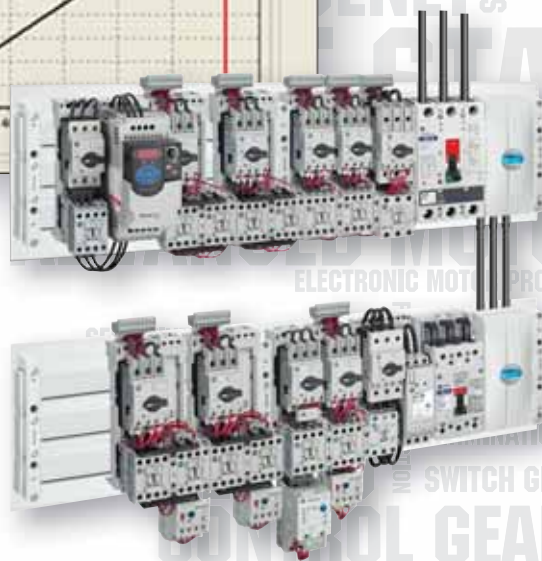
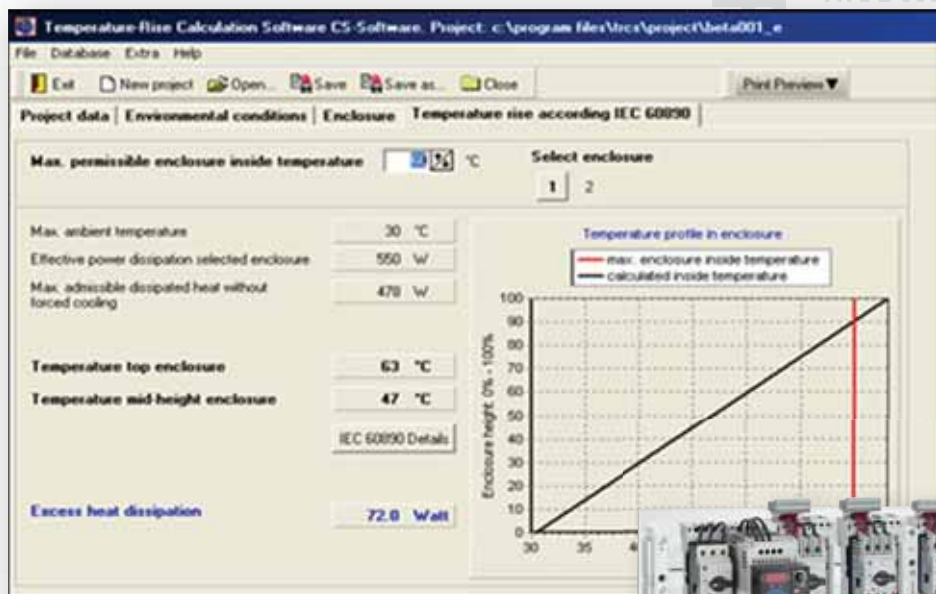


Temperature Rise Calculation Software – Tutorial

In Accordance with the Calculation Method to IEC 60890



LISTEN.
THINK.
SOLVE.



Allen-Bradley • Rockwell Software

Rockwell
Automation

Temperature Rise Calculation Software (TRCS)

Rockwell Automation

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Chapter 1

Temperature Rise Calculation Software (TRCS) – Tutorial

This tutorial will help you become familiar with the TRCS Temperature Rise Calculation Software. It will lead you through a sample project.

Please consider this document as complementary information to the Help file and the User Manual, where you will find detailed information about particular topics.

1.1 The Tutorial Project

It is strongly recommended to work through the MCS Star Tutorial first. By completing the MCS Star tutorial, you will generate a small, versatile busbar assembly project with various starters types and loadfeeders.

MCS Star provides an “Export” function which generates a kind of “reduced” Bill of Material, containing only components which will contribute to the temperature rise in the panel, including their operating current. The component’s power loss data for a wide range of Rockwell Automation products are provided in a database within TRCS.

For more information about the temperature rise calculation model consult the **Help file**, **User Manual** and the standard IEC 60890.

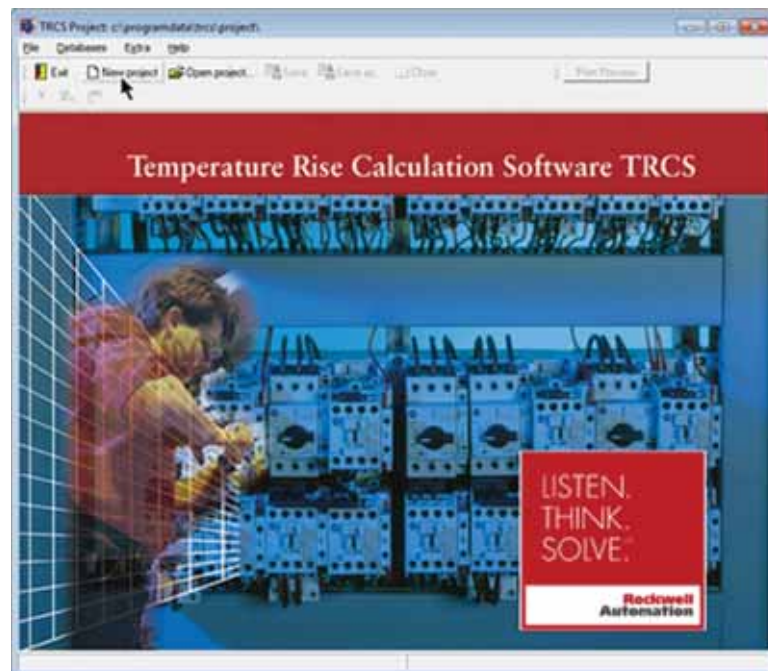
We will use the data exported from MCS Star in this Tutorial.

Chapter 2

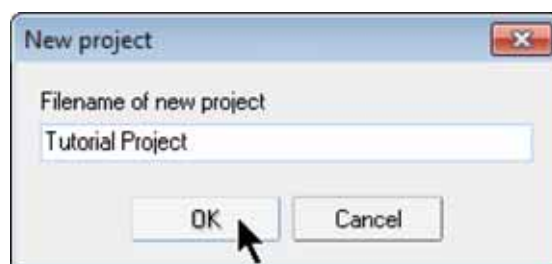
Start with Your First TRCS Project

Start the Temperature Rise Calculation Software (TRCS).

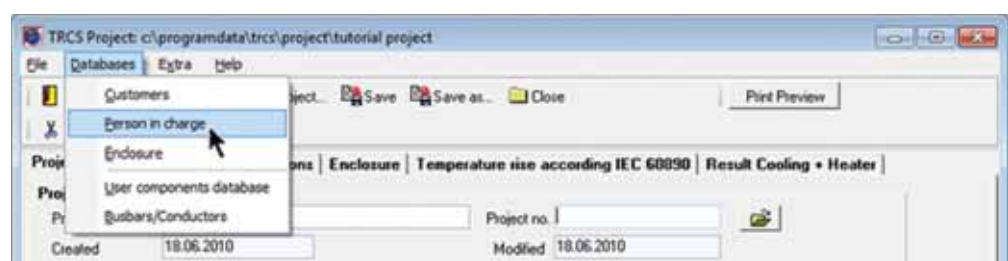
In the startup window, **select the [New Project] button.**



Enter the name of the project, then **select the [OK] button.**

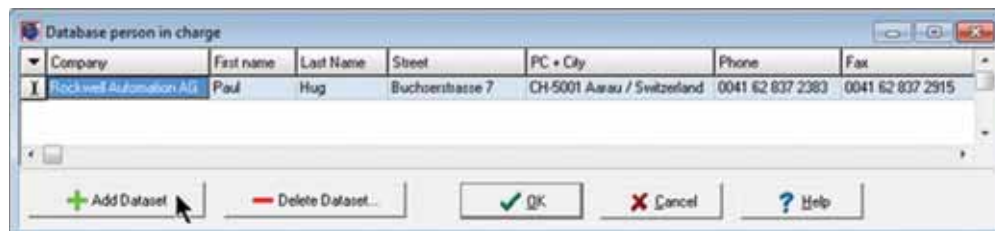


Select the menu item “Databases/Person in charge”.



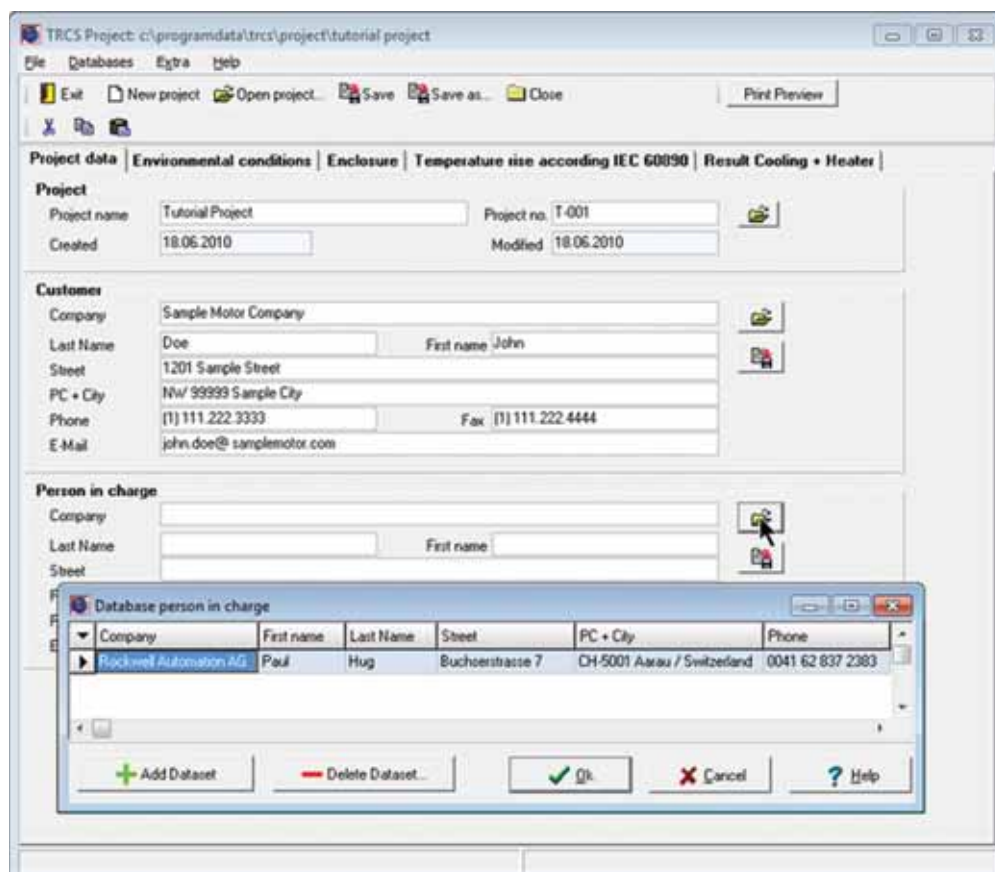
Start with Your First Project (continued)

In the following window, **select the [+ Add Dataset] button**, then enter your personal data into the new row.



In the “Project data” tab, enter the customer data per the example below.

Select the  button in the “Person in charge” section.



Start with Your First Project (continued)

If the data for “**Customer**” and “**Person in charge**” is already entered, it can be retrieved from the database by selecting the  button in the corresponding area.

Newly entered or amended data can be stored in the database by selecting the  button.

The data entry in the “**Project data**” tab is now complete. **Please save your work before you go forward to the next tab.**



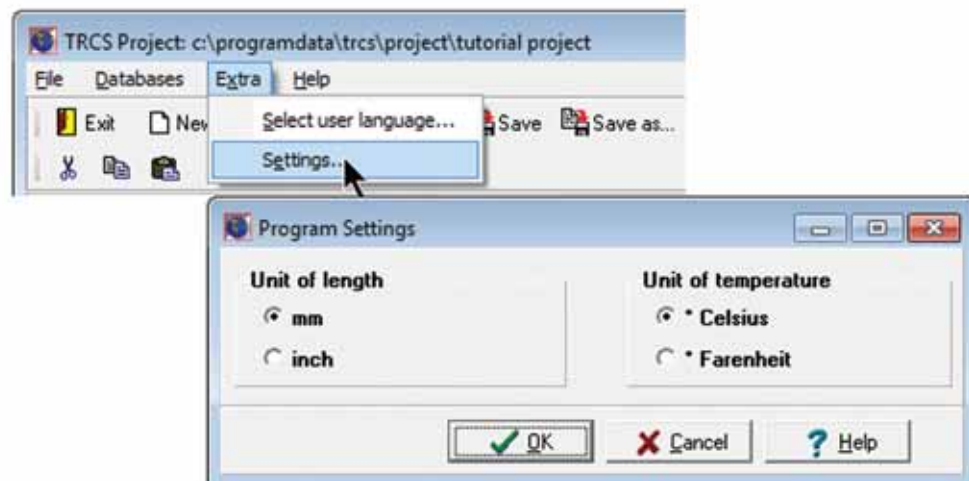
Notes:

- If you want to save intermediate steps or multiple versions of a project, select the [**Save as...**] button and save it under a new filename.
- The program creates the sample project file name “Example” every time you start TRCS. If you want to save changes on the “Example” project, select [**Save as...**] and enter a new file name.

2.1 “Environmental Conditions” Tab

Before you enter the environmental conditions, you may want to change some program settings, like units of measure or temperature. **Select the menu option “Extra /Settings...”**

Make your changes and **select the [OK] button**.



Notes:

Rockwell Automation provides enclosure databases from multiple suppliers with the software. However, if your preferred supplier is not included or if you have some custom enclosure sizes, you can create your own enclosure database.

The component database provided with the software contains nearly 1,900 records, representing more than 15,000 individual Rockwell Automation components with their power loss data. If you regularly need some additional products, just create your own User Components Database.

2.1 “Environmental Conditions” Tab (continued)

Now **enter the data in the “Environmental conditions” tab** as shown below.

Note: Calculations in accordance with IEC 60890 assume that the enclosures are not affected by any sources of radiation (ovens, sun).

The screenshot shows the 'Environmental conditions' tab with the following inputs:

- Max. ambient temperature: 35 °C
- Min. ambient temperature: 5 °C
- Altitude of the location (for filter fan calculation only): 500 m
- Enclosure stands outside: ☐

Maximum ambient temperature

The maximum ambient temperature is required for the calculation of the inside temperature, which is the product of the ambient temperature and the temperature rise caused by the power dissipation of the installed devices, conductors and busbars.

Altitude of the location

If the altitude of the location it is more than 1000 m above sea level, it needs to be considered for filter fan sizing.

The efficiency of a filter fan is inversely proportional to the air density. Assuming a heat dissipation in excess of 60 W (as in our tutorial project), the required air flow changes, depending on the altitude as follows:

Altitude	Required Air flow
Sea Level	7.9 m ³
1,500 m	8.9 m ³
3,000 m	10.0 m ³

Enclosure stands outside

If the enclosure is installed outside, the radiation’s effect is higher, because of increased air movement on the surface. Approximately, a factor of 2 is used for calculations.

2.2 "Enclosure" Tab

Although we don't use all the options in this Tutorial Project, the following illustration provides a short explanation of all the options in this tab. For more detailed information, refer to the **User Manual** or the **Help** file.

Enter the number of enclosures in row (max.8)

Enter the Type of installation

Activate the enclosure you want to calculate

Project data | Environmental conditions | **Enclosure** | Temperature rise according IEC 60890 | Result Cooling + Heater

Number of enclosures: 1 2

Enclosure 1

☐ Select from database

Select Enclosure...

Manufacturer:

Product group:

Type:

☒ Enter manually

Width: 1000 mm

Height: 1800 mm

Depth: 400 mm

Type of installation

Rear face: ☐ free ☒ covered

left side-wall: ☒ free ☐ covered ☐ open

Top surface: ☐ free ☐ covered

right side-wall: ☐ free ☒ covered ☐ open

☒ Air inlet opening

☒ Number of horizontal partitions

50 cmf

0

effective power dissipation in the enclosure 1

☒ Enter manually

350 Watt

☐ Evaluate

Evaluate

... from temperature difference

Select the enclosure(s) from database or enter the dimensions manually

Enter or evaluate power loss data

Input fields for ventilation openings and horizontal partitions

The enclosure dimensions are required for calculating the temperature rise.

Choose "Select from database" and select the [Select Enclosure] button. Then pick the fitting enclosure from there. **Select the manufacturer, the enclosure line and then the model number/size, then select the [OK] button.** To sort the enclosures in a particular order, click on the column title.

Enclosure 1

Rittal

Type /	Width [mm]	Height [mm]	Depth [mm]
AE	5112500	600	1200
CM	5113500	600	1200
CP	5114500	800	1000
CS	5115500	800	1000
DK	5116500	800	1200
EB	5117500	800	1200
ES	5118500	1000	1000
HD	5119500	1000	1200
IN	5120500	1000	1200
IW	5121500	1000	1400
KEL	5122500	1000	1400
KL	5123500	1200	1200
KS			
PC			
QB			

Unit: mm

OK Cancel Help

2.2 “Enclosure” Tab (continued)

In our Tutorial Project, we want to enter the dimensions manually. Configure your enclosure as in the screen shot below:

- **Number of enclosures: 1**
- **Enter the dimensions manually: W = 1,000, H = 1,400, D = 400 mm**
- **Configure the type of installation: rear face covered, all other surfaces free**

Note: The term “covered” means the enclosure surface is against another structure such as the wall of the building or another enclosure.

2.3 Evaluation of Power Loss

There are three possibilities to enter or to calculate the power loss:

1. If known, enter the power loss manually. Example: There is only one big drive in one panel.
2. From temperature measurements. Example: There is an existing panel and tests show that the inside temperature exceeds the limits. TRCS can help to evaluate the required measures to be taken (e.g. openings, ventilation or cooling fans) to meet the requirements.
3. Evaluation by use of the power loss data of the individual components and conductors. In this Tutorial Project, we want to use method 3. Usually, this can be time consuming if a panel contains a lot of different components with different operating currents. But with this method, the software provides the capability to import component lists we have generated with MCS Star. Of course, some additional components and the power conductors still need to be entered or selected manually.

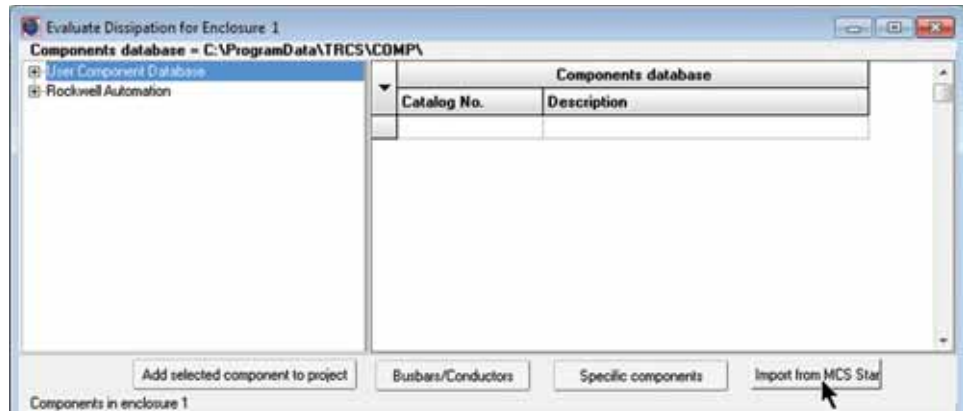
2.3.1

Import a Components List Generated with MCS Star

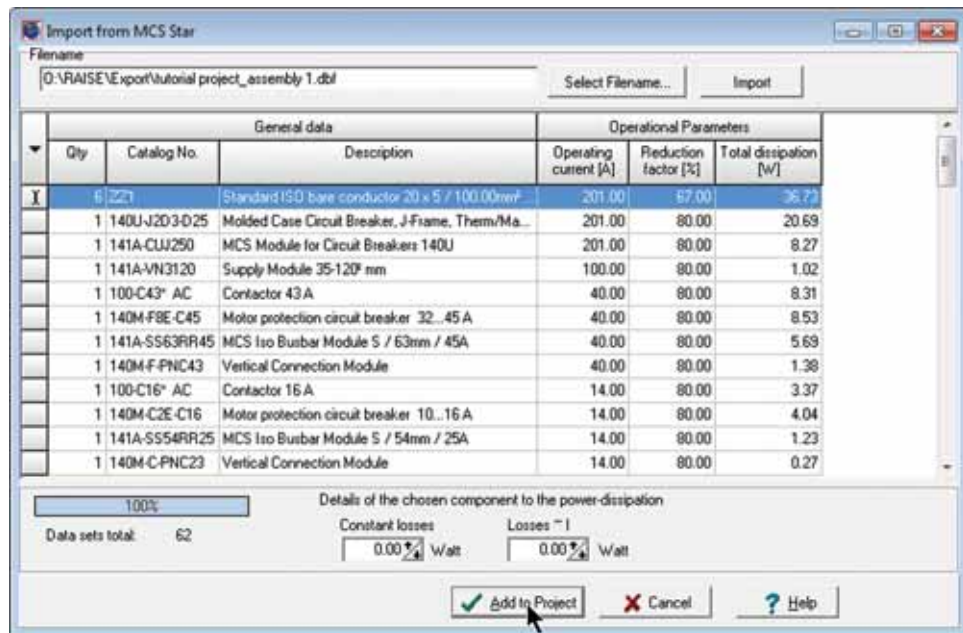
Next, select the [Evaluate] button.



- In the window “Evaluate Dissipation for Enclosure 1” select [Import MCS Star]



- Enter or select the filename of the DBF file you have exported before from MCS Star
- Select the [Import] button



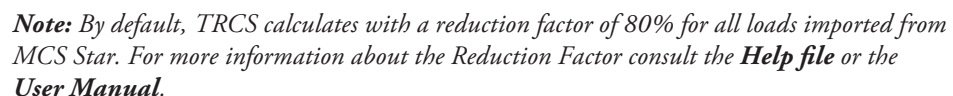
Note:

TRCS does a look-up in the Rockwell Automation Components database. The power-loss data for all components are stored there as follows:

- P_0 Constant losses (e.g. power supply, contactor coils)
- P_1 Losses proportional to the current ($\sim I$; e.g. power semi-conductors)
- P_2 Losses proportional to the square of the current ($\sim P$; e.g. conductors, fuses, contact systems)
- I_{ref} Reference current for P_1 and P_2 (current where P_1 or P_2 occur)

For more information about the temperature rise calculation model consult the **Help file**, **User Manual** and the Standard IEC 60890.

The list of components will now populate in the in the **“Evaluate Dissipation...”** window.

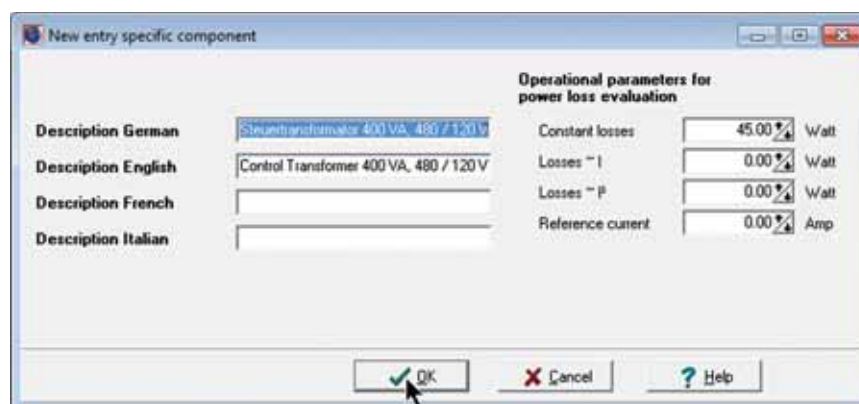


2.3.2 Add Additional Components

Now we want to add a 400VA control transformer. This product is not in the Rockwell Automation Components database, so we have to add it as a specific component manually.

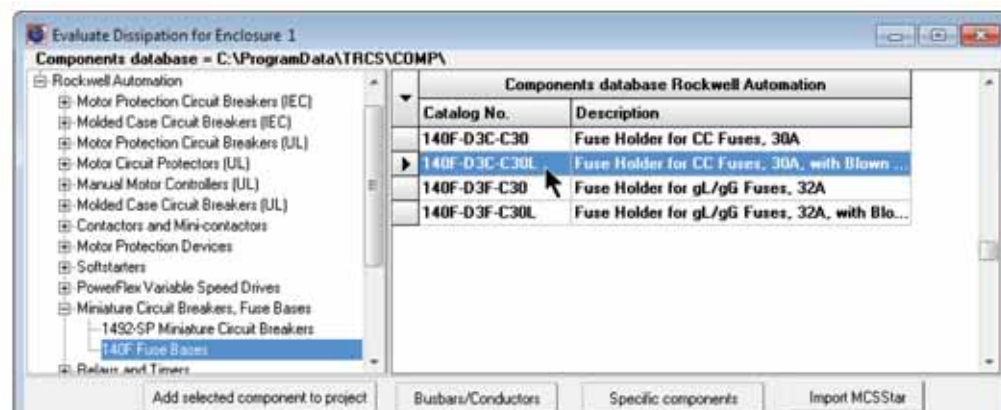
***Note:** If it is considered to be a recurring product, it would make sense to save it in the User Component database. For more information about the User Component database see User Manual or Help file.*

Select [Specific components], then select “Add new dataset”. Fill in at least the English description and the value of 45 W for Constant losses. Select the [OK] button.



From the Components database, we want to add a fuse holder and a busbar module to protect the control transformer supply. **Expand the “Rockwell Automation” folder, expand the “Miniature Circuit Breakers, Fuse Bases” folder and select 140F Fuse Bases.**

The next picture shows the selection of the fuse holder. **Highlight the desired fuse holder and select [Add selected component to project] or just double-click on the desired component. Select in the same way a 141A-GS45RR25 busbar adapter from the “Mounting System” product group.**



2.3.2 Add Additional Components (continued)

Now **select again [Specific components]**, then select “Add New Dataset” and add two CC fuses, 3 A. Enter the parameters as shown in the picture below and select the [OK] button.

		Operational parameters for power loss evaluation	
Description German	Sicherung Typ CC, 3 A	Constant losses	0.00 Watt
Description English	Fuse Type CC, 3 A	Losses ~ I	0.00 Watt
Description French		Losses ~ P	2.00 Watt
Description Italian		Reference current	3.00 Amp

The newly added components appear at the end of the components table. **Now enter the quantities and the operating current as shown in the next picture.**

The transformer is considered to run at constant power loss, so the Operating Current is not required.

Because we considered constant power loss and a Service Factor of 100 %, we do not apply a Reduction Factor to the transformer and its supply circuit.

Components in enclosure 1						
	General data			Operational Parameters		
	Qty	Catalog No.	Description	Operating current [A]	Reduction factor [%]	Total dissipation [W]
	1	100-PwNM23	Power Wire Kit, Horizontal Connection	4.00	80.00	0.02
	1	140M-D8N-B40	Circuit breaker, short-circuit prot. for starters 4.0 A	4.00	80.00	4.56
	1	141A-SS54RR25	MCS Iso Busbar Module S / 54mm / 25A	4.00	80.00	0.10
	1	140M-D-PNC23	Vertical Connection Module	4.00	80.00	0.02
	1	193-EECB	Electronic motor protection relay 1.0...5.0 A	4.00	80.00	1.25
	1	Z22	Control Transformer 400 VA, 480 / 120 V	0.00	100.00	45.00
	1	140F-D3C-C30L	Fuse Holder for CC Fuses, 30A, with Blown Fuse Indication	1.00	100.00	0.01
	1	141A-GS45RR25	MCS Standard Busbar Module S / 45mm / 25A	1.00	100.00	0.01
I	2	Z22	Fuse Type CC, 3 A	1.00	100.00	0.44
Power dissipation enclosure 1: 277 Watt				Delete Dataset	OK	Cancel Help

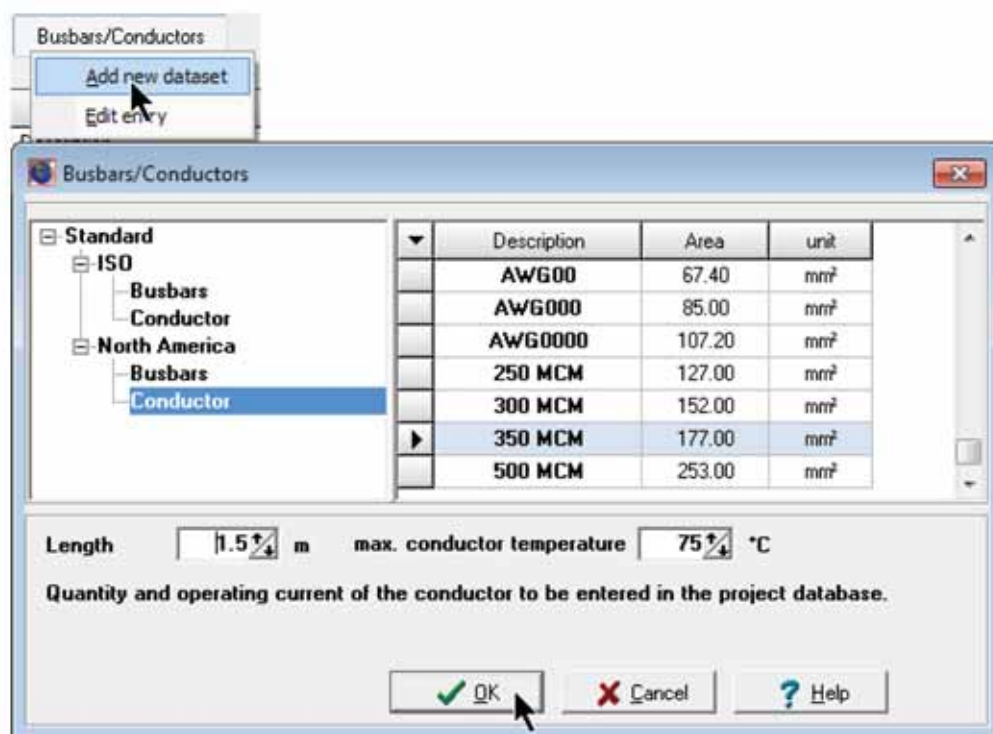
2.3.3 Add Power Conductors

Now we need to add the power conductors for the supply line and all the loads to the list. Consider an average conductor length of 1.5 m (just the length internal to the panel is to be considered) and select the wire sizes according to the required standard.

The size of the supply line is 350 MCM (this information is provided from MCS Star as well).

Select the [Busbars/Conductors] button and select “Add new dataset”.

Select the “Conductor” option under “North America”. Select 350 MCM and a length of 1.5 m. Then select the [OK] button.



Add all the other power conductors according to the picture below as you did the supply conductors above. Enter quantities, operating currents and the standard reduction factor of 80%. It is recommended to consolidate the conductors for identical loads, as shown in the picture.

Components in enclosure 1

Qty	Catalog No.	Description	Operational Parameters		
			Operating current [A]	Reduction factor [%]	Total dissipation [W]
2	Z22	Fuse Type CC, 3 A	1.00	100.00	0.44
3	Z21	Standard US Conductor 350 MCM / 177.00mm² / 1.5 m / 75 °C	171.00	80.00	12.79
6	Z21	Standard US Conductor AWG8 / 8.37mm² / 1.5 m / 75 °C	40.00	80.00	29.40
6	Z21	Standard US Conductor AWG12 / 3.31mm² / 1.5 m / 75 °C	14.00	80.00	9.17
6	Z21	Standard US Conductor AWG10 / 5.26mm² / 1.5 m / 75 °C	21.00	80.00	12.91
3	Z21	Standard US Conductor AWG12 / 3.31mm² / 1.5 m / 75 °C	3.00	80.00	0.21
3	Z21	Standard US Conductor AWG12 / 3.31mm² / 1.5 m / 75 °C	1.10	80.00	0.03
6	Z21	Standard US Conductor AWG12 / 3.31mm² / 1.5 m / 75 °C	4.80	80.00	1.08
6	Z21	Standard US Conductor AWG12 / 3.31mm² / 1.5 m / 75 °C	3.40	80.00	0.54

Power dissipation enclosure 1: 343 Watt

Delete Dataset OK Cancel Help

Note: The busbars, their operating currents and lengths were provided by MCS Star.

2.3.4 Review the List of Components

The number of components and conductors, as well as the operating current (if it does not correspond to the reference current displayed) and a reduction factor, if any, must be entered into this list.

The components imported from MCS Star usually don't need to be changed, except when more accurate information about the Reduction Factor is known.

The component's total power loss, taking into account the quantity, the operating current and the reduction factor, is shown in the right-hand column of the row.

In this Tutorial Project, let's assume that the components imported from MCS Star and their assigned data are correct, so you just have to review the manually added components and conductors according the list below:

▼	General data			Operational Parameters		
	Qty	Catalog No.	Description	Operating current [A]	Reduction factor [%]	Total dissipation [W]
	1	222	Control Transformer 400 VA, 480 / 120 V	0.00	100.00	45.00
	1	140F-D3C-C30L	Fuse Holder for CC Fuses, 30A, with Blown Fuse Indication	1.00	100.00	0.01
	1	141A-GS45RR25	MCS Standard Busbar Module S / 45mm / 25A	1.00	100.00	0.01
	2	222	Fuse Type CC, 3A	1.00	100.00	0.44
	3	221	Standard US Conductor 350 MCM / 177.00mm ² / 1.5 m / 7...	171.00	80.00	12.79
	6	221	Standard US Conductor AWG8 / 8.37mm ² / 1.5 m / 75 °C	40.00	80.00	29.40
	6	221	Standard US Conductor AWG12 / 3.31mm ² / 1.5 m / 75 °C	14.00	80.00	9.17
	6	221	Standard US Conductor AWG10 / 5.26mm ² / 1.5 m / 75 °C	21.00	80.00	12.91
	3	221	Standard US Conductor AWG12 / 3.31mm ² / 1.5 m / 75 °C	3.00	80.00	0.21
	3	221	Standard US Conductor AWG12 / 3.31mm ² / 1.5 m / 75 °C	1.10	80.00	0.03
	6	221	Standard US Conductor AWG12 / 3.31mm ² / 1.5 m / 75 °C	4.80	80.00	1.08
I	6	221	Standard US Conductor AWG12 / 3.31mm ² / 1.5 m / 75 °C	3.40	80.00	0.54

The total power loss of all components in the active enclosure is displayed in the bottom left hand corner of the window. Selecting the [OK] button will accept this value as the active enclosure's effective power dissipation and the window will close. Of course, it is always possible to come back to this window for changes.

You will then return to the “**Enclosure**” tab. The calculated Watt loss shows up in the lower area.

Effective power dissipation in enclosure 1

☐ Enter manually

343

Watt

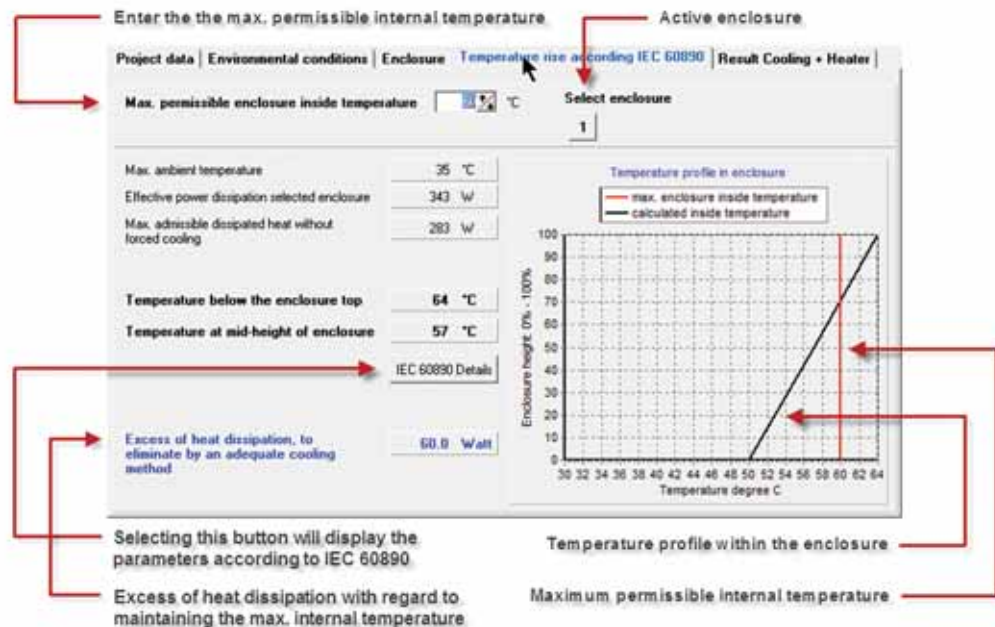
☒ Evaluate

Evaluate

... from temperature difference

2.4 “Temperature Rise According to IEC 60890” Tab

This tab shows the result of the temperature rise calculation as a temperature profile within the enclosure.



If there are multiple enclosures in a row, there will be a numbered button for each one. The active enclosure can be selected using the buttons at the top, without having the need to switch back to the “**Enclosure**” tab.

IEC 60890 refers to cabinets with natural convection. If devices with integral fans are used, this assumption no longer applies. The differences in temperature within the enclosure are reduced and the total heat dissipation across the enclosure’s surface is improved.

The maximum permissible internal enclosure temperature is 60 °C by default, but it can be changed in the upper area of this tab. It is shown as a red limit line in the temperature profile diagram.

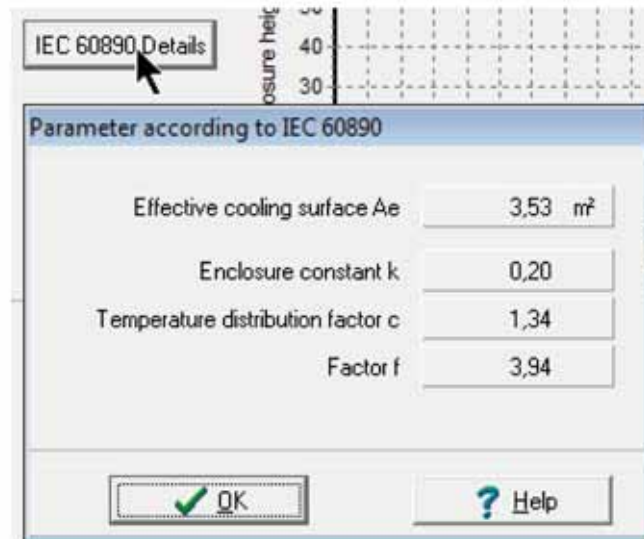
The maximum ambient temperature is taken from the “**Environmental conditions**” tab, the effective power loss for the active enclosure from the “**Enclosure**” tab. The field below that shows the power loss at which the maximum permissible internal enclosure temperature is maintained. The difference is the excess Watt loss that needs to be dissipated. This is shown on the bottom left of the window.

The diagram shows the temperature profile within the enclosure (for enclosures with an effective cooling surface of < 1.25 m², the temperature remains constant in the upper quarter) and the maximum permissible temperature. To the left of this, the temperature values below the enclosure’s roof and at mid-height, calculated in accordance with IEC 60890, are displayed.

2.4 "Temperature Rise According to IEC 60890" Tab (continued)

IEC 60890 Details

Selecting the [IEC 60890 Details] button will display the calculation parameters in accordance with IEC 60890.



IEC 60890 Details

Parameter according to IEC 60890

Effective cooling surface Ae	3,53 m²
Enclosure constant k	0,20
Temperature distribution factor c	1,34
Factor f	3,94

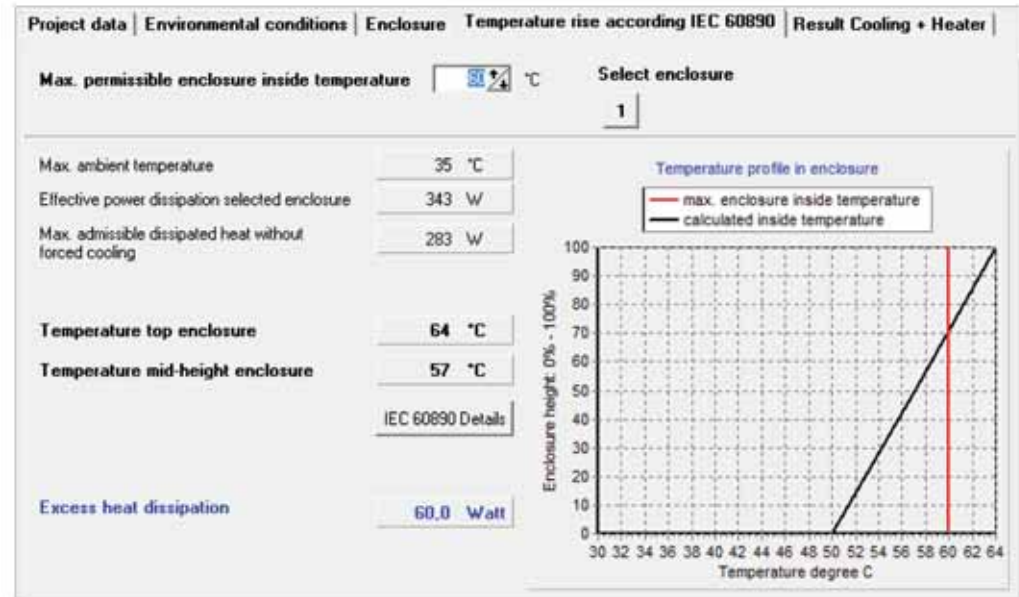
OK Help

The constants k, c and f are determined according to IEC 60890, they are required for the calculation of the heat dissipation excess.

These numeric values don't have any units of measure.

2.4.1 Measures to Take in Case of Heat Dissipation Excess

In our Example, the calculation shows an excess heat dissipation of 60 W, which would cause a temperature excess of 4 °C on top of the enclosure.



Let's try different measures to solve this issue. Make sure you change the settings back to the original values before trying each solution.

- Select a bigger enclosure. If you are not limited by space, this is a very efficient method without an influence to the ingress protection level of the enclosure type.
 - **Go back to the “Enclosure” tab and try it.** For example, an enclosure of 1,000 x 1,600 x 500 solves the issue.
- Install air inlet/outlet openings. Air inlet openings of 50 cm² would solve the issue. It needs to be more if the efficiency is reduced by a filter. This measure is not applicable if a high ingress protection level is required.

Note: The outlet openings need to be at least 1.1 x the cross-section of the inlet openings.

 - **Go back to the “Enclosure” tab and try it. Activate the check box “Air inlet opening”**
- Verify with the customer if the rated ambient temperature must be 35 °C. A reduction to 30 °C would solve the issue.
 - **Go back to the “Environmental Conditions” tab and try it.**
- Verify with the customer if the Reduction Factor for the components (or some of them) can be reduced. Experience shows that in many applications the Simultaneity Factor is < 50%.

Note: See User Manual or Help file and IEC 60439 / IEC 61439 for more information about the Reduction Factor

 - **Go back to the “Enclosure” tab and select the [Evaluate] button. Test how changes in the Reduction Factor influence the power loss.**

2.5 “Result Cooling + Heater” Tab

The temperature rise assessment according IEC 60890 is recognized as a proven method for most standard panels. It refers to cabinets with natural convection only. The “Result Cooling + Heater” tab provides some additional information and functionality.

Depending on the environmental conditions and the permissible inside temperatures, TRCS calculates:

- Necessary heating power to prevent condensation in the enclosure
- Necessary heating power to maintain the minimal enclosure inside temperature
- Required cooling capacity and / or air flow if the calculated inside temperature would exceed the limit

Project data | Environmental conditions | Enclosure | Temperature rise according IEC 60890 | Result Cooling + Heater

Calculation for enclosure no. 1

Max. permissible enclosure inside temperature: 60 °C

Min. admissible enclosure inside temperature: 5 °C

Select enclosure: 1

Material of the enclosure 1: IEC 60890 standard value

Typical middle k-value: $\frac{W}{m^2 K}$

Heater

	Indoor installation	Outdoor installation
Necessary heating power to prevent a dew point underrun	38 Watt	77 Watt
Necessary heating power to safe the minimal enclosure inside temperature, if:		
1. the power is switched off and doesn't produce any own warmth	0 Watt	0 Watt
2. the power is switched on	0 Watt	0 Watt

Cooling

Necessary cooling capacity of a cooling unit: 60.0 Watt or

Necessary air flow of a filter fan: 8 m³/h

2.5.1 Enclosures Made from Different Materials, k-value

Material of the enclosure/k-value

Beside the IEC 60890 standard value, there is a choice of different enclosure materials with different k-values:

Material of the enclosure 1

- IEC 60890 standard value
- variable
- IEC 60890 standard value
- Sheet steel painted
- Stainless steel
- Aluminium
- Aluminium (double wall)
- Polyester

Try the different enclosure materials. You will see, the IEC 60890 standard value is pretty conservative.

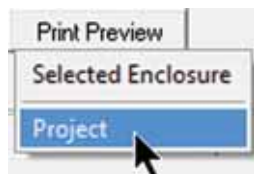
Select “variable” if you want to enter an individual k-value provided by your enclosure supplier.

2.6 Viewing and Printing Reports

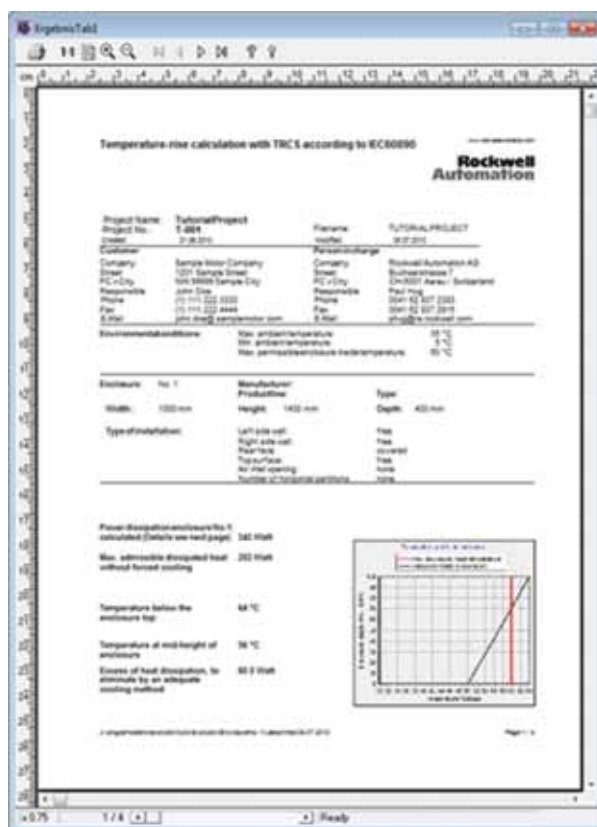
The results of the temperature rise calculation can be printed. The report includes the bill of materials and all components with their individual power dissipation values. This document is intended to be a part of the project documentation.

Select the button [**Print Preview**], menu option “**Project**”.

Note: In a project with only one enclosure, there is no difference between “**Selected Enclosure**” and “**Project**”.



Use the buttons to navigate, zoom and print the document.



Conclusion

You have now completed the tutorial project and you have learned the basics of using the Temperature Rise Calculation Software, TRCS. Please consult the **Help file** and the **User Manual** for more detailed information and features we have not covered in this tutorial, e.g.

- Temperature rise calculation for bigger panels consisting of multiple enclosures (modular enclosure systems), which can be open or closed against each other
- How to handle components missing in the database
- Creating and maintaining your custom component database and enclosure database
- Keeping TRCS up to date

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