User Manual

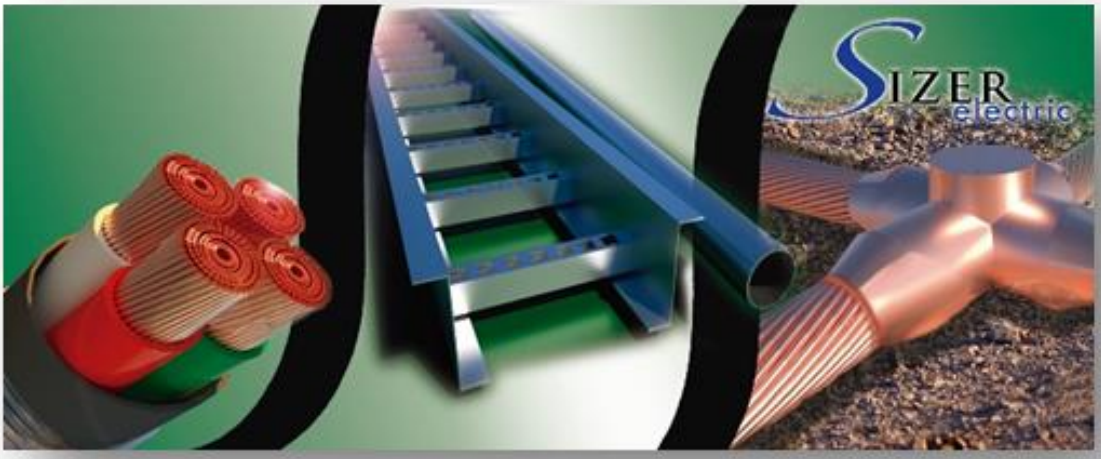

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Table of Contents

Introduction

Sizer Electric was designed and developed to facilitate the processes of low and medium voltage electric conductor selection, cable tray and conduit selection and grounding grid design based on the National Electrical Code 2017 edition.

The simplification of the process is based on the use of a database that gathers all the information necessary for the calculations and incorporates within the logic of operation all applicable criteria for a correct selection of electrical conductors.

Among its main features are:

- Design entirely in Spanish.
- Easy, intuitive and automated capture.
- Comprehensive and friendly reports of data circuits and results, with the possibility to export it to text files.
- Utilities for projects maintenance and the system itself.
- Online help from the program.
- Unlimited circuits calculation

End user Manual organization

For optimal management of this manual, this is divided into two parts:

- System Operation: This part is oriented to the process of installing the program, creating projects Sizer Electric type, circuit capture, reporting and tools for maintenance of the projects created.

- Technical Reports: The theoretical descriptions governing the program will be addressed in this part, as well as suggestions and solutions to problems that may arise when using the software.

Conventions used in the manual

For practical purposes, this manual uses the following conventions:

When it is mentioned:	**Reference is made to:**
The program or the system.	Sizer Electric version X.X,
Windows.	Microsoft Windows 95, 98, 2000 or NT 4.0, XP, Windows Vista, Windows 7.0, Windows 8.0.
Click.	The action of pressing once the left mouse button
Double-click.	The action twice pressing the left mouse button.
Main menu | Menu1 | Menu2 ...	Go to the main menu. Then select the menu 1, in which select menu 2 ...
Press [KEY]	The action of pressing one of the function keys Windows, for example, [ENTER], [F1], [ESC], etc.

Scope

Conductor Selection Module

The Conductor Selection module selects the conductors size for circuits connected in Altern Current with a maximum voltage of 35,000 volts for different types of loads.

Sizer Electric selects the conductor size in low voltage, for conductors with insulation temperatures of 60 °, 90 ° C for 75 °C and medium voltage conductors the insulation temperature can be selected for 90°C, 105°C, 150°C, 200°C and 250°C.

The calculation is made considering 10 different types of loads: Motor Control Centers, motors, transformers, capacitors, feeders, Cranes and hoists, lighting circuits, thermal Trace and control circuits.

Conductors considered for the calculation can be 6 types: Single conductor, Single - conductor armored, single conductor in triples configuration, triplex conductors, Multiconductor, Armored Multiconductor and bare conductors.

The design philosophy for the selection of conductors an cable trays is based on the principles established in the National Electrical Code, 2017 edition or standard NOM-001-SEDE-2012. **Is not part of the scope the selection of conductors under DIN VDE standards or European considerations or other world regulations.**

The conductor size of the selected conductor will eventually meet the following criteria: Ampacity, maximum voltage drop under normal operation, maximum voltage drop during motor start (in the case of engines only), in addition to the short circuit withstand capacity (optional for low voltage) and the selection of the equipment grounding conductor (optional).

The program has the ability to perform calculations considering different voltage conductors on each circuit if necessary. You can also consider different types of raceways or cable trays for each circuit.

The program generates different types of reports detailing the data supplied and the various factors used for calculation.

Conduits and Cable Trays Selection module

The selection conduits and cable trays selection module allows you to select the appropriate width for cable type and conduit diameter. The selection of cable tray comply with the guidelines of Article 392 of the National Electrical Code and Mexican Official Standard NOM-001-SEDE-2012 and the standard to be used for the selection process will be defined by the user in the general data section of the program.

When predefined cable trays or conduit are installed in the facilities, there is the possibility to calculate only the occupied percentage area of the conduit or cable tray.

Because in the filling percentage calculation or conduits and cable tray widths or cable trays selection the conductor circuit tags are associated to conduit and cable trays it is possible to obtain reports of conductor routing paths for a project.

Selection philosophy for cable tray and conduit is based on the principles established in the National Electrical Code or NOM-001-SEDE-2012 standards. **The selection of conduits and cable trays under IEC, DIN or VDE or under European standards is not part of the scope.**

The selection of cable trays is performed for ladder type, channel ventilated type, solid bottom, ventilated trough or mesh type cable trays.

The definition of the diameter and area of the conductors is obtained from the specification of the conductor. The specification of the conductor is a record where the information of the conductor is stored, it is possible to obtain the description of the conductor, diameter and area. Therefore this information can be obtained to integrate the BOMs of project circuits.

Grounding Grid Design module

The Grounding grid design module calculates the touch and step tolerable voltages for a human body of 50 or 70 Kg. Performs calculation of the grounding grid resistance for a soil of uniform resistivity or soils up to 2 layers of different resistivity. Calculates the increase in voltage generated in the grid (Ground Potential Rise or GPR) and the calculates the touch and step potentials generated by the grid while conducting the fault current. The calculations are performed in accordance with best practices of the standard IEEE Std. 80.

Technical reports provides descriptive and comprehensive information of the calculation methods and the equations and references applied in the design.

Chapter

1

Installation and System Registration

For optimal performance of Sizer Electric software, make sure that the computer where it will be installed meets the minimum software and hardware requirements listed below.

Installation Requirements

- •PC with a Pentium 75 MHz or higher.
- Microsoft Windows 95® or later, or Windows NT® 4.0 (Service Pack 3) or later or Windows XP, Windows 2000, Windows Vista, Windows 7 and Windows 8.0®
- USB port
- At least 30MB free hard disk space.
- 16 MB of RAM.
- Mouse or other pointing device for Windows.
- VGA or higher resolution monitor.
- CD-ROM drive or high density 3 ½.

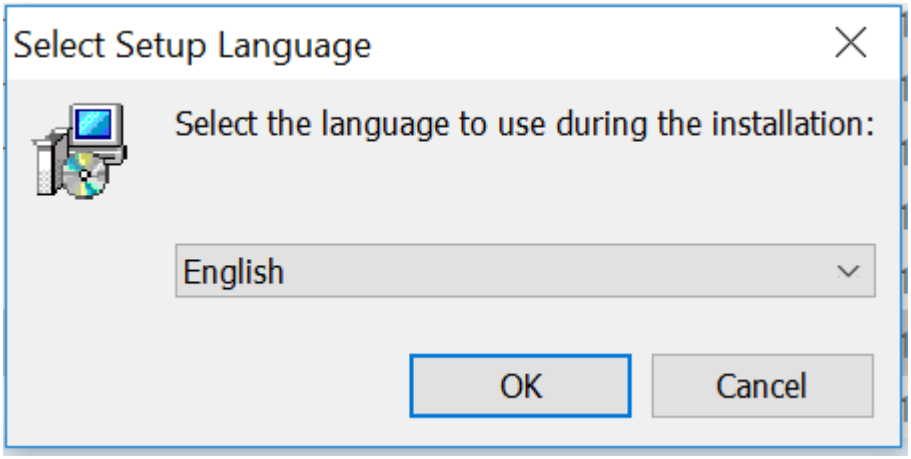
Installation

The program is distributed by a CD containing: Setup files, User Manual and help files, plus additional applications and updates that your operative system may require for the proper execution of the program. You can also download the Setup files from the web site www.sizerelectric.com.

To install the program with the CD:

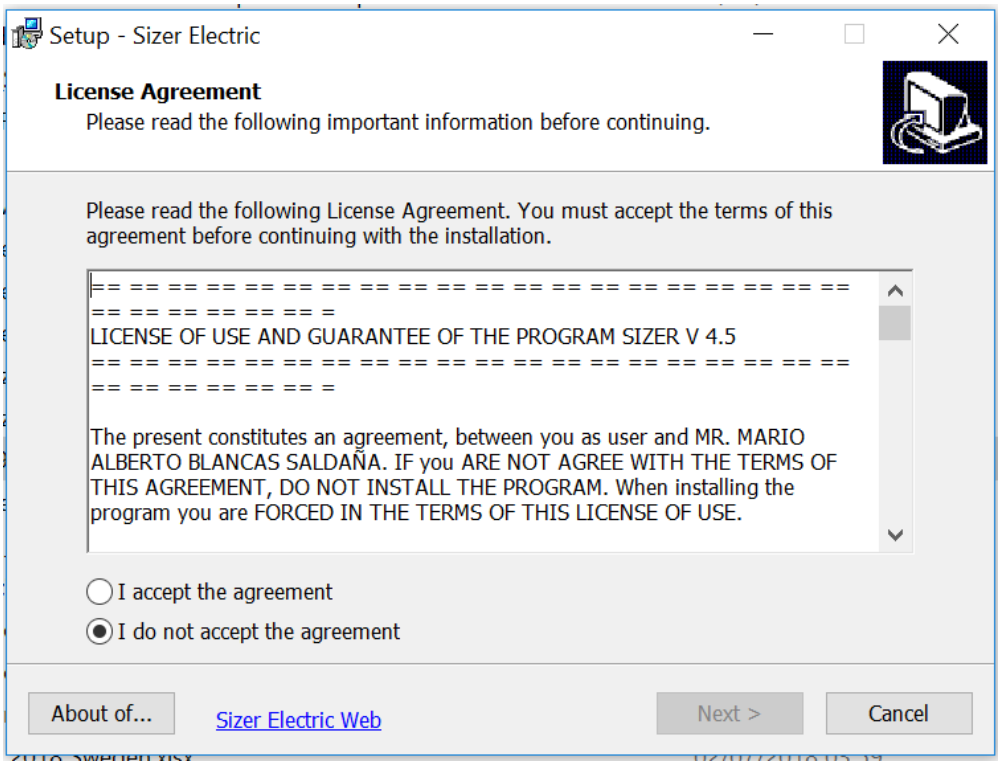
1. IMPORTANT: Close all applications that are in operation and making use of protection keys (Net hasp Hard keys).
2. Insert the disc into the drive of your computer and wait to start the process of installing the program.
3. If you have been waiting for more than one minute and if the installation has not started, go to Windows Explorer, select your drive and locate the Setup.exe file.
4. Follow the instructions in the installation wizard.

   The installation wizard will install the Sizer Electric software and the required drivers.



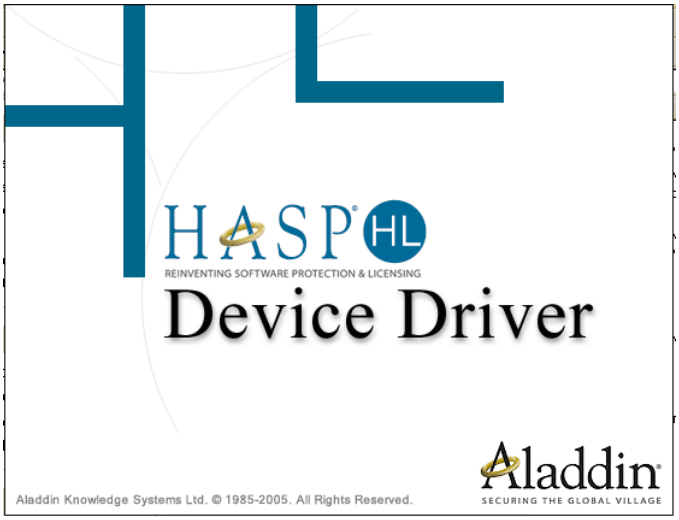
Installation wizard interface

On the *License Agreement* screen read the agreement and select the *"I accept the agreement"* option to enable the *Next* > button. Continue with the installation as shown in the figure below.

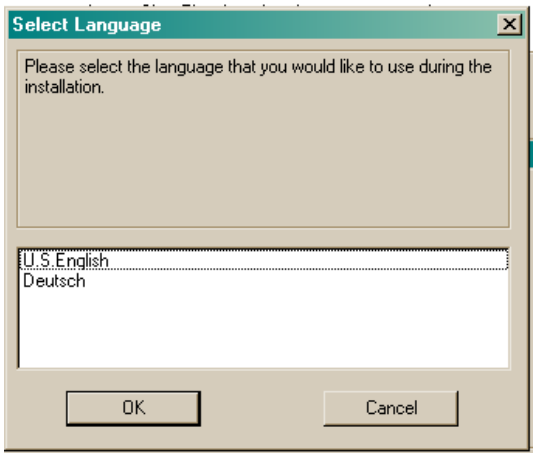


The program Sizer Electric *standalone* version is designed to work with a single user with access via the USB key. In the *network* version it creates a Client / Server structure, so the installation must be performed on both the server and workstations. For more details see chapter: Installing Sizer Electric in a Network.

When finish installing the program execution files some additional applications to manage databases and key drivers protection program will be installed. So the image shown below appears:



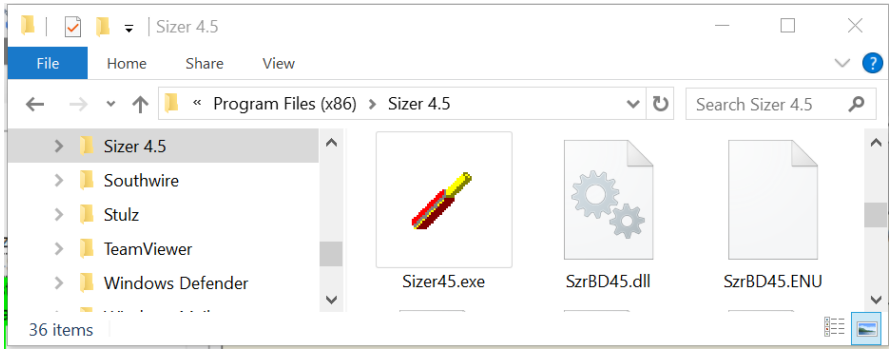
Subsequently, a dialog box requesting the installation language for the protection key drivers is displayed as shown in the following image :



Select the U.S. English language and wait until the end of the process. This process can take several minutes. Upon completion of the installation insert the hard key into the USB socket port on your computer.

IMPORTANT: Close all applications under operation and using nethasp protection keys (Hard keys)

After the installation is completed a new program group named Sizer Electric will be created in your windows start menu, where shortcuts to Sizer Electric program and help can be found.

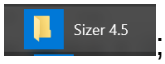


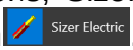
IMPORTANT: The protection key must remain inserted into the USB port on your computer during the execution of the program.

Software Execution

There are several ways to run the program in Windows:

1. **Insert the protection key (hard key) in the USB port on your computer**

2. Select the *Start* button on the Windows taskbar  ; in the menu displayed select the *All Programs* option. This displays a submenu with some of the programs available on your computer; In this submenu select the name *Electric Sizer* 

; with this appears a second submenu with two options, Sizer Electric and Sizer Electric Help, the first option refers to the program 

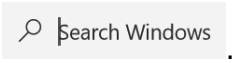
. Select and click on it to run the application. This will display the welcome screen of the program.

   If the program cannot be found within one of the *All Programs* submenu options under the name Electric Sizer, search within the submenus that appear in any of the other options. The location of the program within the menu or submenus depends on where the installation location was defined by the administrator.

3. Using *Windows Explorer*, select the drive where the program was installed and enter the path:

<c:>:\Program files (x86)\Sizer Electric

In case the program cannot be found in the mentioned path …

4. Select the *Start button* on the Windows *taskbar*  , in the menu displayed select the option *Find* 

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A dialog box or Windows Explorer window (depending on the operative system) will be shown. The first window tab contains a *Name* text box and a drop-down list *Search in*.... or in the option *"All files and folders"* type the search criteria or within the text box type the file name *Sizer40.exe and in* the drop-down list select the name of the unit where you want to find the file. Press the *Search* button.

If the program is installed on your computer, it will be displayed in the list of files appearing in the list of found files.

Double-click the file Sizer40.exe. Memorize the path where the executable file is located to run it directly from Windows Explorer on another occasion.

System Registration

On the market there are3 types of editions for *Sizer Electric* software:

- **Demonstrative:** Incudes access to all system features with unlimited entries to the software, after the trial period the system is disabled. This edition is free and registration system is not necessary. .

- **Professional:** In this edition you can install the system on an unlimited number of computers and the software never expires. The USB hard key connected in the computer grants the access to the software.. .

- **Premium (Network version):** The large number of licenses required in design companies can be covered by this edition, which has an additional network application that can enable 10 or more work stations licenses concurrently.

Not the system registry because the (Hardkey) port USB key gives you the possibility to operate the program on any computer where the Sizer Electric program has been installed is necessary. For program updates visit www.sizerelectric.com for information on:

No system registry is required because the USB key (Hardkey) gives you the possibility to operate the program on any computer where the Sizer Electric program has been installed. For program updates visit www.sizerelectric.com for information on:

- Free software updates without for the same version.
- Tutorials and training
- Access to technical information and quarterly newsletters.
- Information about other promotions.

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Chapter

2

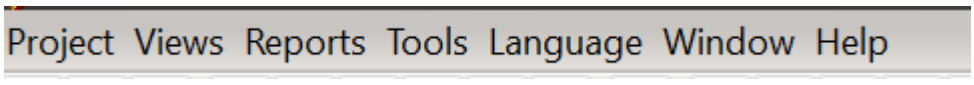
Software elements

This chapter explains what are the elements used for data entry processes and information management within the *Sizer Electric* software.

General Elements

Main menu: At the top of the main screen you will find a menu containing different options, which allow you to access submenus, data entry grids, and windows to specify data.

6 options are located in this menu grouping related tasks.



The functionalities of each options are described below:

File: Here all tasks related to the management of the various projects are carried out. From here you can create a new project, open an existing project, save the project with a new name, change the password for access to the project and choose a different default printer in Windows.

Views: In this option you can access all data capture interfaces: Standards applicable to the project and References. It is possible to access the data entry grids that display the general data, data circuits, conductor summary and tables used by the software to select the conductor size, conduits, cable trays and grounding grids.

Reports: Through this option you can select the different reports presented by the software and select each report preview to review the information and define whether it will printed.

Tools: In this option are grouped utilities, and configurations that the project needs for better information management, in addition to reports and windows customization.

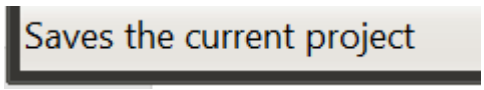
Window: This option allows you to efficiently distribute the information presented on your screen to accelerate the processes of capture and query information and allow you to move between different grids presented on the screen.

Help: On this option will find useful tools to become familiar with the software operation. Through online help, you will identify the characteristics of the data, program management and *Electric Sizer* features.

Toolbars and status bar

For quick access to common system options such as: New project, Open an existing project, Save As, Capture Standards and also grid views, General data and Circuits, *Sizer Electric* has the toolbar. This is located at the top of the main window.

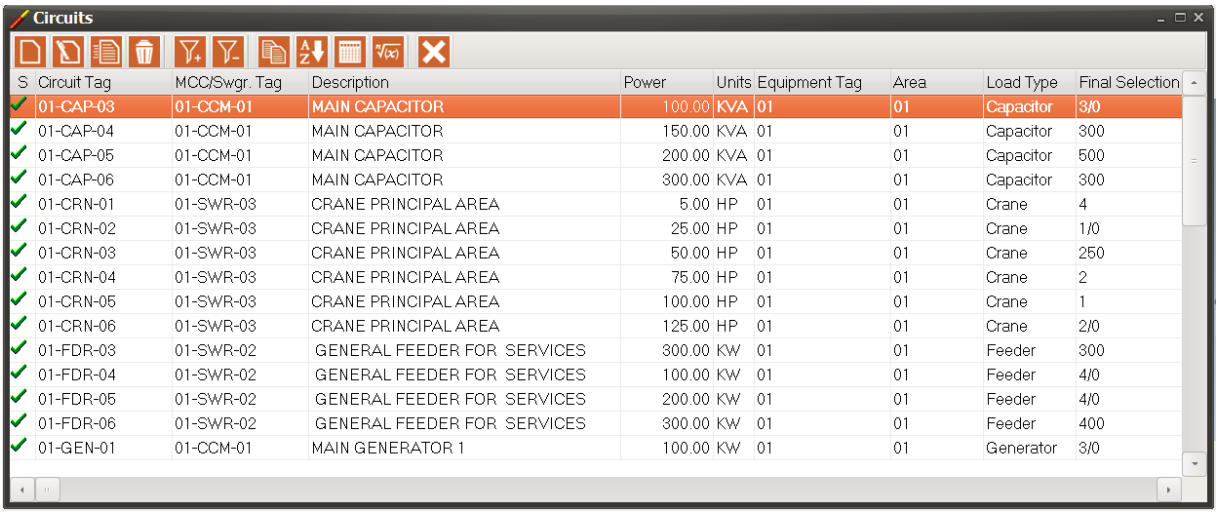
At the bottom of the main window you can locate a bar. This is named *Status bar*, on it you can read the descriptions of the task performed by the element that is being pointed with your mouse. You can also see a *progress bar* where you can follow the progress of the different processes running in the system.



If you are already familiar with the system information management, you can hide one or both bars. This can be done by selecting the option *Tools* in the main menu to disable the status bar box in the project window. This helps you to get a larger area to view your data in the grids.

Data grids

During the development of electric projects is increasingly common to handle large volumes of information to be analyzed, evaluated and corrected with a global vision.



S	Circuit Tag	MCC/Swgr. Tag	Description	Power	Units	Equipment Tag	Area	Load Type	Final Selection
✓	01-CAP-03	01-CCM-01	MAIN CAPACITOR	100.00	KVA	01	01	Capacitor	3/0
✓	01-CAP-04	01-CCM-01	MAIN CAPACITOR	150.00	KVA	01	01	Capacitor	300
✓	01-CAP-05	01-CCM-01	MAIN CAPACITOR	200.00	KVA	01	01	Capacitor	500
✓	01-CAP-06	01-CCM-01	MAIN CAPACITOR	300.00	KVA	01	01	Capacitor	300
✓	01-CRN-01	01-SWR-03	CRANE PRINCIPAL AREA	5.00	HP	01	01	Crane	4
✓	01-CRN-02	01-SWR-03	CRANE PRINCIPAL AREA	25.00	HP	01	01	Crane	1/0
✓	01-CRN-03	01-SWR-03	CRANE PRINCIPAL AREA	50.00	HP	01	01	Crane	250
✓	01-CRN-04	01-SWR-03	CRANE PRINCIPAL AREA	75.00	HP	01	01	Crane	2
✓	01-CRN-05	01-SWR-03	CRANE PRINCIPAL AREA	100.00	HP	01	01	Crane	1
✓	01-CRN-06	01-SWR-03	CRANE PRINCIPAL AREA	125.00	HP	01	01	Crane	2/0
✓	01-FDR-03	01-SWR-02	GENERAL FEEDER FOR SERVICES	300.00	KW	01	01	Feeder	300
✓	01-FDR-04	01-SWR-02	GENERAL FEEDER FOR SERVICES	100.00	KW	01	01	Feeder	4/0
✓	01-FDR-05	01-SWR-02	GENERAL FEEDER FOR SERVICES	200.00	KW	01	01	Feeder	4/0
✓	01-FDR-06	01-SWR-02	GENERAL FEEDER FOR SERVICES	300.00	KW	01	01	Feeder	400
✓	01-GEN-01	01-CCM-01	MAIN GENERATOR 1	100.00	KW	01	01	Generator	3/0

In the development of existing software it has been observed that handling large amounts of information through tables, allows users to more assertive analysis and detect deviations or errors more easily.

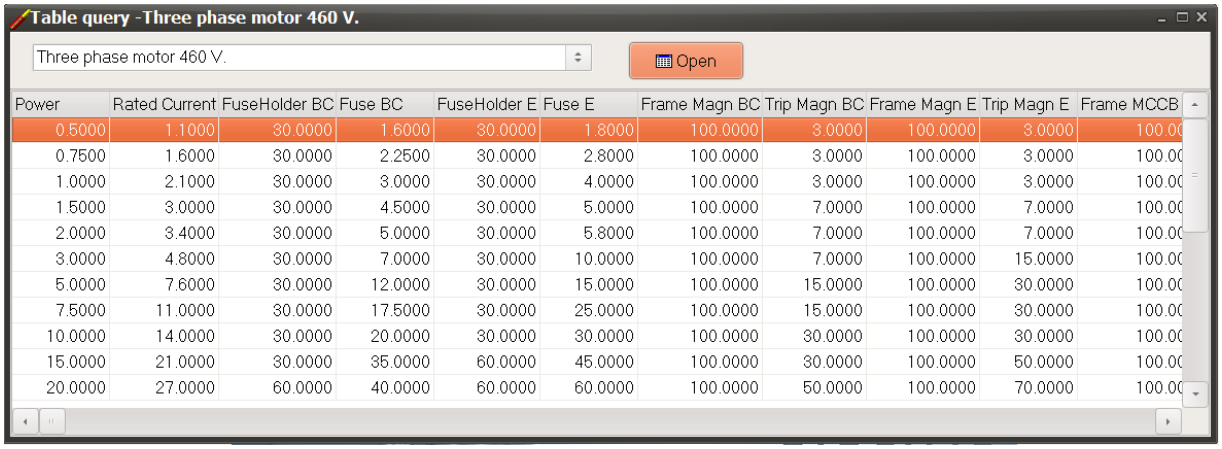
To meet these needs, the program *Electric Sizer* uses windows that present data circuits and general data in tabular form. These windows are named *Data Grids*.

These data grids have a toolbar that lets you optimize information management and are equipped with scroll bars at the bottom and on the left side for easy viewing of the information contained in the project files.

Importantly, in the data grids you ***cannot*** directly edit the data because the information captured could not be validated against other electrical parameters. To capture and edit information is necessary to access the capture windows (with a double click on the grid highlighting the record) where your information is verified and corrected.

Queries

Queries are windows in which information is displayed in different forms, such as tables, lists, etc. Unlike grids, queries cannot add, modify or delete the information displayed. Therefore, queries only serve as a reference point to consult the data used.



Power	Rated Current	FuseHolder BC	Fuse BC	FuseHolder E	Fuse E	Frame Magn BC	Trip Magn BC	Frame Magn E	Trip Magn E	Frame MCCB
0.5000	1.1000	30.0000	1.6000	30.0000	1.8000	100.0000	3.0000	100.0000	3.0000	100.00
0.7500	1.6000	30.0000	2.2500	30.0000	2.8000	100.0000	3.0000	100.0000	3.0000	100.00
1.0000	2.1000	30.0000	3.0000	30.0000	4.0000	100.0000	3.0000	100.0000	3.0000	100.00
1.5000	3.0000	30.0000	4.5000	30.0000	5.0000	100.0000	7.0000	100.0000	7.0000	100.00
2.0000	3.4000	30.0000	5.0000	30.0000	5.8000	100.0000	7.0000	100.0000	7.0000	100.00
3.0000	4.8000	30.0000	7.0000	30.0000	10.0000	100.0000	7.0000	100.0000	15.0000	100.00
5.0000	7.6000	30.0000	12.0000	30.0000	15.0000	100.0000	15.0000	100.0000	30.0000	100.00
7.5000	11.0000	30.0000	17.5000	30.0000	25.0000	100.0000	15.0000	100.0000	30.0000	100.00
10.0000	14.0000	30.0000	20.0000	30.0000	30.0000	100.0000	30.0000	100.0000	30.0000	100.00
15.0000	21.0000	30.0000	35.0000	60.0000	45.0000	100.0000	30.0000	100.0000	50.0000	100.00
20.0000	27.0000	60.0000	40.0000	60.0000	60.0000	100.0000	50.0000	100.0000	70.0000	100.00

Within this type of windows are queries for technical data tables for conductors ampacity and conductor summary.

Data Entry Windows

This type of windows serves as an interface for collection, validation and modification of data, it is also used to entry information for system operation and customization.

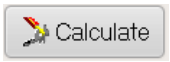
Capture windows that require it, contain a validation process reviews all absolutely captured information to ensure integrity and consistency in the data storage.

Capture windows that require it, contains validation process that reviews absolutely all the information captured to ensure integrity and consistency in the data storage.

To define the future of the information entered, capture windows contain various buttons described below:

The *OK* button located at the bottom of the window allows you to conclude with the capture process of the element on the screen or confirm the of the edition of the data previously entered. Pressing the *OK* button, the software validates the information presented on the screen in a way that lets you correct information avoiding deviations or inconsistencies in the data entered.

The *Cancel* button located at the bottom of the window has three functions: Interrupting a capture process when you are entering a new element, ignore the latest changes made to the data displayed on the window and close the capture window if you did not make any of the above two tasks.



In the circuit data entry window can be found the *Calculate* button, which allows you to start the selection of the circuit conductor size. This button also performs a complete validation of the captured data.

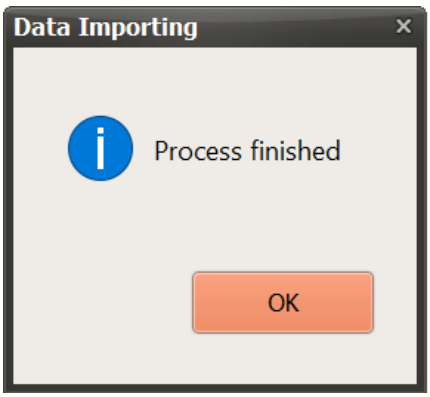
The 3-point button indicates that there is additional information related to the nearest element This may be a window for additional data entry, a help window or dialog to open or save a file.

PREVIOUS and NEXT: These buttons allow you to navigate between the circuits located before and after the active circuit in the capture window.

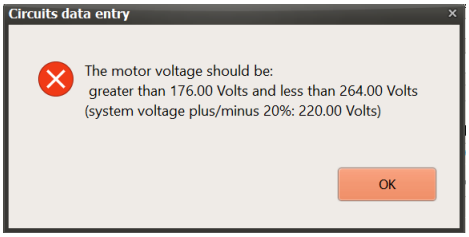
System prompts

During program execution it can display windows that report situations outside the system control, these messages are:

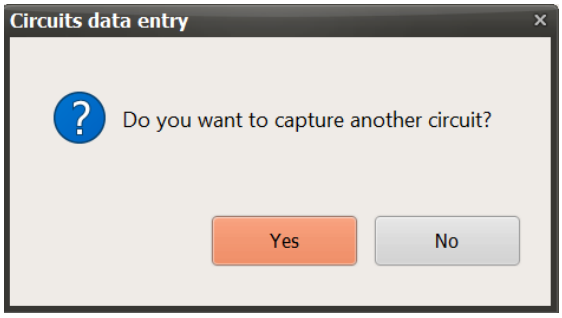
- **Information.** Its purpose is to notify the user to perform an action or just to inform that a process was successfully completed.



- **Error.** These are presented when an invalid data was captured and it must be corrected or the program has found an inconsistency in the operation of the Windows operative system or in the *Sizer Electric* software.



- **User intervention.** These messages ask for direct user action for decision-making in a process.



Chapter

3

Project Operations

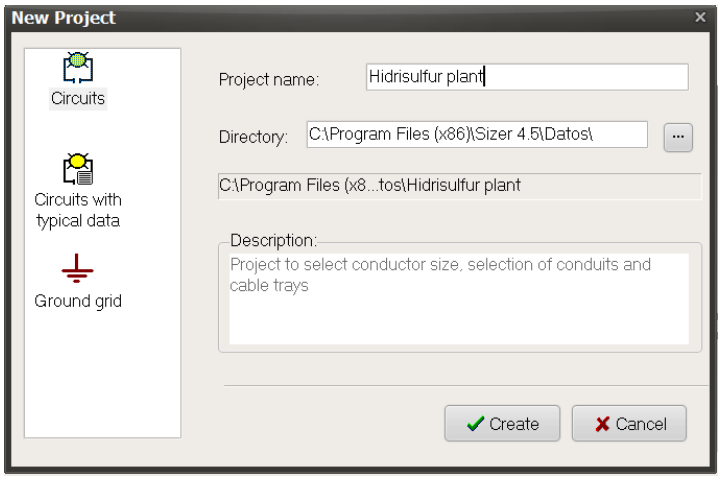
For the organization and control of information captured, the program divided and grouped into sets of files *Sizer Project*.

A *Sizer Electric Project* stores information in a manner that is independent of another project. Therefore, the data entered into a project will only be visible for the *Sizer project*.

Project creation

Location*: File* | *New* 

By selecting this option the following dialog window is shown:



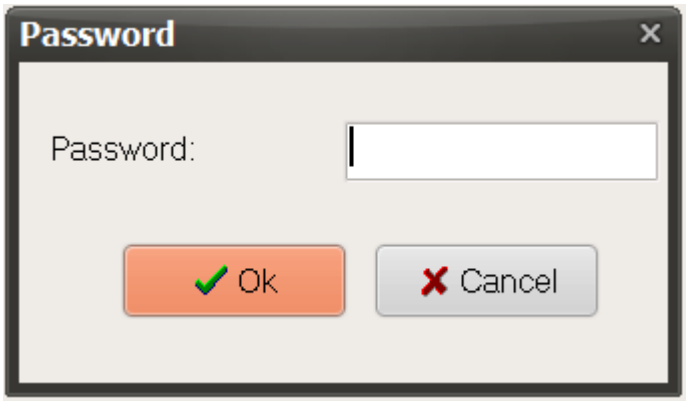
As can be noted, before starting the capture of any type of data, it is necessary to identify the name of the file where the information will be stored. This file has the extension * .SZR and you can only open it through *Sizer Electric* software.

The file name shall not contain special characters (*), (/) or (?). And can be up to 32 characters long.

When a new project is created, the program suggests the data directory as the location where projects created will be stored. However, the user can change this path as required. This location can be a mobile unit or a network drive. For example:

a:\Electric project\, f:\users\data\, c:\documents\proect01, etc.

Note: When a new project is generated, it can protected by a password to prevent unauthorized persons from altering the project information content. The default password that is the keyword: KEY. Next time you try to open the project, the dialog box requesting the password appears, as shown in the figure.

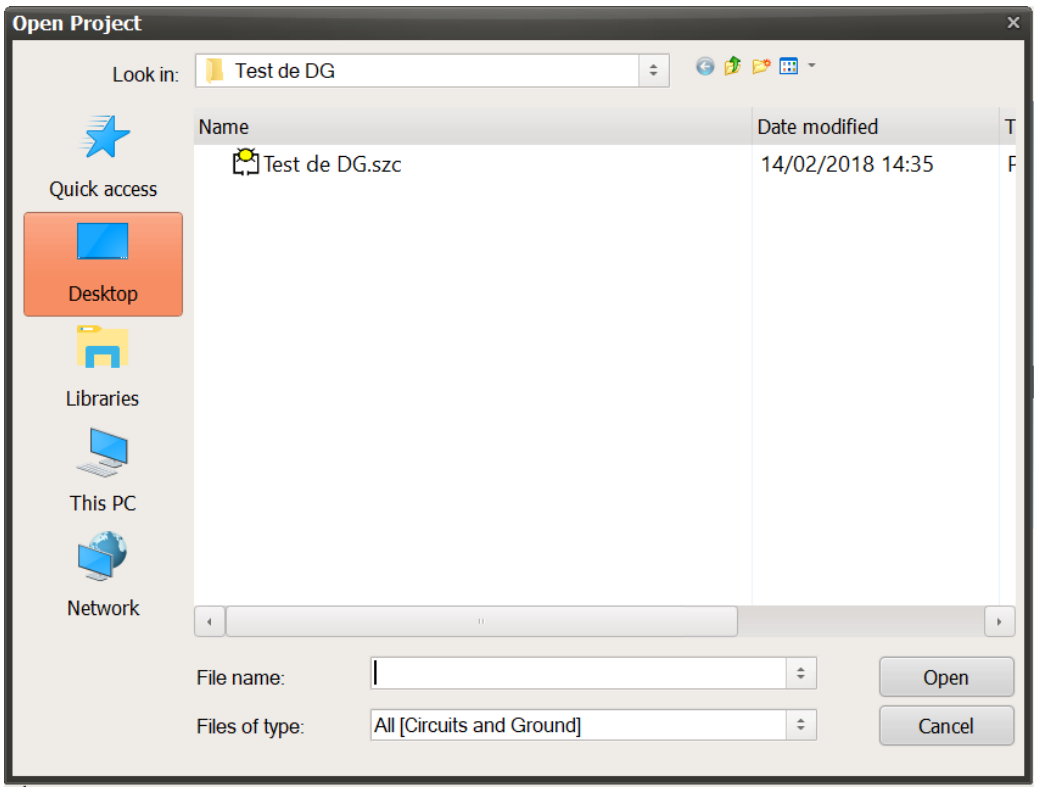


Immediately after the creation of the project, the capture window *References* followed by the capture of *Standards* will be shown. The description and capture of these elements is described below.

Opening projects

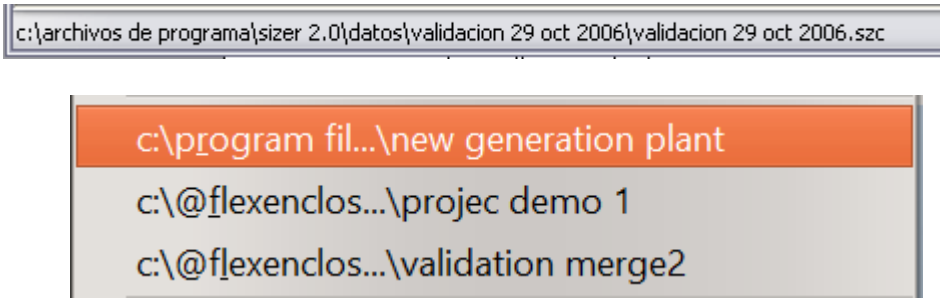
Location*: File* | *Open*

Then a dialog box will be displayed, here you can select the project you want to open, consult or modify.



Once you create a project, this can be open as many times as necessary. To identify which project is open, the program displays at the top of the window the project name.

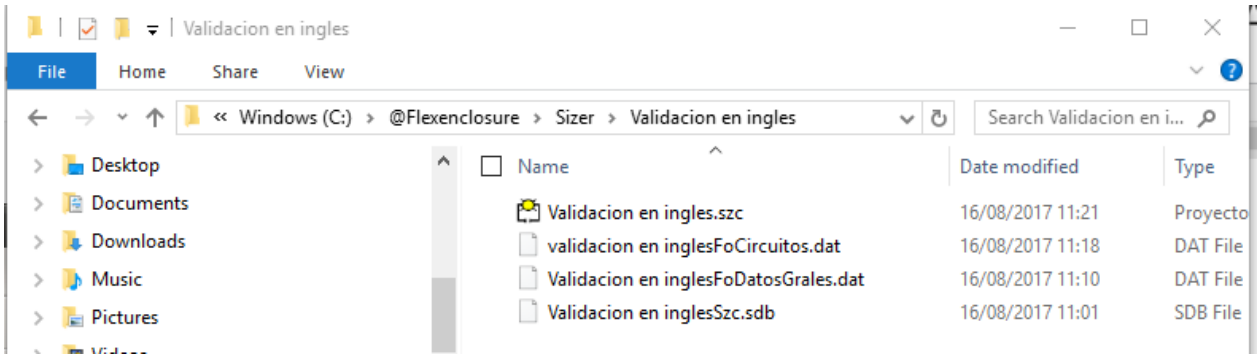
In addition to the options mentioned above, the program stores the name and path of the last three projects open. On the File menu option you can access each of them by simply clicking on the menu. Note that if the Sizer Electric Project path is too long to be displayed, the system contracts the path; but in the status bar the path is fully displayed.



It is also possible to open a *Sizer Electric* project directly from Windows Explorer. It's easy recognize these files because they have an icon with the symbol of an electrical circuit.

The procedure to open the project is as follows: Select the file and double-click on it. *Electric Sizer* software then opens, with the selected project active.

This opening method has some restrictions, since it can only be done if the program is not running at the same time.



Saving a project.

Location*: File* | *Save* 

By modifying a project, the program automatically performs the changes on the files involved, so the *Save* option only makes these changes effective. It is clear that the changes made can no longer be canceled, because when the project is closed or the program execution ends the active project is saved.

Save a project with another name

Location*: File* | *Save as...* 

In the electrical design although projects are different, they have many common data. To avoid repetition of capture processes, the program has the *Save As* ... option, which creates an identical copy of the current project and records it under a new name.

To use this option, it is necessary to open the project to be copy of the project will be created.

Note: When this option is used, the new project will keep the same password, if defined, as the original project.

Close and open projects

Location*: File* | *Close*

When a project is closed, the program closes all grids and queries that may be open at that time and saves the pending changes

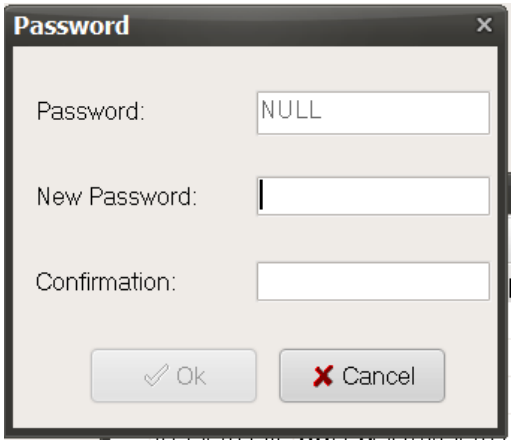
The action to close a project is implicit in the opening of another project, because when a project is opened, it automatically closes the active project. An open project is also closed when the program execution is completed.

Change password

Location*: File* |*Change password*

Each of the projects captured by the *Sizer Electric* software is protected by a password to ensure that project information is not changed by unauthorized personnel. As will be observed when creating a new project, this is protected by the password: KEY. However, it is possible that the user is familiar with another password or it is easier to remember another one. For this reason, the *Sizer Electric* software includes the option to change the password, which will protect only the information of this project. This change will not affect any password of any project captured before.

In the dialog box shown, enter the current password, the new password and to verify that there were no errors in the capture, type the password again in the confirmation box. (Remember, the password assigned to the project by default is the password: KEY).



If the current password is correct and the new password has no errors, the password will be changed and the program will notify it by means of a message on the screen.

Note: To change the password, there should be no grid, query or report open in the event that some of these are open the OK button will be disabled.

Chapter

4

Data Capture

References

Location: *Queries* | *References*

In any electrical project there are specific data that make it different from another project and this information is used to distinguish both electronic and printed information. Thus, in the *References* section should capture the relevant project information to be printed on the program reports. The information captured should have the following characteristics:

Project Name: In this field you should enter the name of the project you want to appear in the reports.

Example:	National-001E	Validation:	Up to 40 characters

Customer: It is the name and address of the customer for whom the project is developed.

Example:	National Intercommunications Inc.	Validation:	Up to 40 characters

Location: In this field you should enter the address of the project or the state where the construction is placed.

Example:	Arizona EUA	Validation:	Up to 40 characters

Document / Technical report: It is a 20-character field in which a legend that will identify defined reports should be entered.

Example:	NAT-E001	Validation:	Up to 20 characters

Captured by: It is the name of the person running the program and / or the capturing the information and preparing calculation reports.

Example:	John Smith	Validation:	Up to 40 characters

E-mail: This is the e-mail address of the person who captures the information. It should have a format with the name, "@" and the domain name accompanied by a period (.) and the extension of the email. This information is required for the 3 persons in this window.

Example:	John.smith@national.com	Validation:	Up to 40 characters

Telephone: It is the telephone number of the person who captures the information. It must have a number format and may include symbols for marking.

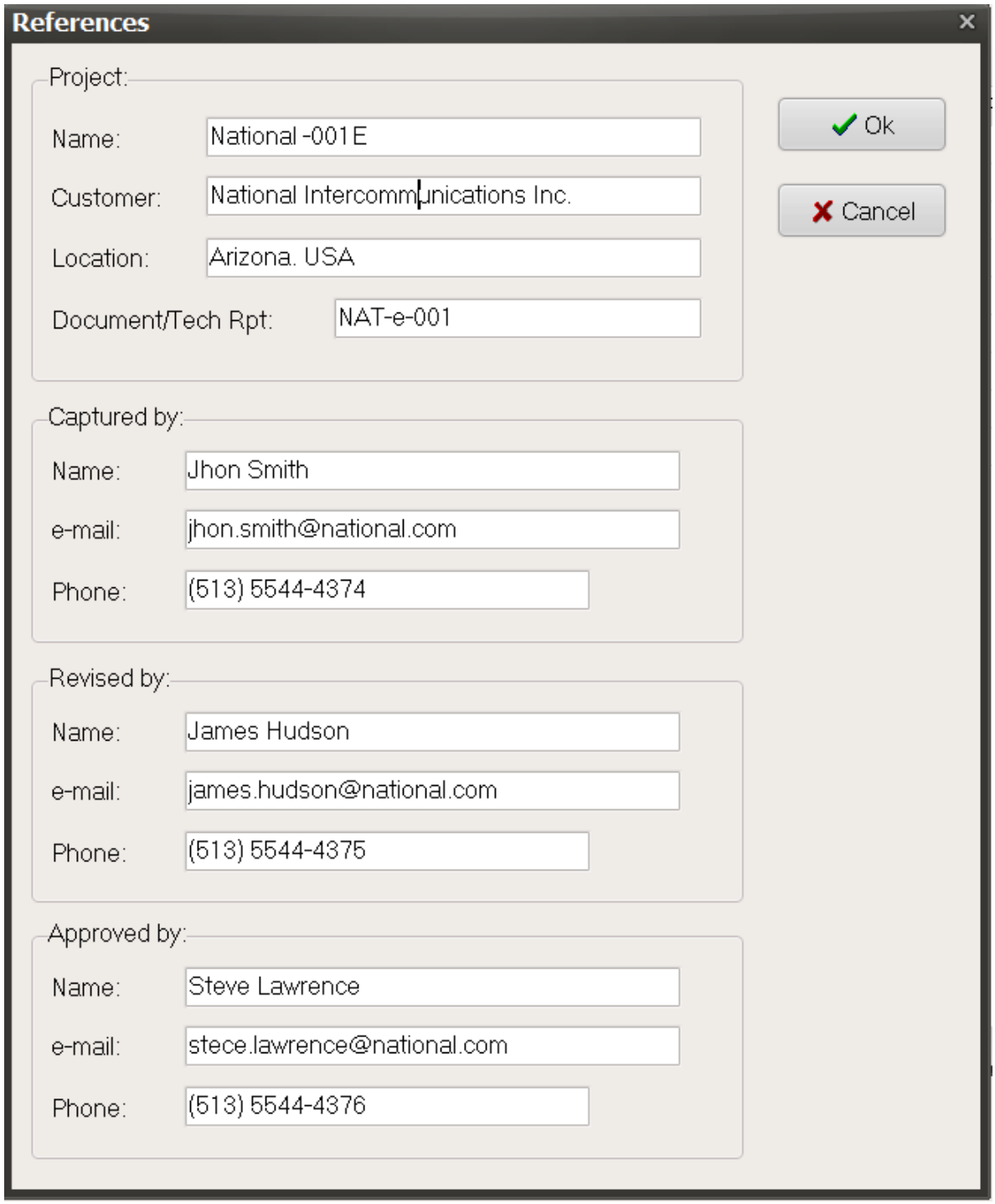
Example:	+52 1 (55) 34 56 78 90	Validation:	Up to 40 characters

Revised by: It is the name of the person responsible for supervising the review process and calculation reports.

Example:	James Hudson	Validation:	Up to 40 characters

Approved by: Is the name of the person certifying the validity of both the reports generated by the program and the calculation reports.

Example:	Steve Lawrence	Validation:	Up to 40 characters



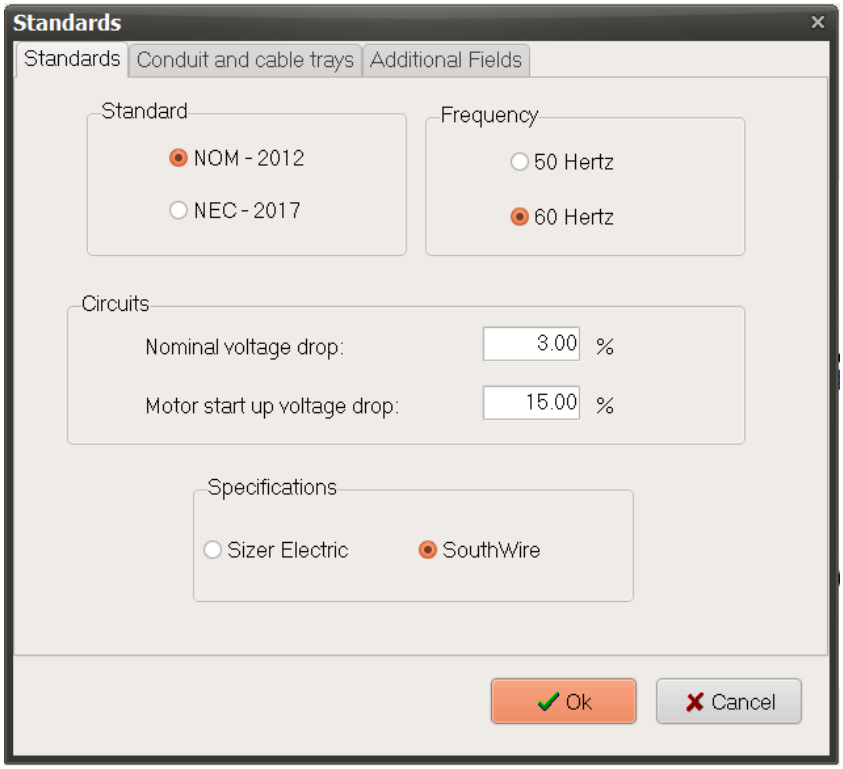
References Window

Applicable standards

Location: *Queries* | *Standards*

The standards represent the criteria that apply to the calculation logic for all circuits captured. This window contains 3 tabs: Standards, Conduit and cable trays and Additional Fields.

Standards



Standards data entry window

In the Standards tab is defined the criteria that applicable for the conductors selection and for cable tray and conduit filling. The fields shown have the characteristics defined below:

Standard. This data prompts the user in the form of options and allows you to choose the standard governing the calculation criteria. You can select the standard NOM-001-SEDE-2012 or the 2017 Edition of National Electrical Code.

> Note: The selection of the applicable standard allows to choose the criteria used to calculate because there are slight deviations from one to another standards

Example:	NOM	Validation:	Not applicable

Nominal voltage drop: Is the value of the voltage drop expressed in percent of the system rated voltage. This value will be considered for the calculation, only if the specific voltage drop circuit data is not defined. For circuits at voltages below 600 V, it should be in the range of 0 to 5%, according to the notes of sections 215.2 (A)(1)(b) Note 2 and 210.19(A)(1) as follows:

"215.2(A)(1)(b)

Informational Note No. 2: Conductors for feeders, as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, will provide reasonable efficiency of operation.

210.19(A)(1)

Informational Note No. 4: Conductors for branch circuits as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, provide reasonable efficiency of operation. See Informational Note No. 2 of 215.2(A)(1) for voltage drop on feeder conductors."

Extracted from National Electrical Code® NFPA 70®, Edition 2017,by National Fire Protection Association, pp. 70-49 and pp-70-61.

Example:	3.0	Validation:	0.0 < Value < 5.0

Motor Start up Voltage Drop: Is the value of the maximum voltage drop expressed in percentage of the system rated voltage that must be present in the conductor when the motor of the circuit is started. This value must be within the range of 0-20%.

The calculation of voltage drop at motor starting is a best practice established between the industrial plants designers and aims to ensure that under motor starting conditions, the voltage drop generated in the circuit conductor does not affect adversely the motor torque. This percentage of voltage drop is not regulated by any institution or regulation.

According to the standard IEEE Std.399 "Recommended Practice for Industrial and Commercial Power System Analysis", the minimum allowable voltage drop the motor terminals is 80% of rated voltage for NEMA B design motors. This may be higher or lower depending on the characteristics of the actual mechanical load on the motor.

Example:	15.0%	Validation:	0.0% < Value < 20.0%

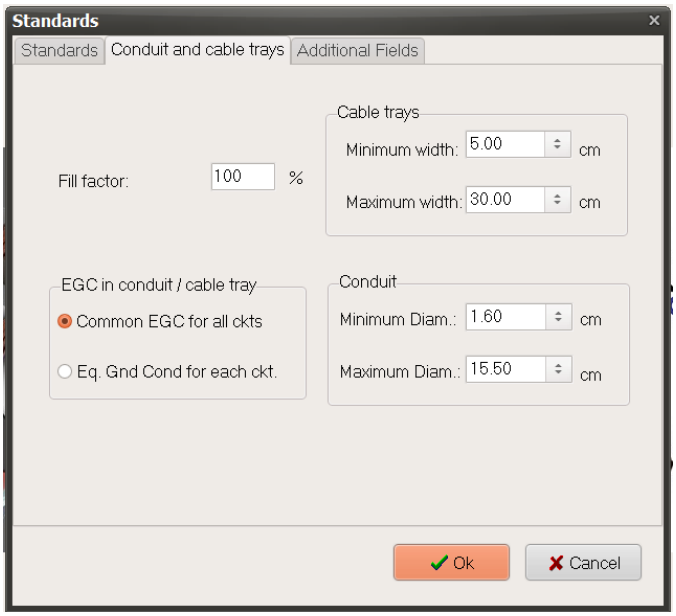
Specifications: This option will allow you to choose the library to obtain the weight and diameter information for the conductors generated after the calculation. Two

options are presented: Sizer Electric generics and the ones from the conductor manufacturer Southwire. By selecting the first one, you will have average and generic information from different manufacturers in the market and in the case of Southwire you will have precise information from the manufacturer to increase the precision in the definition of your conductor cable trays and conduits.

Example:	Southwire	Validation**:**	Select and option

Conduit and cable trays

In this section, is defined the criteria used to calculate the cable tray and conduit filling for the entire project.



The fields on this section are as follows:

Minimum width. This is the minimum width to be used for the selection of cable tray. Cable trays widths allowed are those defined in NEMA VE. 15, 30, 45, 60, 75 and 90 cm.

Example:	15	Validation:	15, 30, 45, 60 , 75 and 90 cm.

Maximum width. This is the maximum width to be used for the selection of cable tray widths. Cable trays widths allowed are those defined in NEMA VE. 15, 30, 45, 60, 75 and 90 cm. If the value of the minimum width is equal to the maximum width, the *Sizer Electric* software will select only cable trays width defined in any of the two fields.

Example:	90	Validation:	15, 30, 45, 60 , 75 and 90 cm.

Minimum diameter. This is the minimum diameter to be used for the selection of conduit diameters. The conduit diameter allowed are those permitted in the NEC 2017 and NOM-001-SEDE-2012. If the Standard selected in this window for calculation is NOM, the diameters are presented in centimeters if the selected standard is displayed NEC diameter are shown in inches.

Example:	15	Validation:	15, 30, 45, 60 , 75 and 90 cm.

Maximum diameter. This is the maximum diameter to be used for the selection of conduits. If the value of the minimum diameter is equal to the maximum diameter, the Sizer Electric software will only select conduit of diameter defined in any of the two fields

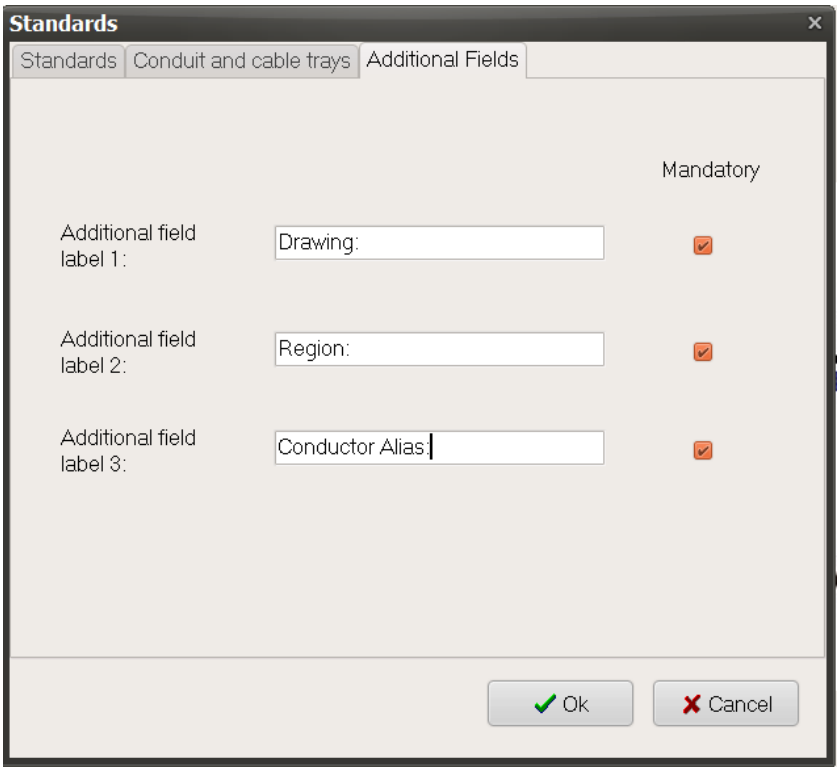
Example:	90	Validation:	15, 30, 45, 60 , 75 y 90 cm.

Fill factor. It is the maximum ratio at which the conduit and cable trays filling is allowed during the selection of cable trays and conduits. Using the maximum permitted areas defined in the NEC-2017 and the NOM-001-SEDE-2012 the program will consider this value as the maximum percentage. Saving the fill difference for future use.

Example:	80.0	Validation:	>0 to 100%.

Grounding conductor (EGC) in Raceway / Cable tray. When installing conductors in cable tray the NEC-2017 statements allow the installation of a common ground conductor for all the circuits on the tray with branches in each equipment connection. This option allows a single equipment grounding conductor considered for all the circuits or an equipment grounding conductor for each circuit. If you select the option: "Consider common ground", only the larger equipment grounding conductor area of the group of conductors installed on the cable tray will be used to calculate the filling area of the cable tray or conduit area. If you select "A EGC per circuit" the equipment grounding conductor area of each circuit assigned to the tray is considered to determine the cable tray width or conduit diameter and the corresponding filling percentage.

Additional fields



During the process of capturing the information of circuits it is possible that it is necessary to add information to achieve a better identification of the circuit, associate it with information of some drawings or link manually or electronically the reports with another document or project process .

Sizer Electric incorporates 3 text type fields up to 25 characters that can be named according to the user needs. The text boxes in this tab allow you to assign the identification to the fields that will be displayed in the *Circuit Capture* window

Each field has a checkbox associated with it that will allow you to define whether this custom field is mandatory (Checked box) or optional. In case of checking the "Mandatory" box the application will validate that the field is filled with some data by the user and that it is not empty.

It is important to note that the application will only validate that the field to be captured on the *Circuit Capture* window has text characters but will not validate the content or format of it.

Example:	Drawing number	**Validation:**	17 characters.

General Data

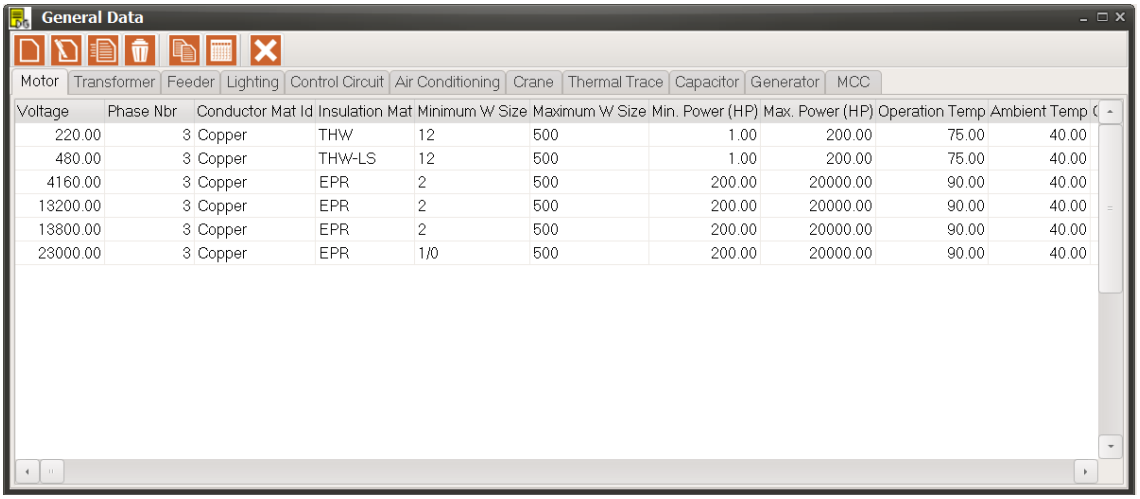
Location: *Queries* | *General Data*

In electrical engineering projects it is common to find restrictions, design criteria or customer specifications defined for a group of equipment with similar characteristics. For example: Motors ranging 1-200 HP should be fed with a voltage of 480 volts and their conductors must have a THW type insulation.

Thus, it is necessary to apply specific design criteria for this segment of equipment of the project. Capturing *General Data* defines the specific criteria for a group of equipment and notifies the user about deviations in the data capture.

The General Data grid is designed to define the criteria and define the minimum and maximum values for which the calculation is governed. These data must be defined by the engineer responsible for the project.

From the group of tabs you must select the type of equipment that is to be recorded. Tabs options are: Motor, transformer, feeder, lighting, circuit control, air conditioning, crane and hoist, heat trace, MCC and capacitor.



Voltage	Phase Nbr	Conductor Mat Id	Insulation Mat	Minimum W Size	Maximum W Size	Min. Power (HP)	Max. Power (HP)	Operation Temp	Ambient Temp
220.00	3	Copper	THW	12	500	1.00	200.00	75.00	40.00
480.00	3	Copper	THW-LS	12	500	1.00	200.00	75.00	40.00
4160.00	3	Copper	EPR	2	500	200.00	20000.00	90.00	40.00
13200.00	3	Copper	EPR	2	500	200.00	20000.00	90.00	40.00
13800.00	3	Copper	EPR	2	500	200.00	20000.00	90.00	40.00
23000.00	3	Copper	EPR	1/0	500	200.00	20000.00	90.00	40.00

General data grid

Note that when the general data grid is active, in the main menu a new option will be added: *Edition*, which will be located between the options *File and Queries*, This option is available only when the grid is active.

The grid contains a tool bar, which contains the following icons associated with specific tasks.

 **Add:** By selecting this option the G*eneral Data* capture will be shown. Here you can enter the data (specifications and restrictions) for any of the load types in the system. To do this, simply select the tab of the selected load and press the *Add* button.

 **Modify:** When you have previously captured data for a load type, you can modify them using this option. It should be noted that any field can be modified, excluding data voltage and number of phases.

 **Copy General Data information:** With this option you can use a *General Data* reference to create a new one. It applies only to *General Data* for the same type of load.

 **Delete:** This option is used to delete a general data. Care should be taken when using this action, because when there are data circuits associated with the overall data, both general data automatically deleted and associated circuits thereto**.**

 **Copy to Clipboard:** When this option is selected, the G*eneral Data* of the active tab is copied to the clipboard, so the user can then paste the information to any spreadsheet or word processor.

 **Columns Customization:** When this option is selected, a dialogue box with all the columns containing the grid is displayed, in this dialogue box you can change the order or hide them.

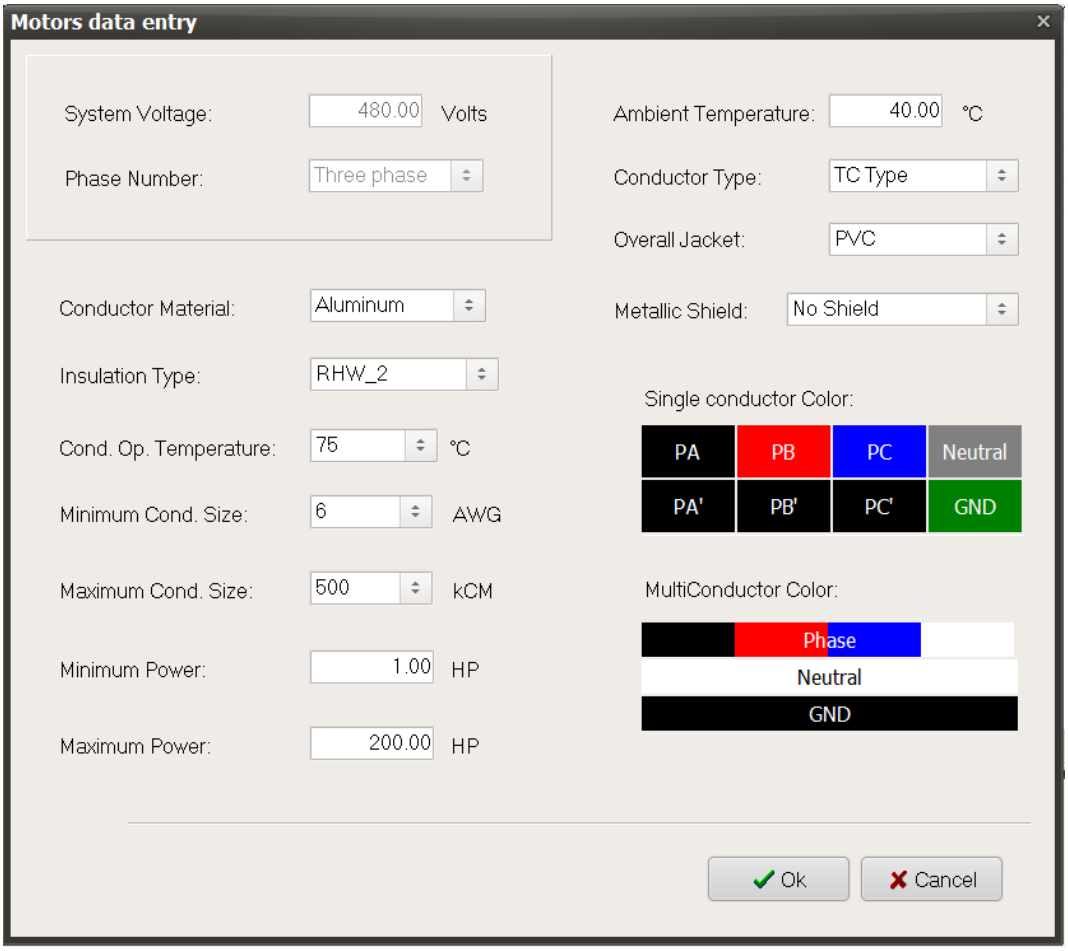
 **Exit:** Closes the *General Data* grid.

General data information must be captured for each type of load and the data must have the following characteristics:

System Voltage: The voltage value at which the equipment is connected. It must be expressed in volts and should be in strict accordance with the design basis of the project. This voltage determines the completion of calculation circuits. Therefore, any circuit with different voltage captured in this section will not be accepted. It should be noted that this voltage is closely related to the number of phases and together, differ from any other permitted voltage for the same type of load.

The definition of the system voltage for each type of load allows you to know what is the minimum and maximum power allowed by voltage level. It also allows to

associate a type of insulation for each voltage captured. So this is mandatory information to be captured before start capturing data for a circuit.



General Data entry window

These voltage values must be preferably according to sections 110-4 and 220-5 of the NOM-001-SEDE-2012 or NEC 2017.

> **"110.4 Voltages.** Throughout this *Code*, the voltage considered shall be that at which the circuit operates. The voltage rating of electrical equipment shall not be less than the nominal voltage of a circuit to which it is connected.
>
> **220.5 Calculations.**
> **(A) Voltages.** Unless other voltages are specified, for purposes of calculating branch-circuit and feeder loads, nominal system voltages of 120, 120/240, 208Y/120, 240, 347, 480Y/277, 480, 600Y/347, and 600 volts shall be used."
>
> Extracted from National Electrical Code® NFPA 70®, Edition 2017,by National Fire Protection Association, pp. 70-44 and pp-70-70.

Example:	448.0	Validation:	0.0 < Value ≤ 35000.0

Number of phases: Identifies whether the system voltage will be supplied in a single phase (1) or three phases (3).

Example:	3 (Three)	Validation:	1 or 3

Conductor material: A definition of the G*eneral Data*, where you select the conductor material to be used to select conductor ampacity in the system voltage for the selected load type. There are two types of materials for which the program performs the selection of conductors: Copper and aluminum.

See section 310-106 (B) of the NEC 2017 for types of materials.

> **"(B) Conductor Material.** Conductors in this article shall be of aluminum, copper-clad aluminum, or copper unless otherwise specified.
>
> Solid aluminum conductors 8, 10, and 12 AWG shall be made of an AA-8000 series electrical grade aluminum alloy conductor material. Stranded aluminum conductors 8 AWG through 1000 kcmil marked as Type RHH, RHW, XHHW, THW, THHW, THWN, THHN, service-entrance Type SE, Style U, and SE Style R shall be made of an AA-8000 series electrical grade aluminum alloy conductor material."
>
> Extracted from National Electrical Code® NFPA 70®, Edition 2017,by National Fire Protection Association, pp. 70-170.

Example:	Copper	Validation:	Aluminum or Copper

Insulation type: In this field you should enter the type of insulation for the electrical conductor. The insulation type will be used later to define the maximum instantaneous temperature elevation during short circuit conditions.

Example:	THW	Validation:	TW, THW, THHW, THW-LS, THWN, XHHW, RHH, RHW-2, THHN, XHHW, XHHW-2, PVC, EPR, EP, XLP y XLPE

Conductor insulation temperature: The maximum operation temperature of the conductor insulation expressed in degrees Centigrade. This value is used for the selection of the circuit conductor allowable ampacity table.

Example:	75	Validation:	60, 75, 90, 105, 150, 200 y 250

Conductor Type: The type of conductor will be used to integrate the conductor's specification and will provide information about its overall diameter and weight. The available options are:

Standard: It is an average conductor with insulation suitable for the system voltage, only considers the conductive material and typical insulation. Mainly for use in conduit, directly buried and underground ducts .

Type TC: (Tray Cable) It is a conductor for use in cable trays. According to section 336-2: Power cable and control for tray, type TC. Factory assembled

assembly of two or more insulated conductors, with or without associated bare or covered grounding conductors, under a non-metallic enclosure. See Cable TC uses in section 336-10. Uses permitted.

Type TCER: (Tray Cable Exposed Runs) It is an approved conductor for use in cable trays when the transition between cable trays and between the cable trays and the equipment or devices has a distance no greater than 1.80 meters without continuous support. The cable must be supported mechanically where it leaves the cable tray to ensure that the minimum radius of curvature is not exceeded.

Armored AIA (Aluminum Interlocked Armor): Armored Cables with interlocked aluminum armor, is a flexible conductor of great mechanical resistance. It is one of the most common types of armor used in industrial applications.

Armored GSA (Galvanized Steel Armor): Armored Cables with galvanized steel armor.

Armored CWA (Corrugated Welded Armor): Armored Cables with corrugated tube armor and welded aluminum.

Example:	Standard	**Validation**:	Item from the list

Minimum and Maximum Conductor Size: Are the minimum and maximum conductors sizes allowed in the project. The selected conductors will strictly be within the range defined by these data. These conductor sizes must be defined according to the statements shown in the tables of allowable ampacity for conductors from NEC 2017 and NOM-001-SEDE-2012.

Definition of the minimum conductor size allows the engineer to indicate at which conductor size the selection of the circuit conductors will start. From the drop-down list displayed in this field it can be seen that the first size shown is according to the minimum possible size for the system voltage following the restrictions of the section 310-106 (a)

310.106 Conductors.
(A) Minimum Size of Conductors. The minimum size of conductors shall be as shown in Table 310.106(A), except as permitted elsewhere in this *Code*.

Table 310.106(A) Minimum Size of Conductors

Conductor Voltage Rating (Volts)	Minimum Conductor Size (AWG)	
	Copper	Aluminum or Copper-Clad Aluminum
0–2000	14	12
2001–5000	8	8
5001–8000	6	6
8001–15,000	2	2
15,001–28,000	1	1
28,001–35,000	1/0	1/0

Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association, pp. 70-170.

Example:	"12", "1/0"or "500"	Validation:	14 AWG – 1000 KCM

Minimum and maximum authorized power: Are the upper and lower limits of the range for which the calculation can be performed for this project. Any power circuit outside this range is not calculated and an error will be shown in the output reports. Power values should be indicated in HP for motors, in KVA and KW for transformer for control circuits, MCCs and feeders.

These power values are set considering that the designer has made a technical and economic study to determine which is the most suitable voltage for the startup and operation of the motors and various equipment.

Example:	300	Validation:	0.0 < Value < 10000.0

Ambient temperature: The temperature of the environment surrounding the conductor in degrees Celsius. It is used to determine the allowable ampacity adjustment factor of the circuit at this temperature.

According to section 310-10 of the applicable standard:

> **"310.15 Ampacities for Conductors Rated 0–2000 Volts.**
> **(A) General.**
>
> **(3) Temperature Limitation of Conductors.** No conductor shall be used in such a manner that its operating temperature exceeds that designated for the type of insulated conductor involved. In no case shall conductors be associated together in such a way, with respect to type of circuit, the wiring method employed, or the number of conductors, that the limiting temperature of any conductor is exceeded.
>
> **Informational Note No. 1:** The temperature rating of a conductor [see Table 310.104(A) and Table 310.104(C)] is the maximum temperature, at any location along its length, that the conductor can withstand over a prolonged time period without serious degradation. The allowable ampacity tables, the ampacity tables of Article 310 and the ampacity tables of Informative Annex B, the ambient temperature correction factors in 310.15(B)(2), and the notes to the tables provide guidance for coordinating conductor sizes, types, allowable ampacities, ampacities, ambient temperatures, and number of associated conductors. The principal determinants of operating temperature are as follows:
> (1) Ambient temperature — ambient temperature may vary along the conductor length as well as from time to time.

(2) Heat generated internally in the conductor as the result of load current flow, including fundamental and harmonic currents.
(3) The rate at which generated heat dissipates into the ambient medium. Thermal insulation that covers or surrounds conductors affects the rate of heat dissipation.
(4) Adjacent load-carrying conductors — adjacent conductors have the dual effect of raising the ambient temperature and impeding heat dissipation.

Informational Note No. 2: Refer to 110.14(C) for the temperature limitation of terminations."

Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-146.

Example:	40.0	Validation:	$0.0 < \text{Value} \leq 225.0$

Insulation type: In this field you should enter the type of insulation for the electrical conductor. The insulation type will be used later to define the maximum instantaneous temperature elevation during short circuit conditions.

Example:	THW	Validation:	TW, THW, THHW, THW-LS, THWN, XHHW, RHH, RHW-2, THHN, XHHW, XHHW-2, PVC, EPR, EP, XLP y XLPE

Overall jacket: Multiconductor, armored cables and some single conductors shall have an outer cover to provide protection against environmental conditions and against corrosive environments. This information is not used for the conductor selection but it will be used to define the circuit conductor specification and later to obtain the total overall diameter and weight of the conductor with this jacket. Three options are presented in the list:

PVC (Polyvinyl Chloride) for industrial use and utilities for use in wet and dry locations, aerial, overall jacket different from black. Indoors and outdoors installation, cable trays, conduit, in underground ducts or directly buried, in dry and wet locations.

CPE (Chlorinated Polyethylene) for use in substations, installation in interiors and exteriors, trays, Conduit pipe, buried ducts or directly buried, in dry and wet installations.

LS0H for low smoke emission zero halogens suitable for installations with a people concentration.

No jacket. In the case of some armored conductors, the conductor may be available without an overall jacket.

Example:	PVC	Validation:	Item from the list

Metallic Shield: Indicates whether the conductor integrates a metallic or semi conductive screen to prevent induced voltages and dielectric stress in the insulation. There are 3 options: No Shield, helical metallic overlapping tape shield

of the same material of the conductor and helical bare conductor shield of the same conductor material. See section 310.10(e) .

“Part II. Installation

310.10 Uses Permitted.
(E) Shielding. Nonshielded, ozone-resistant insulated conductors with a maximum phase-to-phase voltage of 5000 volts shall be permitted in Type MC cables in industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation. For other establishments, solid dielectric insulated conductors operated above 2000 volts in permanent installations shall have ozone resistant insulation and shall be shielded. All metallic insulation shields shall be connected to a grounding electrode conductor, a grounding busbar, an equipment grounding conductor, or a grounding electrode. Informational Note: The primary purposes of shielding are to confine the voltage stresses to the insulation, dissipate insulation carry ground-fault current to facilitate operation of ground-fault protective devices in the event of an electrical cable fault.
Exception No. 1: Nonshielded insulated conductors listed by a qualified testing laboratory shall be permitted for use up to 2400 volts under the following conditions:
(a) Conductors shall have insulation resistant to electric discharge and surface tracking, or the insulated conductor(s) shall be covered with a material resistant to ozone, electric discharge, and surface tracking.
(b) Where used in wet locations, the insulated conductor(s) shall have an overall nonmetallic jacket or a continuous metallic sheath.
(c) Insulation and jacket thicknesses shall be in accordance with Table 310.104(D).
Exception No. 2: Nonshielded insulated conductors listed by a qualified testing laboratory shall be permitted for use up to 5000 volts to replace existing nonshielded conductors, on existing equipment in industrial establishments only, under the following conditions:
(a) Where the condition of maintenance and supervision ensures that only qualified personnel install and service the installation.
(b) Conductors shall have insulation resistant to electric discharge and surface tracking, or the insulated conductor(s) shall be covered with a material resistant to ozone, electric discharge, and surface tracking.
(c) Where used in wet locations, the insulated conductor(s) shall have an overall nonmetallic jacket or a continuous metallic sheath.
(d) Insulation and jacket thicknesses shall be in accordance with Table 310.104(D).
Informational Note: Relocation or replacement of equipment may not comply with the term *existing* as related to this exception.
Exception No. 3: Where permitted in 310.10(F), Exception No. 2.”

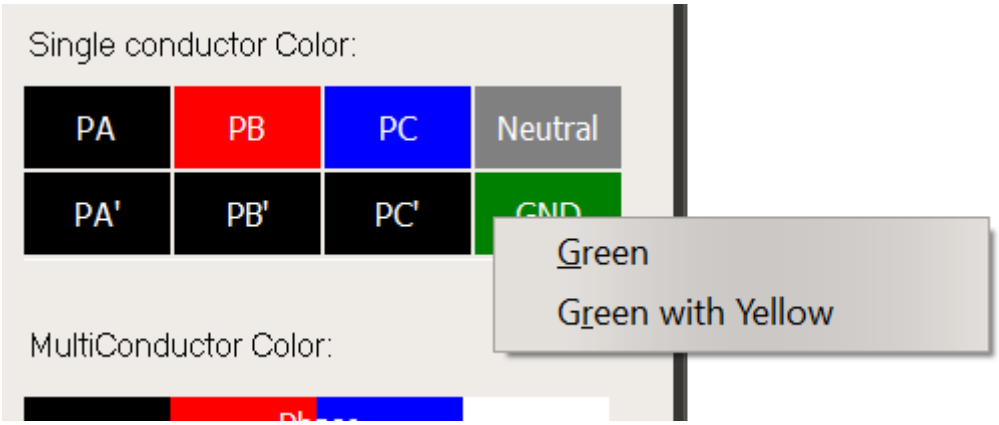
Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association, pp. 70-145.

Example:	No shield	Validation:	Item from the list

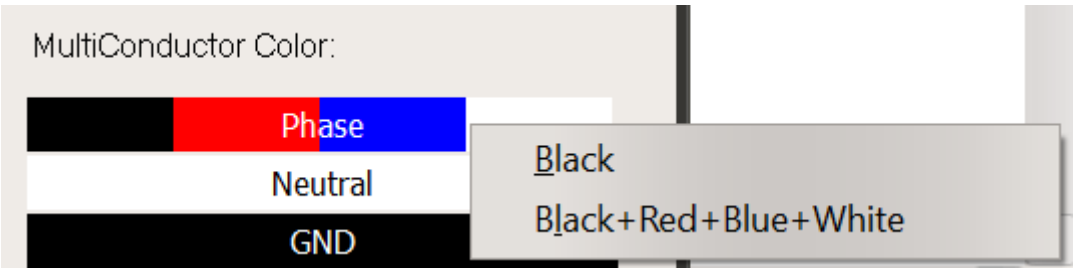
Conductor color In this option you can define the color of the conductors for each phase, as well as the color for the grounded conductor (Neutral) and for the equipment grounding conductor. The color of each of the conductors will be used to integrate the specification of the multiconductor or conductors of the circuit and later you can group the conductors with the same specification, including the color, in order to generate a bill of materials for the project conductors (See Conductor Summary section).

The colors defined in this General Data window will be applied for the type of load (Motor, Transformer, etc.) with the same voltage, insulation and operating temperature. These colors can be modified within the *Circuit Capture* window and will be respected for each circuit even if the colors in the General Data are modified later.

In the case of single conductors, a control with 8 boxes will be shown: 6 to define the phase conductors colors (The phases identified with an apostrophe (') will be for split phase connections in Delta or Wye systems with central branches), one to define the color of the grounded conductor (Neutral) and one more to define the color of the equipment grounding conductor. To modify the color of the conductors, select the corresponding box and left click to display the menu with the color options.



In the case of multiconductor only the color options for the phases, neutral and grounding conductor will be displayed. In the case of multiconductors, all must be black or in the combination Black, Red, Blue for the phases and neutral in white.



For control circuits, a list of references of the color tables defined in the ICEA standard S-58-679-1998 is shown. These tables define the color for the control circuit conductors. These tables are used because the color combination is very broad. The tables of this standard can be found in the program help files.

Color tables of control circuits

Circuit Data

Because of the importance and complexity of the circuit capture, it will be discussed deeply in Chapter 5.

Conductor Summary

Location: *Queries* |*Summary*

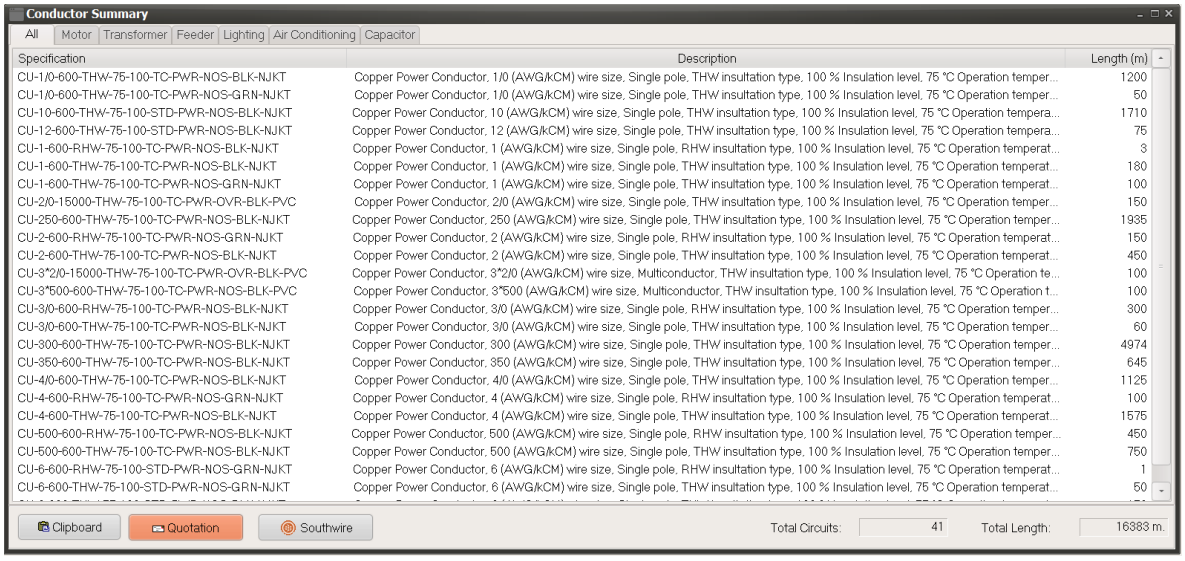
Once you have selected the conductor size for all the circuits of the project, the program has the ability to classify while compute the total lengths. So, when the *Conductor Summary* option is selected a window with different views will appear Each view represents a specific type of load (motor, transformer, etc.). One view will include all circuits. It should be noted that only circuits with calculated loads are presented.

In each tab you can see the summary of the conductors in the project describing, conductor specification followed by the cable description with the respective length. Conductor specification generated by the software has the following structure:

Material – Conductor Size – Rated Voltage – Insulation – Operation Temperature – Insulation Level – Conductor Type – Application – Shield Type – Color- Overall Jacket

i.e. CU-1/0-600-THW-75-100-TC-PWR-NOS-BLK-NJKT

At the bottom of each view the number of circuits as well as the total length for these



Conductor summary view

In this window 3 buttons can be found:

Clipboard: This button allows you to copy the information shown on the screen to the clipboard to later paste it into another application such as MS Excel or MS Word.

Quotation: This button allows you to send the cable summary information to a server so that you can receive by email a quote of the different conductors of the project. The quotation will be sent to the contact's mail that captures the information according to the information captured in the *References* view.

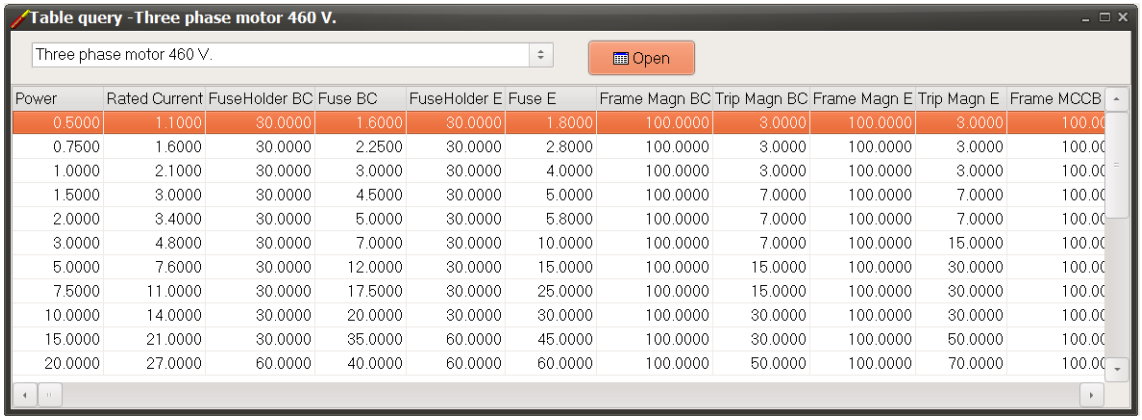
> **Note**: It is important to mention that to send the quotation request you must have an internet connection and the corresponding permissions in the proxy server of your computer. See *System Setting* section for Proxy configuration.

Southwire: This button displays the contact information of the conductor manufacturer Southwire for quote tracking, website information and contact information for conductor specification advice.

Table queries

Location: *Queries* | *Tables*

For information and technical reference, the program offers to the designer the tables used for determining the conductor size. These include tables for low and medium voltage motors, resistance and reactance, etc.



Power	Rated Current	FuseHolder BC	Fuse BC	FuseHolder E	Fuse E	Frame Magn BC	Trip Magn BC	Frame Magn E	Trip Magn E	Frame MCCB
0.5000	1.1000	30.0000	1.6000	30.0000	1.8000	100.0000	3.0000	100.0000	3.0000	100.00
0.7500	1.6000	30.0000	2.2500	30.0000	2.8000	100.0000	3.0000	100.0000	3.0000	100.00
1.0000	2.1000	30.0000	3.0000	30.0000	4.0000	100.0000	3.0000	100.0000	3.0000	100.00
1.5000	3.0000	30.0000	4.5000	30.0000	5.0000	100.0000	7.0000	100.0000	7.0000	100.00
2.0000	3.4000	30.0000	5.0000	30.0000	5.8000	100.0000	7.0000	100.0000	7.0000	100.00
3.0000	4.8000	30.0000	7.0000	30.0000	10.0000	100.0000	7.0000	100.0000	15.0000	100.00
5.0000	7.6000	30.0000	12.0000	30.0000	15.0000	100.0000	15.0000	100.0000	30.0000	100.00
7.5000	11.0000	30.0000	17.5000	30.0000	25.0000	100.0000	15.0000	100.0000	30.0000	100.00
10.0000	14.0000	30.0000	20.0000	30.0000	30.0000	100.0000	30.0000	100.0000	30.0000	100.00
15.0000	21.0000	30.0000	35.0000	60.0000	45.0000	100.0000	30.0000	100.0000	50.0000	100.00
20.0000	27.0000	60.0000	40.0000	60.0000	60.0000	100.0000	50.0000	100.0000	70.0000	100.00

Table query view

Chapter

5

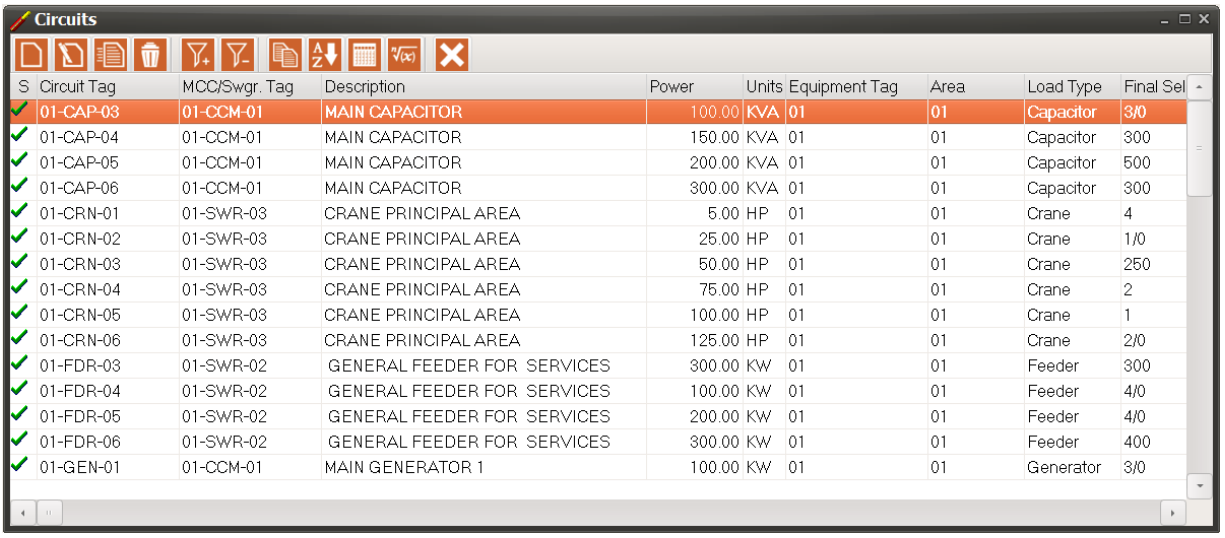
Circuits Capture

 Location: *Queries* | *Circuit Data*

To start the capture process for circuits is necessary to previously have captured the calculation criteria in the *Standards* section and ***General Data*** for the equipment you want to capture. If these requirements have not been covered, the *Main Menu* option and the *circuits icon* of the toolbar are disabled.

By selecting the option *circuit capture* a grid where the captured data circuits will be presented later. Each line represents information of a circuit and each action taken shall apply only to selected circuit in the grid.

Note that in the data circuit grid you cannot enter or edit information directly, to perform these actions, you need to open the circuit capture window. In this window the information will be validated and the data consistency will be confirmed.



S	Circuit Tag	MCC/Swgr. Tag	Description	Power	Units	Equipment Tag	Area	Load Type	Final Sel
✓	01-CAP-03	01-CCM-01	MAIN CAPACITOR	100.00	KVA	01	01	Capacitor	3/0
✓	01-CAP-04	01-CCM-01	MAIN CAPACITOR	150.00	KVA	01	01	Capacitor	300
✓	01-CAP-05	01-CCM-01	MAIN CAPACITOR	200.00	KVA	01	01	Capacitor	500
✓	01-CAP-06	01-CCM-01	MAIN CAPACITOR	300.00	KVA	01	01	Capacitor	300
✓	01-CRN-01	01-SWR-03	CRANE PRINCIPAL AREA	5.00	HP	01	01	Crane	4
✓	01-CRN-02	01-SWR-03	CRANE PRINCIPAL AREA	25.00	HP	01	01	Crane	1/0
✓	01-CRN-03	01-SWR-03	CRANE PRINCIPAL AREA	50.00	HP	01	01	Crane	250
✓	01-CRN-04	01-SWR-03	CRANE PRINCIPAL AREA	75.00	HP	01	01	Crane	2
✓	01-CRN-05	01-SWR-03	CRANE PRINCIPAL AREA	100.00	HP	01	01	Crane	1
✓	01-CRN-06	01-SWR-03	CRANE PRINCIPAL AREA	125.00	HP	01	01	Crane	2/0
✓	01-FDR-03	01-SWR-02	GENERAL FEEDER FOR SERVICES	300.00	KW	01	01	Feeder	300
✓	01-FDR-04	01-SWR-02	GENERAL FEEDER FOR SERVICES	100.00	KW	01	01	Feeder	4/0
✓	01-FDR-05	01-SWR-02	GENERAL FEEDER FOR SERVICES	200.00	KW	01	01	Feeder	4/0
✓	01-FDR-06	01-SWR-02	GENERAL FEEDER FOR SERVICES	300.00	KW	01	01	Feeder	400
✓	01-GEN-01	01-CCM-01	MAIN GENERATOR 1	100.00	KW	01	01	Generator	3/0

Similar as in the *General Data* grid, the circuit contains a menu and a toolbar, which are explained below:

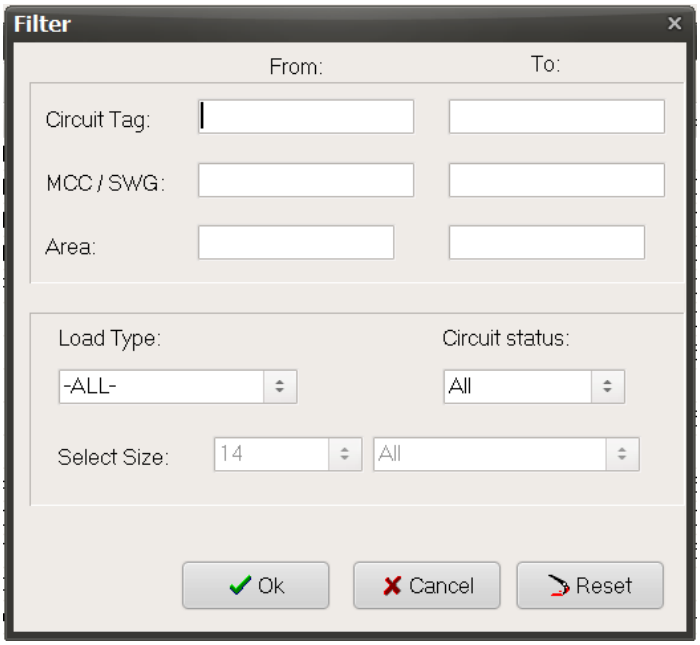
Add: When this option is selected, the circuit data capture window is shown. In it you can register all circuits of the project, without a limit on the number of circuits.

Modify: Having previously captured circuits data, it is possible to modify them by using this option. When the fields of circuit capture are edited and the *Accept* button is pressed, the program performs the calculation to select the conductor size, so the circuit data will always be synchronized with the conductor size selected.

Copy (Circuit): With this option you can take a circuit data as a reference to create a new one. This option is useful when there are circuits with similar data.

Delete: This option is used to delete a circuit. By using this process the circuit is removed from the project data base and it is impossible to undo the action.

Filter: Often during the information capture or during the analysis of the results you need to observe only part of the information that meets specific criteria, such as circuits having only 1/0 AWG sizes or circuits that are connected to a MCC or elements that are within a process area or the combination of these criteria simultaneously. Each time you select this option the following dialog box will appear:

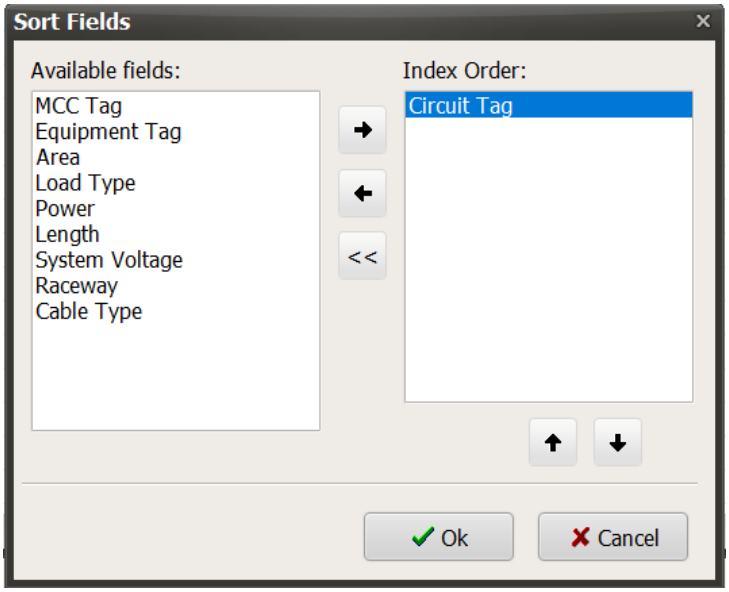


To re-define the filter fields press the button ***Initialize***.
Note: Each time a filter is executed, this takes the group of circuits contained within the previous filter as new universe.

Restore: This option restores the view of all circuits captured after performing a filtering action

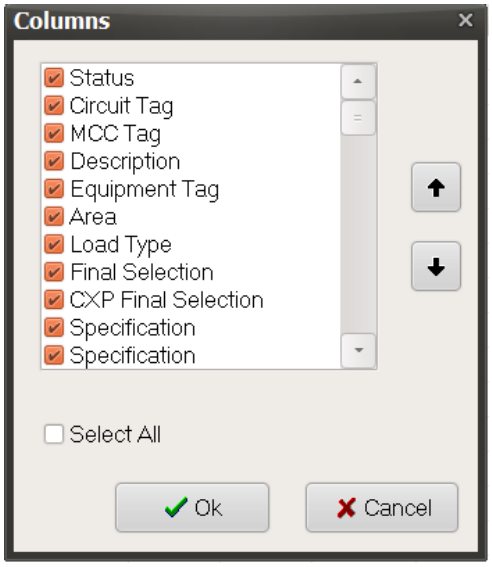
Copy to Clipboard: Selecting this option, circuits are copied to the clipboard so that the user can then paste the information to any spreadsheet or word processor. It is important to clarify that when the filter is active only visible circuits in the grid are copied to the clipboard.

Order: To facilitate the location of the circuits in the grid, the system has the option of ordering the circuits. It is possible to sort in ascending or descending order and include several fields in the order management.
Note: To apply the circuits order is necessary that no report is open in these moments.



Columns Customization: When this option is selected a dialogue box with all the columns containing the grid is displayed, here you can change the order or hide them.

If you want to observe all the columns in the grid, select the check box *Select all*.



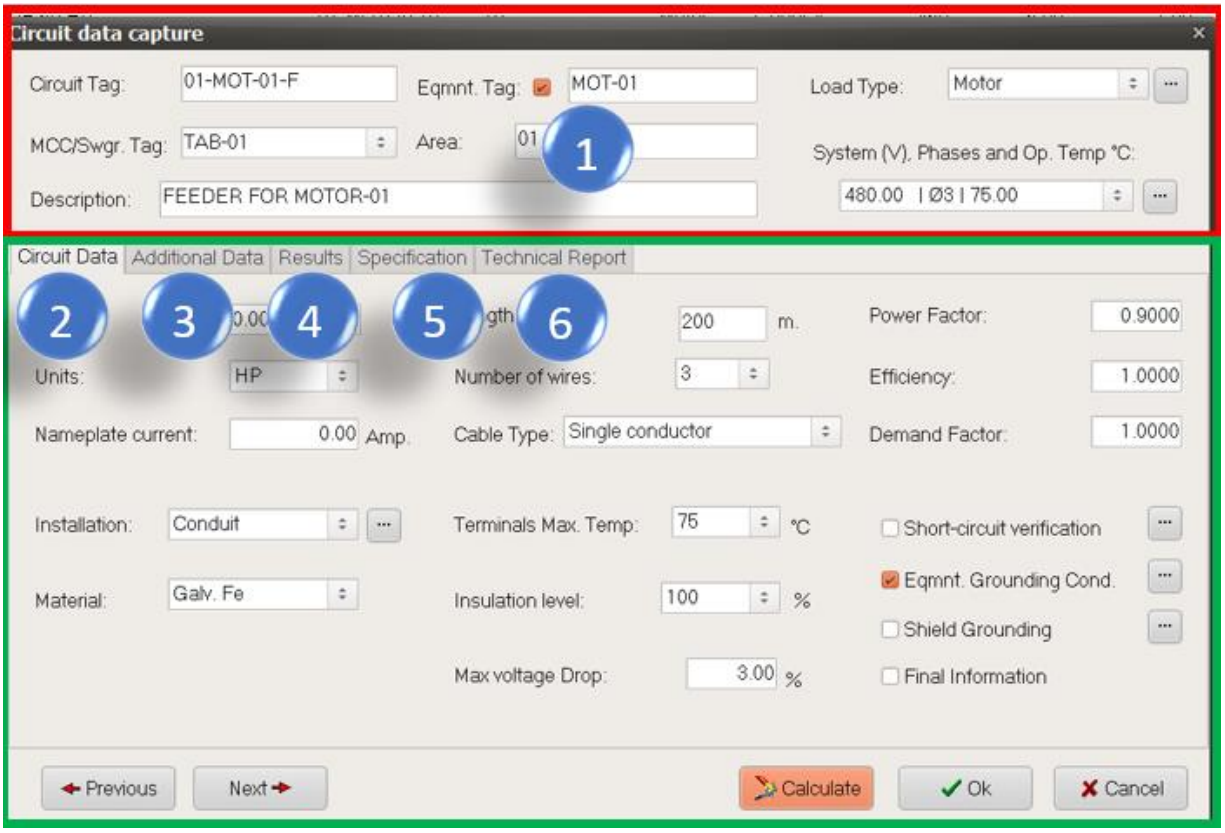
Calculation Report: In the selection of electrical conductors size is always necessary to have a report including the criteria, equations and values involved in the process. To meet this need, *Sizer Electric* creates a calculation report, which is available as long as the circuit is calculated without error. Just highlight the circuit and press this button to see a print preview of *the comprehensive technical report*.

Exit: Closes the data circuit grid.

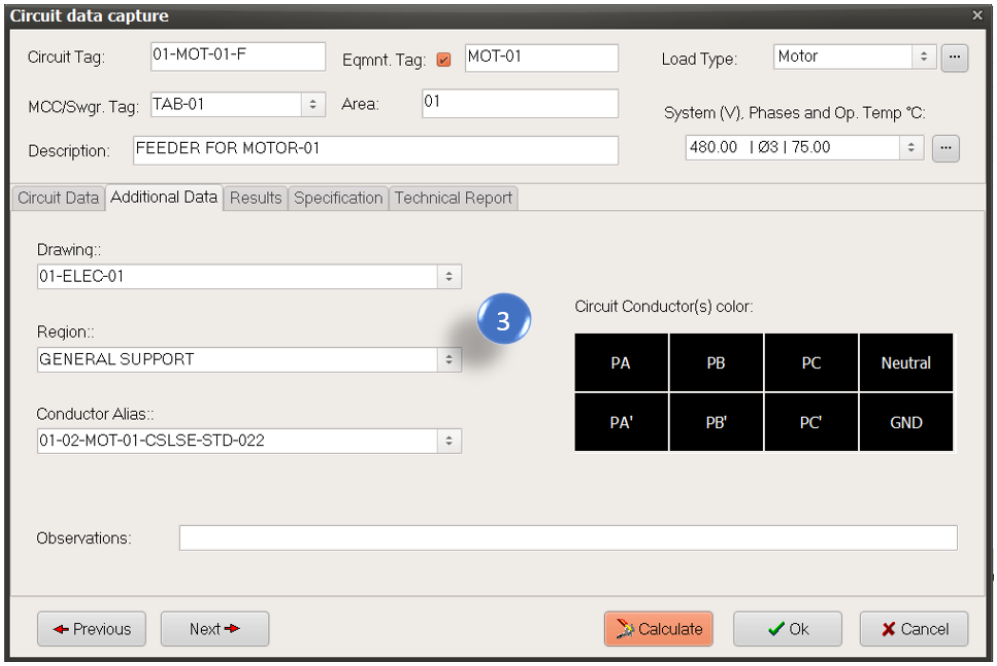
To capture and validate the circuits information is necessary to show the circuit capture window. This is divided into six (6) sections that consist of a main header and 5 tabs for data consultation and information capture. These are described below:

1. *Circuit reference:* Capture the circuit *reference* information.

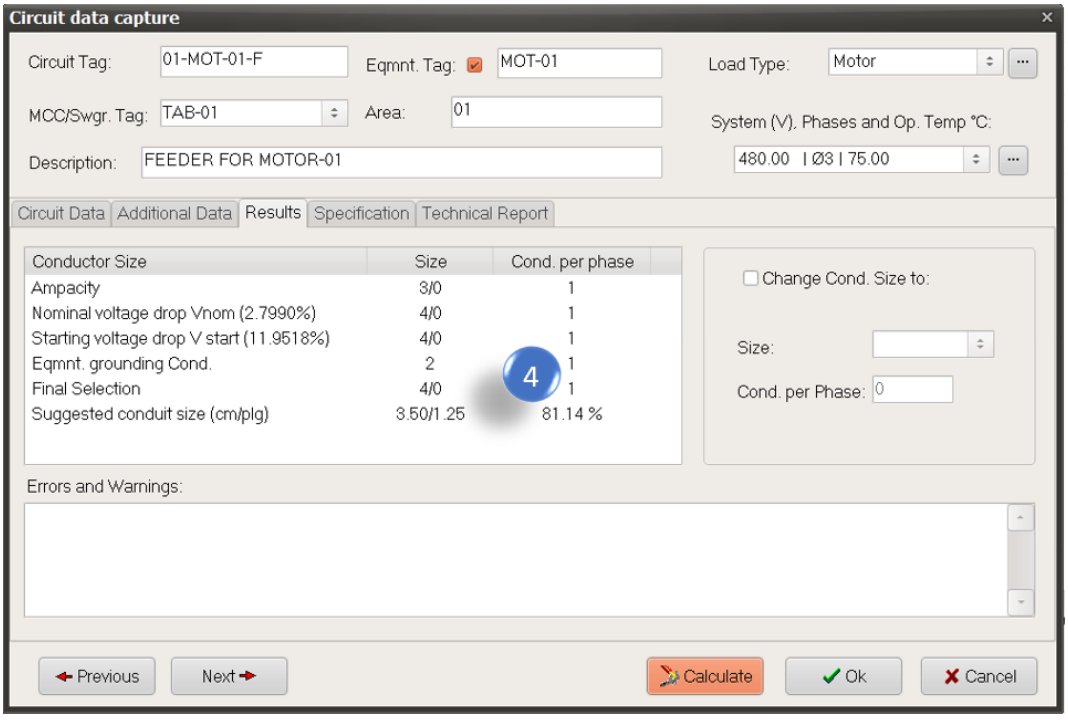
2. *Circuits Data* is a tab where technical circuit information is captured and allows you to choose the criteria for the selection of the conductor size.



3. *Additional information*. This tab shows the 3 customizable fields to complete the circuit information and allows to define the conductor colors to generate a detailed conductor specification.

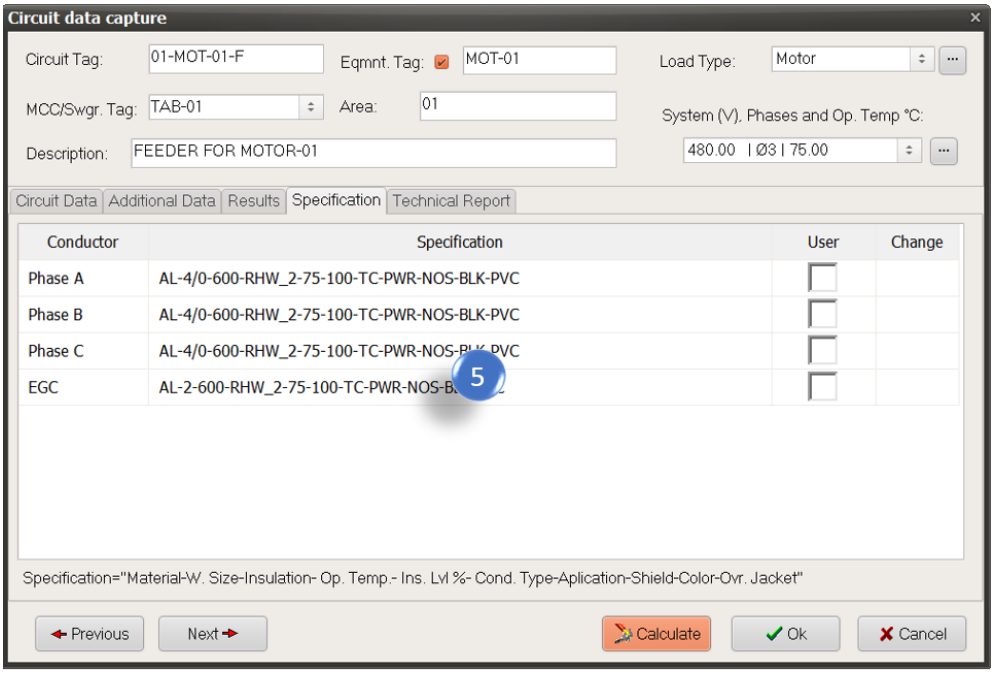


4. *Results:* Is a tab that allows you to see the results of the selection process. In addition you can identify the conductor that met the ampacity, voltage drop and short circuit criteria.

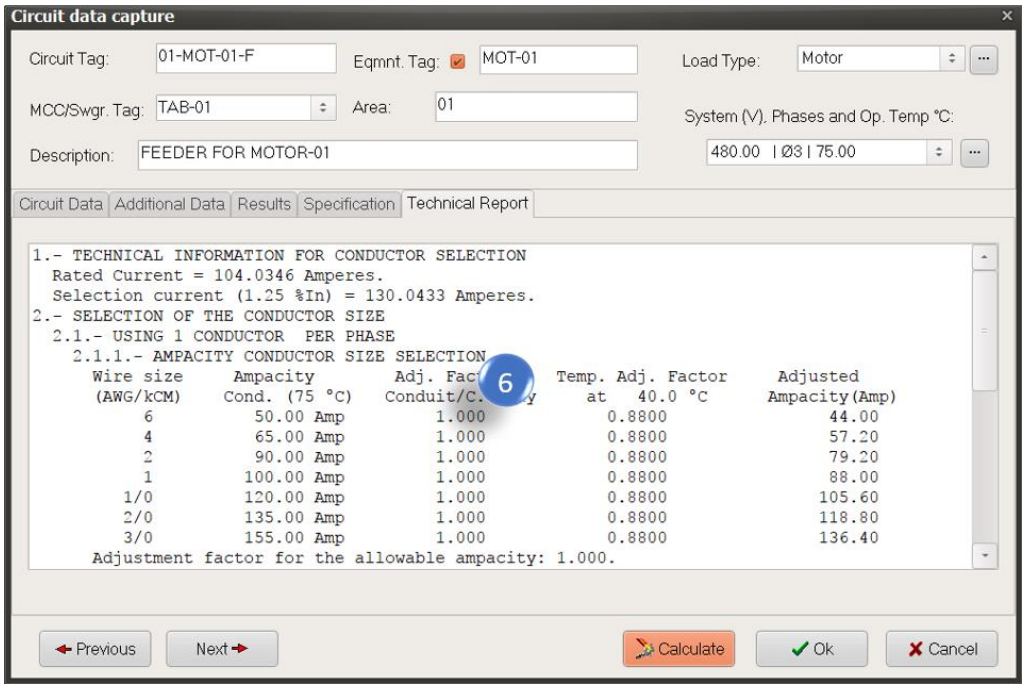


5. *Specifications*. In this section, a chain or a group of mnemonic chains that define the specification of the conductors based on their physical

characteristics are shown. In this section it is also possible to assign a new specifications to the circuit conductors.



6. *Technical Report:* In this section you can see the technical calculation report associated with the circuit. Each time the circuit is calculated this view is updated.



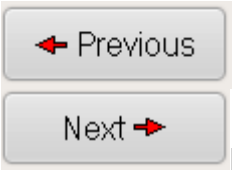
In the status bar is a brief description of the information requested in each field of the capture window. However, when more detailed information about the data being

captured is required, you can press the "F1" key on the keyboard, this will show help file with extensive information of the active window.

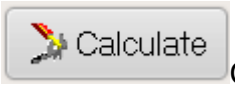
At the bottom of the circuit capture window can be seen three buttons whose functionality is described below:

OK: Update the information that was typed in each field. Pressing this button a validation of all information captured is made and can detect errors or inconsistencies that are shown in any case through message boxes appearing on the screen.

CANCEL: Remove all entries, changes or modifications made in the circuit capture window.



PREVIOUS and NEXT: These buttons allow you to navigate between the circuits located before and after the active circuit in the capture window.



CALCULATE: Performs conductor selection after performing a validation of all captured data. Upon completion of the selection process the *Results* tab will be selected where you can watch the selected conductor and your selection criteria outlined.

Each circuit is processed separately, with applicable considerations, so it allows circuits with totally different characteristics, providing the flexibility needed for the project.

Circuit tag: This field is a string which identifies the circuit. This name must be unique for each circuit. It is a common convention among designers to integrate the number of equipment fed by the circuit and add the following endings:

- P For power circuits.
- R For heating resistances.
- I For intercommunication systems

Example:	01-PUMP01-F	Validation:	Up to 15 characters

MCC or Swgr. tag: This field is a string which identifies the Motor Control Center or switchgear or switchboard feeding the equipment.

Example:	01-CCM-01	Validation:	Up to 15 characters

Description: This field is a string for an explicit identification of the equipment fed by the circuit.

Example:	Principal Motor pump	Validation:	Up to 35 characters

Equipment tag: A string used to identify the equipment that powered by this circuit. The check box next to the number of equipment indicates whether the computer is active (checked) or is a reserve (unchecked) when its load is associated to a MCC load type. 

Example:	01-PUM-01	Validation:	Up to 15 characters

Area: In this field you should enter the identification number of the area where the equipment is installed.

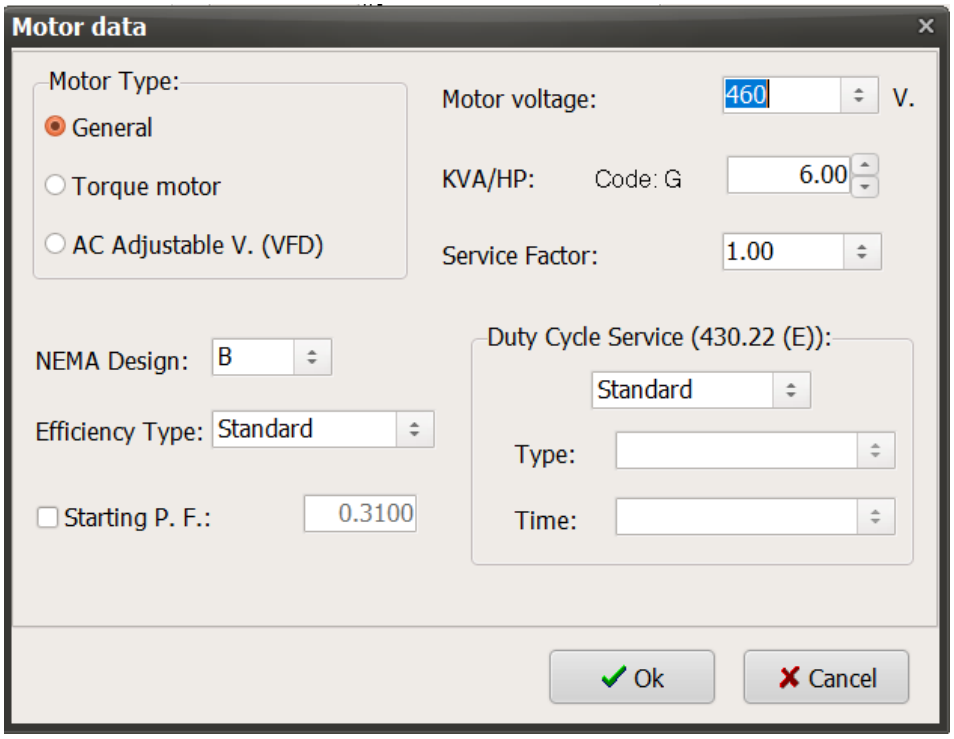
Example:	01	Validation:	Up to 10 characters

Load type: The program is able to calculate 10 different types of loads. Some types of loads such as motors and transformers require additional information requested by auxiliary windows. The types of loads analyzed are:

Motors	Transformers
Feeders	Lighting
Control Circuits	Air conditioning
Cranes and hoists	Thermic Trace
Capacitor	MCC Motor Control Centers

Motors

When the “Motor” load type is selected you must capture information of the motor operating condition and motor NEMA design type in the following window:



You can activate this window by pressing the 3-points button located on one side of the “type of load” drop-down list.

Motor Type: This field is presented as a group of options for the type of motor to be supplied. This option is used to identify the treatment to be given to the motor nameplate current according to 430-6 described in (a), (b) and (c) sections as follows:

> **“430.6 Ampacity and Motor Rating Determination.** The size of conductors supplying equipment covered by Article 430 shall be selected from the allowable ampacity tables in accordance with 310.15(B) or shall be calculated in accordance with 310.15(C). Where flexible cord is used, the size of the conductor shall be selected in accordance with 400.5. The required ampacity and motor ratings shall be determined as specified in 430.6(A), (B), (C), and (D).
>
> **(A) General Motor Applications.** For general motor applications, current ratings shall be determined based on (A)(1) and (A)(2).
>
> **(1) Table Values.** Other than for motors built for low speeds (less than 1200 RPM) or high torques, and for multispeed motors, the values given in Table 430.247, Table 430.248, Table 430.249, and Table 430.250 shall be used to determine the ampacity of conductors or ampere ratings of switches, branch-circuit short-circuit and ground-fault protection, instead of the actual current rating marked on the motor nameplate. **Where a motor is marked in amperes, but not horsepower, the horsepower rating shall be assumed to be that corresponding to the value given in Table 430.247, Table 430.248, Table 430.249, and Table 430.250, interpolated**

if necessary. Motors built for low speeds (less than 1200 RPM) or high torques may have higher full-load currents, and multispeed motors will have full-load current varying with speed, in which case the nameplate current ratings shall be used.

Exception No. 1: Multispeed motors shall be in accordance with 430.22(B) and 430.52.

Exception No. 2: For equipment that employs a shaded-pole or permanent-split capacitor-type fan or blower motor that is marked with the motor type, the full load current for such motor marked on the nameplate of the equipment in which the fan or blower motor is employed shall be used instead of the horsepower rating to determine the ampacity or rating of the disconnecting means, the branch-circuit conductors, the controller, the branch-circuit short-circuit and ground fault protection, and the separate overload protection. This marking on the equipment nameplate shall not be less than the current marked on the fan or blower motor nameplate.

Exception No. 3: For a listed motor-operated appliance that is marked with both motor horsepower and full-load current, the motor full-load current marked on the nameplate of the appliance shall be used instead of the horsepower rating on the appliance nameplate to determine the ampacity or rating of the disconnecting means, the branch-circuit conductors, the controller, the branch-circuit short-circuit and ground fault protection, and any separate overload protection.

(2) Nameplate Values. Separate motor overload protection shall be based on the motor nameplate current rating.

(B) Torque Motors. For torque motors, the rated current **shall be locked-rotor current**, and this nameplate current shall be used to determine the ampacity of the branch-circuit conductors covered in 430.22 and 430.24, the ampere rating of the motor overload protection, and the ampere rating of motor branch-circuit short-circuit and ground-fault protection in accordance with 430.52(B).
Informational Note: For motor controllers and disconnecting means, see 430.83(D) and 430.110.

(C) Alternating-Current Adjustable Voltage Motors. For motors used in alternating-current, adjustable voltage, variable torque drive systems, the ampacity of conductors, or ampere ratings of switches, branch-circuit short-circuit and ground fault protection, and so forth, shall be based on the maximum operating current marked on the motor or control nameplate, or both. If the maximum operating current does not appear on the nameplate, the ampacity determination **shall be based on 150 percent of the values given in Table 430.249 and Table 430.250.**

(D) Valve Actuator Motor Assemblies. For valve actuator motor assemblies (VAMs), the rated current shall be the nameplate full-load current, and this current shall be used to determine the maximum rating or setting of the motor branch circuit short-circuit and ground-fault protective device and the ampacity of the conductors."

Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association, pp. 70-297 and pp. 70-298.

Example:	General	Validation:	General, Torque motor or variable speed

Motor voltage: This voltage data directs the application of the tables of motors for the determination of rated current, power factor and efficiency, so they can have the following values: 575 V, 460 V, 440 V, 380 V, 230 V, 220 V, 208 V, 200 V for motors, if the voltage is different from these values the associated motor database will not be available so you will have to. make sure the motor has the necessary data to perform the calculation, such as power factor and efficiency, otherwise miscalculations may appear and consequently no data is observed in the circuit results.

Example:	440	Validation:	$0.0 < \text{Value} \leq 35000.0$

Locked Rotor Factor /Code letter / Ratio kVA / HP: In the case of motors, this can be considered as the number of times the motor nominal current increases when it starts. However, it represents the amount of apparent power that is demanded to the system for each HP of the motor. From this apparent power the value of the motor start current can be deducted. *Sizer Electric* uses the value of the starting current to calculate the voltage drop at start. The ratio KVA / HP must be in accordance with Article 430-7 (b) of the applicable standard.

"(B) Locked-Rotor Indicating Code Letters. Code letters marked on motor nameplates to show motor input with locked rotor shall be in accordance with Table 430.7(B).
The code letter indicating motor input with locked rotor shall be in an individual block on the nameplate, properly designated.

Table 430.7(B) Locked-Rotor Indicating Code Letters"

Code Letter	Kilovolt-Amperes per Horsepower with Locked Rotor
A	0–3.14
B	3.15–3.54
C	3.55–3.99
D	4.0–4.49
E	4.5–4.99
F	5.0–5.59
G	5.6–6.29
H	6.3–7.09
J	7.1–7.99
K	8.0–8.99
L	9.0–9.99
M	10.0–11.19
N	11.2–12.49
P	12.5–13.99
R	14.0–15.99
S	16.0–17.99
T	18.0–19.99
U	20.0–22.39
V	22.4 and up

Extracted from National Electrical Code® NFPA 70®,
Edition 2017,by National Fire Protection Association, pp. 70-299.

Example:	6.0	Validation:	0.0 < Value ≤ 40.0

Service factor: The motor service factor. For motors this factor must be in the range between 0.85 and 2.0 in compliance with NOM-001-SEDE-2012 and NEC-2017.

Example:	1.0	Validation:	1.0 ≤ Value ≤ 2.0

NEMA Design: The NEMA design type used to manufacture the motor. The characteristics of start current, rated current and protection devices are related to this definition.

Example:	B	Validation:	A, B, C, D or E

Type of efficiency: You must select the motor efficiency type to make the selection of the values of efficiency program library.

Example:	Standard	Validation:	Standard, High Efficiency or Premium

Starting F.P.: This field allows to capture the power factor for motors at starting. To capture this data, the check box aside must be checked. If you do not have this information, the box is left unchecked and the calculation process will assign the power factor from the library and can be consulted in this space after performing the calculation.

Example:	0.3	**Validation:**	0 < Starting PF < 1.0

Motor Use (Duty Cycle Service): The motor operating cycle or duty cycle service define the increase adjustment factor of the motor rated current for the conductor size selection. This increase factor is obtained from the table 430-22 (E) of the selected *Standard*.

Table 430.22(E) Duty-Cycle Service

Classification of Service	Nameplate Current Rating Percentages			
	5-Minute Rated Motor	15-Minute Rated Motor	30- & 60-Minute Rated Motor	Continuous Rated Motor
Short-time duty operating valves, raising or lowering rolls, etc.	110	120	150	—
Intermittent duty freight and passenger elevators, tool heads, pumps, drawbridges, turntables, etc. (for arc welders, see 630.11)	85	85	90	140
Periodic duty rolls, ore- and coal-handling machines, etc.	85	90	95	140
Varying duty	110	120	150	200

Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association, pp. 70-303.

Example:	Standard	Validation:	Standard or Intermittent

Motor use type (Service): In combination with the use of the motor or duty cycle service select the increase factor of the rated current.

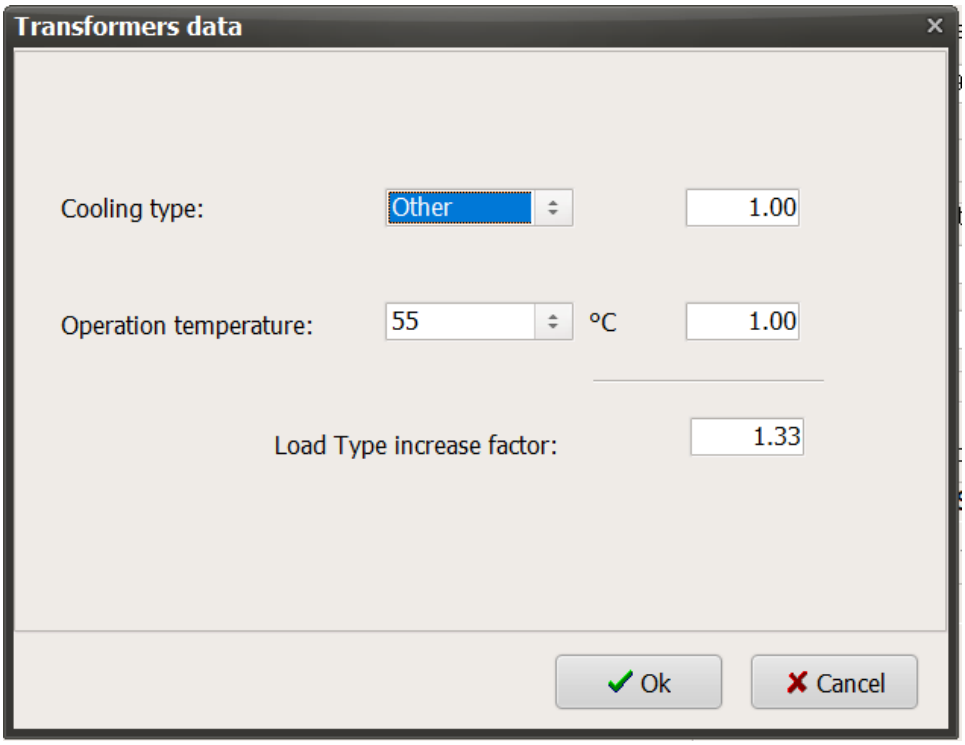
Example:	Intermittent	Validation:	Short, Intermittent, Periodic, Varying duty,

Engine use time: In combination with the use of the motor service determines the factor to increase the rated current.

Example:	5 minutes	Validation:	5, 15, 30-60 or Continuous

Transformer

When the transformer load type is selected, you should capture the data requested in the following window:



Cooling Type: The cooling of a transformer allows it to operate with higher power ratings. There may be different cooling "steps" based on the transformer manufacturing. That is, you can have one or more cooling methods. Each of which will allow a certain percentage of transformer rated capacity increase and therefore its current increases. There are values of load increase standardized for each type of cooling according to the NOM-J-285 standard and the NEMA TR-1 Standard. Therefore the definition of the steps, assist in determining the capacity factor increase.

Example:	AIR	Validation:	AIR, OA, FA, OA/OA, OA/OA/FA ó FA/OA/OA.

Capacity Factor: The capacity increase percentage (based on rated capacity) the transformer can provide with the cooling steps

Example:	1.0	Validation:	1.0 ≤ Value ≤ 2.0

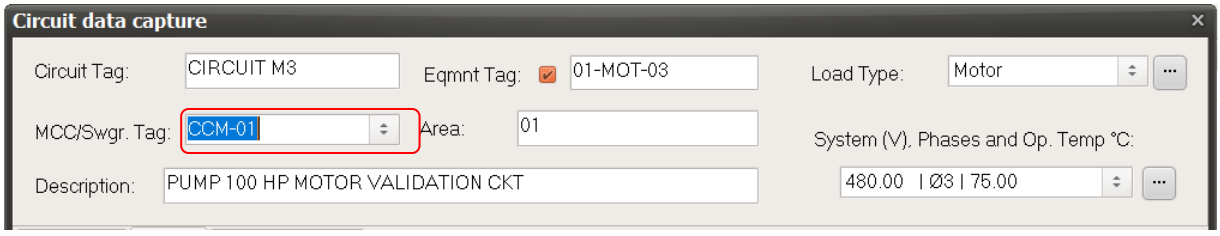
Motor Control Center (MCC)

The selection of conductors for a Motor Control Centers (MCC) is based on the requirements of section 430-24 of the National Electrical Code:

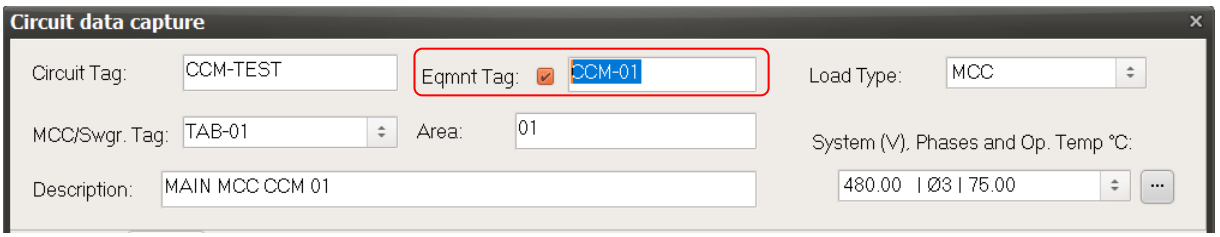
> "Several motors or a motor(s) and other loads" which indicated that "conductors supplying several motors and other loads shall have an ampacity not less than the sum of each of the following:
>
> (1) 125 percent of the full load current rating of the highest rated motor as determined by 430.6 (A).
> (2) The sum of the full-load current ratings of all other motors in the group, as determined by 430.6 (A).
> (3) 100 percent non continuous non-motor load.
> (4) 125 percent of the continuous non-motor load."

Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association, pp. 70-303.

Because the feeder conductor selection for the MCC will be in accordance with the loads that it feeds, *Sizer Electric* groups all loads of circuits having the same description in the "MCC No." field as the "Equipment number" of the MCC load type and performs the sum of the loads, the higher motor load is identified and applies corresponding adjusting factor (1.25).



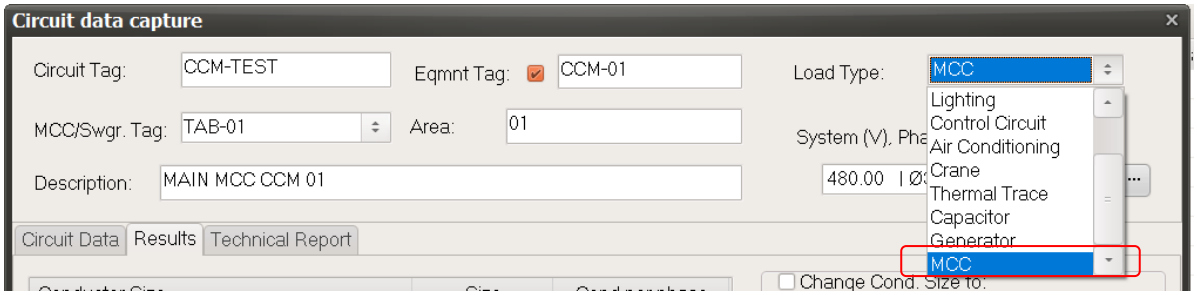
Circuit loads with the "MCC No." equal to the "Equipment No." field of the MCC-load will be grouped and added



For the MCC the loads with "MCC/Swgr. Tag" matching "Equipment tag." will be added to the CCM rated power.

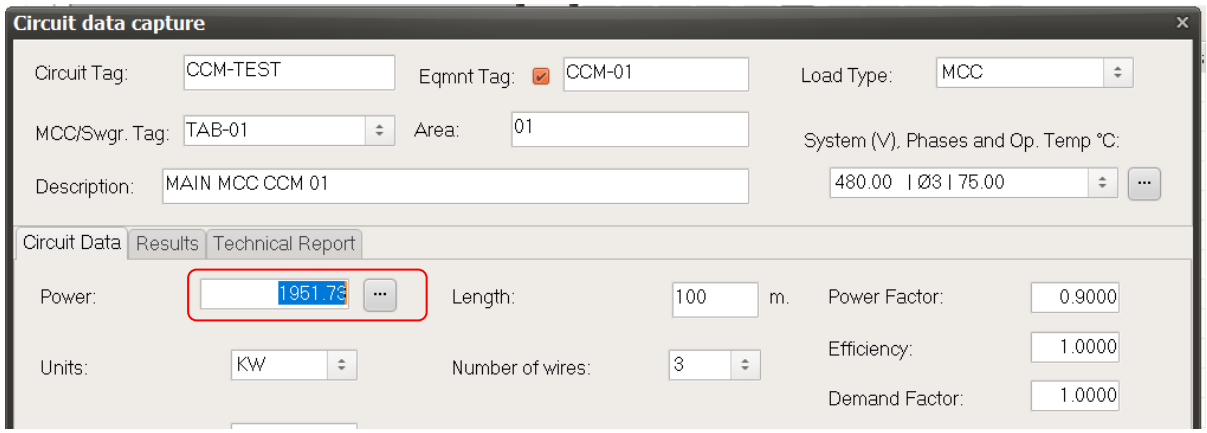
Therefore it is recommended to capture the MCC circuit before the associated loads. Thus, when capturing a motor loads or other loads, the "MCC or SWG" field be previously populated.

To capture a MCC circuit you should select the MCC option in the "Load type" field, as shown in the following figure. Remember that this option is available should you have captured information for MCCs in the section: "General Data"



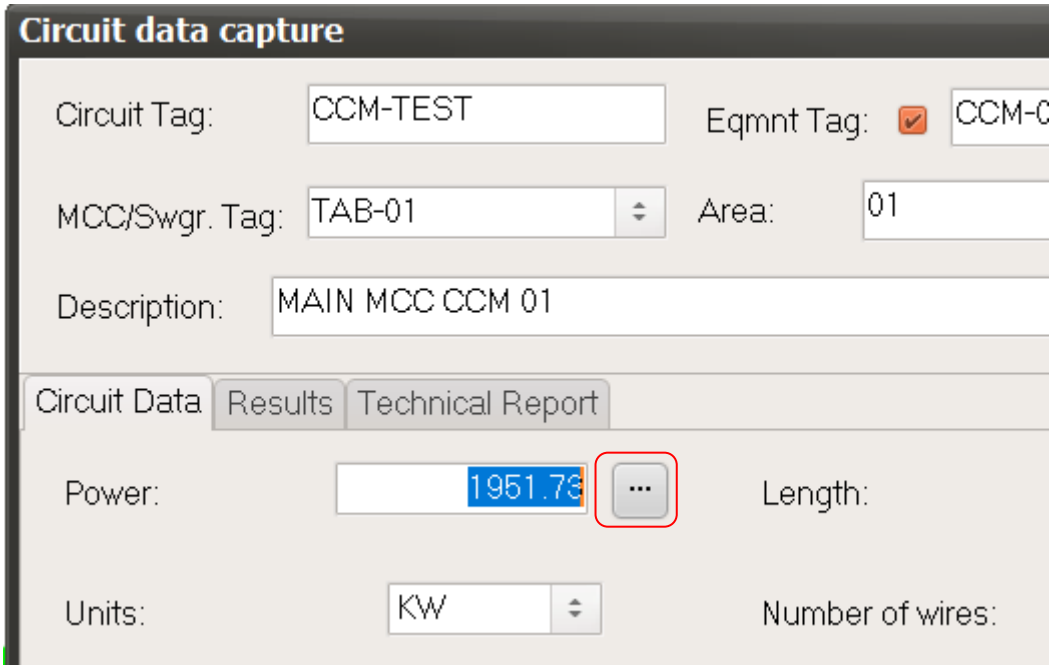
MCC option in the field "Load Type"

The rest of the information is populated as any other load. In the case of MCCs the only variant is that the "Power" field appears prefilled with a value representing the sum of the power of the loads associated considering the current percentage increases.



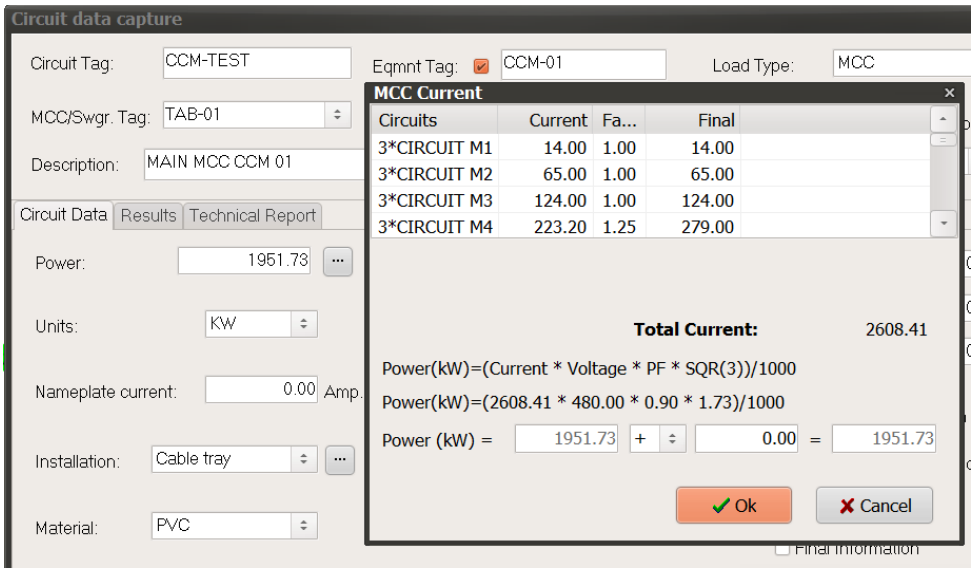
MCCs power calculated based on current associated loads.

For the detail of the circuits associated with the MCC, select the button with the three points or ellipsis (...).



Button to check the detail of the circuits associated to the MCC.

The window to be displayed in the grid will present on the top the description of the loads associated with the MCC. That is, it will show the circuits that when captured, indicated the "MCC" field with the same text as the name of the CCM of this circuit (indicated in field Equipment number). The grid also indicates the value of the current of the equipment, the calculation factor and the final current is the product of the current and the calculation factor.



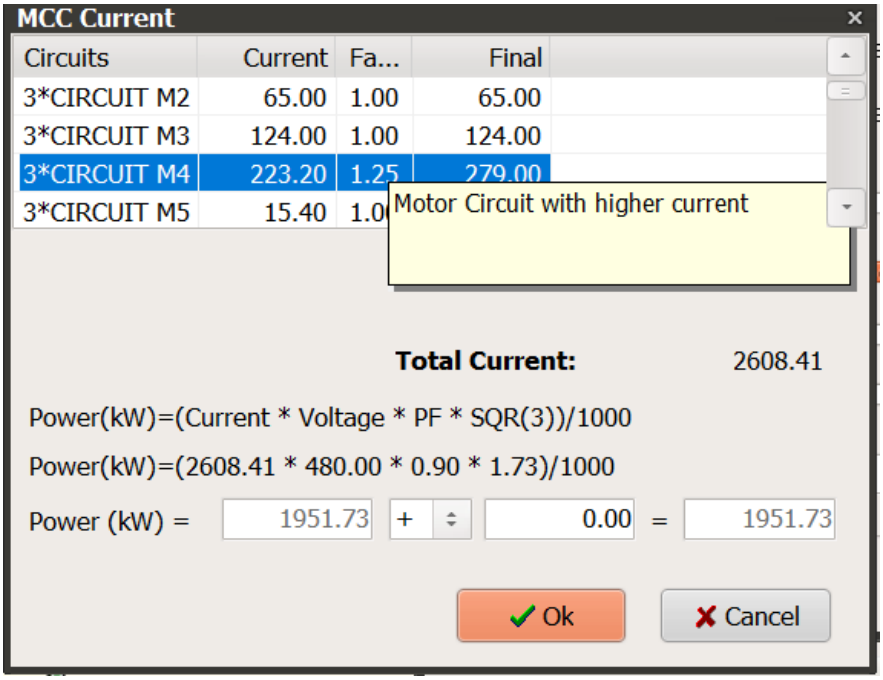
Details of the circuits associated to the MCC

The calculation factor can have 4 values:

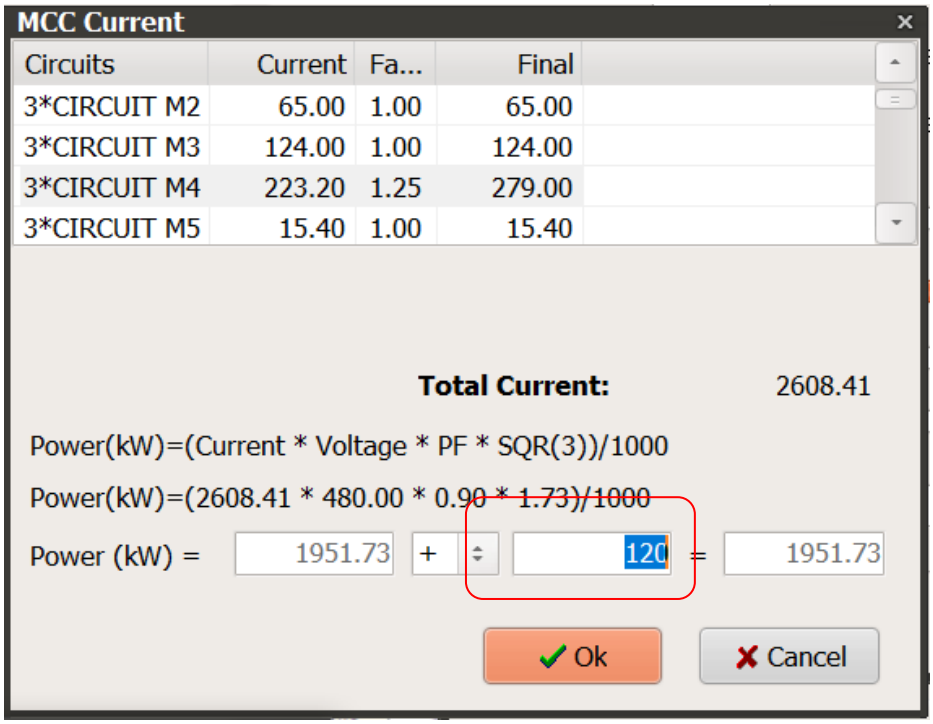
• The factor is 1.0 for circuits without error associated with the MCC
• The factor is 1.25 for the highest motor or higher circuit load.
• The factor is 0 for circuits with mistakes, circuits with different voltage system voltage from the MCC rated voltage and circuits with the check box "Number of Equipment" disabled 

(Used for reserve or back up circuits only).

To identify the origin of the multiplication factor you can move the mouse over the row of the circuit and click on the "Factor" field. A tool tip will show the considerations used to determine the multiplication factor as shown in the following figure:



In the lower section the power associated with the MCC is calculated by the sum of the final currents calculated for the loads (current affected by calculation factors) shown. In this section you can identify a field to add or subtract loads in Kilowatts to the MCC power, as shown in the figure below. This field can be used to add future load.



Additional load for the MCC.

Rated Power: In this field the rated power of the load circuit should be provided. It should be within the power range defined for the minimum and maximum power values indicated in the *General Data*. This shall be entered as follows:

Example:	100.0	Validation:	0.0 < Value < 1000.0

Units: In this field you should capture the units in which the nominal power of the equipment is given. The units changes depending on the load type as follows:

Load Type	Units
Motors	HP or KW
Feeders	KW
Control circuits	KW
Cranes and hoists	HP
Capacitor	KVA or KVAR
Transformers	KVA
Lighting	KW
Air conditioner	HP or KW
Thermal Trace	KVA or KW
MCC	KW

Example:	HP	Validation:	HP, KW, KVA or KVAR

Feeders

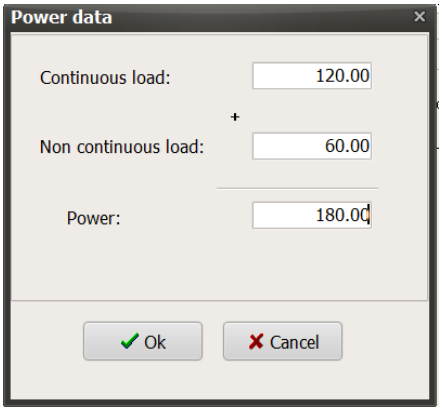
To meet the requirements of section 215 of the National Electrical Code 2017 and the Mexican Official Standard is necessary to identify the total load that the feeder supplies continuously and the load supplied intermittently. This information should be entered in the *Power* field. See section 220.10 and 215.2 of the National Electrical Code 2017 and Official Mexican Standard NOM-001-SEE-2012:

> “215.2 Minimum Rating and Size.
>
> (A) Feeders Not More Than 600 Volts.
>
> (1) General. Feeder conductors shall have an ampacity not less than required to supply the load as calculated in Parts III, IV, and V of Article 220. Conductors shall be sized to carry not less than the larger of 215.2(A)(1)(a) or (b).
>
> (a) Where a feeder supplies continuous loads or any combination of continuous and non-continuous loads, the minimum feeder conductor size shall have an allowable ampacity not less than the non-continuous load plus 125 percent of the continuous load.
>
> Exception No. 1: If the assembly, including the overcurrent devices protecting the feeder(s), is listed for operation at 100 percent of its rating, the allowable ampacity of the feeder conductors shall be permitted to be not less than the sum of the continuous load plus the non-continuous load.
>
> Exception No. 2: Where a portion of a feeder is connected at both its supply and load ends to separately installed pressure connections as covered in 110.14(C)(2), it shall be permitted to have an allowable ampacity not less than the sum of the continuous load plus the non-continuous load. No portion of a feeder installed under the provisions of this exception shall extend into an enclosure containing either the feeder supply or the feeder load terminations, as covered in 110.14(C)(1).
>
> Exception No. 3: Grounded conductors that are not connected to an overcurrent device shall be permitted to be sized at 100 percent of the continuous and non-continuous load.
>
> (b) The minimum feeder conductor size shall have an allowable ampacity not less than the maximum load to be served after the application of any adjustment or correction factors.
>
> Informational Note No. 1: See Examples D1 through D11 in Informative Annex D.
>
> Informational Note No. 2: Conductors for feeders, as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, will provide reasonable efficiency of operation.

Informational Note No. 3: See 210.19(A), Informational Note No. 4, for voltage drop for branch circuits".

Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association, pp. 70-67 and . 70-68.

To enter the continuous and non-continuous load in the *Power* field you will find a button with (…) to enter the different kind of load power. In the following window you must define the continuous and non-continuous load:



Capture window for continuous and non-continuous load for feeders.

Power units will be defined in the general circuit data window, in this window you should only indicate the magnitude of the load power.

Continuous load: According to the definitions in Article 100 of the National Electrical Code 2017 and NOM-001-SEDE-2012 is a maximum load current flows for three hours or more.

No continuous load: The current of a load that flows steadily for less than 3 hours

The sum of continuous and non-continuous power must be in the power range defined in the minimum and maximum power values indicated in the general data.

Example:	100.0	*Validation:*	0.0 < Value < 1000.0

Nameplate current: There are times when it the equipment nameplate currents provided by the equipment supplier. This current may be entered in this field and will be used as the equipment current to select conductors under ampacity criteria. **The program will only use this nameplate current to select the conductor if the "Final information" check box is checked as shown below:**

Otherwise (provisional information), the determination of the conductor and the current calculation will be made according to power data and reference tables found in the database..

Example:	400	Validation:	0 < Value < 100000

Circuit length: This field defines the circuit length in meters. The maximum length value used for the calculation is 1000 meters.

Example:	300	Validation:	0 < Value < 1000

System voltage and number of phases. It is the system voltage value in volts and phases in which the equipment is connected and it must be previously declared in the *General Data* of the project; otherwise, the circuit will not be calculated. This information cannot be entered or selected in this window. To add, or modify the System voltage and phase number data you should go to the *General Data* capture window of the load type required.

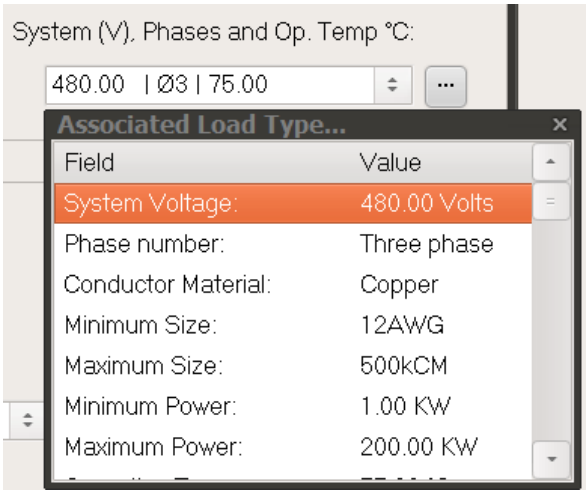
These voltage values should preferably as described in section 110-4 and 220-5.

"110.4 Voltages. Throughout this *Code*, the voltage considered shall be that at which the circuit operates. The voltage rating of electrical equipment shall not be less than the nominal voltage of a circuit to which it is connected.

220.5 Calculations.
(A) Voltages. Unless other voltages are specified, for purposes of calculating branch-circuit and feeder loads, nominal system voltages of 120, 120/240, 208Y/120, 240, 347, 480Y/277, 480, 600Y/347, and 600 volts shall be used."

Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-44 and pp-70-70.

You can display the general data associated with the circuit simply pressing the 3-points button (...) located on one side of the field.



Example:	448.0 | Φ3	Validation:	Mandatory field

Power Factor: This is an optional data for commercial motors in case of voltages described in *"System voltage"* because *Sizer Electric* can determine this value from

reference tables for standard efficiency, high efficiency and premium efficiency motors.

Example:	0.918	Validation:	0.0< Value < 1.0

Efficiency: The ratio between input power and output power of the equipment. This is an optional data for commercial engines in case of voltages described in *"System voltage"* because *Sizer Electric* can determine this value from reference tables for standard efficiency, high efficiency and premium efficiency motors

Example:	0.89	Validation:	0.0< Value ≤ 1.0

Demand factor: Is the feeder or equipment demand factor. It should be defined in accordance with Article 220-11, 220-13 and 430- 24

"220.42 General Lighting. The demand factors specified in Table 220.42 shall apply to that portion of the total branch circuit load calculated for general illumination. They shall not be applied in determining the number of branch circuits for general illumination.

Table 220.42 Lighting Load Demand Factors"

Type of Occupancy	Portion of Lighting Load to Which Demand Factor Applies (Volt-Amperes)	Demand Factor (%)
Dwelling units	First 3000 at	100
	From 3001 to 120,000 at	35
	Remainder over 120,000 at	25
Hospitals*	First 50,000 or less at	40
	Remainder over 50,000 at	20
Hotels and motels, including apartment houses without provision for cooking by tenants*	First 20,000 or less at	50
	From 20,001 to 100,000 at	40
	Remainder over 100,000 at	30
Warehouses (storage)	First 12,500 or less at	100
	Remainder over 12,500 at	50
All others	Total volt-amperes	100

Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-72.

"220.44 Receptacle Loads — Other Than Dwelling Units. Receptacle loads calculated in accordance with 220.14(H) and (I) shall be permitted to be made subject to the demand factors given in Table 220.42 or Table 220.44.

Table 220.44 Demand Factors for Non-Dwelling Receptacle Loads"

Portion of Receptacle Load to Which Demand Factor Applies (Volt-Amperes)	Demand Factor (%)
First 10 kVA or less at	100
Remainder over 10 kVA at	50

Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-72.

"430.26 Feeder Demand Factor. Where reduced heating of the conductors results from motors operating on duty-cycle, intermittently, or from all motors not operating at one time, the authority having jurisdiction may grant permission for feeder conductors to have an ampacity less than specified in 430.24, provided the conductors have sufficient ampacity for the maximum load determined in accordance with the sizes and number of motors supplied and the character of their loads and duties.
Informational Note: Demand factors determined in the design of new facilities can often be validated against actual historical
experience from similar installations. Refer to ANSI/IEEE Std. 141, *IEEE Recommended Practice for Electric Power Distribution for Industrial Plants,* and ANSI/IEEE Std. 241, *Recommended Practice for Electric Power Systems in Commercial Buildings,* for information on the calculation of loads and demand factor."

Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-304.

See also section 430.24 and 430.25:

"430.24 Several Motors or a Motor(s) and Other Load(s). Conductors supplying several motors, or a motor(s) and other load(s), shall have an ampacity not less than the sum of each of the following:
(1) 125 percent of the full-load current rating of the highest rated motor, as determined by 430.6(A)
(2) Sum of the full-load current ratings of all the other motors in the group, as determined by 430.6(A)
(3) 100 percent of the non-continuous non-motor load
(4) 125 percent of the continuous non-motor load.
Informational Note: See Informative Annex D, Example No. D8. *Exception No. 1: Where one or more of the motors of the group are used for short-time, intermittent, periodic, or varying duty, the ampere rating of such motors to be used in the summation shall be determined in accordance with 430.22(E). For the highest rated motor, the greater of either the ampere rating from 430.22(E) or the largest continuous duty motor full-load current multiplied by 1.25 shall be used in the summation.*
Exception No. 2: The ampacity of conductors supplying motor-operated fixed electric space-heating equipment shall comply with 424.3(B).
Exception No. 3: Where the circuitry is interlocked so as to prevent simultaneous operation of selected motors or other loads, the conductor ampacity shall be permitted to be based on the summation of the currents of the motors and other loads to be operated simultaneously that results in the highest total current

430.25 Multimotor and Combination-Load Equipment. The ampacity of the conductors supplying multimotor and combination-load equipment shall not be less than the minimum circuit ampacity marked on the equipment in accordance with 430.7(D). Where the equipment is not factory-wired and the individual nameplates are visible in accordance with 430.7(D)(2), the conductor ampacity shall be determined in accordance with 430.24."

Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-303.

Example:	0.80	Validation:	0.0< Value ≤ 1.0

Installation: This data defines the type of raceway, cable tray, duct or other conductor handling media where the conductor is installed and can be:

- Conduit
- Cable tray
- Combination of both (Conduit and cable tray)
- Duct
- Air

As defined in Article 100 of the applicable standard:

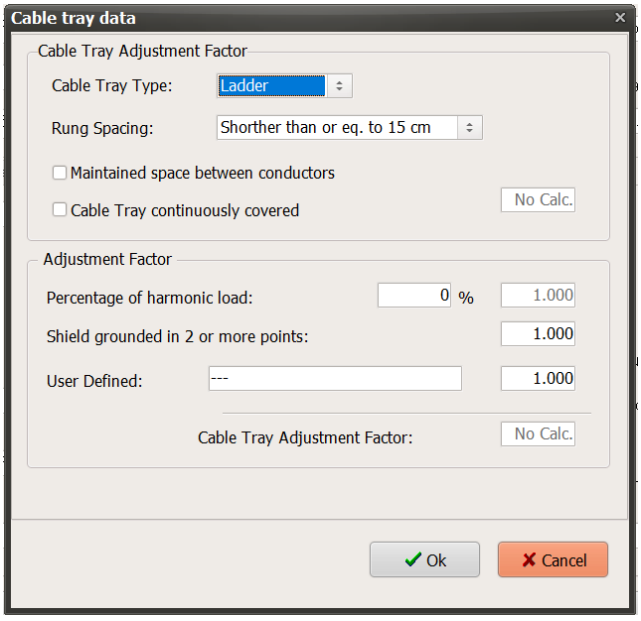
> "**Raceway.** An enclosed channel designed expressly for holding wires, cables, or busbars, with additional functions as permitted in this *Code*. (CMP-8)
> Informational Note: A raceway is identified within specific article definitions."
>
> *Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-34.*

Example:	Conduit	**Validation:**	Cable tray, Conduit, Conduit and Cable tray, duct or air

By selecting the desired type of raceway/cable tray a window requesting additional information is presented. See the following section for specific details.

Cable trays

When Cable tray type is selected for installation media you must capture the data requested in the next window.



Cable Tray Type: This information is intended for the designer to automatically select the minimum conductor sizes applicable to the type of cable tray where single conductors are installed. Therefore you must identify whether it is a ladder type cabe tray or solid bottom tray.

Example:	Ladder	Validation:	Ladder or Solid bottom

Rung Spacing: This information is intended for the designer automatically select the minimum sizes applicable for the support ladder type cable trays where single conductors are installed and represents the separation between two rungs of the ladder type.

According to the criteria defined in section 392-10 (b) of the applicable *Standard*:

> "**392.10 Uses Permitted.** Cable tray shall be permitted to be used as a support system for service conductors, feeders, branch circuits, communications circuits, control circuits, and signaling circuits. Cable tray installations shall not be limited to industrial establishments. Where exposed to direct rays of the sun, insulated conductors and jacketed cables shall be identified as being sunlight resistant. Cable trays and their associated fittings shall be identified for the intended use.
> **(A) Wiring Methods.** The wiring methods in Table 392.10(A) shall be permitted to be installed in cable tray systems under the conditions described in their respective articles and sections.
> **(B) In Industrial Establishments.** The wiring methods in Table 392.10(A) shall be permitted to be used in any industrial establishment under the conditions described in their respective articles. In industrial establishments only, where conditions of maintenance and supervision ensure that only qualified persons service the installed cable tray system, any of the cables in 392.10(B)(1) and (B)(2) shall be permitted to be installed in ladder, ventilated trough, solid bottom, or ventilated channel cable trays.
> **(1) Single-conductor cables shall be permitted to be installed in accordance with (B)(1)(a) through (B)(1)(c).**
> (a) Single-conductor cable shall be **1/0 AWG or larger and shall be of a type listed and marked on the surface for use in cable trays. Where 1/0 AWG through 4/0 AWG single conductor cables are installed in ladder cable tray, the maximum allowable rung spacing for the ladder cable tray shall be 225 mm (9 in.).**
> (b) Welding cables shall comply with the provisions of Article 630, Part IV. (c) Single conductors used as equipment grounding conductors shall be insulated, covered, or bare, and **they shall be 4 AWG or larger.**
> **(2)** Single- and multiconductor medium voltage cables shall be Type MV cable. Single conductors shall be installed in accordance with 392.10(B)(1)..".
>
> Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-228.

Example:	>= 23 cm	Validation:	>= 23 cm, <= 23 cm or <=15 cm

Cover Option:. This option define the installation conditions of conductors specifically if the cable tray is continuously covered for more than 1.8 m (6ft) preventing the free air movement around the conductors installed in cable trays leading to use lower ampacity percentages of conductors (also called adjustment factors when expressed in per unit) . According to section 392-80 (a) (1) and 392-80 (a) (2) and 392-80 (b) (1) section, and 392-80 (b) (2) see also the sections cited in "Cable tray Adjustment Factor" later in this chapter.

> **"392.80 Ampacity of Conductors.**
> **(A) Ampacity of Cables, Rated 2000 Volts or Less, in Cable Trays.**
>
> Informational Note: See 110.14(C) for conductor temperature limitations due to termination provisions.

(1) Multiconductor Cables. The allowable ampacity of multiconductor cables, nominally rated 2000 volts or less, installed according to the requirements of 392.22(A) shall be as given in Table 310.15(B)(16) and Table 310.15(B)(18), subject to the provisions of (A)(1)(a), (b), (c), and 310.15(A)(2).

(a) The adjustment factors of 310.15(A)(3)(a) shall apply only to multiconductor cables with more than three current-carrying conductors. Adjustment factors shall be limited to the number of current-carrying conductors in the cable and not to the number of conductors in the cable tray.

(b) Where cable trays are continuously covered for more than 1.8 m (6 ft) with solid unventilated covers, not over 95 percent of the allowable ampacities of Table 310.15(B)(16) and Table 310.15(B)(18) shall be permitted for multiconductor cables.

(c) Where multiconductor cables are installed in a single layer in uncovered trays, with a maintained spacing of not less than one cable diameter between cables, the ampacity shall not exceed the allowable ambient temperature-corrected ampacities of multiconductor cables, with not more than three insulated conductors rated 0 through 2000 volts in free air, in accordance with 310.15(C).

Informational Note: See Table B.310.15(B)(2)(3).

(2) Single-Conductor Cables. The allowable ampacity of single-conductor cables shall be as permitted by 310.15(A)(2). The adjustment factors of 310.15(B)(3)(a) shall not apply to the ampacity of cables in cable trays. The ampacity of single conductor cables, or single conductors cabled together (triplexed, quadruplexed, etc.), nominally rated 2000 volts or less, shall comply with the following:

(a) Where installed according to the requirements of 392.22(B), the ampacities for 600 kcmil and larger single conductor cables in uncovered cable trays shall not exceed 75 percent of the allowable ampacities in Table 310.15(B)(17) and Table 310.15(B)(19). Where cable trays are continuously covered for more than 1.8 m (6 ft) with solid unventilated covers, the ampacities for 600 kcmil and larger cables shall not exceed 70 percent of the allowable ampacities in Table 310.15(B)(17) and Table 310.15(B)(19).

(b) Where installed according to the requirements of 392.22(B), the ampacities for 1/0 AWG through 500 kcmil single-conductor cables in uncovered cable trays shall not exceed 65 percent of the allowable ampacities in Table 310.15(B)(17) and Table 310.15(B)(19). Where cable trays are continuously covered for more than 1.8 m (6 ft) with solid unventilated covers, the ampacities for 1/0 AWG through 500 kcmil cables shall not exceed 60 percent of the allowable ampacities in Table 310.15(B)(17) and Table 310.15(B)(19).

(c) Where single conductors are installed in a single layer in uncovered cable trays, with a maintained space of not less than one cable diameter between individual conductors, the ampacity of 1/0 AWG and larger cables shall not exceed the allowable ampacities in Table 310.15(B)(17) and Table 310.15(B)(19).

(B) Ampacity of Type MV and Type MC Cables (2001 Volts or Over) in Cable Trays. The ampacity of cables, rated 2001 volts, nominal, or over, installed according to 392.22(C) shall not exceed the requirements of this section.

Informational Note: See 110.40 for conductor temperature limitations due to termination provisions.

(1) Multiconductor Cables (2001 Volts or Over). The allowable ampacity of multiconductor cables shall be as given in Table 310.60(C)(75) and Table 310.60(C)(76), subject to the following provisions:

(1) Where cable trays are continuously covered for more than 1.8 m (6 ft) with solid unventilated covers, not more than 95 percent of the allowable ampacities of Table 310.60(C)(75) and Table 310.60(C)(76) shall be permitted for multiconductor cables.

(2) Where multiconductor cables are installed in a single layer in uncovered cable trays, with maintained spacing of not less than one cable diameter between cables, the ampacity shall not exceed the allowable ampacities of Table 310.60(C)(71) and Table 310.60(C)(72).

(2) Single-Conductor Cables (2001 Volts or Over). The ampacity of single-conductor cables, or single conductors cabled together (triplexed, quadruplexed, etc.), shall comply with the following:

(1) The ampacities for 1/0 AWG and larger single-conductor cables in uncovered cable trays shall not exceed 75 percent of the allowable ampacities in Table 310.60(C) (69) and Table 310.60(C)(70). Where the cable trays are covered for more than 1.8 m (6 ft) with solid unventilated covers, the ampacities for 1/0 AWG and larger single conductor cables shall not exceed 70 percent of the allowable ampacities in Table 310.60(C)(69) and Table 310.60(C)(70).
(2) Where single-conductor cables are installed in a single layer in uncovered cable trays, with a maintained space of not less than one cable diameter between individual conductors, the ampacity of 1/0 AWG and larger cables shall not exceed the allowable ampacities in Table 310.60(C)(69) and Table 310.60(C)(70).
(3) Where single conductors are installed in a triangular or square configuration in uncovered cable trays, with a maintained free air space of not less than 2.15 times the diameter (2.15 × O.D.) of the largest conductor contained within the configuration and adjacent conductor configurations or cables, the ampacity of 1/0 AWG and larger cables shall not exceed the allowable ampacities in Table 310.60(C)(67) and Table 310.60(C)(68)."

Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association, pp. 70-233 and pp 70-234.

Example:	Yes	Validation:	Checked / Unchecked

Maintained space between conductors: For the correct application of the adjustment factors indicate if there is a maintained space of not less than one cable diameter between conductors along its path to ensure adequate air circulation between them. Refer to section 392.A(2) for more details about the effect of this installation condition con conductors allowable ampacity.

Example:	Yes	Validation:	Checked / Unchecked

Cable tray adjustment factor: When conductors are installed on a cable tray, under certain conditions of installation (covered or with maintained spaces between conductors), you can only a percentage of the allowable ampacity defined in the ampacity tables of the applicable Standard. This percentage, expressed in per unit represents the adjustment factor of conductor ampacity.

When the designer indicates that the cable tray and if it is continuously covered for more than 1.80 m, and if there is an space between conductors, the software selects the adjustment factor applicable to the specific type of conductor according to statements of section 392.80.

For cases where different adjustment factors are required to those considered by the NEC 2017 and the standard NOM-001-SEDE-2012 these should be captured in this text box and will be considered only if they are minor those indicated in the selected standard. If omitted, the software will assign the adjustment factor according to the criteria cited by the sections 392-80 (a) (1) and 392-80 (a) (2) of the selected standard.

Example:	0.77	Validation:	$0.0 < \text{Value} \leq 1.0$

Percentage of harmonic load (adjustment factor for Harmonic Load): The adjustment to the ampacity of the conductor when it is installed in an environment where a harmonic content is expected. This generates distortion in the fundamental wave and consequently generate additional heat in conductor.

This factor is calculated according to the conductor size and the percentage of harmonic content installation using Figure 9-11 "Cable derating vs harmonic with six pulse harmonic current distortion" from section 9.8.2.3 of Standard IEEE Std.141 “IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book).”

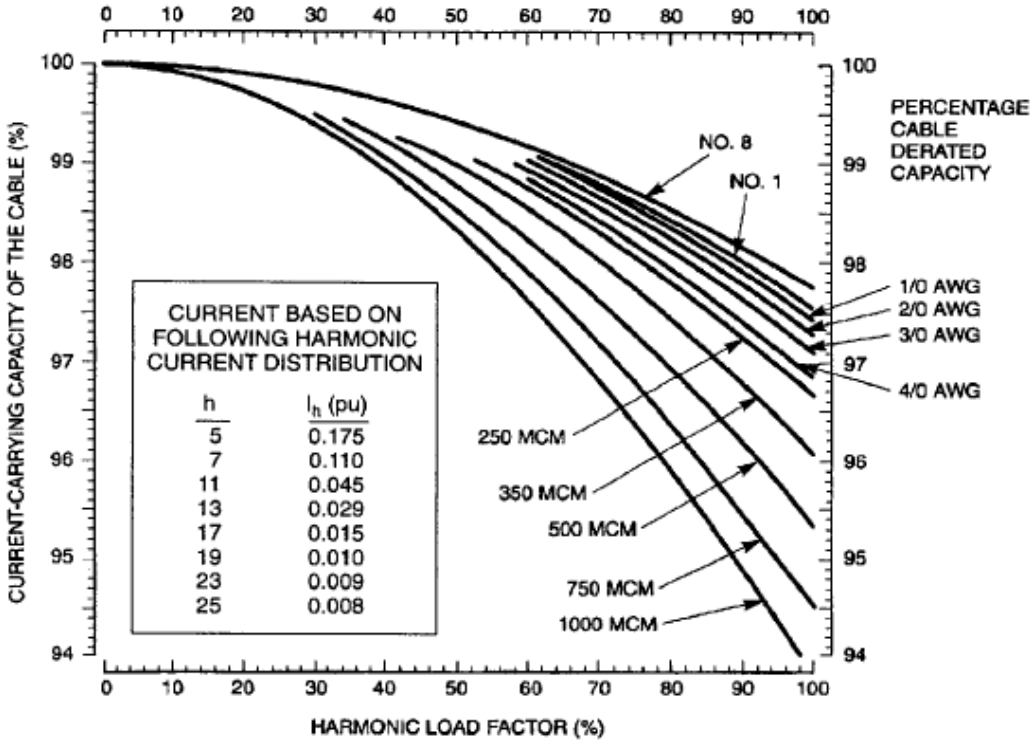


Figure 9-11 "Cable derating vs harmonic with six pulse harmonic current distortion" obtained from IEEE Std.141 Red Book.

Because the derating factor depends on the conductor size, during the capture process the program will show the label "No Calc.". Once the calculation has been performed and the conductor size is selected, the appropriate derating factor used will be available on this window.

Shield grounded in 2 or more points: This adjustment factor is used to meet the guidelines of section 310-60 (c) (1) of the NEC 2017 and Official Mexican Standard NOM-001-SEDE-2012, indicating:

> **“(1) Grounded Shields.** Ampacities shown in Table 310.60(C)(69), Table 310.60(C)(70), Table 310.60(C)(81), and Table 310.60(C)(82) shall apply for cables with shields grounded at one

point only. Where shields for these cables are grounded at more than one point, ampacities shall be adjusted to take into consideration the heating due to shield currents.
Informational Note: Tables other than those listed contain the ampacity of cables with shields grounded at multiple points. “

Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association, pp. 70-153.

Unfortunately neither the National Electrical Code or the Mexican Official Standard defines the adjustment factor which is required for the case of metal shields grounded at more than one point. The recommendation is to separately perform a calculation of the temperature rise on the shield for the effect of current circulation and sum this temperature rise to the definition of ambient temperature. Because currents flowing through shields generally generates an average temperature elevation between 3 and 5 °C is a common practice to consider an adjustment factor of 0.9 for this grounding condition. However, in any case it is recommended to analyze the thermal resistive circuit, and apply the thermal Ohm's law to thermal circuits and calculate the actual temperature rise.

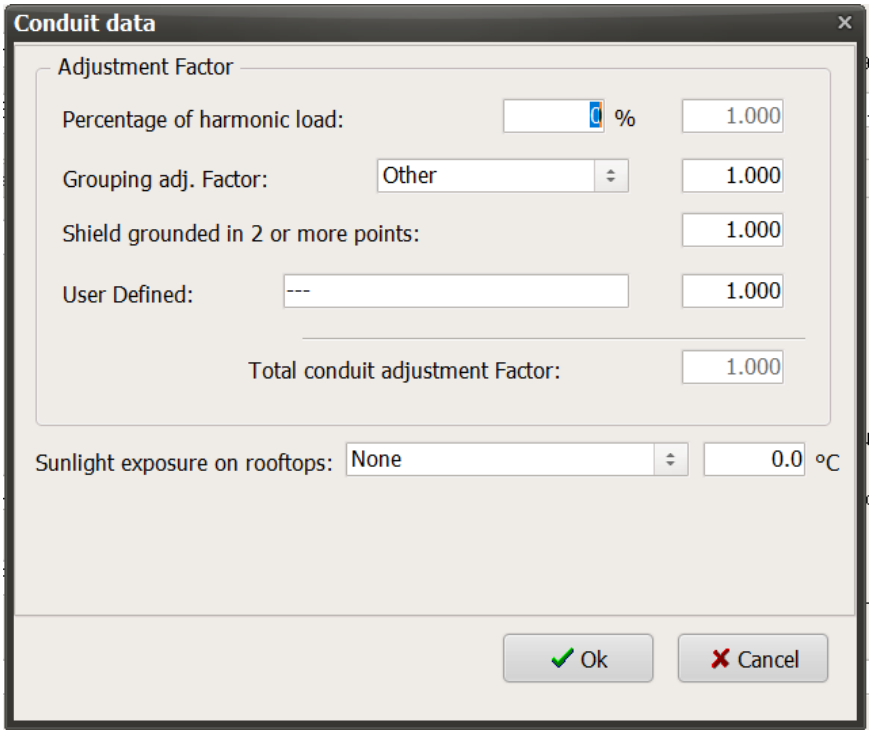
Example:	*0.9*	*Validation:*	*0.0 < Value > 1.0*

User Defined: This adjustment factor is used to meet a particular specification applicable to the project in the conductors ampacity. For example consider a future increase of 20% load, in this case the adjustment factor will be 0.8. This factor may be named by the user in the first field, and define a greater than zero and less than unity in the second field value.

Example:	*0.77*	*Validation:*	*0.0 < Value > 1.0*

Conduit

Adjustment Factors Window for conduit contains the following options to define the adjustment factors for ampacity of conductors installed conduits.



Conduit Adjustment Factors (Standard NFPA 70-NEC)

Percentage of harmonic load (adjustment factor for Harmonic Load): The adjustment to the ampacity of the conductor when it is installed in an environment where a harmonic content is expected. This generates distortion in the fundamental wave and consequently generate additional heat in conductor.

This factor is calculated according to the conductor size and the percentage of harmonic content installation using Figure 9-11 "Cable derating vs harmonic with six pulse harmonic current distortion" from section 9.8.2.3 of Standard IEEE Std.141 “IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book).”

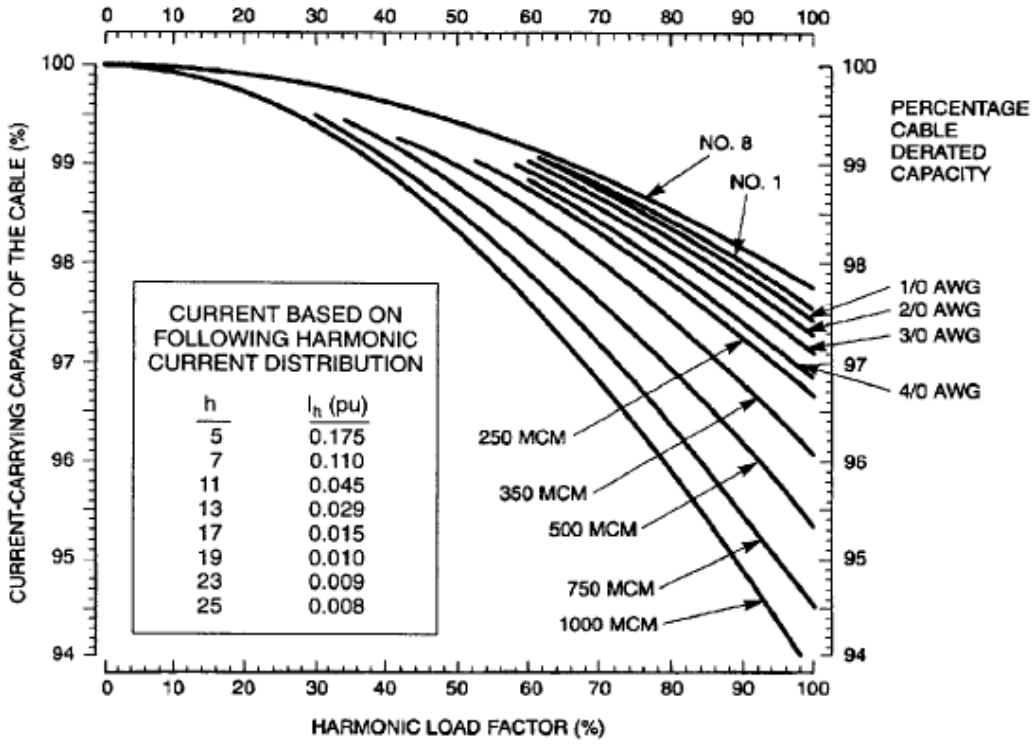


Figure 9-11 "Cable derating vs harmonic with six pulse harmonic current distortion" obtained from IEEE Std.141 Red Book.

Because the derating factor depends on the conductor size, during the capture process the program will show the label "No Calc.". Once the calculation has been performed and the conductor size is selected, the appropriate derating factor used will be available on this window.

Grouping adjustment factor: The adjustment to be made in the conductor allowable ampacity when it is installed with more than 3 current carrying conductors in accordance with Section 310-15 (b) (3) (a):

"(3) Adjustment Factors.
(a) *More than Three Current-Carrying Conductors.* Where the number of current-carrying conductors in a raceway or cable exceeds three, or where single conductors or multiconductor cables are installed without maintaining spacing for a continuous length longer than 600 mm (24 in.) and are not installed in raceways, the allowable ampacity of each conductor shall be reduced as shown in Table 310.15(B)(3)(a). Each current carrying conductor of a paralleled set of conductors shall be counted as a current-carrying conductor. Where conductors of different systems, as provided in 300.3, are installed in a common raceway or cable, the adjustment
factors shown in Table 310.15(B)(3)(a) shall apply only to the number of power and lighting conductors (Articles 210, 215, 220, and 230).
Informational Note No. 1: See Annex B for adjustment factors for more than three current-carrying conductors in a raceway or cable with load diversity.
Informational Note No. 2: See 366.23 for adjustment factors for conductors and ampacity for bare copper and aluminum bars in auxiliary gutters and 376.22(B) for adjustment factors for conductors in metal wireways.
(1) Where conductors are installed in cable trays, the provisions of 392.80 shall apply.
(2) Adjustment factors shall not apply to conductors in raceways having a length not exceeding 600 mm (24 in.).

(3) Adjustment factors shall not apply to underground conductors entering or leaving an outdoor trench if those conductors have physical protection in the form of rigid metal conduit, intermediate metal conduit, rigid polyvinyl chloride conduit (PVC), or reinforced thermosetting resin conduit (RTRC) having a length not exceeding 3.05 m (10 ft), and if the number of conductors does not exceed four.
(4) Adjustment factors shall not apply to Type AC cable or to Type MC cable under the following conditions:
a. The cables do not have an overall outer jacket.
b. Each cable has not more than three current-carrying conductors.
c. The conductors are 12 AWG copper.
d. Not more than 20 current-carrying conductors are installed without maintaining spacing, are stacked, or are supported on "bridle rings."

(5) Neutral Conductor.
(a) A neutral conductor that carries only the unbalanced current from other conductors of the same circuit shall not be required to be counted when applying the provisions of 310.15(B)(3)(a).
(b) In a 3-wire circuit consisting of two phase conductors and the neutral conductor of a 4-wire, 3-phase, wye-connected system, a common conductor carries approximately the same current as the line-to-neutral load currents of the other conductors and shall be counted when applying the provisions of 310.15(B)(3)(a).
(c) On a 4-wire, 3-phase wye circuit where the major portion of the load consists of nonlinear loads, harmonic currents are present in the neutral conductor; the neutral conductor shall therefore be considered a current-carrying conductor.

Table 310.15(B)(3)(a) Adjustment Factors for More Than Three Current-Carrying Conductors"

Number of Conductors[1]	Percent of Values in Table 310.15(B)(16) Through Table 310.15(B)(19) as Adjusted for Ambient Temperature if Necessary
4–6	80
7–9	70
10–20	50
21–30	45
31–40	40
41 and above	35

Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-147 and pp. 70-148.

In order to meet the conditions of grouping adjustment factors of Section 310-15 (b) (3) (a) note 1 of within the software you should select the OTHER option in the list of grouping factors for the cases of "*10 or more"* current carrying conductors in the same conduit with a multiple variety of loads and then capture the percentage applicable adjustment factor considering the demand indicated in the notes at the bottom of the table referred above.

Example:	*0.77*	*Validation:*	*0.0 < Value > 1.0*

Shield grounded in 2 or more points: This adjustment factor is used to meet the guidelines of section 310-60 (c) (1) of the NEC 2017 and Official Mexican Standard NOM-001-SEDE-2012, indicating:

"(1) Grounded Shields. Ampacities shown in Table 310.60(C)(69), Table 310.60(C)(70), Table 310.60(C)(81), and Table 310.60(C)(82) shall apply for cables with shields grounded at one point only. Where shields for these cables are grounded at more than one point, ampacities shall be adjusted to take into consideration the heating due to shield currents.

> **Informational Note:** Tables other than those listed contain the ampacity of cables with shields grounded at multiple points. “
>
> Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-153.

Unfortunately neither the National Electrical Code or the Mexican Official Standard defines the adjustment factor which is required for the case of metal shields grounded at more than one point. The recommendation is to separately perform a calculation of the temperature rise on the shield for the effect of current circulation and sum this temperature rise to the definition of ambient temperature. Because currents flowing through shields generally generates an average temperature elevation between 3 and 5 °C is a common practice to consider an adjustment factor of 0.9 for this grounding condition. However, in any case it is recommended to analyze the thermal resistive circuit, and apply the thermal Ohm's law to thermal circuits and calculate the actual temperature rise.

Example:	*0.77*	*Validation:*	*0.0 < Value > 1.0*

Adjustment factor for sunlight exposure on rooftops. When NEC 2017 standard is selected an increase in ambient temperature around the conductor is applied as shown in Table 310.15 (B) (2) NEC-2017 when conduits are installed in rooftops. The temperature increase will depend on distance above roof to bottom of conduit. The temperature indicated in Table 310.15 (B) (2) (c) is added to the ambient temperature considered for determining the temperature adjustment factor.

When the official Mexican standard is selected as the calculating criteria, the adjustment factor by exposure to solar radiation on rooftops should be selected according to section 310-15 (b) (3) (c)

> (c) *Raceways and Cables Exposed to Sunlight on Rooftops.* Where raceways or cables are exposed to direct sunlight on or above rooftops, raceways or cables shall be installed a minimum distance above the roof to the bottom of the raceway or cable of 23 mm (⅞ in.). Where the distance above the roof to the bottom of the raceway is less than 23 mm (⅞ in.), a temperature adder of 33°C (60°F) shall be added to the outdoor temperature to determine the applicable ambient temperature for application of the correction factors in Table 310.15(B)(2)(a) or Table 310.15(B)(2)(b).
>
> *Exception: Type XHHW-2 insulated conductors shall not be subject to this ampacity adjustment.*
> Informational Note: One source for the ambient temperatures in various locations is the ASHRAE *Handbook — Fundamentals*.

Tabla 310-15(b)(3)(c).- Ajustes a la temperatura ambiente para canalizaciones circulares expuestas a la luz solar en o por encima de azoteas

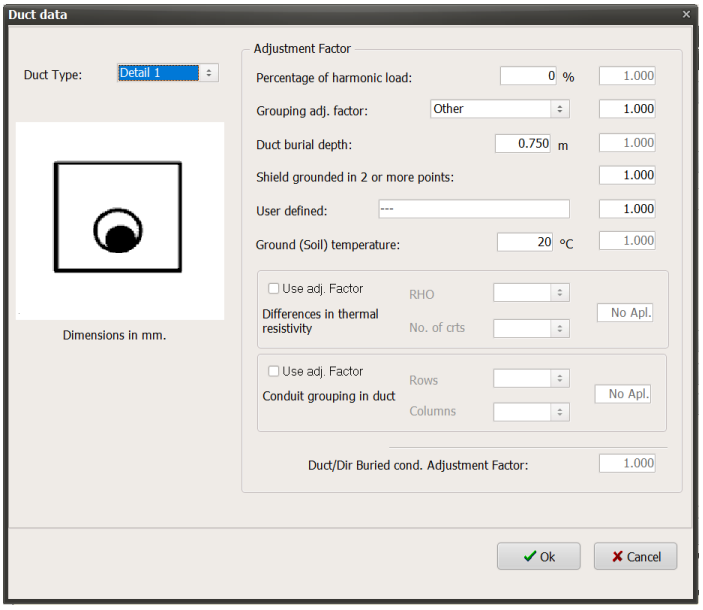
Distancia por encima del techo hasta la base del tubo conduit milímetros	Sumador de temperatura °C
De 0 hasta 13	33
Más de 13 hasta 90	22
Más de 90 hasta 300	17
Más de 300 hasta 900	14

User Defined: This adjustment factor is used to meet a particular specification applicable to the project in the conductors ampacity. For example consider a future increase of 20% load, in this case the adjustment factor will be 0.8. This factor may be named by the user in the first field, and define a greater than zero and less than unity in the second field value.

Example:	*0.77*	*Validation:*	*0.0 < Value > 1.0*

Duct

Duct Adjustment Factors Window contains the following options for adjustment on the allowable ampacity of conductors installed in ducts or directly buried.



Window of Adjustment Factors for duct and directly buried cable

Ground (soil) temperature: It is used to determine the adjustment factor for soil temperature. As indicated in section 13.4.1 of IEEE Std. 399 this factor is used to determine the ampacity of conductors when the ambient and / or the maximum allowable temperature differ from the temperatures at which the allowable ampacity tables of the NEC-2017 or NOM-001-SEDE-2017 are based on (This temperature is indicated in the tables). The equation used by the software to calculate the effect of the change in ambient ground temperature is given by the following equations:

$$F_t = \left[\frac{T'_c - T'_a}{T_c - T_a} \times \frac{234.5 + T_c}{234.5 + T'_c}\right]^{1/2} \text{(copper)}$$

$$F_t = \left[\frac{T'_c - T'_a}{T_c - T_a} \times \frac{228.1 + T_c}{228.1 + T'_c}\right]^{1/2} \text{(aluminum)}$$

Where:

Tc: Is the rated conductor temperature in ° C at which the conductor ampacity is specified.

T'c: Is the maximum allowable operating temperature of the conductor in ° C

Ta: Is the ambient temperature in ° C at which the conductor ampacity is specified

T'a: Is the current (maximum) soil temperature in ° C

Consider that the value of allowable operating temperature is fixed (conductor operating temperature) to calculate the adjustment factor

Percentage of harmonic load (adjustment factor for Harmonic Load): The adjustment to the ampacity of the conductor when it is installed in an environment where a harmonic content is expected. This generates distortion in the fundamental wave and consequently generate additional heat in conductor.

This factor is calculated according to the conductor size and the percentage of harmonic content installation using Figure 9-11 "Cable derating vs harmonic with six pulse harmonic current distortion" from section 9.8.2.3 of Standard IEEE Std.141 “IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (Red Book).”

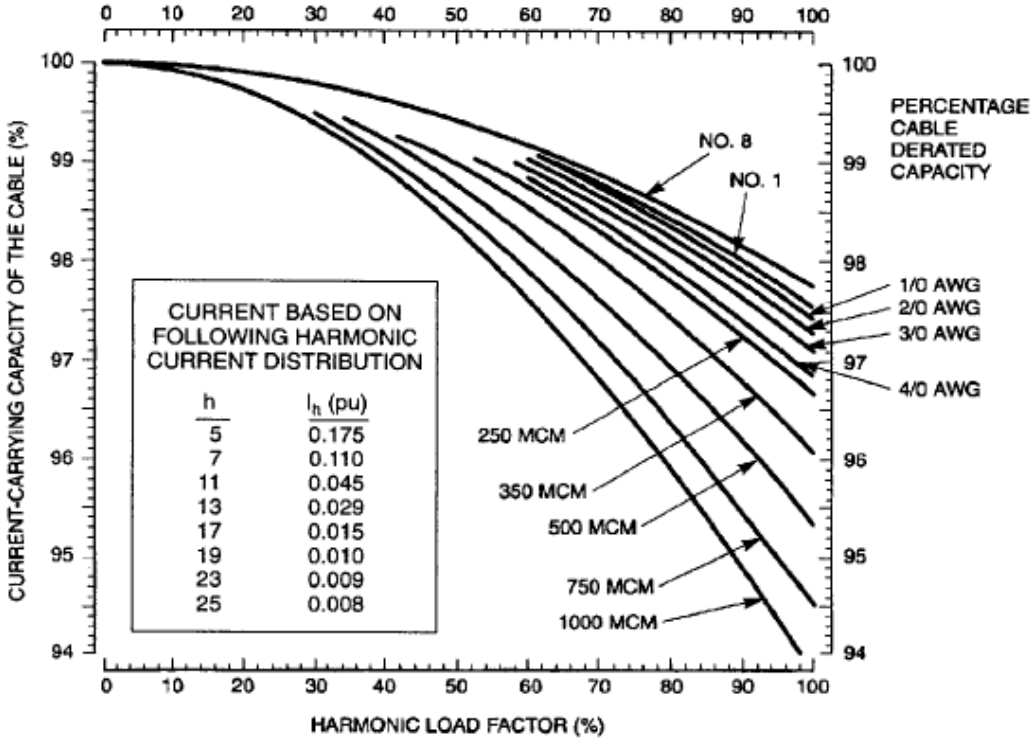


Figure 9-11 "Cable derating vs harmonic with six pulse harmonic current distortion" obtained from IEEE Std.141 Red Book.

Because the derating factor depends on the conductor size, during the capture process the program will show the label "No Calc.". Once the calculation has been performed and the conductor size is selected, the appropriate derating factor used will be available on this window.

Grouping adjustment factor: The adjustment to be made in the conductor allowable ampacity when it is installed with more than 3 current carrying conductors in accordance with Section 310-15 (b) (3) (a):

"(3) Adjustment Factors.
(a) *More than Three Current-Carrying Conductors.* Where the number of current-carrying conductors in a raceway or cable exceeds three, or where single conductors or multiconductor cables are installed without maintaining spacing for a continuous length longer than 600 mm (24 in.) and are not installed in raceways, the allowable ampacity of each conductor shall be reduced as shown in Table 310.15(B)(3)(a). Each current carrying conductor of a paralleled set of conductors shall be counted as a current-carrying conductor. Where conductors of different systems, as provided in 300.3, are installed in a common raceway or cable, the adjustment
factors shown in Table 310.15(B)(3)(a) shall apply only to the number of power and lighting conductors (Articles 210, 215, 220, and 230).
Informational Note No. 1: See Annex B for adjustment factors for more than three current-carrying conductors in a raceway or cable with load diversity.
Informational Note No. 2: See 366.23 for adjustment factors for conductors and ampacity for bare copper and aluminum bars in auxiliary gutters and 376.22(B) for adjustment factors for conductors in metal wireways.
(1) Where conductors are installed in cable trays, the provisions of 392.80 shall apply.
(2) Adjustment factors shall not apply to conductors in raceways having a length not exceeding 600 mm (24 in.).
(3) Adjustment factors shall not apply to underground conductors entering or leaving an outdoor trench if those conductors have physical protection in the form of rigid metal conduit, intermediate metal conduit,

rigid polyvinyl chloride conduit (PVC), or reinforced thermosetting resin conduit (RTRC) having a length not exceeding 3.05 m (10 ft), and if the number of conductors does not exceed four.
(4) Adjustment factors shall not apply to Type AC cable or to Type MC cable under the following conditions:
a. The cables do not have an overall outer jacket.
b. Each cable has not more than three current-carrying conductors.
c. The conductors are 12 AWG copper.
d. Not more than 20 current-carrying conductors are installed without maintaining spacing, are stacked, or are supported on "bridle rings."

(5) Neutral Conductor.
(a) A neutral conductor that carries only the unbalanced current from other conductors of the same circuit shall not be required to be counted when applying the provisions of 310.15(B)(3)(a).
(b) In a 3-wire circuit consisting of two phase conductors and the neutral conductor of a 4-wire, 3-phase, wye-connected system, a common conductor carries approximately the same current as the line-to-neutral load currents of the other conductors and shall be counted when applying the provisions of 310.15(B)(3)(a).
(c) On a 4-wire, 3-phase wye circuit where the major portion of the load consists of nonlinear loads, harmonic currents are present in the neutral conductor; the neutral conductor shall therefore be considered a current-carrying conductor.

Table 310.15(B)(3)(a) Adjustment Factors for More Than Three Current-Carrying Conductors"

Number of Conductors[1]	Percent of Values in Table 310.15(B)(16) Through Table 310.15(B)(19) as Adjusted for Ambient Temperature if Necessary
4–6	80
7–9	70
10–20	50
21–30	45
31–40	40
41 and above	35

Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-147 and pp. 70-148.

In order to meet the conditions of grouping adjustment factors of Section 310-15 (b) (3) (a) note 1 of within the software you should select the OTHER option in the list of grouping factors for the cases of "*10 or more"* current carrying conductors in the same conduit with a multiple variety of loads and then capture the percentage applicable adjustment factor considering the demand indicated in the notes at the bottom of the table referred above.

Example:	*0.77*	*Validation:*	*0.0 < Value > 1.0*

Duct /Cond. burial depth: Is the distance measured from the finished floor level to the upper face of the duct. This measurement is used to determine the adjustment factor due to increase in the depth of burial associated to surrounding temperature increases. The depth of burial adjustment factor is used to meet the guidelines of Section 310-60 (c) (2) of NEC-2017 and Official Mexican Standard NOM-001-SEDE 2012, which states:

> **"(2) Burial Depth of Underground Circuits.** Where the burial depth of direct burial or electrical duct bank circuits is modified from the values shown in a figure or table, ampacities shall be permitted to be modified as indicated in (B)(2)(a) and (B)(2)(b).
>
> (a) Where burial depths are increased in part(s) of an electrical duct run, a decrease in ampacity of the conductors
> shall not be required, provided the total length of parts of the duct run increased in depth is less than 25 percent of the total run length.
>
> (b) Where burial depths are deeper than shown in a specific underground ampacity table or figure, an ampacity derating factor of 6 percent per 300 mm (1 ft) increase in depth for all values of rho shall be permitted.
>
> No ampacity adjustments shall be required where the burial depth is decreased."
>
> Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-153.

The Note of the ducts layouts within the Figure '"310.60 Cable Installation Dimensions for Use with Table 310.77 trough table 310.86" of the NFPA 70 (National Electrical Code) describes the maximum burial depths permitted to consider the ampacities of conductors without decrement .

> "Note: Minimum burial depths to top electrical ducts or cables shall be in accordance with 300.50. Maximum depth to the top of electrical duct banks shall be 750 mm (30 in.) and maximum depth to the top of direct-buried cables shall be 900 mm (36 in.)."
>
> Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-155.

This note is also defined in Figure 310-60.- Cable installation dimensions for use with Tables 310-60c) (77) to 310-60c) (86) of the Official Mexican Standard NOM-001-SEE-2012 as follows.

> "Note 1: Minimum burial depths to top electrical ducts or cables shall be in accordance with 300.50. Maximum depth to the top of electrical duct banks shall be 750 mm (30 in.) and maximum depth to the top of direct-buried cables shall be 900 mm (36 in.)."

The program uses the following algorithms to determine the value of the depth adjustment factor:

For underground ducts (Installation Details 1 to 4):

$$BDAF = 1-(((h -0.75) / 0.3) *0 .06)$$

Where:

BDAF=Burial depth adjustment factor

h = Depth measured to the top level of duct in meters.

For conductors directly buried (installation details 5 to 10)

$$BDAF = 1-(((h - 0.9) / 0.3) * 0.06)$$

Where:

BDAF= Burial depth adjustment factor
h = Depth measured to the top level of directly buried conductors bur in meters

Shield grounded in 2 or more points: This adjustment factor is used to meet the guidelines of section 310-60 (c) (1) of the NEC 2017 and Official Mexican Standard NOM-001-SEDE-2012, indicating:

> **"(1) Grounded Shields.** Ampacities shown in Table 310.60(C)(69), Table 310.60(C)(70), Table 310.60(C)(81), and Table 310.60(C)(82) shall apply for cables with shields grounded at one point only. Where shields for these cables are grounded at more than one point, ampacities shall be adjusted to take into consideration the heating due to shield currents.
> **Informational Note:** Tables other than those listed contain the ampacity of cables with shields grounded at multiple points. "
>
> Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-153.

Unfortunately neither the National Electrical Code or the Mexican Official Standard defines the adjustment factor which is required for the case of metal shields grounded at more than one point. The recommendation is to separately perform a calculation of the temperature rise on the shield for the effect of current circulation and sum this temperature rise to the definition of ambient temperature. Because currents flowing through shields generally generates an average temperature elevation between 3 and 5 °C is a common practice to consider an adjustment factor of 0.9 for this grounding condition. However, in any case it is recommended to analyze the thermal resistive circuit, and apply the thermal Ohm's law to thermal circuits and calculate the actual temperature rise.

Example:	*0.77*	*Validation:*	*0.0 < Value > 1.0*

User Defined: This adjustment factor is used to meet a particular specification applicable to the project in the conductors ampacity. For example consider a future increase of 20% load, in this case the adjustment factor will be 0.8. This factor may be named by the user in the first field, and define a greater than zero and less than unity in the second field value.

Example:	*0.77*	*Validation:*	*0.0 < Value > 1.0*

Differences in thermal resistivity RHO: This adjustment factor is used to comply with the recommendations of section 13.4.2 of IEEE Std.399 which states:

> "Soil thermal resistivity (RHO) indicates the resistance to heat dissipation of the soil °C-cm / W. Tables 13-5 through 13-17 Tables indicate the adjustment factors required when the actual soil temperature resistivity is different from RHO of 90 °C-cm / W at which the base ampacities are specified. These tables are calculated based on an assumption that the soil has a uniform and constant thermal resistivity. "

Because the adjustment factors vary depending on the selected conductor size, *Sizer Electric* selects the appropriate factor for the conductor size under test in the iterative process, based on the actual value of RHO and the number of circuits within the duct array according to the following tables from IEEE Std.399:

Table 13-5—F_{th}: Thermal resistivity adjustment factor for 0–1000 V cables in duct banks with base ampacity given at an RHO of 90 °C-cm/W

Cable Size	Number of CKT	RHO (°C-cm/W)							
		60	90	120	140	160	180	200	250
#12–#1	1	1.03	1.0	0.97	0.96	0.94	0.93	0.92	0.90
	3	1.06	1.0	0.95	0.92	0.89	0.87	0.85	0.82
	6	1.09	1.0	0.93	0.89	0.85	0.82	0.79	0.75
	9+	1.11	1.0	0.92	0.87	0.83	0.79	0.76	0.71
1/0–4/0	1	1.04	1.0	0.97	0.95	0.93	0.91	0.89	0.86
	3	1.07	1.0	0.94	0.90	0.87	0.85	0.83	0.80
	6	1.10	1.0	0.92	0.87	0.84	0.81	0.78	0.74
	9+	1.12	1.0	0.91	0.85	0.81	0.78	0.75	0.70
250–1000	1	1.05	1.0	0.96	0.94	0.92	0.90	0.88	0.85
	3	1.08	1.0	0.93	0.89	0.86	0.83	0.81	0.77
	6	1.11	1.0	0.91	0.86	0.83	0.80	0.77	0.72
	9+	1.13	1.0	0.90	0.84	0.80	0.77	0.74	0.69

Table 13-6—F_{th}: Thermal resistivity adjustment factor for 1001–35 000 V cables in duct banks with base ampacity given at an RHO of 90 °C-cm/W

Cable Size	Number of CKT	RHO (°C-cm/W)							
		60	90	120	140	160	180	200	250
#12–#1	1	1.03	1.0	0.97	0.95	0.93	0.91	0.90	0.88
	3	1.07	1.0	0.94	0.90	0.87	0.84	0.81	0.77
	6	1.09	1.0	0.92	0.87	0.84	0.80	0.77	0.72
	9+	1.10	1.0	0.91	0.85	0.81	0.77	0.74	0.69
1/0–4/0	1	1.04	1.0	0.96	0.94	0.92	0.90	0.88	0.85
	3	1.08	1.0	0.93	0.89	0.86	0.83	0.80	0.75
	6	1.10	1.0	0.91	0.86	0.82	0.79	0.77	0.71
	9+	1.11	1.0	0.90	0.84	0.80	0.76	0.73	0.68
250–1000	1	1.05	1.0	0.95	0.92	0.90	0.88	0.86	0.84
	3	1.09	1.0	0.92	0.88	0.85	0.82	0.79	0.74
	6	1.11	1.0	0.91	0.85	0.81	0.78	0.75	0.70
	9+	1.12	1.0	0.90	0.84	0.79	0.75	0.72	0.67

Table 13-7—F_{th}: Thermal resistivity adjustment factor for cables directly buried with base ampacity given at an RHO of 90 °C-cm/W

Cable Size	Number of CKT	RHO (°C-cm/W)							
		60	90	120	140	160	180	200	250
#12–#1	1	1.10	1.0	0.91	0.86	0.82	0.79	0.77	0.74
	2	1.13	1.0	0.90	0.85	0.81	0.77	0.74	0.70
	3+	1.14	1.0	0.89	0.84	0.79	0.75	0.72	0.67
1/0–4/0	1	1.13	1.0	0.91	0.86	0.81	0.78	0.75	0.71
	2	1.14	1.0	0.90	0.85	0.80	0.76	0.73	0.69
	3+	1.15	1.0	0.89	0.84	0.78	0.74	0.71	0.67
250–1000	1	1.14	1.0	0.90	0.85	0.81	0.78	0.75	0.71
	2	1.15	1.0	0.89	0.84	0.80	0.76	0.73	0.69
	3+	1.16	1.0	0.88	0.83	0.78	0.74	0.71	0.67

Because the adjustment factor depends on the conductor size, during the data capture process *Sizer Electric* will show the label "No Disp." (also for Conduit Adjustment Factor field). Once the calculation has been performed and the conductor size was selected, the final and adequate adjustment factor will be available on the this window.

Example:	0.60	Validation:	0.0 < Valor ≤ 1.0

Conduit Grouping in ducts (Adjustment factor): It is very common that for some duct installations the use of the details shown in the NEC-2017 (Figure 310.60 Cable Installation dimensions for Use with table 310-77 trough Table 310.86) is not applicable. When a different duct layout is required the adjustment factors defined in IEEE Std.399 applied to the Duct installation Detail 1, can provide the ampacity required for layouts up to 4 rows to 15 columns. This adjustment factor is used to comply with the recommendations of section 13.4.3 of IEEE Std.399 which states: .

Fg (grouping adjustment factor). “Grouped cables operate at a higher temperature than isolated cables. The increase in the operating temperature is due to the presence of other cables in the group which act as heat sources. Therefore the amount of interference temperature rise from other cables depends on the separation of the cables and the surrounding media.”

For underground ducts with voltages lower than 5000 volts, the *Sizer Electric* software considers the adjustment factor according to the number of rows and columns and conductor size applying the table below (extracted from 399 IEEE Std.):

Table 13-8—F_g: Grouping adjustment factor for 0–5000 V 3/C, or triplexed cables in duct banks (no spare ducts, nonmetallic conduits of 5 in with center-to-center spacing of 7.5 in)

Cable size	No. of rows	Number of columns														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
#8	1	1.00	.942	.885	.835	.795	.768	.745	.727	.710	.698	.688	.679	.671	.664	.658
	2	.930	.840	.772	.723	.687	.660	.638	.620	.604	.592	.582	.572	.564	.557	.550
	3	.870	.772	.694	.632	.596	.569	.548	.532	.519	.508	.498	.490	.482	.476	.470
	4	.820	.710	.629	.571	.536	.509	.490	.472	.458	.446	.436	.428	.420	.412	.405
#6	1	1.00	.930	.874	.826	.790	.760	.737	.718	.702	.690	.680	.671	.663	.656	.650
	2	.920	.813	.747	.700	.665	.638	.615	.598	.583	.572	.561	.552	.544	.537	.530
	3	.860	.747	.679	.625	.588	.560	.540	.525	.510	.498	.490	.481	.473	.467	.460
	4	.810	.700	.620	.565	.531	.503	.484	.467	.452	.440	.431	.422	.415	.408	.400
#4	1	1.00	.925	.871	.817	.781	.750	.726	.707	.691	.678	.668	.659	.651	.646	.640
	2	.920	.809	.742	.693	.659	.632	.610	.593	.579	.567	.555	.547	.539	.530	.525
	3	.850	.742	.668	.615	.578	.551	.531	.514	.500	.489	.480	.471	.464	.458	.450
	4	.805	.690	.610	.560	.524	.497	.477	.460	.447	.435	.425	.418	.410	.401	.395
#2	1	1.00	.918	.858	.808	.770	.741	.720	.701	.688	.677	.667	.658	.650	.641	.635
	2	.920	.800	.723	.680	.648	.623	.602	.586	.572	.560	.549	.540	.530	.522	.514
	3	.840	.723	.657	.608	.568	.540	.520	.504	.490	.479	.470	.461	.454	.447	.440
	4	.800	.685	.608	.553	.518	.490	.471	.453	.440	.429	.420	.411	.402	.395	.390
#1	1	1.00	.918	.849	.799	.753	.721	.699	.682	.669	.659	.650	.643	.639	.632	.630
	2	.920	.795	.702	.650	.613	.583	.563	.546	.530	.520	.510	.502	.494	.488	.482
	3	.830	.702	.618	.562	.525	.500	.480	.464	.450	.440	.430	.421	.413	.406	.400
	4	.740	.634	.551	.497	.465	.440	.421	.405	.392	.383	.374	.366	.359	.352	.348
1/0	1	1.00	.910	.842	.791	.745	.716	.694	.678	.665	.655	.646	.639	.635	.628	.626
	2	.915	.790	.700	.642	.604	.575	.555	.537	.523	.511	.503	.494	.486	.480	.475
	3	.817	.700	.610	.554	.520	.494	.474	.457	.444	.432	.424	.415	.408	.400	.394
	4	.735	.629	.546	.492	.460	.435	.417	.402	.391	.381	.371	.363	.355	.349	.343
2/0	1	1.00	.910	.842.	.791	.745	.716	.694	.678	.665	.655	.646	.639	.635	.628	.626
	2	.915	.790	700	.642	.604	.575	.555	.537	.523	.511	.503	.494	.486	.480	.475
	3	.817	.700	.610	.554	.520	.494	.474	.457	.444	.432	.424	.415	.408	.400	.394
	4	.735	.629	.546	.492	.460	.435	.417	.402	.391	.381	.371	.363	.355	.349	.343
3/0	1	1.00	.910	.842	.791	.745	.716	.694	.678	.665	.655	.646	.639	.635	.628	.626
	2	.915	.790	.700	.642	.604	.575	.555	.537	.523	.511	.503	.494	.486	.480	.475
	3	.817	.700	.610	.554	.520	.494	.474	.457	.444	.432	.424	.415	.408	.400	.394
	4	.735	.629	.546	.492	.460	.435	.417	.402	.391	.381	.371	.363	.355	.349	.343
4/0	1	1.00	.908	.830	.780	.737	.709	.690	.673	.660	.650	.642	.635	.628	.623	.619
	2	.910	.770	.684	.635	.599	.570	.550	.532	.518	.506	.498	.489	.481	.475	.470
	3	.810	.684	.602	.548	.515	.489	.469	.452	.440	.429	.420	.411	.403	.397	.391
	4	.730	.624	.541	.487	.456	.431	.414	.399	.388	.378	.368	.360	.352	.346	.341
250	1	1.00	.905	.830	.777	.725	.692	.668	.646	.628	.615	.603	.597	.590	.583	.580
	2	.890	.770	.675	.609	.570	.542	.519	.500	.485	.474	.466	.458	.450	.445	.440
	3	.780	.675	.579	.518	.480	.454	.434	.420	.408	.398	.390	.383	.378	.373	.370
	4	.694	.588	.512	.460	.422	.397	.379	.364	.352	.345	.338	.331	.327	.323	.320

Table 13-8—F_g: Grouping adjustment factor for 0–5000 V 3/C, or triplexed cables in duct banks (no spare ducts, nonmetallic conduits of 5 in with center-to-center spacing of 7.5 in) (*Continued*)

Cable size	No. of rows	Number of columns														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
350	1	1.00	.905	.830	.770	.720	.688	.661	.640	.622	.608	.597	.590	.583	.578	.573
	2	.887	.749	.664	.609	.570	.540	.518	.499	.484	.474	.465	.458	.450	.445	.440
	3	.775	.664	.575	.515	.479	.453	.433	.419	.406	.397	.389	.382	.377	.372	.369
	4	.690	.587	.511	.457	.421	.395	.377	.362	.351	.343	.336	.330	.325	.321	.318
500	1	1.00	.897	.815	.762	.708	.678	.652	.630	.613	.599	.588	.581	.575	.570	.565
	2	.882	.745	.656	.608	.569	.539	.516	.498	.483	.473	.463	.457	.450	.444	.439
	3	.770	.656	.570	.514	.478	.452	.432	.417	.404	.395	.388	.381	375	.370	.367
	4	.685	.585	510	.454	.420	.393	.374	.360	.349	.340	.333	.328	.323	.319	.315
750	1	1.00	.890	.802	.747	.700	.670	.640	.622	.605	.590	.580	.572	.566	.560	.555
	2	.870	.725	.641	.591	.552	.522	.500	.484	.469	.457	.448	.440	.434	.430	.425
	3	.760	.641	.560	.507	.470	.445	.425	.410	.398	.389	.380	.374	.369	.363	.360
	4	.680	.579	.501	.448	.413	.389	.371	.357	.346	.337	.330	.323	.318	.314	.310
1000	1	1.00	.885	.795	.740	.695	.665	.639	.618	.600	.585	.574	.567	.561	.555	.551
	2	.858	.716	.632	.582	.544	.513	.493	.474	.460	.448	.439	.431	.425	.420	.415
	3	.748	.632	.551	.499	.464	.439	.419	.403	.392	.383	.375	.369	.363	.358	.355
	4	.676	.574	.497	.444	.409	.385	.367	.353	.342	.333	.326	.319	.315	.311	.308

For underground ducts with voltages from 5,001 to 35,000 volts, the Sizer Electric software considers the adjustment factor according to the number of rows, columns and conductor size using the following table (Extracted from IEEE Std.399.):

Table 13-9—F_g: Grouping adjustment factor for 5001–35 000 V 3/C, or triplexed cables in duct banks (no spare ducts, nonmetallic conduits of 5 in with center-to-center spacing of 7.5 in)

Cable size	No. of rows	Number of columns														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
#6	1	1.00	.920	.854	.803	.758	.726	.699	.678	.660	.646	.635	.628	.620	.615	.610
	2	.920	.800	.714	.660	.620	.590	.570	.552	.540	.530	.521	.515	.509	.503	.500
	3	.840	.714	.625	.569	.530	.501	.484	.470	.459	.450	.442	.436	.429	.423	.420
	4	.770	.642	560	.506	.469	.441	.422	.406	.394	.385	.378	.371	.367	.362	.358
#4	1	1.00	.920	.852	.800	.755	.722	.695	.673	.655	.642	.630	.623	.615	.610	.605
	2	.920	.795	.714	.660	.620	.590	.570	.552	.540	.530	.521	.515	.434	.430	.425
	3	.835	.709	.615	.561	.521	.493	.474	.459	.488	.439	.430	.424	.420	.416	.412
	4	.760	.630	.548	.498	.460	.430	.410	.395	.382	.374	.367	.361	.356	.352	.350
#2	1	1.00	.910	.836	.784	.748	.714	.688	.665	.649	.635	.625	.616	.609	.602	.598
	2	.920	.782	.689	.639	.599	.570	.548	.531	.518	.508	.500	.494	.489	.484	.480
	3	.820	.689	.600	.544	.505	.479	.460	.445	.433	.424	.417	.410	.405	.400	.395
	4	.746	.622	.539	.484	.445	.415	.396	.382	.370	361	.353	.348	.342	.338	.334
#1	1	1.00	.905	.827	.777	.731	.697	.670	.645	.626	.610	.598	.588	.579	.571	.565
	2	.920	.771	.681	.629	.590	.560	.538	.519	.502	.491	.480	.471	.462	.455	.450
	3	.816	.681	.588	.532	.497	.469	.448	.432	.418	.407	.397	.389	.382	.376	.370
	4	.785	.605	.524	.471	.435	.410	.390	.376	.364	.353	.347	.340	.333	.328	.323
1/0	1	1.00	.904	.825	.775	.729	.695	.668	.643	.624	.609	.597	.587	.578	.570	.564
	2	.912	.765	.671	.619	.580	.549	.527	.509	.494	.481	.471	.462	.453	.446	.440
	3	.811	.671	.581	.525	.488	.460	.440	.423	.409	.398	.387	.379	.372	.365	.359
	4	.730	.604	.518	.464	.431	.406	.385	.372	.359	.349	.341	.335	.329	.324	.320

Table 13-9—F_g: Grouping adjustment factor for 5001–35 000 V 3/C, or triplexed cables in duct banks (no spare ducts, nonmetallic conduits of 5 in with center-to-center spacing of 7.5 in) (*Continued*)

Cable size	No. of rows	Number of columns														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2/0	1	1.00	.904	.823	.773	.728	.694	.668	.643	.624	.609	.580	.597	.587	.578	.570
	2	.903	.761	.667	.612	.573	.542	.520	.500	.488	.475	.463	.455	.448	.441	.434
	3	.800	.667	.578.	.520	.482	.454.	.433	.418	.402	.391	.382	.374	.367	.360	.353
	4	.722	.597	511	.460	.425	400	.380	.365	.353	.343	.335	.329	.322	.317	.312
3/0	1	1.00	.898	.814	.765	.722	.690	.661	.637	.618	.602	.590	.580	.571	.563	.556
	2	.898	.752	.664	.609	.570	.539	.451	.498	.483	.471	.461	.451	.443	.437	.429
	3	.802	.664	.572	.514	.479	.451	.430	.414	.399	.388	.379	.371	.364	.357	.350
	4	.720	.593	.508	.456	.421	.396	.377	.362	.350	.340	.332	.327	.320	.314	.310
4/0	1	1.00	.894	.811	.762	.717	.682	.653	.631	.612	.597	.585	.574	.566	.558	.550
	2	.896	.743	.656	.603	.565	.536	.513	.496	.480	.468	.459	.449	.441	.434	.427
	3	.795	.656	.564	.513	.474	.447	.427	.411	.397	.386	.377	.369	.362	.355	.349
	4	.711	.584	.502	.450	.417	.392	.374	.359	.348	.338	.329	.324	.317	.311	.307
250	1	1.00	.892	.811	.762	.715	.679	.645	.620	.600	.583	.572	.564	.557	.552	.550
	2	.885	.741	.654	.594	.552	.523	.500	.482	.469	.457	.447	.438	.430	.422	.416
	3	.785	.654	.559	.498	.459	.429	.408	.388	.373	.361	.351	.342	.335	.328	.321
	4	.701	.580	.500	.448	.414	.385	.365	.348	.332	.321	.311	.302	.295	.288	.281
350	1	1.00	.890	.807	.754	.700	.661	.634	.609	.589	.572	.561	.552	.548	.542	.540
	2	.872	.733	.641	.580	.538	.510	.488	.470	.455	.443	.432	.423	.415	.408	.400
	3	.772	.641	.550	.492	.451	.420	.396	.377	.362	.350	.340	.331	.323	.316	.310
	4	.681	.572	.491	.440	.402	.375	.354	.337	.322	.311	.300	.292	.285	.278	.271
500	1	1.00	.885	.801	.745	.692	.650	.620	.593	.573	.559	.548	.539	.533	.529	.526
	2	.862	.728	.634	.572	.531	.502	.480	.462	.447	.435	.425	.415	.407	.400	.391
	3	.765	.634	.542	.483	.446	.415	.391	.373	.358	.346	.335	.327	.319	.311	.305
	4	.676	.574	.497	.444	.409	.385	.367	.353	.342	.333	.326	.319	.315	.311	.308
750	1	1.00	.879	.790	.780	.682	.647	.615	.589	.570	.556	.545	.536	.530	.524	.520
	2	.850	.710	.622	.560	.520	.490	.469	.450	.436	.424	.412	.402	.394	.388	.381
	3	.755	.622	.530	.479	.441	.410	.387	.368	.352	.341	.331	.322	.314	.307	.300
	4	.671	.560	.480	.430	.392	.366	.345	.328	.314	.302	.292	.284	.277	.270	.263
1000	1	1.00	.873	.786	.730	.680	.642	.609	.582	.562	.548	.537	.528	.521	.516	.512
	2	.844	.705	.614	.554	.514	.485	.463	.445	.430	.418	.406	.397	.390	.383	.376
	3	.745	.614	.523	.472	.434	.403	.381	.363	.348	.337	.327	.318	.309	.301	.294
	4	.663	.552	.473	.422	.385	.359	.338	.321	.307	.295	.285	.278	.270	.263	.256

Grouping adjustment factor directly buried conductors: It is very common that for some directly buried conductor installations the use of the details shown in the NEC-2017 (Figure 310.60 Cable Installation dimensions for Use with table 310-77 trough Table 310.86) is not applicable. When a different layout of buried conductors is required, the adjustment factors defined in IEEE Std.399 applied to the installation Detail 5 of the ampacity tables, can provide the ampacity required for layouts up to 2 rows to 12 columns. This adjustment factor is used to comply with the recommendations of section 13.4.3 of IEEE Std.399 which states:

> Fg (grouping adjustment factor). “Grouped cables operate at a higher temperature than isolated cables. The increase in the operating temperature is due to the presence of other cables in the group which act as heat sources. Therefore the amount of interference temperature rise from other cables depends on the separation of the cables and the surrounding media.”

For directly buried conductors, the Sizer Electric software considers the adjustment factor according to the number of layers and the number of horizontal cables using the table below (extracted from 399 IEEE Std.):

Table 13-10—F_g: Grouping adjustment factor for directly buried 3/C, or triplexed cables (7.5 in horizontal and 10 in center-to-center vertical spacing)

Number of layers	Number of horizontal cables						
	1	2	3	4	6	9	12
1	1.0	0.82	0.70	0.63	0.56	0.51	0.49
2	0.81	0.62	0.53	0.48	0.41	—	—

Table 13-11—F_g: Grouping adjustment factor for directly buried 1/C, or triplexed cables (7.5 in horizontal and 10 in center-to-center vertical spacing)

Number of layers	Number of horizontal cables			
	3	6	9	12
1	1.0	0.79	0.71	0.68
2	0.73	0.58	—	—

Example:	0.88	Validation:	0.0 < Value ≤ 1.0

Air

Adjustment Factor Air: Is the adjustment that has to be done in the conductor ampacity, by the installation conditions in air or to meet use requirements.

Example:	0.77	Validation:	0.0 < Value ≤ 1.0

Messenger

Messenger Adjustment Factor: Is the adjustment to be done in the conductors ampacity, by the installation conditions or to meet user needs. .

Example:	0.77	Validation:	$0.0 < \text{Value} \leq 1.0$

Material Type: This field must provide the material of the conduit, duct or cable tray to be used, and in the case of a system with conduit and cable tray (Both), the user will provide the data of the material which predominates for the two installation materials. 4 types of materials are defined for calculation, steel (S), aluminum (A) and PVC (P), FRP. Material information is used for determining the circuit reactance affected by surrounding magnetic or nonmagnetic materials ..

Example:	Steel	Validation:	Steel, Aluminum, PVC, FRP or Concrete

Cable Type: In this field you should capture the type of conductor to be used. These are defined according to the generic definitions for ducts, conduits and cable trays in the Mexican Official Standard NOM-001-SEDE-2012 and NEC-2017**.**

Example:	Single conductor	Validation:	Single-conductor, Single-conductor-armored, Single conductor triplexed, Multiconductor, Armored-Multiconductor, Bare.

Terminals Max. Temp.: This field is used to define the maximum temperature of system connectors or terminals. It is important to clarify that this temperature will be used for the determination of the conductor ampacity when it is defined with a different value from the conductor maximum operating temperature. This complies with the statements of the section 110-14 of the NEC-2017.

> **110.14 Electrical Connections.** Because of different characteristics of dissimilar metals, devices such as pressure terminal or pressure splicing connectors and soldering lugs shall be identified for the material of the conductor and shall be properly installed and used. Conductors of dissimilar metals shall not be intermixed in a terminal or splicing connector where physical contact occurs between dissimilar conductors (such as copper and aluminum, copper and copper-clad aluminum, or aluminum and copper-clad aluminum), unless the device is identified for the purpose and conditions of use. Materials such as solder, fluxes, inhibitors, and compounds, where employed, shall be suitable for the use and shall be of a type that will not adversely affect the conductors, installation, or equipment. Connectors and terminals for conductors more finely stranded than Class B and Class C stranding as shown in Chapter 9, Table 10, shall be identified for the specific conductor class or classes.
>
> **(A) Terminals.** Connection of conductors to terminal parts shall ensure a thoroughly good connection without damaging the conductors and shall be made by means of pressure connectors (including set-screw type), solder lugs, or splices to flexible leads. Connection by means of wire-binding screws or studs and nuts that have upturned lugs or the equivalent shall be permitted for 10 AWG or smaller conductors. Terminals for more than one conductor and terminals used to connect aluminum shall be so identified.
>
> **(B) Splices.** Conductors shall be spliced or joined with splicing devices identified for the use or by brazing, welding, or soldering with a fusible metal or alloy. Soldered splices shall first be

spliced or joined so as to be mechanically and electrically secure without solder and then be soldered. All splices and joints and the free ends of conductors shall be covered with an insulation equivalent to that of the conductors or with an identified insulating device.
Wire connectors or splicing means installed on conductors for direct burial shall be listed for such use.
(C) Temperature Limitations. The temperature rating associated with the ampacity of a conductor shall be selected and coordinated so as not to exceed the lowest temperature rating of any connected termination, conductor, or device. Conductors with temperature ratings higher than specified for terminations shall be permitted to be used for ampacity adjustment, correction, or both.

(1) Equipment Provisions. The determination of termination provisions of equipment shall be based on 110.14(C)(1)(a) or (C)(1)(b). Unless the equipment is listed and marked otherwise, conductor ampacities used in determining equipment termination provisions shall be based on Table 310.15(B)(16) as appropriately modified by 310.15(B)(7).

(a) Termination provisions of equipment for circuits rated 100 amperes or less, or marked for 14 AWG through 1 AWG conductors, shall be used only for one of the following:

(1) Conductors rated 60°C (140°F).
(2) Conductors with higher temperature ratings, provided the ampacity of such conductors is determined based on the 60°C (140°F) ampacity of the conductor size used.
(3) Conductors with higher temperature ratings if the equipment is listed and identified for use with such conductors.
(4) For motors marked with design letters B, C, or D, conductors having an insulation rating of 75°C (167°F) or higher shall be permitted to be used, provided the ampacity of such conductors does not exceed the 75°C (167°F)
ampacity.

(b) Termination provisions of equipment for circuits rated over 100 amperes, or marked for conductors larger than 1 AWG, shall be used only for one of the following:

(1) Conductors rated 75°C (167°F)
(2) Conductors with higher temperature ratings, provided the ampacity of such conductors does not exceed the 75°C (167°F) ampacity of the conductor size used, or up to their ampacity if the equipment is listed and identified
for use with such conductors

(2) Separate Connector Provisions. Separately installed pressure connectors shall be used with conductors at the ampacities not exceeding the ampacity at the listed and identified temperature rating of the connector.
Informational Note: With respect to 110.14(C)(1) and (C)(2), equipment markings or listing information may additionally restrict the sizing and temperature ratings of connected conductors.
(D) Installation. Where a tightening torque is indicated as a numeric value on equipment or in installation instructions provided by the manufacturer, a calibrated torque tool shall be used to achieve the indicated torque value, unless the equipment manufacturer has provided installation instructions for an alternative method of achieving the required torque.

Example:	*60 C*	*Validation:*	*60,75,90,105,150,200 C*

Insulation level: In this field the insulation level applicable to the conductor should be selected from the list. The value defined will be used to complete the conductor specification. The insulation level must be defined in accordance with the references in Table 310-104 (e):

"**100 Percent Insulation Level.** Cables in this category shall be permitted to be applied where the system is provided with relay protection such that ground faults will be cleared as rapidly as possible but, in any case, within 1 minute. While these cables are applicable to the great majority

of cable installations that are on grounded systems, they shall be permitted to be used also on other systems for which the application of cables is acceptable, provided the above clearing requirements are met in completely de-energizing the faulted section.

133 Percent Insulation Level. This insulation level corresponds to that formerly designated for ungrounded systems. Cables in this category shall be permitted to be applied in situations where the clearing time requirements of the 100 percent level category cannot be met and yet there is adequate assurance that the faulted section will be de-energized in a time not exceeding 1 hour. Also, they shall be permitted to be used in 100 percent insulation level applications where additional insulation is desirable.

173 Percent Insulation Level. Cables in this category shall be permitted to be applied under all of the following conditions:

(1) In industrial establishments where the conditions of maintenance and supervision ensure that only qualified persons service the installation
(2) Where the fault clearing time requirements of the 133 percent level category cannot be met
(3) Where an orderly shutdown is essential to protect equipment and personnel
(4) There is adequate assurance that the faulted section will be de-energized in an orderly shutdown
Also, cables with this insulation thickness shall be permitted to be used in 100 or 133 percent insulation level applications where additional
insulation strength is desirable."

Example:	*133%*	*Validation:*	*100, 133,173%*

Voltage drop: This field shall indicate the maximum voltage drop that must have the selected conductor with the calculated current. The calculation of the voltage drop will be performed from the method described below:

The voltage drop of a power system can be calculated by selecting the most appropriate formula to the desired accuracy and if the voltage is known as the end of the load or at the circuit power source.

Equations to calculate the voltage drop: In the following equations, the voltages and voltage drops are phase to neutral. To calculate the voltage drop line to neutral of a three-phase system, you should multiply the voltage drop line to neutral by the square root of three. In the United States, for single-phase systems, the voltage drop from line to line, is obtained by multiplying the voltage drop line to neutral by 2.
Under certain conditions, you can get a result with a negative sign with the following formulas. In such cases the result should be interpreted as evidence that the load voltage is greater than the source voltage. However, these cases will be rare since the vast majority of systems will load voltages that are less than the supply voltages. The nomenclature used in the formulas are as follows:

E	Voltage drop line to neutral.

Es	Voltage line to neutral at the source side.
Er	Line to neutral voltage at the load end.
θ	Angle which cosine is the load power factor
I	Line current.
R	Circuit resistance in ohms.
X	Circuit reactance in ohms (By convention, the inductive reactance is positive and the capacitive reactance is negative).
Cos θ	Power factor load in decimals.
Sen θ	Reactive load factor in decimal (By convention, sinθ is positive and for loads with leading power factor)

The following formulas are accurate, if *Er* is known:

$$E = \left[\left(Er * \cos\theta + I * R\right)^2 + \left(Er * sen\theta + I * X\right)^2\right]^{\frac{1}{2}} - Er$$

If *Es* is known:

$$E = Es + I * R * \cos\theta + I * X * sen\theta - \left[Es^2 - \left(I * X * \cos\theta - I * R * sen\theta\right)^2\right]^{\frac{1}{2}}$$

For practical purposes, the following approximate formula is of sufficient accuracy.

$$E = I * \left(R * \cos\theta + X * sen\theta\right)$$

Sizer Electric calculates the voltage drop expressed in percent using the following equations:

For three-phase circuits:

$$e\% = \frac{\sqrt{3} * L * \left(\frac{I_N}{CF}\right) * \left(R * \cos\theta + X * \text{sen}\,\theta\right)}{V * 10}$$

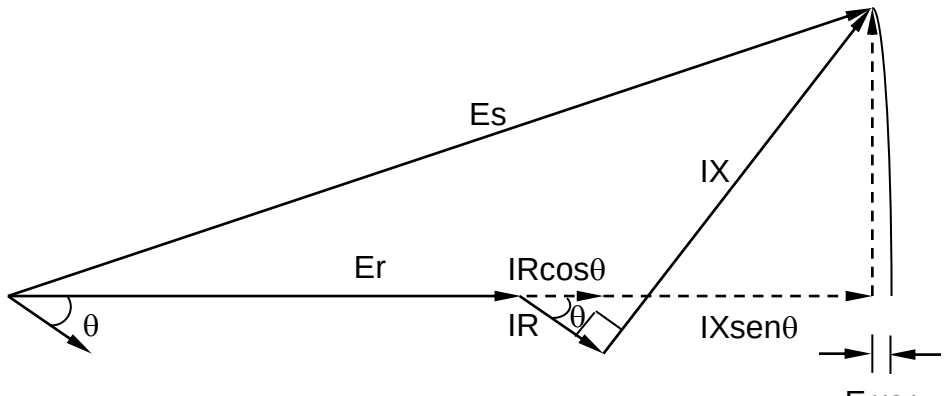
For single-phase circuits:

$$e\% = \frac{2 * L * \left(\frac{I_N}{CF}\right) * \left(R * \cos\theta + X * \text{sen}\,\theta\right)}{V * 10}$$

Where:

e%	Voltage drop in Percent.
L	Conductor length [m].
I_N	Rated current. [Amp.]
CF	Number of conductors per phase
R	Resistance [Ohms/ Km].
X	Reactance [Ohms/ Km].
V	System Voltage [Volts].
θ	Phase shift angle between the voltage and current.
cos θ	Power factor

In the phasor diagram you can see the approximate formula is accurate enough for most applications.



In practical cases the angle between Es and Er is small and approaches zero when the power factor of the load approaches the feeding system power factor.

For circuits with voltages below 600 V, the voltage drop of a circuit must be in the range of 0 to 5% according to the provisions of sections 215-2 (a) Note 3 and 210-19 (a) (1) note 4 as follows:

> "215.2(A)(1)(b)
>
> **Informational Note No. 2:** Conductors for feeders, as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch circuits to the farthest outlet does not exceed 5 percent, will provide reasonable efficiency
> of operation.
>
> 210.19(A)(1)
>
> **Informational Note No. 4:** Conductors for branch circuits as defined in Article 100, sized to prevent a voltage drop exceeding 3 percent at the farthest outlet of power, heating, and lighting loads, or combinations of such loads, and where the maximum total voltage drop on both feeders and branch

circuits to the farthest outlet does not exceed 5 percent, provide reasonable efficiency of operation. See Informational Note No. 2 of 215.2(A)(1) for voltage drop on feeder conductors."

Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association, pp. 70-49 and pp-70-61

Example:	3.0	Validation:	0.0 < Value ≤ 5.0

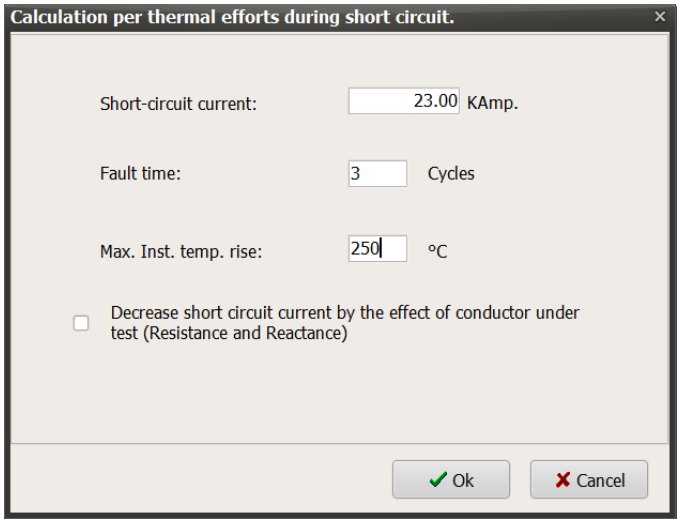
Conductor short circuit withstand capacity

During the selection of the conductor size you may include a calculation by thermal stresses during short conditions to comply with the provisions of section 110-10 of the NEC 2017 and Official Mexican Standard NOM-001-SEDE-2012

"110.10 Circuit Impedance, Short-Circuit Current Ratings, and Other Characteristics. The overcurrent protective devices, the total impedance, the equipment short-circuit current ratings, **and other characteristics of the circuit to be protected shall be selected and coordinated to permit the circuit protective devices used to clear a fault to do so without extensive damage to the electrical equipment of the circuit.** This fault shall be assumed to be either between two or more of the circuit conductors or between any circuit conductor and the equipment grounding conductor(s) permitted in 250.118. Listed equipment applied in accordance with their listing shall be considered to meet the requirements of this section."

Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association, pp. 70-49 and pp-70-44

This process is optional for low voltage circuits but mandatory for medium voltage circuits. By selecting the check box or clicking the 3-points button the following capture window is displayed.



Short circuit current: Is the value of short circuit current that occurs during a fault in the connection point of the equipment. It can be considered the value of the current closest to the equipment bus. In reality the bus current is diminished by the resistance and reactance of the conductor and the dissipation time of the failure. This value shall be expressed in kilo Amperes.

Example:	220.0	Validation:	0.0 < Value < 10000.0

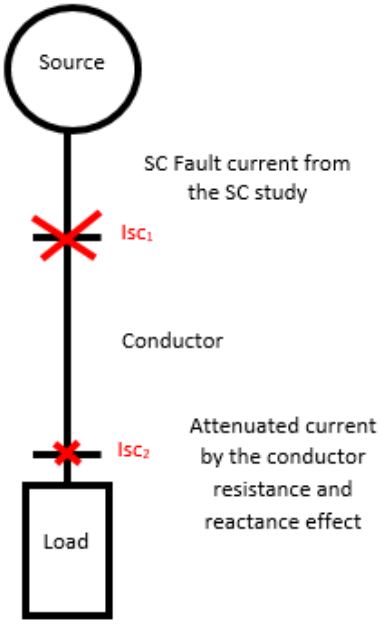
Fault time: Is the time it takes to the protection device to open the circuit to release the fault. This is also the time that the conductor must withstand the short circuit current. This time is important in the selection of a conductor by thermal stresses during short circuit, since a very large time leads to a larger conductor size. It must be expressed in cycles considering a 60 Hz frequency.

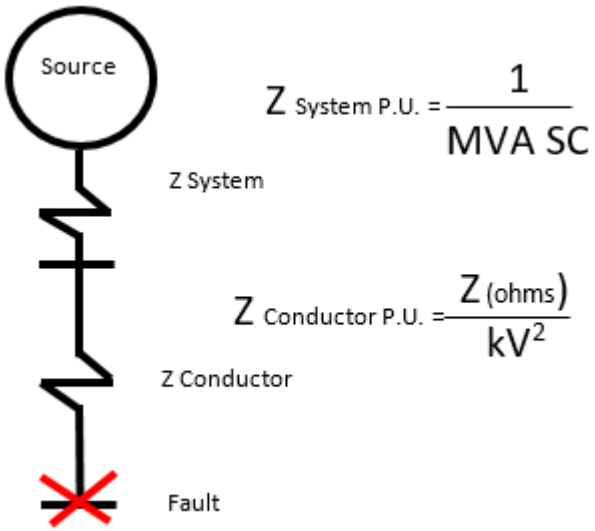
Example:	3.0	Validation:	0.0 < Value< 10.0

Maximum Instantaneous temperature rise: All conductors with insulation may be subjected to a higher temperature than the operation for a short time without experiencing early aging or insulation damage. This temperature it is called maximum instantaneous temperature elevation. This temperature is used to calculate the conductor size (area) required not to exceed the maximum instantaneous temperature rise in the conductor insulation.

Example:	3.0	Validation:	75.0 ≤ Value ≤ 200.0

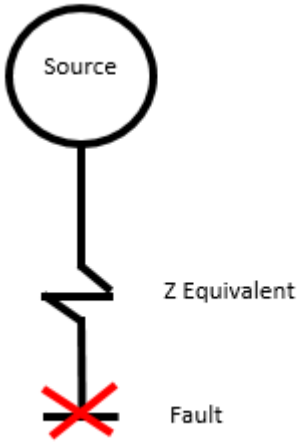
Decrease the short circuit current by the conductor size effect: Usually during the development of a short circuit study no analysis of the fault current is performed at the conductor end close to the load. This short circuit current represents the fault actually flowing through the conductor. Therefore, *Sizer Electric* consider the alternative to calculate the fault current at the end of the conductor applying the per unit calculation method (1 MVA base) and considering the values of the selected conductor resistance and reactance as follows:





$$Z_{\text{System P.U.}} = \frac{1}{\text{MVA SC}}$$

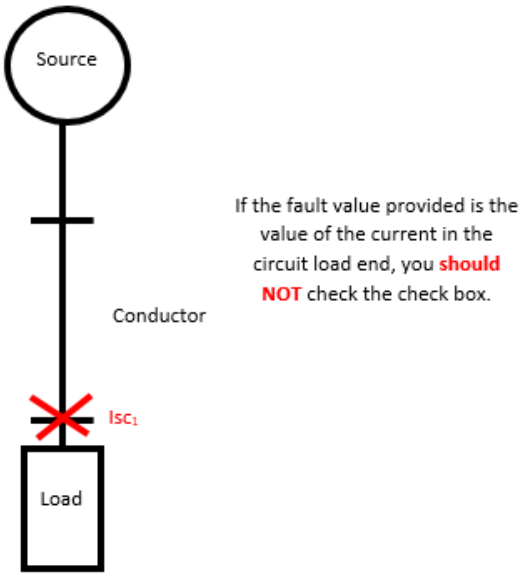
$$Z_{\text{Conductor P.U.}} = \frac{Z_{(\text{ohms})}}{kV^2}$$



$$Z_{\text{Equivalent}} = Z_{\text{System P.U.}} + Z_{\text{Conductor P.U.}}$$

Important Notes:

1. Because the calculating method used to determine the decrease of the fault current that will support the conductor is Per Unit (PU), the user must provide the value of the fault current that occurs in time captured in the text box "fault time". This is, because in the p.u. calculating method is not considered the decrease the short circuit current in time by the effect of the change in system impedances.
2. The value of the Base Power considered for calculating in p.u. is 1 MVA.
3. The impedance is calculated iteratively for each conductor size considered in selecting the minimum area required by thermal stresses.
4. **If the value of the fault current provided in the "short circuit current" field is the value of the fault current at the end of the conductor. You should NOT select the check box because the impedance effect of the conductor in the short circuit current would be doubled.**



Example:	Verified	*Validation*:	Checked or Unchecked

Refer to guidelines of section 240-92 (b) in the case of branches or branches considered as feeders for the calculation

"240.92 Location in Circuit. An overcurrent device shall be connected in each ungrounded circuit conductor as required in 240.92(A) through (E).

(B) Feeder Taps. For feeder taps specified in 240.21(B)(2), (B)(3), and (B)(4), the tap conductors shall be permitted to be sized in accordance with Table 240.92(B).

Table 240.92(B) Tap Conductor Short-Circuit Current Ratings"

Tap conductors are considered to be protected under short-circuit conditions when their short-circuit temperature limit is not exceeded. Conductor heating under short-circuit conditions is determined by (1) or (2):

(1) *Short-Circuit Formula for Copper Conductors*

$$(I^2/A^2)t = 0.0297 \log_{10} [(T_2 + 234)/(T_1 + 234)]$$

(2) *Short-Circuit Formula for Aluminum Conductors*

$$(I^2/A^2)t = 0.0125 \log_{10} [(T_2 + 228)/(T_1 + 228)]$$

where:

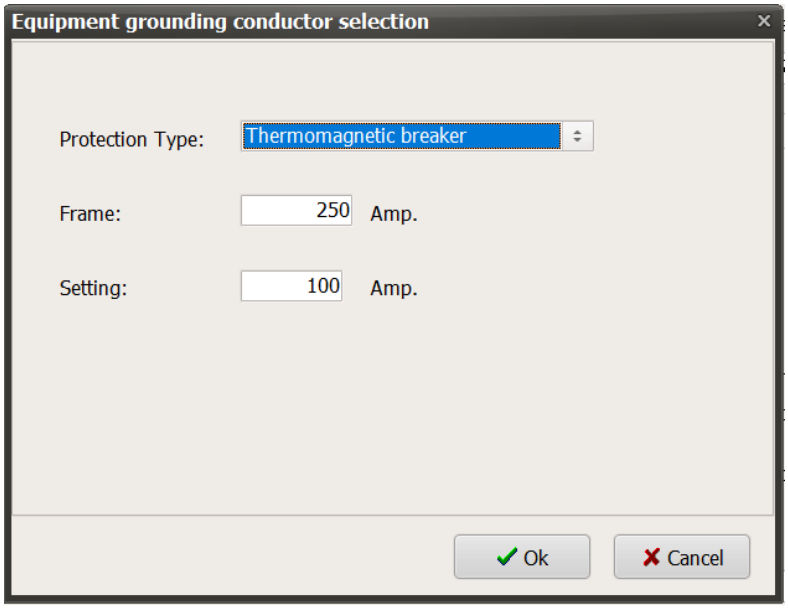
I = short-circuit current in amperes
A = conductor area in circular mils
t = time of short circuit in seconds (for times less than or equal to 10 seconds)
T_1 = initial conductor temperature in degrees Celsius
T_2 = final conductor temperature in degrees Celsius

Copper conductor with paper, rubber, varnished cloth insulation, $T_2 = 200$
Copper conductor with thermoplastic insulation, $T_2 = 150$
Copper conductor with cross-linked polyethylene insulation, $T_2 = 250$
Copper conductor with ethylene propylene rubber insulation, $T_2 = 250$
Aluminum conductor with paper, rubber, varnished cloth insulation, $T_2 = 200$
Aluminum conductor with thermoplastic insulation, $T_2 = 150$
Aluminum conductor with cross-linked polyethylene insulation, $T_2 = 250$
Aluminum conductor with ethylene propylene rubber insulation, $T_2 = 250$

Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-49 and pp-70-102

Equipment Grounding Conductor (EGC)

In this check box must be defined whether or not is required the equipment grounding conductor. If necessary, consult or edit this information you must select the 3-points button (...), located on one side of this box, which shows the EGC capture window.



In the event that the EGC is required you must indicate the type of protection, frame or size of the fuse holder and Setting of the Short circuit instantaneous protective device or fuse capacity in the capture window that appears when you select this check box.

Type of protection: You should indicate the type of the protective device used for circuit protection. This type of device and its operating curve depends on the nominal value and the frame or the fuse to be used for the equipment. The program has a library with typical setting values and frames for certain types of motors. However, these values shall be modified to meet the results of the coordination study.

Example:	Thermomagnetic breaker	Validation:	Thermomagnetic breaker, Magnetic breaker or Fuse

Frame / Fuse holder: The value of the rated current of the device in Amperes.

Example:	250.0	Validation:	0.0 < Value < 10000.0

Setting / Fuse: The setting value of the protection device in Amperes or fuse capacity in ampers**.** This value will be used to select the size of the equipment grounding conductor according to requirements of section 250.122 as follows:.

"250.122 Size of Equipment Grounding Conductors.
(A) General. Copper, aluminum, or copper-clad aluminum equipment grounding conductors of the wire type shall not be smaller than shown in Table 250.122, but in no case shall they be required to be larger than the circuit conductors supplying the equipment. Where a cable tray, a raceway, or a cable armor or sheath is used as the equipment grounding conductor, as provided in 250.118 and 250.134(A), it shall comply with 250.4(A)(5) or (B)(4). Equipment grounding conductors shall be permitted to be sectioned within a multiconductor cable, provided the combined circular mil area complies with Table 250.122.
(B) Increased in Size. Where ungrounded conductors are increased in size from the minimum size that has sufficient ampacity for the intended installation, wire-type equipment grounding conductors, where installed, shall be increased in size proportionately, according to the circular mil area of the ungrounded conductors.
(C) Multiple Circuits. Where a single equipment grounding conductor is run with multiple circuits in the same raceway, cable, or cable tray, it shall be sized for the largest overcurrent device protecting conductors in the raceway, cable, or cable tray. Equipment grounding conductors installed in cable trays shall meet the minimum requirements of 392.10(B)(1)(c).
(D) Motor Circuits. Equipment grounding conductors for motor circuits shall be sized in accordance with (D)(1) or (D)(2).
(1) General. The equipment grounding conductor size shall not be smaller than determined by 250.122(A) based on the rating of the branch-circuit short-circuit and ground-fault protective device.
(2) Instantaneous-Trip Circuit Breaker and Motor Short-Circuit Protector. Where the overcurrent device is an instantaneous trip circuit breaker or a motor short-circuit protector, the equipment grounding conductor shall be sized not smaller than that given by 250.122(A) using the maximum permitted rating of a dual element time-delay fuse selected for branch circuit short-circuit and ground-fault protection in accordance with 430.52(C)(1), Exception No. 1.

Table 250.122 Minimum Size Equipment Grounding Conductors for Grounding Raceway and Equipment"

Rating or Setting of Automatic Overcurrent Device in Circuit Ahead of Equipment, Conduit, etc., Not Exceeding (Amperes)	Size (AWG or kcmil)	
	Copper	Aluminum or Copper-Clad Aluminum*
15	14	12
20	12	10
60	10	8
100	8	6
200	6	4
300	4	2
400	3	1
500	2	1/0
600	1	2/0
800	1/0	3/0
1000	2/0	4/0
1200	3/0	250
1600	4/0	350
2000	250	400
2500	350	600
3000	400	600
4000	500	750
5000	700	1200
6000	800	1200

Extracted from National Electrical Code® NFPA 70®, Edition 2017, by National Fire Protection Association, pp. 70-49 and pp-70-123, 70-124 and 70-125

Example:	250.0	Validation:	0.0 < Value < 10000.0

Final information: During the project stages the information used pass through two different status:

- **Preliminary Status**. When the information is obtained from equipment catalogs or standard information not confirmed by the supplier. During this stage of information conductors and associated equipment should be selected according to the most critical conditions that may arise or taking into account information from recognized institutions.

- Final status. When the equipment has been acquired, you can be sure that the information of the equipment is a reliable data for the selection of equipment and circuits.

Because of the different project status of the project, this check box defines if the information is final (FINAL = True) or is still preliminary (PROVISIONAL = False).

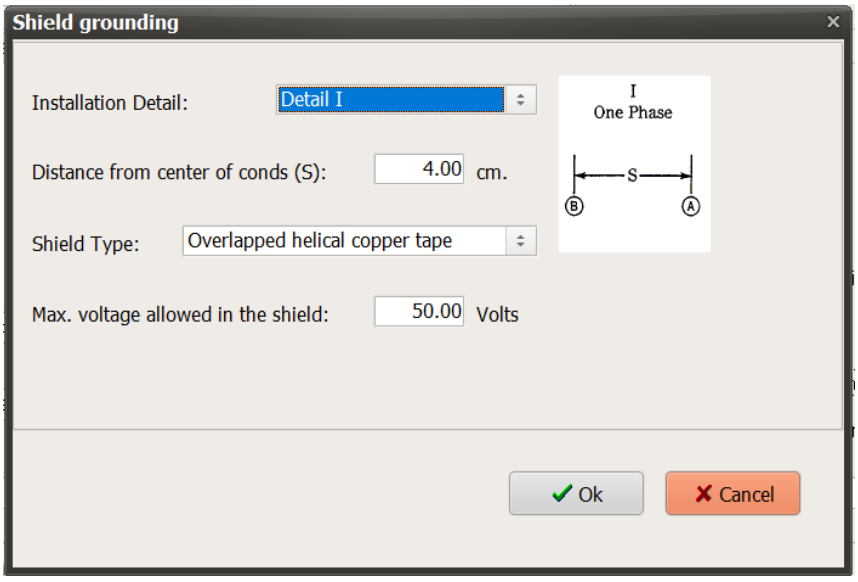
Example:	False	Validation:	Checked / Unchecked

Observations: This field is used to store information that is not necessarily technical but required to control circuit administration.

Example:	Verify circuit length on site	Validation:	Up to 200 characters

Conductor Shield grounding

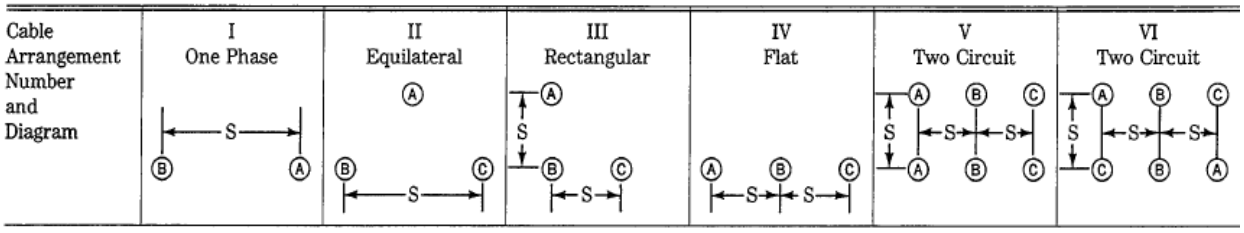
The shields grounded on one end in conductors carrying alternating current generate induced voltage in the ungrounded end. A maximum voltage of 25 V is the commonly accepted limit under normal operating conditions. The *Sizer Electric* software calculates the maximum voltage induced at the end of a conductor grounded at one end only. The calculation is performed using the recommendations of IEEE Std.525, section 6.2.5. To do this, *Sizer Electric* is assisted by the following capture window.



Shield grounding window

Where:

Installation Detail: Allows you to select the installation conditions of the circuit that will be used to select the formula to be applied in calculating the induced voltage. Details are 6 according to Table 1 " Formulas for calculating induced shielding voltages and shield losses for single-conductor cables" from IEEE Std.525. As can be appreciated, the installation details can be:



Example:	Detail I	*Validation:*	Detail I to VI

Distance between conductors: Is the distance measured between centers of conductors of different phases in centimeters.

Example:	*12*	*Validation:*	0 to 200 cm

Shield Type: Describe the type of conductor shield. This value is used only as a description for the report.

Example:	Helicoidal	*Validation:*	Only options in the list

Maximum shield voltage: The maximum permissible value at the ungrounded end of the shield. This value can range from 1 V. to 50 V. maximum.

Example:	50 V.	*Validation:*	0 to 50 V.

According to section 6.2.5 of the IEEE Std. 525 the value of the mutual reactance according to the following formulas are calculated neglecting proximity losses to practical purposes:

$$X_M = 2\pi f\left(0.1404 \log_{10} \frac{S}{r_m} \mu\Omega/\text{ft}\right)$$

$$a = 2\pi f(0.1404 \log_{10} 2)\,\mu\Omega/\text{ft}$$

$$b = 2\pi f(0.1404 \log_{10} 5)\,\mu\Omega/\text{ft}$$

$$R_s = \frac{\rho}{8 r_m t} \mu\Omega/\text{ft}$$

Where:

X_M	is the mutual inductance of shield and conductor (μΩ/ft)
a, b	is the mutual inductance correction factors (μΩ/ft)
μΩ	is the micro-ohm—Ω X 10^{-6}
R_s	is the resistance of shield (μΩ/ft)
t	is the thickness of metal tapes used for shielding (inches)
f	is the frequency (Hertz)
S	is the spacing between center of cables (inches)
r_m	is the mean radius of shield (inches)
ρ	is the apparent resistivity of shield in Ω-cmil/ft at operating temperature (assumed 50° C). This includes allowance for the spiraling of the tapes or wires

According to the conductors installation detail the value of the induced voltage at the ungrounded end of the conductor is calculated using the formulas in Table 1 Formulas for calculating induced shielding voltages and shield losses for single-conductor cables" of IEEE Std. 525.

Induced Shield Voltage-Shields Open Circuited (multiply by 10^{-6} to obtain V/ft)

	I One Phase	II Equilateral	III Rectangular	IV Flat	V Two Circuit	VI Two Circuit
Cable — A Cable — C	IX_M	IX_M	$\frac{I}{2}\sqrt{3Y^2+\left(X_M-\frac{a}{2}\right)^2}$	$\frac{I}{2}\sqrt{3Y^2+\left(X_M-a\right)^2}$	$\frac{I}{2}\sqrt{3Y^2+\left(X_M-\frac{b}{2}\right)^2}$	$\frac{I}{2}\sqrt{3Y^2+\left(X_M-\frac{b}{2}\right)^2}$
Cable — B	IX_M	IX_M	IX_M	IX_M	$I\left(X_M+\frac{a}{2}\right)$	$I\left(X_M+\frac{a}{2}\right)$

Note that the formulas are defined for use imperial dimensions. Therefore, the Sizer Electric applies formulas converting conductor values to English system and finally

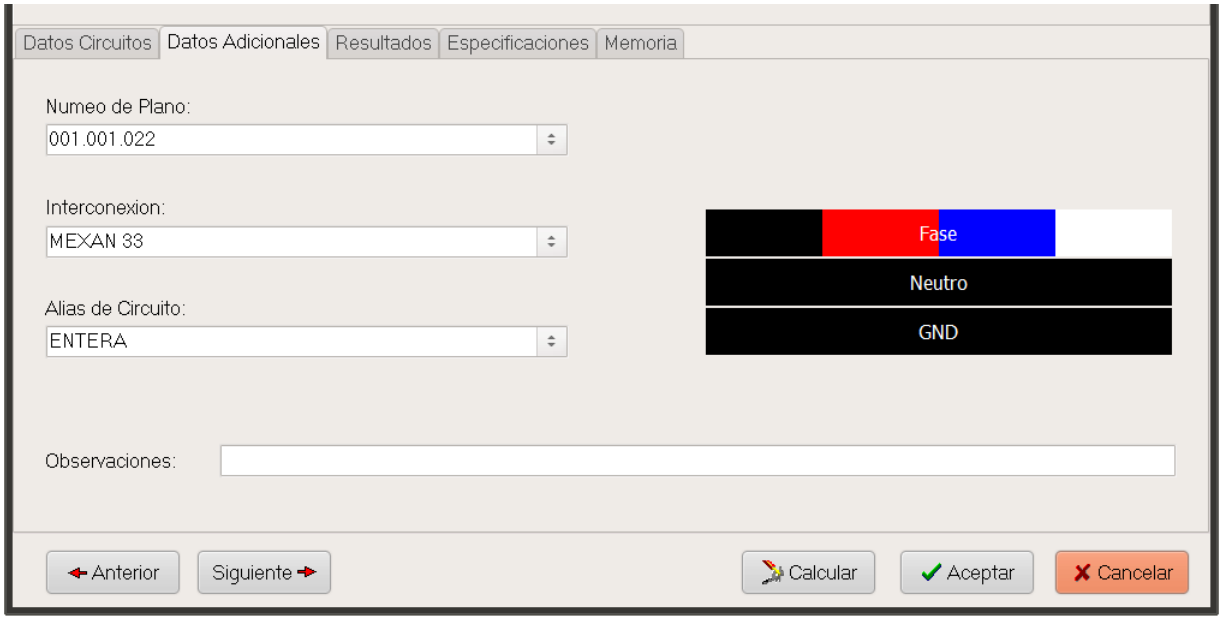
converting the value of the induced voltage to the international system. This information is presented in the report of the induced voltage and to calculate the maximum grounding distance.

The calculated voltage is the value of the voltage induced in the end of the conductor if it is not grounded. However, when it is necessary to know the maximum grounding for the shield to not exceed the value of the maximum allowable voltage the following algorithm is applied:

Grounding distance = (Induced voltage in shield * Circuit Length) / (Maximum voltage allowed)

Additional Data

In the *Additional Data* tab you can find 3 customizable fields for free use as well as the control to assign a specific color for each circuit conductor.



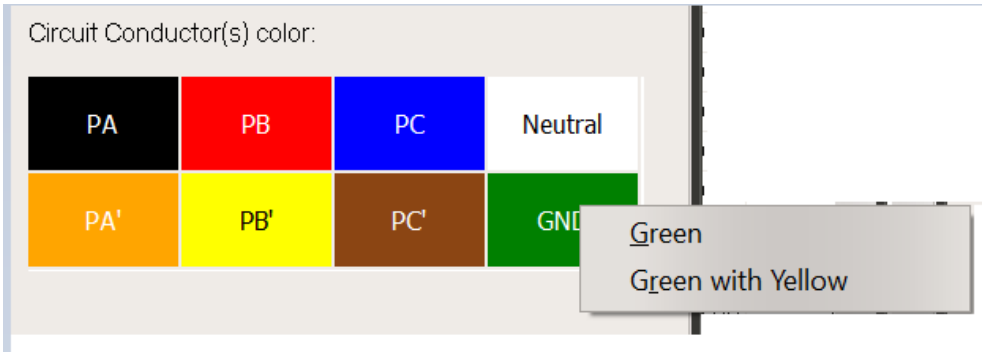
Custom fields If the name of these fields has not been defined in the Standards section, 3 fields with the legends "Additional field" no.1 to 3 will appear. These fields are provided so that the user can capture additional information for a better reference of the circuit or to relate manually or automatically the information of the reports or Excel exported files with other documents of the process. See the process for naming the fields in the *Standards* section. The fields shown are presented as a list. This list is filled with the data previously captured in this field in order to facilitate the capture process. Fill in the fields manually or select an item from the list.

Example:	Drawing 2234-0033-48	Validation:	Text up to 25 characters

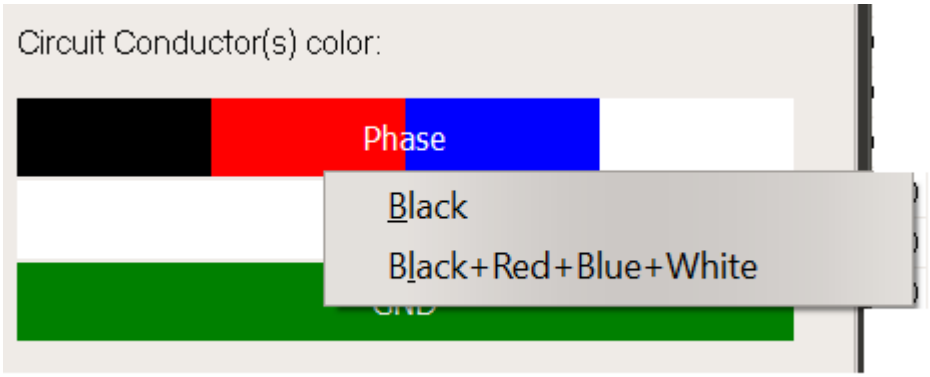
Conductor color: In this option it is possible to define the color of the conductors for each phase, as well as the color for the grounded conductor (Neutral) and for the equipment grounding conductor. The color will be used to integrate the specification

of the multiconductor or each conductor of the circuit and later it will be used to group the conductors with the same specification, including the color to generate a bill of materials for the project (See *Conductor Summary* section).

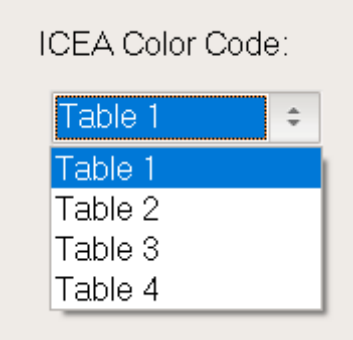
In the case of single conductors, a control with 8 boxes will be shown: 6 to define the colors of the phase conductors (The phases identified with an apostrophe (') is used for split phase connections in delta or Wye systems with central derivations), One to define the color of the Neutral and one more to define the color of the equipment grounding conductor. To modify the conductor color, select the corresponding box and click with the left button to display the menu with the color options. The colors initially shown will be those assigned in *General Data* for the type of load. When the colors of the circuit are modified, these will be used for the integration of the circuit specification.



In the case of multiconductor only the color options for the phases, neutral and grounding will be presented. Multiconductor colors can only be black or in the combination: Black, Red, Blue for the phases and neutral in white. This restriction is due to the conductor manufacturing process.



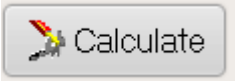
For control circuits, a list of references to the color tables defined in the ICEA standard S-58-679-1998 is presented. These tables define the color for control circuit conductors. These tables are used because the color combination is very broad. The tables of this standard can be found in more detail in the program help files.



Example:	Color selection	*Validation*:	Item from the list

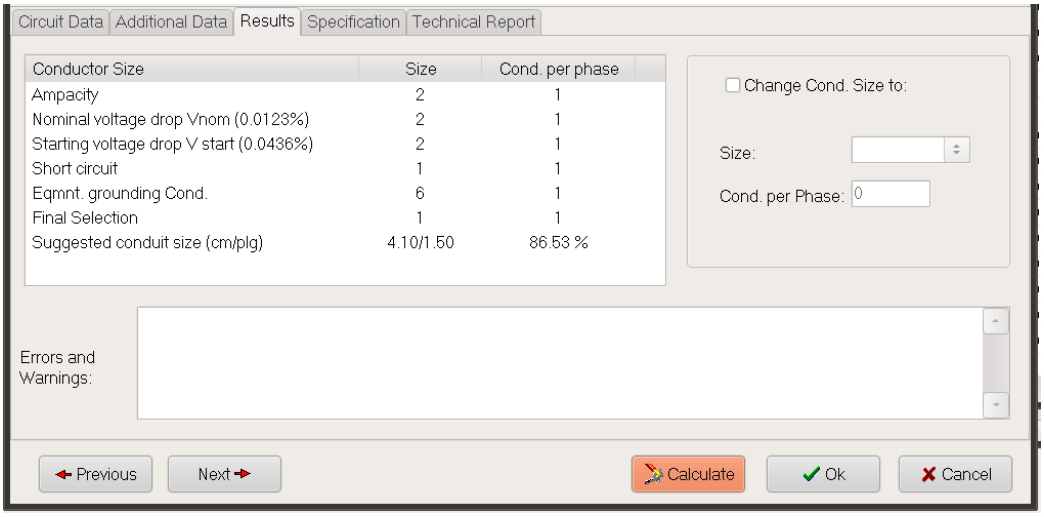
Calculate circuit and conductor selection

Within the Circuit data capture window you can locate a button labeled *Calculate* to perform the conductor size selection process and show the results in the summary tabs on this window..



This button is responsible for a full assessment of the information contained within the fields and is responsible for starting the conductor selection process.

If all the information is valid, then Results tab is automatically selected and the conductor selected under the different conditions is shown. So you can appreciate conductor size finally selected.



In the results tab is a window where you can see the warnings and errors found during the process of calculation for some inconsistent data or warnings may occur

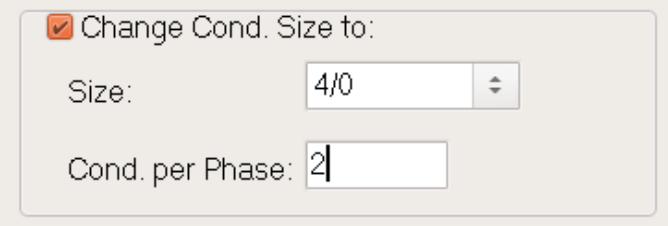
for some criteria that have been considered by the program according to the required standard resulting in an conductor over sizing.

A list containing the conductor size and number of conductors per phase that meet the requirements of ampacity, nominal voltage drop, voltage drop during motor starting conditions and short circuit conductor size is shown in this tab. If you calculate the conductor size under short circuit conditions this conductor size will also appear.

End User Conductor Size Selection

Sometimes due to the availability of materials, it is necessary to install a different conductor size from the selected by Sizer Electric, and may have an array of different conductors per phase.

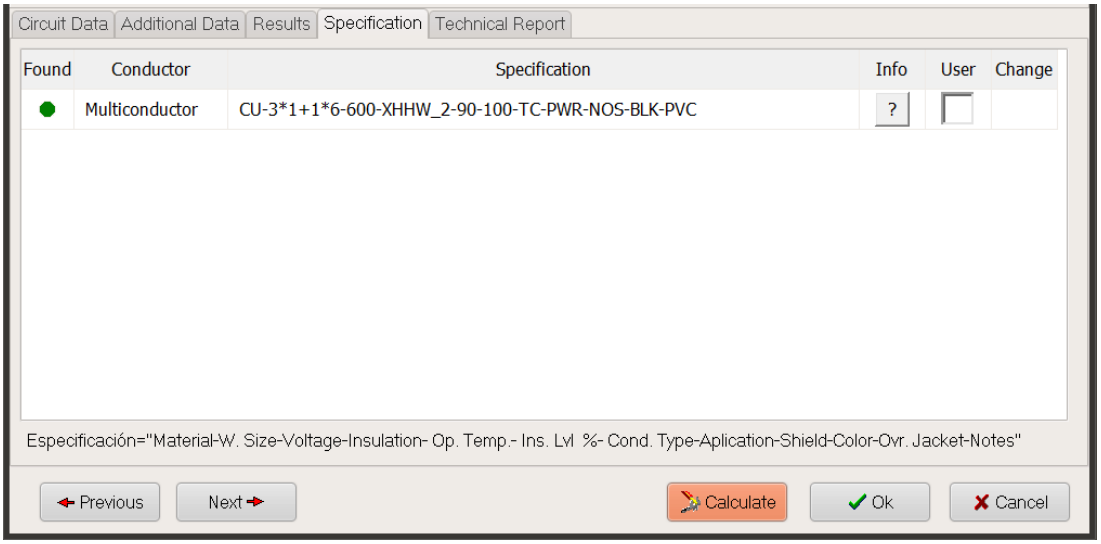
For these conditions, the program has the option to indicate a different conductor size and a different number of conductors per phase. In the following section of the Results tab you can change them. *Sizer Electric* will perform a verification of compliance with such arrangement and conductor size.



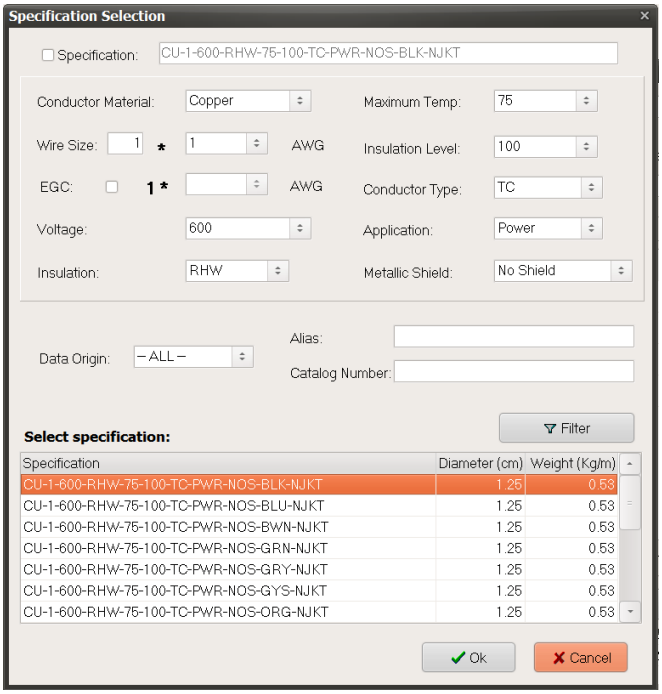
It is important to note that the program validates that the selection made by the user meets the ampacity, voltage drop and thermal stresses criteria. Otherwise the program will inform the deviations using an error message and the circuit is not processed saving the circuit data as a circuit with errors.

End User Specification Selection

When selecting the conductor size, *Sizer Electric* generates an automatic specification of the circuit according to the type of conductor, size and system voltage. These specifications can be located in the "Specification" tab. An ***Specification*** is an element that associates overall diameter, weight and full conductor description. All possible combinations of specification generated by the program are predefined in the project.



To change the specification of a circuit conductor, the check box must be selected and a button will appear in the *Change* column. Pressing this button displays a window where you can select from the specification catalog the one preferred by the user.



The information associated to the specification such as weight, diameter and description will be used for cable trays and conduit sizing for tray type cable. (See chapter 7 for more details in specifications creation and end user selection)

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Chapter

6

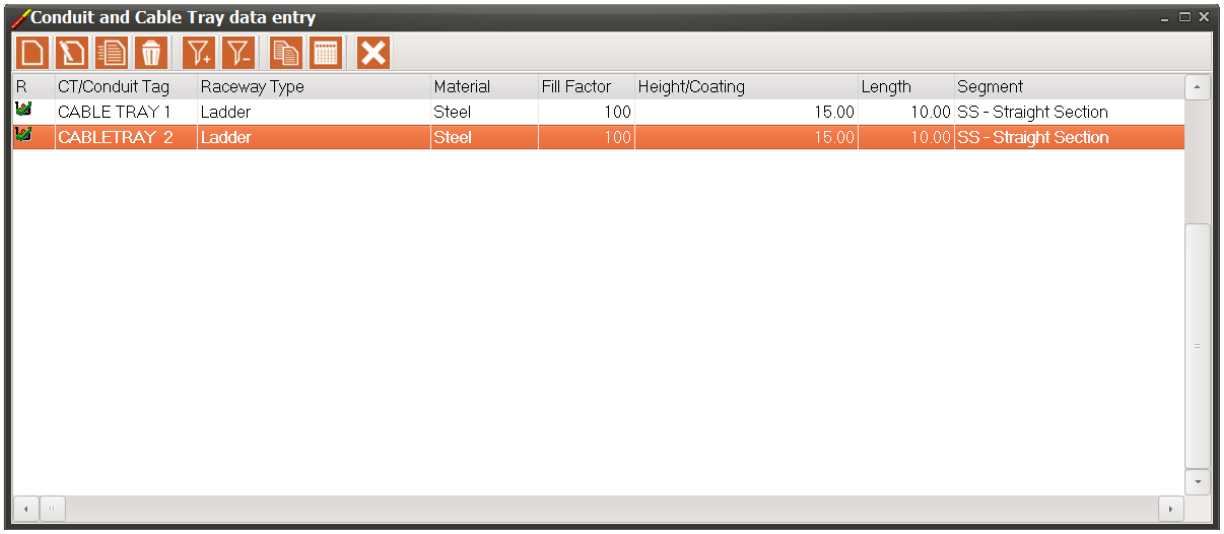
Cable trays capture and circuit allocation

Location: *Queries* | *Cable Trays* | *Capture*

To start the capture process for cable trays, conduits and ducts is necessary to have previously captured the calculation criteria within the *General Data* option. If these requirements have not been covered, the *Capture* option in the *Main Menu* and the *icon* for capture of the toolbar will be disabled.

By selecting the *Capture* option a grid for cable trays and ducts will be presented once the trays and conduit information is captured the grid will display the information later. Each line represents information of a cable tray/Conduit section (or view) and each action taken shall apply only to selected cable tray or conduit in the grid.

Note that in the tray/Conduit data grid you cannot directly enter or edit information, because to perform these actions, you need to open a cable try/Conduit data entry window.



Just as in the circuit grid the grid for trays/conduit contains its own menu and toolbar, which are explained below:

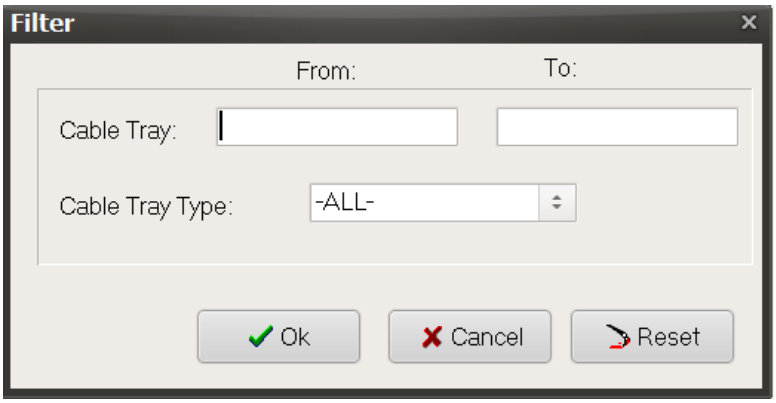
Add: When this option is selected, the data capture window for trays and conduits is displayed. In it you can register all cable trays sections or views and required in your project, without a limit on the number of trays or conduits.

Modify: For trays and conduits data previously captured, you can modify them using this option.

Copy tray / conduit: With this option you can take data from a tray or conduit as reference to create a new one. This option is useful when there are trays or conduits with similar information

Delete: This option is used to delete a cable tray section or conduit. By using this process the pipeline is removed from the system and is not possible to recover it.

Filter: Often you only need to observe some information that meets specific criteria during the capture or during analysis of the results, such as observing the cable trays only or conduits only. Each time you select this option the following dialog box appears:



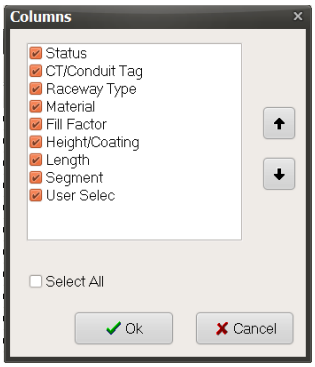
To re-define the fields filter press the *Initialize* button.

Note: Whenever a filter is executed, the universe taken as the group of trays and conduits contained within the previous filter

Restore: This option restores the view on the grid for all the trays and conduits captured, after performing the filtering action

Copy to Clipboard: When selected, data from the trays and conduits are copied to the clipboard so that the user can then paste the information to any spreadsheet or word processor. It is important to clarify that when the filter is active only visible circuits on the grid are copied to the clipboard.

Customizing columns: When this option is selected a dialogue with all the columns contained in the grid is displayed, in which you can change the order or hide them. If you want to observe all the columns in the grid, select the check box *Select all*.



Exit: Closes the data grid of cable trays and conduits.

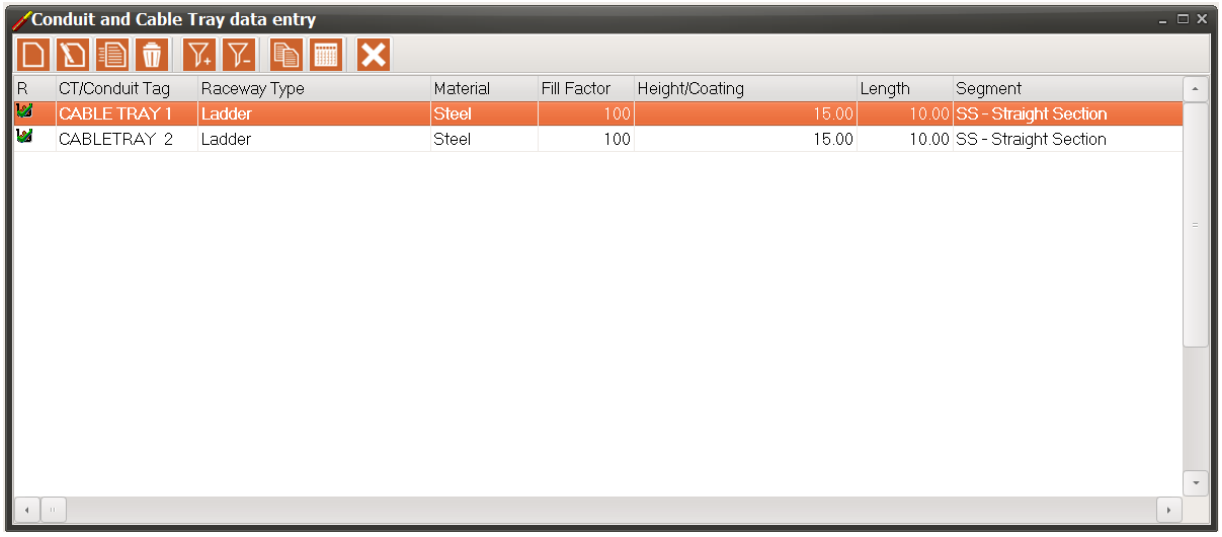
The selection process for Cable trays and conduits is integrated by two parts listed below:

1. Conduits and Cable Tray capture
2. Circuit allocation into a tray or conduit previously captured

Is necessary to follow the previous two steps in the sequence indicated.

Cable Trays and Conduits Capture

The first part of the process is to capture the particular characteristics of the cable tray or conduit through the cable trays and conduit grid. To do this, select the "*Queries"* option in the main menu and then select the "Trays and Conduits" of the displayed menu or select the icon  of the toolbar. Following the grid appears as shown in the figure below.

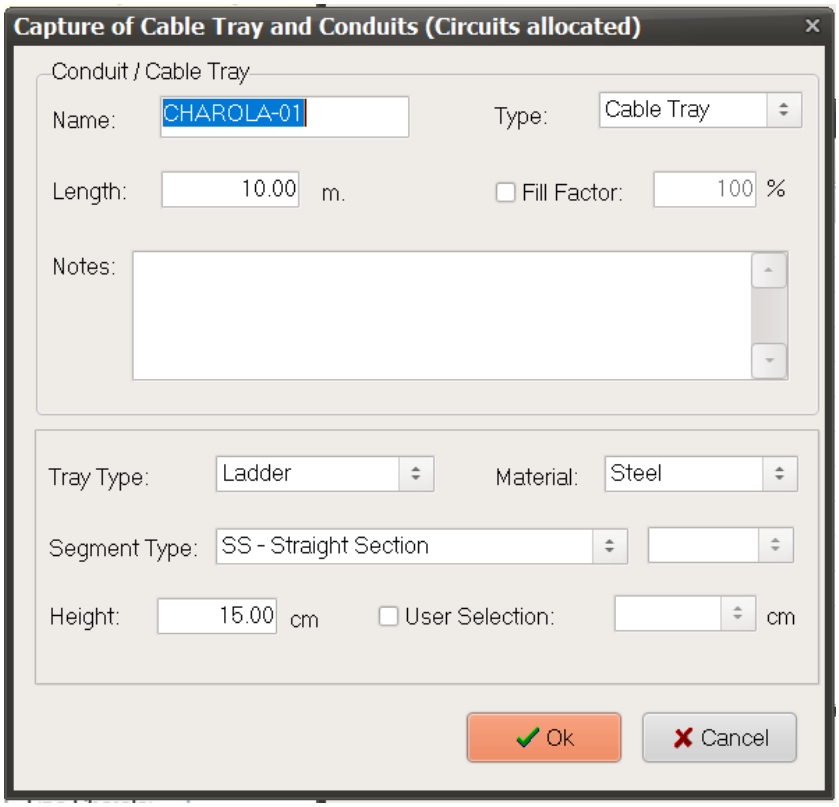


To add a new tray or pipeline must select the "New" icon in the toolbar  .

To edit later the information you must select the corresponding row and once highlighted you must double-click it. It is also possible to access tray or conduit information by selecting the corresponding line and pressing the *"Edit"* icon located in the *Tools menu* at the top of this grid. 

With these steps the capture trays and conduit window appears. The fields to fill allow to know the most relevant information of a cable tray section or conduit. In order to select the width of a cable tray or the diameter of a conduit must capture the identification within this window

There are two variations on the information presented in the window and depend on the option that is selected in the *"Conduit/Tray"* field. When the "*Cable tray"* option is selected, the window presented is as follows:



The information required in the fields is described below:

Name: Defines the segment identification or cable tray view or cross section. It represents the cable tray to be analyzed and its definition must be unique and unrepeatable in the project. This definition may represent a sector of a cable tray network or specifically a view of the cable tray. The definition of what is represented (a cross section or a segment) is defined by the length field.

Example:	O1-CHAR-01	*Validation*:	Not applicable

Cable Tray Type: You must define the type of cable support to be selected because there are different considerations in the NEC 2017about the number of conductors permitted in ladder type cable trays, Solid bottom, ventilated trough, etc. The mesh type cable trays have the same restrictions as the ladder type cable trays.

Example:	Ladder	*Validation*:	Ladder, Ventilated trough, Solid bottom, ventilated channel, Mesh

Length: Defines the length in meters of the segment to be analyzed. This length may represent the length of a section or length of a set of sections of cable tray. This length is totalized for all segments where it is assigned a circuit and is used to compare if the total length of the segments is equal to or less than the length used to calculate the conductor size.

Example:	10	*Validation*:	>0 and less than 10000 m

Notes: It is an alphanumeric field that allows you to add information to complement the description of the cable tray section.

Example:	Straight section of 100 meters	*Validation*:	Up to 15 characters

Material: You must define the material type of the tray. Although there are no criteria for selecting the number of conductors allowed in cable trays that are affected by the material, this definition is required to have further information to classify the cable trays.

Example:	Steel	*Validation*:	Steel, Aluminum, FRP

Segment Type: This field defines the type of segment being represented. That is, if it is a straight cable tray section, an interior curve, an exterior curve, a derivation, etc. This field has an associated field adjacent to it, which is activated if complementary segment information is needed. For example, in the case of horizontal Tees is necessary to define the curvature radius. This information is not relevant for defining the width of the tray but provides additional information for cable trays and conduits reports that helps the realization of BOMs.

Example:	SS-Straight S	*Validation*:	Segments in the list

Height. The height of the tray represents the dimension of the of the lateral, vertical walls of the tray. The definition of the height of the tray is a mechanical and not an electrical consideration. The definition of cable tray height should be defined according to the weight of the conductors to be installed in the tray as well as the distance between the mechanical supports of the cable tray sections. Refer to cable tray manufacturer catalog for more information about the definition of cable tray height. The cable tray height is used only for determining the useful filling area when installed exclusively control conductors on the tray. For power conductors the cable tray height is not used to select the cable tray width.

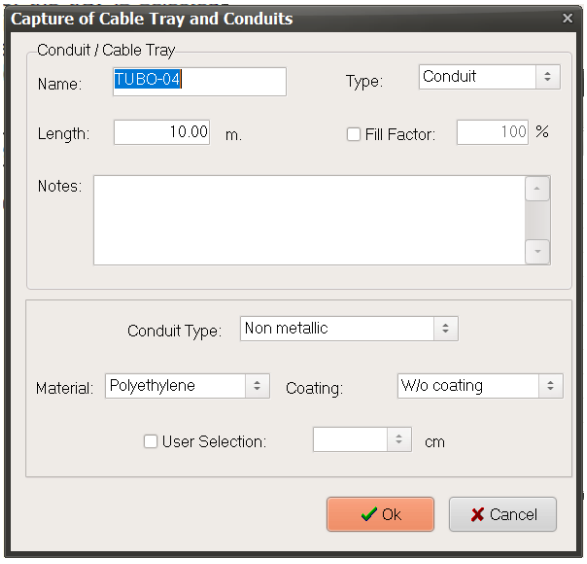
NOTE: As part of the program results, the weight per linear meter conductors allocated in the tray is provided. It is recommended that once the allocation of conductors in the cable tray has been made it is checked if the cable tray height defined and the spacing between supports is suitable for the weight of the conductors.

Example:	10 cm	*Validation*:	8 to 45 cm

User selection: This option allows the user to predetermine the width of the cable tray. The program has two calculation options. When this option is disabled the proper width of the tray according to the assigned circuits is selected. If this check box is activated and the width of the tray is selected in the combo box aside, *Sizer Electric* will only calculate the fill percentage with the number of conductors assigned. This option provides the flexibility to perform the verification of cable trays filling for systems with predefined cable tray widths.

Example:	45	*Validation*:	15, 30, 45, 60, 75 and 90 cm

When the "Conduit" is selected in the "Conduit/Tray" field, the window displayed is as follows:



Name: Defines the identification of the segment or conduit cross section. It represents the conduit to be analyzed. Its definition must be unique and unrepeatable. This definition may represent a sector of a conduit network or specifically a conduit cross section. The definition of what is represented in the system (Segment or a cross section) is defined by the *Length* field.

Example:	O1-TUB-01	*Validation*:	Not applicable

Length: Defines the length of the segment to be analyzed. This length may represent the length of a section or length of a set of conduit sections. This length is totalized for all segments where a circuit is assigned and is used to compare if the total length of the segments is equal to or less than the length used for calculating the size of the conductor.

Example:	10	*Validation*:	>0 and less than 10000 m

Notes: This is an alphanumeric field that allows you to add information to complement the description of the conduit.

Example:	Conduit in production area	*Validation*:	Up to 15 characters

Material: You must define the type of conduit material. Although there are no criteria for selecting the number of conductors in conduit to be affected by the material, this data is required to have information for classifying and totalizing the conduit type.

Example:	Aluminum	*Validation*:	Aluminum, Steel, Galvanized Fe, PVC

Coating: You must define the coating of the tube. Although there are no criteria for selecting the number of conductors in conduit to be affected by the coating, this information is required to have information for classifying and totalizing the type of conduit.

Example:	Epoxic	*Validation*:	Options in the list

User selection: This option allows the user to predetermine the conduit diameter. The program has two calculation options: When this option is disabled, the appropriate diameter is selected according to the circuits assigned. If this check box is activated and the tube diameter is selected in the combo box aside, only the percentage of filling is calculated with the number of conductors assigned in the conduit. This option provides the flexibility to perform the verification of filling for predefined conduit diameters as in the case of underground duct conduits.

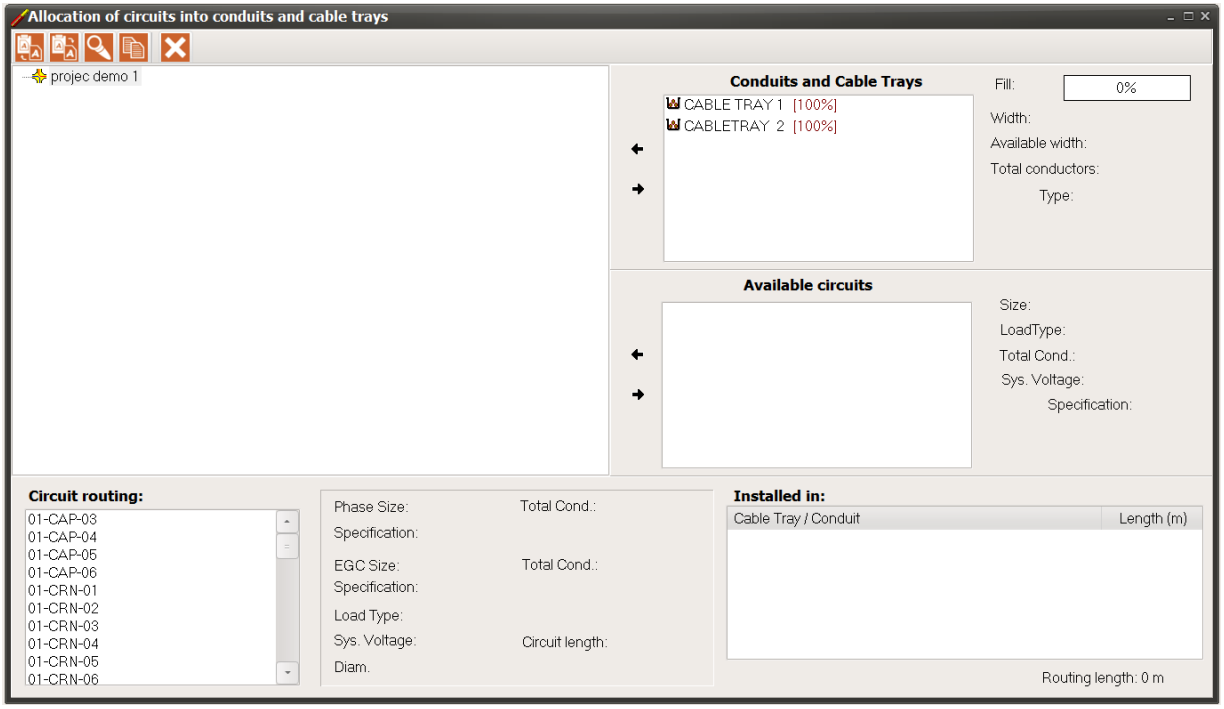
Example:	3.5 cm	*Validation*:	Only diameters in the list-.

After the capture or record of the tray sections is completed is possible to allocate circuits in the conduit or cable tray to determine the proper width or filling percentage.

Circuit allocation in Conduits and Cable trays

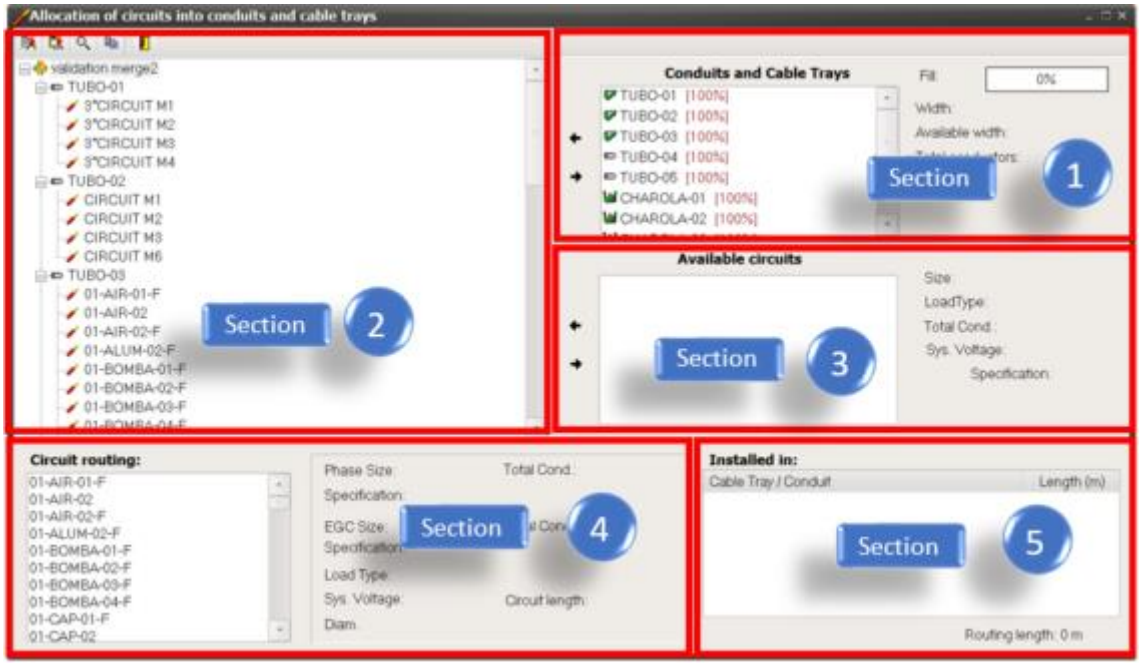
Once you have completed the cable tray / conduit cross section capture as indicated in the previous section you can assign or allocate circuits on these to select the diameter of conduits or widths of cable trays or calculate the fill percentages.

To access the allocation window in the *Main Menu* select the option *"Queries".* From the submenu displayed select *"Trays and conduits"* and select the *"Allocation"* option. You can also display window selecting the icon *Allocation* in the *toolbar*. The icon for circuit allocation is:  Pressing this icon or by following the steps from the main menu the following *Circuit Allocation Window* appears.



Circuit Allocation Window for cable trays and conduits.

In this window the circuit allocation is performed but it also displays information about the cable trays and conduit filling, you can view information on the conductor specifications and provides information about the routing of circuits. In order to identify all the information handled in this window it is divided into 5 sections which are shown in the following figure:



Sections of the circuit allocation window

Section 1 ***Cable trays / Conduits:*** Lists the conduits and cable trays available that were previously captured in conduit and cable trays capture window. In this section also appears information about filling percentage and available width / available area, number of total conductors assigned and conduit or cable tray type

Section 2 ***Allocation:*** This section will show the information of the cable trays to be analyzed and the number of circuits assigned to them. The organization scheme of this section is similar to the files and folders distribution of Windows Explorer ®. This section has a hierarchy taking as the root the name of the project, as a folder the cable tray or conduits and as files the circuit allocated in each cable tray or conduit.

Section 3 ***Circuits Available*** shows the names or identification of all circuits captured in the Conductor Size Selection module of *Electric Sizer*. This section also contains the specification information of the circuit.

Section 4 ***Circuit identification and routing*** shows the circuit information to perform a route trace of circuit. That is, once the circuit is assigned to one or more trays through the list of circuits located in this section, it is possible to identify trays or raceways where the circuit is installed. This section provides general information about the load supplied by the circuit, voltage, circuit length and specification associated with the circuit. This section operates in conjunction with section 5.

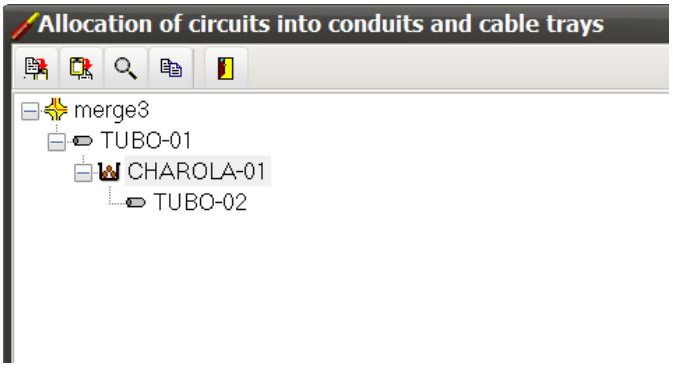
Section 5 ***Routing*** shows all trays or conduits where the circuit is allocated in the list of section 4. Displays information about the length of each cable tray/conduit section and totals the length of the entire path obtained by the sum of the lengths of all cable trays or conduits sections.

Cable trays /conduits allocation for analysis

In the *"Tray/conduit"* list shown in section 1 select the element you want to analyze by double-clicking through the mouse on the selected conduit or by pressing the left arrow button located on the left side of the list. The conduit/tray identification will be located and connected to the project root name in window section 2. When the conduit/tray is integrated in the project, on the list this will be marked by a sign of acceptance in the list on section 1 as shown in the following figure:

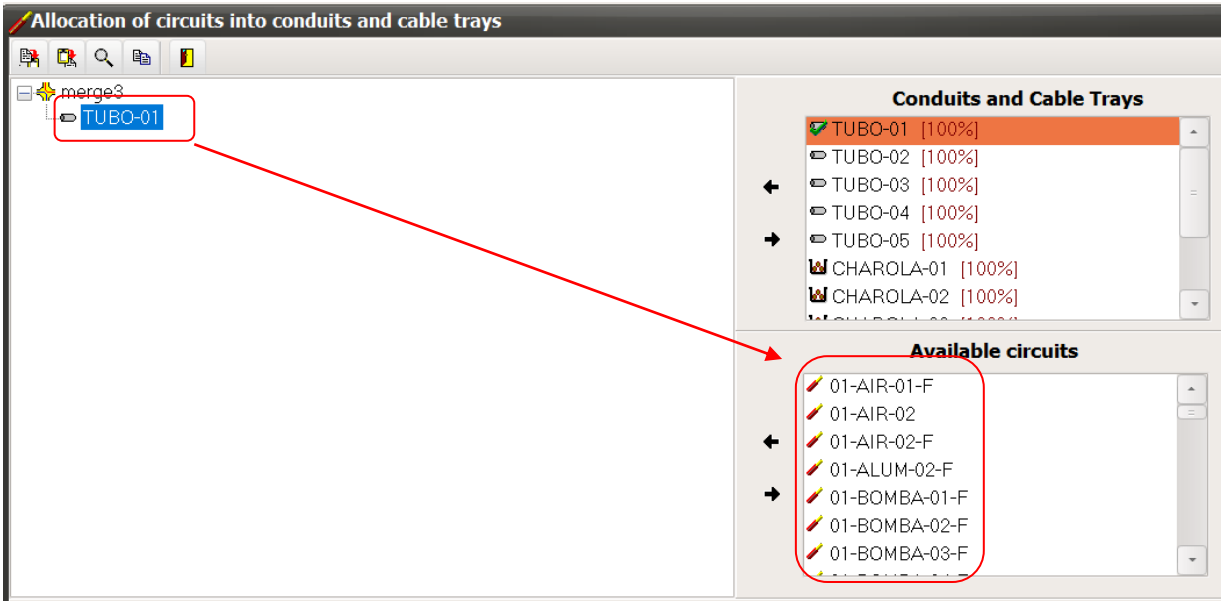
Conduit allocated in Project for analysis

To create a network of interconnected conduits or cable trays select the element on section 1 and repeat the allocation process described above. You can create a hierarchy of conduits and trays in electrical installations representing mechanical interconnection as shown in the following figure:



Hierarchy or interconnected cable trays and conduits

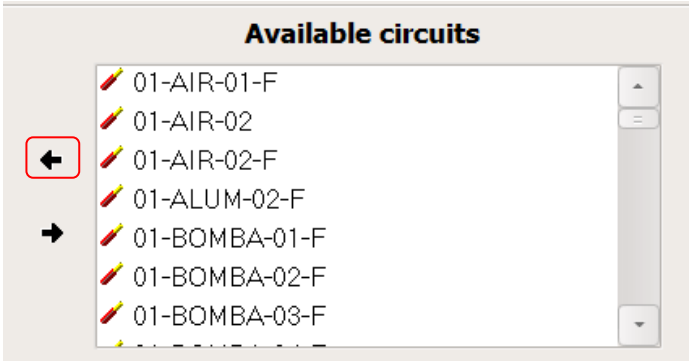
By selecting the identification of the cable tray/Conduit within allocation Section 2, the list of conductors *"Available Circuits"* in section 3 displays the list of circuits that can be assigned to the selected cable tray or Conduit. As shown in the figure below:



List of circuits shown in the "Available Circuits" section when the cable tray/Conduit is selected in section 2 "Allocation"

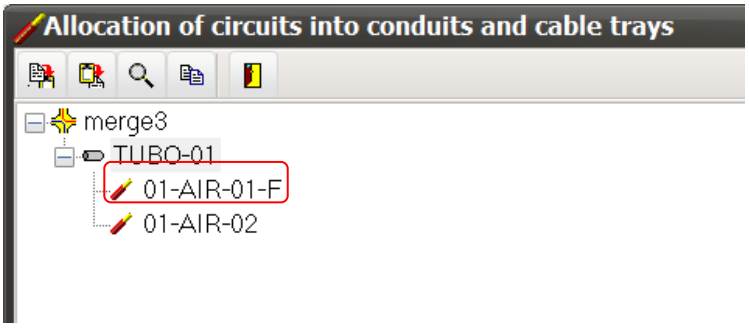
Circuit allocation in cable trays or conduits

To allocate a circuit into a cable tray or conduit you should select the circuit in the list section of available circuits with the mouse as shown in the following figure and double-click using the mouse or select the arrow icon located at the left side of the list 



Circuit available to be assigned to cable tray or conduit

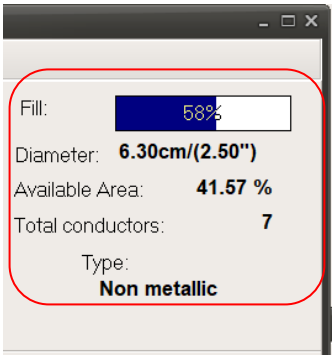
When you double click on the circuit or press the left arrow button  the circuit disappears from the *"Available Circuits"* list in section 3 and is associated with the cable tray or conduit in section 2 "*Allocation*" as shown below:



Circuit allocated in conduit

IMPORTANT: The circuit is allocated into the cable tray or conduit that is selected (highlighted) in section 2 "Assignment". So you should make sure that before assigning the circuit proper cable tray or conduit is selected.

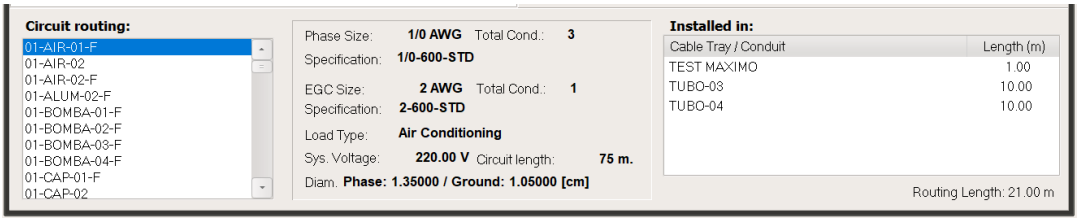
At the time you allocate a circuit into a cable tray or conduit in section 1 *"Conduit/Tray"* the percentage of cable tray/conduit filling, selected width or diameter available and the number of total conductors assigned to the cable tray or conduit will appear as shown below:



Cable tray or conduit filling Information

For information about the criteria used for selection or filling the tray or channeling see "Selecting and filling cable trays and conduits" in this chapter.

Also in section 4 of "Circuit Routing" you can see that by selecting the circuit assigned to the cable tray the specification information is displayed and the list on the right side the cable tray/conduit where the circuit was allocated is added. As the circuit may be assigned to different trays or conduits the list is updated with the identifications of the trays or conduits. This makes it possible to perform a circuit routing.



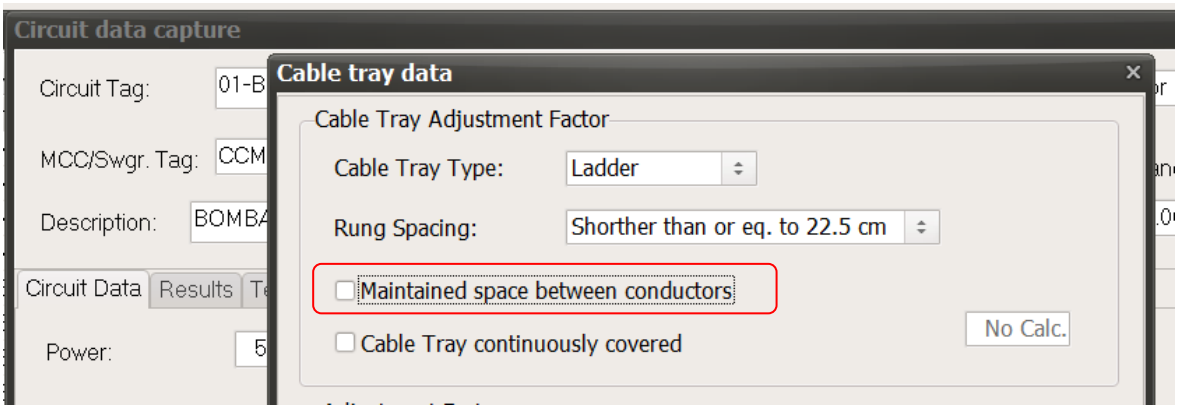
Circuit Routing through conduits or cable trays.

In the lower right section of the list titled *"Installed on:"* the sum of conduits/cable trays lengths where the conductor is installed is shown. When the sum of the segment lengths exceeds the length that was used to select the conductor size, this label will appear in red color indicating that it is necessary to verify the circuit length used in the selection of the conductor size.

Selection and filling of cable trays and conduits

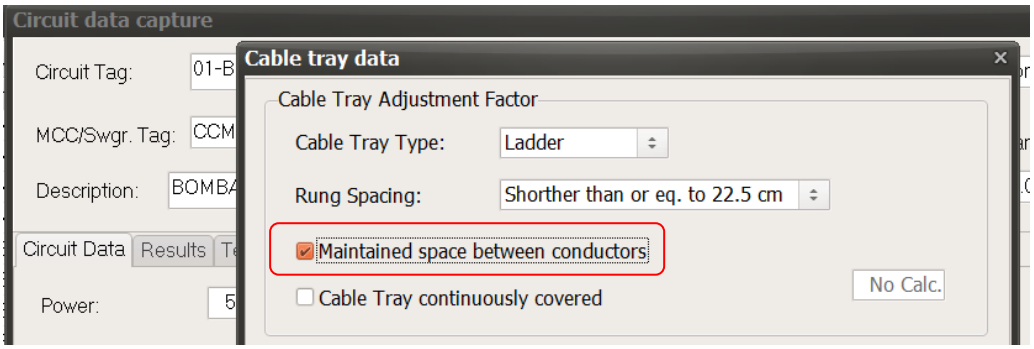
Guidelines of standard NFPA-70 or National Electrical Code sections 392.22 (A), (B) and (C) are used in the selection of cable tray width. In the case of the selection under the Official Mexican Standard NOM-001-SEDE-2012, section 392-22 (a) (b) and (c) are followed. The guidelines for the selection of conduit diameters or calculation of conduit fill are defined in chapter 9 tables 1 and 4 of the standard NFPA-70 or National Electrical Code or chapter 10 when the official Mexican standard NOM-001-SEDE-2012 is used.

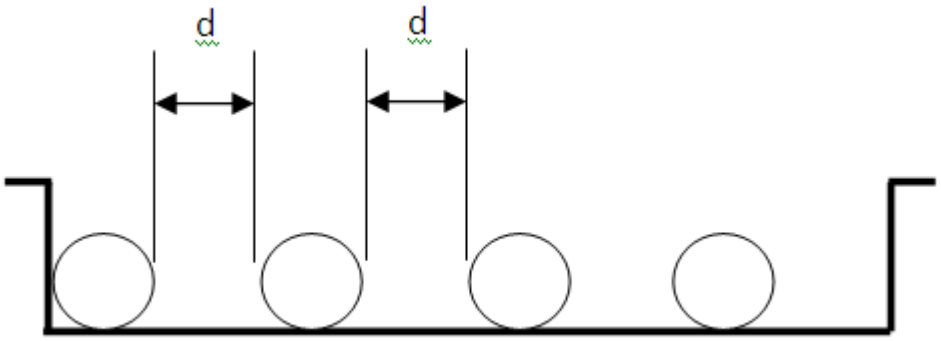
The selection of cable trays width is performed for the combinations of circuits installed on the tray. **It is necessary to clarify that the sizing process takes into account the information used to calculate the conductor in the conductor size selection module.** For example if it is required that the cable tray is selected considering no space between conductors, the circuits assigned to the cable tray should be calculated as a circuit "***Without*** *maintained space between conductors*" in the installation window of the *Conductor size selection module* as shown in the following figure:



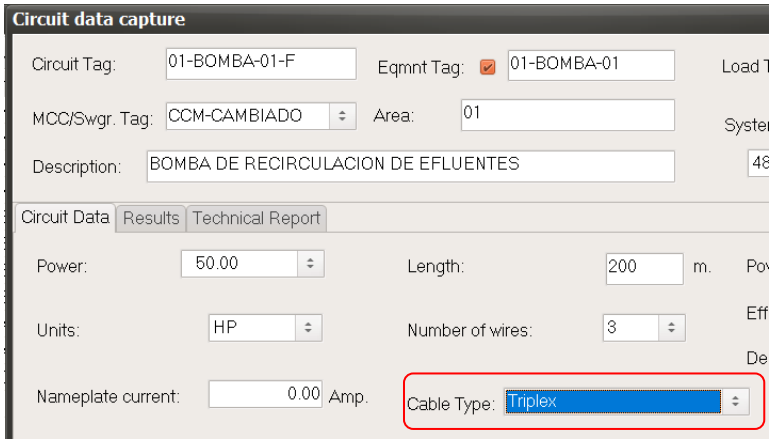
With this condition the cable tray width is sized considering the following layout:

On the other hand if the cable tray width is required to be selected considering a maintained space of not less than one cable diameter between individual conductors, circuits assigned to the tray should be calculated as circuits "***With*** *maintained space between conductors*" on the installation window of the *Conductor size selection module.*



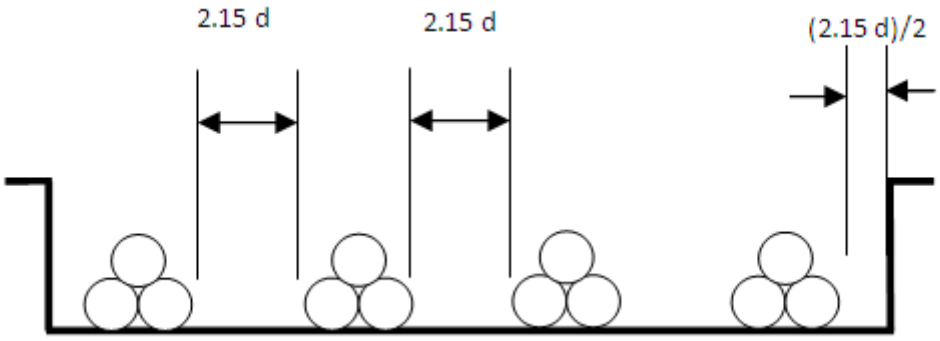


Where single conductors are installed in triangular or square configuration (Triplex, quadruplex, etc.) in addition to considering the maintained space between conductors you must select the Triangular or Triplex single conductor type in the circuit capture window, as shown in the following figure:

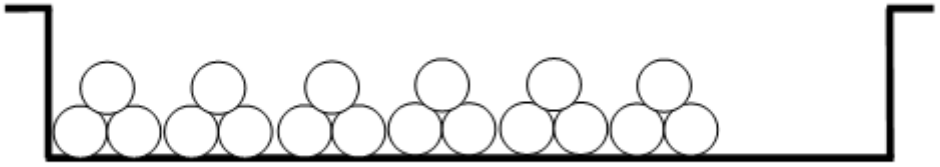


Circuit capture window. (Field cable type)

Triangular and Triplex layouts with maintained free airspace (implies a minimum separation of not less than 2.15 times one conductor diameter of the largest conductor according to 392.80(2)(d) NEC-2017:



Triangular and Triplex layouts without maintained free airspace (Not defined in the NEC-2017) are considered as a single lay installation with the sum of upper conductors diameters as free space:



This is handled to **prevent inconsistencies between the criteria used to select the conductor size per ampacity criteria and actual installation conditions** (associated with the cable tray width selection). If the conductors were selected considering a maintained spacing between them (involving ampacity adjustment more benevolent) then *Sizer Electric* ensures that the diameter of the conductors an the free air spacing is considered when selecting the cable tray width (For example: Sum conductor Diameter + a diameter of spacing between them).

If the circuit was calculated without considering the maintained spacing (Conductor ampacity Adjustment Factors more rigid) only the sum of diameters is considered for selecting the cable tray width. The same applies in the case of circuits in triangular configuration but in this case it is considered that the separation distance between conductors is 2.15 times the largest conductor diameter.

The requirements included in the NOM-001-SEDE-2012 and NEC-2017 regarding the cable tray selection and filling used by *Sizer Electric* are as follows:

> **"392.22 Number of Conductors or Cables.**
> **(A) Number of Multiconductor Cables, Rated 2000 Volts or Less, in Cable Trays.** The number of multiconductor cables, rated 2000 volts or less, permitted in a single cable tray shall not exceed the requirements of this section. The conductor sizes shall apply to both aluminum and copper conductors. Where dividers are used, fill calculations shall apply to each divided section of the cable tray.
> **(1) Ladder or Ventilated Trough Cable Trays Containing Any Mixture of Cables.** Where ladder or ventilated trough cable trays contain multiconductor power or lighting cables, or any mixture of multiconductor power, lighting, control, and signal cables, the maximum number of cables shall conform to the following:
> (a) Where all of the cables are 4/0 AWG or larger, the sum of the diameters of all cables shall not exceed the cable tray width, and the cables shall be installed in a single layer.

Where the cable ampacity is determined according to 392.80(A)(1)(c) , the cable tray width shall not be less than the sum of the diameters of the cables and the sum of the required spacing widths between the cables.

(b) Where all of the cables are smaller than 4/0 AWG, the sum of the cross-sectional areas of all cables shall not exceed the maximum allowable cable fill area in Column 1 of Table 392.22(A) for the appropriate cable tray width.

(c) Where 4/0 AWG or larger cables are installed in the same cable tray with cables smaller than 4/0 AWG, the sum of the cross-sectional areas of all cables smaller than 4/0 AWG shall not exceed the maximum allowable fill area resulting from the calculation in Column 2 of Table 392.22(A) for the appropriate cable tray width. The 4/0 AWG and larger cables shall be installed in a single layer, and no other cables shall be placed on them.

(2) Ladder or Ventilated Trough Cable Trays Containing Multiconductor Control and/or Signal Cables Only. Where a ladder or ventilated trough cable tray having a usable inside depth of 150 mm (6 in.) or less contains multiconductor control and/or signal cables only, the sum of the cross-sectional areas of all cables at any cross section shall not exceed 50 percent of the interior cross-sectional area of the cable tray. A depth of 150 mm (6 in.) shall be used to calculate the allowable interior cross-sectional area of any cable tray that has a usable inside depth of more than 150 mm (6 in.).

(3) Solid Bottom Cable Trays Containing Any Mixture of Cables. Where solid bottom cable trays contain multiconductor power or lighting cables, or any mixture of multiconductor power, lighting, control, and signal cables, the maximum number of cables shall conform to the following:

(a) Where all of the cables are 4/0 AWG or larger, the sum of the diameters of all cables shall not exceed 90 percent of the cable tray width, and the cables shall be installed in a single layer.

(b) Where all of the cables are smaller than 4/0 AWG, the sum of the cross-sectional areas of all cables shall not exceed the maximum allowable cable fill area in Column 3 of Table 392.22(A) for the appropriate cable tray width.

(c) Where 4/0 AWG or larger cables are installed in the same cable tray with cables smaller than 4/0 AWG, the sum of the cross-sectional areas of all cables smaller than 4/0 AWG shall not exceed the maximum allowable fill area resulting from the computation in Column 4 of Table 392.22(A) for the appropriate cable tray width. The 4/0 AWG and larger cables shall be installed in a single layer, and no other cables shall be placed on them.

(4) Solid Bottom Cable Tray Containing Multiconductor Control and/or Signal Cables Only. Where a solid bottom cable tray having a usable inside depth of 150 mm (6 in.) or less contains multiconductor control and/or signal cables only, the sum of the cross sectional areas of all cables at any cross section shall not exceed 40 percent of the interior cross sectional area of the cable tray. A depth of 150 mm (6 in.) shall be used to calculate the allowable interior cross-sectional area of any cable tray that has a usable inside depth of more than 150 mm (6 in.).

(5) Ventilated Channel Cable Trays Containing Multiconductor Cables of Any Type. Where ventilated channel cable trays contain multiconductor cables of any type, the following shall apply:

(a) Where only one multiconductor cable is installed, the cross-sectional area shall not exceed the value specified in Column 1 of Table 392.22(A)(5).

(b) Where more than one multiconductor cable is installed, the sum of the cross-sectional area of all cables shall not exceed the value specified in Column 2 of Table 392.22(A)(5).

(6) Solid Channel Cable Trays Containing Multiconductor Cables of Any Type. Where solid channel cable trays contain multiconductor cables of any type, the following shall apply:

(a) Where only one multiconductor cable is installed, the cross-sectional area of the cable shall not exceed the value specified in Column 1 of Table 392.22(A)(6).

(b) Where more than one multiconductor cable is installed, the sum of the cross-sectional area of all cable shall not exceed the value specified in Column 2 of Table 392.22(A)(6).

(B) Number of Single-Conductor Cables, Rated 2000 Volts or Less, in Cable Trays. The number of single conductor cables, rated 2000 volts or less, permitted in a single cable tray section shall not exceed the requirements of this section. The single conductors, or conductor assemblies, shall be evenly distributed across the cable tray. The conductor sizes shall apply to both aluminum and copper conductors.

(1) Ladder or Ventilated Trough Cable Trays. Where ladder or ventilated trough cable trays contain single-conductor cables, the maximum number of single conductors shall conform to the following:

(a) Where all of the cables are 1000 kcmil or larger, the sum of the diameters of all single-conductor cables shall not exceed the cable tray width, and the cables shall be installed in a single layer. Conductors that are bound together to comprise each circuit group shall be permitted to be installed in other than a single layer.

(b) Where all of the cables are from 250 kcmil through 900 kcmil, the sum of the cross-sectional areas of all single conductor cables shall not exceed the maximum allowable cable fill area in Column 1 of Table 392.22(B)(1) for the appropriate cable tray width.

(c) Where 1000 kcmil or larger single-conductor cables are installed in the same cable tray with single-conductor cables smaller than 1000 kcmil, the sum of the cross sectional areas of all cables smaller

than 1000 kcmil shall not exceed the maximum allowable fill area resulting from the computation in Column 2 of Table 392.22(B)(1) for the appropriate cable tray width.
(d) Where any of the single conductor cables are 1/0 through 4/0 AWG, the sum of the diameters of all single conductor cables shall not exceed the cable tray width.

Table 392.22(A) Allowable Cable Fill Area for Multiconductor Cables in Ladder, Ventilated Trough, or Solid Bottom Cable Trays for Cables Rated 2000 Volts or Less

Inside Width of Cable Tray		Maximum Allowable Fill Area for Multiconductor Cables							
		Ladder or Ventilated Trough or Wire Mesh Cable Trays, 392.22(A)(1)				Solid Bottom Cable Trays, 392.22(A)(3)			
		Column 1 Applicable for 392.22(A)(1)(b) Only		Column 2[a] Applicable for 392.22(A)(1)(c) Only		Column 3 Applicable for 392.22(A)(3)(b) Only		Column 4[a] Applicable for 392.22(A)(3)(c) Only	
mm	in.	mm^2	$in.^2$	mm^2	$in.^2$	mm^2	$in.^2$	mm^2	$in.^2$
50	2.0	1,500	2.5	1,500 – (30 Sd)[b]	2.5 – (1.2 Sd)[b]	1,200	2.0	1,200 – (25 Sd)[b]	2.0 – Sd[b]
100	4.0	3,000	4.5	3,000 – (30 Sd)[b]	4.5 – (1.2 Sd)	2,300	3.5	2,300 – (25 Sd)	3.5 – Sd
150	6.0	4,500	7.0	4,500 – (30 Sd)[b]	7 – (1.2 Sd)	3,500	5.5	3,500 – (25 Sd)[b]	5.5–Sd
200	8.0	6,000	9.5	6,000 – (30 Sd)[b]	9.5 – (1.2 Sd)	4,500	7.0	4,500 – (25 Sd)	7.0 – Sd
225	9.0	6,800	10.5	6,800 – (30 Sd)	10.5 – (1.2 Sd)	5,100	8.0	5,100 – (25 Sd)	8.0 – Sd
300	12.0	9,000	14.0	9,000 – (30 Sd)	14 – (1.2 Sd)	7,100	11.0	7,100 – (25 Sd)	11.0 – Sd
400	16.0	12,000	18.5	12,000 – (30 Sd)	18.5 – (1.2 Sd)	9,400	14.5	9,400 – (25 Sd)	14.5 – Sd
450	18.0	13,500	21.0	13,500 – (30 Sd)	21 – (1.2 Sd)	10,600	16.5	10,600 – (25 Sd)	16.5 – Sd
500	20.0	15,000	23.5	15,000 – (30 Sd)	23.5 – (1.2 Sd)	11,800	18.5	11,800 – (25 Sd)	18.5 – Sd
600	24.0	18,000	28.0	18,000 – (30 Sd)	28 – (1.2 Sd)	14,200	22.0	14,200 – (25 Sd)	22.0 – Sd
750	30.0	22,500	35.0	22,500 – (30 Sd)	35 – (1.2 Sd)	17,700	27.5	17,700 – (25 Sd)	27.5 – Sd
900	36.0	27,000	42.0	27,000 – (30 Sd)	42 – (1.2 Sd)	21,300	33.0	21,300 – (25 Sd)	33.0 – Sd

Table 392.22(A)(5) Allowable Cable Fill Area for Multiconductor Cables in Ventilated Channel Cable Trays for Cables Rated 2000 Volts or Less

Inside Width of Cable Tray		Maximum Allowable Fill Area for Multiconductor Cables			
		Column 1 One Cable		Column 2 More Than One Cable	
mm	in.	mm^2	$in.^2$	mm^2	$in.^2$
75	3	1500	2.3	850	1.3
100	4	2900	4.5	1600	2.5
150	6	4500	7.0	2450	3.8

Table 392.22(A)(6) Allowable Cable Fill Area for Multiconductor Cables in Solid Channel Cable Trays for Cables Rated 2000 Volts or Less

Inside Width of Cable Tray		Column 1 One Cable		Column 2 More Than One Cable	
mm	in.	mm^2	$in.^2$	mm^2	$in.^2$
50	2	850	1.3	500	0.8
75	3	1300	2.0	700	1.1
100	4	2400	3.7	1400	2.1
150	6	3600	5.5	2100	3.2

(2) Ventilated Channel Cable Trays. Where 50 mm (2 in.), 75 mm (3 in.), 100 mm (4 in.), or 150 mm (6 in.) wide ventilated channel cable trays contain single-conductor cables, the sum of the diameters of all single conductors shall not exceed the inside width of the channel.

(C) Number of Type MV and Type MC Cables (2001 Volts or Over) in Cable Trays. The number of cables rated 2001 volts or over permitted in a single cable tray shall not exceed the requirements of this section.

The sum of the diameters of single-conductor and multiconductor cables shall not exceed the cable tray width, and the cables shall be installed in a single layer. Where single conductor cables are triplexed, quadruplexed, or bound together in circuit groups, the sum of the diameters of the single conductors shall not exceed the cable tray width, and these groups shall be installed in single layer arrangement."

Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association, pp. 70-230 to 70-232.

Selection and filling of conduits

Following you could find a portion of Chapter 10 of the Official Mexican Standard NOM-001-SEDE-2012 and chapter 9 of NEC-2017 where the guidelines to select the conduit diameter or to calculate the conduit percentage of filling are defined:

Chapter 9
TABLES

Table 1 Percent of Cross Section of Conduit and Tubing for Conductors and Cables

Number of Conductors and/or Cables	Cross-Sectional Area (%)
1	53
2	31
Over 2	40

Informational Note No. 1: Table 1 is based on common conditions of proper cabling and alignment of conductors where the length of the pull and the number of bends are within reasonable limits. It should be recognized that, for certain conditions, a larger size conduit or a lesser conduit fill should be considered.
Informational Note No. 2: When pulling three conductors or cables into a raceway, if the ratio of the raceway (inside diameter) to the conductor or cable (outside diameter) is between 2.8 and 3.2, jamming can occur. While jamming can occur when pulling four or more conductors or cables into a raceway, the probability is very low.

Notes to Tables

(1) See Informative Annex C for the maximum number of conductors and fixture wires, all of the same size (total cross-sectional area including insulation) permitted in trade sizes of the applicable conduit or tubing.
(2) Table 1 applies only to complete conduit or tubing systems and is not intended to apply to sections of conduit or tubing used to protect exposed wiring from physical damage.
(3) Equipment grounding or bonding conductors, where installed, shall be included when calculating conduit or tubing fill. The actual dimensions of the equipment grounding or bonding conductor (insulated or bare) shall be used in the calculation.
(4) Where conduit or tubing nipples having a maximum length not to exceed 600 mm (24 in.) are installed between boxes, cabinets, and similar enclosures, the nipples shall be permitted to be filled to 60 percent of their total cross-sectional area, and 310.15(B)(3)(a) adjustment factors need not apply to this condition.
(5) For conductors not included in Chapter 9, such as multiconductor cables and optical fiber cables, the actual dimensions shall be used.
(6) For combinations of conductors of different sizes, use actual dimensions or Table 5 and Table 5A for dimensions of conductors and Table 4 for the applicable conduit or tubing dimensions.
(7) When calculating the maximum number of conductors or cables permitted in a conduit or tubing, all of the same size (total cross-sectional area including insulation), the next higher whole number shall be used to determine the maximum number of conductors permitted when the calculation results in a decimal greater than or equal to 0.8. When calculating the size for conduit or tubing permitted for a single conductor, one conductor shall be permitted when the calculation results in a decimal greater than or equal to 0.8.
(8) Where bare conductors are permitted by other sections of this *Code*, the dimensions for bare conductors in Table 8 shall be permitted.
(9) A multiconductor cable, optical fiber cable, or flexible cord of two or more conductors shall be treated as a single conductor for calculating percentage conduit or tubing fill area. For cables

that have elliptical cross sections, the cross-sectional area calculation shall be based on using the major diameter of the ellipse as a circle diameter. Assemblies of single insulated conductors without an overall covering shall not be considered a cable when determining conduit or tubing fill area. The conduit or tubing fill for the assemblies shall be calculated based upon the individual conductors.

(10) The values for approximate conductor diameter and area shown in Table 5 are based on worst-case scenario and indicate round concentric-lay-stranded conductors. Solid and round concentric-lay-stranded conductor values are grouped together for the purpose of Table 5.

Round compact-stranded conductor values are shown in Table 5A. If the actual values of the conductor diameter and area are known, they shall be permitted to be used.

Table 4 Dimensions and Percent Area of Conduit and Tubing (Areas of Conduit or Tubing for the Combinations of Wires Permitted in Table 1, Chapter 9)

Article 358 — Electrical Metallic Tubing (EMT)

Metric Designator	Trade Size	Over 2 Wires 40%		60%		1 Wire 53%		2 Wires 31%		Nominal Internal Diameter		Total Area 100%	
		mm²	in.²	mm²	in.²	mm²	in.²	mm²	in.²	mm	in.	mm²	in.²
16	½	78	0.122	118	0.182	104	0.161	61	0.094	15.8	0.622	196	0.304
21	¾	137	0.213	206	0.320	182	0.283	106	0.165	20.9	0.824	343	0.533
27	1	222	0.346	333	0.519	295	0.458	172	0.268	26.6	1.049	556	0.864
35	1¼	387	0.598	581	0.897	513	0.793	300	0.464	35.1	1.380	968	1.496
41	1½	526	0.814	788	1.221	696	1.079	407	0.631	40.9	1.610	1314	2.036
53	2	866	1.342	1299	2.013	1147	1.778	671	1.040	52.5	2.067	2165	3.356
63	2½	1513	2.343	2270	3.515	2005	3.105	1173	1.816	69.4	2.731	3783	5.858
78	3	2280	3.538	3421	5.307	3022	4.688	1767	2.742	85.2	3.356	5701	8.846
91	3½	2980	4.618	4471	6.927	3949	6.119	2310	3.579	97.4	3.834	7451	11.545
103	4	3808	5.901	5712	8.852	5046	7.819	2951	4.573	110.1	4.334	9521	14.753

Article 362 — Electrical Nonmetallic Tubing (ENT)

Metric Designator	Trade Size	Over 2 Wires 40%		60%		1 Wire 53%		2 Wires 31%		Nominal Internal Diameter		Total Area 100%	
		mm²	in.²	mm²	in.²	mm²	in.²	mm²	in.²	mm	in.	mm²	in.²
16	½	73	0.114	110	0.171	97	0.151	57	0.088	15.3	0.602	184	0.285
21	¾	131	0.203	197	0.305	174	0.269	102	0.157	20.4	0.804	328	0.508
27	1	215	0.333	322	0.499	284	0.441	166	0.258	26.1	1.029	537	0.832
35	1¼	375	0.581	562	0.872	497	0.770	291	0.450	34.5	1.36	937	1.453
41	1½	512	0.794	769	1.191	679	1.052	397	0.616	40.4	1.59	1281	1.986
53	2	849	1.316	1274	1.975	1125	1.744	658	1.020	52	2.047	2123	3.291
63	2½	—	—	—	—	—	—	—	—	—	—	—	—
78	3	—	—	—	—	—	—	—	—	—	—	—	—
91	3½	—	—	—	—	—	—	—	—	—	—	—	—

Article 348 — Flexible Metal Conduit (FMC)

Metric Designator	Trade Size	Over 2 Wires 40%		60%		1 Wire 53%		2 Wires 31%		Nominal Internal Diameter		Total Area 100%	
		mm²	in.²	mm²	in.²	mm²	in.²	mm²	in.²	mm	in.	mm²	in.²
12	⅜	30	0.046	44	0.069	39	0.061	23	0.036	9.7	0.384	74	0.116
16	½	81	0.127	122	0.190	108	0.168	63	0.098	16.1	0.635	204	0.317
21	¾	137	0.213	206	0.320	182	0.283	106	0.165	20.9	0.824	343	0.533
27	1	211	0.327	316	0.490	279	0.433	163	0.253	25.9	1.020	527	0.817
35	1¼	330	0.511	495	0.766	437	0.677	256	0.396	32.4	1.275	824	1.277
41	1½	480	0.743	720	1.115	636	0.985	372	0.576	39.1	1.538	1201	1.858
53	2	843	1.307	1264	1.961	1117	1.732	653	1.013	51.8	2.040	2107	3.269
63	2½	1267	1.963	1900	2.945	1678	2.602	982	1.522	63.5	2.500	3167	4.909
78	3	1824	2.827	2736	4.241	2417	3.746	1414	2.191	76.2	3.000	4560	7.069
91	3½	2483	3.848	3724	5.773	3290	5.099	1924	2.983	88.9	3.500	6207	9.621
103	4	3243	5.027	4864	7.540	4297	6.660	2513	3.896	101.6	4.000	8107	12.566

Extracted from National Electrical Code® NFPA 70®, Edition 2017,
by National Fire Protection Association,

Chapter

7

Conductor Specifications Capture

Location: *Queries* | *Specifications*

The specification represents the description of the most representative characteristics of a conductor associated with a circuit. As part of the conductor size selection process only the information about the nominal size of the copper or aluminum conductor is obtained but there is no more information on the overall dimensions, insulation level or insulation type. Through the specification, *Sizer Electric* can associate all this information to a circuit so that it can describe the complete conductor characteristics.

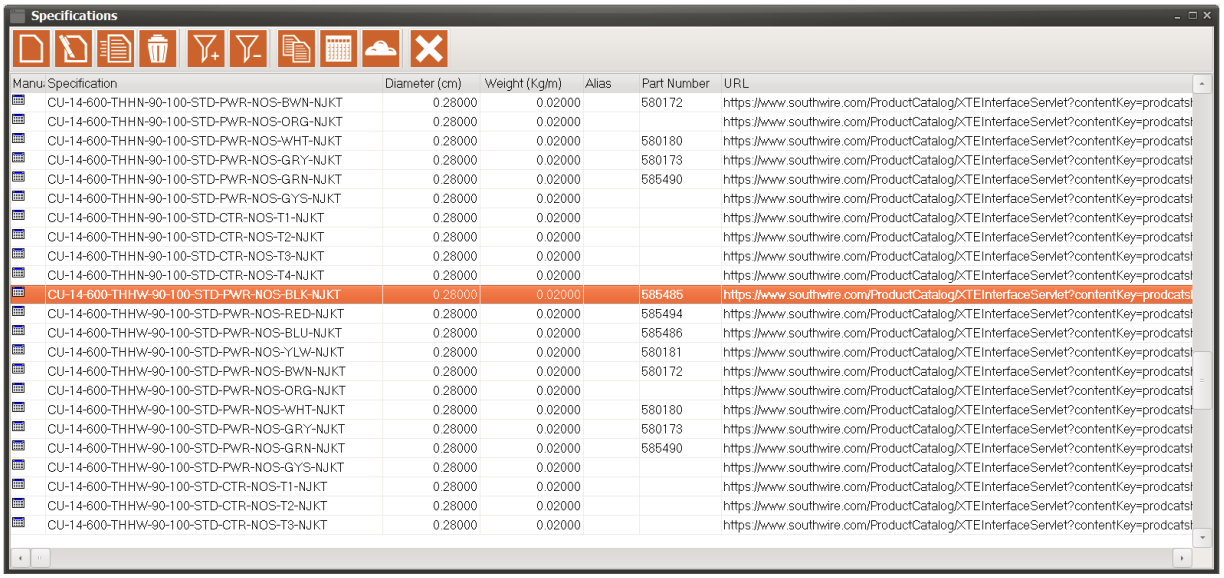
Additionally through the specification you may assign the overall diameter and weight per length of a conductor. This information is subsequently used to determine the width of cable tray or diameter of the conduit where the circuit is installed. The specification information can be revised and edited according to the project needs.

It is important to note that *Sizer Electric* includes 2 libraries: One from Sizer Electric and one from the manufacturer Southwire. These libraries can be selected in the "Standards" section. The *Sizer Electric* library is defined based on average values, diameters and weights of different manufacturers in the market. The Southwire library

integrates accurate information of all the conductors of this manufacturer which increases the precision in the selection of cable trays and conduits, and facilitates the acquisition and supply process for these materials. Additionally, you can obtain an immediate quotation of the conductors of your project (See *Conductor Summary* section).

Note: Make sure that in the "*Standards*" section the library of specifications appropriate to the requirements of your project has been selected since any edition of the information will be made on the selected library.

To access the *Specifications* information available in the *Sizer Electric* database you must select the *"Queries"* option from the *main menu* and then in the submenu displayed, select the *"Specifications"* option. Then the following grid will be shown:



Manu.	Specification	Diameter (cm)	Weight (Kg/m)	Alias	Part Number	URL
	CU-14-600-THHN-90-100-STD-PWR-NOS-BWN-NJKT	0.28000	0.02000		580172	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHN-90-100-STD-PWR-NOS-ORG-NJKT	0.28000	0.02000			https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHN-90-100-STD-PWR-NOS-WHT-NJKT	0.28000	0.02000		580180	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHN-90-100-STD-PWR-NOS-GRY-NJKT	0.28000	0.02000		580173	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHN-90-100-STD-PWR-NOS-GRN-NJKT	0.28000	0.02000		585490	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHN-90-100-STD-PWR-NOS-GYS-NJKT	0.28000	0.02000			https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHN-90-100-STD-CTR-NOS-T1-NJKT	0.28000	0.02000			https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHN-90-100-STD-CTR-NOS-T2-NJKT	0.28000	0.02000			https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHN-90-100-STD-CTR-NOS-T3-NJKT	0.28000	0.02000			https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHN-90-100-STD-CTR-NOS-T4-NJKT	0.28000	0.02000			https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-PWR-NOS-BLK-NJKT	0.28000	0.02000		585485	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-PWR-NOS-RED-NJKT	0.28000	0.02000		585494	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-PWR-NOS-BLU-NJKT	0.28000	0.02000		585486	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-PWR-NOS-YLW-NJKT	0.28000	0.02000		580181	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-PWR-NOS-BWN-NJKT	0.28000	0.02000		580172	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-PWR-NOS-ORG-NJKT	0.28000	0.02000			https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-PWR-NOS-WHT-NJKT	0.28000	0.02000		580180	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-PWR-NOS-GRY-NJKT	0.28000	0.02000		580173	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-PWR-NOS-GRN-NJKT	0.28000	0.02000		585490	https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-PWR-NOS-GYS-NJKT	0.28000	0.02000			https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-CTR-NOS-T1-NJKT	0.28000	0.02000			https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-CTR-NOS-T2-NJKT	0.28000	0.02000			https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl
	CU-14-600-THHW-90-100-STD-CTR-NOS-T3-NJKT	0.28000	0.02000			https://www.southwire.com/ProductCatalog/XTEInterfaceServlet?contentKey=prodcatsl

This grid presents an additional icon in the toolbar which is shown below:

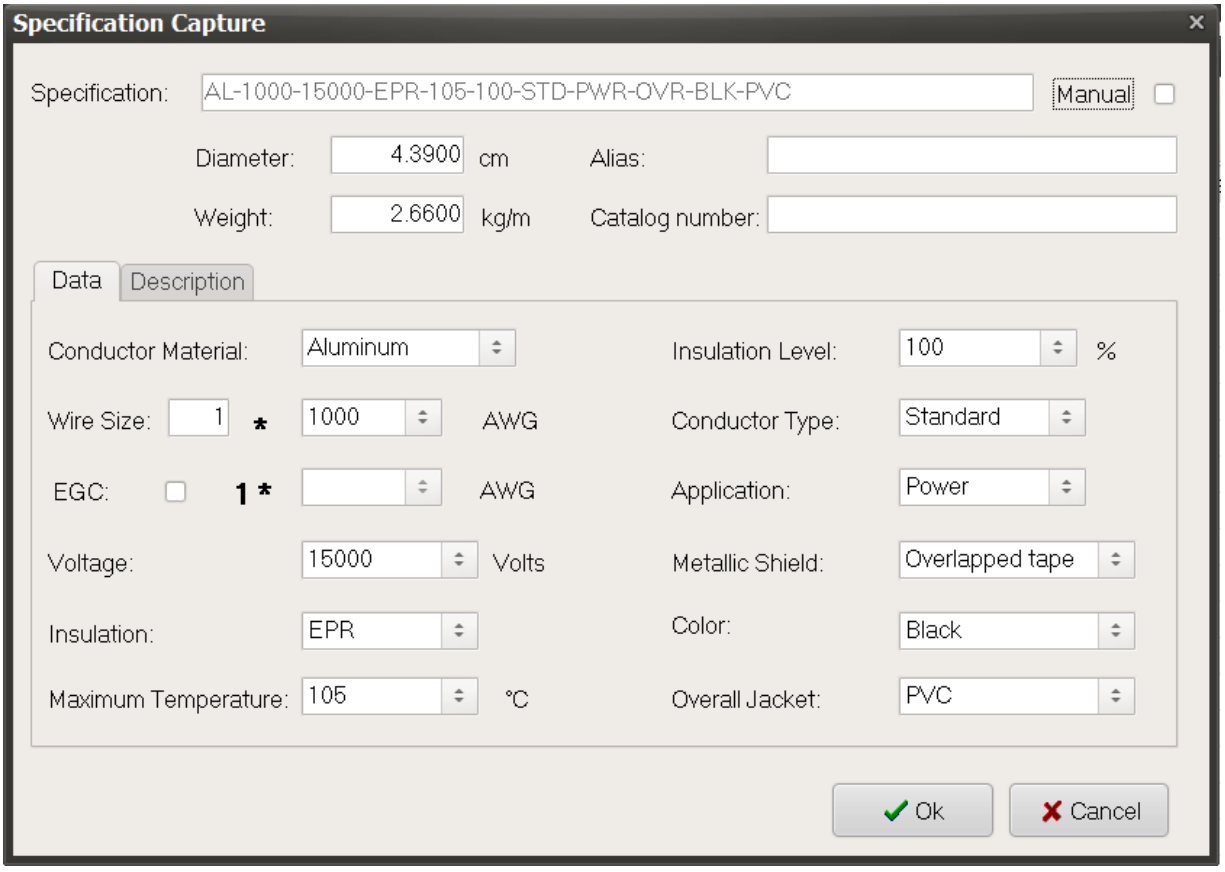
Button for consulting website information of the conductor specification

This option allows you to open the URL of the conductor specification using the Internet browser installed on the computer This allows you to view product information online.

If you need to edit information of any particular specification you must select the corresponding row and click on it to highlight it, then double-click using the mouse. It is also possible to access the specification information by selecting the corresponding row and pressing the *"Edit"* icon located in the Tools menu at the top of this grid.

Icon to modify specifications.

Then the specifications capture / edition window and will be shown:



Specifications Capture Window

Following is the information to be captured in each of the fields of the Specifications window :

Specification: This is a unique and unrepeatable name that identifies the specification in the project. There are two possibilities to define a specification: One is to capture it directly into the text box, to do this you must activate the check box next to the specification box named "*Manual".* Second option is to select the information in the lists of the fields in the capture window, a string of characters with the prefixes of the information captured will be assembled in the specification text box.

Because the specification name is associated with the conductor selection results, there must be a specification for each combination of possible results in the calculation method.

Manual: As indicated in the definition above, this check box indicates whether the name of the specification is provided by the user (*Checked*) or if the specification will be integrated by the information captured in the fields of the window (*Unchecked*).
Diameter: This is the total overall diameter of the conductor defined in for the specification. This value shall be expressed in centimeters.

Weight: The definition of weight per linear meter of the conductor specification. This value is used to total the weight per linear meter to be carried on the cable tray.

Alias: This field allows you to assign a custom name to the specification to link or refer the information with other user's internal documentation or systems.

Catalog number: It is the commercial identification of the manufacturer of the product. It is usually obtained from technical manuals or catalogs of the manufacturer. This information will be included in the description of the conductors specification to specifically associate the conductor with a key-code recognized by the manufacturer.

DATA TAB

In the data tab, the conductor information is entered. If the "Manual" box was not selected, the information captured in these fields will integrate the conductor specification. The data to be entered are the following.

Conductor Material: It is the definition of the material for the construction of the conductor. It can be copper or aluminum.

Size: This field includes 2 text boxes, the first one represents the number of conductors for multiconductor. Enter number "1" for a single pole conductor. The second text box represents the nominal size of the conductor expressed in AWG or kCM.

EGC: The nominal size of the equipment grounding conductor for multiconductor. This reference is in AWG or kCM.

Voltage: It is the value of the nominal operation voltage of the conductor in volts.

Insulation: It is the type of insulation of the conductor according to the selected standard.

Maximum temperature: It is the maximum conductor operation temperature according to the insulation selected in degrees centigrade.

Insulation level: The capacity of the conductor insulation to withstand over voltages caused by the type of grounding and the fault dissipation time.

Conductor Type: Describes the type of conductor with six possible options: *Standard* that is an average electric cable. TC type that is the conductor permitted for use in

trays "TC - Cable Tray". Type TC-ER (Type TC - Exposed Run) for TC type conductors that can extend their installation in sites without support or continuous raceways. There are 3 options for Armed cable: Armored AIA (Aluminum Interlocked Armor), Armored GSA (Galvanized Steel Armor) and Armored CWA (Corrugated Welded Armor). These options are available because the diameter and weight of the conductor (used for the selection of cable trays and raceways) varies according to the type of conductor. In addition precise definition of the type of conductor is necessary to integrate its specification and description.

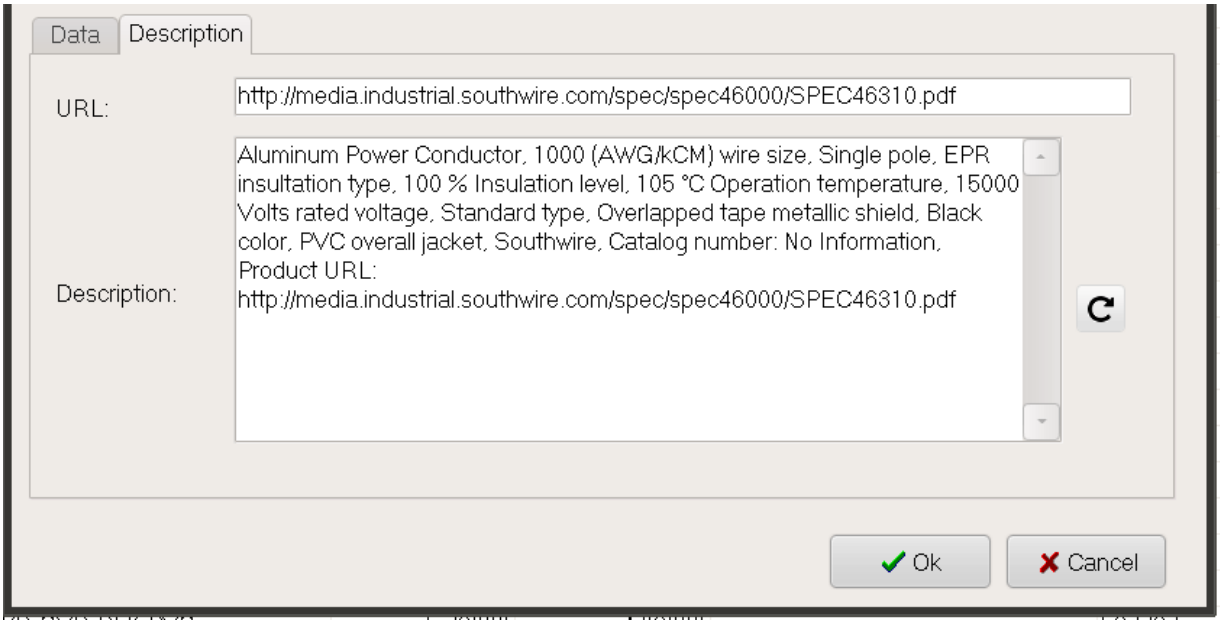
Application: It allows to define the use and type of energy that will be carried by the conductor. There are 2 options: *Power* for energy cables and *Control* for circuits of this type.

Metallic Shield: Indicates if the conductor has a metallic shield built in to avoid dielectric stress inside the conductor insulation. There are 3 options: No shield, With helicoidal overlapping metallic tape shield of the same material as the conductor (OVR-Overlapped) and With Bare Copper Conductor Shield (BCW- Bare Copper Wires).

Color: In this field you select the color of the particular conductor. In the case of single pole power cables specification, any color can be selected. For power multiconductor specification, only the Black or B + R + B + W (Black, Red, Blue, and White) color combination can be selected. For control conductors, the options are the 4 descriptive tables included in the ICEA standard S-58-679-1988 that describes the color sequence for control circuits.

DESCRIPTION TAB

In the Description tab 2 fields are shown:



URL: (Uniform Resource Locator) is a resource identifier or internet address that represents the relative address where the online conductor catalogue is located. This is particularly useful for consulting the latest information of the conductor's manufacturer and facilitating the information exchange with the rest of the work teams such as purchase areas, construction, etc.

Once the URL of the product has been captured, it can be consulted by selecting the specification record and pressing the following button in the toolbar:

Button to consult the information of the website of the conductor specification

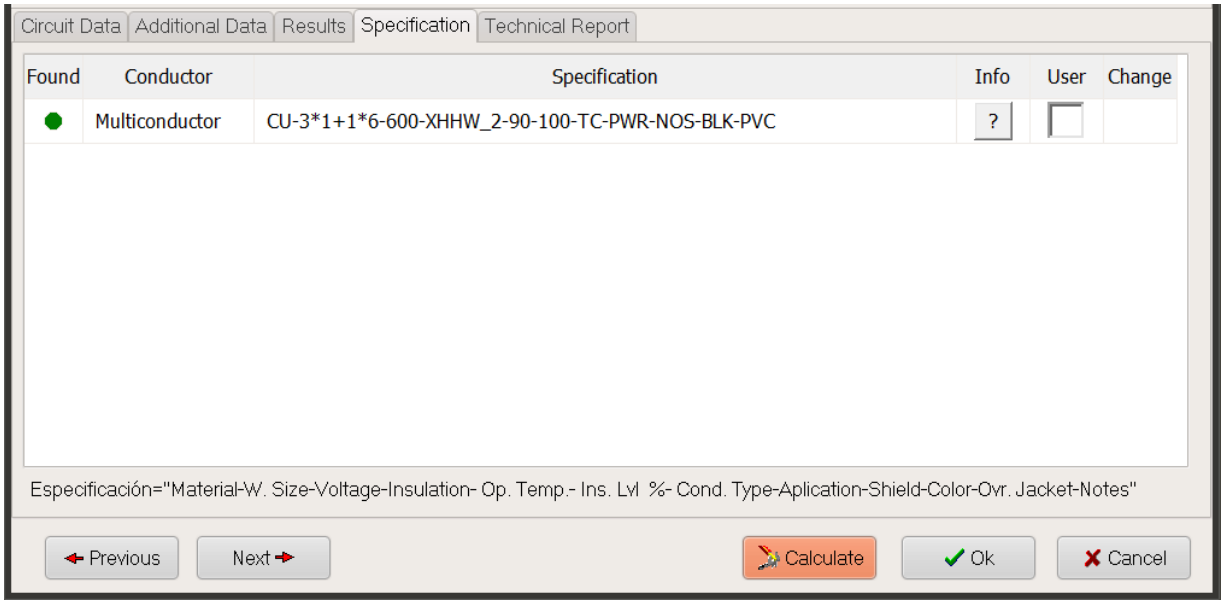
Description: This is an alphanumeric field used to enter the conductor comprehensive description. If the "*Manual*" box was not selected, the information presented will be generated automatically based on the data captured in the *Data* tab. If the "Manual" box was checked it will show the last specification description shown for free editing. This description will appear later in the *Conductor Summary* section where the project conductors are described and summarized.

The button located next to the text box allows updating the information of the description created when the specification is integrated from the information of the fields. This button also allows you to refresh the information when updating the product URL, the Alias or the Catalog Number.

Button to refresh the description field

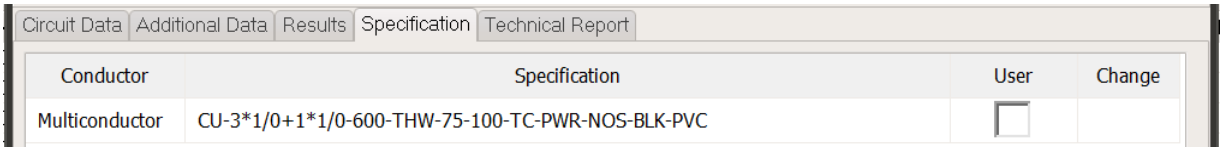
Selection of specifications by User

Once you have calculated the conductors nominal size a specification is presented in the *Specification* tab, as shown in the following window:



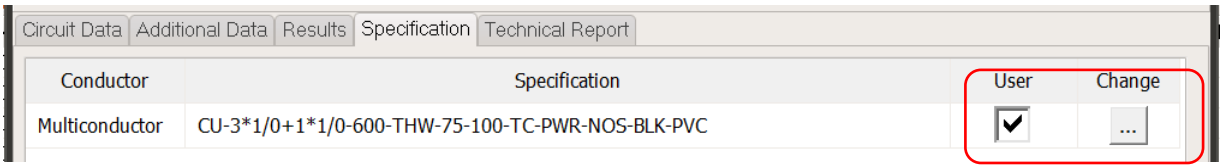
Customized Specification Selection

When calculating the size of the conductor, *Sizer Electric* generates an automatic specification of the circuit according to the type of conductor, size and system voltage. All possible combinations of specification generated by the program are predefined in the project.

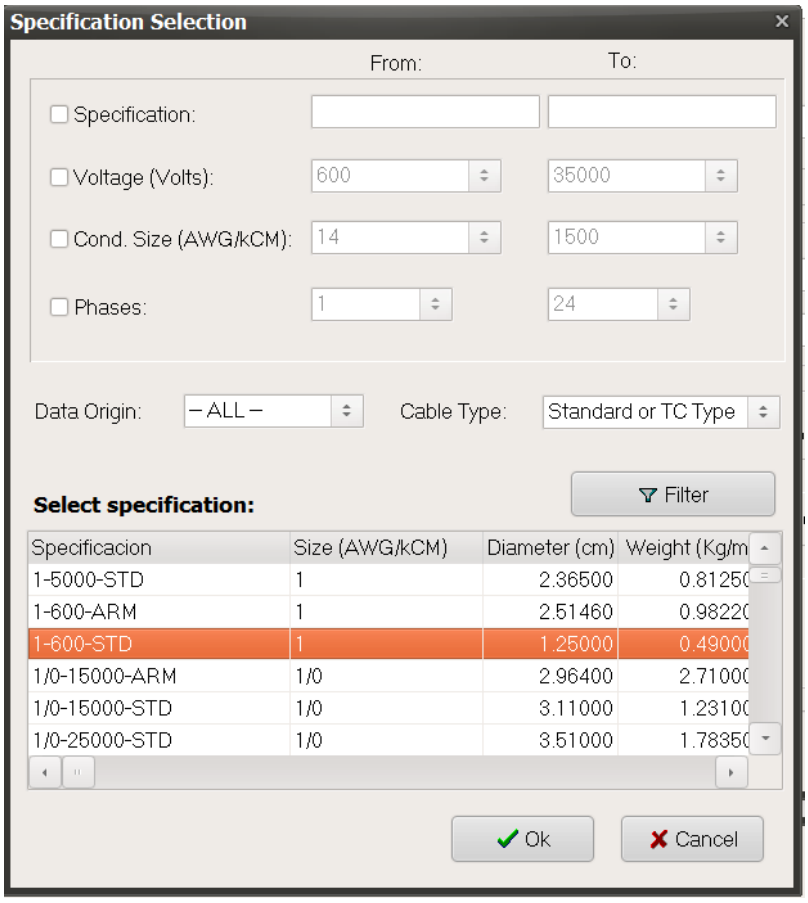


The information associated to the specification such as weight, diameter and description will be used for cable trays and conduit sizing. (See chapter 6 *Circuit Allocation on cable trays and specifications*)

However, if the specification does not match the needs of your project you can associate a different specification by checking the *User* box. This action will show a button  in the *Change* column as a sign that a different specification can be associated with this conductor.

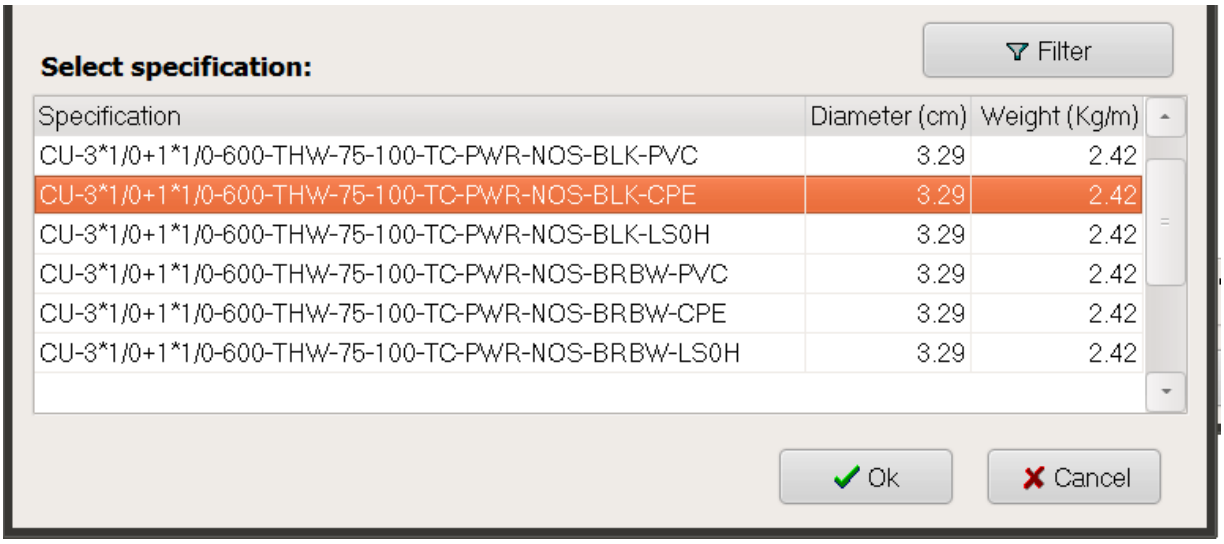


To associate another specification press the button  and the window shown below appears:

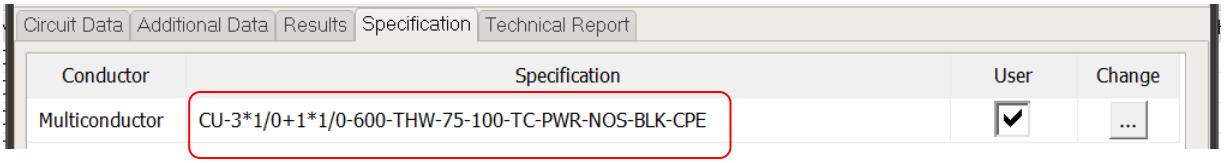


This window displays the available specifications in the project. Because the number of specifications in the project can be very big, it may be necessary to apply some filters to locate the specification required. In the upper section of this window there are different criteria available to filter the specifications. To apply a filter, select the check box located on the left side of the filter criteria you want to activate and set the filtering criteria. Press the button  and then the list located at the bottom will show only the specifications that meet the filtering criteria. To undo the filter clear the checkboxes of the filter criteria and click the *"Filter"* button again.

Select from the list the specification you want to associate to the conductor. Once the new specification for the circuit is selected from the list (highlighted), press the *"OK"* button.



By selecting the specification, it is associated to the circuit.



New specification associated with the circuit.

Then the new specification is associated to the circuit and its diameter, weight and description will be used for the selection of cable trays and conduits.

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Chapter

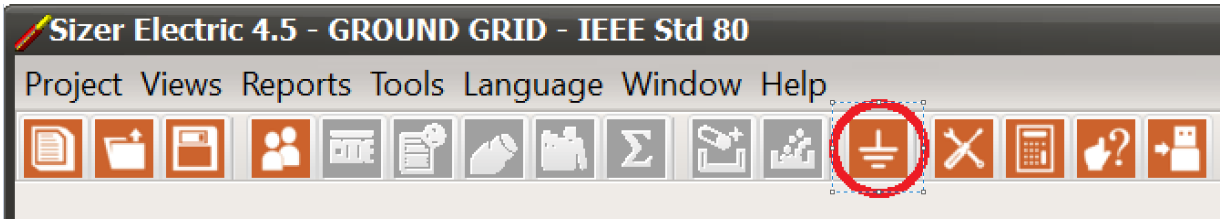
8

Grounding Grid Calculation

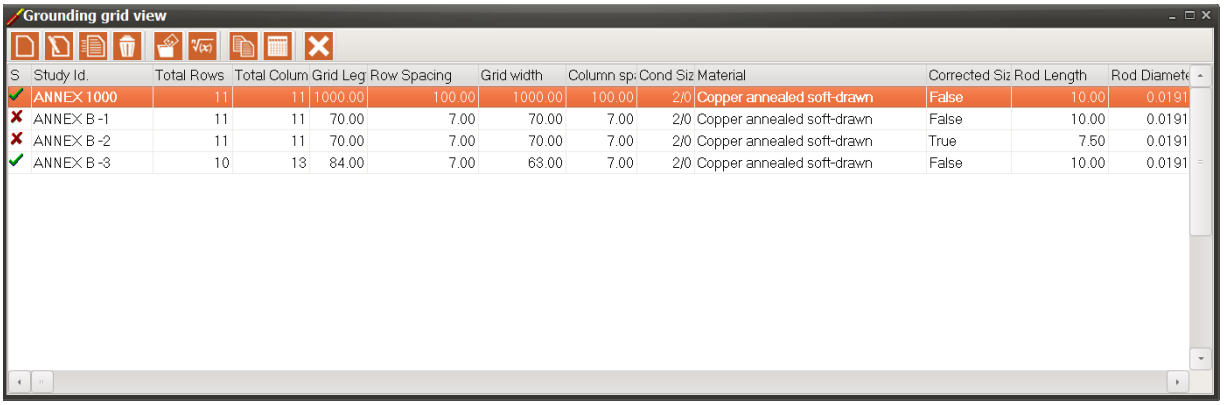
Grounding grid capture

To start the process of a grounding grid design you must be selected option *"Queries"* and then select the *Grounding grid* option in the submenu displayed as follows:

You can access the application by selecting the *Grounding Grid* icon in the toolbar



Then the grounding grid window will be shown



In the reticle you can see the data for analysis Each row or record represents an analysis or study of a grounding grid. This grid contains its own toolbar icons. The icons functionality is explained below:

Add: When this option is selected, the data capture window for Grounding grid studies is shown. On it you can register the different studies that for the project, without a limit on the number of studies.

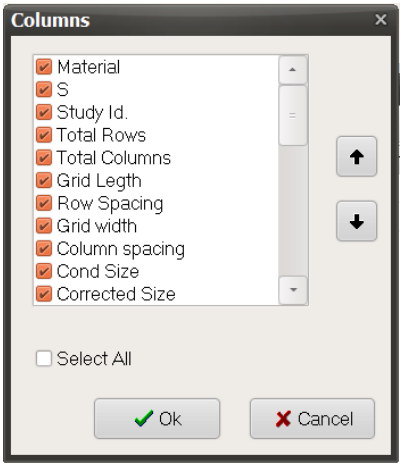
Modify: Having previously captured data from a grounding grid study, you can modify them using this option.

Copy Grid: With this option you can use data from a study as a reference to create a new one. This option is useful when there are similar data analysis

Delete: To delete a grounding grid you should use this option. By pressing this icon the grid study selected is removed from the system and it is not possible to recover it.

Copy to Clipboard: By selecting this option the study data are copied to the clipboard so the user can then paste the information to any spreadsheet or word processor.

Columns Customization: When this option is selected a dialogue box with all the columns contained in the table is displayed, in which you can change the columns order or hide them.



If you want to see all the columns in the grid, select the check box *Select All.*

Save Image: Allows you to store the layout graphic generated of the grounding grid in an image format (* .jpg, * .bmp)

Calculation report: In the grounding grid analysis is always necessary to have a reference about the criteria and values involved in the calculation. To meet this need, the system creates a comprehensive calculation report, which is available as long as analysis is performed without errors. You just must select the study in the grid (row) and then press this icon.

Exit: Closes the grounding grid window.

Grounding Grid Design

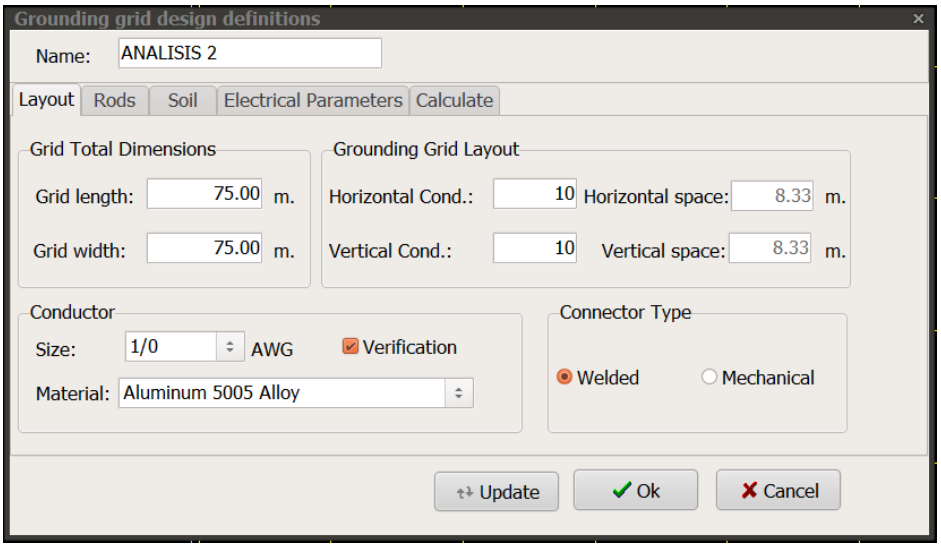
By selecting the option *"New"* in the grounding grid screen toolbar two new windows will be displayed simultaneously. These windows are :

- **Grounding Grid Capture Window:** Where data used in the design and calculation of the grounding grid are defined (See item 1 in figure below).
- **Graphic Grounding Grid Layout:** Where the physical layout of the grounding grid according to the data entered. This graphic will always be displayed in the back. (See item 2 in the figure below)

The capture window consists of a text box where the name of the analysis should be captured to identify the study. This window also contains 5 tabs. In the first 4 the data for analysis should be captured. In the fifth tab the analysis results are presented and concludes whether the grounding grid design meets the requirements defined by the IEEE Std. 80. Following the data to be captured are described for each of these tabs.

Layout

This section details the geometric layout of the grounding grid as well as the conductor size used to construct the grid.



Data to be captured:

Grid Length: This field must be indicated in meters and represent the largest side of the grounding grid. The value grounding grid length must be greater than the dimension captured for the grounding grid width**.**

Example:	75	***Validation*:**	Greater than 0 and less than 9999 meters / larger than grid width

Grid width: This field must be indicated in meters and represents smaller of the grounding grid. The value of the grid width should be less than the dimension captured for grid length.

Example:	50	***Validation*:**	Greater than 0 and less than 9999 meters / shorter than grid width

Vertical conductors: In this field you should indicate the number of conductors arranged vertically in the grid layout. Because the equations of standard IEEE Std. 80 apply only to grids with uniform spacing between conductors, the conductor location in the layout will be equidistant considering the ratio between the number of vertical conductors. by the grid length.

Example:	8	***Validation*:**	Greater than 0 and less than 9999 meters

Horizontal Conductors: This field must indicate the number of conductors arranged horizontally in the grid layout. Because the equations of standard IEEE Std. 80 apply only to grids with uniform spacing between conductors, the conductor location in the layout will be equidistant considering the ratio between the number of horizontal conductors by the grid width

Example:	8	***Validation*:**	Greater than 0 and less than 9999 meters

Size: In this field you must select the wire size in AWG or KCM.

Example:	1/0 AWG	***Validation*:**	1/0 AWG to 1000 KCM

Material: In this field you must select the conductor material. The type of material will determine the thermal characteristics used to calculate the conductor capacity to withstand thermal stresses during the fault current flowing through the grid. The types of materials to select are available according to Table 2 in Section 11.3.1.2. IEEE Std. 80- 2000 *(See the reference table on next page)*.

Example:	Copper, annealed soft drawn	***Validation*:**	Materials in the list

Table 2—Material constants

Material	Conductivity (%)	T_m [a] (°C)	K_f
Copper, annealed soft-drawn	100.0	1083	7.00
Copper, commercial hard-drawn	97.0	1084	7.06
Copper, commercial hard-drawn	97.0	250	11.78
Copper-clad steel wire	40.0	1084	10.45
Copper-clad steel wire	30.0	1084	12.06
Copper-clad steel rod	20.0	1084	14.64
Aluminum EC Grade	61.0	657	12.12
Aluminum 5005 Alloy	53.5	652	12.41
Aluminum 6201 Alloy	52.5	654	12.47
Aluminum-clad steel wire	20.3	657	17.20
Steel 1020	10.8	1510	15.95
Stainless clad steel rod	9.8	1400	14.72
Zinc-coated steel rod	8.6	419	28.96
Stainless steel 304	2.4	1400	30.05

Table No 2 Extracted from section 11.3.1.2 of the IEEE Std. 80.

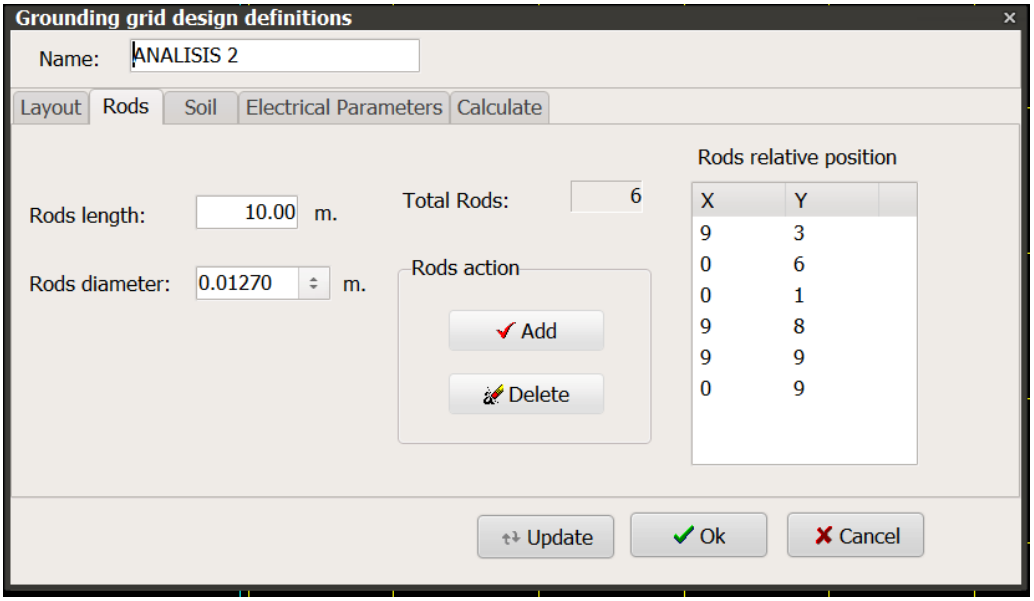
Verification: This check box indicates whether it is required that during the calculation process the size and material of the conductor used for the grid re verified to withstand thermal stresses occurring during the fault current flow. In the case that the box is not checked the conductor size specified will be used in the calculation without verifying its ability to withstand thermal stresses.

Example:	Checked	*Validation*:	Checked / Unchecked

Add and remove grounding rods to the layout

To add or remove rods in the grounding grid design is necessary to select the *"Rods"* tab of the capture window.

This section describes the physical characteristics of the rods to be located in the grid layout and after defining those features, locate the rods in the in the grid area.



Two fields should be filled for grid rods definition:

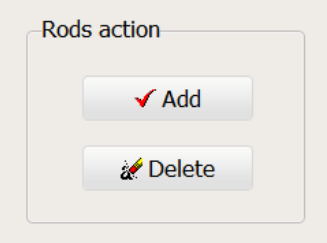
Rods Length: This field specifies the length of the rods expressed in meters. For the calculation shall be deemed to all rods arranged in the layout have the same length.

Example:	3.05 m	*Validation*:	longer than 0 and less than 100 m

Rods Diameter: In this field the diameter of the rods is expressed in meters. For the calculation shall be deemed to all rods arranged in the array have the same diameter.

Example:	0.0159 m	*Validation*:	Wider than 0.001m less than 1 m

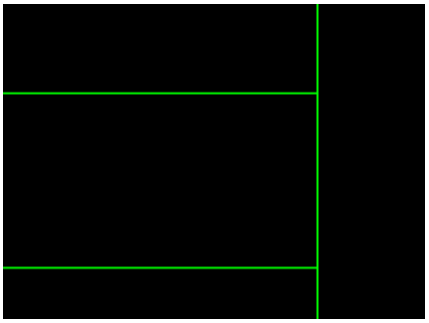
This section operates interactively with the graphic layout window in the back. In the frame *Rods action* there are two buttons:



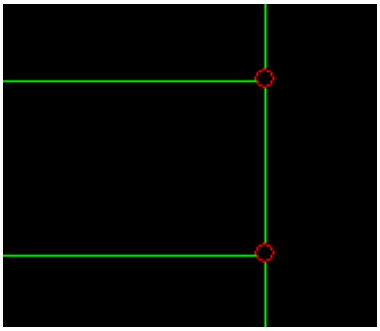
The ***Add*** and ***Delete*** button allows you to include or remove a rods from the graphical layout in back of the system.

Add Grounding Rods

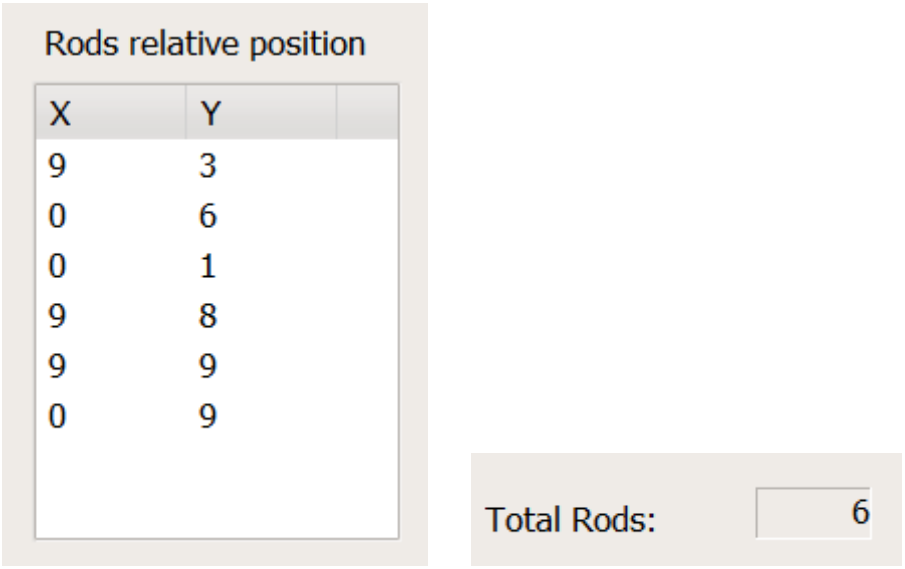
To add a rod must press the *"Add"* button this will cause the cursor to change within the graph indicating it is in *addition* mode.



You must select an intersection of conductors within the graph and press the click on the mouse to place the rod. It is appreciated that the rod was placed in the position indicated in the graph when a circle appears at the intersection of the conductors as shown in the following figure:



At the same time it appears in the list of the relative location coordinates of the rod according to the intersection of the conductors and the number of rods will increase in the counter at the bottom of this section as shown below:

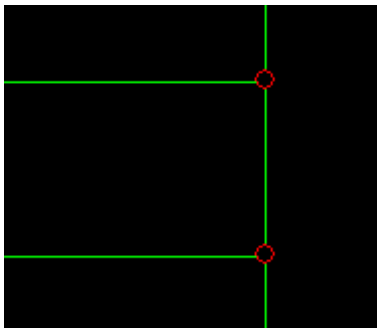


The relative position of the rods will be kept at the intersections of the conductors when the dimensions of the grid are changed or when the number of horizontal and vertical conductors of the array are changed. When a change is made in any of these data and a rod cannot be located in the relative position it will be automatically removed.

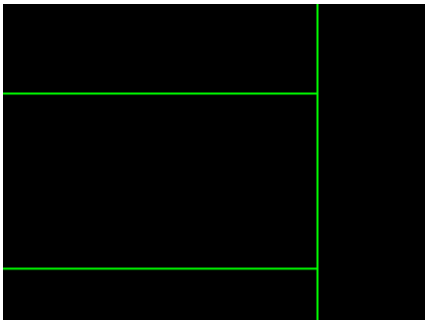
IMPORTANT NOTE: *The rods cannot be located in an area outside an intersection of conductors. Although the calculation method does not involve the physical arrangement of the grounding rods, Sizer Electric will only allow rods at the intersections of conductors.*

Delete Grounding Rods

To delete a grounding rod you must press the "*Delete*" button this will cause the cursor pointer to change within the graph indicating it is in the *deletion* mode.



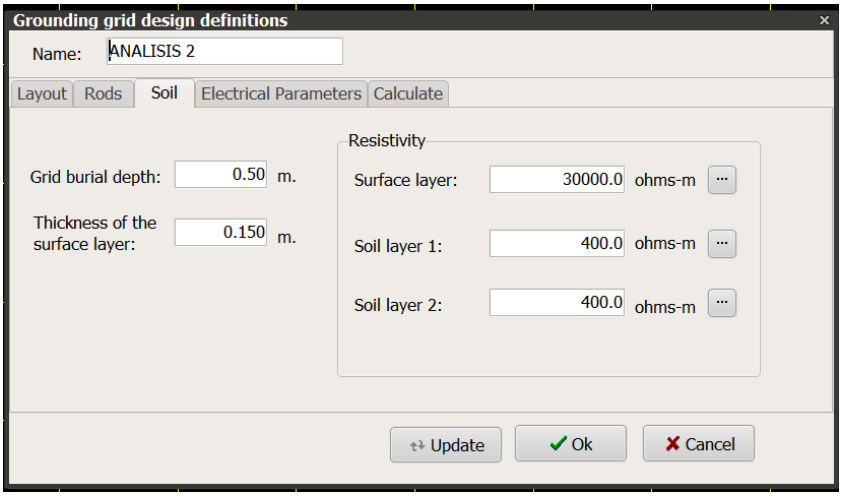
You must selected the rod to be removed in the graph and press the click on it to remove the rod. It is appreciated that the rod was removed from the position when the intersection of the conductors is restored in the graph and the circular symbol representing the rod disappears, as shown below:



The rod removed graphically will also be removed from the list of rods and will be reflected as a decrease in the rods counter of this section.

Soil Characteristics

In this section you should define the most representative data of the soil where the grounding grid will be installed:



The date to be defined in this section are presented below:

Grid Burial Depth: Is the burial depth of the grounding grid layout. This distance is measured from the finished floor without the gravel surface layer. Typically this value is commonly defined as 0.6 meters because at lower burial depths the soil resistivity is significantly affected by temperature and humidity variations.

Thickness of the Surface layer: Is the thickness of the surface layer of gravel placed over solid soil to become a higher resistivity zone limiting the grid potential rise in the field. Generally the value of this layer is defined from 15 to 20 cm.

Resistivity

Surface layer: Is the resistivity value expressed in ohms-centimeters of the gravel layer placed over the finished floor level. This value is generally taken as a reference from Table 7 of Section 13 of the standard IEE Std.80 as follows:

Table 7—Typical surface material resistivities

Number	Description of surface material (U.S. state where found)	Resistivity of sample Ω·m	
		Dry	Wet
1	Crusher run granite with fines (N.C.)	140×10^6	1300 (ground water, 45 Ω·m)
2	1.5 in (0.04 m) crusher run granite (Ga.) with fines	4000	1200 (rain water, 100 W)
3	0.75–1 in (0.02–0.025 m) granite (Calif.) with fines	—	6513 (10 min after 45 Ω·m water drained)
4	#4 (1 -2 in) (0.025-0.05 m) washed granite (Ga.)	1.5×10^6 to 4.5×10^6	5000 (rain water, 100 Ω·m)
5	#3 (2–4 in) (0.05-0.1 m) washed granite (Ga.)	2.6×10^6 to 3×10^6	10 000 (Rain water, 100 Ω·m)
6	Size unknown, washed limestone (Mich.)	7×10^6	2000–3000 (ground water, 45 Ω·m)
7	Washed granite, similar to 0.75 in (0.02 m) gravel	2×10^6	10 000
8	Washed granite, similar to pea gravel	40×10^6	5000
9	#57 (0.75 in) (0.02 m) washed granite (N.C.)	190×10^6	8000 (ground water, 45 Ω·m)
10	Asphalt	2×10^6 to 30×10^6	10 000 to 6×10^6
11	Concrete	1×10^6 to 1×10^9 [a]	21 to 100

Soil: Is the soil resistivity value obtained from a geoelectric study on the installation site. The value of soil resistivity should be defined at the burial depth of the grid. The resistivity value must be defined in ohms-m.

In some cases when the value of soil resistivity is high, some chemicals are added such as clays or carbon components that modify the value of soil resistivity. However in these cases it is not possible to determine the value of soil resistivity after adding these components. As a reference these components commonly reduce up to 50% the value of the soil relative resistivity.

If a resistivity analysis is not available the resistivity values according to the values in Table 8 section 13 of the standard IEEE Std.80 can be used depending on the predominant material in the ground as shown below:

Table 8—Range of earth resistivity

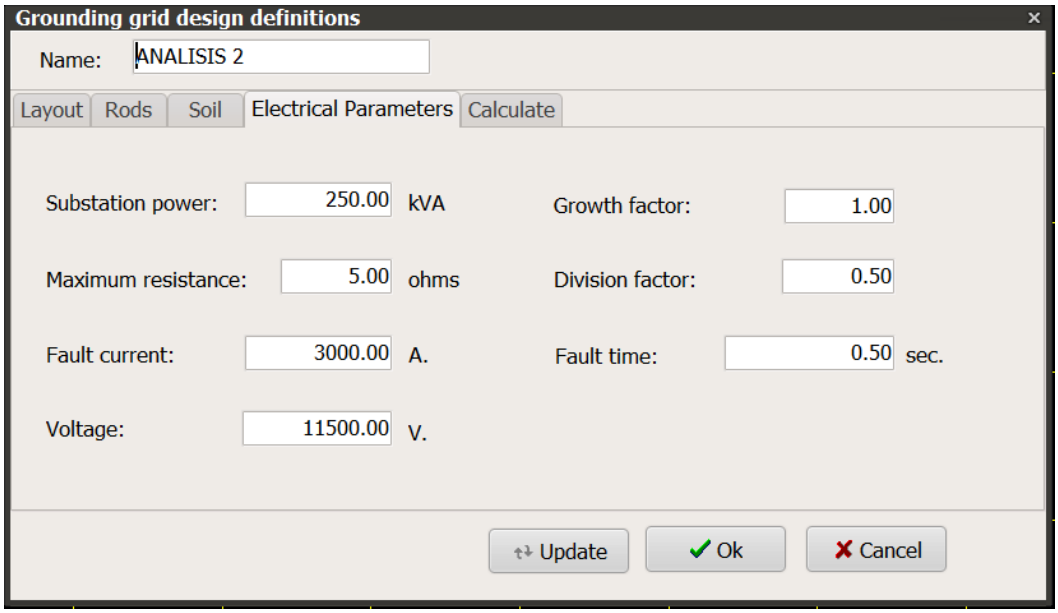
Type of earth	Average resistivity (Ω·m)
Wet organic soil	10
Moist soil	10^2
Dry soil	10^3
Bedrock	10^4

Soil Layer 2: Sometimes the resistivity of the soil where the grounding grid will be installed is not uniform due to the soil materials diversity. In these cases the grid can be in a soil layer with different resistivity from the resistivity of the layer in contact with the grounding rods. When the soil has two resistivity layers the Schwartz and Sunde models are used for determining the resistance of the grounding grid. The resistivity of layer 2 will always be considered as the soil layer located beneath the soil layer where the grounding grid is located. The value of the second soil layer resistivity must be captured in ohms per meter.

Connectors Type: The type of connectors that will be used to join the conductor intersections of the grid will determine the maximum allowable temperature rise of the grid during the calculation of the thermal stress during fault current circulation. When welded connectors are used it is considered that the system can support a similar melting temperature as the copper while mechanical connectors cannot allow an elevation temperature greater than 650 degrees.

Electrical parameters to design the Grounding Grid

This section describes the electrical parameters used during the design of the grounding grid. On this tab, 6 relevant fields are required. Those are shown below:



Substation Power: The power of the substation for which the grounding grid will be calculated. This value will be used to determine the maximum allowed resistance for the power and voltage substation in accordance with Section 921-25 (b) of the Official Mexican Standard NOM-001-SEDE-2012. If value is expressed in kVA.

Tabla 921-25 (b).- Resistencia a tierra del sistema.

Resistencia (ohms)	Tensión máxima (kV)	Capacidad máxima del transformador (kVA)
5	mayor que 35	mayor que 250
10	35	mayor que 250
25	35	250

Maximum S.E. Resistance: Is the value of the maximum resistance allowed for the grid design. This value should be provided when the resistance required in the project is different from the values given in Section 921-25 (b) of the Official Mexican Standard NOM-001-SEDE-2012. Its value is expressed in ohms.

Fault current: The value of the fault current required to be dissipated by the grounding grid. This value is the value of the ground fault current obtained from the energy provided by the power supply or utility system. In the case of substation transformers it should be considered as the value of the ground fault current on the

primary side of the transformer. In some cases it can be considered the value of the three-phase fault current according to the standard IEEE Std.80 recommendations. This value must be expressed in amperes.

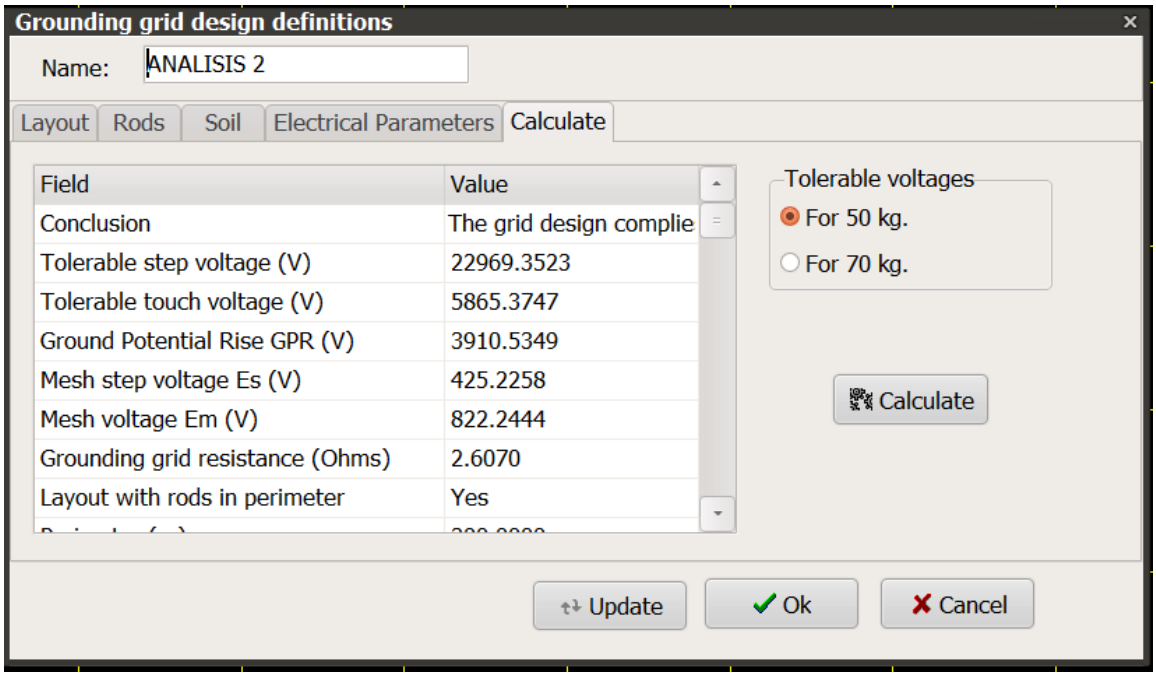
Growth Factor: A factor greater than one in a per unit base factor, that describes the expected percentage growth in the fault current values for the future. This value is usually provided by the utility company in the contribution fault values or available short circuit power prospection at the incoming line. This value can be obtained from the system short circuit analysis. The value is unitary.

Division factor: It is a smaller than one in a per unit base factor that takes into consideration that the fault current may have a separation into one or more paths such as poles or metal structures. This value must be determined from the analysis of system possible conduction paths as a whole. This value is dimensionless.

Fault Time: This is the time that the ground fault current is present in the system flowing through the grounding grid. Generally it is considered as the time set for the ground fault protection in the main substation protective device. If there is not an specific time defined during the ground grid design of a conservative value of 0.5 seconds to medium voltage systems may be considered until the maximum response time is obtained from the Protective Device Coordination Study.

Calculation of the grounding grid

In this section the criteria for calculating grid-potential rise,-resistance and tolerable voltages for human body are defined and is possible to verify the analysis results.



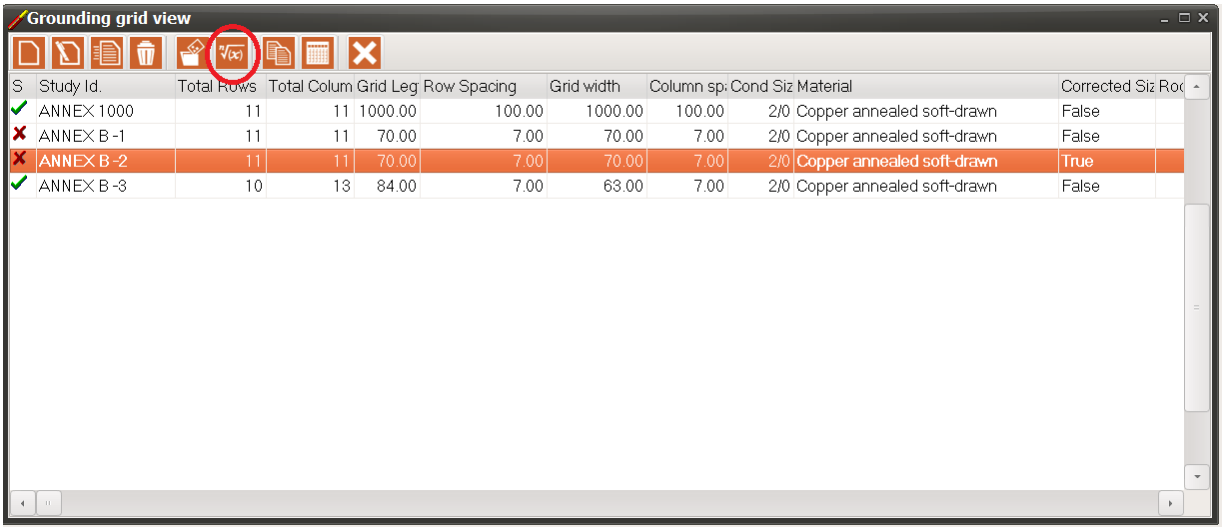
In the frame of tolerable potentials you should define if the calculation of tolerable voltages by the human body will be calculated for a person weighing 50 or 70 kg according to the calculation method defined in IEEE Std. 80.

This section provides a list of analysis results of the latest calculation according to the calculation method specified in IEEE Std. 80.The first item in the list shows the conclusion of the analysis indicating if the layout design meets the safety criteria recommended in the IEEE Std. 80, which compares the tolerable step and touch voltage by the human body against the grid touch and step potential generated with the array defined. Likewise, the conclusion of the analysis compares the value of the grid total resistance with the maximum allowed resistance by Mexican Official Standard NOM-001-SEDE-2012 and the value of maximum grid resistance user-defined in the electrical parameters section.

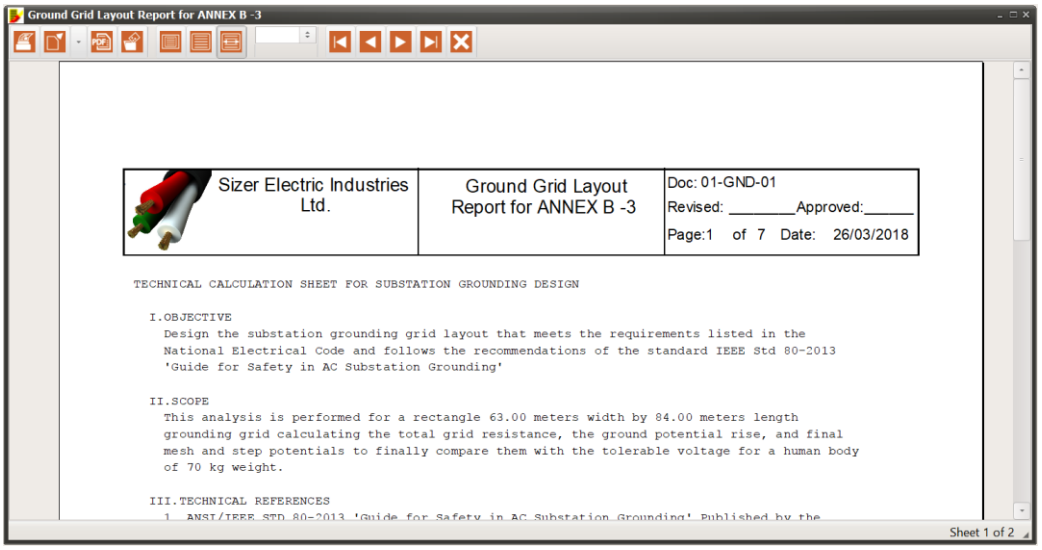
The list of results is generated for an engineering supervision to determine the changes required in the calculation data to obtain the adequate grid design. Once the optimal design is completed you can select the technical report option to print a comprehensive report with a detailed calculation process. To print this report press the *Accept* button to close the capture window and on the grid, select the row related to the study required and press the icon ***"Calculation report"*** in the tool bar. (See the next section for more details)

Grounding grid technical report

Obtain a printing of the technical report with a comprehensive analysis by selecting the row of the study required and pressing the icon ***"Calculation report"*** in the tool bar.



This will display the technical report according to the following format (For customization of reports see ***"Customizing Reports"*** topic in the "Reports" section of this manual):



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Chapter

9

Reports and software options

Reports

To print on the captured data and results generated in the system, you have the reporting option . All reports are presented primarily as a preview, if the report is the one required, you only need to select the print option button in the report preview. In general, the reports have the following toolbar for the administration:

Print. By selecting this option the printing of the active document is ordered.

Export. The report can not only be printed on paper, but it is also possible to save it to a file, this can be text type (TXT), comma delimited (CSV) or an Internet document (HTML).

Export to Acrobat. This option allows you to export the report shown in the screen to an Adobe Acrobat reader *.pdf format.

See full page: This option adjusts along the sheet report to the preview window.

100% View: Selecting this option allows to observe in detail the preview.

Page width view. This option the fits sheet width of the report to the preview window.

First page. By using this option leads us to the first page of the report.

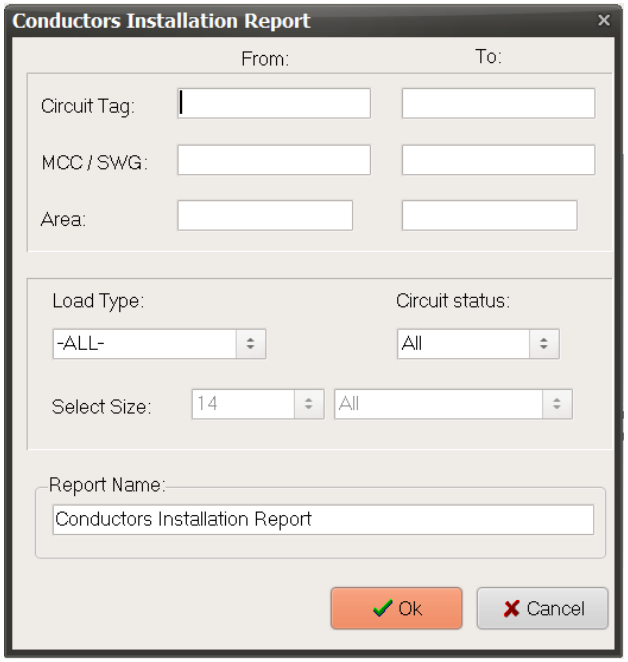
Previous page. Go to the previous page of the report.

Next page. Go to the next page of the report.

Last page. Using this option lead us to the last page of the report.

Close. Closes the report preview window.

With the exception of references and general data reports, all others have a filter to select the circuits or elements to be printed, this filter is based on the operation philosophy of the grid circuit filter discussed in Chapter 4, with the addition of a new field that allows us to customize the report title in the ***Report Name*** field.



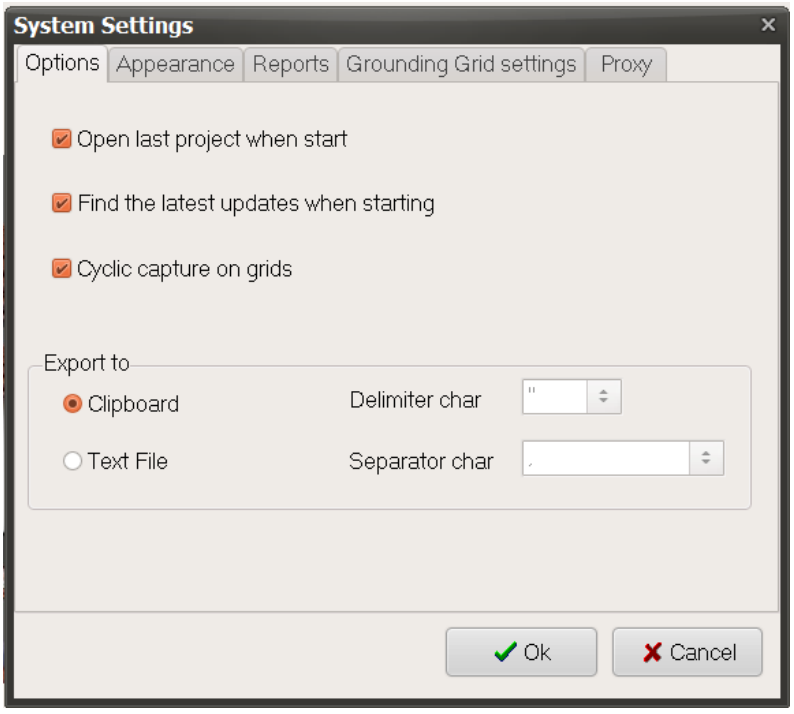
Following the reports with their respective fields are listed:

Report name	Fields
References	Project name, Customer, Location, Document / Memory, Captured by, Reviewed by, Approved by.
General data	System voltage, number of phases, Conductor material, Minimum size, maximum size, minimum power, maximum power, operating temperature, ambient temperature, insulation material, conductor shield
Conductors	Number Circuit, No. MCC or switchgear, conductor type, selected size, conductors per phase, ground size, voltage drop, voltage drop at start, conduit type, short circuit current, fault time , Maximum temperature rise.
Technical report	Circuit number, load type, Power Units, Length, rated current, corrected Current, Starting Current factor temperature adjustment factor, adjustment conduit Factor, installation type, Service factor, demand Factor, Power factor efficiency.
Circuits Data	Circuit number, equipment number, description, MCC No. or swgr, Area, load type, rated power, system voltage, number of phases, Units, Length, conductor type, selected Size, conductors per phase, Equipment grounding conductor size.
Selection criteria	Circuit number, conductor selected by ampacity, conductors per phase by ampacity, Conductor selected voltage drop, conductors per phase voltage drop, Conductor selected by drop at start, conductors per phase by drop at start, selected Conductor short circuit , conductors per phase short circuit, a Conductor selected by the user, conductors per phase per user, Conductor final selection, conductors per phase final selection, Conductor selected for grounding conductors per phase grounding, voltage drop, drop voltage at start.

System Settings

Location: *Tools* | *System Settings*

When System Settings option is selected in the *Main Menu and* Tools, a dialog box, which consists of five sections or tabs appears.



The *Options* section contains the following fields:

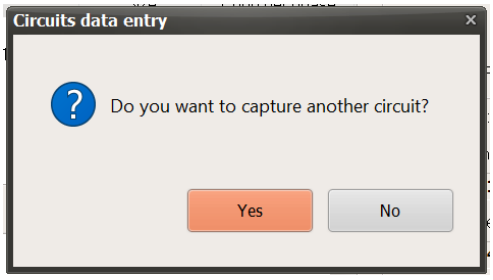
Show toolbar and Show Status Bar. During data collection it is sometimes necessary to have all the available work area, so the program can hide or show both the taskbar and the status bar with only select the associated check box.

Open last Project at start. When a project is in the design process, its use becomes constant, so checking this box will automatically open the last project closed at system startup this box. It is clear that when opening up the project a dialog box will prompt to ask for the password if the project is protected.

Cyclic capture on grids. As you noticed, it is common that during the process of capturing circuits data and general equipment information from a group of loads there is similar between the elements, so capture processes become a tedious task .

If the characteristics of your project dictate that the data of a circuit are the same as the next circuit you can enable the cyclic capture on grids. This capture mode commands *Sizer Electric* to keep the data within the boxes captured with the last circuit captured or characteristic captured, General Data of the last load, so that at the

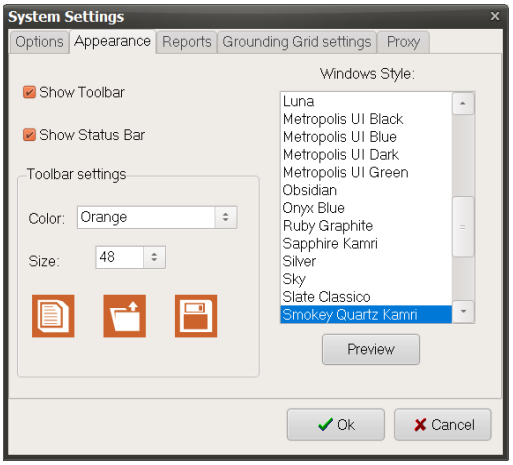
end of the capture process when pressing the OK button a window will prompt the following message:



When you select *Yes*, the circuit will be recorded and will be the basis for a new one, if you select *No* the circuit is not recorded and the capture window will close and finally if you decide to *Cancel* the information will not be saved but the capture window will not be closed

Export. To use the export process, you must specify the format that will be used to export the data. It is mandatory that one grid is active to copy data to the clipboard or to a text file. To export to a text file, in addition you must configure the columns alpha-numeric delimiter character.

Appearance Tab



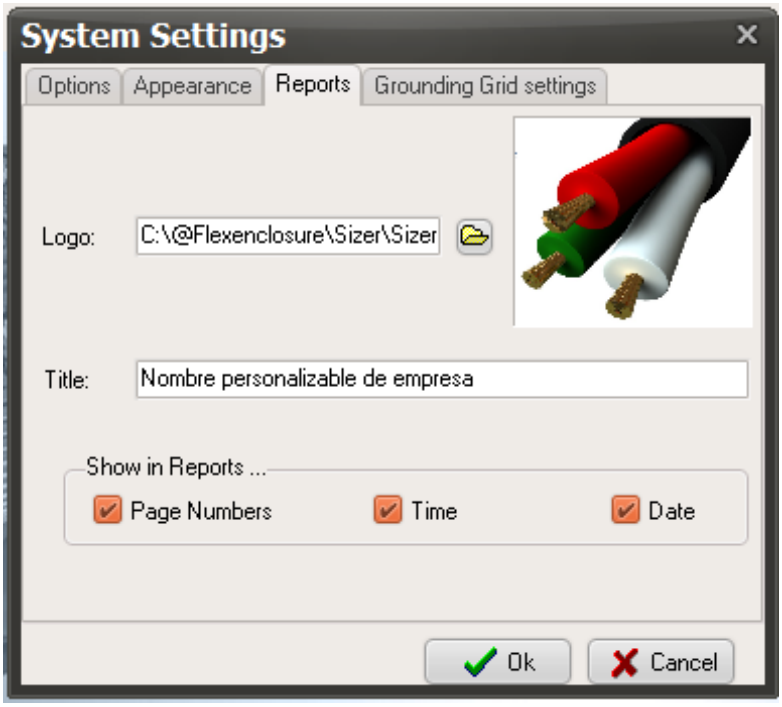
Show Toolbar. In this option you can show or hide the Tool bar at the top of the Graphic User Interface. The toolbar may be hidden to increase the area for the grids.

Show Status Bar. This check box present the notification bar located at the bottom of the screen. The Status bar describes the function of the menu options and icons in the tool bar and shows the progress of the computation tasks.

Windows Style. In this list you can select the background of the application to customize the appearance of your application.

Toolbar settings. Customize the size and color of the icons in the toolbar to harmonize those with the window style selected.

In the *Reports* tab



The final presentation of your work is the primary objective in any task performed. It is a common requirement that the information generated for customers have an identification that describe the company developing the project. In compliance with these requirements, the program has the ability to customize the printing reports including your company logo and company name.

To select the image that identifies your company you should only indicate the file path or press 3-points button where a window that will help you select your company logo appears. In the *Title* box indicate the legal name of your company.

In addition, the program has the flexibility to add in the report: The sheet number, the date and time when it was printed, all with just activate the respective check boxes

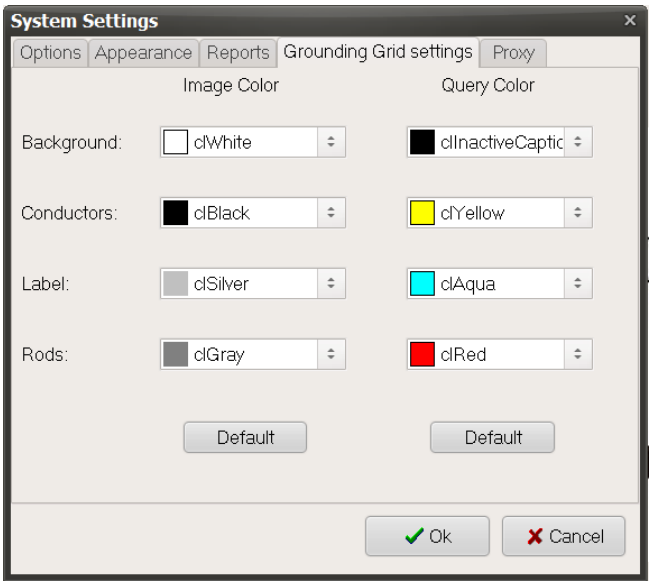
Grounding Grid Settings

Background: This option show two different lists of colors: One for the image shown in the report and the second color defines the color depicted in the capture window

Conductors: Define the colors to be used to represent the conductor in the reports and in the capture window.

Label: Define the colors to be used for the labels in the grid applicable for the reports and in the capture window.

Rods: Define the colors to be used for the symbols for the rods representation in the grounding grid applicable for the reports and in the capture window.

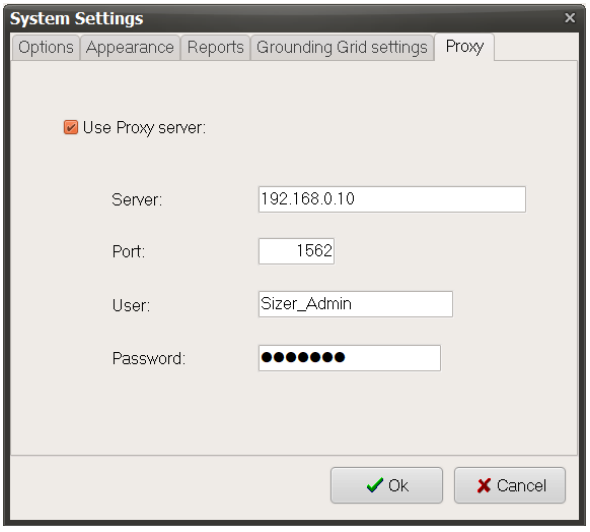


Proxy

The proxy or proxy server is a program or device that acts as an intermediary for requests made by a client to a server. This allows to offer functionalities such as access control, traffic registration, restriction to certain types of traffic and web cache among others. It is commonly used to restrict access to specific web pages.

Sizer Electric requires the information of the proxy server to process through this the permissions for sending the information of the project specifications and obtain the record of the consecutive number of the quotation requested.

If your network has a proxy server, the network administrator can provide the IP address and port of the proxy server as well as a user and password with the necessary privileges to exchange information with the Sizer Electric server. With this configuration you can send the information of the specifications of your project to obtain via e-mail a quotation and the technical support required for the conductors.



Use Proxy Server: If your computer is connected in a LAN or WAN and it has a proxy server for information intermediation, this box should be checked. If your equipment is *Stand Alone* or is *station* type, the box should remain unchecked.

Server: Is the unique IP address that identifies the proxy server.

Port: It is the communication port used to exchange data. It is usually an integer number of 4 digits.

User: It is a unique identifier that distinguishes an element registered in the server. This should have *Read* privileges for data query.

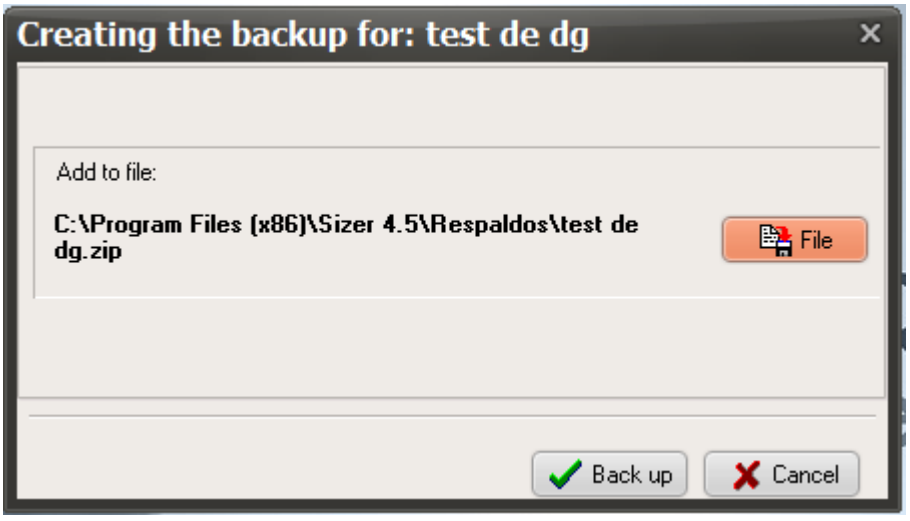
Password: It is the access key for user's identity validation.

Projects Back up

Location: *Options* | *Project back up*

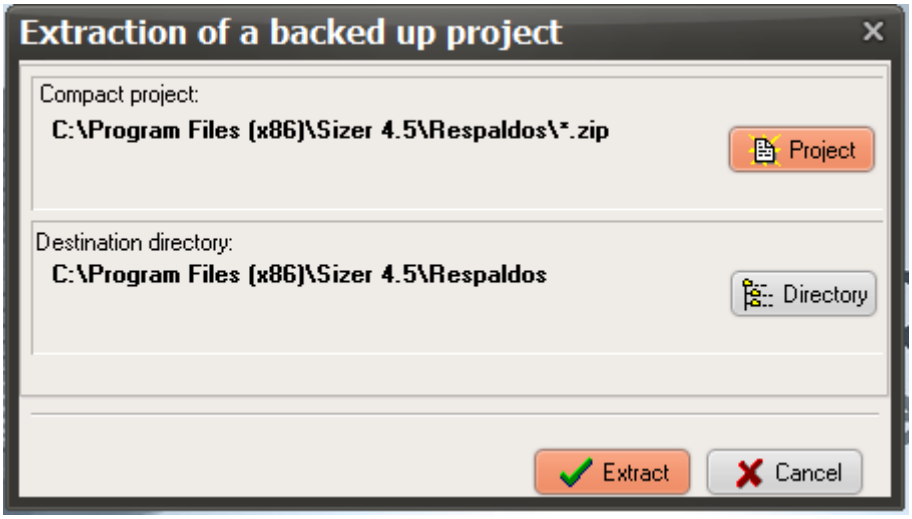
This process is used to copy the projects developed with the program to other devices such as a floppy disk, a network drive or on the same hard disk. By doing this a project history and a protection back up file are created in the event that a file is permanently damaged.

Compress files. With this option, the project backup will be created. It is advisable to make backups at least once a month and these are stored in a different computer hard drive. To perform the compression process, it is only necessary to select the file or create a new one with the *File* button and start the process with the *Backup* button.



Restore compression. When selecting this option you can restore a previously compressed file. To do this select the backup file you want to restore with the ***File*** button and also select the destination directory where you want to store the project. It is important to note that if there is a project with the same name as the project to

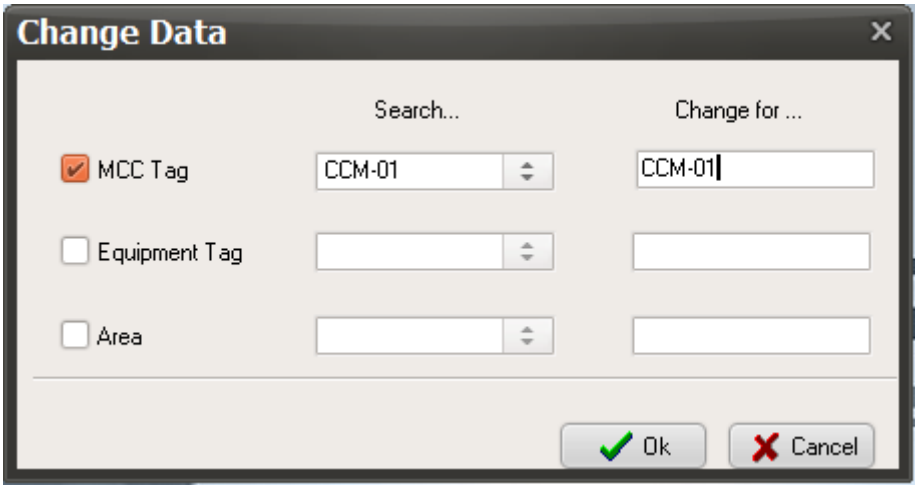
restore in the destination directory, the process is not performed. This in order not to overwrite any project.



Change data

Location: *Tools* | *Change data*

In the process of electrical projects design there are occasions in which data circuits change together. For example, when a group of circuits are connected to an MCC named 01-MCC-01 and switches to 01-CCM-02, in this case you will need to modify the MCC name on each circuit.

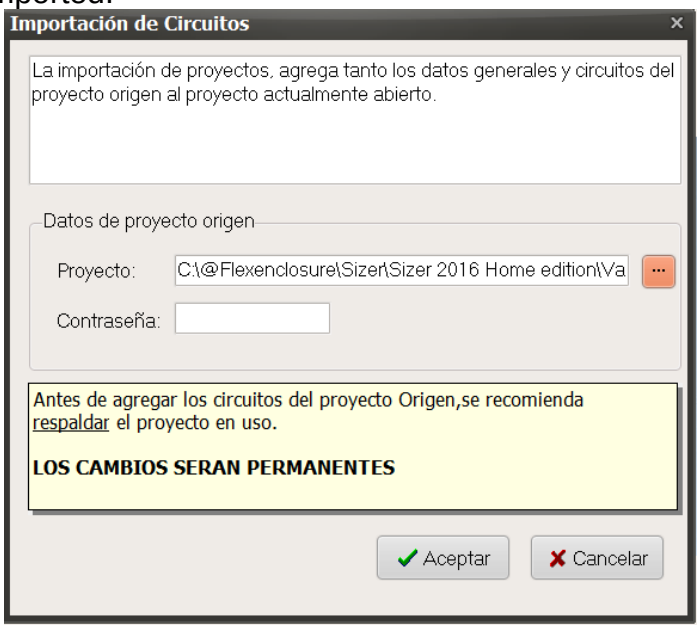


To meet this requirement you only need to select the checkboxes of the fields you want to change. In doing so the field list is filled in the *Search ...* field where you can select the item to change and capture the new element label in the *Change by ...* box

Import project

Location: *Tools* | *Import project*

You can import the data from circuits, cable trays and ground grid of another project. When selecting this option a dialog window will be shown that will allow you to select the project to be imported.



During the importation process there may be some inconsistencies or duplication in the information of the project that is being imported. Therefore, the application will validate the changes and will notify by means of a report the final status of the imported information.

Specifications

Location: *Tools* | *Specifications*

The application allows modifications to the specifications of the conductors as can be verified in the "Specifications" chapter. Sometimes it is convenient to reuse this information or it may be necessary to restore the system information to avoid corrupting the data. This option presents 3 alternatives:

Import from another project. By providing the direction of a captured project, it is possible to import only the specifications of this project without any other information being imported.

Initialize Table: Restores the values of the original Sizer Electric database.

Update Table: Updates the values not previously modified by the user to the default values of the program. The specifications modified by the user are not altered.

Calculator

Location: *Options* | *Calculator*

The program has the option to activate the Windows® calculator for purposes of technical calculations.

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Chapter

10

Restrictions and warnings

A. Motors. Efficiency and power factor values are determined from *Sizer Electric* data base and are average values for standard efficiency motors. These values should not be considered as guaranteed values, if the calculation with guaranteed efficiency values required, you must capture those in the fields designated for such data.

B. If the nominal current (Name plate current) is available for the circuit, this information may be considered mandatory if the status field is declared as *"final"*. For this case, you must also provide the power factor.

C. In the event that in the field of *Installation type*, is considered the *Cable tray* option you should also provide data cable tray data such as cable tray material, Rung spacing, Cover, and maintained spacing between conductors, for the correct selection and application of adjustment factors.

   For the case that in the field *Installation type* the *Conduit and Cable tray* option is selected, you must provide the *material* for cable tray, *rung spacing*, *cover*, maintained spacing between conductors, the material present should be the predominant between the two systems. In the *Conduit and Cable tray* case, the conductor are selected for both systems, with their respective factors and

considerations. The print order determines which systems presents the most critical case. Thus, the system has the largest number of conductors per phase is printed- If the number of conductors is the same, the system with the greater conductor size or greater conductor arrangement is selected If both selections have the same size, the program chooses the conductor or arrangement of conductors with the highest voltage drop. In the event that all the above conditions and the voltage drop is the same for both systems, the conduit is printed first as installation, because this calculation is performed first in the software algorithm. Therefore, in the final print the more critical (higher) voltage, the corrected current, the adjustment factors, the number of conductors per phase and the size selected for the type of conductor is the one that appears first in the print order.

D. In the service factor field the values entered should be provided within the range of 0.85 to 2.0 according to 430-22 (a) table NOM-001-SEDE-2012 and standard 430-22 (a) of the "National Electrical Code "2017.

E. If within the software input data no power factor or efficiency is provided, the program will determine these values from reference tables for the adequate motor voltage. If the motor power value is standard, ie, if found within the table, the power factor and efficiency corresponding to the 100% power load is assigned. If the motor power is not standard, power factor and efficiency of the motor of the immediate next power is assigned.

F. The program uses conductor allowable ampacity tables and databases for motors and temperature adjustment factors. It is recommended that these tables are kept updated with the *Sizer Electric* updates available on the web site: *www.sizerelectric.com* into *"Downloads"* section. "

G. Within the capture windows data validation is performed to reduce the number of errors during the process. It also associates the type of load units and equipment voltage in the same way the characteristics of the cable tray with the type of conductor. Because of this the information cannot be uploaded using Excel® or similar spread sheets.

H. During the capture process in some fields appear typical data in other fields containing related information. This is in order to simplify the process. However, they may be modified by the user.

I. In selecting the conductor size of the circuit, three main criteria are considered: conductor ampacity, voltage drop in operating conditions and voltage drop during start (motors only). Applying for the latter case the current resulting from the multiplication of the rated current for the number of times it increases during startup. In circuit data report generated by the program, the conductor size that meets the criteria set for each event. For conductor ampacity the *Selection Current* displayed is already multiplied by: Demand factor, Service factor and in the case of motors the Use factor that varies with the service type. This factor can vary from 1.25 to 2.0 times the motor rated current

according to the criteria of section 430-22 (e). It is necessary to clarify that the temperature adjustment factor an the adjustment factor of the characteristics of *installation type* are not applied to this *Selection Current* but are applied to table ampacities according to NOM-001-SEDE-2012 standard, section 392

J. There are differences in the consideration of minimum conductors sizes for cable trays. The NEC 2017 considers in section 392.10 (1) (a) the minimum conductor size as 1/0 AWG for ladder type cable trays with maximum run spacing of 9 inches (22.86 cm) and minimum conductor size of 250 KCM for ladder type cable trays with rung spacing of more than 23 cm. Article 392.10 within the scope covers, ladder type cable trays, solid through, solid bottom trays and similar structures. Meanwhile the Mexican Standard NOM-001-SEDE-2012 considered the same minimum sizes; however, in the note of Article 392-10 (a) (1) (a) of uses permitted, extends the range to 4 AWG minimum size if the cable tray rung spacing is 22.5 cm. Within the section 392-10 (a) (1) (c) of the official Mexican standard and section 392.10 (1) (c) of the National Electrical Code, the conductor size 4 AWG or larger is allowed in cable trays if these are used for grounding purposes. Therefore within the *Sizer Electric* algorithm those both criteria are used, the selected rules are applied with the standard selected in the Standards section. ie Mexican Official Standard NOM-001-SEDE-2012 or NEC-2017.

K. Minimum conductor size. The allowed minimum conductor size used for the selection in the project are defined in the *General Data* section. However, the minimum conductor sizes for selection of single conductors installed in cable trays shall be those established by the respective regulations (NOM or NEC). Under this criterion, the conductor carrying less than the allowable current for the minimum conductor size current, will be assigned the minimum size for example: Size 1 / 0AWG for cable trays with rung spacing of 22.5 cm or size 250 KCM for cable trays with run spacing greater than 22.5 cm. For this condition you should prevent not to install single conductors carrying small current in cable trays, since the application of minimum conductor size statements, the conductor area may be oversized with a consequent increase in cost. So it is necessary to perform further analysis to check for conductors carrying small monopole currents. In this case is more convenient to use multiconductor.

L. The adjustment factors for conductors with features described in the preceding paragraph, shall be considered by using the most critical factors depending on the type of conductor and cable type. These are 0.6 for single conductors installed in covered cable trays and 0.65 for single conductors installed in trays without cover.

M. To determine equipment grounding conductor size the Article 250-122 of the Mexican Official Standard NOM-001-SEDE-2012 and NEC 2017 is taken into consideration in which the conductor size is selected depending on the setting or shot circuit automatic protection device, so the considerations listed below were conducted, with the adjustment captured for these elements. It should be

noted that the final conductor size of the equipment grounding conductor, shall be reviewed and if necessary resized, when the final adjustment of this device is determined from a Protective Device Coordination Study.

1. In the case of feeders and control circuits it is considered the setting of the overcurrent protection device as the immediate superior commercial value, corresponding to the nominal current multiplied by the service factor.

2. In the case of transformers the adjustment or tripping overcurrent protection device is considered as equal to or immediately lower commercial value, corresponding to 250% of transformer rated current.

3. In the case of motors operating at different voltages to which databases have considered the setting of the overcurrent protection device should be equal to or immediately lower than the commercial value, corresponding to 250% of motor rated current .

N. For circuits having three phases and neutral, you must check whether through the neutral conductor flows the unbalance current, as in the case of circuits supplying discharge lamps, for this case you must provide the grouping factor for more than 3 current carrying conductors extracted from the grouping factor table on section 310-15 (b) (5) of the Official Mexican Standard NOM-001-SEDE-2012 or NEC-2017.

O. In accordance with section 250-122 of the NEC-2017 and Official Mexican Standard NOM-001-SEDE-2012, the program adjusts the size of the equipment conductor grounding to compensate for the voltage drop area differences in phase conductor . This compensation is proportional to the cross sections areas AWG. In circuits where multiconductor cable is used, the adjustment of the equipment grounding conductor according to the above is also performed. However, if the conductor area resulting from this conductor is less than the minimum size allowed by the UL-1277 specification "Underwriters Laboratories" the program assigns the conductor size defined by the UL.

P. When circuits for direct buried conductors are calculated, a total adjustment factor obtained from the components defined in the duct adjustment factors capture window by arrangement, depth, number of products, etc. Because the adjustment factor depends on the conductor size testing, during the capture process data the program will indicate the legend "*No Calc.*" in the fields requiring definition conductor size or interpolation. Once the calculation has been performed and the conductor was determined, the appropriate total adjustment factor will be available on the capture windows.

Appendix

A

Windows Configuration

Monitor Configuration

Sizer Electric has different windows or GUIs (Graphical User Interfaces) for capture, validation and storage processes for project data. These windows were designed to be properly displayed on a 600 x 800 pixels definition. If your monitor is SVGA or higher you will not find any difficulties configuring its definition to these values.

To configure the monitor to this definition follow these steps:

1. Select the *Start* button on the Windows taskbar.

2. From the *Start* menu select *Configuration* menu. In newer Windows versions you can also select the Control Panel option.

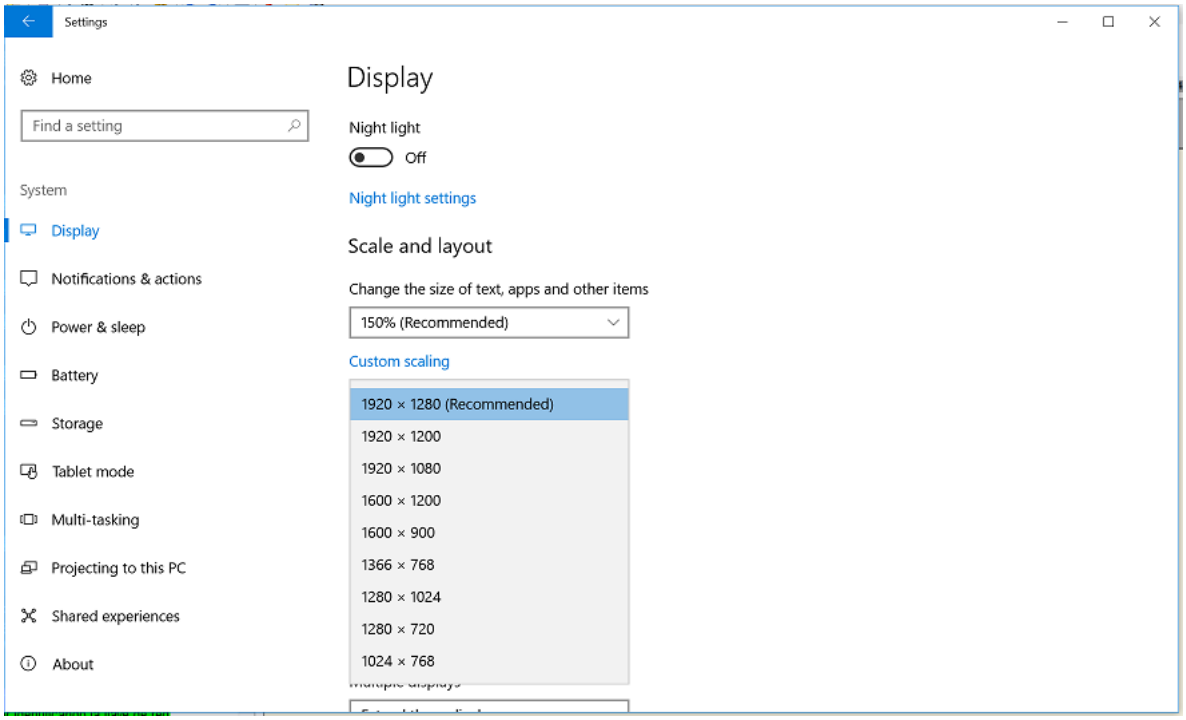
3. In the *Configuration* submenu select the *Control Panel* option will be presented. This window shows the different configuration options of the system.

4. Select the *Hardware and sound* option and Select the Display icon that shows the window for monitor settings.

5. Select the *Settings* tab *(or Advanced Display Settings for newer Windows versions)*.

6. Locate the *Display resolution* box and select *"600x800"* pixels or higher resolution.

7. Press the *Apply* button, Windows sends a message that will test before setting the new configuration and notifies you if the change was successfully applied.



NOTE: If your video board is not more than 1 Mb, your monitor does not support this configuration and the screen is observed completely dark If this happens, restart your computer. Boot Windows in fault mode, and repeat the operation to recover the previous configuration. The program may not properly be displayed on your monitor.

Numbers Configuration

Sizer Electric uses the international system for defining numbers. That is, decimal numbers should be separated from integer numbers by a point and with no commas separation for thousands and larger numbers. It is possible that abnormalities in validation processes occur if the numbers entered in the program have the character comma (,) as a means of separation between decimals and integers. To ensure proper performance of the program set regional setting of your system to the *English system*.

To configure your number system:

1. Select the *Start* button on the Windows taskbar.

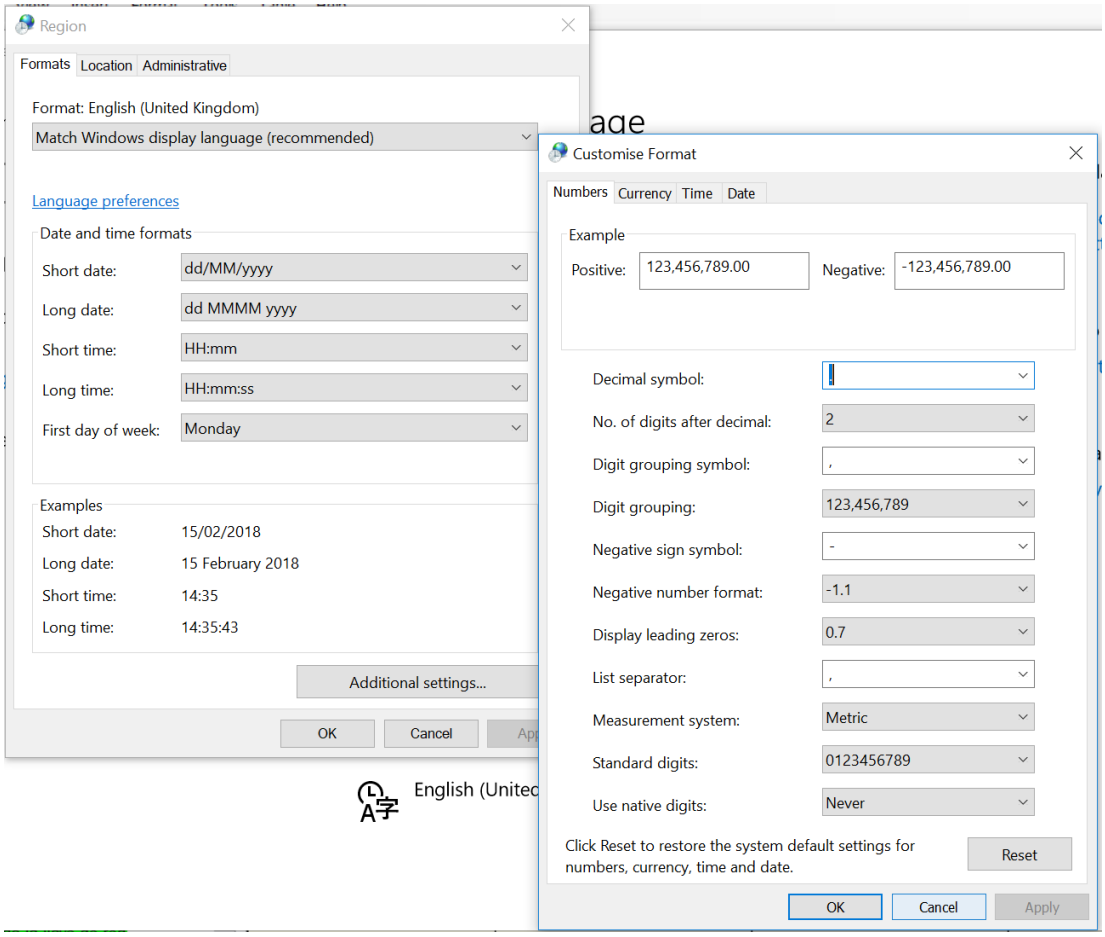
2. From the *Start* menu select the *Settings* menu.

3. The in the setup submenu, you should select the *Control Panel* option. This displays a window showing the different configuration options of the system.

4. Select the *Regional Settings* icon that opens the window for system configuration. For newer Windows versions select "*Time, language and region"*

5. Select the *Number* tab. For Newer windows versions select the Format tab and then select the *"Additional Settings.."* button.

6. Locate the Symbol drop-down list and select as the decimal character a point (.)
7. Press the *Apply* button. Windows will send a message describing that it will perform a test before setting the new configuration and will notify you if the change was applied successfully.



Conflicts and clarifications

Below is a table where you can find some conflicts or clarifications that might arise during the operation of *Electric Sizer*. As well as some of the solutions:

Conflict	Cause / Clarification	Solution
When you start the program requests a password that is unknown.	The program begins by opening the last open project	If the password has not been changed enter the keyword. KEY or CLAVE If you want to disable the "Open last project" Main Menu + Options+ System Setup+
The grid or reticle does not show all the data captured	Applied filter or hidden columns	Disable the filter using the "Remove filter" icon or customize the reticle.

Conflict	Cause / Clarification	Solution
The generated file is very large	Database is not compacted	To compact the database select "Compact Database" option on *Main Menu + System Setup+ Options*
Inappropriate validation in data capture windows	Numerical error in the system configuration.	Configure your system numbers. *See the previous section*
The screen capture is very large and cannot be fully displayed on screen.	Monitor Configuration	Set your monitor to a definition of 600 x 800 pixels.
The top left section of the reports is empty.	Company logo or name is not defined for the document. Is not customized yet	Customize the report printing. *See chapter10*
I require to modify the legend that appears in reports. (Middle upper section)	Report has not been customized	At the bottom of the window that appears when you select the type of report, indicate the new legend for the report..
The icons described in the help or in the manual are not observed	Problems in Windows libraries	Windows NT in earlier editions had problems with some graphics handling. Install service packs for these applications.
When calculating a circuit a system message indicating that there is no space available on the disc appears.	When performing a calculation text file is created in your hard disk in the directory where the project is located:.	Free hard disk space in your computer, or relocate your data file to a drive with enough free space.
By selecting printing reports an system error message appears.	Printer driver error	Reinstall the printer driver.

Conflict	**Cause / Clarification**	Solution
The rated currents of the report are greater than that obtained by the formula to calculate power for loads balanced	The current for motor conductor selection should be based on the nominal currents of the motor table proposed for the voltage level according to section 430-1 of the applicable standard NEC/NOM.	See the selected standard in section 430-1
Validation inappropriate data capture windows	Numeric error in the system configuration.	Configure your operative system format numbers
The selection current is very large	The selection current is the product of the increase factors defined in section 430-122 (a) divided by the adjustment factor applied for conduit, duct or tray installation.	See the selected standard (NOM/ NEC) in section 430-22 and 430-22 table (a) ad adjustment factor for 310.15 and 392.

Analytic Index