1	No Connection joint	Figure 6	Table 8

Table 4 – MVSW1 – Temperature rise test MVSW1\_02\_M\_R65111  
Bare bus bar Without ventilation openings  
Circuit breaker resistance as seen from the terminals – 54  $\mu\Omega$  per phase

Measuring point	Test temperature rise ( K )	Simulation ( K )	Difference
A - Terminals for the connection to external conductors	39	38	< 5 %
B – C – D – connection between bars and circuit breaker ( ** )	56 al-72	55 a 72	< 5 %
E – Connection between the horizontal and vertical bars	44	46	< 5 %
F – Short circuit point	34	37	< 9 %
Door	12 ( * )	11	< 15 %
Internal air	Not measured	18 to 26	( ***)

END

