

# ArCADia-POWER NETWORKS

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ArCADia-POWER NETWORKS User Manual



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## Table of Contents

<b>1</b>	<b><i>Introduction .....</i></b>	<b><i>4</i></b>
1.1	About .....	5
1.2	Features and functionalities of the program.....	5
<b>2</b>	<b><i>Installing and running the program .....</i></b>	<b><i>6</i></b>
2.1	Installing .....	7
2.2	Running.....	7
2.3	Opening a project (CAD).....	7
2.4	Saving a project (CAD) .....	8
2.5	Autosave and back-up copy (CAD).....	8
<b>3</b>	<b><i>Working with the software.....</i></b>	<b><i>9</i></b>
3.1	Basic software information .....	10
3.2	Software element description.....	10
3.2.1	General software options.....	12
3.3	Calculations .....	13
3.4	Description of facilities.....	17
3.4.1	Transformer station .....	17
3.4.2	Buried line.....	18
3.4.3	Overhead line .....	22
3.4.4	Cable connection .....	23
3.4.5	Connection point .....	25
3.4.6	Distribution board .....	27
3.4.7	Cable joint box .....	28
3.4.8	Power pole.....	29
3.4.9	Protective pipe.....	32
3.4.10	Insert survey point.....	33
3.4.11	Changing views of 2D items .....	35
3.4.12	Editing and introducing types.....	36
3.4.13	Generating a schematic diagram.....	42
3.4.14	Generation of lists .....	43
3.4.15	Example material list.....	44
3.4.16	Generating network verification reports.....	44
3.4.17	Exemplary network verification report.....	46



# 1 INTRODUCTION

## Introduction

### 1.1 ABOUT

**ArCADia-POWER NETWORKS** is an intelligent tool that expands ArCADia-INTELLICAD/AutoCAD with features necessary to create professional documentation concerning the design of external LV power networks. The software is addressed both to designers of networks, installations of electric and power networks, as well as to anyone associated with the electro-technical industry. The user of the **ArCADia-POWER NETWORKS** software is able to quickly create drawings of external power networks on spatial development plans or to make their own drawing showing the network between the LV transformer and switchboard in the building. The user may also use a library of items employed when designing, along with an option to edit the items and add parameters to them. Apart from the efficient creation of technical drawings, the software carries out calculations necessary to design the network correctly and create professional technical documentation. Merging specialized features used in the application for creating technical drawings of external power networks along with carrying out the calculations and running validity checks on the designed network provides the perfect tool for designing LV networks.

### 1.2 FEATURES AND FUNCTIONALITIES OF THE PROGRAM

The technical scope of functionalities provided by the software and its basic functions:

- Designing power cable and overhead connectors for buildings.
- Designing extensive cable and overhead lines
- Designing external lighting installation networks
- Execution of technical calculations
- Selection of buried and overhead lines
- Selection of power protection measures
- Inspection of electric shock protection via quick automatic power cut-off
- Generating of network verification report reports and material lists

All calculations and the verification carried out by **ArCADia-POWER NETWORKS** were developed based on the following standards and regulations:

- [1] PN-87/E-90050. General-purpose power conductors to be placed permanently. General requirements and tests.
- [2] SEP N SEP-E-004 standard "Power and signal cable lines – Designing and construction"
- [3] PN-91/E-05009/482 – Protection against electric shock.
- [4] PN-EN 60865-1:2002 (U) Calculation of short-circuit currents effects. Part 1: Definitions and calculation methods
- [5] PN-EN 60909-0:2002 (U) Short-circuit currents in three-phase AC networks. Part 0: Calculations of currents.
- [6] PN-EN 60269-1:2001 (U) LV safety thermal fuses. General requirements
- [7] PN-EN 60947-3:2002 (U) LV distribution and control devices. Part 3: Load switches, disconnecting switches, switch disconnectors and sets of connectors with safety thermal fuses.
- [8] "Album linii napowietrznych wielotorowych niskiego napięcia z przewodami izolowanymi samonośnymi o przekroju 25-120 mm<sup>2</sup>", Poznań, June 1999.
- [9] PN-IEC 60364-5-523 "Electric installations in buildings. Selection and installation of electric equipment. Continuous current-carrying capacity of conductors".
- [10] PN-IEC 60364-4-41 "Electric installations in buildings. Protection for safety. Protection against electric shock".

## 2 INSTALLING AND RUNNING THE PROGRAM

## Installing and running the program

Hardware requirements:

- Procesor Intel Core 2 Duo lub AMD Athlon II (recommended min. Intel Core i5-6500)
- 3 GB RAM (recommended min. 12 GB and system 64-bit)
- 5 GB of free HDD space (recommended SSD)
- For standard 3D view graphics card compatible with DirectX 9.0c 1GB RAM, for advanced 3D view graphics card compatible with DirectX 11 and min. 3GB RAM
- Windows 10 , Windows 8.1 , Windows 7 SP1 (recommended Windows 10 64-bit)

### 2.1 INSTALLING

The program installation is started automatically when the CD is inserted into the CD drive. The installation should be started manually if the Autostart function is disabled. Open the CD content (Computer/CD drive) and run the Setup.exe file from the program folder. Once the installation is started, proceed according to instructions displayed on the screen.

### 2.2 RUNNING

The software may be started by double-clicking on the CAD program icon located on the desktop and then selecting one of the icons in the **ArCADia-POWER NETWORKS** toolbar.

### 2.3 OPENING A PROJECT (CAD)


Any of the following file types may be opened:

- A standard DWG drawing file.
- Any of the following sample drawings supplied with the ArCADia-INTELLICAD software may be used.
- A DXF drawing exchange file.
- A DWG network transmission file.
- A DWT drawing template file.

In order to quickly access the last edited drawing choose File> <file name>. The software stores the names of the last four drawings. In order to quickly access a drawing from the Open drawing dialogue box, double-click the drawing name.

A drawing may be opened when browsing drawings on the computer using e.g. Windows Explorer. All you need to do to open the drawing in IntelliCAD is to double-click the file. Miniature drawings displayed when browsing facilitate the identification of the selected drawing.

Opening an existing drawing

1. Use one of the following methods:
  - Choose File>Open.
  - On the Standard toolbar select the Open (  ) tool.
  - Write *open* and then press Enter.
2. Choose the type of the file you want to open from file type.
3. Choose the folder that contains the selected drawing.
4. Do one of the following:
  - Choose the drawing that you want to open and click Open.
  - Double-click the drawing you want to open.

If the drawing requires a password, provide the password, then click OK to verify the password and click Open again.

## Installing and running the program

### 2.4 SAVING A PROJECT (CAD)

A drawing may be saved at any moment.

In order to save a drawing use one of the following methods:

- On the Standard toolbar click Save.
- Choose File>Save.
- Write *save* and then press Enter.
- Write *qsave* and then press Enter.

When you save a particular drawing for the first time, the system will display a dialogue box Save drawing as, which enables you to select the folder and provide the name for the drawing. You can use any name at all when saving the drawing for the first time. In order to save the same drawing under a different name later, select File>Save as and then type in the new name.

### 2.5 AUTOSAVE AND BACK-UP COPY (CAD)

In order to avoid data loss in case of a power outage or another system error, it is necessary to save your drawing files often. The software may be configured to periodically save your drawings automatically. The *Autosave* setting determines the interval in minutes between automatic saves. The software resets this interval each time when the user saves a drawing file.

When the *Autosave* feature is activated, the software creates copies of the drawing. This file is automatically saved to the folder provide under Options>Paths/Files>Temporary file and given the extension indicated in the Drawing autosave file extension (SV\$ by default).

Configuring ArCADia-IntelliCAD to automatically save drawings

1. Do one of the following:
  - Select Tools>Options.
  - Write *config* and then press Enter.
2. Click the General tab.
3. In the *Autosave* area select one of the check boxes in order to enable the *Autosave* feature and select the autosave frequency.
4. Click OK.



## 3 WORKING WITH THE SOFTWARE

## Working with the software

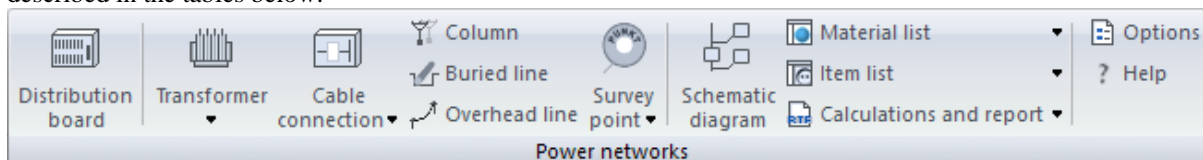
### 3.1 BASIC SOFTWARE INFORMATION

**ArCADia-POWER NETWORKS** enables designing both cable and overhead power networks. The route is to be drawn in the metre scale (1 unit on the ArCADia-INTELLICAD screen corresponds to 1 metre in the design). The course of action for designing networks is as follows:

1. You can start drawing the network by designing the power source or defining the connection point. The user can also place poles, connectors or a distribution board and then insert the power source. Technical calculations will not be carried out if the designed network does not contain the power source and a branching element (connector or distribution board).
2. If we are building a LV network along with a transformer station, we should use the transformer as the power source in the drawing. If we are planning an expansion of an existing network, we should define properties of the connection point (information about the existing network). The next step is the location of distribution and branching points, i.e. cable connectors, electric poles and distribution boards.
3. When designing an external lighting network (road lighting, local terrain lighting) the user should determine the location of the take-off points, such as distribution boards (when designing connections) or lighting poles.
4. Once the power supply and distribution facilities are in place, we can begin designing the network. Depending on the area development, we can choose between a buried and an overhead line.
5. Using the buried or overhead line, we connect to the power source (mouse-click on the transformer) and continue with the line, routing it towards a branching or terminal element. This procedure can be carried out in the reverse order.
6. Once the network has been designed, a network structural diagram can be generated.
7. Once the network has been designed, a report can be generated, showing the results of technical calculations along with a validity verification for the designed network.
8. The user can also generate a list of materials necessary to erect the designed network.

### 3.2 SOFTWARE ELEMENT DESCRIPTION

The **ArCADia-POWER NETWORKS** adds its own tools to the ArCADia-INTELLICAD/AutoCAD menu, as described in the tables below:



















Drawing 1. ArCADia-POWER NETWORKS toolbar

*\*BIM* – options available to ArCADia BIM license holders, i.e. after purchasing one of the following programs: ArCADia, ArCADia AC, ArCADia LT or ArCADia PLUS.

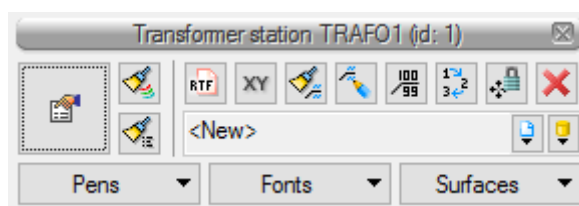
Functions of the **ArCADia-POWER NETWORKS** toolbar:

Icon	Function	Description	<i>*BIM</i>
	<i>Show/Hide Project Manager</i>	Displays or hides the level management window.	✓
	<i>Insert transformer station</i>	Inserts a transformer station along with a description.	X
	<i>Insert connection point</i>	Inserts a connection point along with a description.	X
	<i>Insert distribution board</i>	Inserts a distribution board along with a description.	X








## Working with the software

	<i>Insert cable joint</i>	Inserts a cable joint along with a description.	<b>X</b>
	<i>Insert cable joint box</i>	Inserts a cable joint box along with a description	<b>X</b>
	<i>Insert buried line</i>	Inserts a buried line along with a description.	<b>X</b>
	<i>Insert overhead line</i>	Inserts an overhead line along with a description.	<b>X</b>
	<i>Insert power pole</i>	Inserts a power pole along with a description	<b>X</b>
	<i>Insert protective pipe</i>	Inserts a protective pipe along with a description.	<b>X</b>
	<i>Insert survey point</i>	Inserts survey points on a projection along with a description	<b>X</b>
	<i>Insert schematic diagram</i>	Generates a schematic diagram of the designed network	<b>X</b>
	<i>Generate report</i>	Generates a report presenting technical calculations and the validity of the designed network.	<b>X</b>
	<i>Generate material list</i>	Generates a list of materials used in the design.	<b>X</b>
	<i>Insert material list for selected elements</i>	Inserts material list from the installation elements selected on the projection.	<b>X</b>
	<i>Insert item list</i>	Inserts an item list of the sewage installation along with the graphical symbols, names, markings and quantity.	<b>X</b>
	<i>Insert selected elements list</i>	Inserts a list of installation elements selected on the projection.	<b>X</b>
	<i>Insert a list of coordinates for survey points</i>	Generates a report containing the X, Y survey coordinates in a RTF file.	<b>X</b>
	<i>Program option settings</i>	Enables the use of standard options for the entire project.	<b>X</b>
	<i>Show help</i>	Displays the help window.	<b>X</b>

Once an item is clicked, the following toolbar is shown on the model:



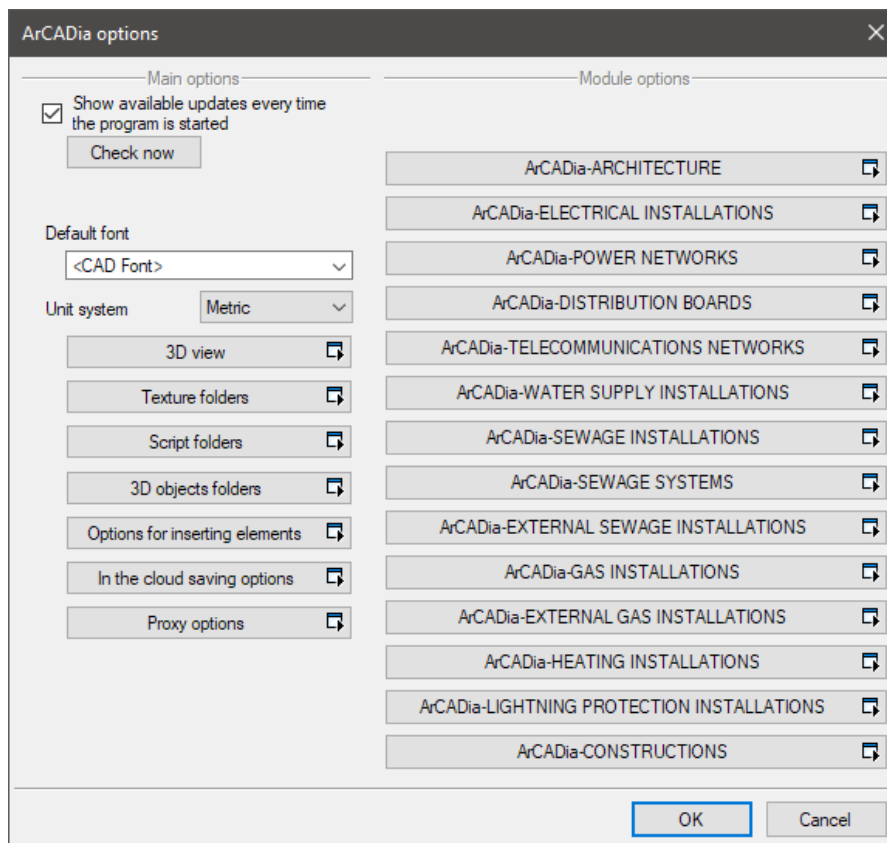
### description painter

-  - type painter
-  - fonts pens painter
-  - set description on the link
-  - edit description
-  - generate report to file
-  - item coordinate report
-  - object renumbering
-  - move with connections

## Working with the software

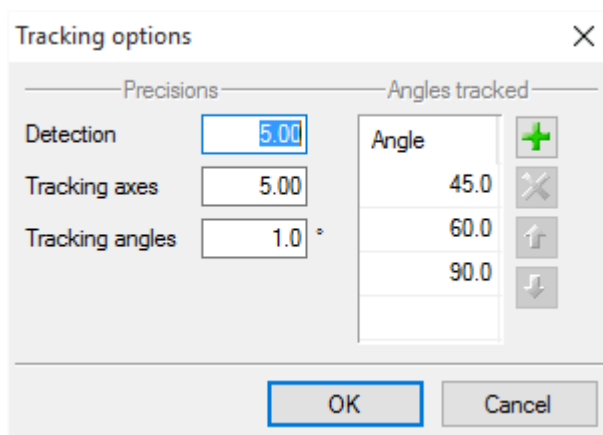
### 3.2.1 General software options

The user will also have the possibility to display an options window from the **ArCADia menu**. An action bar will extend, where the user needs to select **Options**. The general options window of ArCADia software will be displayed and then the user should click **ArCADia-ELECTRICAL NETWORKS**.






Drawing 2. ArCADia BIM system options window



On the left side of the options window one of the last buttons is the inserting options button. After clicking the button the user may open the **Options for inserting elements** window:



Drawing 3. Tracking options window

## Working with the software

On the left side the user may define how precisely (maximum distance from the element axis which will allow for detection) will the elements, axes and angles be detected while element axis  and angles  tracking is enabled and elements detection  is enabled.

**Angles tracked** may be inserted on the right side of the window. In the table the user may add, using the  button, another angle which they want to track when inserting elements. If the user wants to delete one of the angles, he needs to select it by clicking it in the table and then delete one of the values using the  button on the right.

After defining the modification precision and the number and values of the angles tracked, the user may confirm the changes using the **OK** button (changes will be saved in the software) or reject them using the **Cancel** button (all changes done at the time in the tracking options window will be cancelled).

### 3.3 CALCULATIONS

Once the network has been designed and appropriate parameters have been assigned to it, **ArCADia-POWER NETWORKS** will carry out standard calculations:

- maximum and minimum short-circuit currents (single-phase and three-phase short-circuit currents, surge current) on individual sections of the designed network,
- calculation of load currents (1-phase or 3-phase) on individual sections of the designed network,
- calculation of voltage drops,
- calculation of short-circuit loop impedance,
- calculation of peak power in the designed network,
- determination of the protection trip current for short-circuits within a time-frame defined by the user,
- determination of continuous current-carrying capacity.

Once the technical calculations are carried out and the necessary parameters are established, **ArCADia-POWER NETWORKS** informs the user about the validity of the designed network sections; namely, it verifies the correct choice of cables or overhead line conductors (due to the long-term current carrying capacity and voltage drop), correct choice of protection (retention of electric shock protection) and coordination of conductors and cables with protective measures.

In the report the designer can see a list of potential errors in the created network. The report also informs the designer where and why a mistake was committed. The user can preview the partial calculations, i.e. the software quotes technical information (values of determined parameters) for each designed section. The report also contains a list of materials necessary to erect the designed network.

The report is generated in the RTF format and contains all the information necessary for professional technical documentation.

Technical calculations begin by defining a power source, which in our software is a **transformer** or **connection point**.

At this stage, the software determines the transformer resistance and reactance. The user has two options with which to define the transformer: standard and non-standard. In the standard option, resistance and reactance values are assigned for the rated transformer power, while in the non-standard option the user inputs two parameters, i.e. the short-circuit voltage and power losses in winding. Resistance and reactance are calculated based on these values from the following formulas:

- **percentage short-circuit voltage  $u_x\%$  [%]** – each transformer, depending on its power, has a percentage short-circuit voltage

$$(1) \quad u_{x\%} = \sqrt{u_{z\%}^2 - u_{r\%}^2} \quad \text{– short-circuit voltage passive component}$$

- **power losses in winding  $\Delta P_{Cu}$  [W]:**

## Working with the software

$$(2) \quad u_{r\%} = \frac{\Delta P_{Cu}}{S_T} \cdot 100 \quad - \text{transformer short-circuit voltage active component}$$

- **transformer resistance [Ω]:**

$$(3) \quad R_T = \frac{u_{r\%}}{100} \cdot \frac{U_n^2}{S_T}$$

- **transformer reactance [Ω]:**

$$(4) \quad X_T = \frac{u_{x\%}}{100} \cdot \frac{U_n^2}{S_T}$$

The designer can connect a specific number of power circuits to the transformer, i.e. the transformer rated power must be equal or higher than the peak power:

$$(5) \quad S_N \geq \frac{P}{\cos \varphi}$$

where:

$\cos \varphi$  – power coefficient input by the user,  
**P** – maximum load power (total calculated power demand in the network).

The next calculations are carried out after defining a power circuit connected to the transformer. First the software calculates the load current in a specific circuit.

If the designer defines the circuit as single-phase and connects it to a defined control connector ZK-1 (the calculated power demand will be stated along with the  $\cos \varphi$  power coefficient), then you should use formula (6). If this is a three-phase circuit, use formula (7).

**I<sub>L</sub> – load current present in the designed power circuit**

$$(6) \quad I_L = \frac{P_0}{\sqrt{3} \cdot U_N \cdot \cos \varphi} \quad - \text{three-phase load current present in a particular circuit.}$$

where:

**P<sub>0</sub>** – design power,  
**U<sub>N</sub>** – 400 [V] line-to-line voltage,  
**cos φ** – power coefficient input by the user,

$$(7) \quad I_L = \frac{P_0}{U_{Nf} \cdot \cos \varphi} \quad - \text{single-phase load current present in a specific circuit.}$$

where:

**U<sub>Nf</sub>** – 230 [V] phase voltage,

The next step in the calculations carried out by **ArCADia-POWER NETWORKS** concerns voltage drops in a specific circuit. To this end the software uses the following formulas:

Voltage drop formula for three-phase circuits:

$$(8) \quad \Delta U_{\%L1} = \frac{100 \cdot P_0 \cdot l}{\gamma \cdot s \cdot U_N^2}$$

## Working with the software

Voltage drop formula for single-phase circuits:

$$\Delta U_{\%L1} = \frac{200 \cdot P_0 \cdot l}{\gamma \cdot s \cdot U_f^2} \quad (9)$$

where:

**l** – length of the power supply cable [m],

**s** – conductor cross-section (this parameter is to be input by the designer),

**γ** – conductor conductivity

**γ = 35 [m/(Ω\*mm<sup>2</sup>)]** for aluminium

**γ = 58 [m/(Ω\*mm<sup>2</sup>)]** for copper

**P** – installed power [W],

**U<sub>f</sub>** – phase voltage, i.e. 230 V,

**U<sub>N</sub>** – line-to-line voltage, i.e. 400 V,

Calculating the maximum permissible voltage drop (at the network terminal), we sum up the voltage drop values on all sections designed by the user, i.e.:

$$\Delta U_{\% \text{ perm.max.}} = \Delta U_{L1\%} + \Delta U_{L2\%} + \dots + \Delta U_{Ln\%} \quad (10)$$

In order to calculate the short-circuit currents in a particular circuit the software first calculates the resistance **R<sub>L</sub>** and reactance **X<sub>L</sub>** of the designed power circuit and the resulting short-circuit loop impedance **Z<sub>K</sub>**. To this end, the following formulas are used:

$$Z_K = \sqrt{(R_K)^2 + (X_K)^2} \quad (11)$$

where:

**R<sub>k</sub> = R<sub>Tr</sub> + R<sub>L1</sub> + R<sub>L2</sub> + ...** – sum of resistances in the individual sections of the designed network,

**R<sub>Tr</sub>** – transformer resistance, depending on its power,

**R<sub>L1</sub>** – each overhead line and each power cable have their resistances that depend from the conductor material (copper or aluminium), its cross-section and the length of the designed section.

$$R_L = \frac{l}{\gamma \cdot S} \quad (12)$$

where:

**l** – length of the power supply cable [m],

**s** – conductor cross-section (this parameter is to be input by the designer),

**γ** – conductor conductivity

**γ = 35 [m/(Ω\*mm<sup>2</sup>)]** for aluminium

**γ = 58 [m/(Ω\*mm<sup>2</sup>)]** for copper

**X<sub>k</sub> = X<sub>Tr</sub> + X<sub>L1</sub> + X<sub>L2</sub> + .....** – sum of reactances of the individual sections of the designed network,

**R<sub>Tr</sub>** – transformer reactance, depending on its power,

**R<sub>L1</sub>** – each overhead line and each cable have their reactances that depend from the material of the conductor (copper or aluminium), its cross-section and length of the designed section.

Calculations of initial, maximum and minimum short-circuit currents (single-phase short-circuit

## Working with the software

current, three-phase short-circuit current, surge current) on individual sections of the designed network are carried out with the following formulas:

### - Three-phase short-circuit current:

$$(13) \quad I_{P3-f} = \frac{c \cdot U_n}{\sqrt{3} \cdot Z_K} \quad \text{-- initial current of the three-phase short-circuit,}$$

where:

$Z_K$  – substitute compliant impedance of the short-circuit circuit

### - Single-phase short-circuit current:

$$(14) \quad I_{P1-f} = \frac{0,95 \cdot U_{nf}}{Z_{KZ}} \quad \text{-- initial current of the single-phase short-circuit (L1-PE short),}$$

where:

$U_{nf}$  – phase voltage in the power supply network, i.e. 230 V

$Z_{KZ}$  – impedance of the short-circuit loop in case of a single-phase short-circuit (L1–PE) is equal to the total impedances of the transformer, phase conductors and protective conductors.

Calculations of short-circuit loop impedance are carried out assuming that the cross-sections of the phase and protective conductors are identical (the software does not take into account any possible PE protective conductor cross-section shrinkage).

$$(15) \quad Z_{KZ} = \sqrt{(R_K)^2 + (X_K)^2}$$

where:

$R_{kZ} = R_{Tr} + 2 \cdot R_{L1} + 2 \cdot R_{L2} + \dots$  – sum of resistances from individual sections of the designed network, taking into account a PE return conductor.

$X_{kZ} = X_{Tr} + 2 \cdot X_{L1} + 2 \cdot X_{L2} + \dots$  – sum of reactances from individual sections of the designed network, taking into account a PE return conductor.

### - Surge current:

$$(16) \quad i_U = \sqrt{2} \cdot K \cdot I_{p1}$$

where:

$I_p$  – initial short-circuit current



$K$  – surge coefficient can be read from figure 2.2 in H. Markiewicz's "Electric installations".

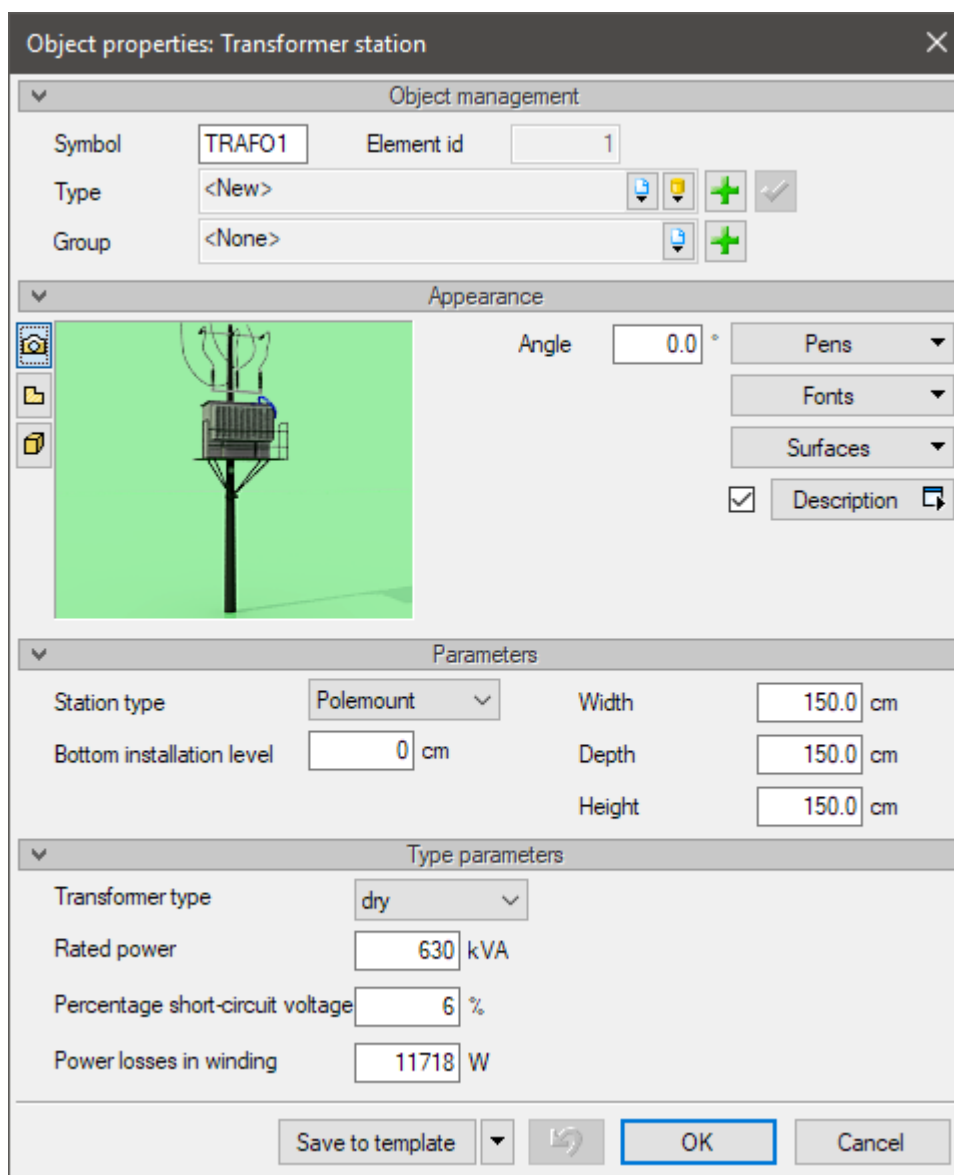


## Working with the software

### 3.4 DESCRIPTION OF FACILITIES

#### 3.4.1 Transformer station





Once the  icon is selected, we can add an element to the project. A window with the properties of the designed transformer station is displayed by selecting the  button or double clicking on the inserted element.





**Object properties: Transformer station**




**Object management**

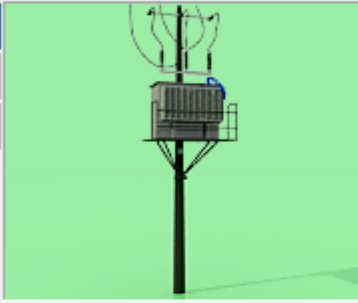
Symbol: TRAF01    Element id: 1




Type: <New>       


Group: <None>     

**Appearance**


  



Angle: 0.0°    Pens:     Fonts:     Surfaces: 

☒ Description 


**Parameters**

Station type: Polemount     Width: 150.0 cm

Bottom installation level: 0 cm    Depth: 150.0 cm

Height: 150.0 cm



**Type parameters**

Transformer type: dry 

Rated power: 630 kVA

Percentage short-circuit voltage: 6 %

Power losses in winding: 11718 W

Save to template         OK    Cancel

Drawing 4. Transformer station properties window

First we define the visual features of the facility, i.e. we assign the transformer symbol, placement angle and dimensions shown in the drawing.

Next we select the transformer station type. The following types are available:

**Polemount** – mounted on special platforms installed on (usually concrete) poles. These stations are usually prefabricated, so there are lots of stations of the same type. Additional elements in such stations are overvoltage

## Working with the software

limiters that are placed between the input line and station transformer. Older station types also contained fuses and disconnectors.

**Internal** – usually located inside buildings on residential, service and industrial premises, devices of this type differ depending on the room in which they are located. Depending on the room dimensions, elements like the transformer, MV distribution board, LV distribution board and distribution board bus conductors can be distributed differently against one another.

**Container** – usually placed in containers or stand-alone buildings. The solutions used for container transformers are repetitive and in the case of urban, stand-alone units the locations of individual components may vary, depending on the dimensions of the rooms. Container stations can have casings made of steel, aluminium or concrete.

The user then defines style parameters.

### Transformer type:

**Oil-filled transformers** – used as high-power transformers, these units are equipped with an oil tank where the transformer cooling oil is cooled. One of the disadvantages of oil is its combustibility, while others include the risk of fire and explosion caused by an internal short-circuit. In the event that an electric arc is formed there is a risk of oil vapour ignition when the duration of an internal short-circuit is long enough for large amounts of gas to be generated through the decomposition of oil caused by the arc.

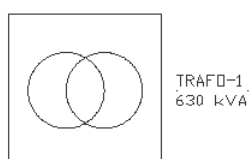
**Dry transformers** (air-insulated) – these are competitive for oil-filled transformers within the medium power range. Low fire risk allows the transformer to be placed near power take-offs. Heat emission is on the average 15% lower in comparison with an identical oil-filled transformer unit. Their failure ratio is definitely lower in comparison with oil-filled transformers. These units can withstand short overloads.

**The transformer power, short-circuit voltage and power losses in winding** are parameters that allow determining the transformer resistance and reactance, which are necessary to carry out short-circuit calculations and to verify the criteria for selecting a transformer for the designed network.

The values of these parameters depend on the transformer type.

A “Transformer station” is the facility from which we begin designing a power network.

If we have defined the desired transformer parameters, we may proceed to determining the location of the facility in the drawing (bitmap or DWG map). The facility takes the following form in the drawing:





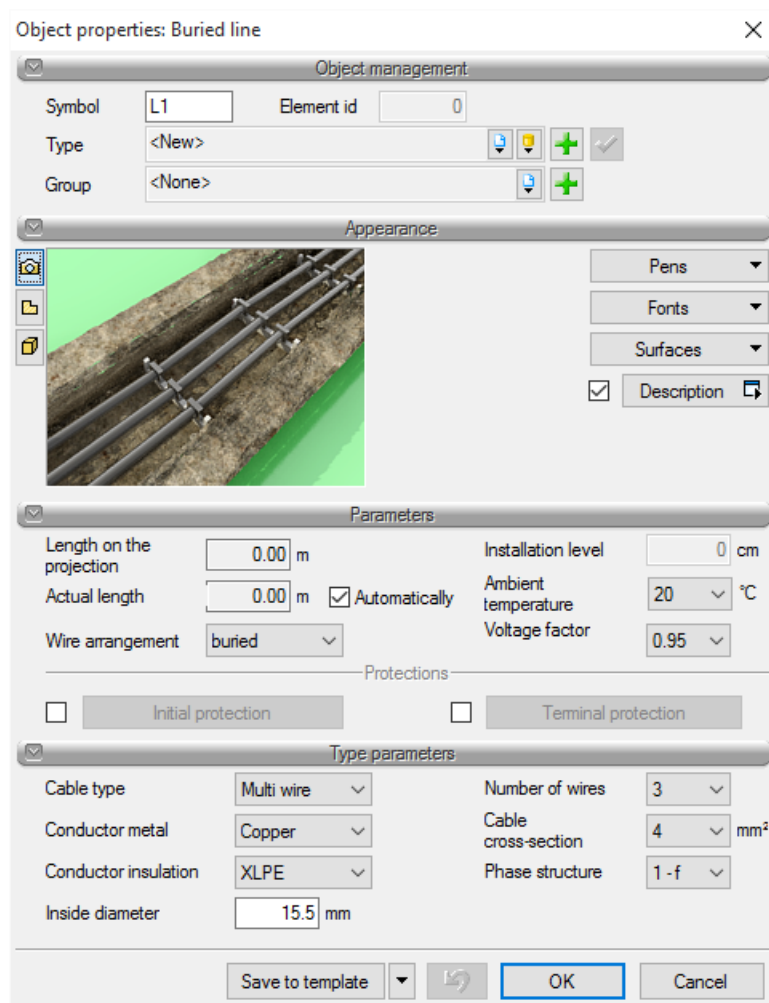
### 3.4.2 Buried line

A **buried power line** is a multi-core cable, a bundle of single-core cables in a multi-phase arrangement along with cable fixtures, placed along a common route and connecting terminals of the same two-electric devices, single- or multi-phase or single- or multi-pole. Such lines are erected both for direct current and alternating current. Buried lines are usually placed in the ground, but thanks to their advantages, their use was expanded into other applications. They can be laid in cable ducts, on walls and structures, in tubes, they can be suspended on load-bearing strings etc.

Buried lines are primarily used where the erection of overhead lines is burdensome and not recommended due to dense development and high industrialisation. This applies in particular to industrial facilities and urban areas.

## Working with the software

Once the  icon is clicked, we can add an element to the project. The buried line properties editing window is displayed by selecting the  button or double-clicking the inserted element.



Drawing 5. Buried line properties window

In the first buried line design stage the user selects a short-circuit and overload protection system for the line.

ArCADia-POWER NETWORKS provides the following four options:

**Protection – protective conductor** – short-circuit and overload protection devices will be placed at the beginning of the designed line (buried line protection) and at the end (supplied device protection).

**Protection – conductor** – short-circuit and overload protection devices will be placed only at the beginning of the designed line (buried line protection).

**Conductor** – the designed buried line without protection devices.

**Conductor – protection** – short-circuit and overload protection devices will be placed only at the end of the designed line (buried line protection).

Then the user defines visual aspects and properties of the designed line.

### DESCRIPTION OF CABLE LINE PARAMETERS:

**Cable route length** – this is the length of a buried line section drawn by the designer (line length in the drawing).

## Working with the software

**Length** – this is a parameter defining the total length of the designed buried line section, i.e. taking into account the bends and vertical sections not shown in the drawing. This value is adopted by the software for technical calculations.

**Ambient temperature [°C]** – this is the temperature of the surrounding environment when the analysed conductor, which is located in this environment, is not under load.

**Voltage factor** – a multiplier that needs to be applied to the rated network voltage in order to define the highest or the lowest network voltage value during a short-circuit.

Network rated voltage $U_n$	Voltage factor $c$ , used to calculate:	
	maximum short-circuit current $c_{\max}^{1)}$	minimum short-circuit current $c_{\min}$
Low voltage between 100 V and 1000 V	1.05 <sup>2)</sup>	0.95
	1.10 <sup>3)</sup>	

Tab 1. Voltage factor  $c$

- 1)  $c_{\max} \cdot U_n$  cannot exceed the highest device voltage,  $U_m$
- 2) For LV (within a range of +6%, e.g. for 380 or 400 V)
- 3) For LV (within a +10% voltage range).

**Max. earth current cut-off time** – regulations concerning the protection against electric shock (automatic disconnection of supply) resulting from indirect touch require that the short-circuit earth currents in networks be tripped by protective devices within a specific period of time. The maximum permissible tripping times in networks depend on the rated voltage to earth and the permissible limit voltage under the particular environmental conditions (50 V or 25 V).

Rated voltage to earth $U_0$ [V]	Voltage factor $c$ , used to calculate:	
	maximum short-circuit current $c_{\max}^{1)}$	minimum short-circuit current $c_{\min}$
	0.4	
Low voltage 400 V	0.4	0.2

Tab 2. Permissible tripping times for earth short-circuits in TN networks

In certain circumstances (mostly in outdoor networks), longer tripping times than those provided in table 2 are allowed, however not longer than 5 seconds.

**Wire arrangement** – the method of laying a cable is the parameter that influences the definition of the continuous current-carrying capacity of a specific cable. Due to its designated purpose (designing external power networks) the software provides two placement options: in the ground and overhead (open spaces).

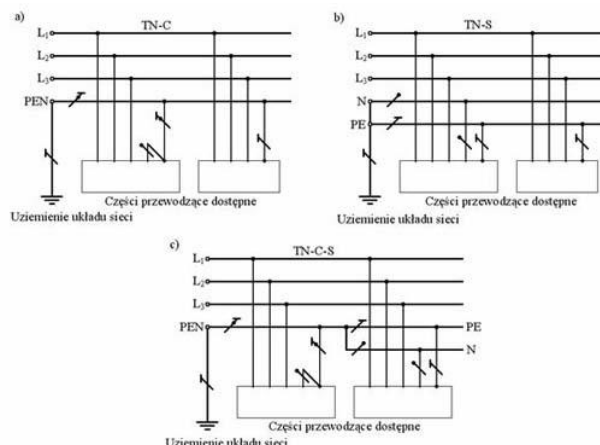
**Conductor metal** – suitable electricity conductors are usually aluminium or copper. Aluminium has a lower

electric conductivity in comparison with copper ( $\gamma_{Al} = 35 \frac{m}{\Omega \cdot mm^2}$ ,  $\gamma_{Cu} = 58 \frac{m}{\Omega \cdot mm^2}$ ), but it is a metal significantly cheaper than copper.

## Working with the software

**Conductor insulation** – insulation separates conductor cores from one another and from other earthed elements, protects the conductors against adverse weather conditions and prevents people from touching the elements. Conductor insulation is usually made of polyvinyl chloride (plasticised PVC – limit temperature 70 °C) or cross-linked polyethylene (XLPE, limit temperature 90 °C).

**Network layout** – ArCADia-POWER NETWORKS enables designing TN network layouts. This is a system in which the neutral point (zero) is earthed directly and conducting elements are connected to it by protective PE or by protective-neutral PEN, due to which the short-circuit loop is made entirely of metal. The software differentiates between two sub-systems: TN-C – with a common protective-neutral PEN conductor and TN-S – equipped with two separate conductors: neutral (N) and protective (PE).



Drawing 6. Schematic diagram of sub-systems: a) TN-C, b) TN-S and c) TN-C-S:

**Number of phase conductors** – the number of conductors that conduct electric current.

**Conductor cross-section** – the user may use standard conductor core cross-sections. The conductor cross-section is an important parameter, influencing the calculations of short-circuit currents and voltage drops.

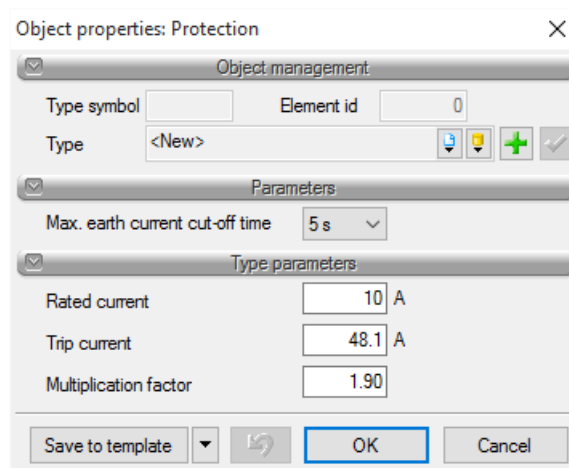
**Cable type** – a power supply buried line can contain a single multi-core cable or a bundle of single-core cables. The cable type that we will use influences the continuous current-carrying capacity of the designed buried line.

**Protections** – conductors connecting electricity consumers with the power supply source should be protected against the consequences of short-circuits and overloads by protective devices that trip the power supply when an overload or short-circuit occurs.

The user may use a library of the most frequently employed short-circuit and overload protection measures, such as fuses or overcurrent circuit breakers. Protections are divided by type, kind and rated current value. Each protection has a short-circuit trip current value assigned for three durations: 0.2 [s], 0.4 [s], 5 [s] and a protection trip current value through a bimetal thermal overload release.

In order to define the protection, click the button “terminal/initial protection”. The following window appears:

## Working with the software



Drawing 7. Protection properties window

The library of protective devices is contained in the “**Type library**”

Due to the broad range of protection devices available in the market, the **ArCADia-POWER NETWORKS** user can create their own protection. The user enters the name and technical parameters of the device, such as: **protection rated current** and trip current for three durations: **0.2 [s], 0.4 [s], 5 [s]** and enters the value of **multiplicity ratio for the protection device rated current** in order to obtain the trip current for the defined protection during long-lasting overloads. The protection created by the user will be stored in the library, which they will be able to use when creating new designs. In order to create your own protection, click “**Add type**”.



After defining the properties of the designed buried line, the user continues to draw the buried line. Line drawing begins with a transformer station by clicking at the item centre or with a “connection point” and ends with a “cable connector” or “distribution board”.

The drawing shows the basic features and properties of the buried line, i.e. the designed cable type, route length and diameter. A symbol marking the number of the designed line can be seen under the buried line.

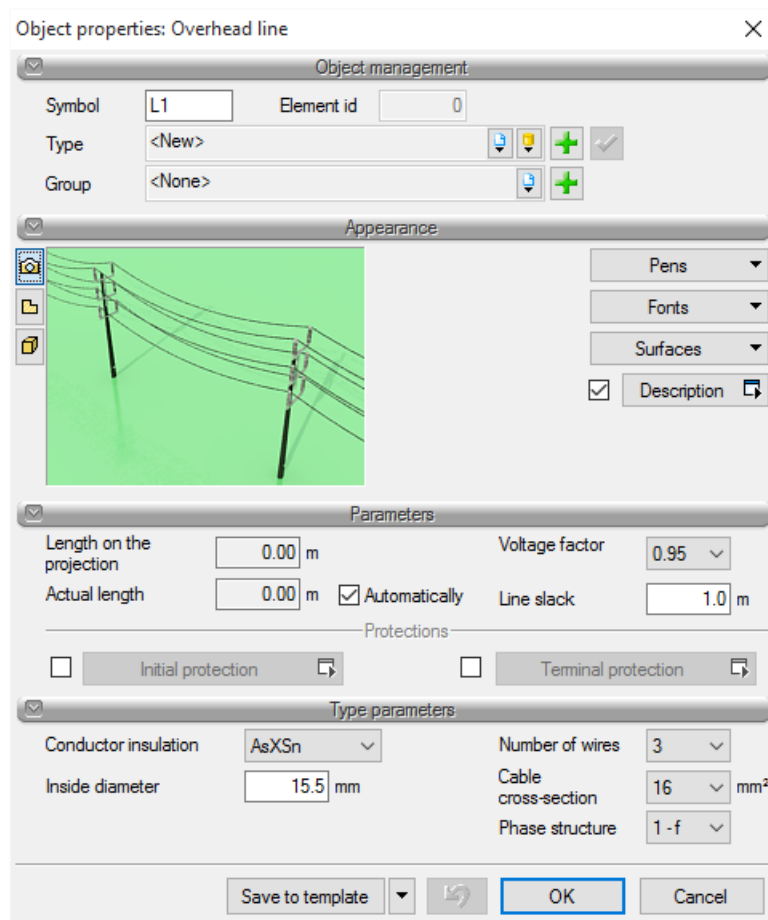
An example buried TN-S line made of copper conductor, with XLPE insulation, 4 mm<sup>2</sup> core cross-section, 15.5 mm cable diameter, one phase conductor and 5.0 m route length.

2xYKXS 1x4, Ø15.5mm, L=6.4m  
L-1

### 3.4.3 Overhead line

Once the  icon is clicked, we can add an element to the project. The overhead line properties editing window is displayed by selecting the  button or double-clicking the inserted element.

## Working with the software



Drawing 8. Overhead line properties window

Parameters of an **overhead line** are almost identical to those of a buried line.



In overhead lines the conductor types come in three categories, namely:

- bare aluminium conductor (non-insulated),
- insulated AsXS conductor (XLPE insulation),
- insulated AsXS<sub>n</sub> conductor (XLPE insulation, fire retardant),

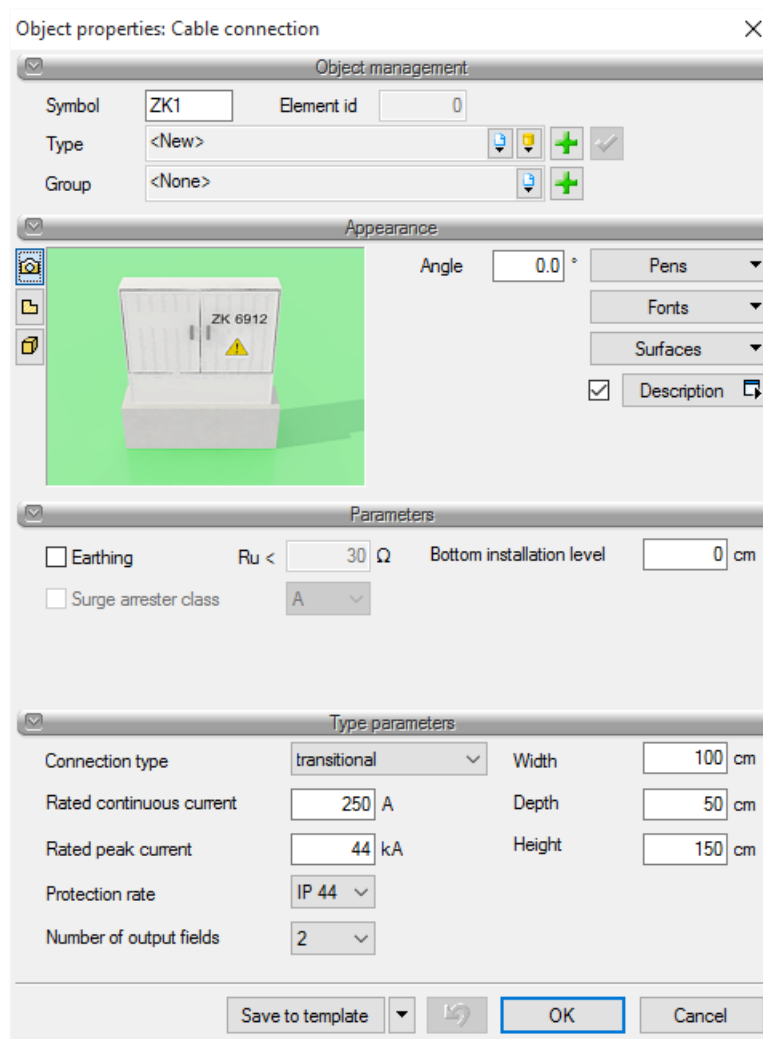
An additional parameter is the **line sag**, meaning the distance between the centre of the span between two poles and a straight line connecting the conductor suspension points.

### 3.4.4 Cable connection

**Electric installation connection** – electric device in which a connection is made between the common distribution electric network with the electric installation of the recipient.

Once the  icon is clicked, we can add an element to the project. The cable connection properties editing window is displayed by selecting the  button or double-clicking the inserted element.

## Working with the software



Drawing 9. Cable connection properties window

As in all items, we begin with the definition of the visual features and the location angle in the drawing.

Further on the user defines whether the specific connection is earthed, what the maximum permissible earthing resistance should be and whether it has a particular class overvoltage limiter. This information is reflected in the drawing:



Next, we define the style parameters: connection size, rated continuous current, peak current, number of outgoing bays and protection degree. These parameters are strictly associated with the cable connection type. If the rated continuous current and peak current values are lower than the load current and short-circuit current on lines input to the connection respectively, the generated report will produce a message informing about selecting an incorrect connection.

A very important cable connection parameter is the calculated power demand that we want to send, as this enables calculations that allow to select an appropriate buried line and overhead line.



## Working with the software

Entering the **rated continuous current** and **peak current** values enables **ArCADia-POWER NETWORKS** to verify whether a specific connection type fulfils the conditions of the designed network with respect to load and surge resistance.

**Number of outgoing bays** – the user declares how many circuits (buried or overhead lines) can be output from a specific connection.

Cable connection types:

- **transitional**: calculated power demand cannot be determined for a transitional connection, which prevents the software from carrying out calculations.

- **transitional-terminal**: we define the calculated power demand, coincidence factor and  $\cos \varphi$  coefficient. These values allow technical calculations to be carried out. The defined coincidence factor is used to calculate the load power on the designed fragments of a power network.



- **terminal**: we define the calculated power demand, coincidence factor and  $\cos \varphi$  coefficient. These values allow technical calculations to be carried out.

- **nodal**: an additional parameter in a node connection is the short-circuit loop impedance. This parameter is used to carry out short-circuit calculations when the user begins designing a network with a specific connection.

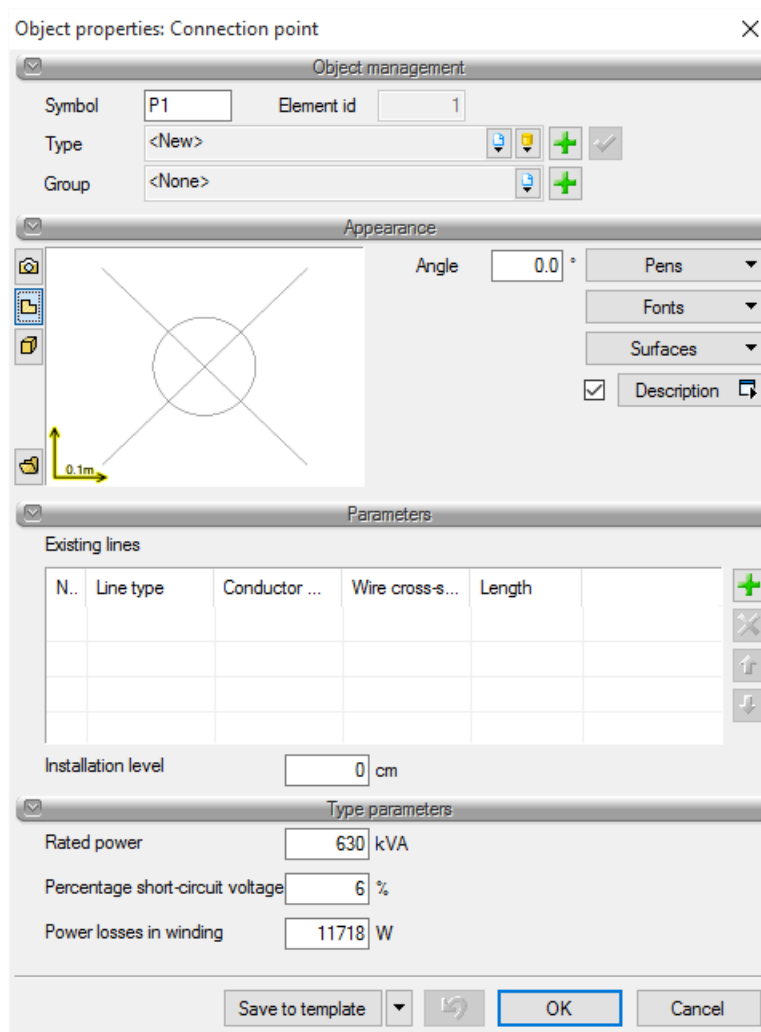
### 3.4.5 Connection point

Very often, designers are supposed to expand the existing power network or to create a connection from a pole or a cable connector. The “Connection point” enables the user to do so.

The connection point is a location with which we begin the expansion of an existing network by defining properties of the existing network that are necessary to carry out technical calculations.

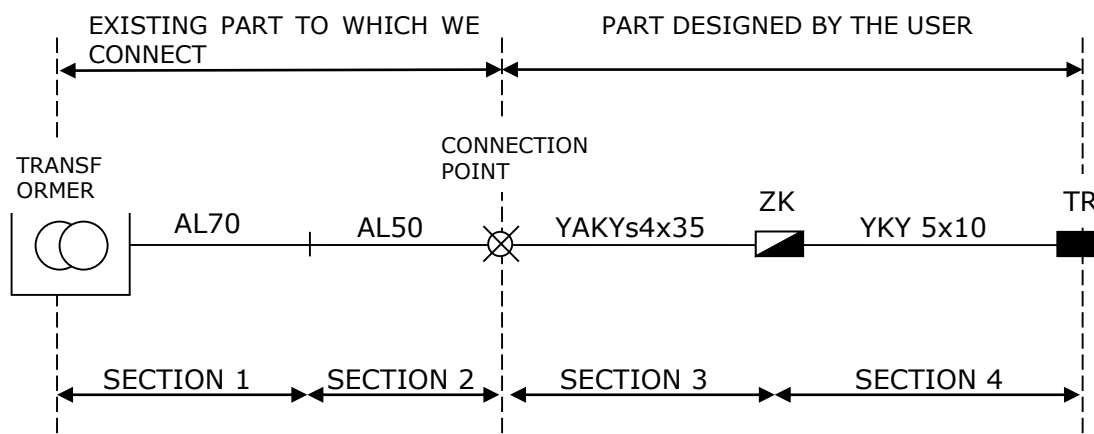
Once the  icon is clicked, we can add an element to the project. The connection point properties editing window is displayed by selecting the  button or double-clicking the inserted element.

## Working with the software



Drawing 10. Connection point properties window

In the **“Parameters”** tab there is a table in which we can define the properties of an existing network between the connection location and the transformer station, e.g.:



The user inputs the line type, conductor metal, core rated cross-section and length. These parameters will enable short-circuit calculations (inspection of electric shock protection by using a quick supply disconnection system).

In the **“Style parameters”** tab the user defines technical parameters of the transformer powering an existing network, to which we want to connect.



## Working with the software

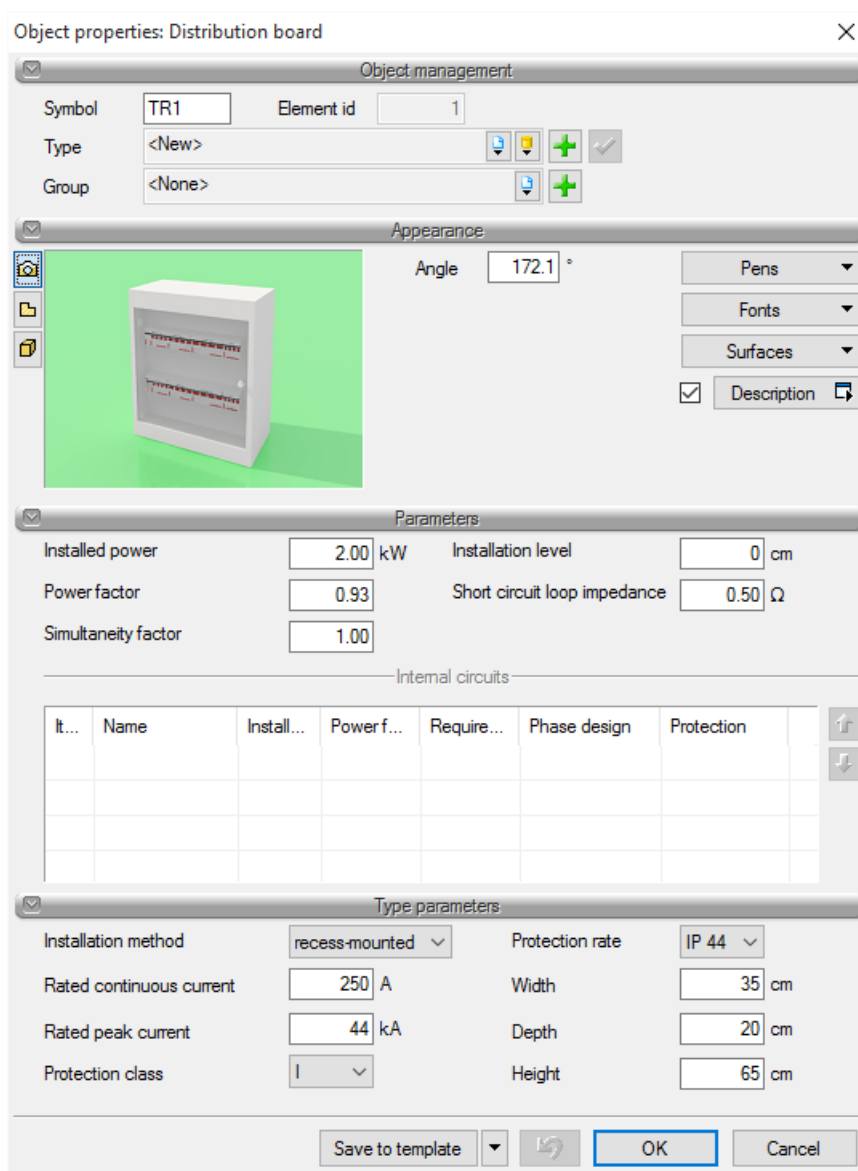
After the parameters for the existing network fragment are defined, we determine the connection point location on the drawing, such as an existing pole or cable connection.

✕ P-1.

### 3.4.6 Distribution board

**Distribution board** – ArCADia-POWER NETWORKS defines the distribution board as an internal switchgear in the building to which the so-called internal power supply line is routed.

Once the  icon is clicked, we can add an element to the project. The designed distribution board properties editing window is displayed by selecting the  button or double-clicking the inserted element.



Object properties: Distribution board

Object management

Symbol: TR1 Element id: 1

Type: <New>

Group: <None>

Appearance

Angle: 172.1 °

Parameters

Installed power: 2.00 kW Installation level: 0 cm

Power factor: 0.93 Short circuit loop impedance: 0.50 Ω

Simultaneity factor: 1.00

Internal circuits

It...	Name	Install...	Power f...	Require...	Phase design	Protection

Type parameters

Installation method: recess-mounted Protection rate: IP 44

Rated continuous current: 250 A Width: 35 cm

Rated peak current: 44 kA Depth: 20 cm

Protection class: I Height: 65 cm

Save to template OK Cancel

Drawing 11. Distribution board properties window

The “distribution board” parameters are: installed power, power factor, coincidence factor.

**Installed power** – sum of rated powers from all the consumers installed in the building.

## Working with the software

**Coincidence factor** – defines the number of devices operating simultaneously in a particular building. The user selects the factor value individually for each building.



**Power factor** –  $\cos \varphi$  is a measure of energy consumption. The power factor defines how much power delivered to a specific system is converted to active power (which the system uses effectively). The user assumes the anticipated power factor in the power supply circuit connected to the distribution board.

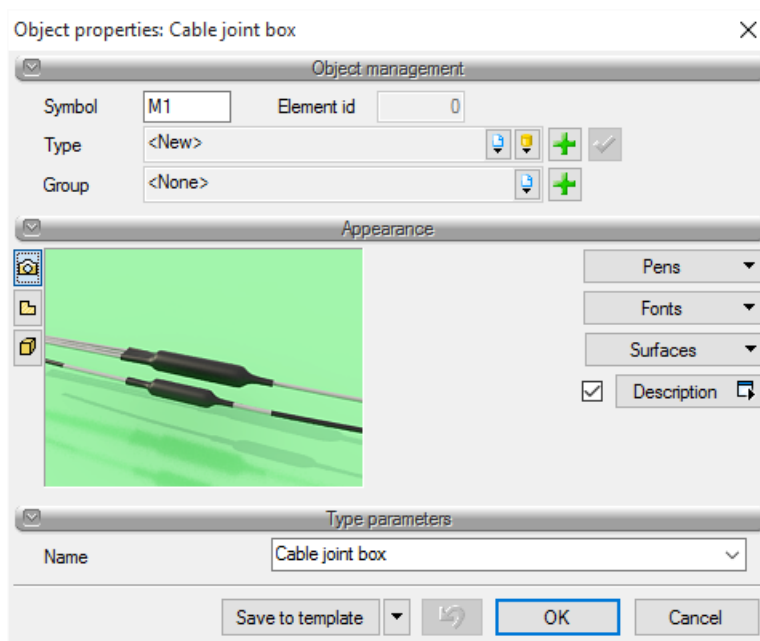
The style parameters for the distribution board are load properties of the board (rated continuous current, peak current) and the board dimensions that are reflected in the drawing:



### 3.4.7 Cable joint box

**Cable joint box** – this is an element of the cabling equipment for a buried power line, used to connect two cable sections in such a manner that their mechanical and electric resistance at the connection point is not lower than that of the cable.

Once the  icon is clicked, we can add an element to the project. A window defining the properties of the cable joint box is displayed by selecting the  button or double clicking on the inserted element.



Drawing 12. Cable joint box properties window

The user can choose between four types of cable joint boxes:



- branch cable joint
- straight cable joint
- tee cable joint
- stop cable joint

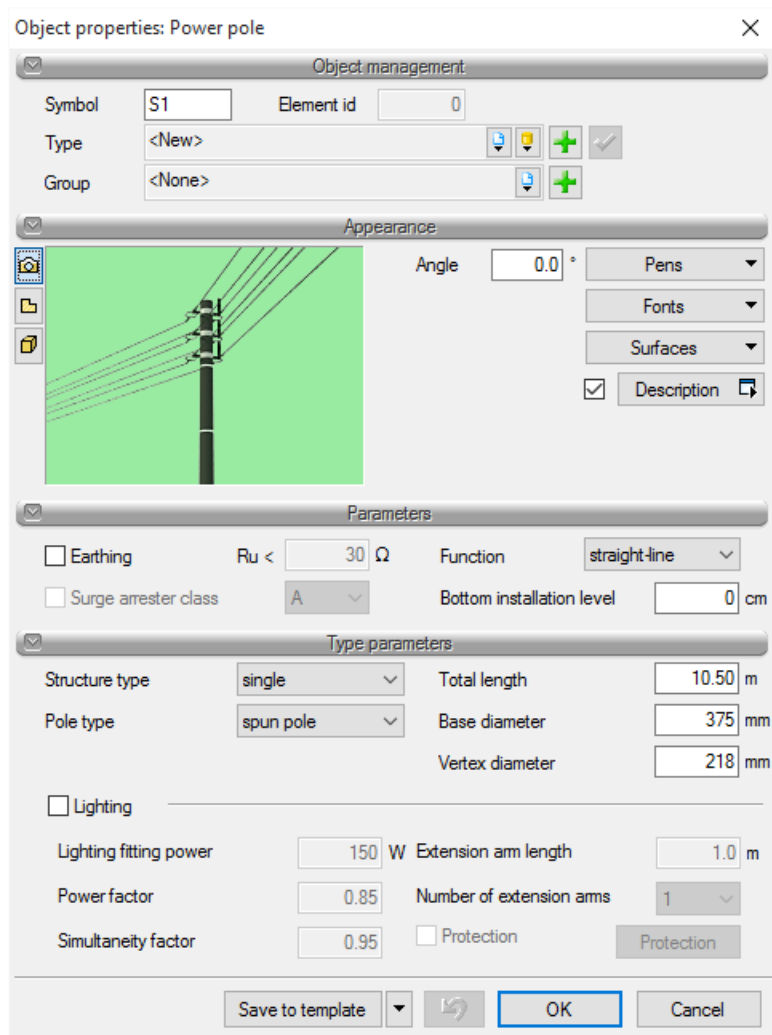
As in the case of all other items, we begin by defining the visual features in the drawing.

## Working with the software

### 3.4.8 Power pole

**Power pole** – ArCADia-POWER NETWORKS enables inserting power poles into the design, which are used to design overhead network sections and in external lighting systems.

Once the  icon is clicked, we can add an element to the project. A window enabling the definition of properties of the designed power pole is displayed by selecting the  button or double clicking on the inserted element.



Drawing 13. Power pole properties window

By ticking the “**earthing**” or “**limiter**” box in the “**Parameters**” tab the user declares that the pole is earthed and equipped with an overvoltage limiter. The user is able to enter the permissible value of earthing resistance. This parameter is reflected in the drawing.

#### Pole functions:

**Intermediate** – used when the line route is not bent by more than 2 degrees.

**Corner** – influenced by the resultant tension force from both pole sides. Corner angles are not large; therefore, the resultant force is not high.

**Terminal** – such poles are adapted to withstand an exclusively unilateral conductor tension and are therefore placed at the beginning and end of a line.

## Working with the software

**Section** – such poles are placed in straight line sections at the ends of tension sections with intermediate poles in the middle.

**Branch** – such poles are placed where the line branches off.

**Buried depth** – burying depth under the ground surface.

Then the user defines “**Style parameters**”, i.e. the pole design type (single, double, A-pole, with support, lighting post), rod type and length, base and tip diameters.

Pole symbols in the drawing:

Pole functions: P – Intermediate; N – Corner; O – Section; K – Terminal; R – Branch

Pole construction types: single, twin, with support, A-pole

Single intermediate pole:



rod length: 8.2; 9.2; 10.0; 12.0 [m]

buried depth: 1.9 - 2.4 [m]

Intermediate twin pole, "a" variant:



rod length: 8.2; 9.2; 10.0; 12.0 [m]

buried depth: 1.9 - 2.5 [m]

Intermediate twin pole, "b" variant:



rod length: 8.2; 9.2; 10.0; 12.0 [m]

buried depth: 1.9 - 2.5 [m]

Twin corner pole:



rod length: 8.2; 9.2; 10.0; 12.0 [m]

buried depth: 1.9 - 2.5 [m]

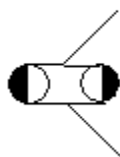
Corner pole with support:

## Working with the software



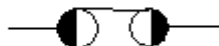
rod length: 8.2; 9.2; 10.0; 12.0 [m]  
buried depth: 1.9 - 2.1 [m]  
1.3 - 1.6 [m] for support

Corner A-pole:



rod length: 8.2; 9.2; 10.0; 12.0 [m]  
buried depth: 1.9 - 2.2 [m]

Section A-pole:



rod length: 8.2; 9.2; 10.0; 12.0 [m]  
buried depth: 1.9 - 2.2 [m]

Twin terminal pole:



rod length: 8.2; 9.2; 10.0; 12.0 [m]  
buried depth: 1.9 - 2.5 [m]

Terminal pole with support:



rod length: 8.2; 9.2; 10.0; 12.0 [m]  
buried depth: 1.9 - 2.1 [m]  
1.3 - 1.6 [m] for support

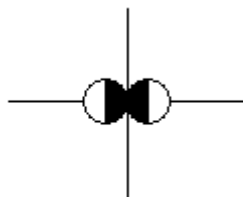
Terminal A-pole:



rod length: 8.2; 9.2; 10.0; 12.0 [m]  
buried depth: 1.9 - 2.1 [m]

Intermediate branch pole:

## Working with the software



rod length: 8.2; 9.2; 10.0; 12.0 [m]

buried depth: 1.9 - 2.1 [m]

When selecting a specific pole the user should obtain a list of the materials necessary for its reinforcement.



In order to design a lighting network the user can design lighting posts and geometric dimensions of the lighting installation.

Once the user has selected a lighting post, parameter selection options for the power of the fitting, power factor, coincidence factor, extension arm length and the number of extension arms.

The user can also install a lighting fitting on a power pole by ticking the “**Lighting**” check box.

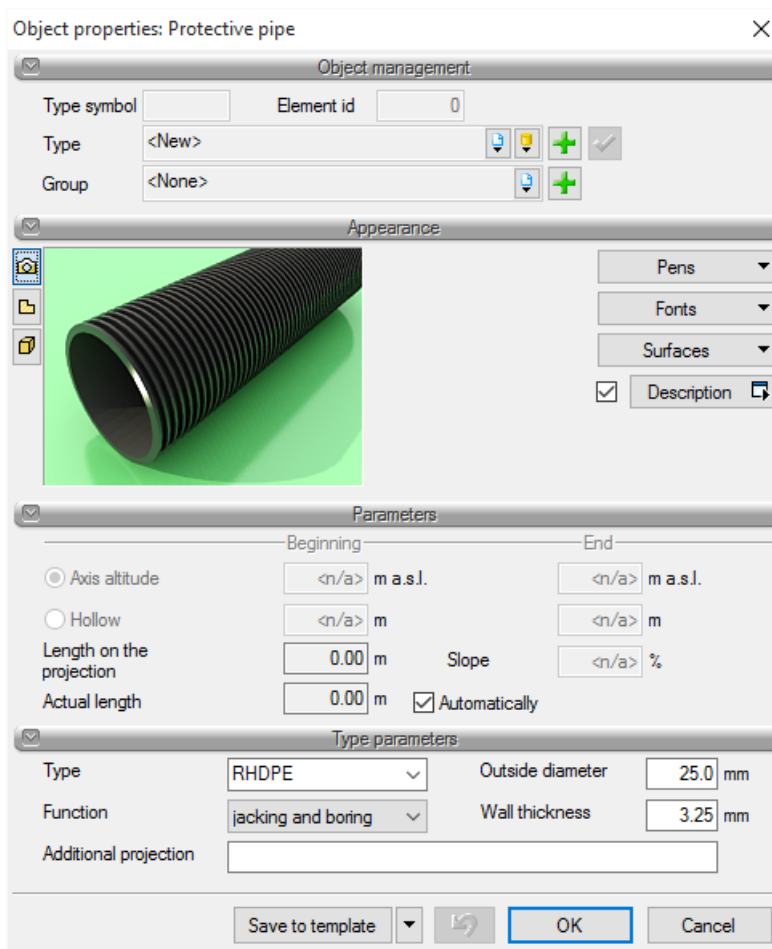
### 3.4.9 Protective pipe

**Protective pipe** – ArCADia-POWER NETWORKS enables inserting protective pipes into the design, which are used to protect cables and conductors against weather conditions.

Once the  icon is clicked, we can add an element to the project. A window defining the properties of the designed protective pipe is displayed by selecting the  button or double clicking on the inserted element.

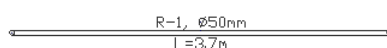


## Working with the software





Drawing 14. Protective pipe properties window

The user defines the protective pipe diameter and its use. Next they determine its desired length in the drawing. The beginning and end of the protective pipe are defined in the drawing.

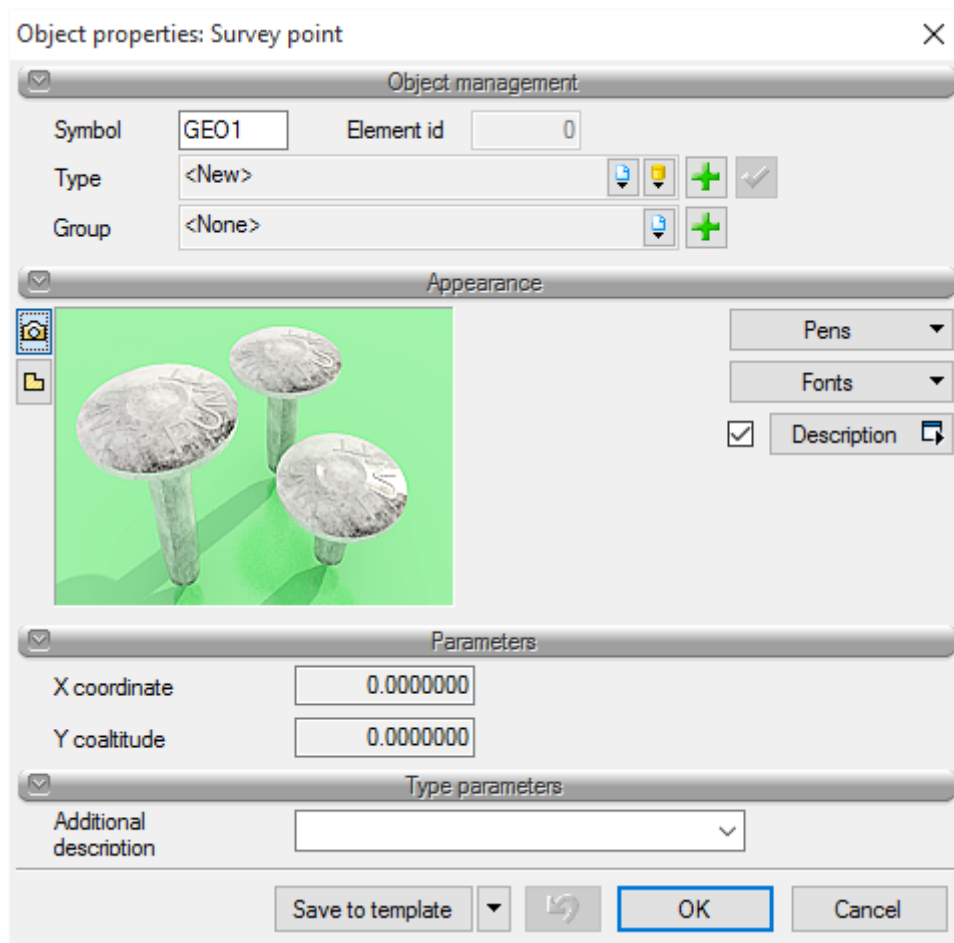


### 3.4.10 Insert survey point

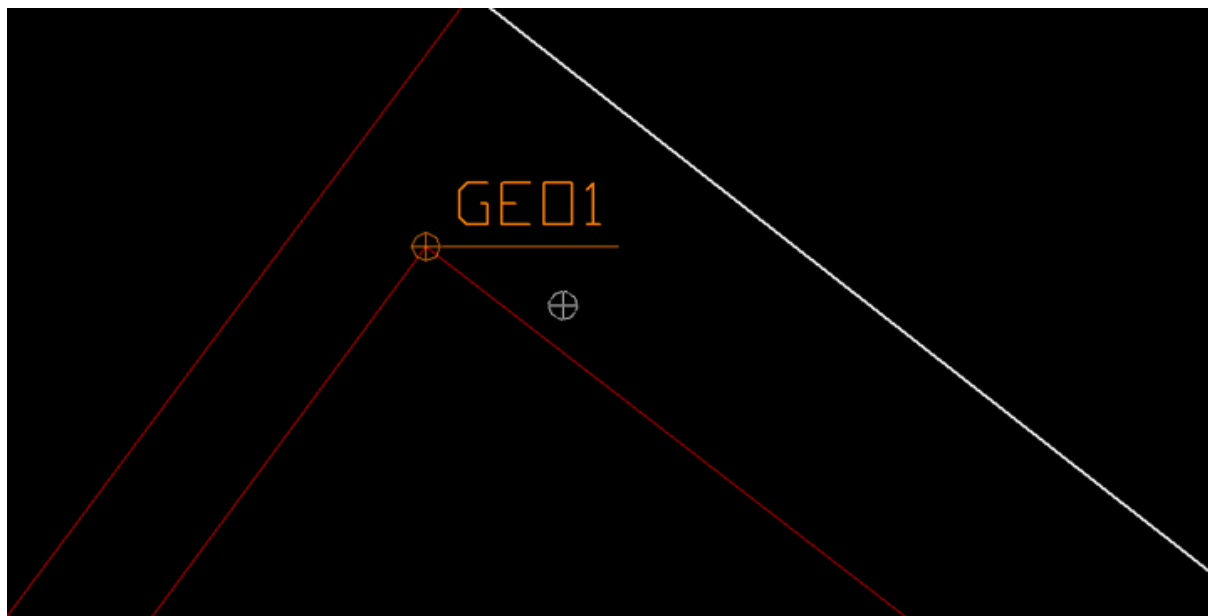
**Survey point** – ArCADia-POWER NETWORKS enables the insertion of geodetic coordinates (X, Y) for any points in the projection.

Once the  icon is clicked, we can add an element to the project. A window defining the properties of the survey point is displayed by selecting the  button or double clicking on the inserted element.


## Working with the software



Drawing 15. Survey point properties window.




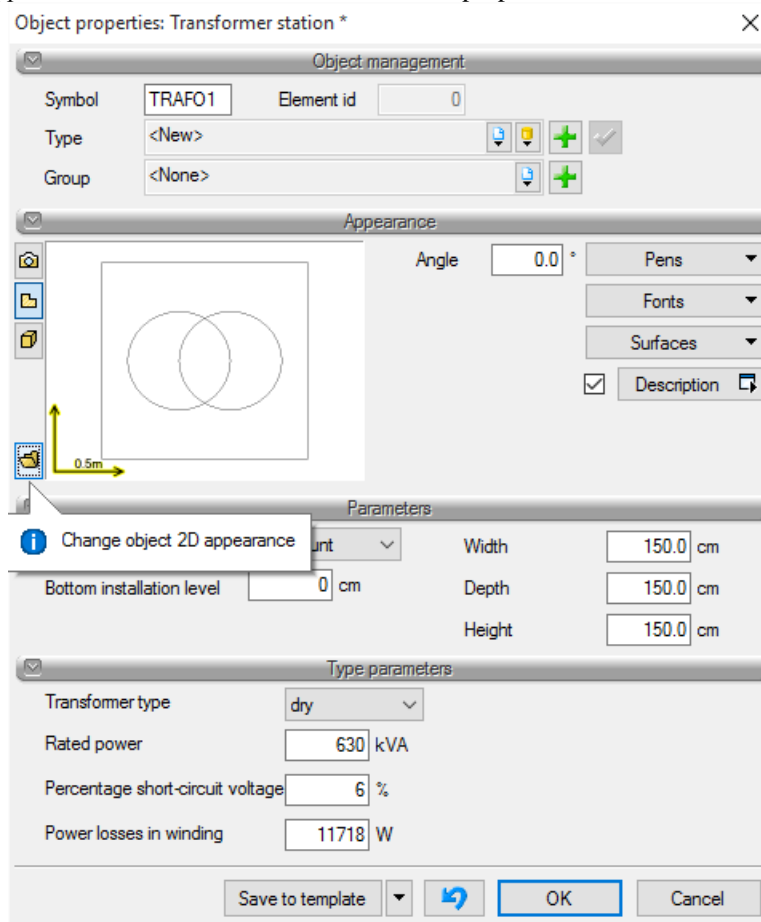
Drawing 16. View of the survey point in the projection.

In order to generate a report with the geodetic coordinates, the user should click . Geodetic coordinates are stored in an RTF file under any name.

## Working with the software

### 3.4.11 Changing views of 2D items

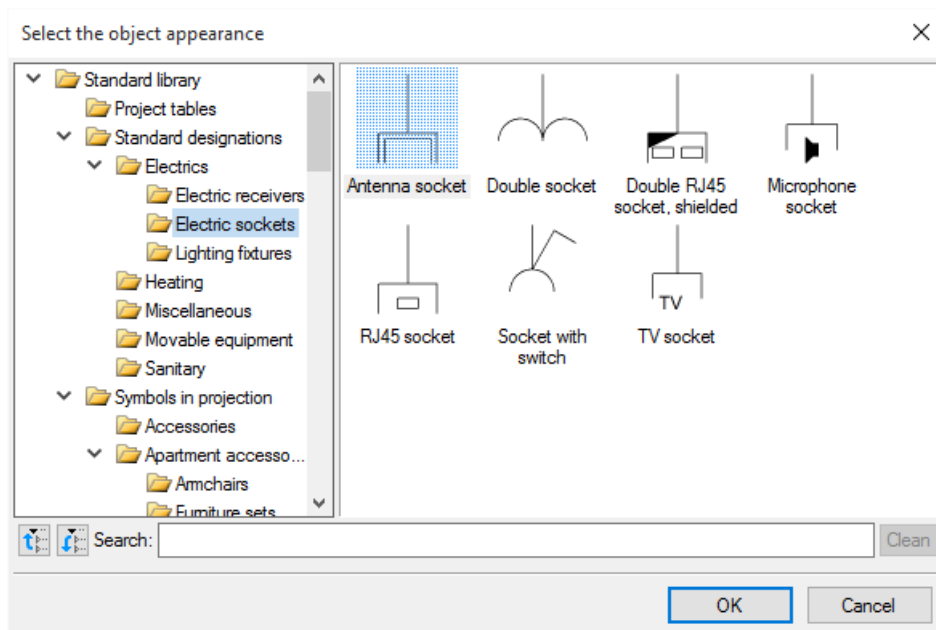
Each item in the ArCADia-POWER NETWORKS module has its own predefined 2D symbol (appearance) on the projection. The user may change this view into one created by themselves using the view change feature. The “Change item 2D appearance”  icon is available in the item properties window in the View control group.



Drawing 17. “Change item 2D appearance” icon location properties window


After clicking the icon the user gains access to the 2D appearances library. Folders and sub-folders contain the appearances of typical electric devices.

## Working with the software



Drawing 18. 2D item appearance selection window


The user can draw the appearance of a 2D item themselves and save it in the 2D item library using the **Item explorer**.

Once a view is inserted using ArCADia-INTELLICAD or AutoCAD, click the  icon in order to name the newly created 2D item and then select an area on the projection where the item has been drawn. It will be added to the user's elements folder. From there on it will be available in the element properties and can be used to change the 2D item appearance.


### 3.4.12 Editing and introducing types.

To display the **Type library editor** dialog box, click the icon:

*ArCADia software:*

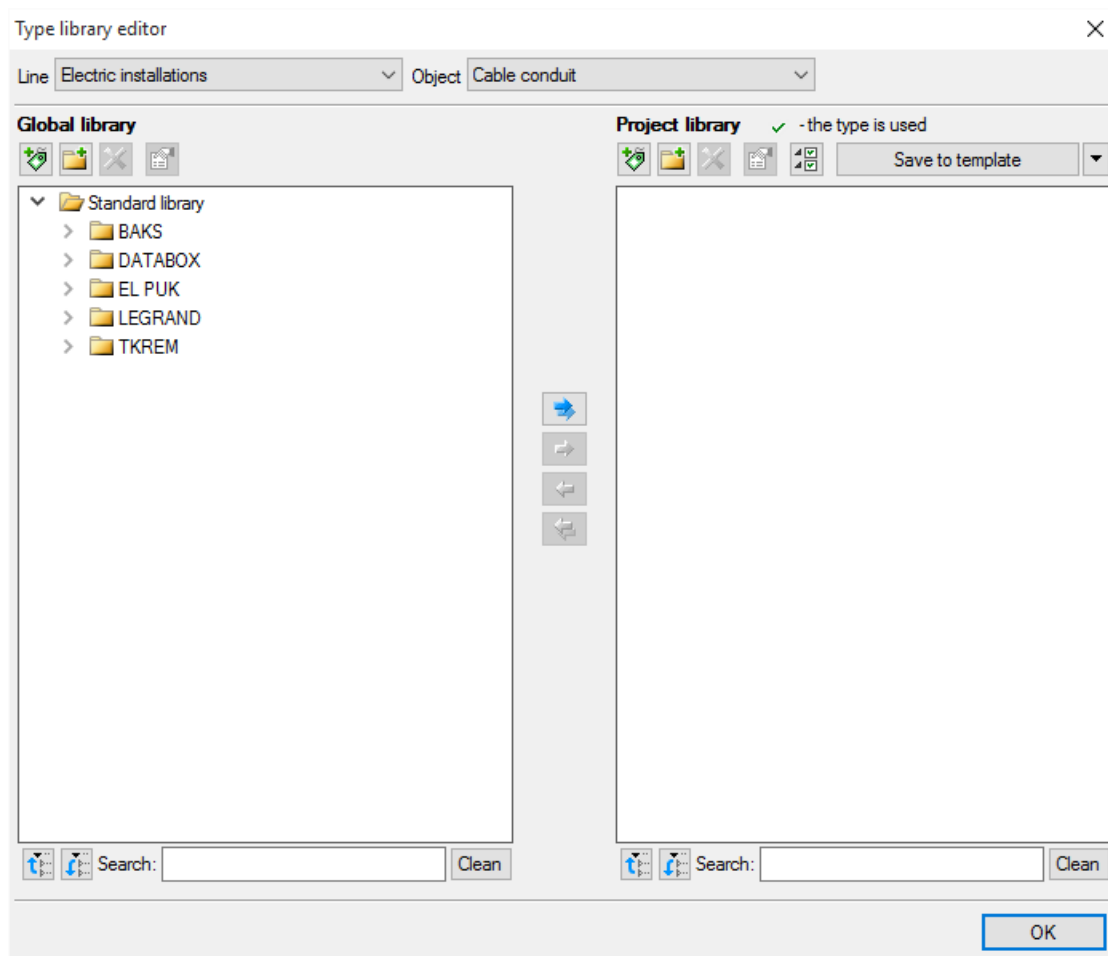
- The **System** ribbon ⇒ **Type Library** ⇒ 

*AutoCAD or ArCADia-INTELLICAD software:*

- **ArCADia-SYSTEM** toolbar ⇒ 
- or write
- ISA\_ETL.

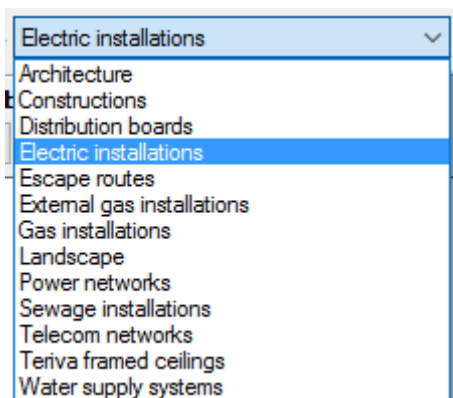
The **Type library editor** is used to edit and introduce new item types into the **ArCADia** software. It facilitates access to manufacturers catalogues and enables selecting only those catalogues which the user uses most often when designing. Additionally, types are divided into a **Standard library** (i.e. the library provided with a given software version) and a **User library**, where all the new or user modified element types are saved.

## Working with the software



Drawing 19. Type library editor window

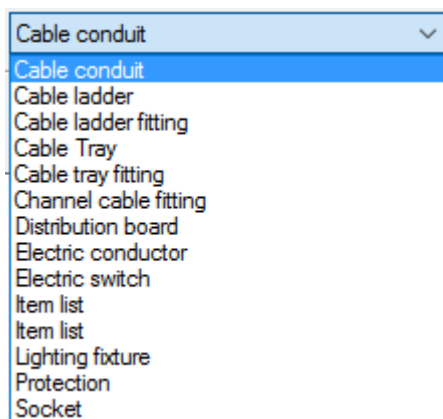
In the upper part of the type editor window (Drawing 199) the user has the possibility to select a branch from the drop-down list where all the branch-modules available in **ArCADia BIM** are listed.



Drawing 20. Drop-down list view of the branches available in the ArCADia BIM system

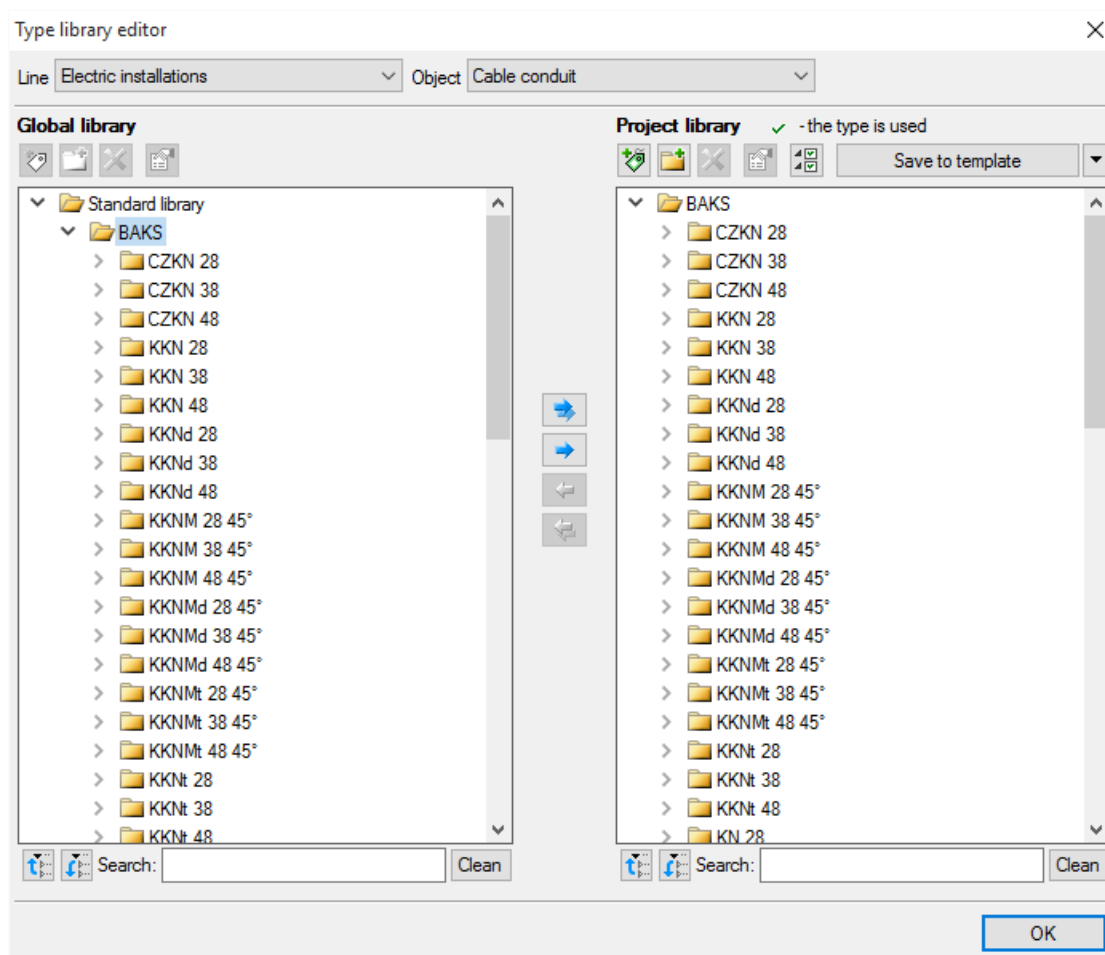
After selecting the appropriate branch the user has access to all the items from the **Elements** drop-down list (on the right) available in the selected branch (module), e.g. buried line (Drain. 21).

## Working with the software



Drawing 21. Drop-down list of the elements available in the electrical networks branch in the ArCADia BIM system

After clicking on the selected element in the **Global library** all element types will be available. During the first run it will be the **Standard library** types (files provided with a given version of the software). During the design process you may add additional types into the libraries, creating a **User library**.



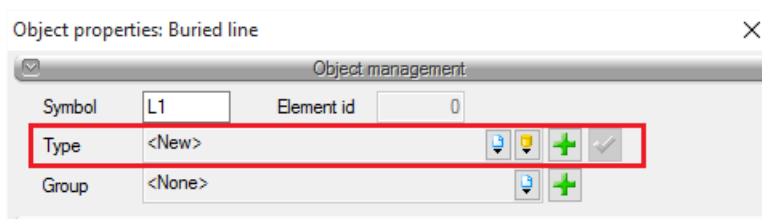
Drawing 22. Type library editor window after selecting an appropriate branch and one of its elements.

The lower part of the editor window is divided into the **Global library** (left) page and **Project library** (right) page.

## Working with the software

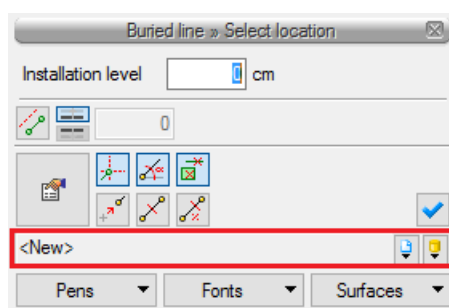
The **Global library** is the place where all the default element types available for the user and the elements added when working with the software are added; it is divided into the **Standard library** (a library provided with a given version of the software, which the user does not change) and a **User library**, which contains elements (types) saved by the user when working with the software.

**Project library** – where all the element types used or available for use in the project are listed. Type for the element can be selected from the Element properties window (Drawing. 23, Drawing 24):




Rys. 1. Type insertion from the level of item properties

and in the modification and insertion windows:


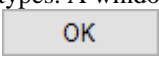
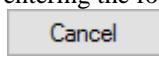


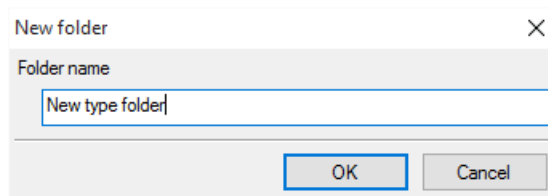
Drawing 23. Type insertion point from the element modification and insertion window level

Above the type library windows there are icons with the following functions:


**Add new type**  – after clicking this icon the user has the possibility to add a new type to the **Global library** or the **Project library** (to the **User library**). It is also possible to edit type properties for the particular element, where the user may determine all the element's characteristic parameters, including type parameters, view.


**NOTE!** Clicking the **Add new type** icon when a type has been previously highlighted in the **Library** will add a new type based on the highlighted one. This facilitates entering a catalogue of items to the library, e.g. supplied by one company, where the only distinctive feature is e.g. the diameter.

**Add new folder**  – after clicking this icon the user has the possibility to add a new folder, where he can then later add element types. A window prompting for the folder name will appear. After entering the folder name you need to press the  button in order to add the folder to the library or  to cancel the command.




Drawing 24. Folder types insertion window

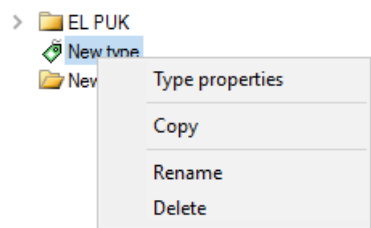
**Delete**  – after clicking this icon the user may delete the selected type or folder.

**Type properties**  – after clicking this icon the user will have access to the properties of the selected type. These values can be edited and saved here.

## Working with the software

**Leave only the types used in the project**  – after clicking this icon in the Project library, only the types used in the project (used in any object in the project) will remain visible.

After clicking a type with the right mouse button, a menu becomes available:





**Type properties** – works the same as the icon described above.

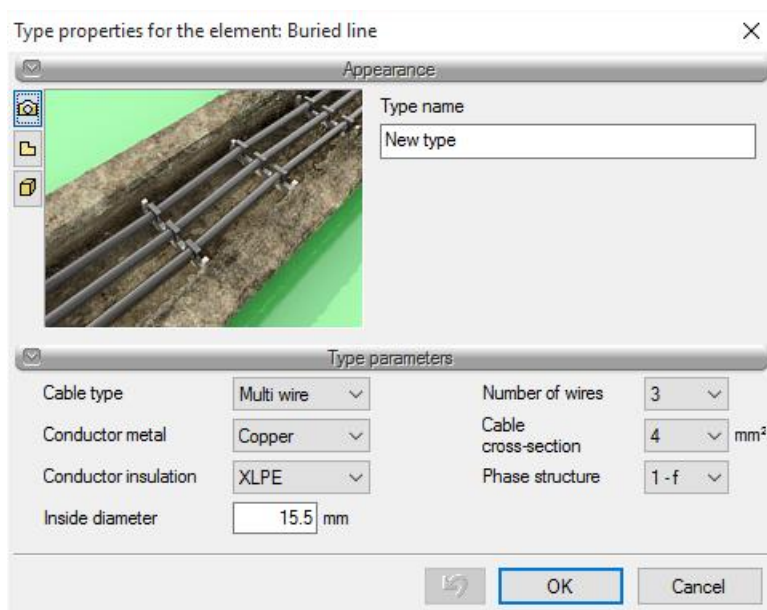
**Copy** – copies the type.

**Paste** – pastes a previously copied type and inserts it with the same name and subsequent number.


**Rename** – the user may rename an already inserted type.

**Delete** – works the same as the icon described above.

The  button is located above the project library. Once you click this button, the **Project library** settings will be saved in the template and will be accessible for future projects using this template. Next to it there is an  icon – when clicked, it provides the user with a list of available templates.

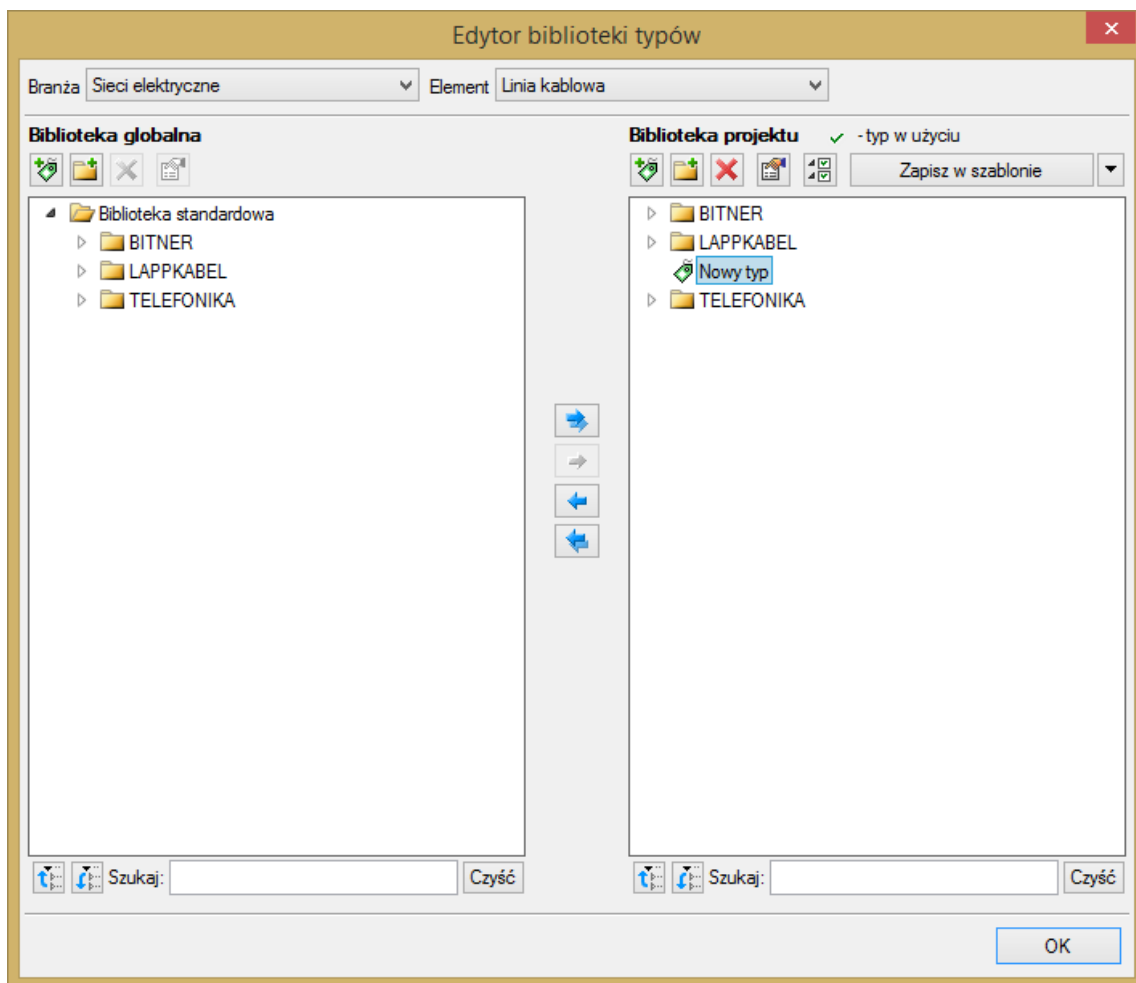


Drawing 25. Sample properties window

In the **Project library** window you can also check what types of a particular element are currently in use in the projection, which is displayed in the form of a  symbol on the left of the name of a particular type.





## Working with the software



Drawing 26. The type library editor window after entering the type to the project library.


The following icons are available below the two libraries:


**Hide everything** . After clicking the same icon the types tree in a given library will be hidden down to the main catalogues.


**Extend everything** . After clicking this icon, the type tree in a given library will be extended.


The user may also search the library by typing a part or the entire name of the desired type in the **Search:**  field. The button **Clean** is located next to the field. After clicking the button, the editing search field will be cleared.

Once you select types or folders, the transfer buttons located between the libraries are activated.

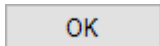
**Copy all to the project library**  - copies the entire global library content to the project library.

**Copy to the project library**  - copies the selected elements to the project library.

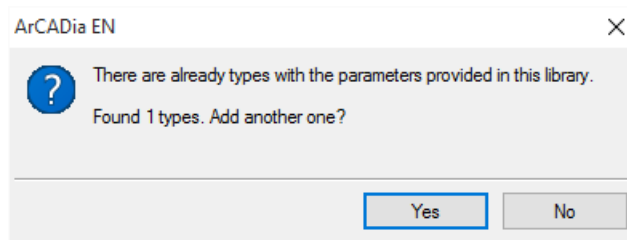
**Copy to the global library**  - copies the selected elements to the global library.

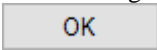
**Copy all to the global library**  - copies the entire project library content of the selected element to the global library.

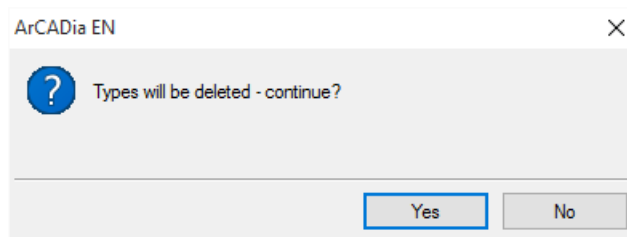
Messages that may be displayed when working with the **Type library editor**:

1. This message informs the user that a type with this name already exists. After clicking the , information from the new type will be saved and will overwrite the information in the previous type.

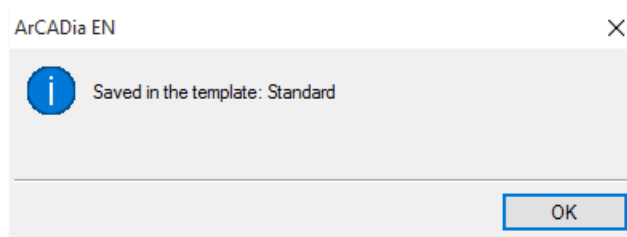
## Working with the software



2. This message informs the user that the types marked by the user are going to be deleted. The  button confirms type deletion.




3. This message informs that the layout of the project library was saved to a project template, e.g. Standard.



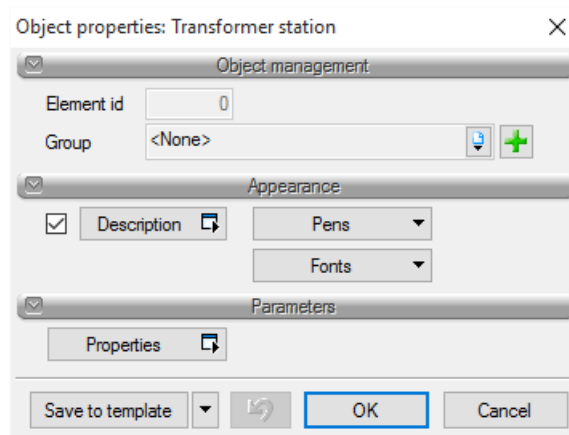
**NOTE!** If the user has made any changes in the **Project library** while working with the project, modified existing types or expanded the library by adding new types, the new types will become available for future projects. The user should add the new types to the **Global library** using the transfer buttons.

### 3.4.13 Generating a schematic diagram

**ArCADia-POWER NETWORKS** enables generating structural diagrams showing the designed buried lines, overhead lines and individual items (transformer station, connections, overhead line poles, lighting posts, electric boards). The diagram presents the power supply layout for the designed network in a schematic form, starting from the transformer (or a connection point) up to the last object in the designed network. All the items generated in the diagram can be edited and their properties can be defined.

Once the  icon is clicked, a view handle (system of coordinates) appears on the bar, where you can enter a location on the projection of the generated diagram. Once the diagram is generated, when you click an item (e.g **Transformer station**), the following window appears:

## Working with the software




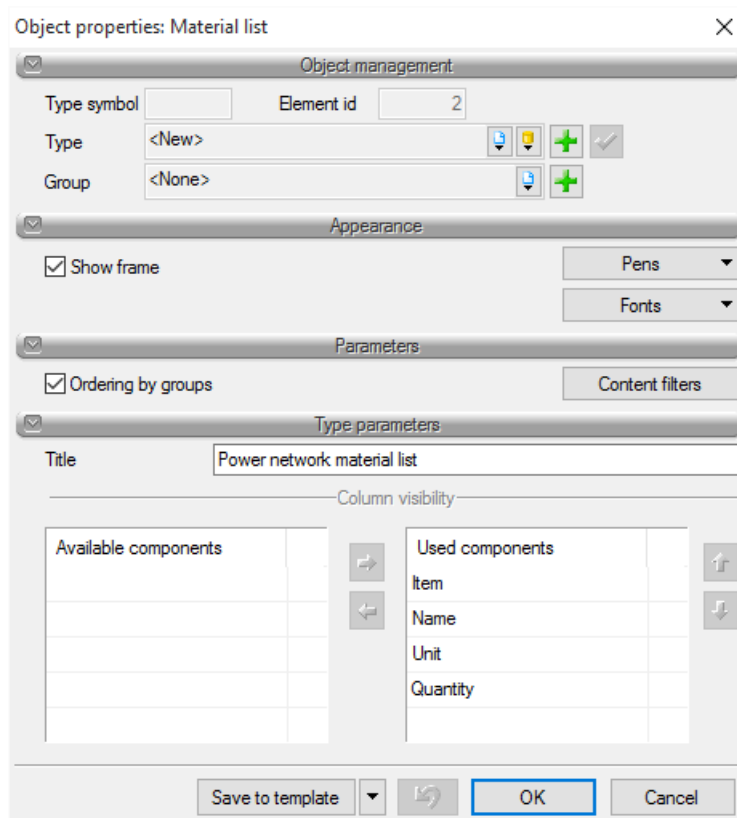
Drawing 27. Properties window for an item on the generated diagram

This window will defining the colour, item description and its technical properties by clicking the **Properties** button.

### 3.4.14 Generation of lists

**ArCADia-POWER NETWORKS** enables generating lists of items used in the design. The software saves the list in RTF format, which can be opened in any version of MS Word or OpenOffice.

Once the  icon is clicked, a “Save report/list” dialogue box appears from the bar. This box is used to select the location where the generated lists will be saved on the hard drive. In order to preview the saved file you need to locate the path and open the file by double-clicking it.



Drawing 28. List configuration window

## Working with the software


### 3.4.15 Example material list

## Material list

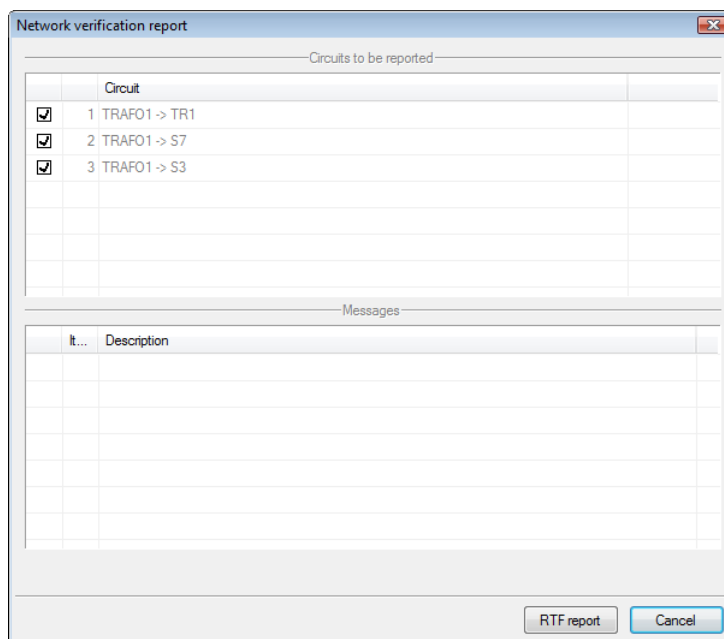
Item no.	Name	Unit	Quantity
1.	Protective pipe DVK $\Phi$ 160 mm	m	7.8
2.	Distribution board 200/150/70 cm 250 A IP 44	pcs.	1
3.	Lighting post L = 10.50 m 1x150 W, extension arm 1.0 m	pcs.	7
4.	Industrial time-delay fuse: WT-00, WT-1 16 A	pcs.	1
5.	Industrial time-delay fuse: WT-00, WT-1 125 A	pcs.	1
6.	Overcurrent circuit breaker, C 63 A class	pcs.	1
7.	Industrial time-delay fuse: WT-00, WT-1 100 A	pcs.	1
8.	Industrial time-delay fuse: WT-00, WT-1 25 A	pcs.	1
9.	Small-size 6A time-delay fuse	pcs.	1
10.	Transitional two-pole connector: 250 A 100/150/50 cm IP 44	pcs.	1
11.	Transitional two-pole connector: 250 A 100/150/50 cm IP 44	pcs.	1
12.	Dry-type transformer 630 kVA	pcs.	1
13.	Splitting element	pcs.	1
14.	Multi-core buried line, YKY 5x50 mm <sup>2</sup>	m	80
15.	Multi-core buried line, YAKXS 4x10 mm <sup>2</sup>	m	74
16.	Multi-core buried line, YAKXS 4x70 mm <sup>2</sup>	m	40
17.	Multi-core buried line, YAKXS 4x35 mm <sup>2</sup>	m	45

### 3.4.16 Generating network verification reports

**ArCADia-POWER NETWORKS** enables generating network verification reports concerning items inserted into the project. The software saves the reports in RTF format, which can be opened in any version of MS Word or OpenOffice.

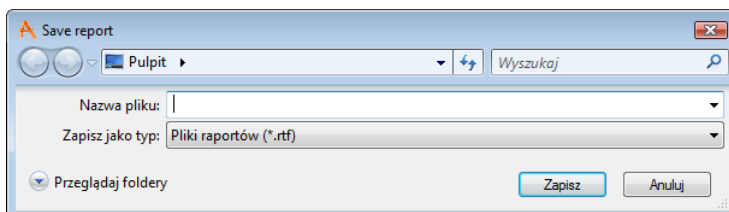
This function is selected by clicking the  icon on the tool bar. First, the software verifies the designed circuits. If any irregularities are disclosed, they will be displayed in the “Network verification report” window. If at least one correct circuit can be found in the designed network, we can obtain a report by clicking the “RTF report” button.

## Working with the software



Drawing 29. Network inspection report window

The “Save report/list” dialogue box appears for correctly designed networks or when the report is to be generated only for correct circuits. This window is used to select the save destination path on the HDD for the generated report. In order to preview the saved file you need to locate the path and open the file by double-clicking it.



Drawing 30. Save report/list dialogue box

The generated report contains a specification of all the circuits output from the transformer. A table shows the values of load currents, short-circuit currents, line resistance and reactance, voltage drops and lengths of the designed network sections.

The remaining parts of the report include a verification of the correctness of cable, conductor short-circuit and overload protection selection, as well as verifying that electric shock protection is retained.

## Working with the software

**3.4.17 Exemplary network verification report****Specification of lines output from TRAFO-1 transformer**

Section marking	Length [m]	Resistance [ $\Omega$ ]	Reactance [ $\Omega$ ]	Voltage drop [%]	Load current [A]	Short-circuit current [kA]		Surge current [kA]
						Single-phase	Three-phase	
L-1	40.0	0.018	0.003	0.37	55.87	4.12	6.55	5.96
L-2	80.0	0.030	0.006	0.62	55.87	2.10	3.87	3.03
L-3	45.0	0.039	0.003	0.02	1.69	2.58	4.68	3.72
L-4	14.0	0.042	0.001	0.02	1.69	1.10	2.11	1.58
L-5	4.0	0.012	0.000	0.00	0.48	1.14	2.21	1.64
L-6	3.8	0.011	0.000	0.00	1.21	0.97	1.87	1.39
L-7	8.5	0.026	0.001	0.00	0.24	0.90	1.76	1.30
L-8	18.8	0.056	0.002	0.02	0.97	0.72	1.42	1.04
L-9	7.6	0.023	0.001	0.01	0.73	0.63	1.24	0.90
L-10	8.7	0.026	0.001	0.00	0.48	0.55	1.08	0.79
L-11	8.8	0.026	0.001	0.00	0.24	0.48	0.96	0.70

## Working with the software

### Verification of voltage drops in circuits

#### Circuit voltage drop TRAFO-1 → TR-1

$$\Delta U_{\max} = \Delta U_{L-2} + \Delta U_{L-1}$$

$$\Delta U_{\max} = 0.62\% + 0.37\% = 0.99\%$$

is lower than the permissible value, which is 5.00%.

#### Circuit voltage drop TRAFO-1 → S-7

$$\Delta U_{\max} = \Delta U_{L-11} + \Delta U_{L-10} + \Delta U_{L-9} + \Delta U_{L-8} + \Delta U_{L-6} + \Delta U_{L-4} + \Delta U_{L-3}$$

$$\Delta U_{\max} = 0.00\% + 0.00\% + 0.01\% + 0.02\% + 0.00\% + 0.02\% + 0.02\% = 0.08\%$$

is lower than the permissible value, which is 5.00%.

#### Circuit voltage drop TRAFO-1 → S-3

$$\Delta U_{\max} = \Delta U_{L-7} + \Delta U_{L-5} + \Delta U_{L-4} + \Delta U_{L-3}$$

$$\Delta U_{\max} = 0.00\% + 0.00\% + 0.02\% + 0.02\% = 0.05\%$$

is lower than the permissible value, which is 5.00%.

### L-1 line

#### Condition of continuous current-carrying capacity

$$I_{dd} \geq I_o$$

$$138.00 \text{ A} \geq 55.87 \text{ A}$$

#### Coordination condition for conductor with protection – protection at circuit start

$$I_o \leq I_{Nprot} \leq I_{dd}$$

$$55.87 \text{ A} \leq 125.00 \text{ A} \leq 138.00 \text{ A}$$

$$I_Z \leq 1.45 \cdot I_{dd}$$

$$200.00 \text{ A} \leq 200.10 \text{ A}$$

Industrial time-delay fuse: WT-00, WT-1 125 A fulfils protection the coordination conditions with the power supply circuit

#### Single-phase short-circuit breaking capacity verification – protection at circuit start

$$\Sigma R = 0.005 \Omega$$

$$\Sigma X = 0.014 \Omega$$

$$Z_{zw} = 0.015 \Omega$$

$$I_{p1} \geq I_Z$$

$$12075.00 \text{ A} \geq 713.60 \text{ A}$$

From the current-time protection characteristics - Industrial time-delay fuse: WT-00, WT-1 125 A – it can be concluded that the short-circuit breaking condition in a period shorter than required (5 s) is fulfilled.

**Conclusion:** the designed circuit fulfils the requirements in the scope of electric shock protection efficiency.

#### Coordination condition for conductor with protection – protection at circuit end

$$I_o \leq I_{Nprot} \leq I_{dd}$$

$$55.87 \text{ A} \leq 100.00 \text{ A} \leq 138.00 \text{ A}$$

$$I_Z \leq 1.45 \cdot I_{dd}$$

$$160.00 \text{ A} \leq 200.10 \text{ A}$$

Industrial time-delay fuse: WT-00, WT-1 100 A fulfils protection the coordination conditions with the power supply circuit

#### Single-phase short-circuit breaking capacity verification – protection at circuit end

$$\Sigma R = 0.040 \Omega$$

$$\Sigma X = 0.020 \Omega$$

$$Z_{zw} = 0.045 \Omega$$

$$I_{p1} \geq I_Z$$

$$4120.34 \text{ A} \geq 579.60 \text{ A}$$

From the current-time protection characteristics - Industrial time-delay fuse: WT-00, WT-1 100 A – it can be concluded that the short-circuit breaking condition in a period shorter than required (5 s) is fulfilled.

## Working with the software

**Conclusion:** the designed circuit fulfils the requirements in the scope of electric shock protection efficiency.

### L-2 line

#### Condition of continuous current-carrying capacity

$$I_{dd} \geq I_o$$
$$167.00 \text{ A} \geq 55.87 \text{ A}$$

#### Coordination condition for conductor with protection – protection at circuit end

$$I_o \leq I_{Nprot} \leq I_{dd}$$
$$55.87 \text{ A} \leq 63.00 \text{ A} \leq 167.00 \text{ A}$$
$$I_z \leq 1.45 \cdot I_{dd}$$
$$91.35 \text{ A} \leq 242.15 \text{ A}$$

Overcurrent circuit breaker, C 63 A class fulfils the coordination conditions for protection with the power supply circuit

#### Single-phase short-circuit breaking capacity verification – protection at circuit end

$$\Sigma R = 0.099 \Omega$$

$$\Sigma X = 0.031 \Omega$$

$$Z_{zw} = 0.104 \Omega$$

$$I_{p1} \geq I_z$$
$$2102.57 \text{ A} \geq 630.00 \text{ A}$$

From the current-time characteristics of the protection – overcurrent circuit breaker, C 63 A class – it can be concluded that the condition of short-circuit breaking in a period shorter than required (5 s) is fulfilled.

**Conclusion:** the designed circuit fulfils the requirements in the scope of electric shock protection efficiency.

### L-3 line

#### Condition of continuous current-carrying capacity

$$I_{dd} \geq I_o$$
$$94.00 \text{ A} \geq 1.69 \text{ A}$$

#### Coordination condition for conductor with protection – protection at circuit start

$$I_o \leq I_{Nprot} \leq I_{dd}$$
$$1.69 \text{ A} \leq 25.00 \text{ A} \leq 94.00 \text{ A}$$
$$I_z \leq 1.45 \cdot I_{dd}$$
$$40.00 \text{ A} \leq 136.30 \text{ A}$$

Industrial time-delay fuse: WT-00, WT-1 25 A fulfils protection the coordination conditions with the power supply circuit

#### Single-phase short-circuit breaking capacity verification – protection at circuit start

$$\Sigma R = 0.005 \Omega$$

$$\Sigma X = 0.014 \Omega$$

$$Z_{zw} = 0.015 \Omega$$

$$I_{p1} \geq I_z$$
$$14339.06 \text{ A} \geq 98.80 \text{ A}$$

From the current-time protection characteristics – Industrial time-delay fuse: WT-00, WT-1 25 A – it can be concluded that the short-circuit breaking condition in a period shorter than required (5 s) is fulfilled.

**Conclusion:** the designed circuit fulfils the requirements in the scope of electric shock protection efficiency.



## Working with the software

### L-4 line

#### Condition of continuous current-carrying capacity

$$I_{dd} \geq I_o$$

$$47.00 \text{ A} \geq 1.69 \text{ A}$$

#### Coordination condition for conductor with protection – protection at circuit start

$$I_o \leq I_{Nprot} \leq I_{dd}$$

$$1.69 \text{ A} \leq 16.00 \text{ A} \leq 47.00 \text{ A}$$

$$I_Z \leq 1.45 \cdot I_{dd}$$

$$25.60 \text{ A} \leq 68.15 \text{ A}$$

Industrial time-delay fuse: WT-00, WT-1 16 A fulfils protection the coordination conditions with the power supply circuit

#### Single-phase short-circuit breaking capacity verification – protection at circuit start

$$\Sigma R = 0.082 \, \Omega$$

$$\Sigma X = 0.021 \, \Omega$$

$$Z_{zw} = 0.085 \, \Omega$$

$$I_{p1} \geq I_Z$$

$$2170.31 \text{ A} \geq 62.50 \text{ A}$$

From the current-time protection characteristics – Industrial time-delay fuse: WT-00, WT-1 16 A – it can be concluded that the short-circuit breaking condition in a period shorter than required (5 s) is fulfilled.

**Conclusion:** the designed circuit fulfils the requirements in the scope of electric shock protection efficiency.

### L-5 line

#### Condition of continuous current-carrying capacity

$$I_{dd} \geq I_o$$

$$47.00 \text{ A} \geq 0.48 \text{ A}$$

### L-6 line

#### Condition of continuous current-carrying capacity

$$I_{dd} \geq I_o$$

$$47.00 \text{ A} \geq 1.21 \text{ A}$$

### L-7 line

#### Condition of continuous current-carrying capacity

$$I_{dd} \geq I_o$$

$$47.00 \text{ A} \geq 0.24 \text{ A}$$

### L-8 line

#### Condition of continuous current-carrying capacity

$$I_{dd} \geq I_o$$

$$47.00 \text{ A} \geq 0.97 \text{ A}$$

### L-9 line

#### Condition of continuous current-carrying capacity

$$I_{dd} \geq I_o$$

$$47.00 \text{ A} \geq 0.73 \text{ A}$$

## Working with the software

### **L-10 line**

**Condition of continuous current-carrying capacity**

$$I_{dd} \geq I_o$$

$$47.00 \text{ A} \geq 0.48 \text{ A}$$

### **L-11 line**

**Condition of continuous current-carrying capacity**

$$I_{dd} \geq I_o$$

$$47.00 \text{ A} \geq 0.24 \text{ A}$$