Getting started with ProSec®
in ProSimPlus® environment

Use Case 1: Main features overview

Software & Services In Process Simulation

We guide You to efficiency

ProSim

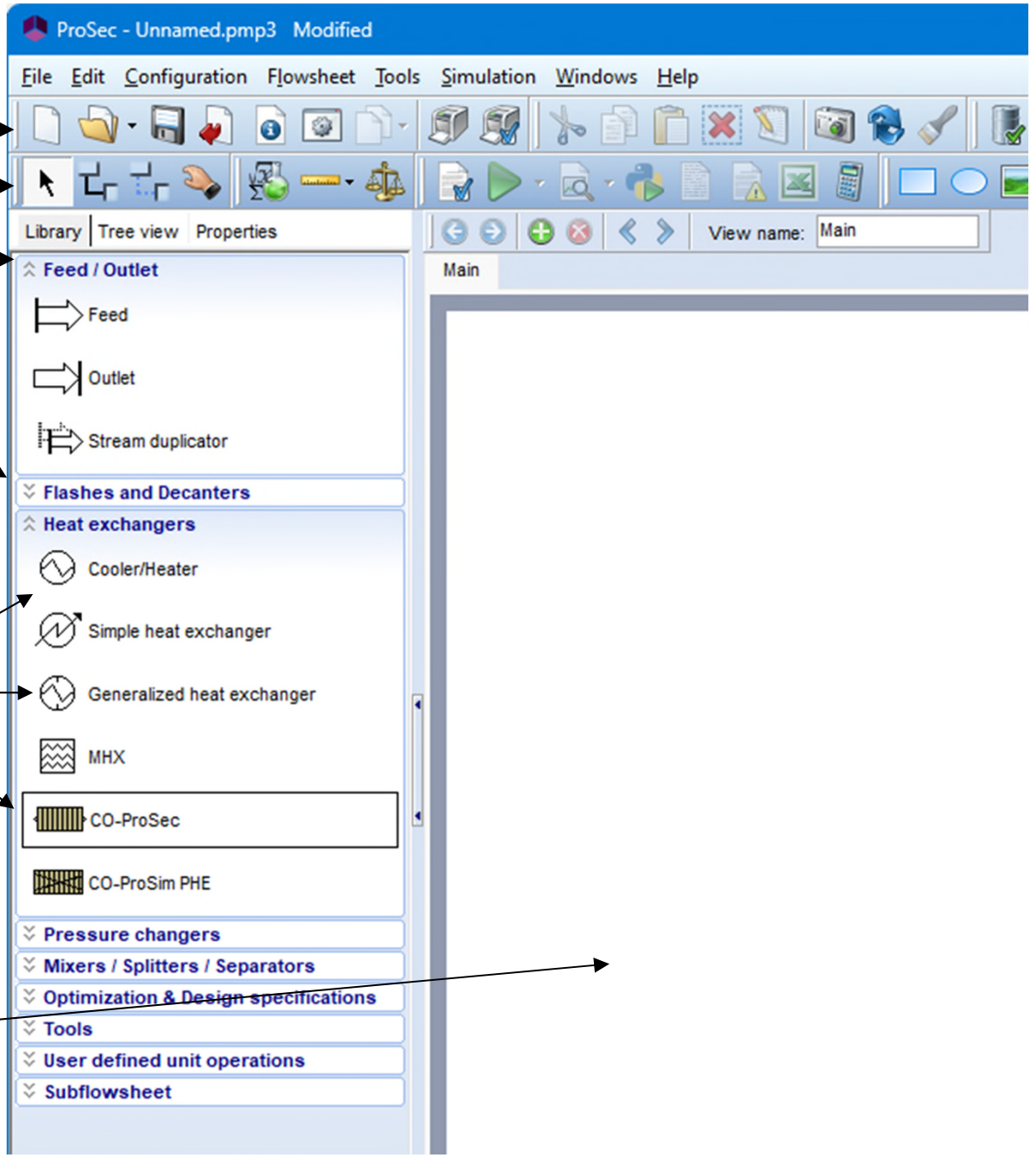
Introduction

This document presents a general overview of ProSec, ProSim's CAPE-OPEN compliant unit operation dedicated to the simulation of brazed plate-fin heat exchangers. In this document, ProSec is used in ProSimPlus, ProSim's steady state simulation software.

This step by step guide describes the different functions that are used to build a simulation of a brazed plate-fin heat exchanger with ProSec. It is based on a simple heat exchanger with two fluids.

For more information about the use of ProSimPlus environment, please consult "Getting started with ProSimPlus" documents.

Before we start: ProSimPlus interface



Project management menu

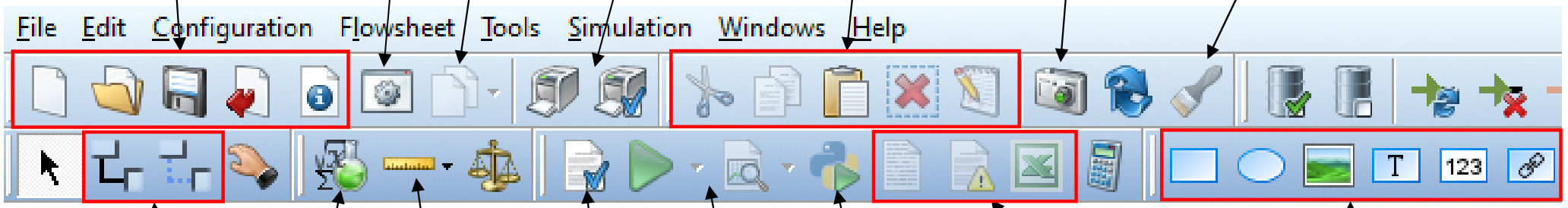
Project building menu

Categories list

Unit operations, within the selected categories

Drawing area

Before we start: ProSimPlus interface



File management (new, open, save, close, edit synopsis)

ProSimPlus Preferences

Open the files linked to the simulation

Setup the drawing area, Print

Object management (cut, copy, paste, delete, open configuration window)

Copy the flowsheet (to paste in another document)

Copy the format

Streams (material, information)

Thermodynamic profile(s) (components, models, binary interaction parameters…) and Set(s) of reactions

Unit systems (unit operations description and reports)

Simulation report parameters

Run the simulation (with options) and Case study

Call to an external solver

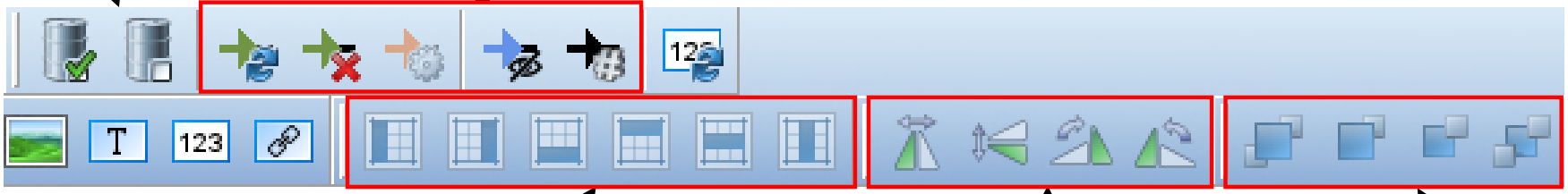
Last simulation results (report, history file, MS-Excel workbook)

Graphical objects (text, image, shapes, tags, links)

Before we start: ProSimPlus interface

TBP/ASTM Assay curves of material streams (select, deselect)

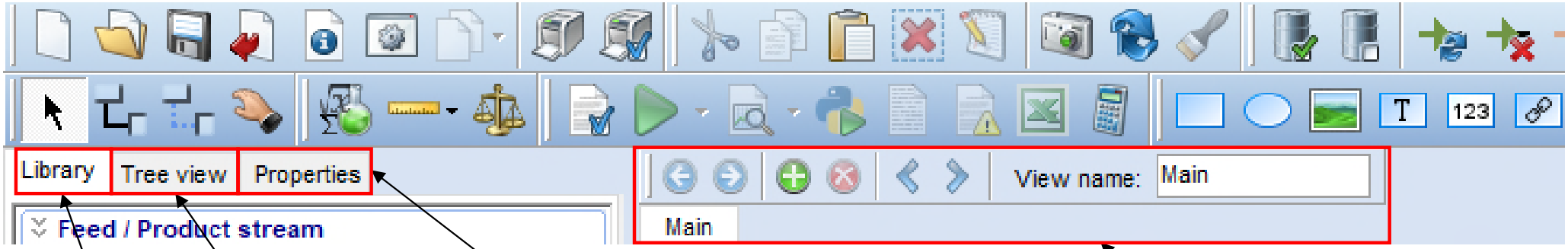
Streams management (link, initialization, number…)



Arrange the graphical objects on the flowsheet (**align, center**…)

Objects position (mirror, inverse, rotate…)

Arrange the objects **layout** in the flowsheet (front, back…)



Access to the library of unit operations

Access to the existing object on the flowsheet

Access to the graphical properties and the name of the selected object

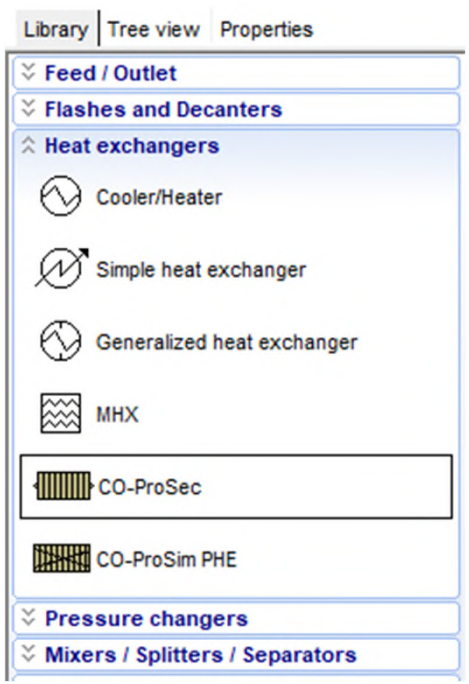
Management of the views of the flowsheet (creating, moving, renaming…)

Before we start: ProSimPlus interface

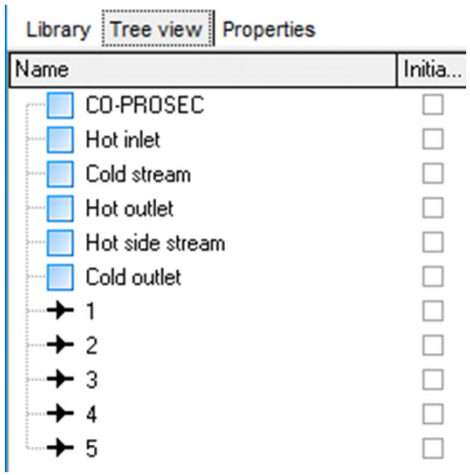
- Unit operations library, tree view or properties

  Beside the Library View, which presents the unit operations available in ProSimPlus within categories, the Tree View lists the items (streams and unit operations) used in the flowsheet. Selecting one (or several with the Ctrl button) item in the list selects the corresponding item in the flowsheet. Double clicking on the item in the list opens its configuration window.

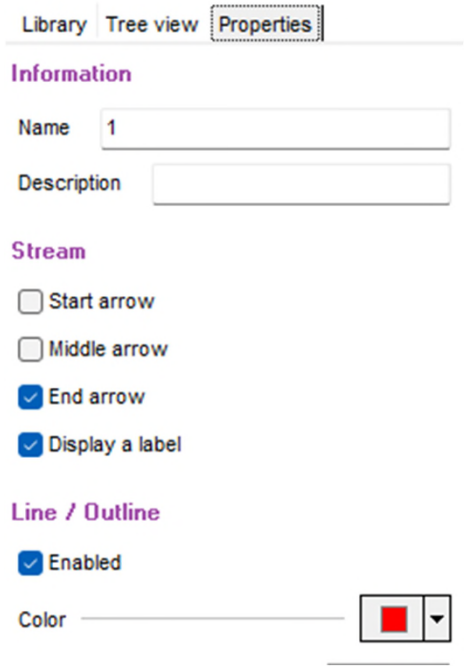
  The Properties tabs allows to modify the graphical aspect of any selceted items of the flowsheet.



Library view



Tree view

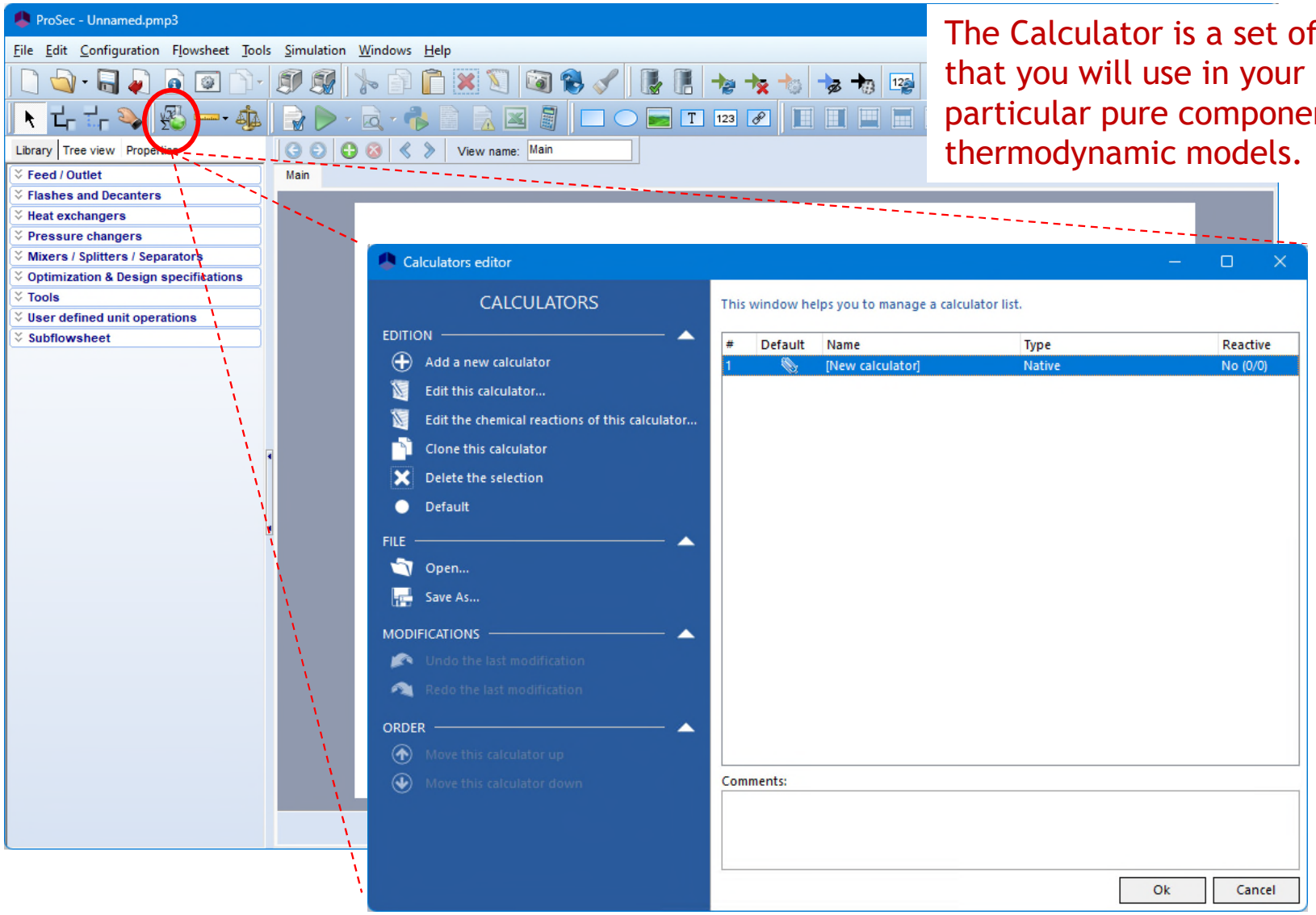


Properties

Building the flowsheet

- The steps are the following:
  - ✓ Step 1: Select your components
  - ✓ Step 2: Select your thermodynamic model
  - ✓ Step 3: Create your flowsheet
  - ✓ Step 4: Run the simulation
  - ✓ Step 5: Reports generated
  - ✓ Step 6: Analyze the results from the flowsheet
  - ✓ Step 7: Share the simulation

Step 1: Select your components

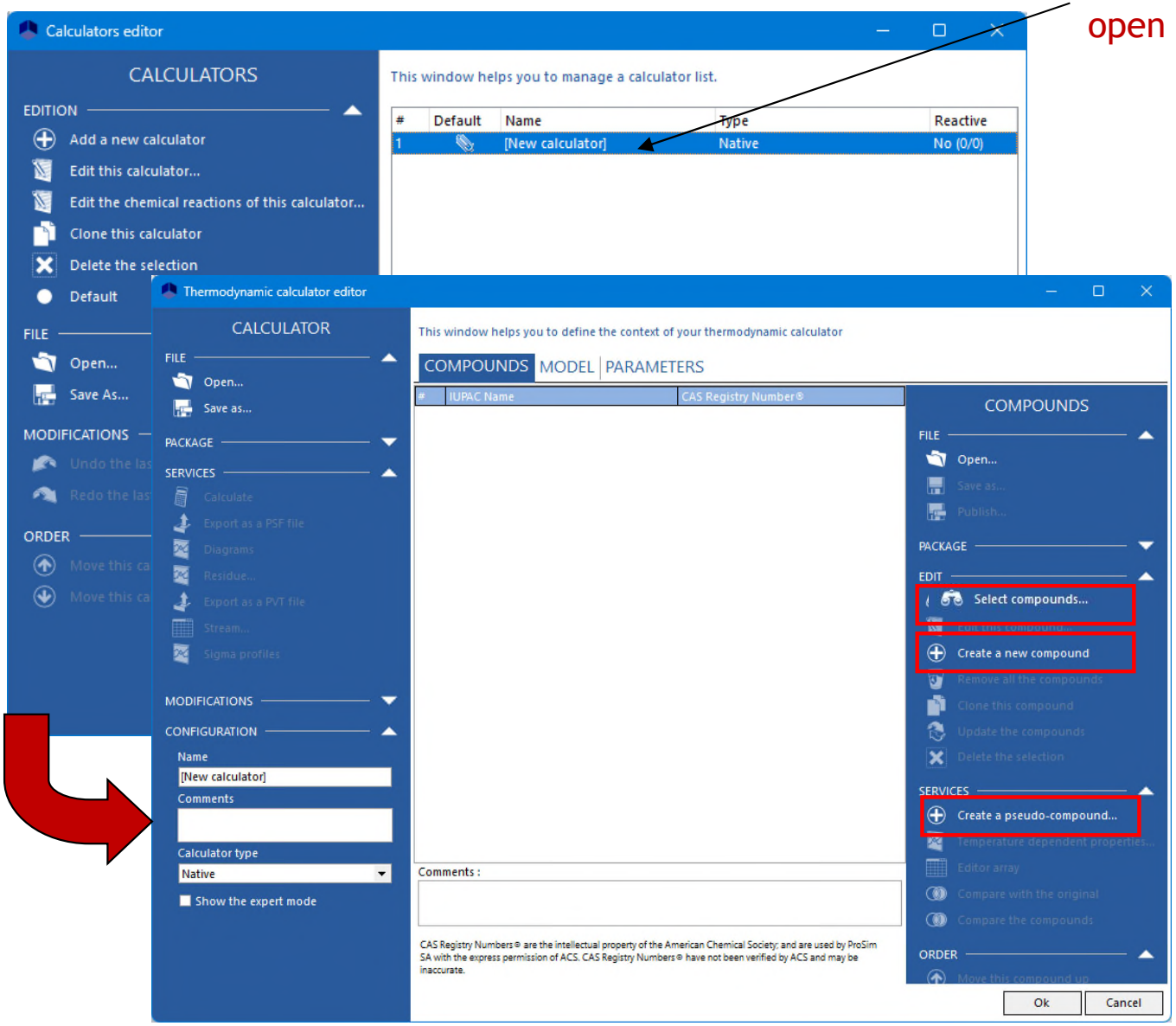


The Calculator is a set of thermodynamic data that you will use in your process. It includes in particular pure components and thermodynamic models.

Click on the Thermodynamics and Compounds icon to open the calculators editor.

You can use several calculators in the same flowsheet.

Step 1: Select your components



Double click on the “New calculator” to open the calculator environment window.

To search for a component in one of the databases, click on “Select compounds”

To create a component “from scratch” with the properties that you have, click on “Create a new compound”

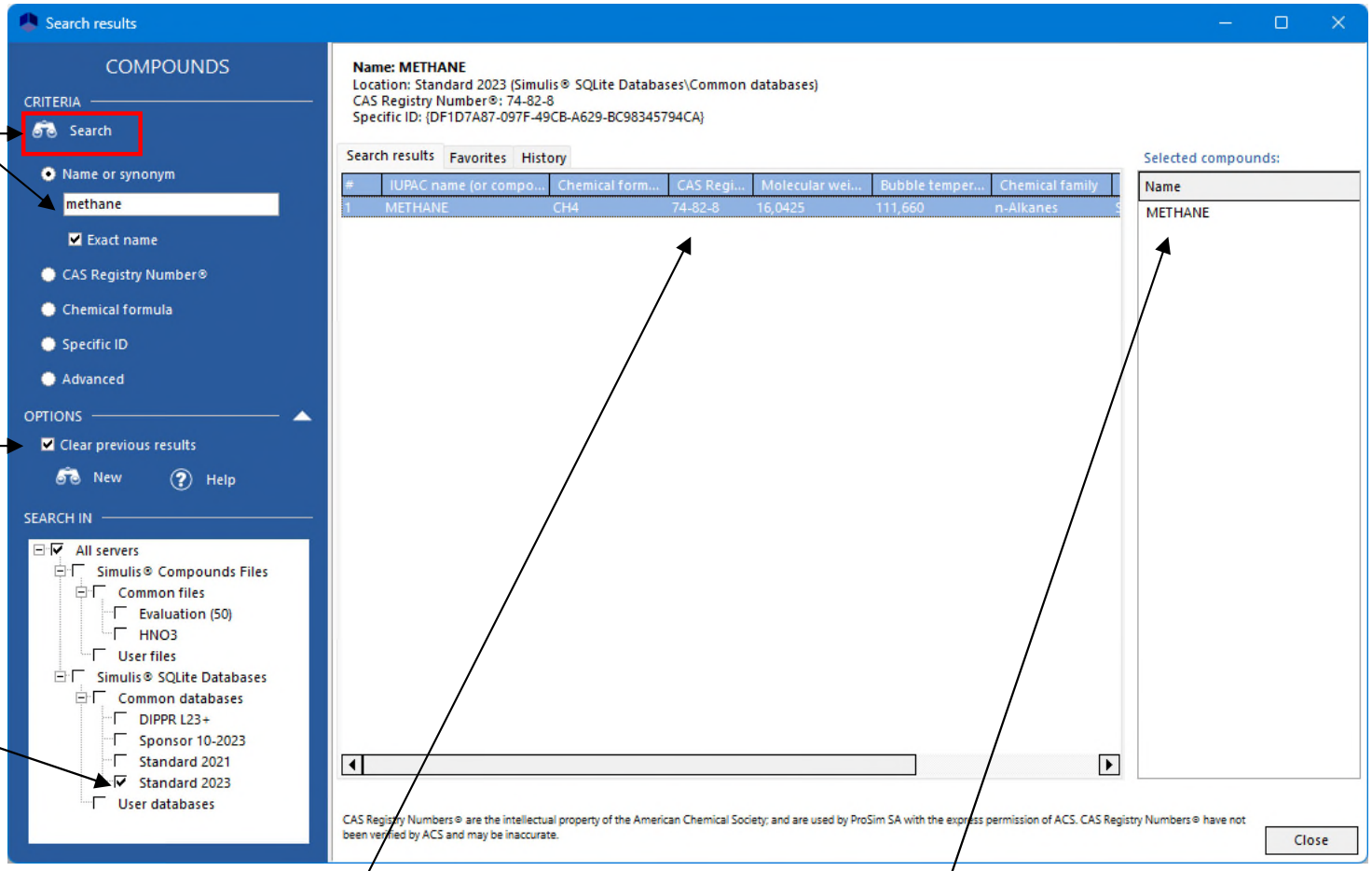
To create pseudo compounds, without lights ends, click on “Create a pseudo-compound”

Step 1: Select your components

Enter the name of the compound you are looking for or select another criteria. Once entered, press "Search"

Check this box to clear previous results

The databases registered on your computer are listed here. Select the last one (in date)



Search results are displayed in central window.

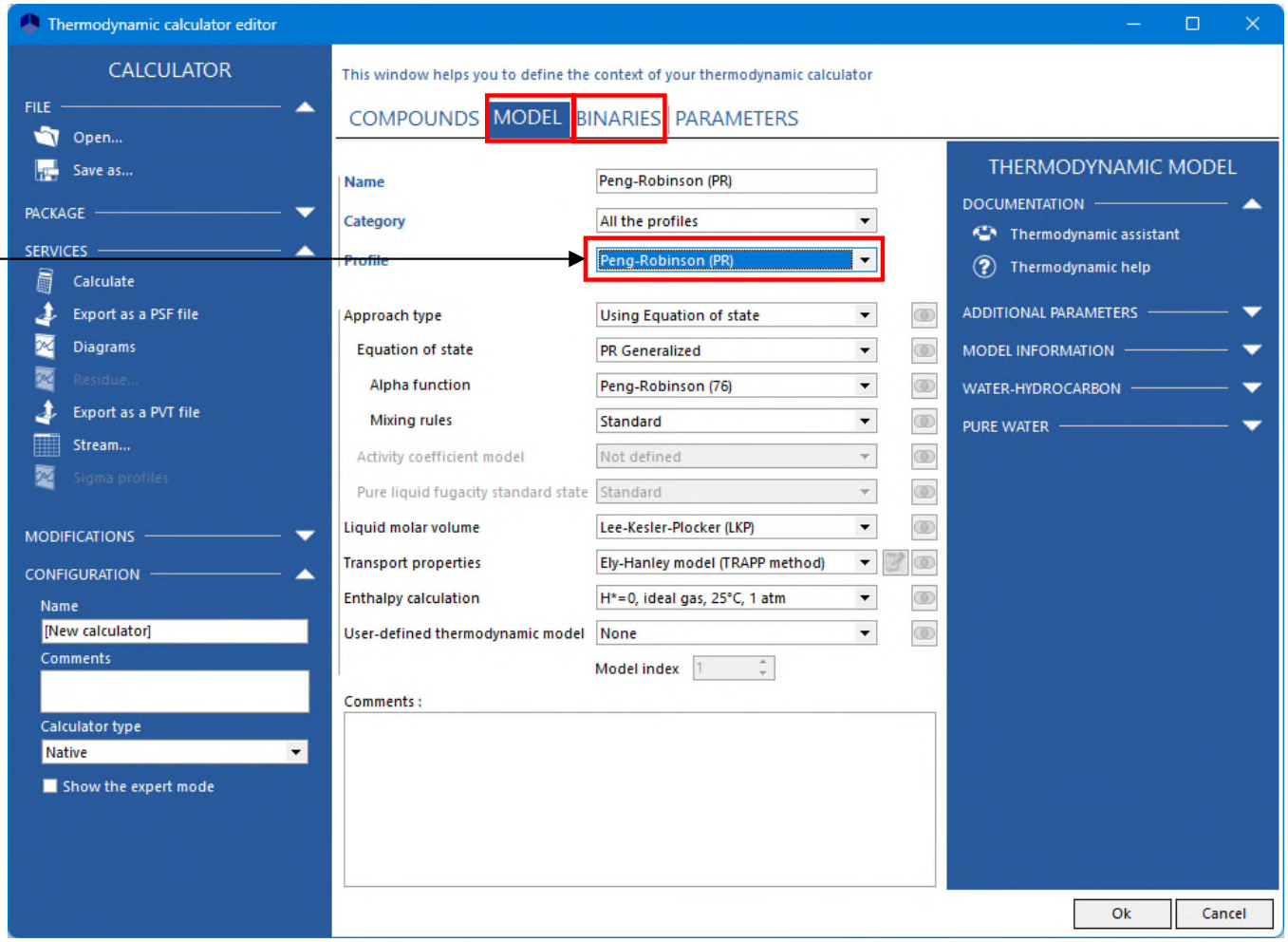
Double click on the compound you require to select it.
The selection will be displayed on the right window.

Repeat the operation to select all the components that you need.
For this simulation you will need methane and ethane.

Step 2: Select your thermodynamic model

Once all components are selected, close the component search window to return to the Calculator edition environment.
Click on the “Model” tab to enter the thermodynamic selection environment.

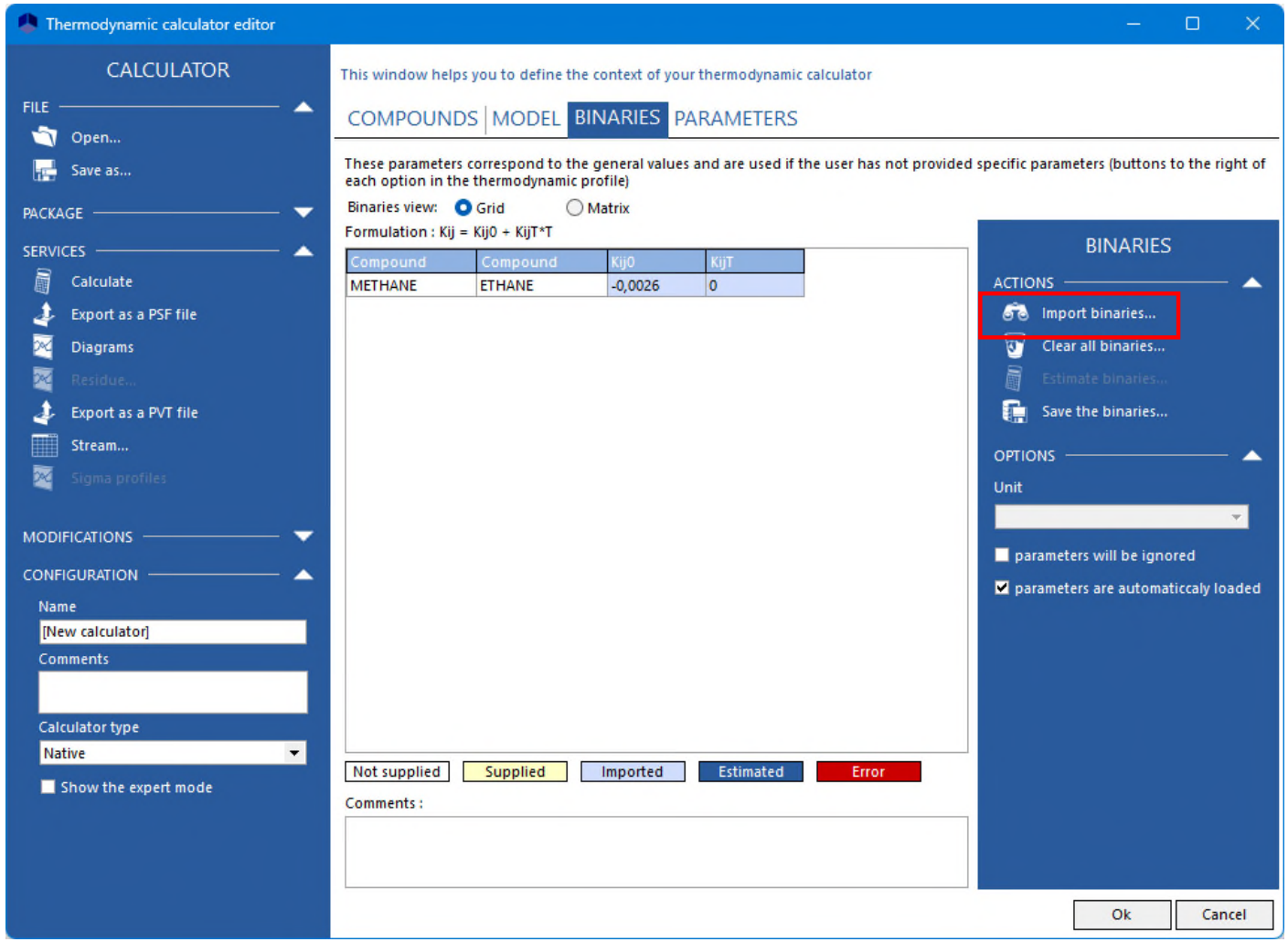
Select an appropriate thermodynamic model using the pull down menu.
Here we use Peng-Robinson.



When the selected thermodynamic model requires binary interaction parameters, the “Binaries” tab appears.

Step 2: Select your thermodynamic model

By default, for a new calculator, the available binaries are automatically loaded.



Now that your thermodynamic profile is completed click on “OK” to validate and close the window.

Step 3: Create the flowsheet

A. ProSec unit operation

B. Feed (inlet) and product (outlet)

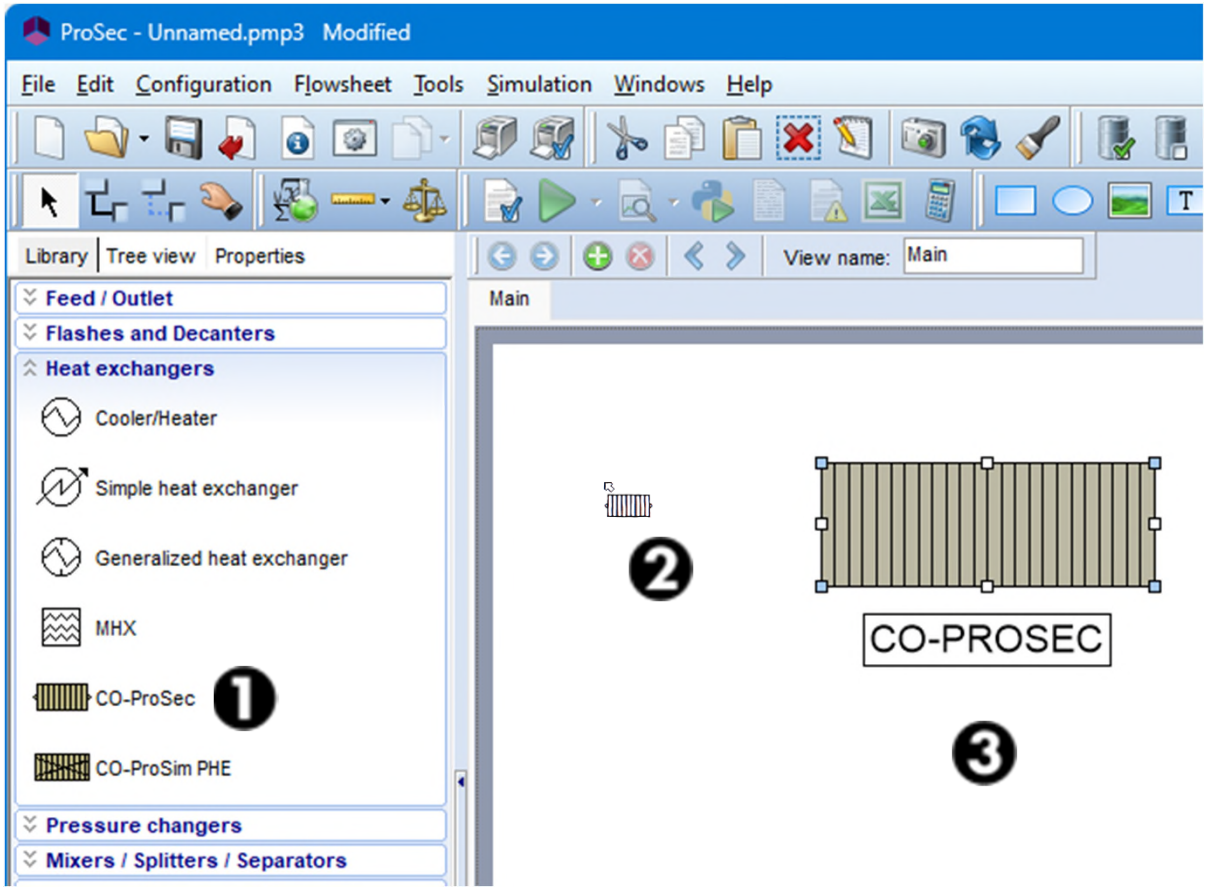
C. Connect all the unit operations with streams

Step 3: Create the flowsheet
A- ProSec unit operation

1- Click on “CO-ProSec” icon in the library category “Heat exchangers” to select ProSec unit operation.

2- Move the mouse onto the drawing sheet to where you want to place the unit operation.

3- Click again, to release the unit.



A comprehensive set of features allows you resize, rotate, reposition, align, etc. the element on the drawing area.

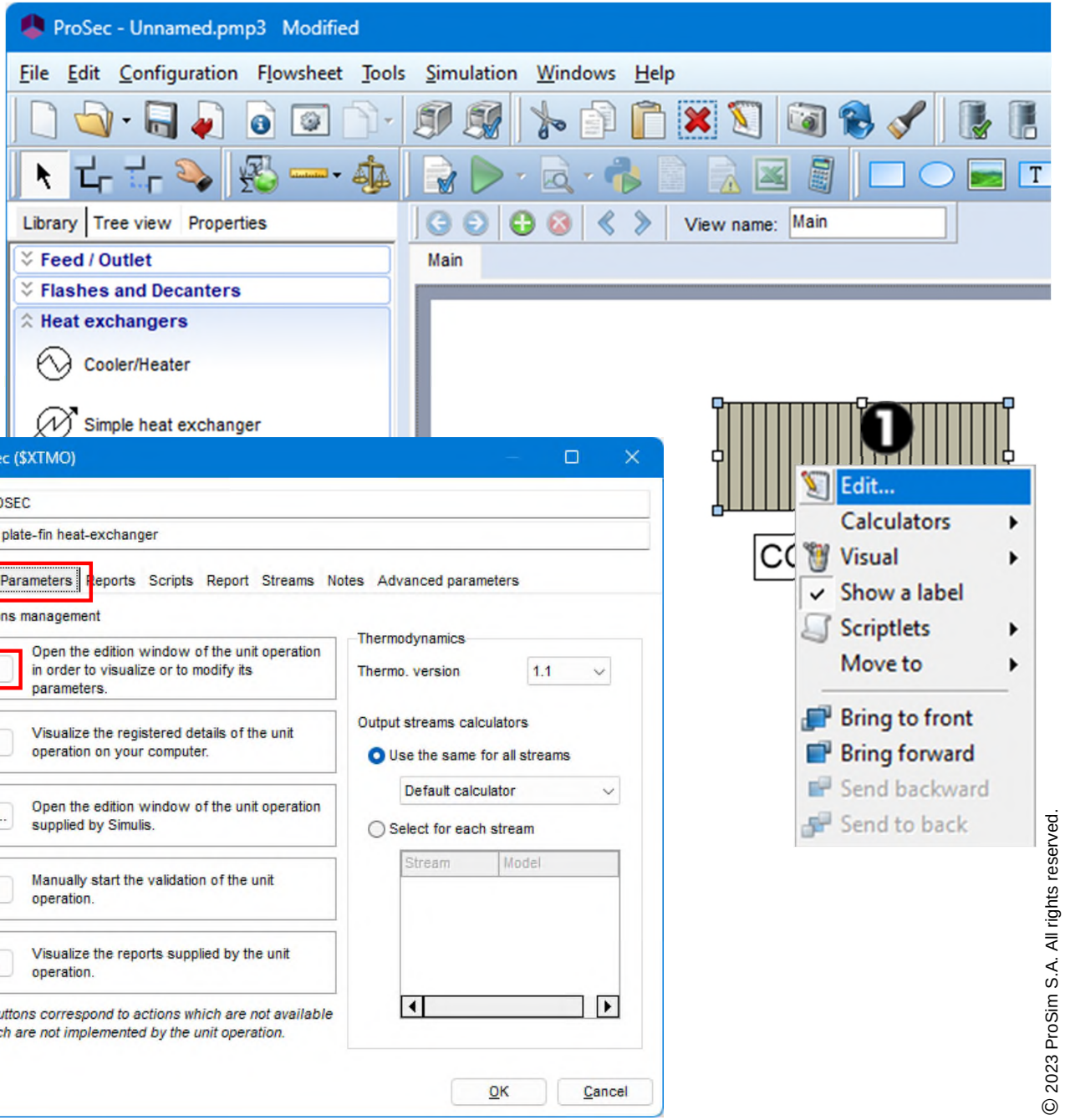
Step 3: Create the flowsheet
A- ProSec unit operation

To configure the ProSec unit operations:

1. Double-click on its icon on the flowsheet or select “Edit…” in the contextual menu

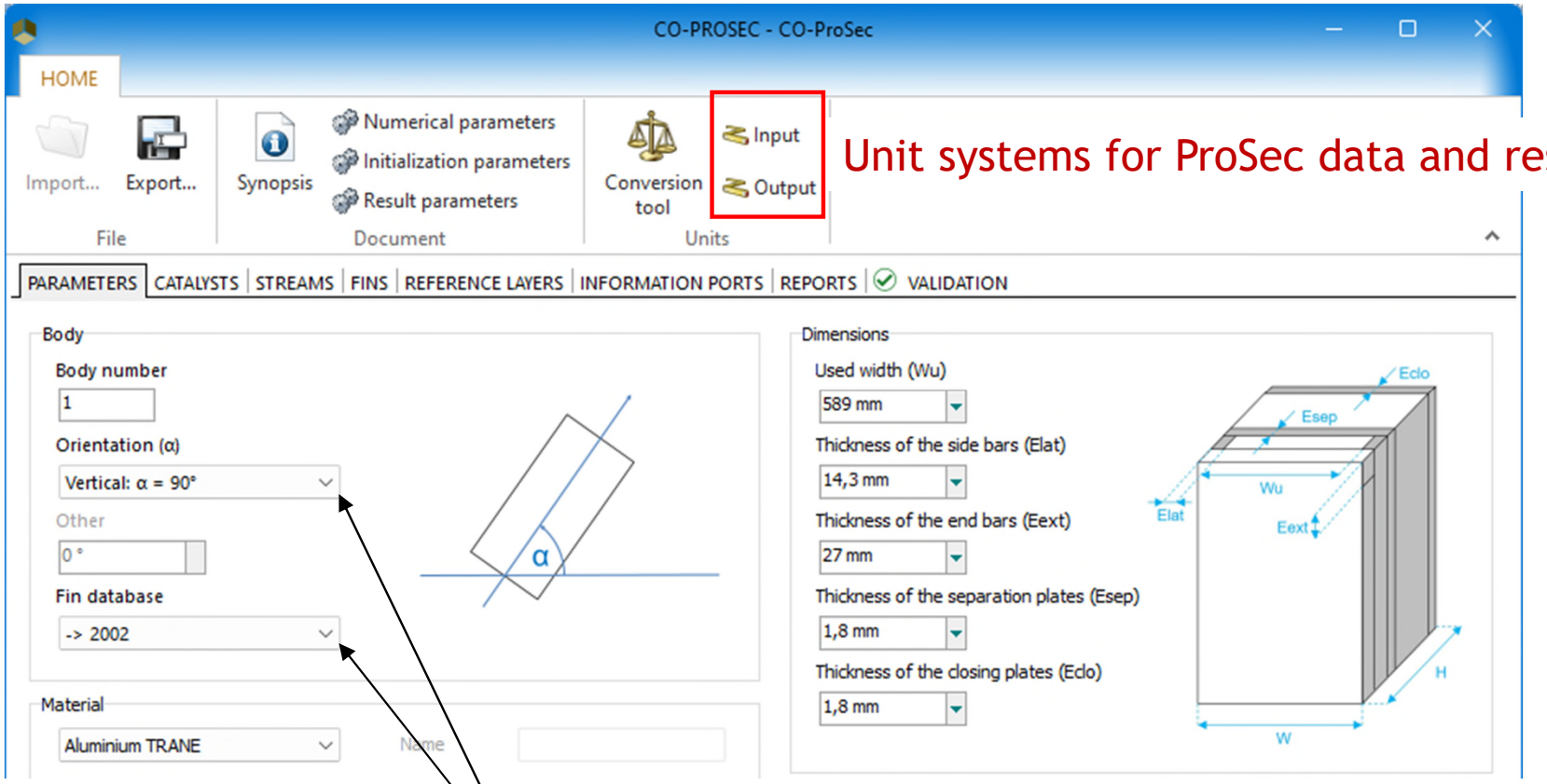
2. Press the “Parameters” tab

3. Press the “Edit…” button



Step 3: Create the flowsheet
A- ProSec unit operation

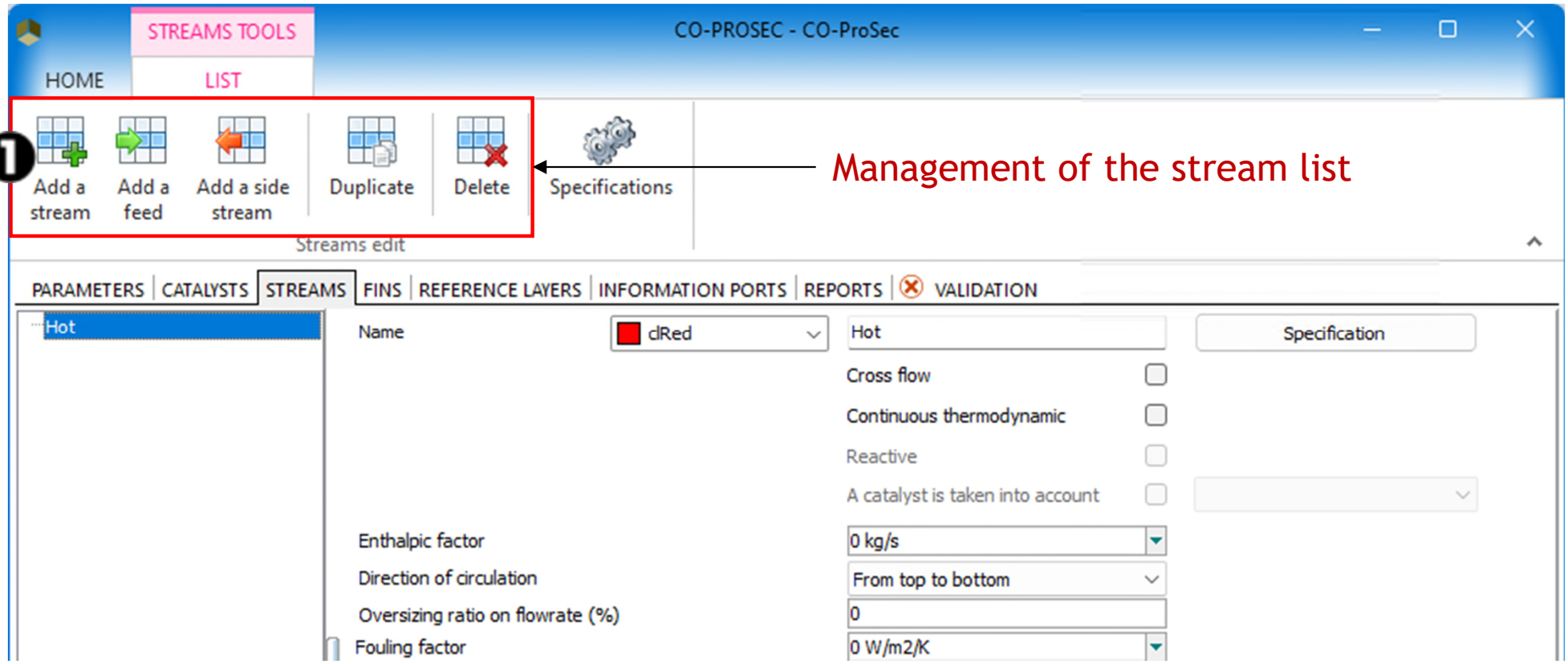
- "Parameters" tab
  - ✓ Fill in the general characteristics of the heat exchanger as shown on the figure below



Step 3: Create the flowsheet
A- ProSec unit operation

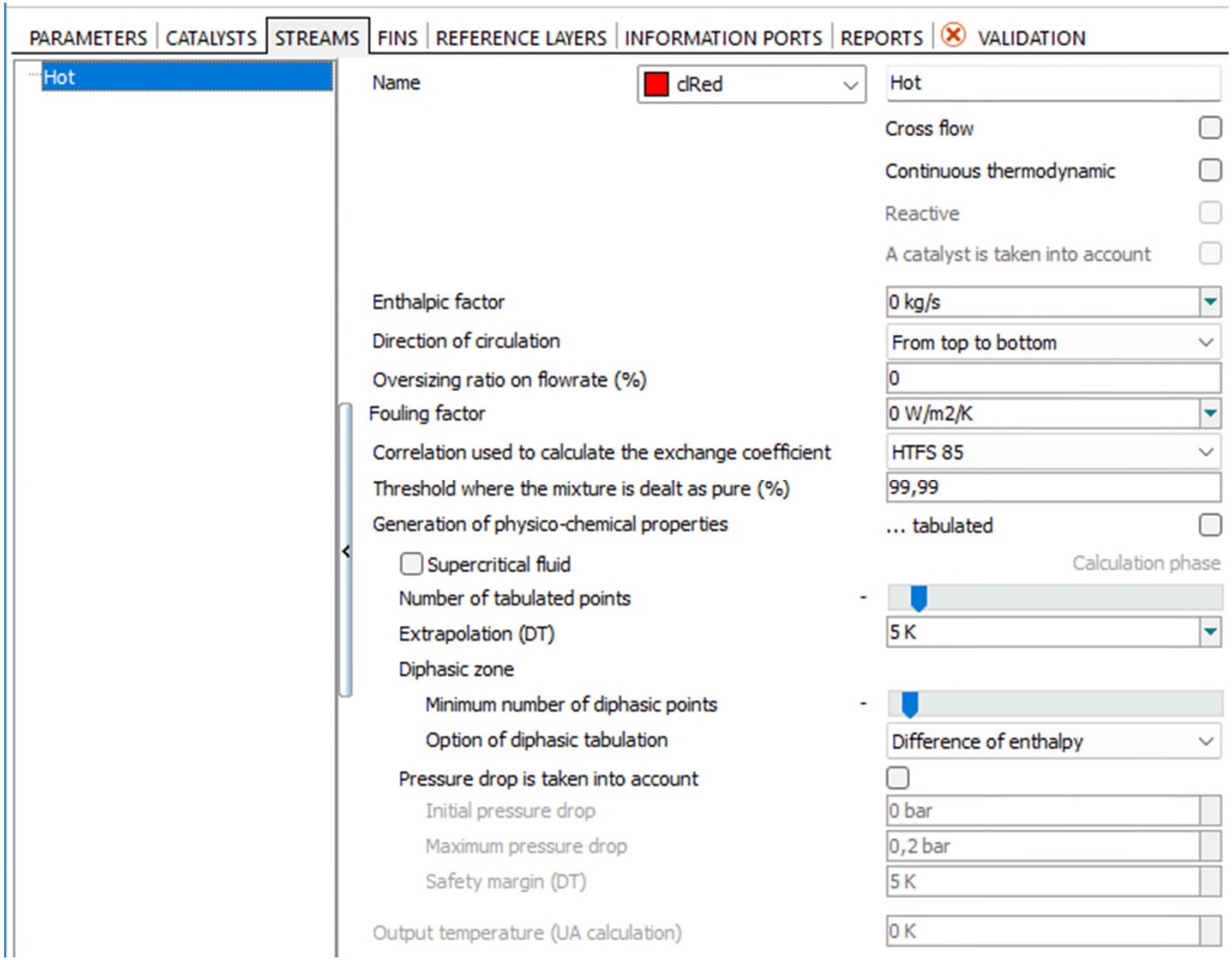
- "Streams" tab
  - ✓ Describe the two streams of the heat exchanger: a hot stream with a side stream and a cold stream

1. Click on "Add a stream" to add the hot stream



Step 3: Create the flowsheet
A- ProSec unit operation

- "Streams" tab
  2. Describe the stream "Hot" characteristics

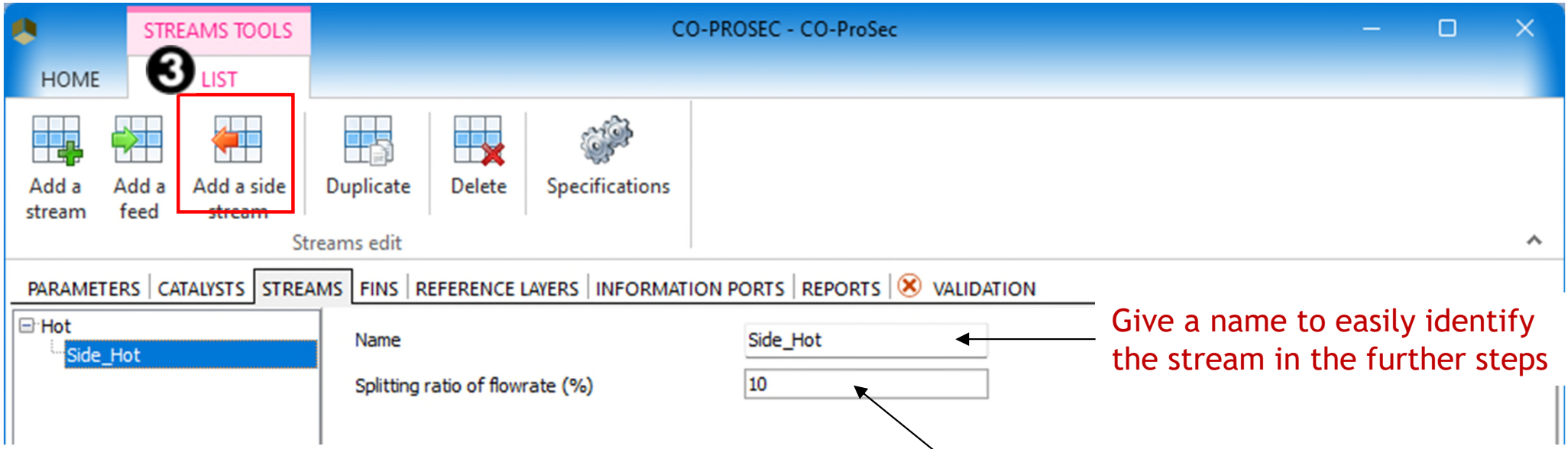


Give a name and select a color to easily identify the stream in the further steps

Change the default correlation for the heat transfer coefficient calculation

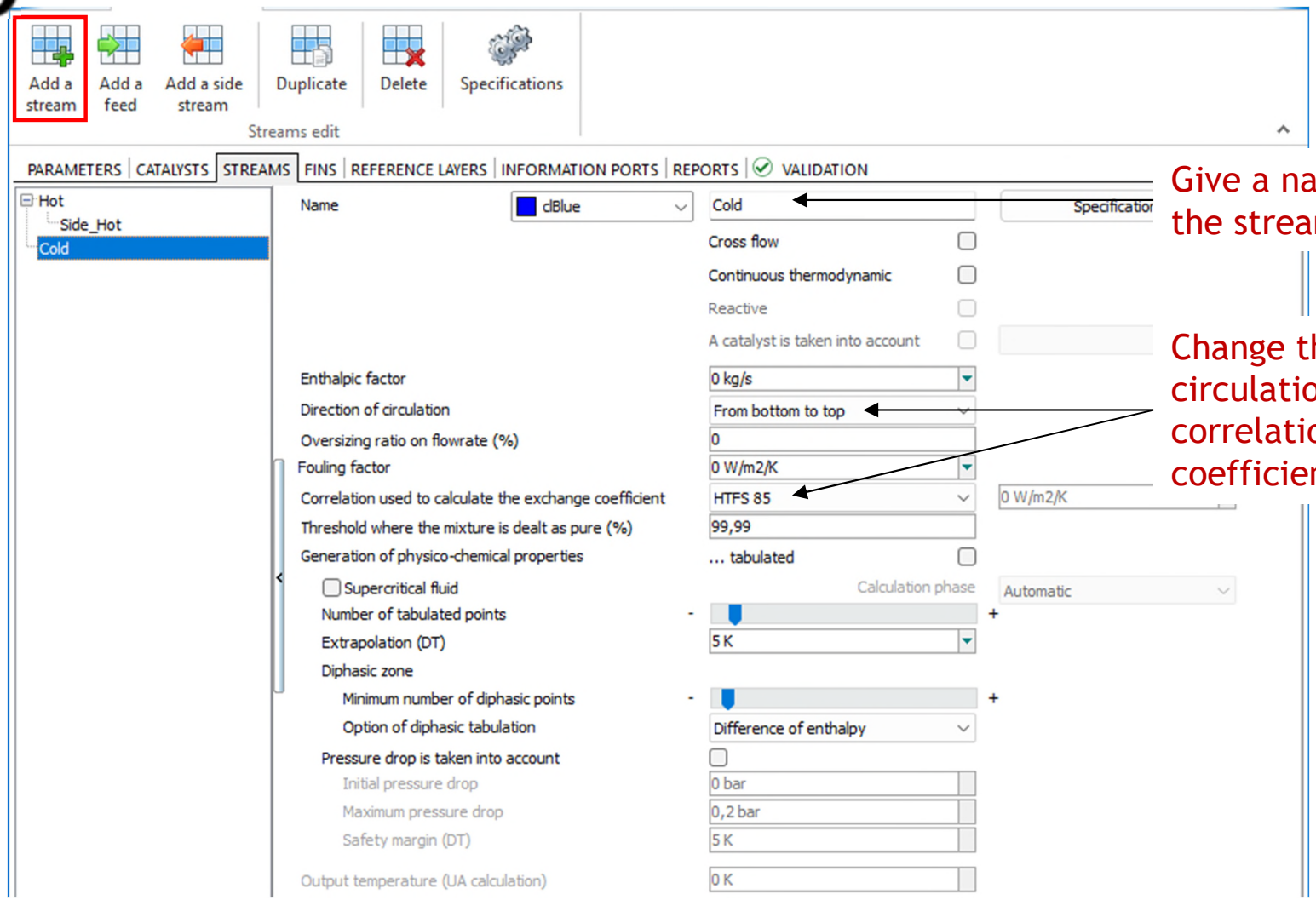
Step 3: Create the flowsheet
A- ProSec unit operation

- "Streams" tab
  3. Click on "Add a side stream" to add the stream "Hot" side stream
  4. Fill in the characteristics of this side stream



Step 3: Create the flowsheet
A- ProSec unit operation

- "Streams" tab
  5. Click on "Add a stream" to add the cold stream
  6. Describe the stream "Cold" characteristics



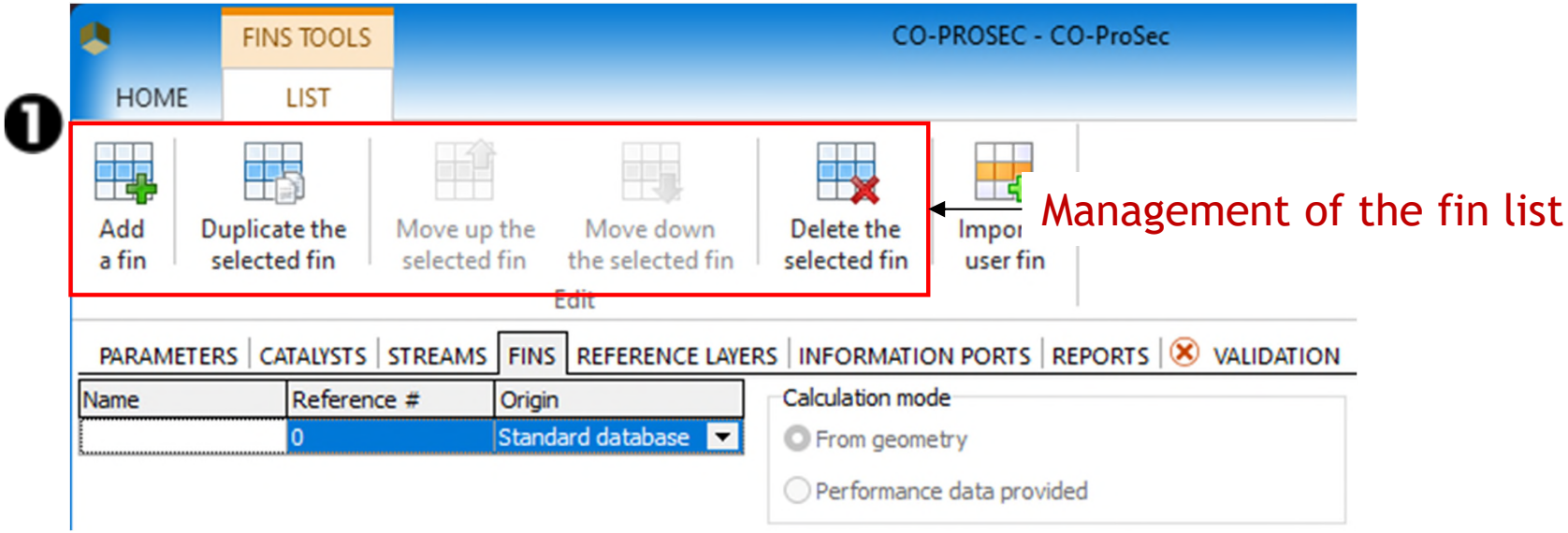
Give a name to easily identify the stream in the further steps

Change the default direction of circulation and the default correlation for the heat transfer coefficient calculation

Step 3: Create the flowsheet
A- ProSec unit operation

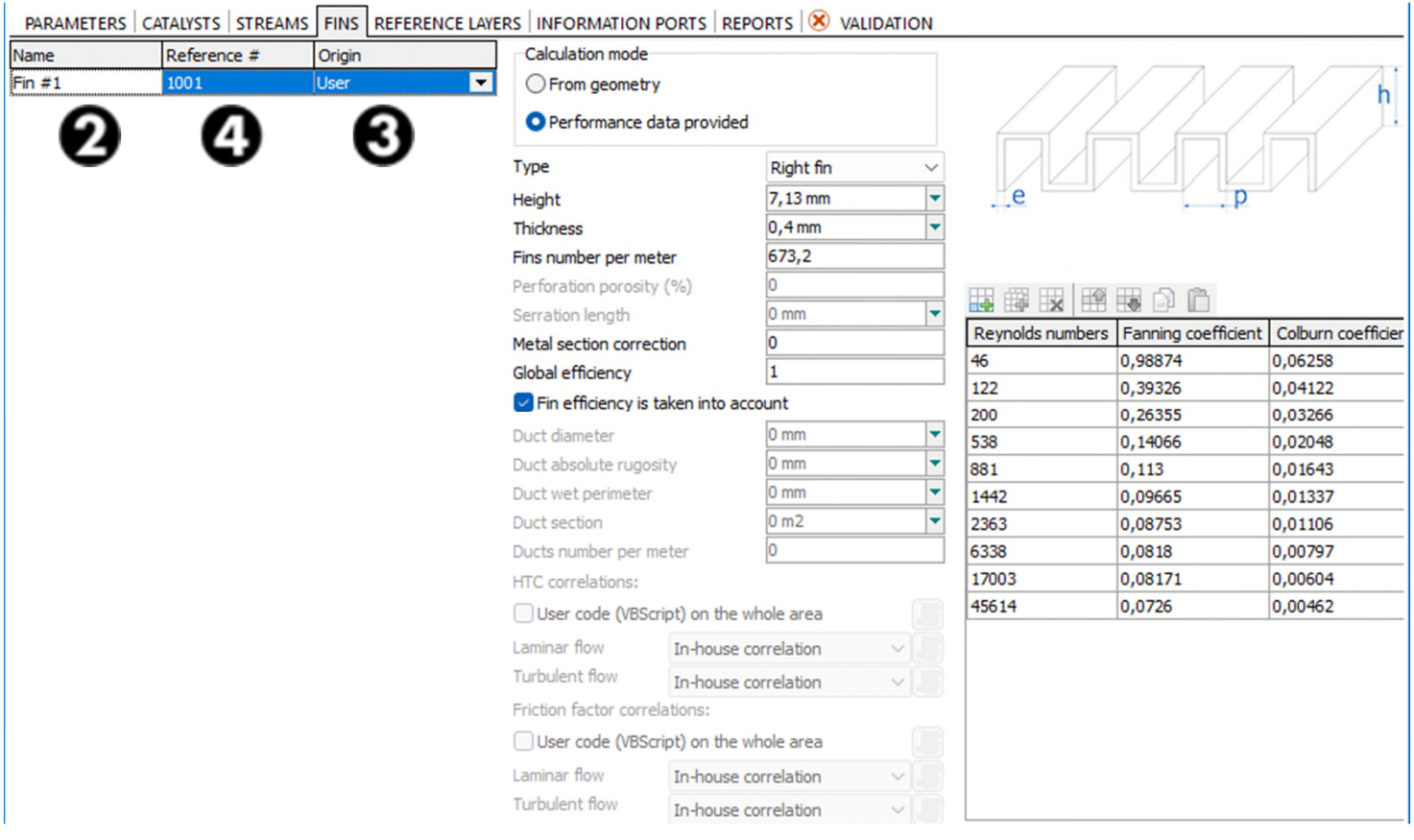
- "Fins" tab
  - ✓ Describe the two fins used in the heat exchanger
  - ✓ Fin #1 (for heat exchange zones) is a user-defined, for which performance data are given
  - ✓ Fin #2 (for distributors) is a user-defined, for which performance data are calculated from correlations

1. Click on "Add a fin"



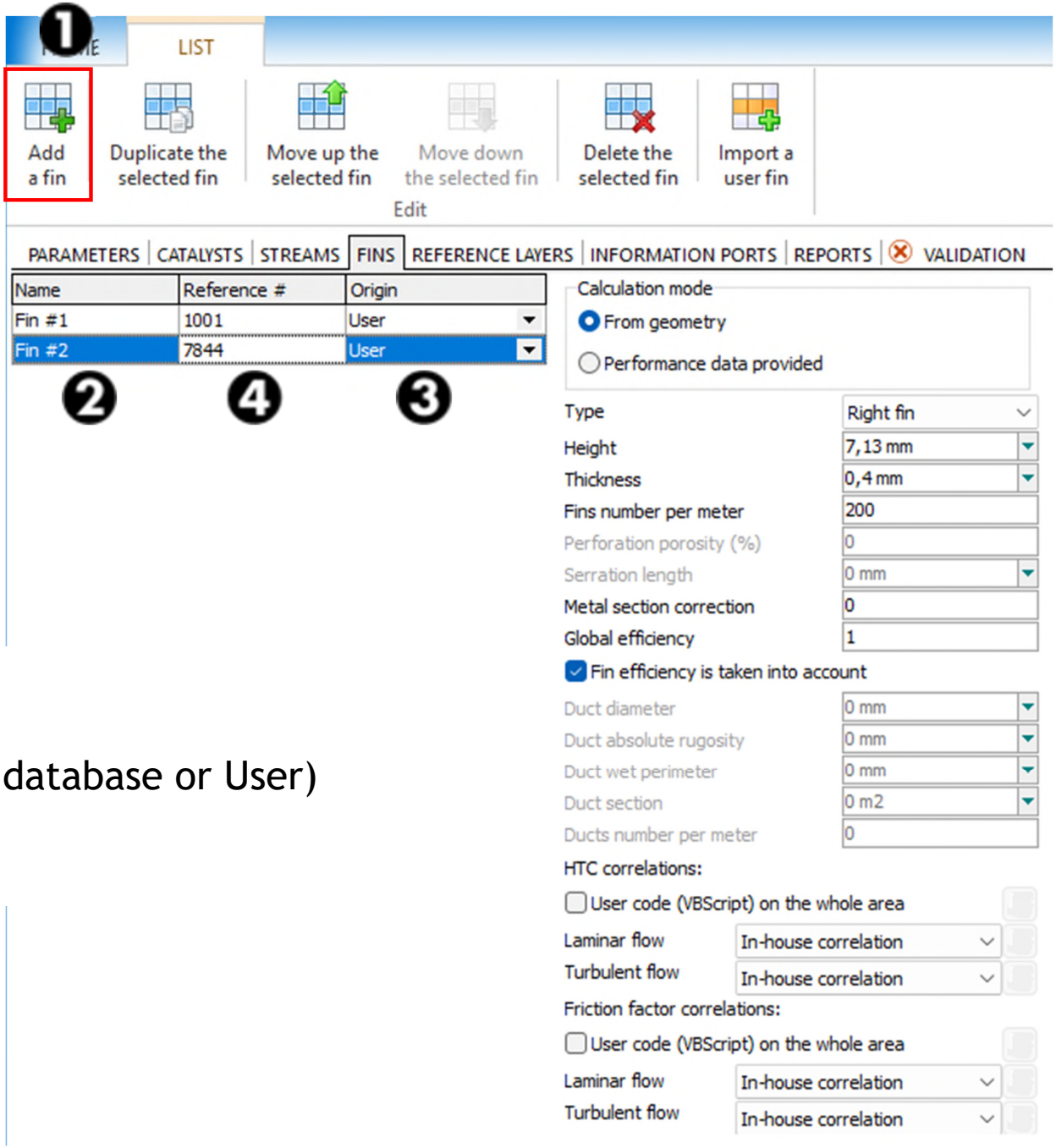
Step 3: Create the flowsheet
A- ProSec unit operation

- "Fins" tab
  - ✓ Fin #1 description
  2. Give a name
  3. Select the "Origin" (Standard database or User)
  4. Give a reference number
  5. Fill in the characteristics



Step 3: Create the flowsheet
A- ProSec unit operation

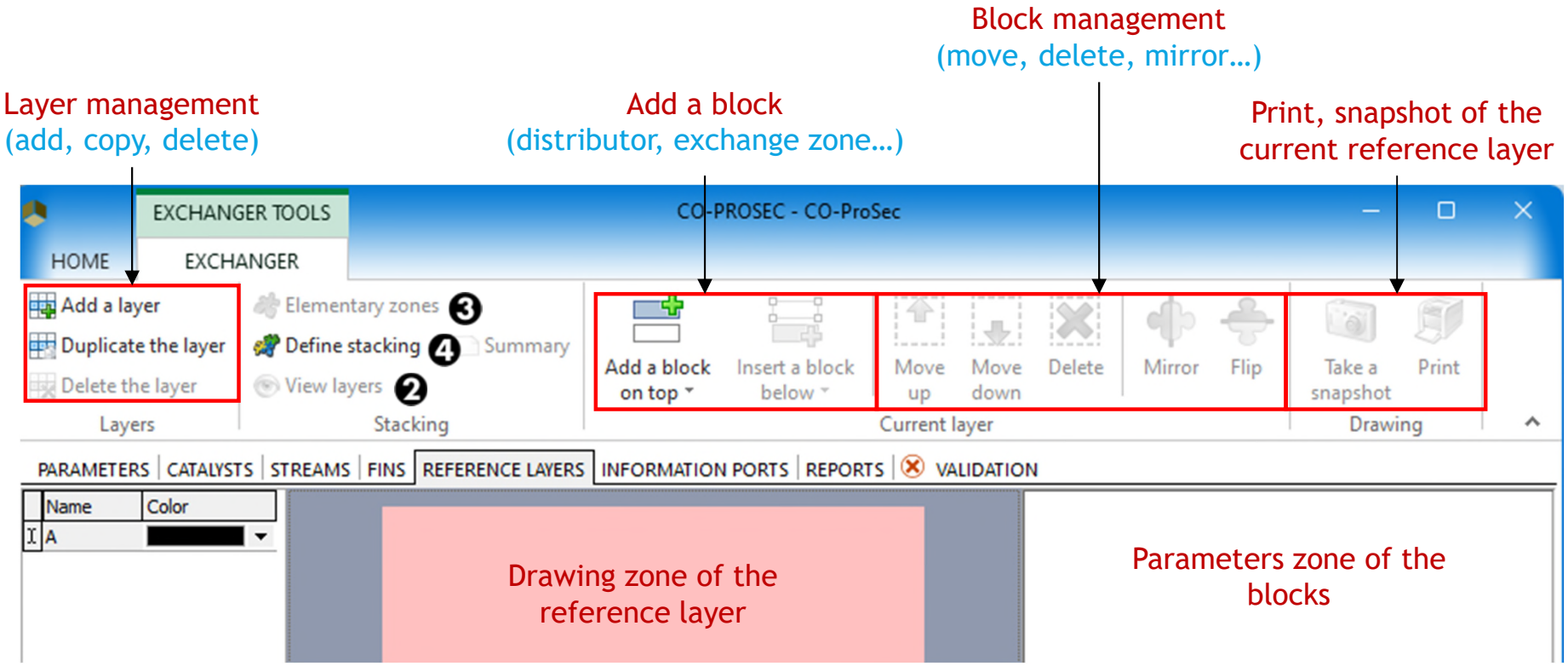
- "Fins" tab
  - ✓ Fin #2 description



1. Click on "Add a fin"
2. Give a name
3. Select the "Origin" (Standard database or User)
4. Select the reference "7844"
5. Fill in the characteristics

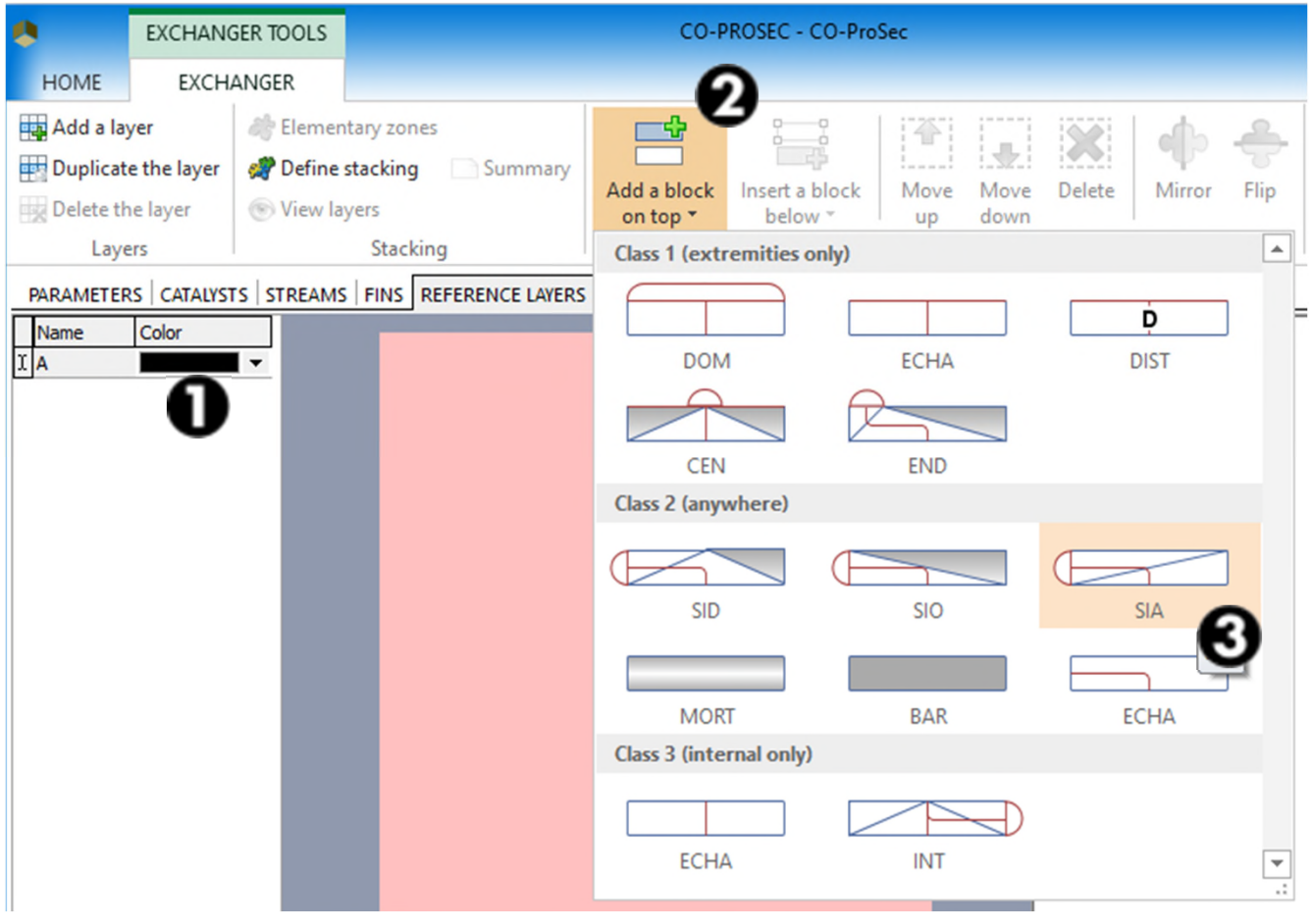
Step 3: Create the flowsheet
A- ProSec unit operation

- "Reference layer" tab
  - ✓ Describe the reference layer, the meshing and the stacking
  1. Describe the reference layers
  2. Visualize the layers
  3. Adjust the number of discretization cells
  4. Define the stacking



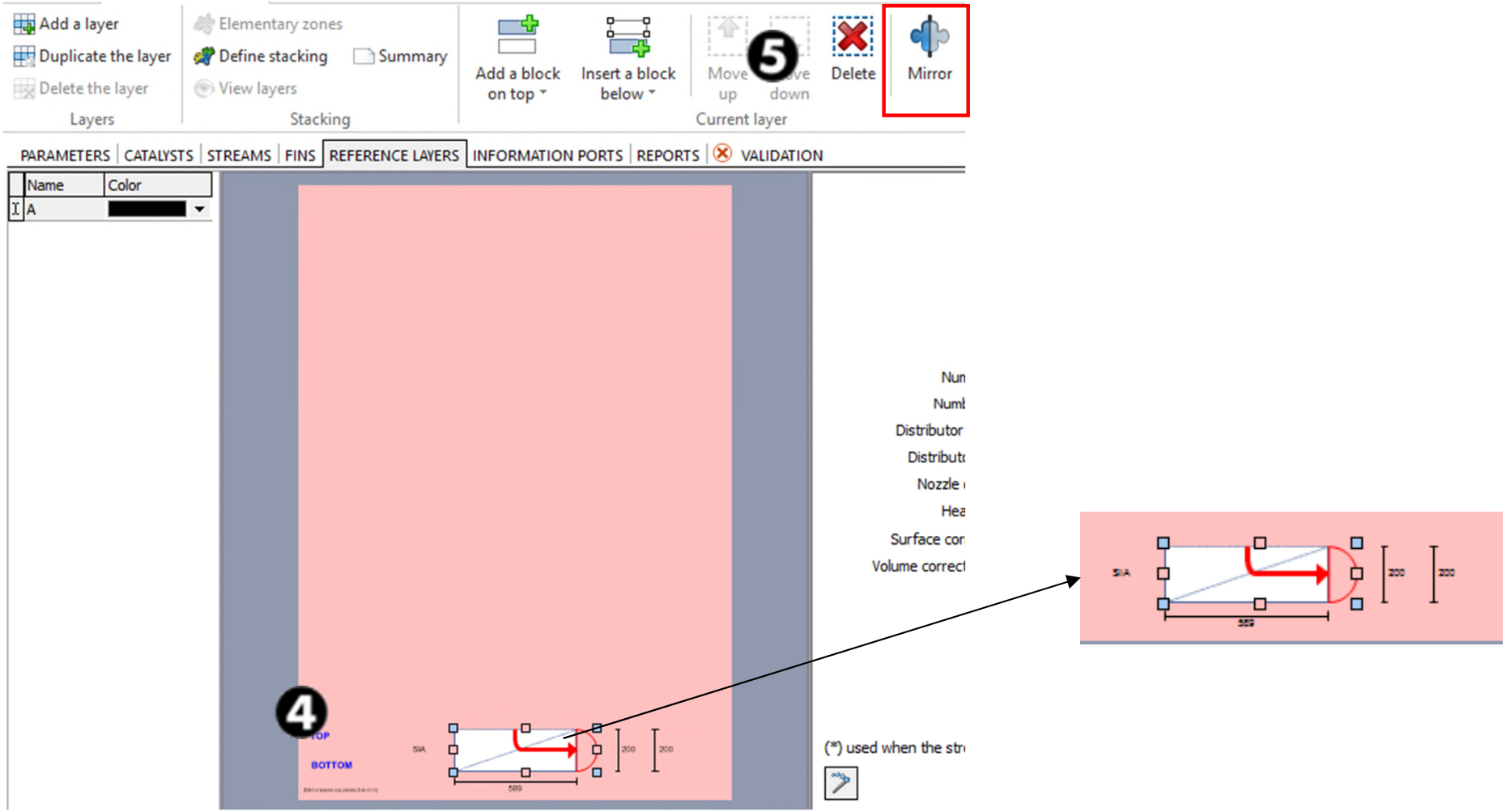
Step 3: Create the flowsheet
A- ProSec unit operation

- "Reference layer" tab
  - ✓ Describe the reference layer "A" (hot stream reference layer)
  1. Select a color to easily identify this layer in the stacking description
  2. Click on "Add a block on top"
  3. Select the first block to add a "SIA" distributor



Step 3: Create the flowsheet
A- ProSec unit operation

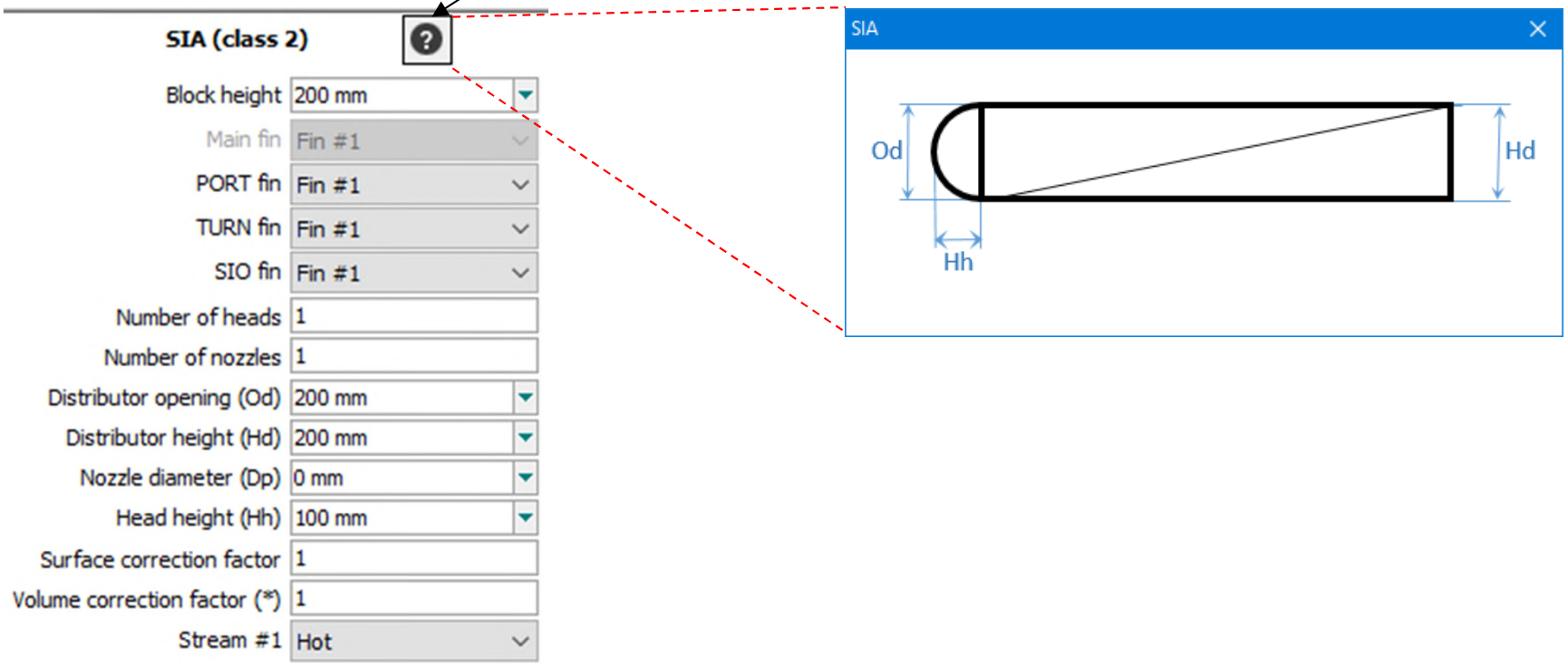
- "Reference layer" tab
  4. Click on the block to select it
  5. Click on "Mirror" to change the position of its head



Step 3: Create the flowsheet
A- ProSec unit operation

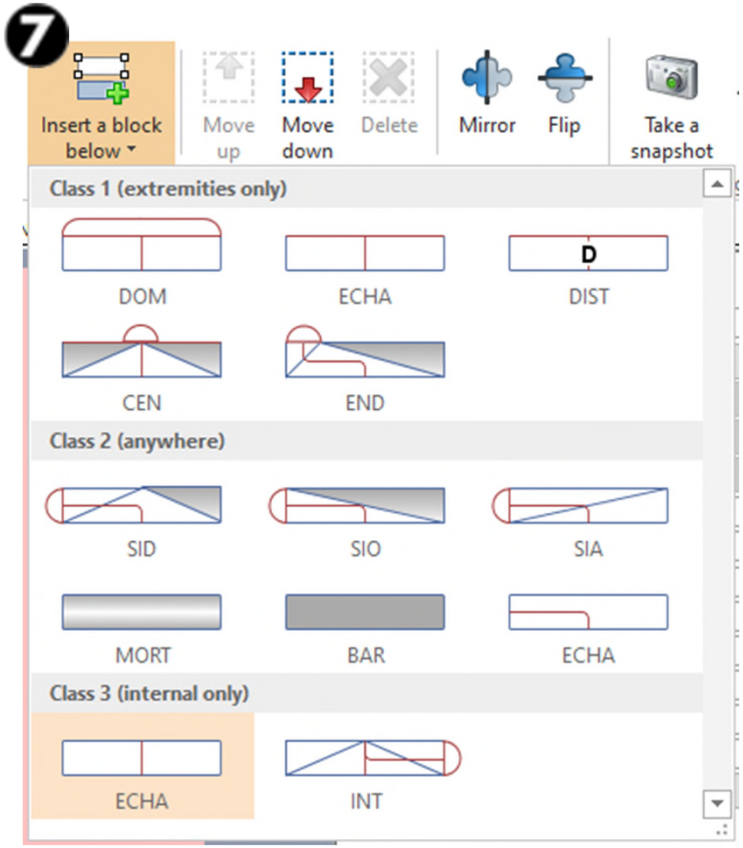
- "Reference layer" tab
  6. Fill in its parameters

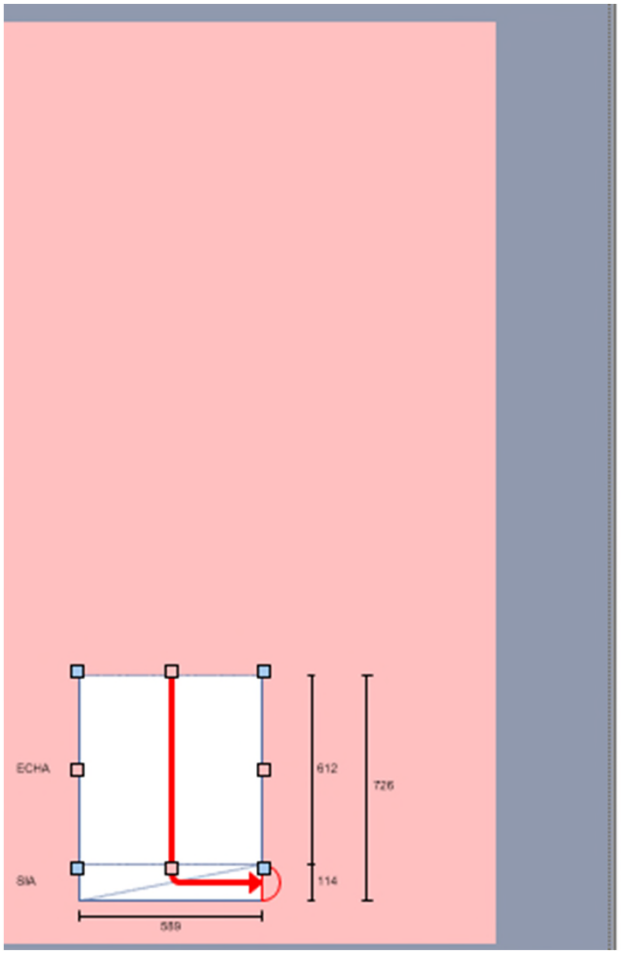
To identify the sizing dimensions

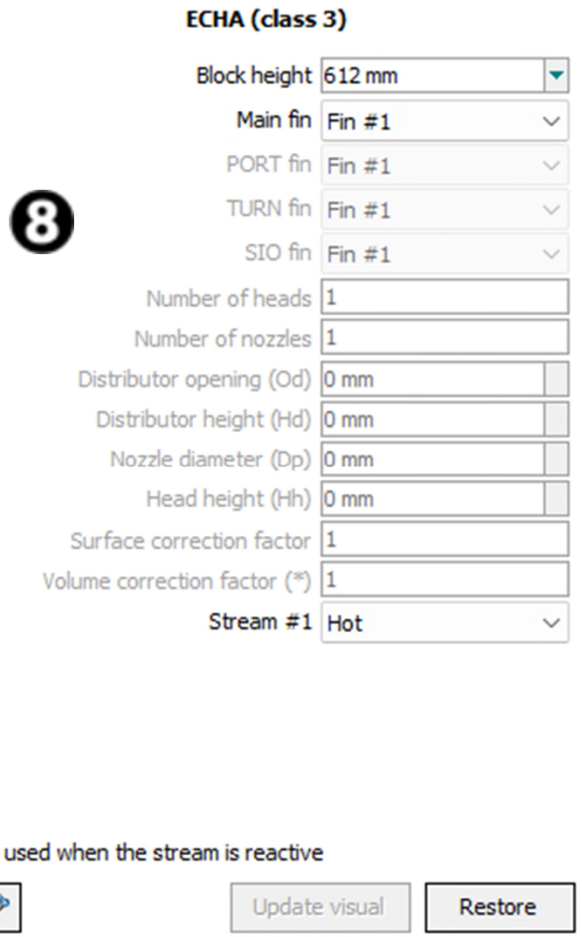


Step 3: Create the flowsheet
A- ProSec unit operation

- "Reference layer" tab
  7. Click on "Add a block on top" and select a heat exchange zone "ECHA"
  8. Select this block and enter its parameters

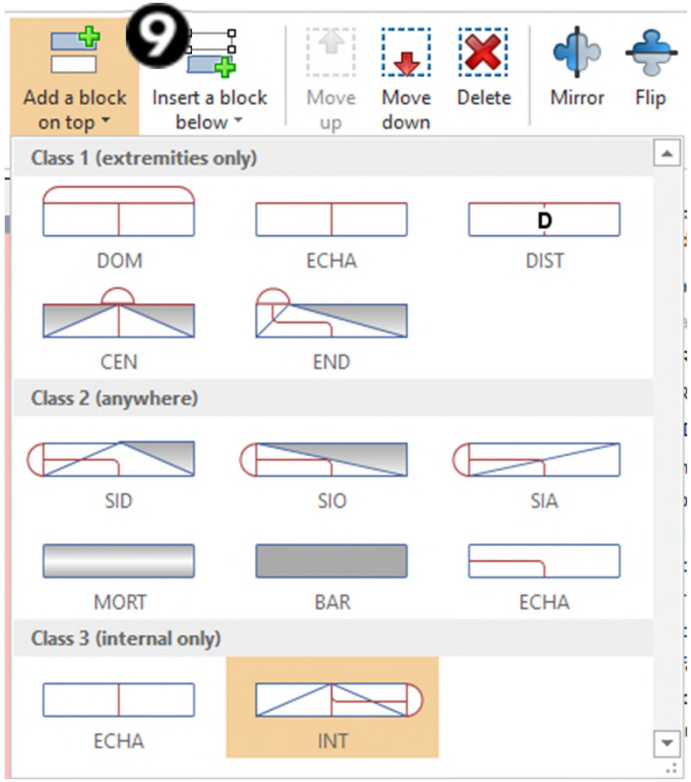


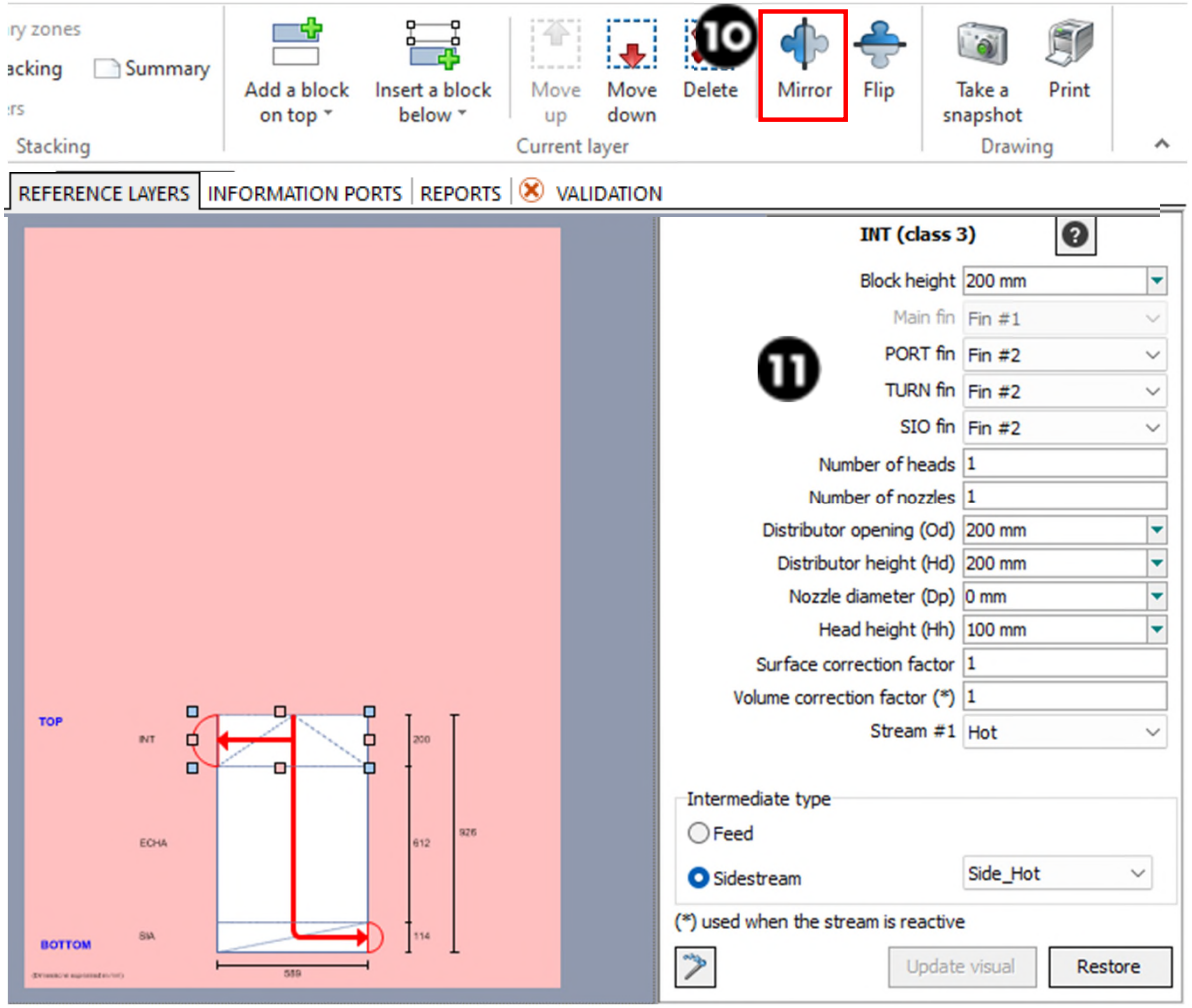




Step 3: Create the flowsheet
A- ProSec unit operation

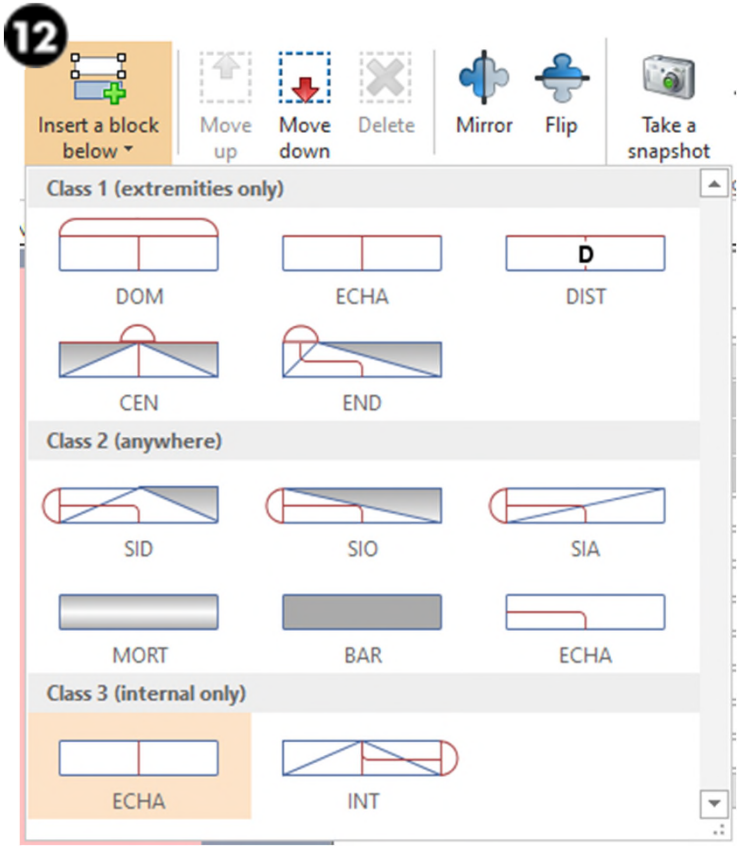
- "Reference layer" tab
  9. Click on "Add a block on top" and select an "INT" distributor
  10. Click on "Mirror" to change the position of its head
  11. Select this block and enter its parameters

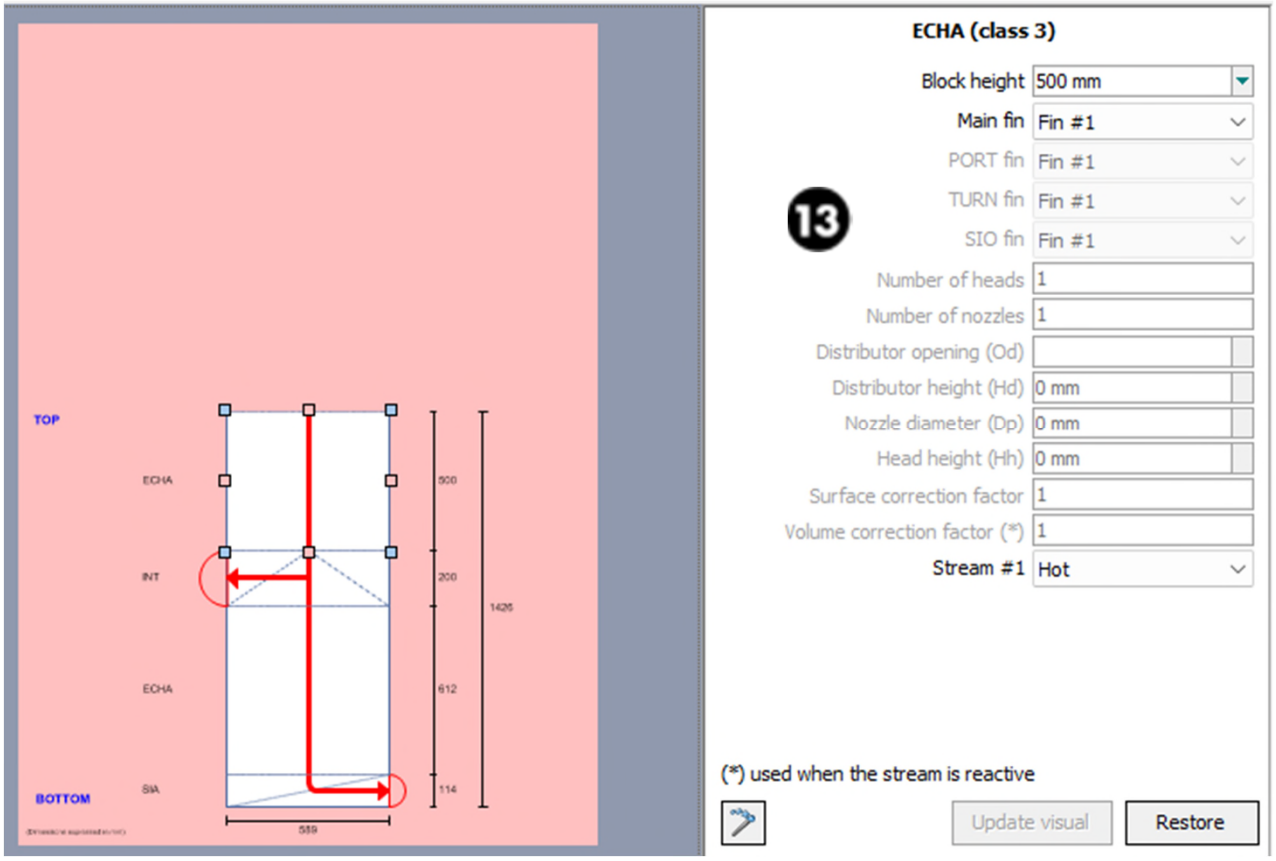




Step 3: Create the flowsheet
A- ProSec unit operation

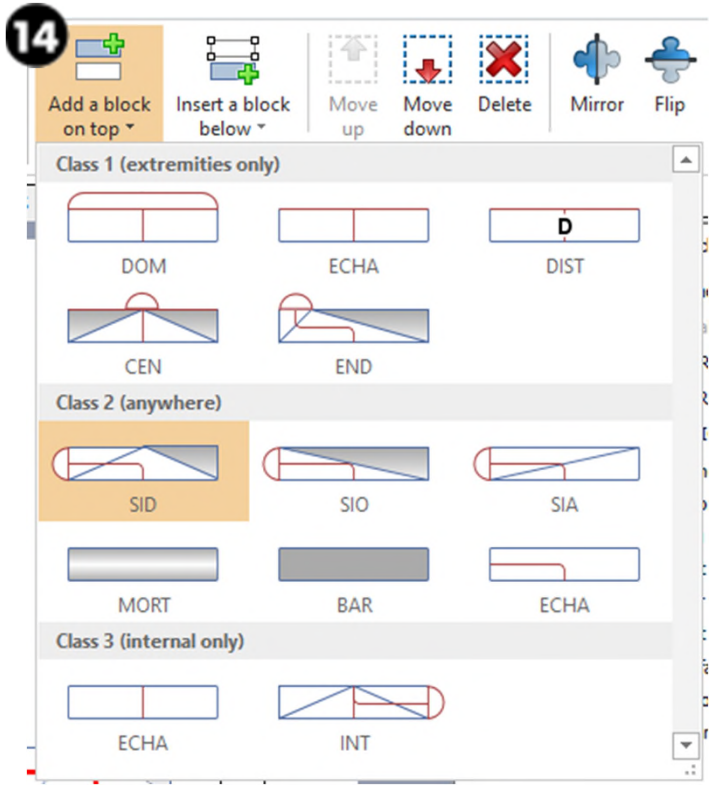
- "Reference layer" tab
  12. Click on "Add a block on top" and select a heat exchange zone "ECHA"
  13. Select this block and enter its parameters

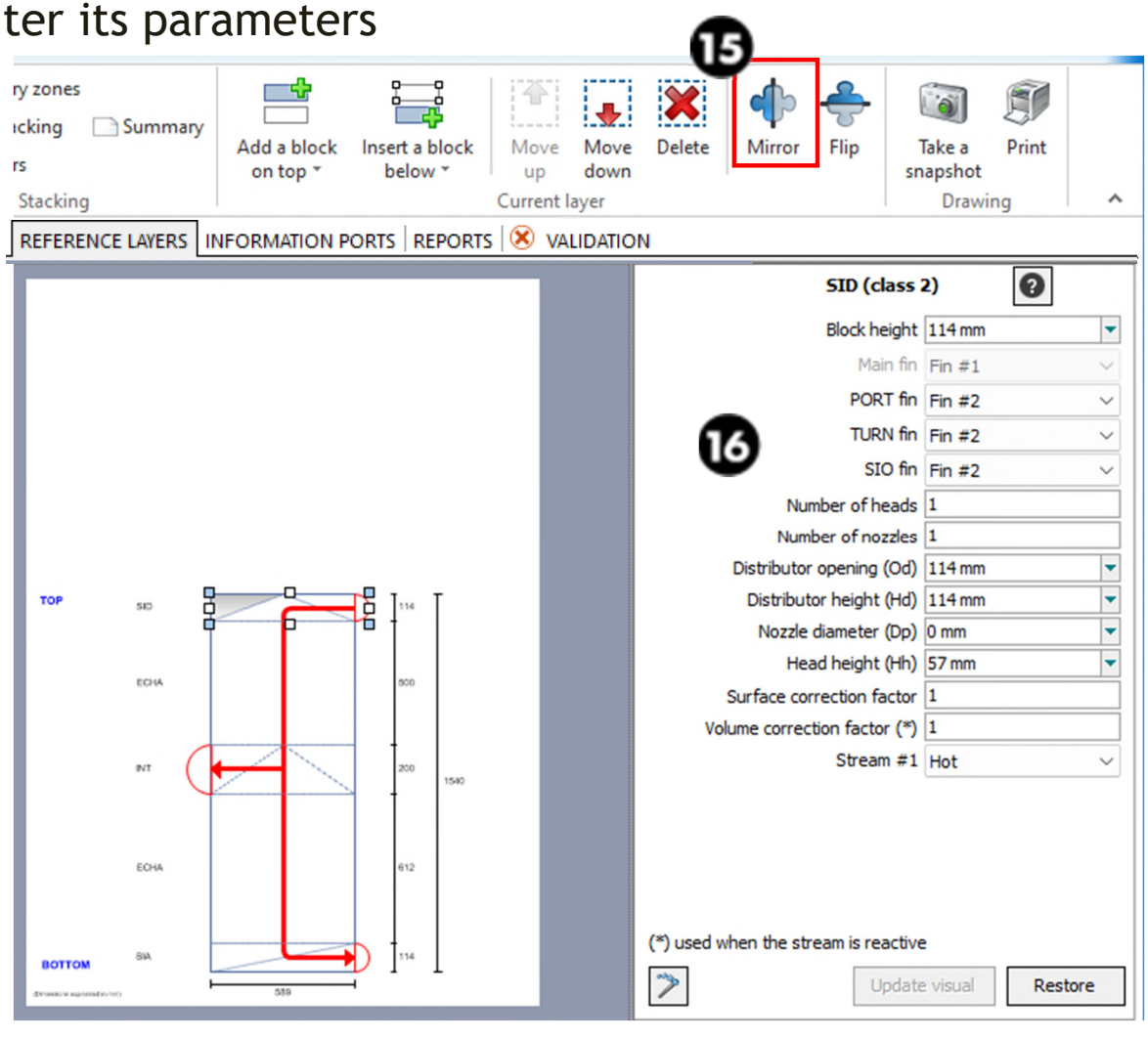




Step 3: Create the flowsheet
A- ProSec unit operation

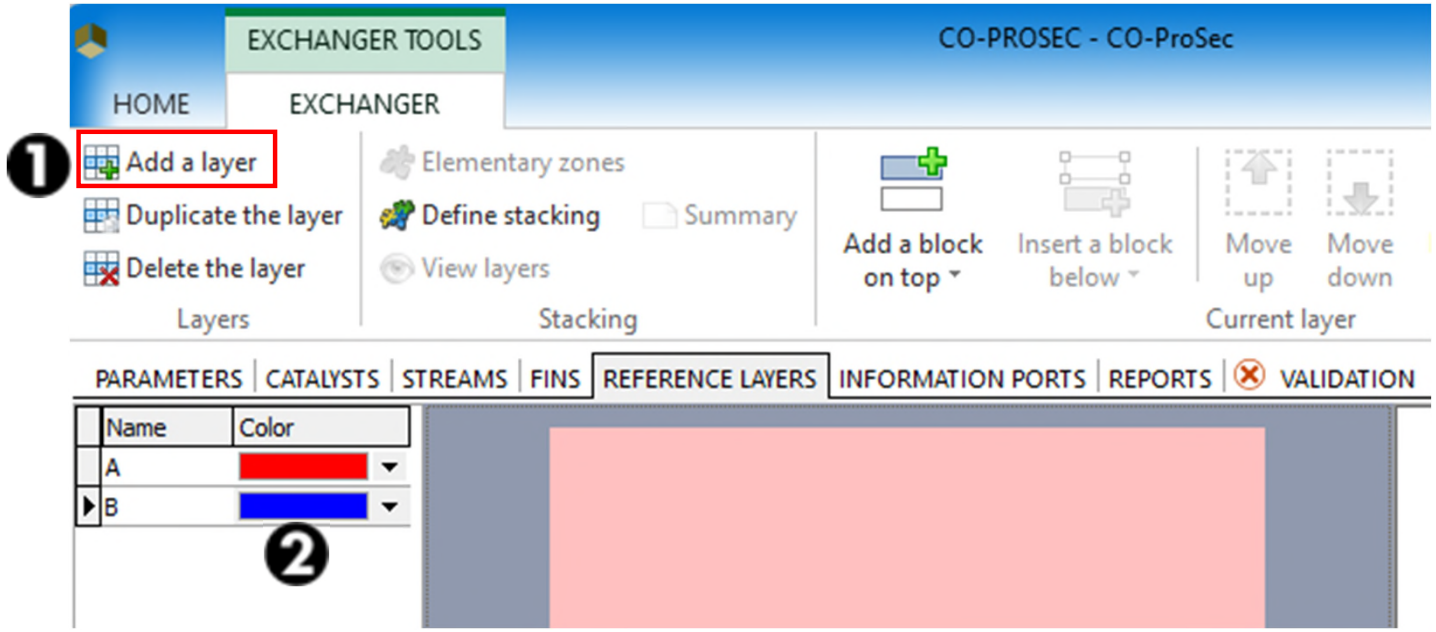
- "Reference layer" tab
  14. Click on "Add a block on top" and select an "SID" distributor
  15. Click on "Mirror" to change the position of its head
  16. Select this block and enter its parameters





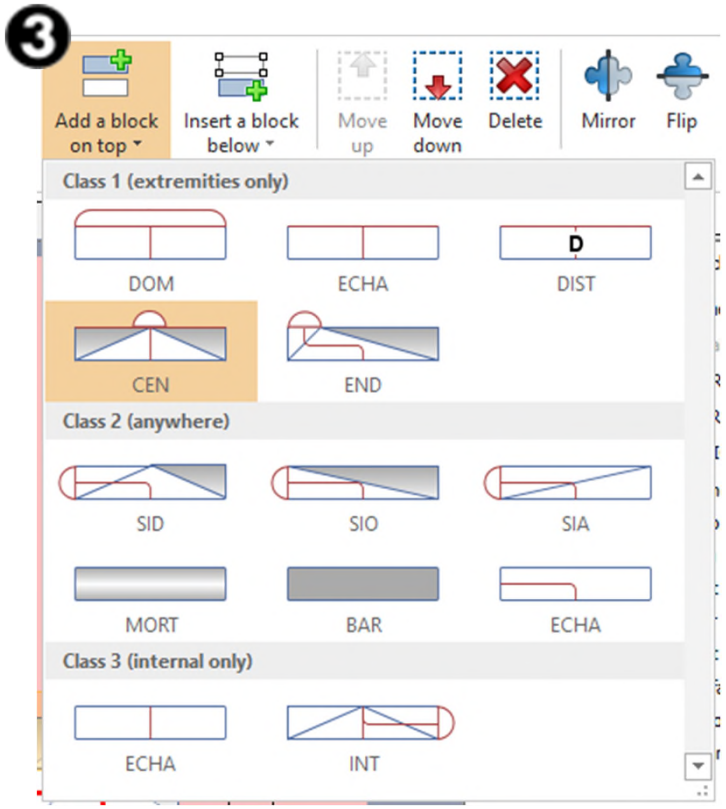
Step 3: Create the flowsheet
A- ProSec unit operation

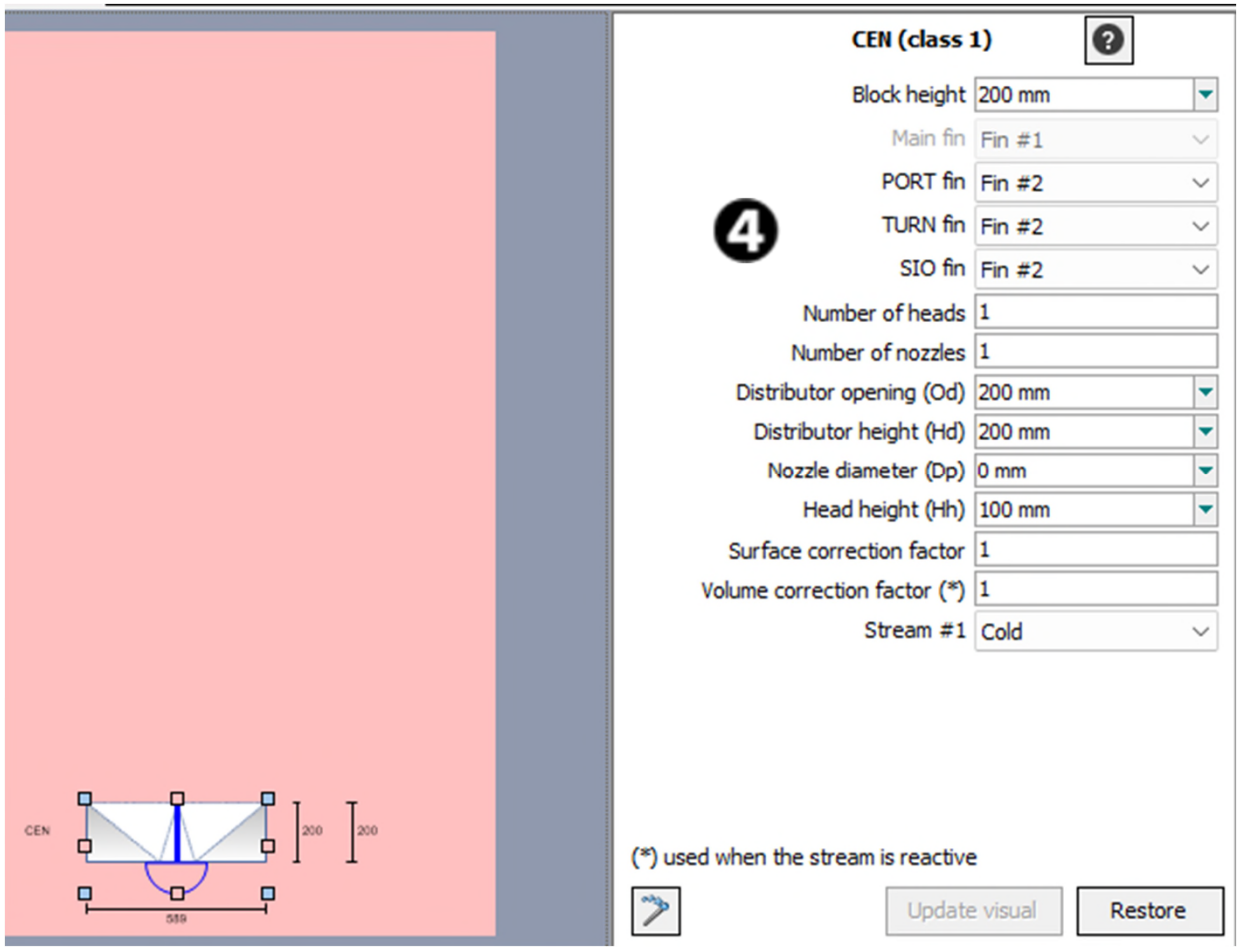
- "Reference layer" tab
  - ✓ Describe the reference layer "B" (cold stream reference layer)
  1. Click on "Add a layer" to add a new reference layer
  2. Select a color to easily identify this layer in stacking description



Step 3: Create the flowsheet
A- ProSec unit operation

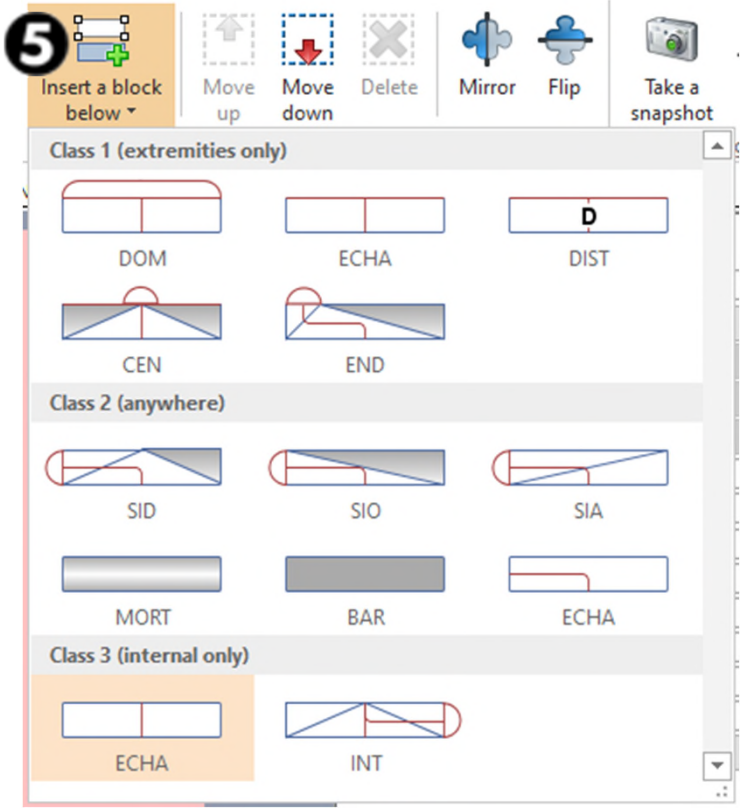
- "Reference layer" tab
  3. Click on "Add a block on top" and select a "CEN" distributor
  4. Select this block and enter its parameters

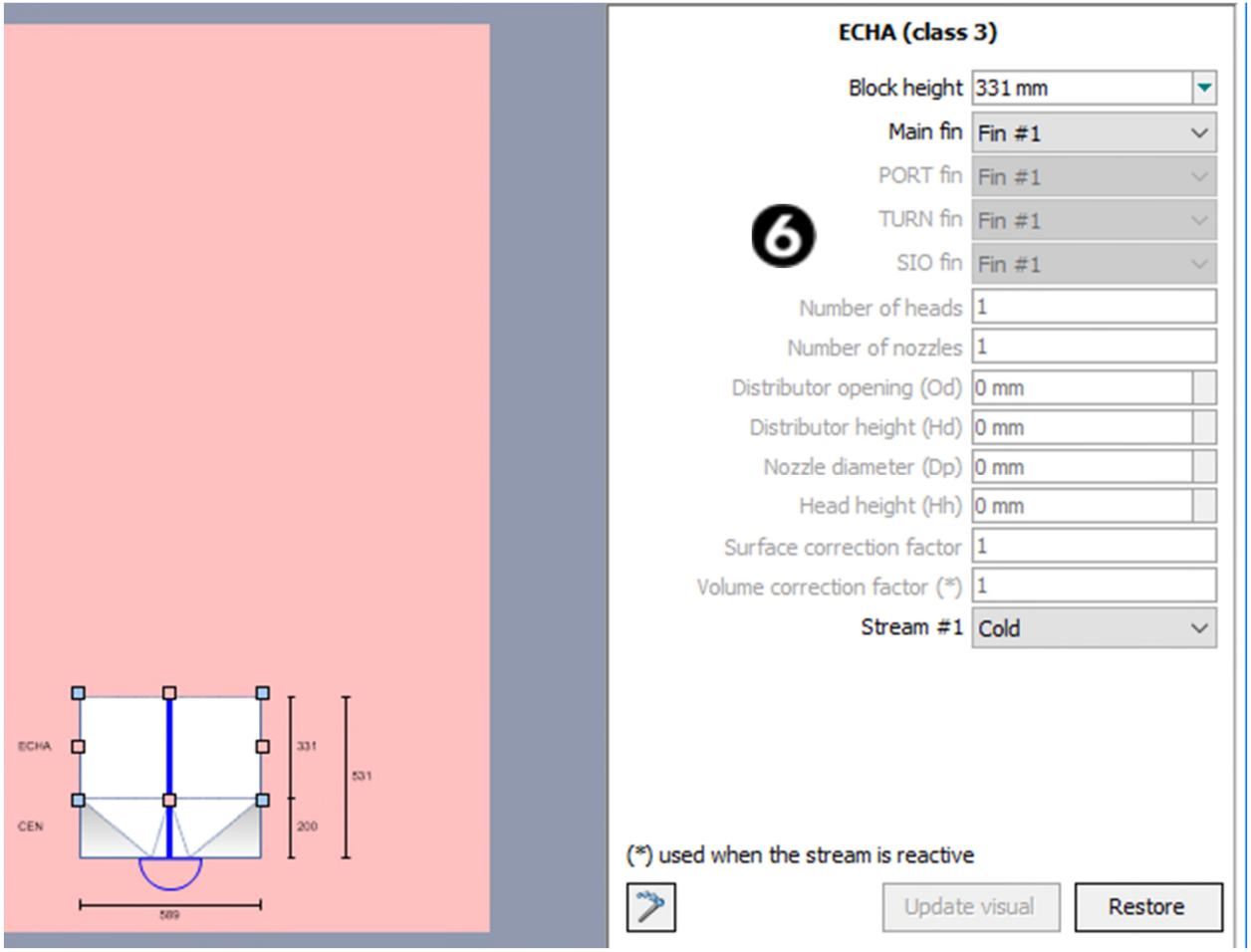




Step 3: Create the flowsheet
A- ProSec unit operation

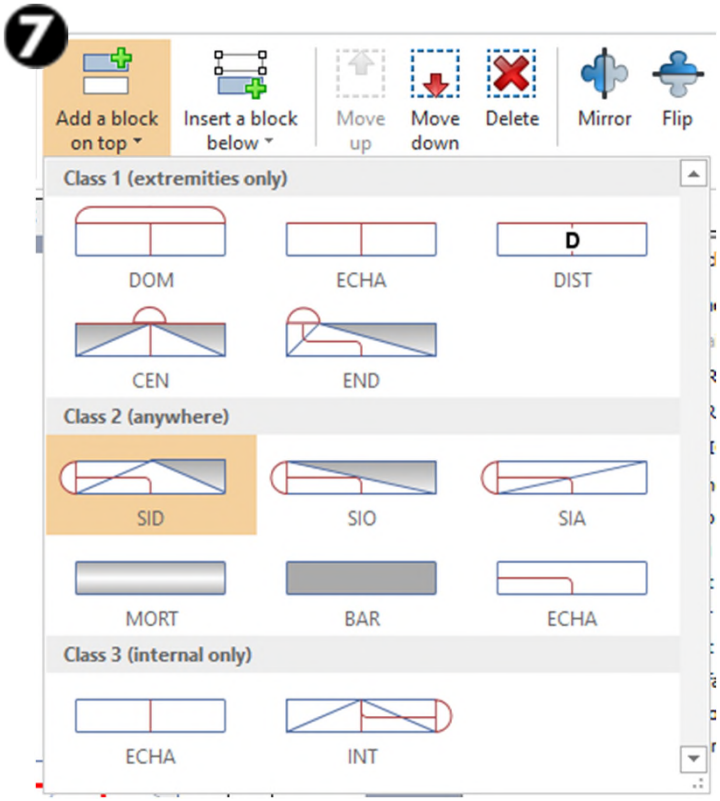
- "Reference layer" tab
  5. Click on "Add a block on top" and select a heat exchange zone "ECHA"
  6. Select this block and enter its parameters

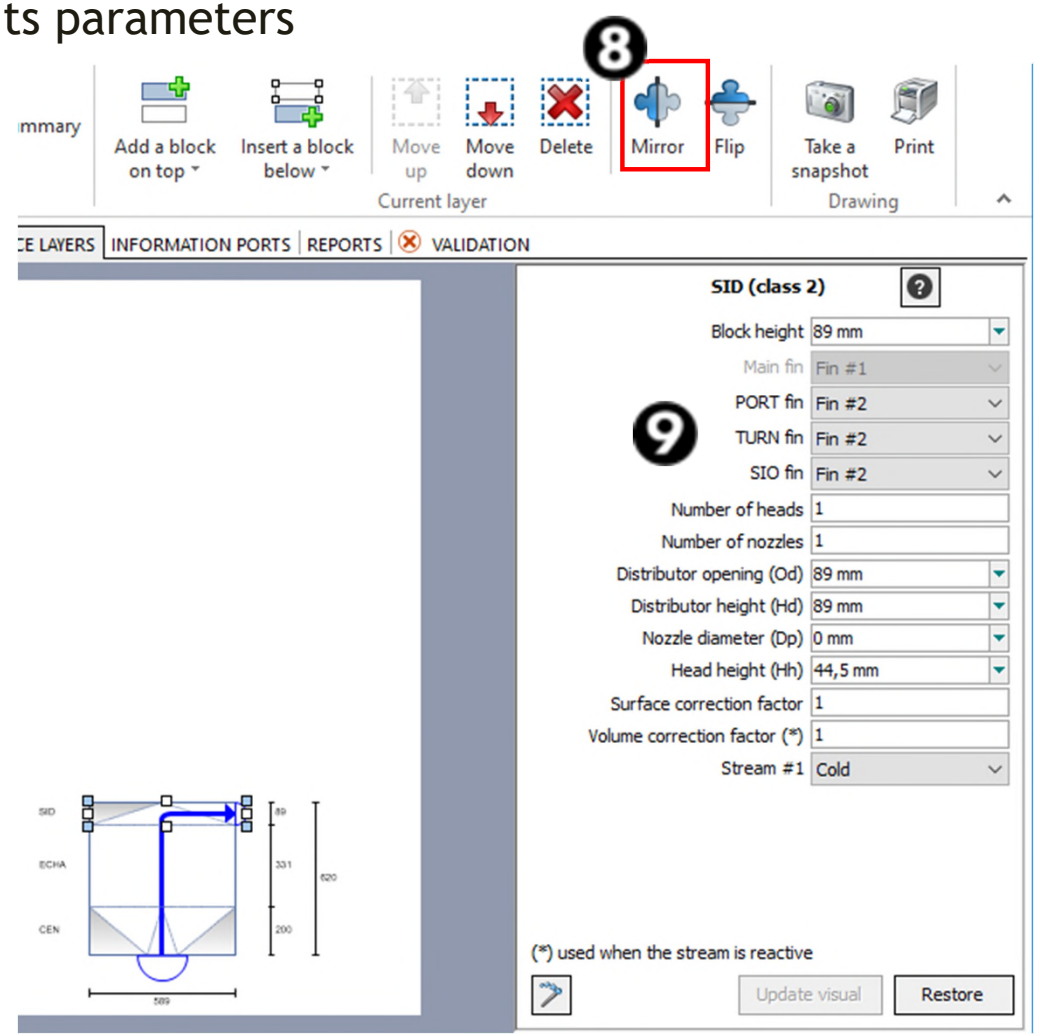




Step 3: Create the flowsheet
A- ProSec unit operation

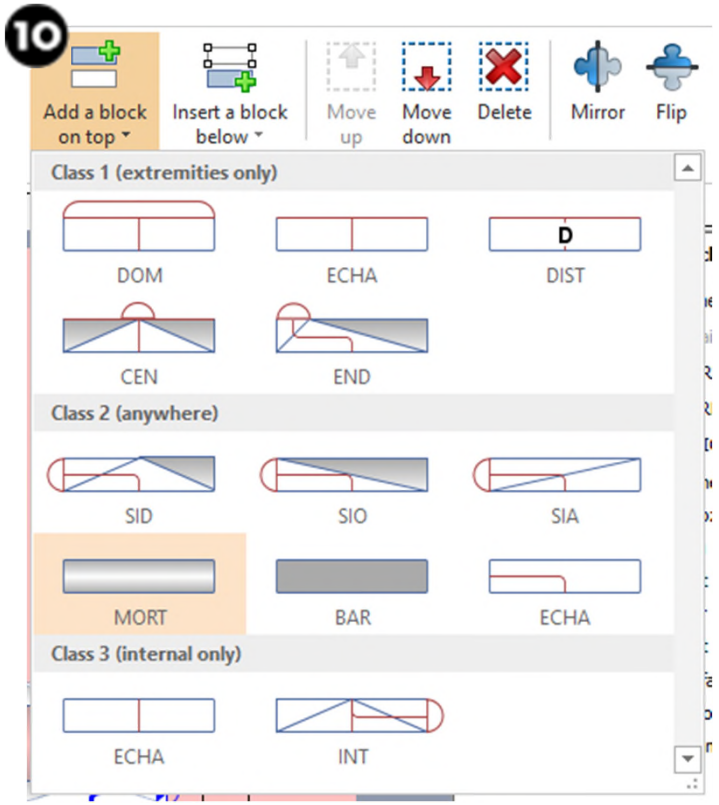
- "Reference layer" tab
  7. Click on "Add a block on top" and select a "SID" distributor
  8. Click on "Mirror" to change the position of its head
  9. Select this block and enter its parameters

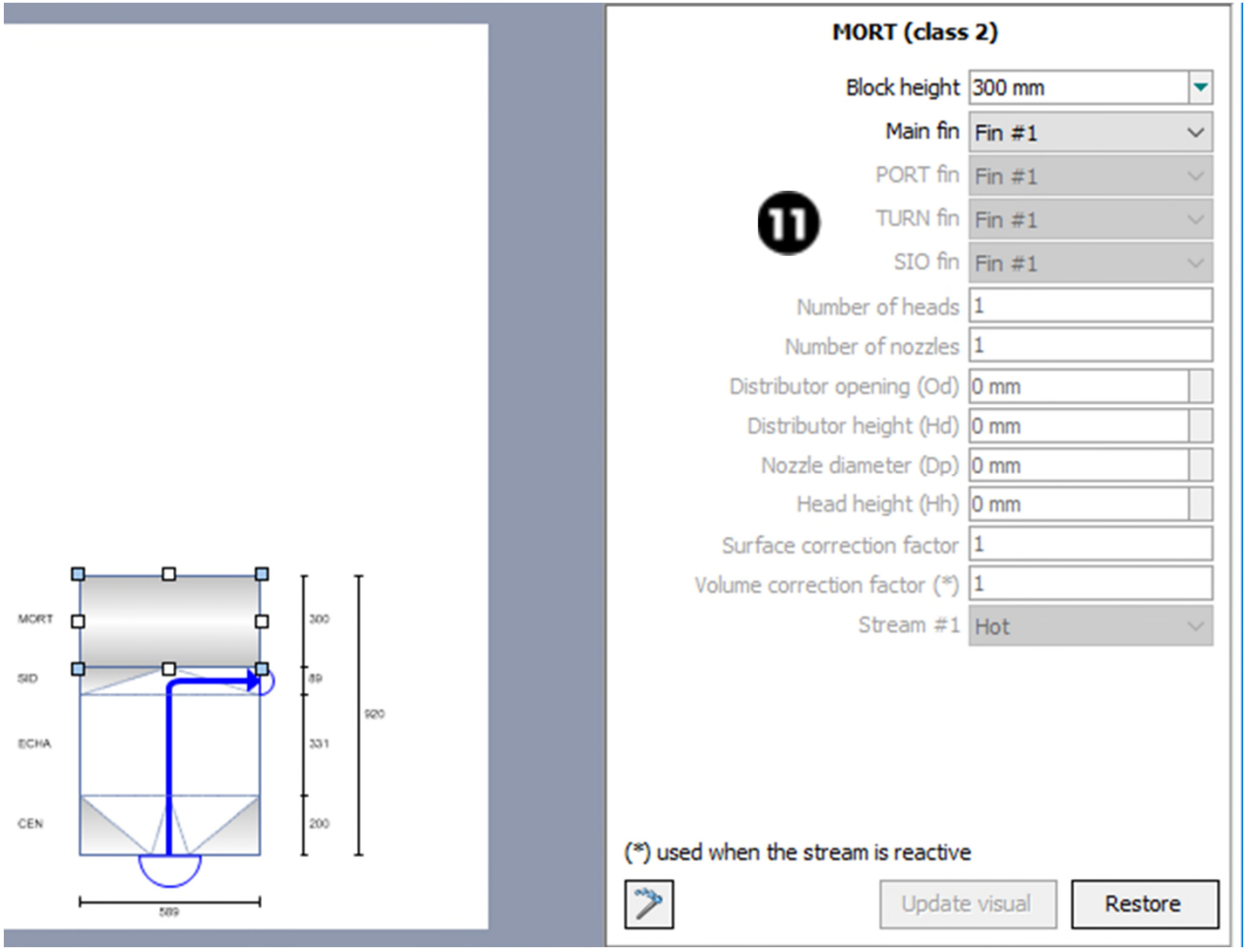




Step 3: Create the flowsheet
A- ProSec unit operation

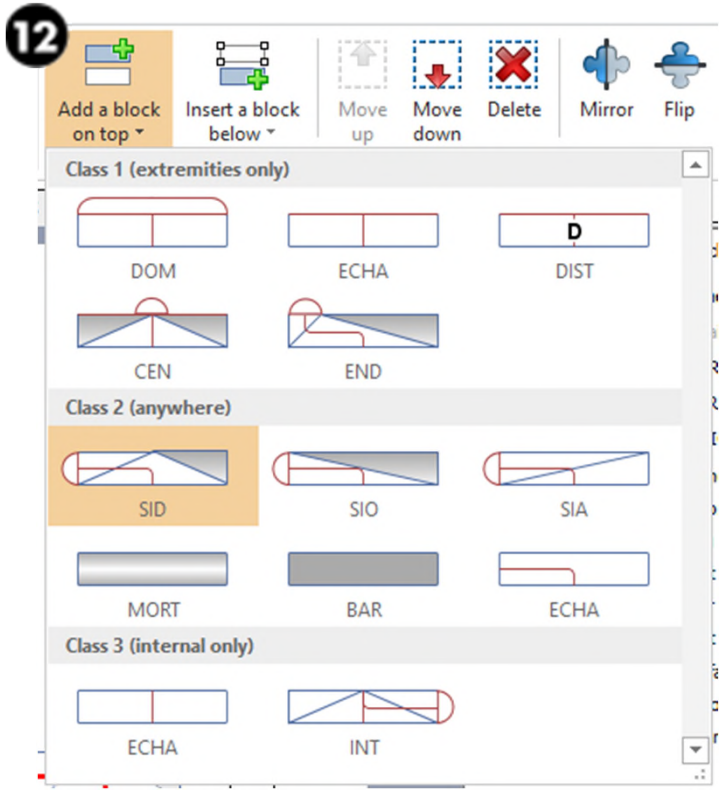
- "Reference layer" tab
  10. Click on "Add a block on top" and select a "MORT" zone, i.e. a zone in which no fluid flows (only conduction occurs)
  11. Select this block and enter its parameters

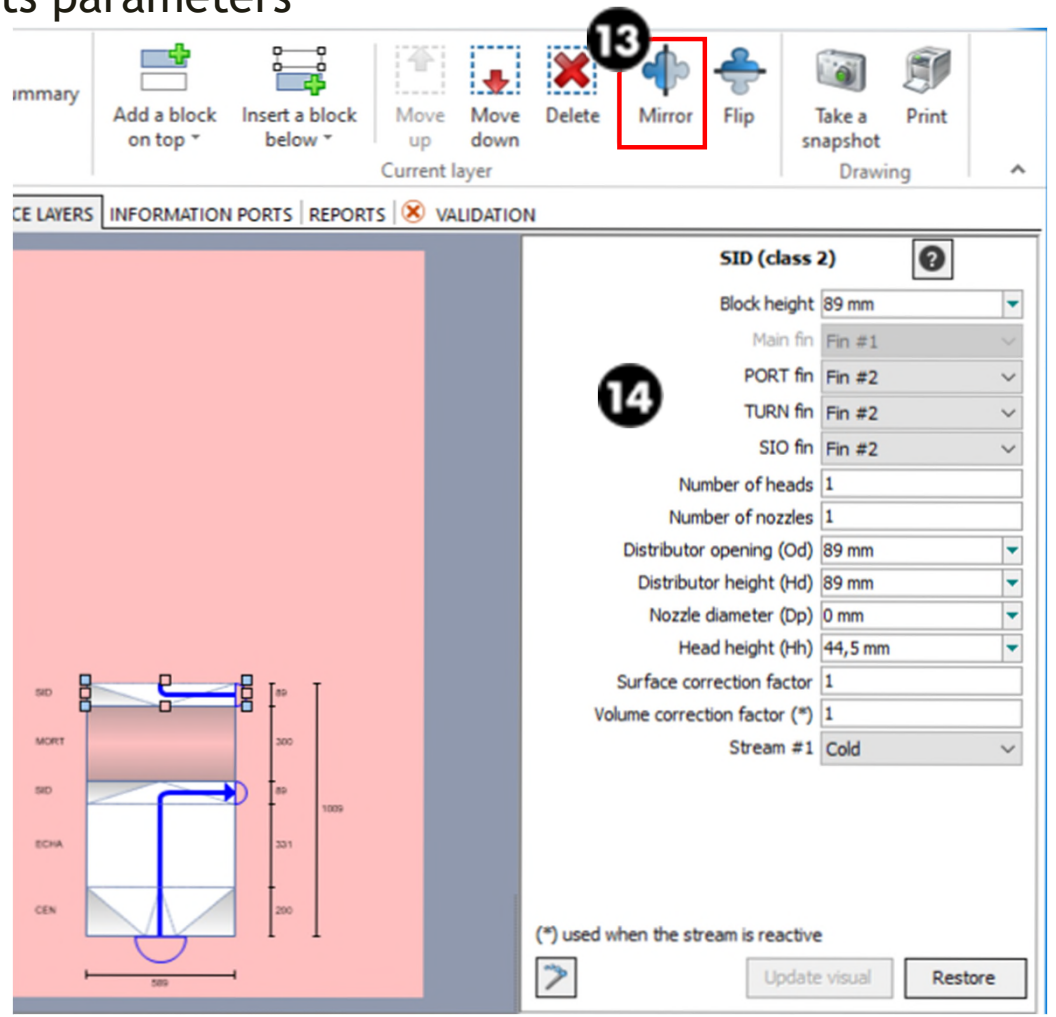




Step 3: Create the flowsheet
A- ProSec unit operation

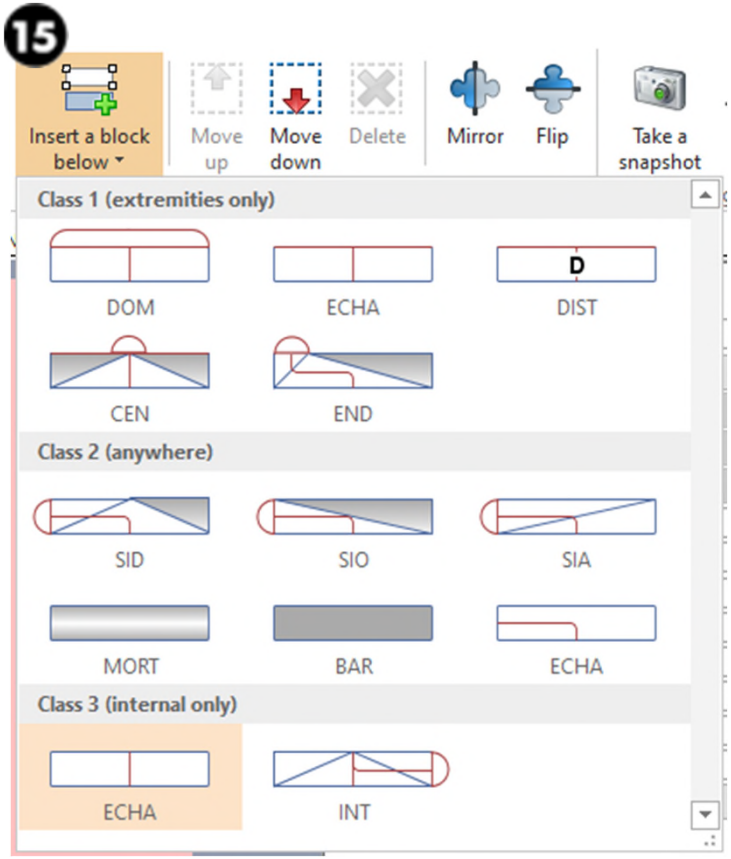
- "Reference layer" tab
  12. Click on "Add a block on top" and select a "SID" distributor
  13. Click on "Mirror" to change the position of its head
  14. Select this block and enter its parameters

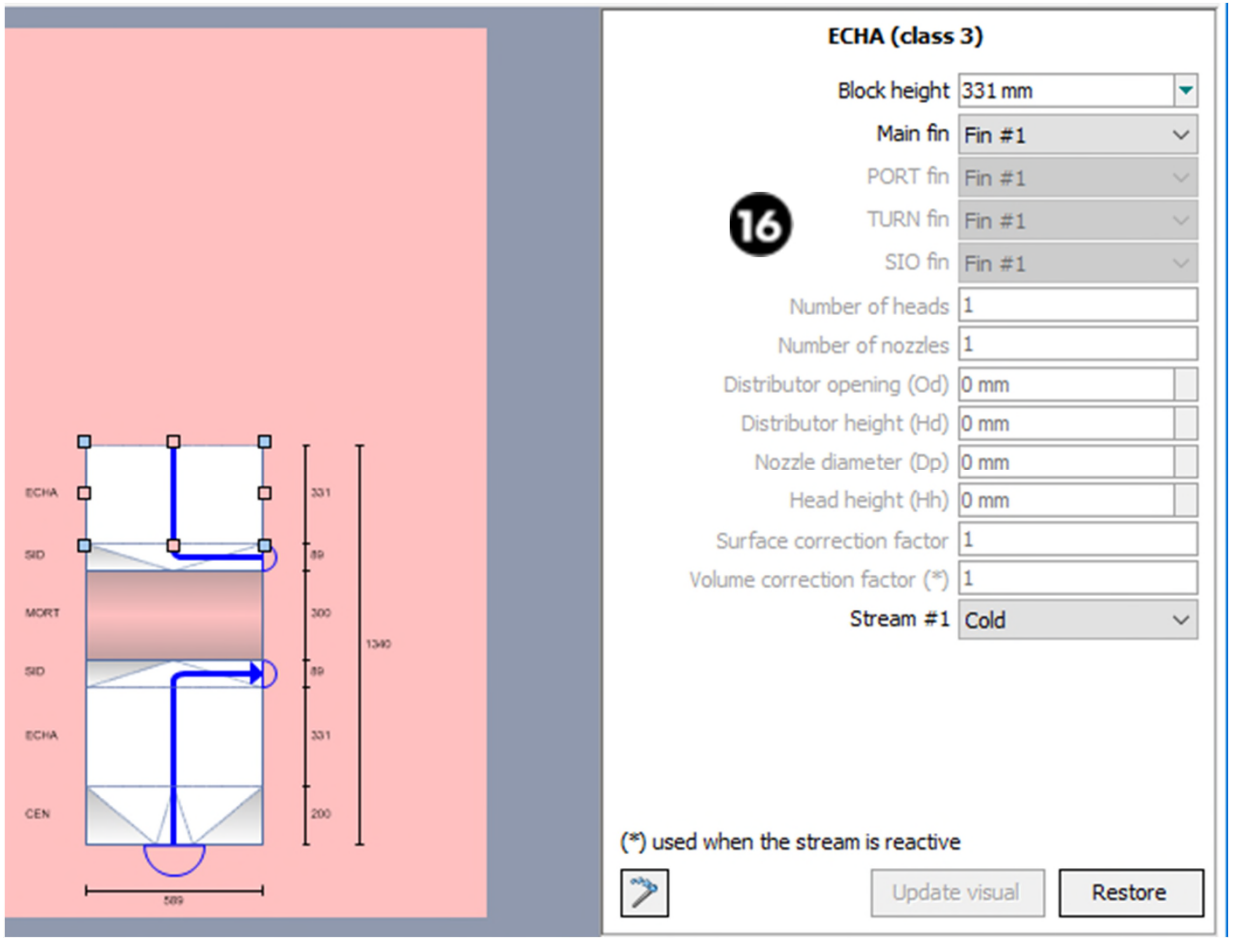




Step 3: Create the flowsheet
A- ProSec unit operation

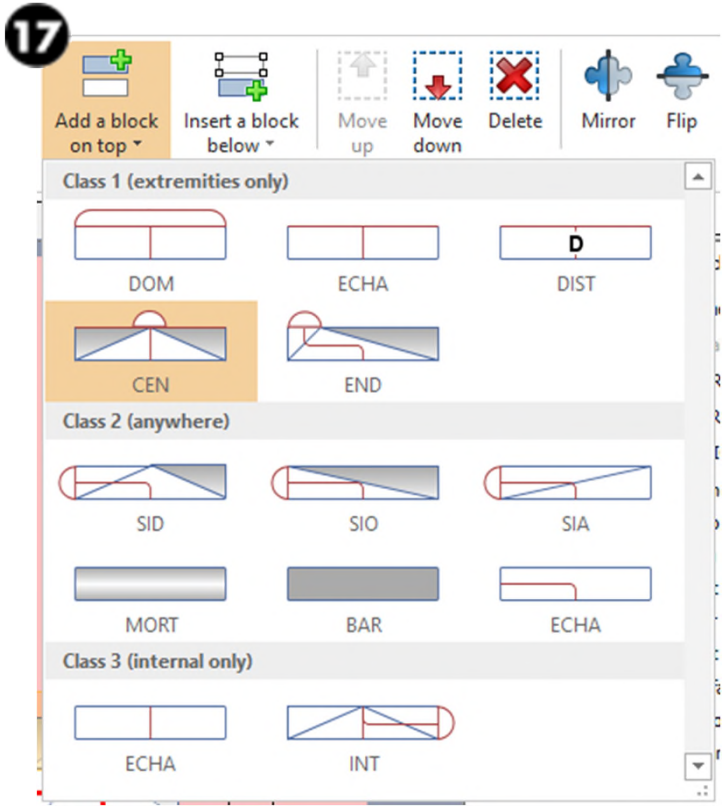
- "Reference layer" tab
  15. Click on "Add a block on top" and select a heat exchange zone "ECHA"
  16. Select this block and enter its parameters

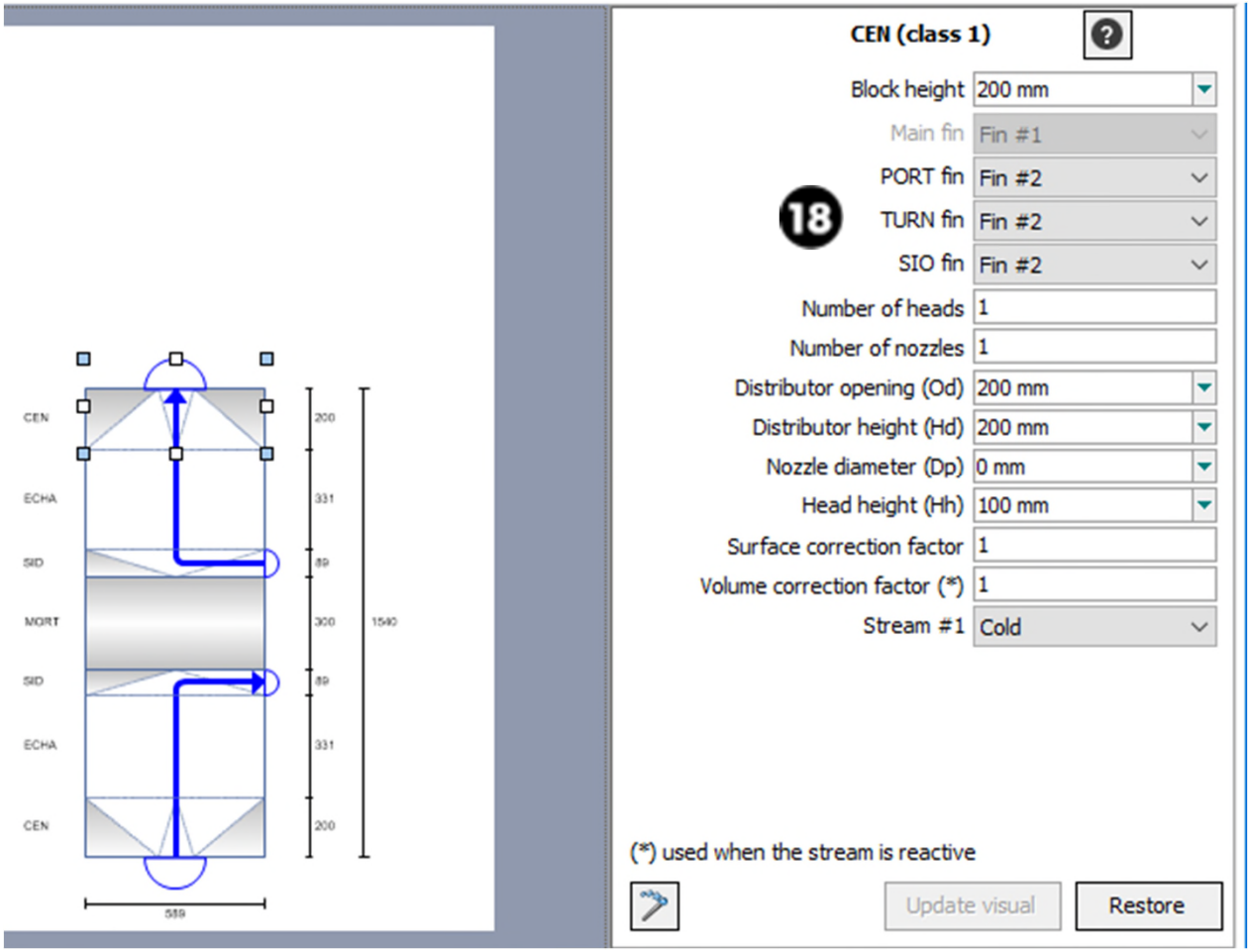




Step 3: Create the flowsheet
A- ProSec unit operation

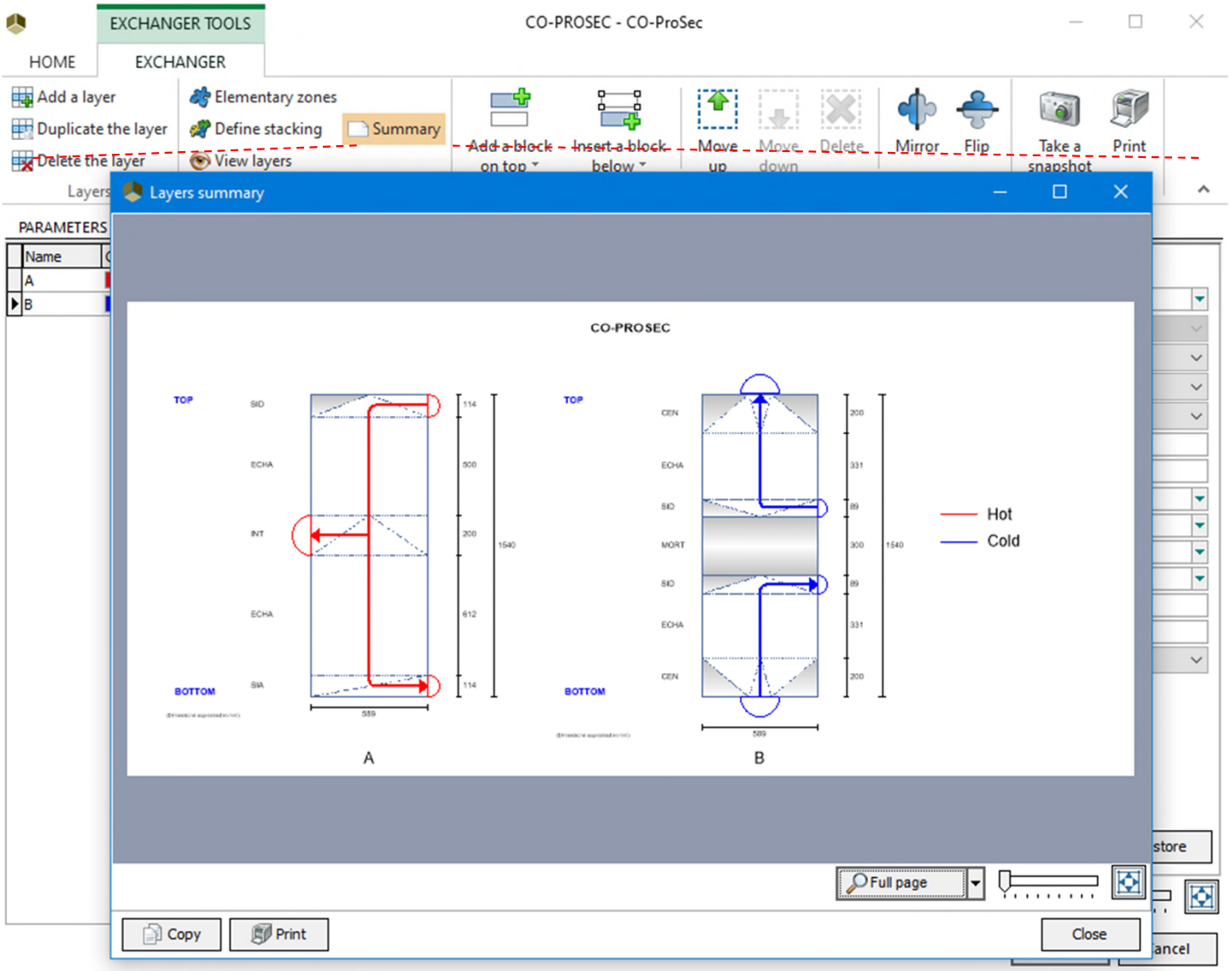
- "Reference layer" tab
  17. Click on "Add a block on top" and select a "CEN" distributor
  18. Select this block and enter its parameters





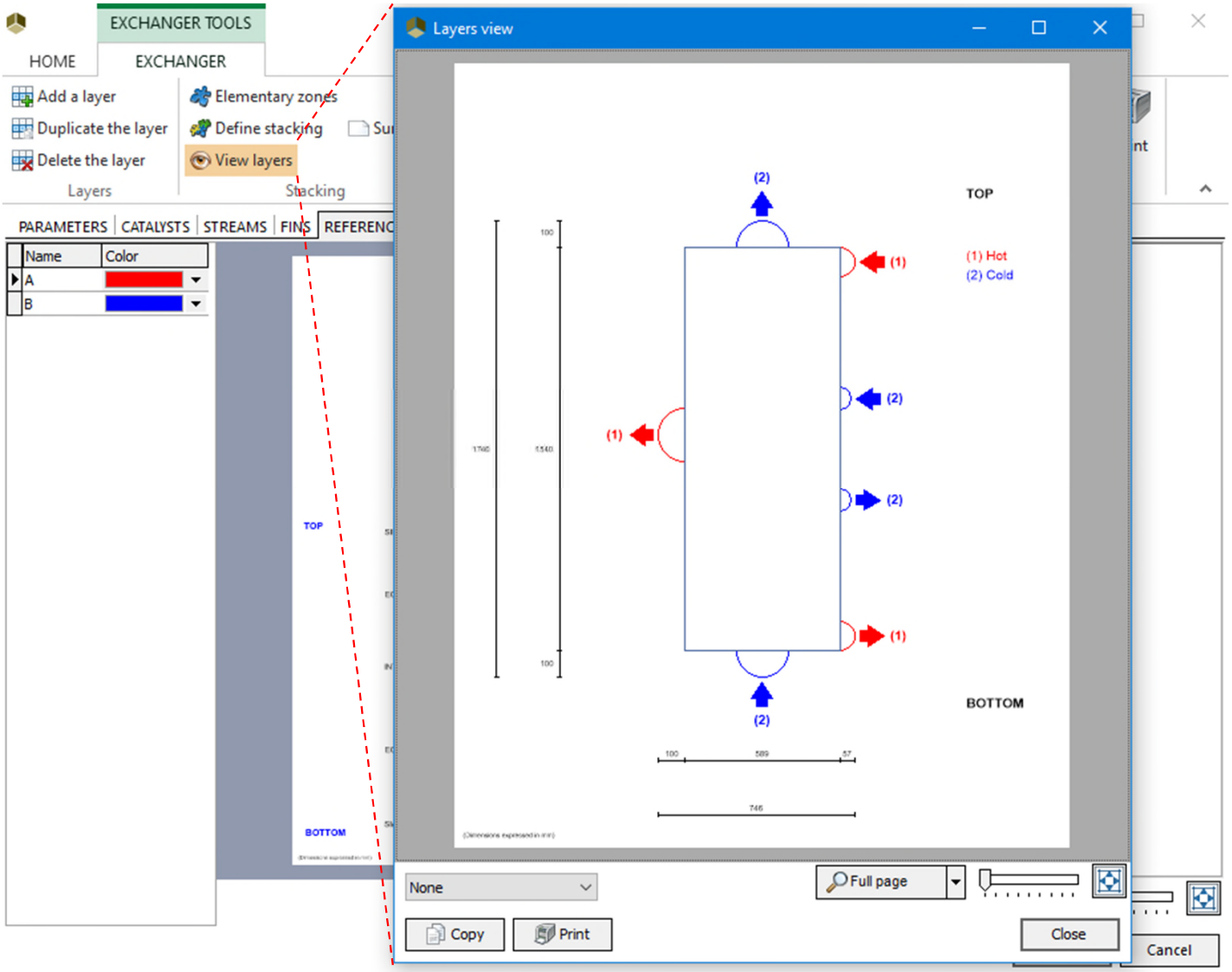
Step 3: Create the flowsheet
A- ProSec unit operation

- "Reference layer" tab
  - ✓ Click on "Summary" to visualize the whole reference layers



Step 3: Create the flowsheet
A- ProSec unit operation

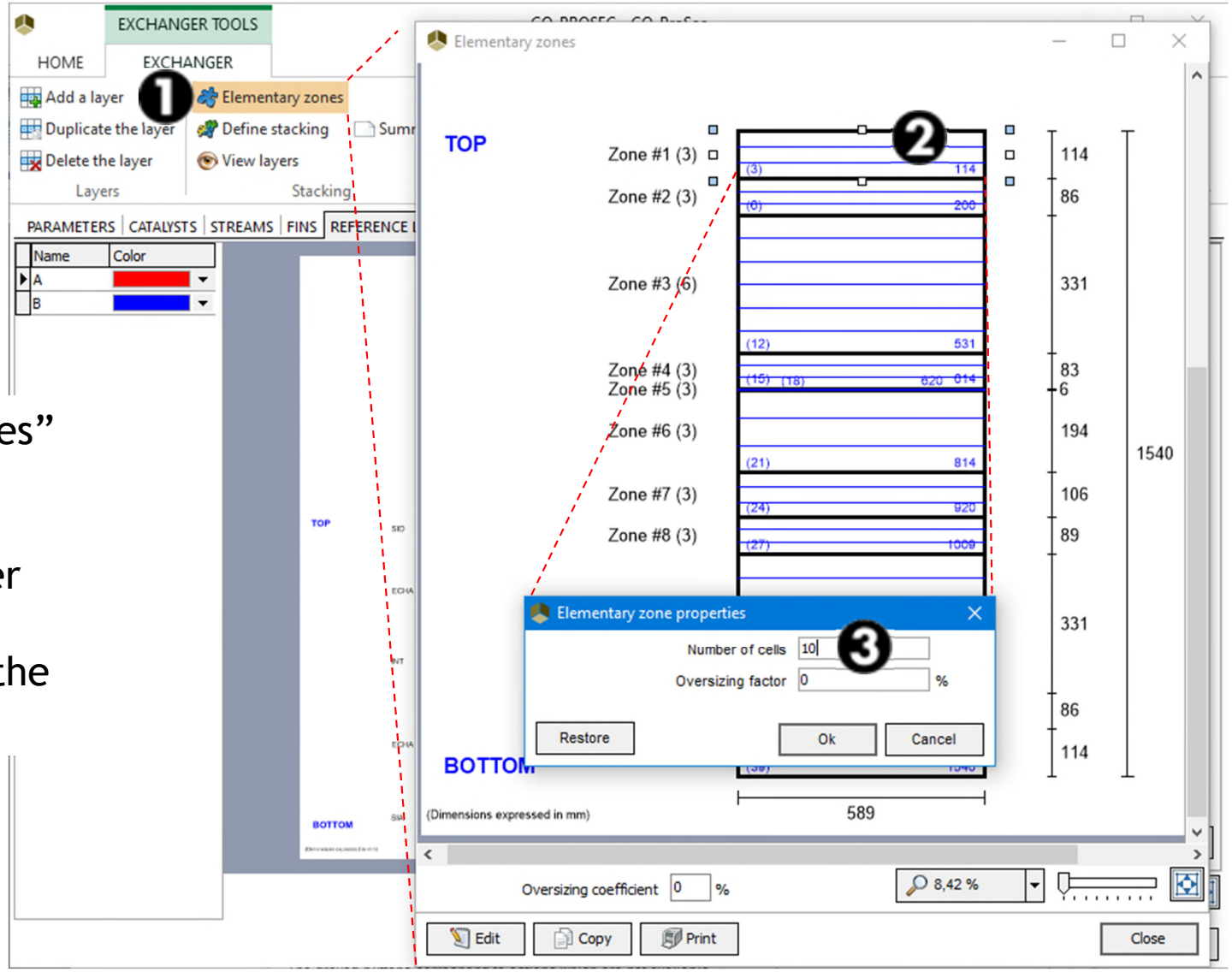
- "Reference layer" tab
  - ✓ Click on "View layers" to visualize the sketch of the heat exchanger (head position…)



Step 3: Create the flowsheet
A- ProSec unit operation

- "Reference layer" tab
  - ✓ Adjust the number of discretization cells

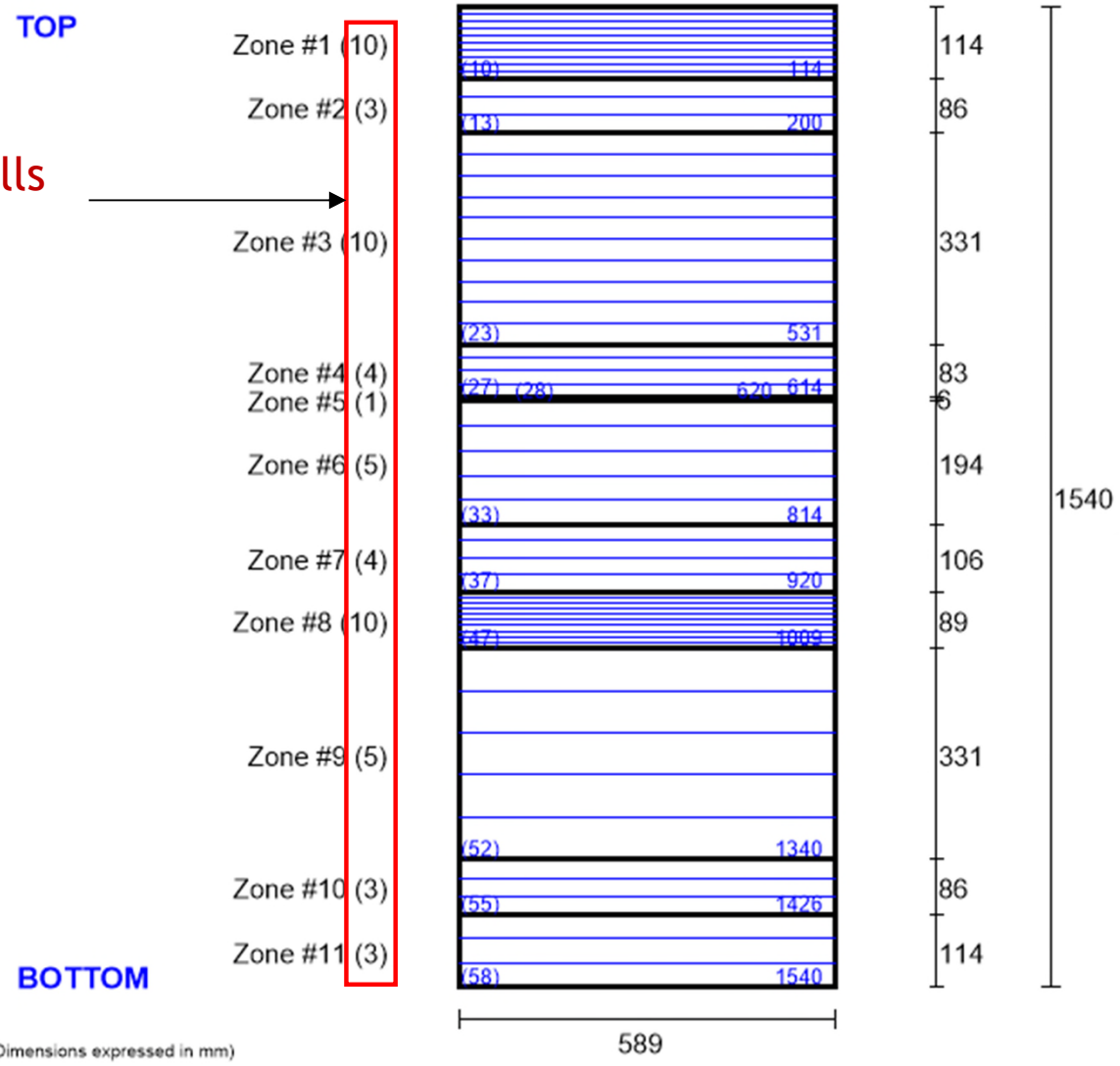
1. Click on "Elementary zones"
2. Double-click on the first elementary zone
3. Modify the default number of cells
4. Repeat point 2 and 3 for the other elementary zones



Step 3: Create the flowsheet
A- ProSec unit operation

- "Reference layer" tab
  - ✓ Adjust the number of discretization cells

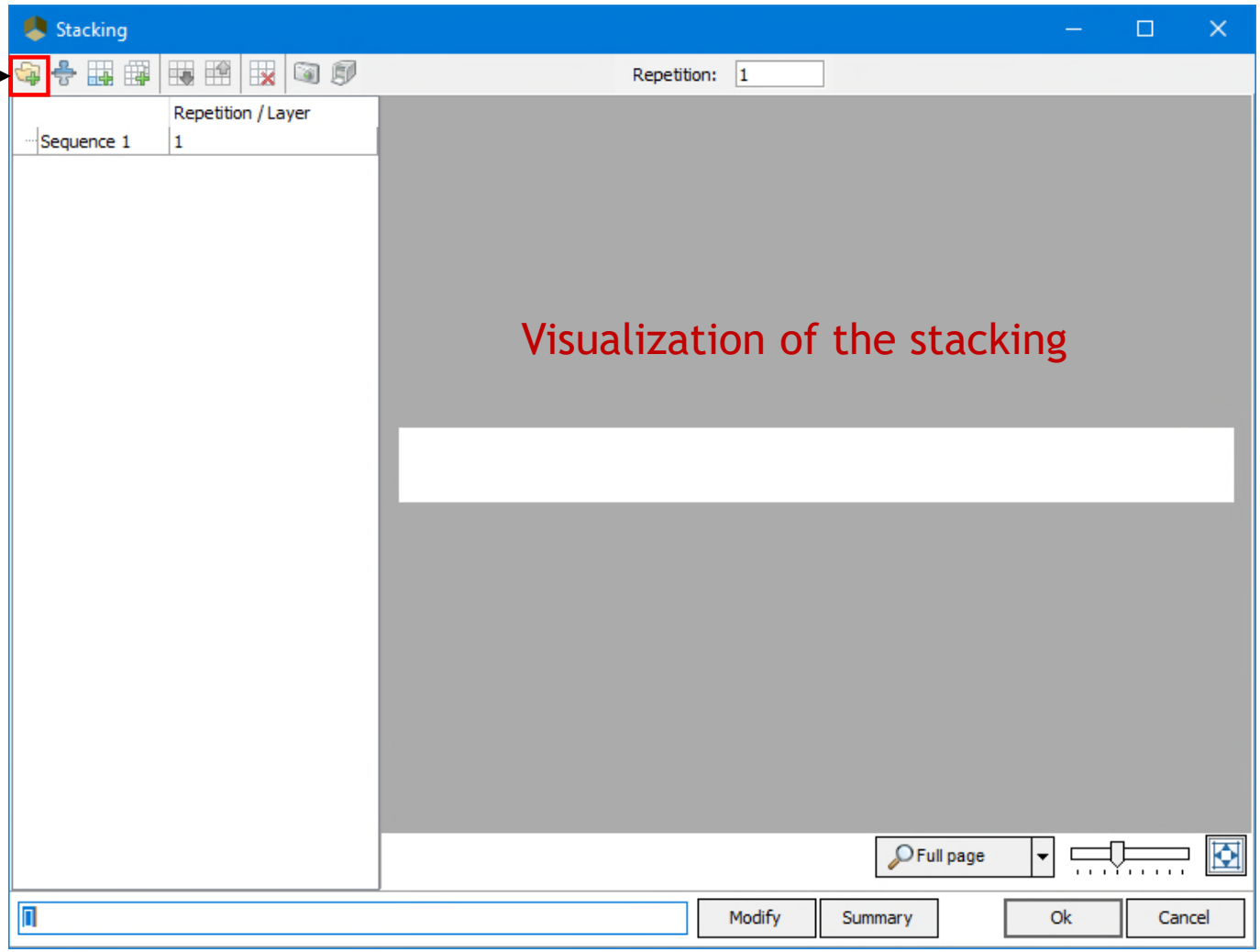
Number of discretization cells for each elementary zone



Step 3: Create the flowsheet
A- ProSec unit operation

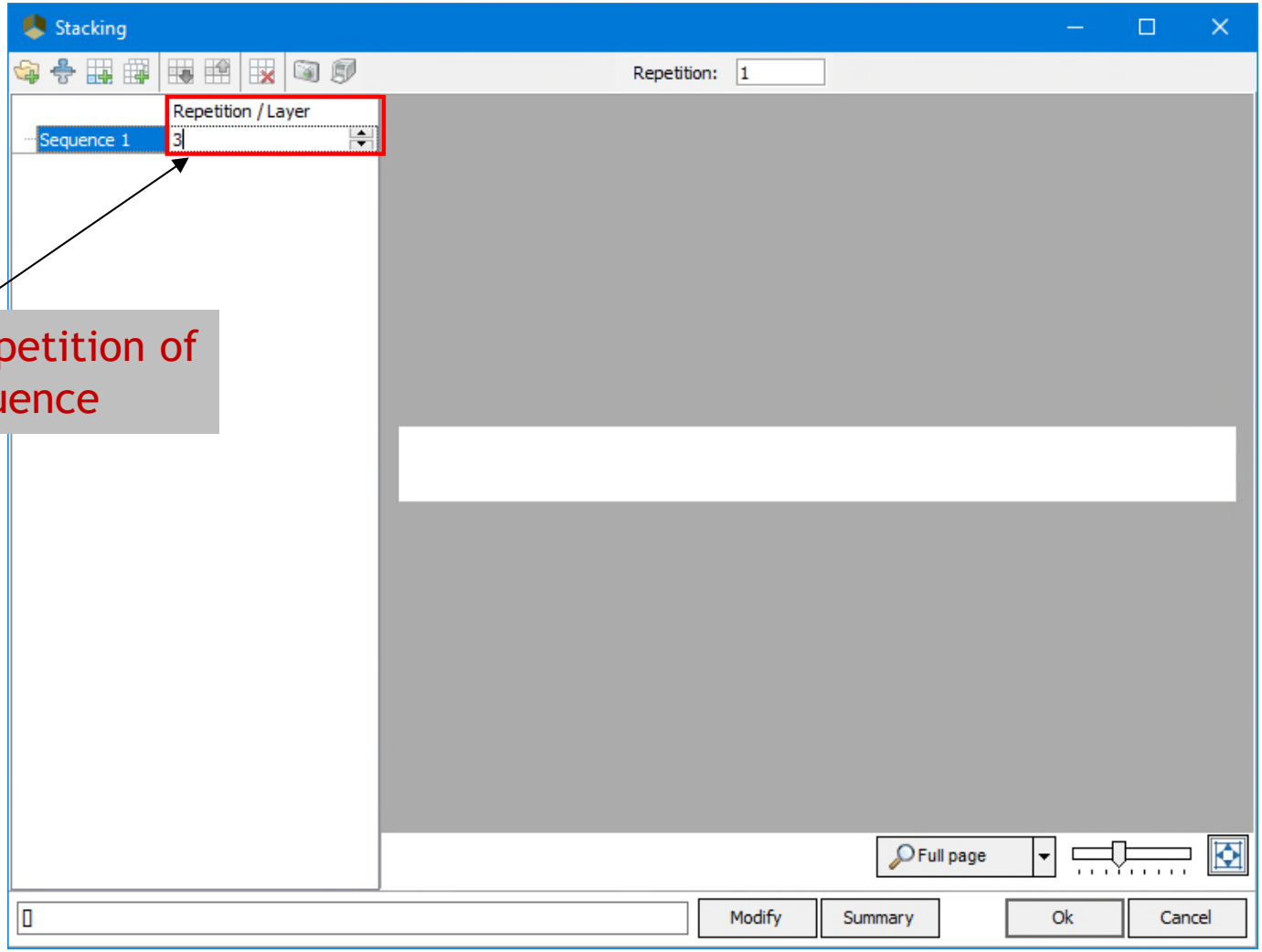
- "Reference layer" tab
  - ✓ Define the stacking: A B A B A B (6 layers)
  1. Click on "Add a new sequence"

Add a sequence →



Step 3: Create the flowsheet
A- ProSec unit operation

- "Reference layer" tab
  - ✓ Define the stacking: A B A B A B (6 layers)
  - 2. Specify 3 repetition for the "Sequence 1"

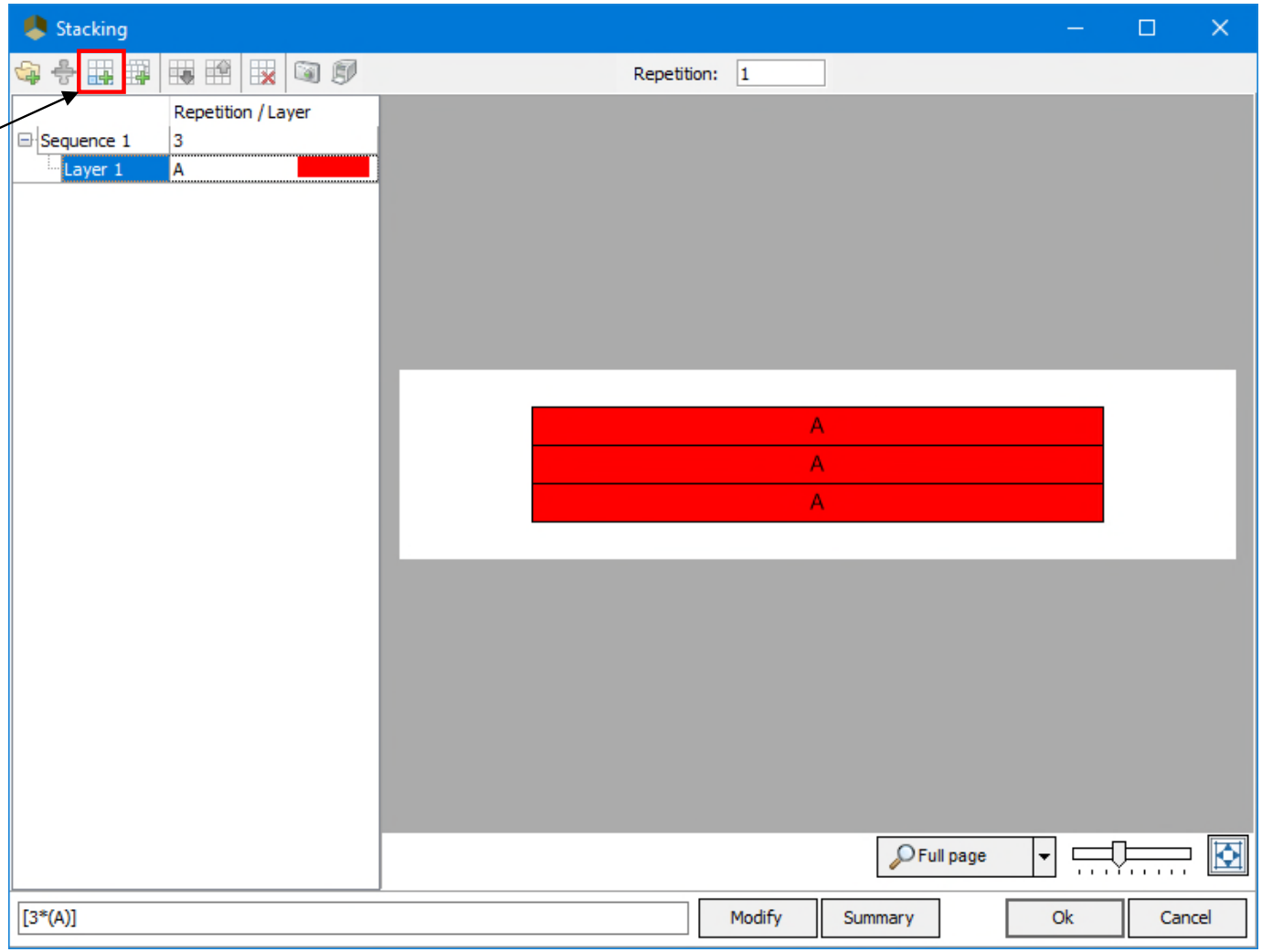


Number of repetition of this sequence

Step 3: Create the flowsheet
A- ProSec unit operation

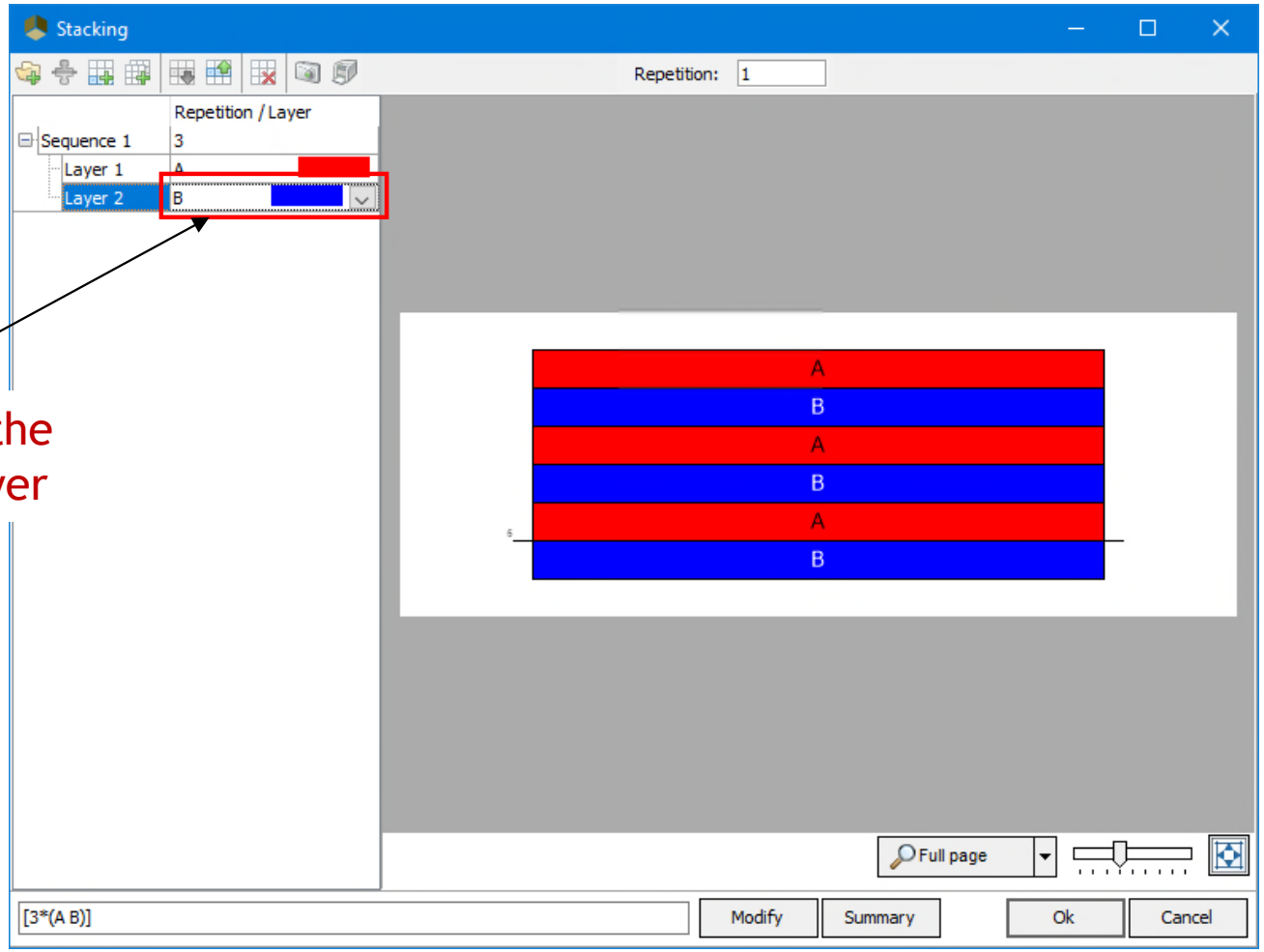
- "Reference layer" tab
  - ✓ Define the stacking: A B A B A B (6 layers)
  - 3. Click on "Add a new layer in the selected sequence"

Add a layer in a sequence



Step 3: Create the flowsheet
A- ProSec unit operation

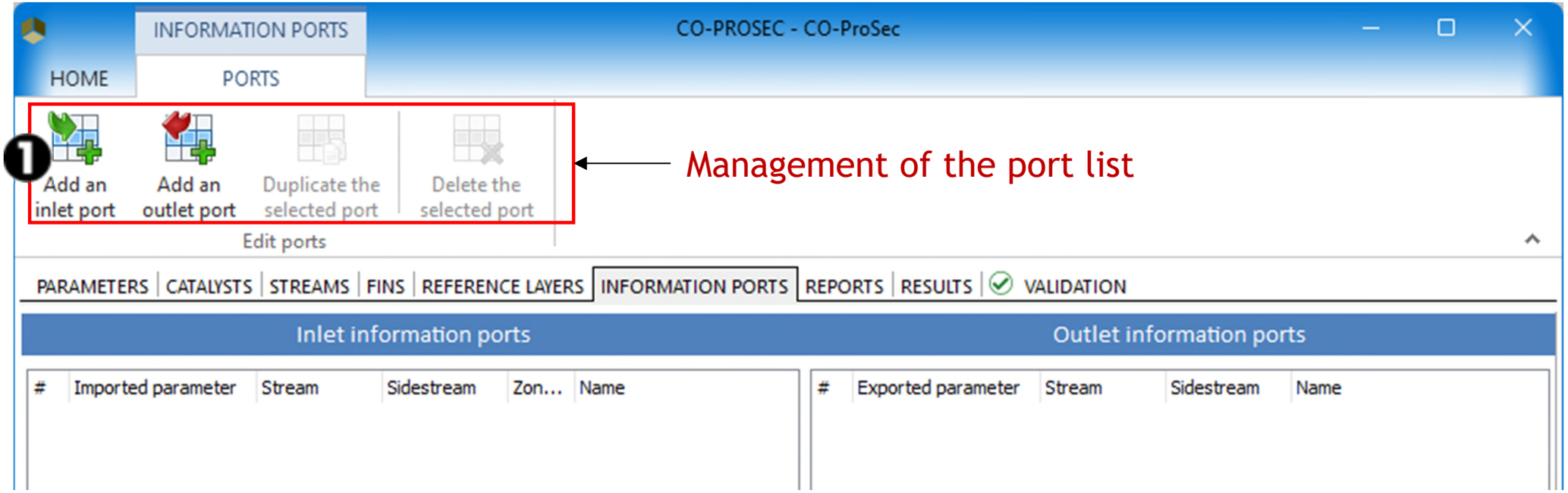
- "Reference layer" tab
  - ✓ Define the stacking: A B A B A B (6 layers)
  4. Click a second time on "Add a new layer in the selected sequence"
  5. With the menu of the "Layer 2", select the reference layer "B"



Selection of the reference layer

Step 3: Create the flowsheet
A- ProSec unit operation

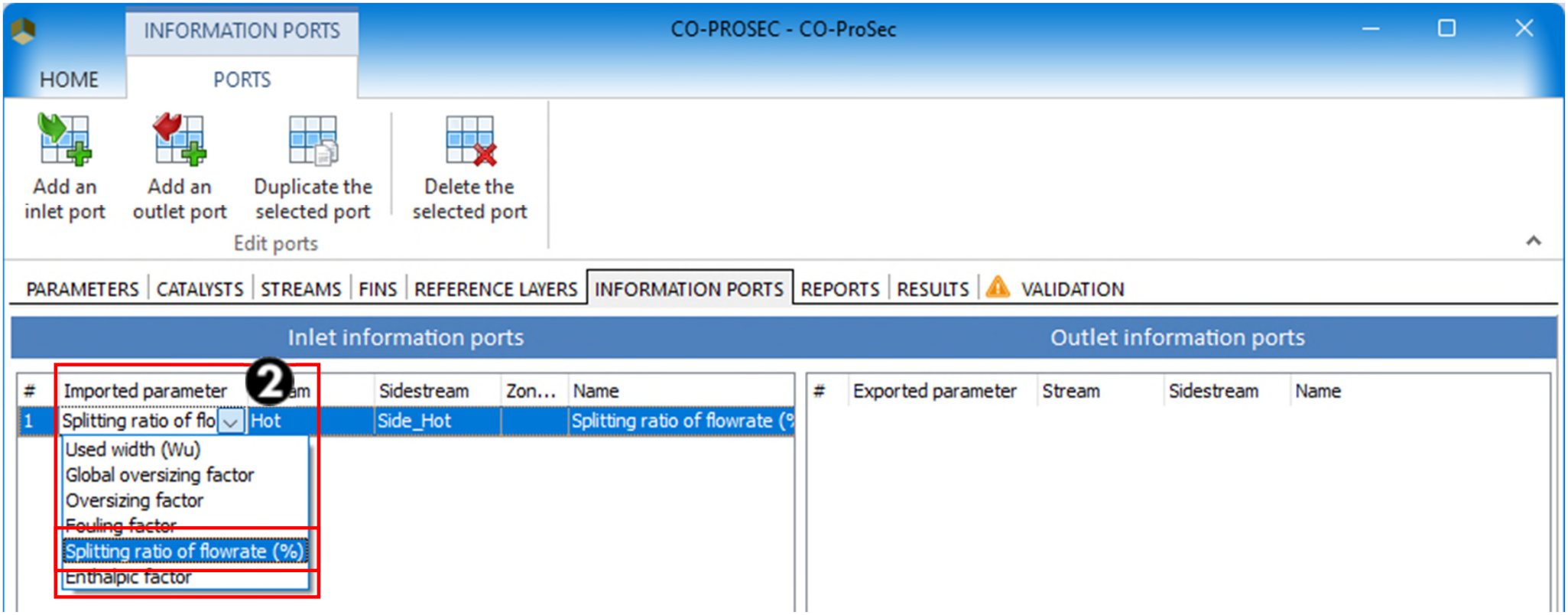
- "Information ports" tab
  - ✓ Add inlet/outlet information ports
  1. Click "Add an inlet port"



Step 3: Create the flowsheet
A- ProSec unit operation

- "Information ports" tab

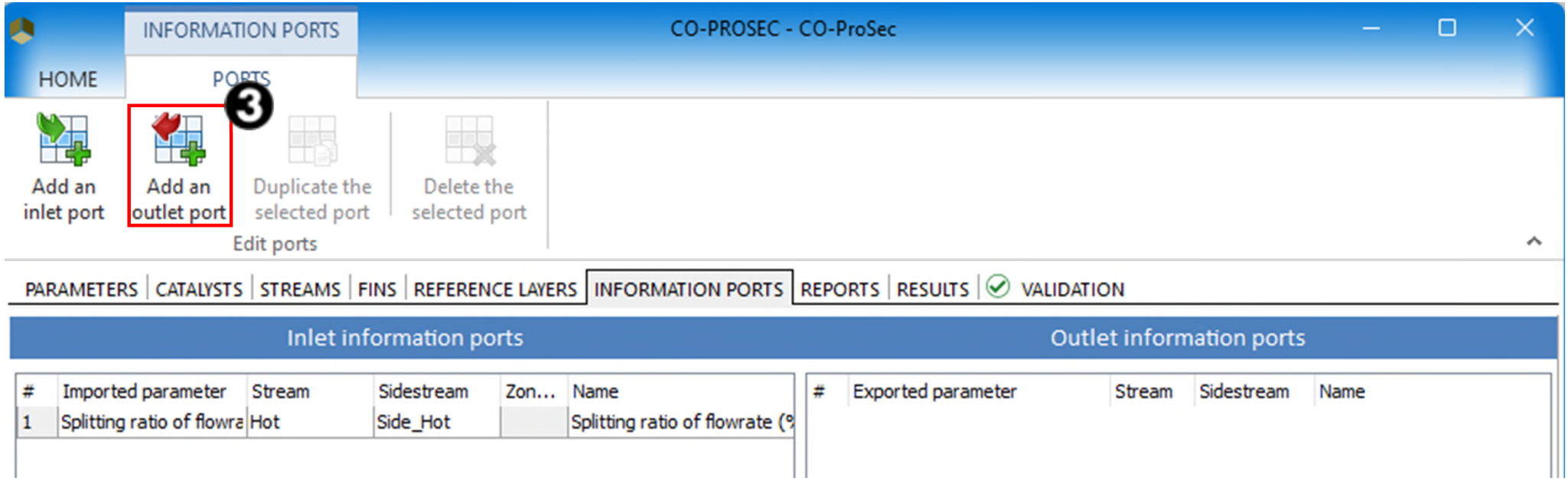
2. Select the parameter to import from another unit operation of the simulation for the inlet information port: the imported value will replace the value defined in the interface



Step 3: Create the flowsheet
A- ProSec unit operation

- "Information ports" tab

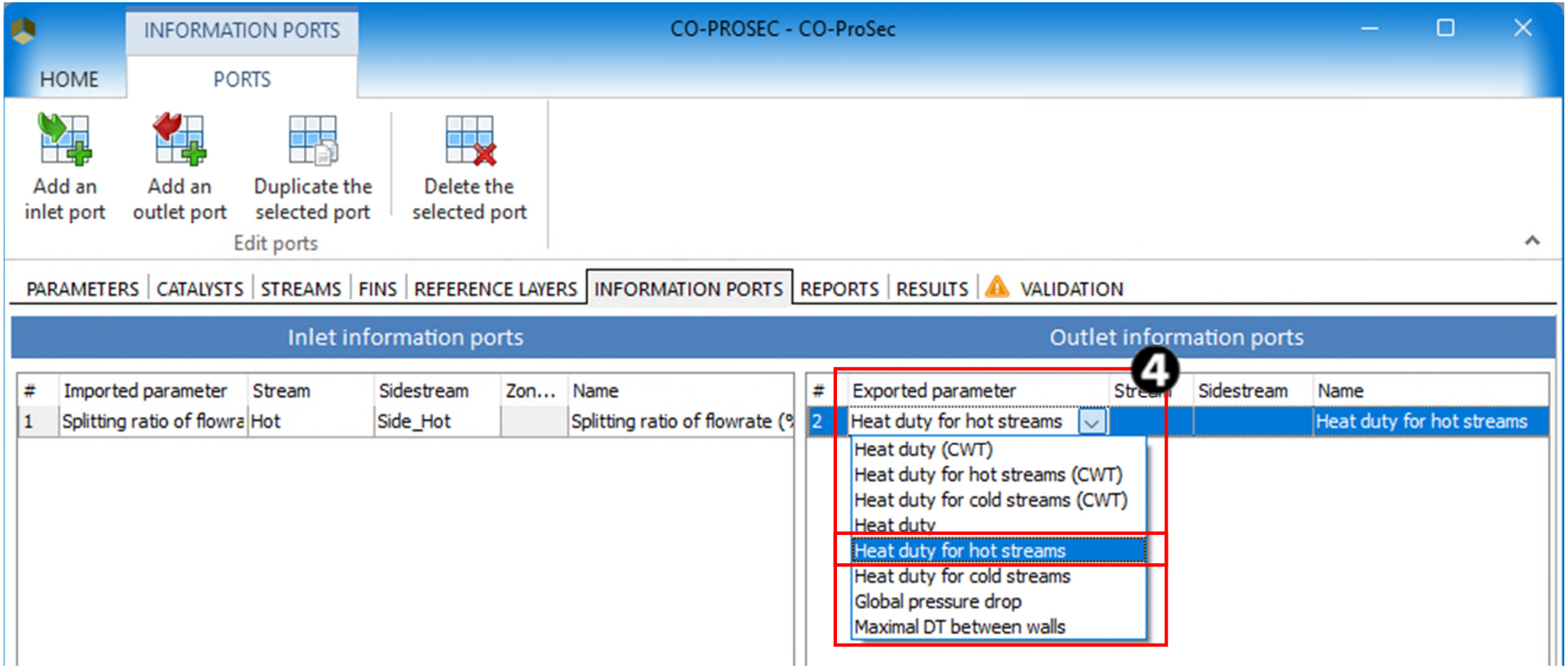
3. Click "Add an outlet port"



Step 3: Create the flowsheet
A- ProSec unit operation

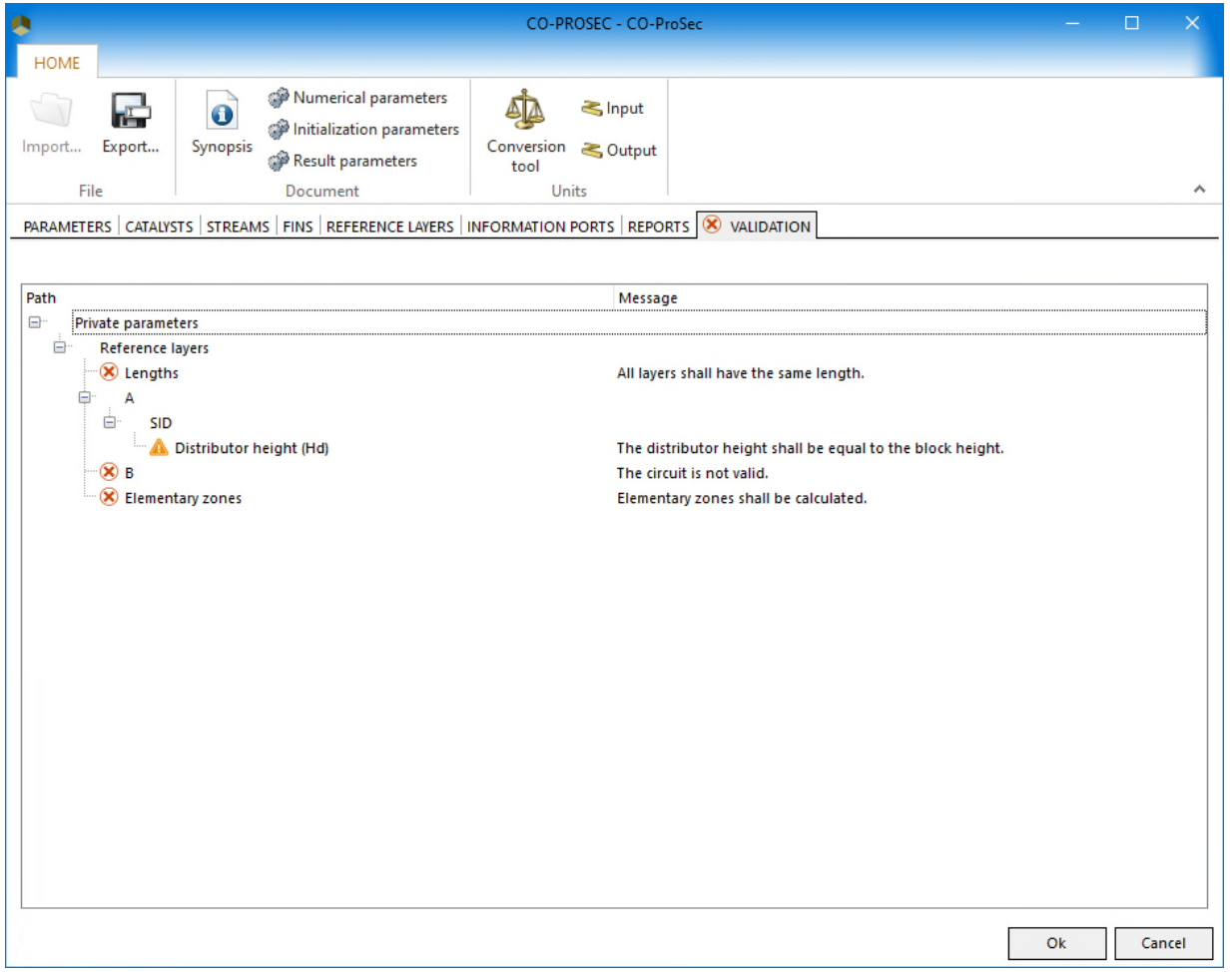
- "Information ports" tab

4. Select the parameter to export



Step 3: Create the flowsheet
A- ProSec unit operation

- "Validation" tab
  - ✓ The validation tab lists the eventual errors. At this point, errors are present due to the lack of material connections. To solve this problem, close all ProSec windows by clicking on "Ok" button.



Step 3: Create the flowsheet
B- Inlets and outlets

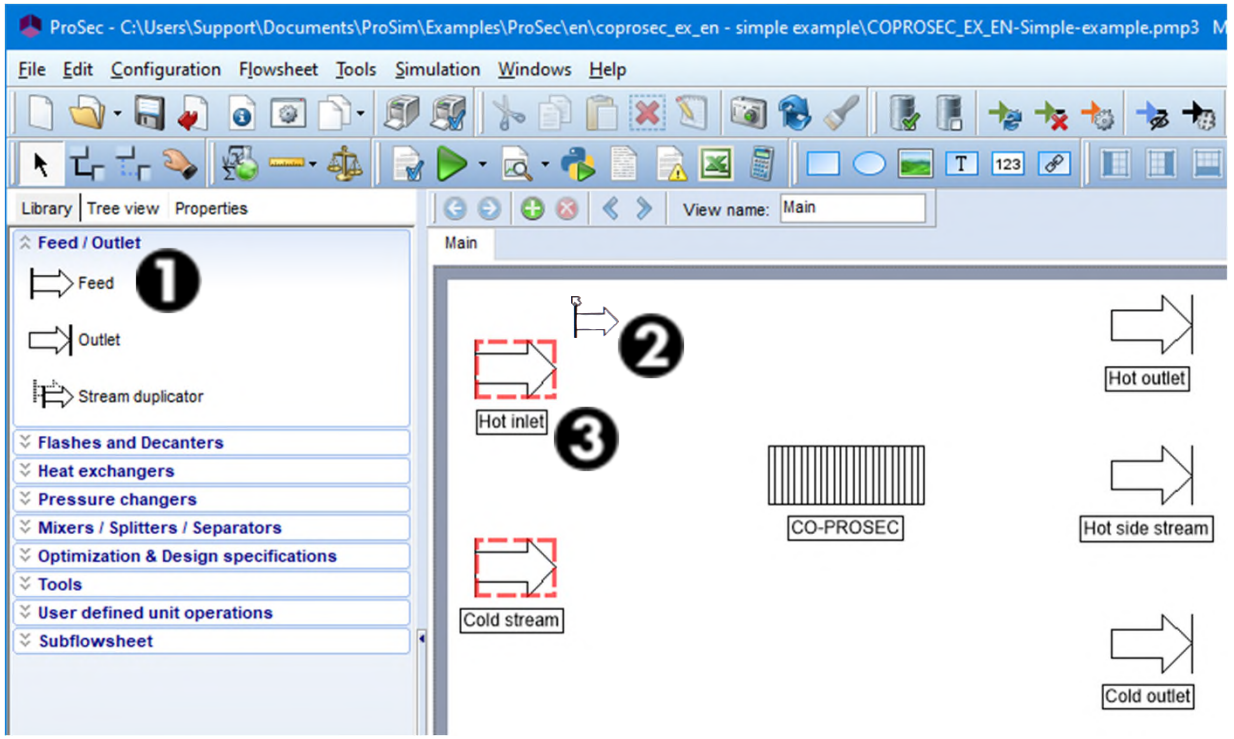
Two process feeds and three process outlets are needed for this example.

1- Click on “Process feed” icon in the library category “Feed / Product stream” to select a process feed unit operation.

2- Move the mouse onto the drawing sheet and reach the desired position.

3- Click again, to release the unit.

4- Repeat to add the second process feed and the three process outlets

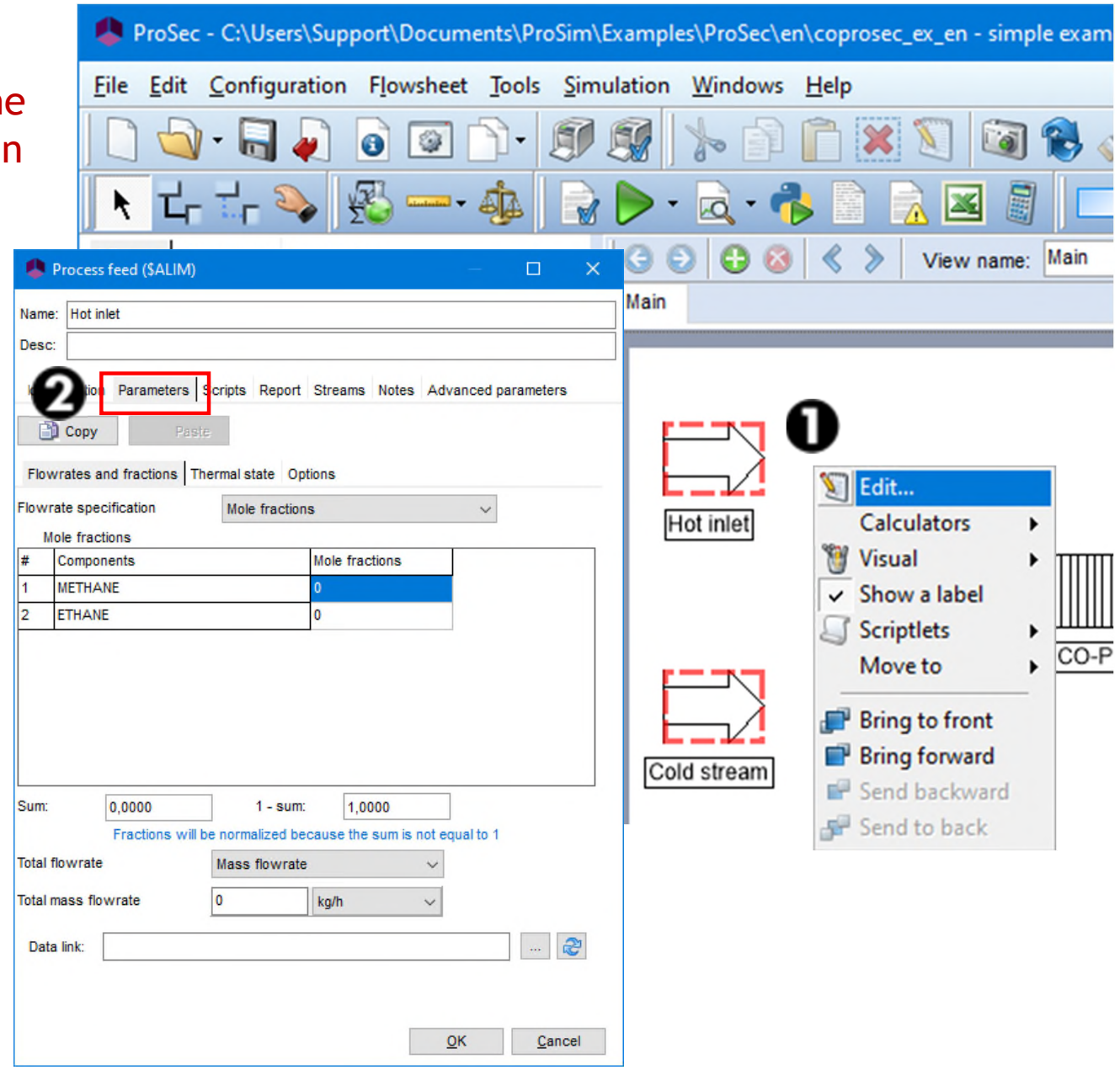


Step 3: Create the flowsheet
B- Inlets and outlets

To configure a process feed:

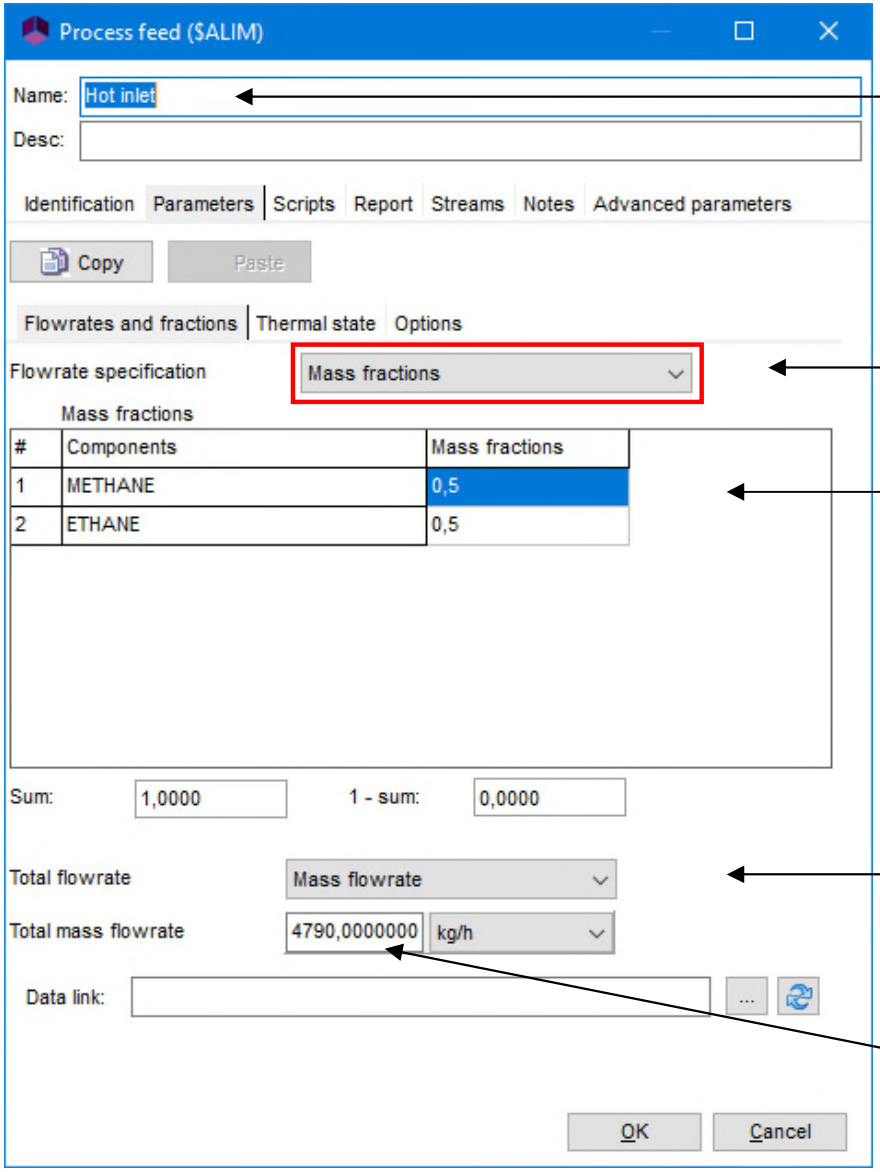
1. Double-click on its icon on the flowsheet or select “Edit…” in the contextual menu.

2. Press the “Parameters” tab.



Step 3: Create the flowsheet
B- Inlets and outlets

- Hot stream inlet characteristics



Change the default name (option)

Select “Mass fraction”

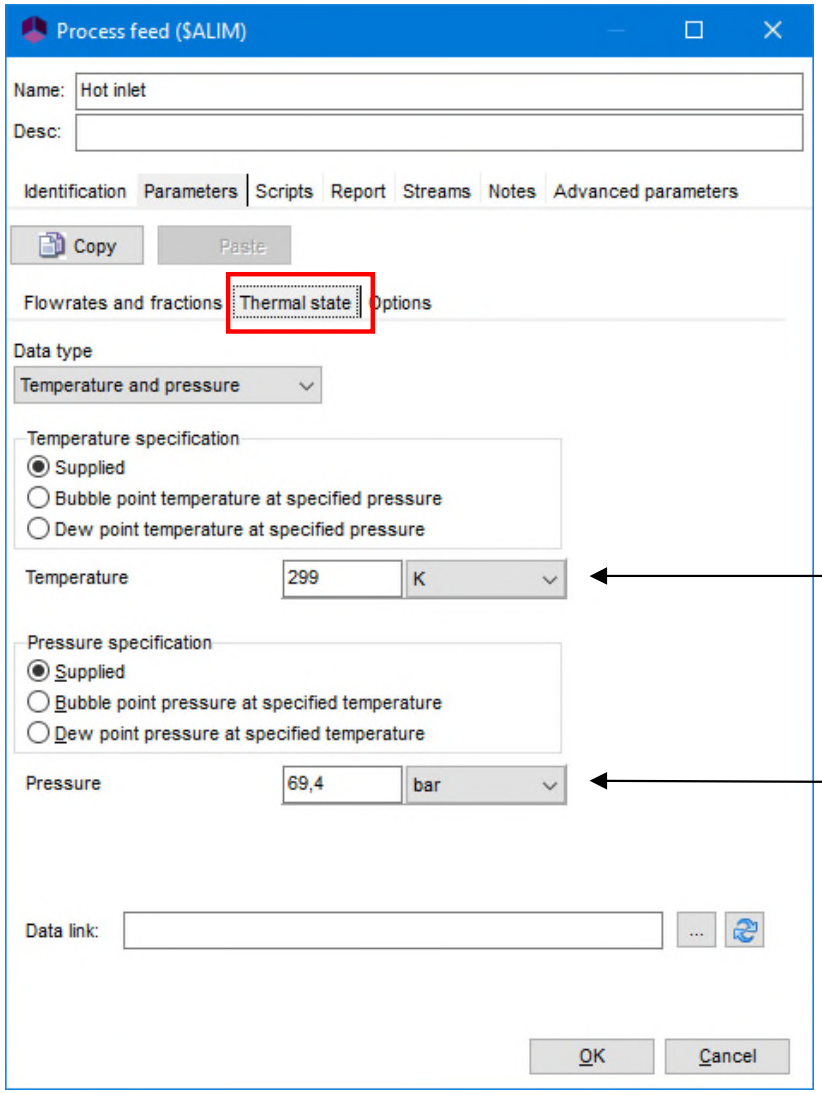
Fill in the mass fractions

Select “Mass flowrate”

Fill in the mass flow rate

Step 3: Create the flowsheet
B- Inlets and outlets

- Hot stream inlet characteristics

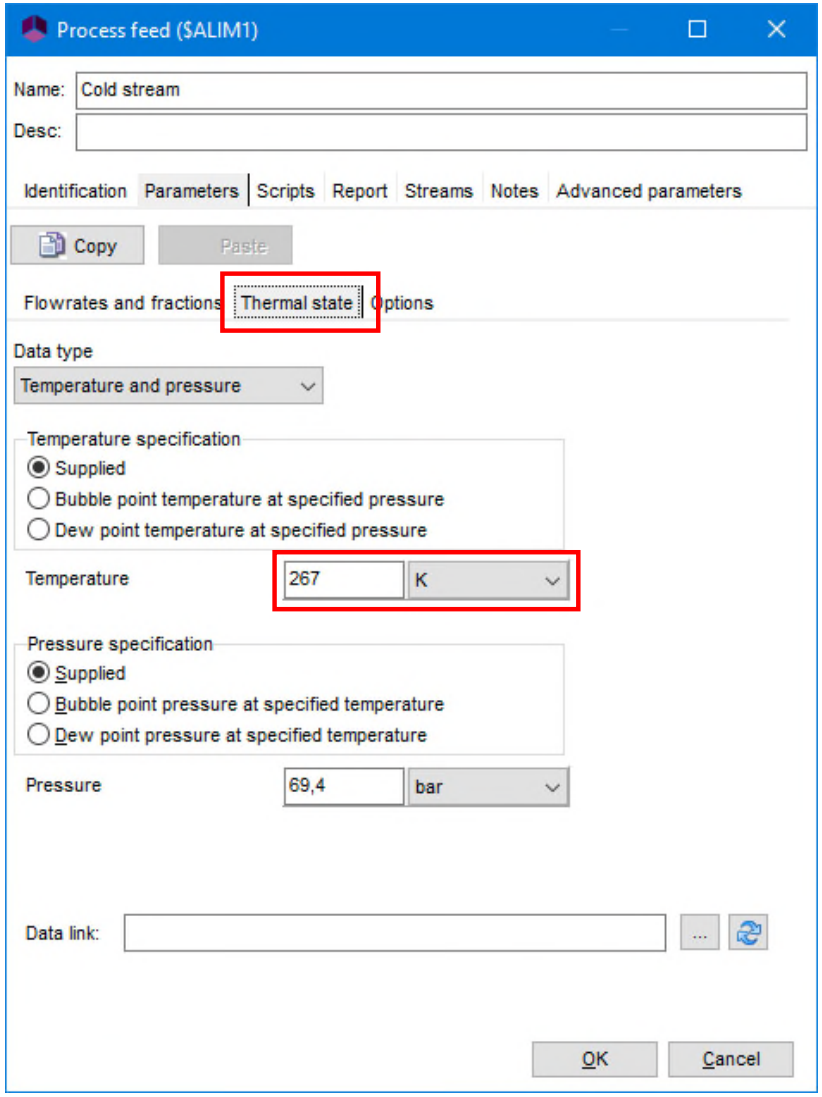


Specify the temperature

Specify the pressure

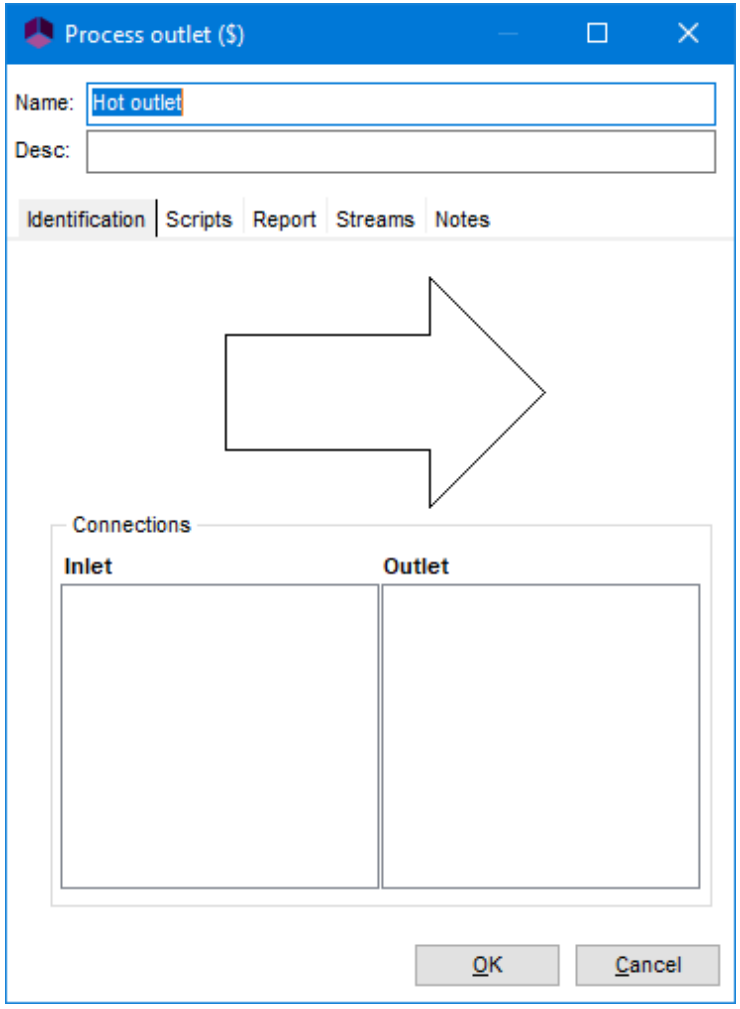
Step 3: Create the flowsheet
B- Inlets and outlets

- Cold stream inlet characteristics
  - ✓ Same characteristics as the hot stream except the temperature



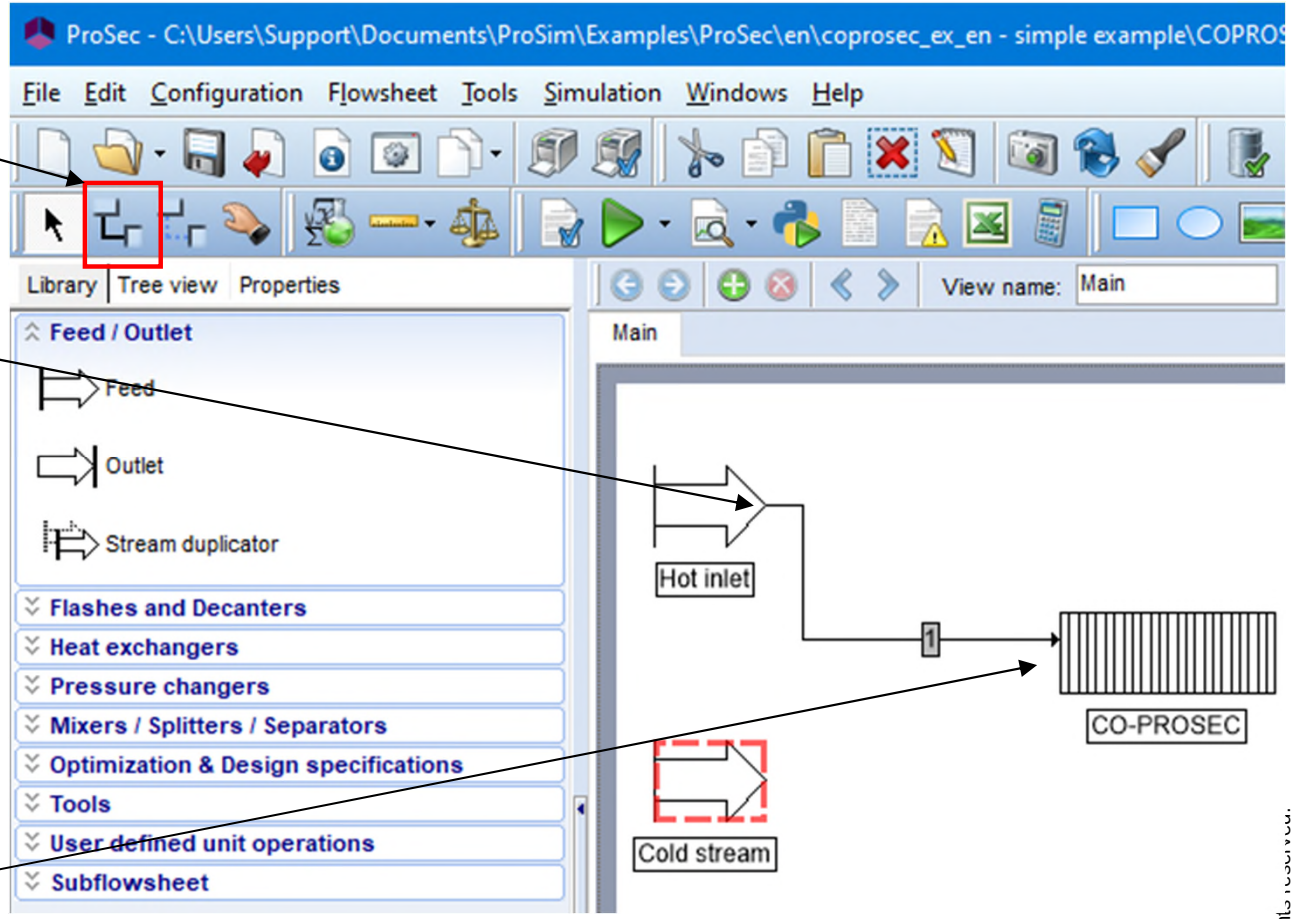
Step 3: Create the flowsheet
B- Inlets and outlets

- Process outlets
  - ✓ No parameters are needed for process outlets



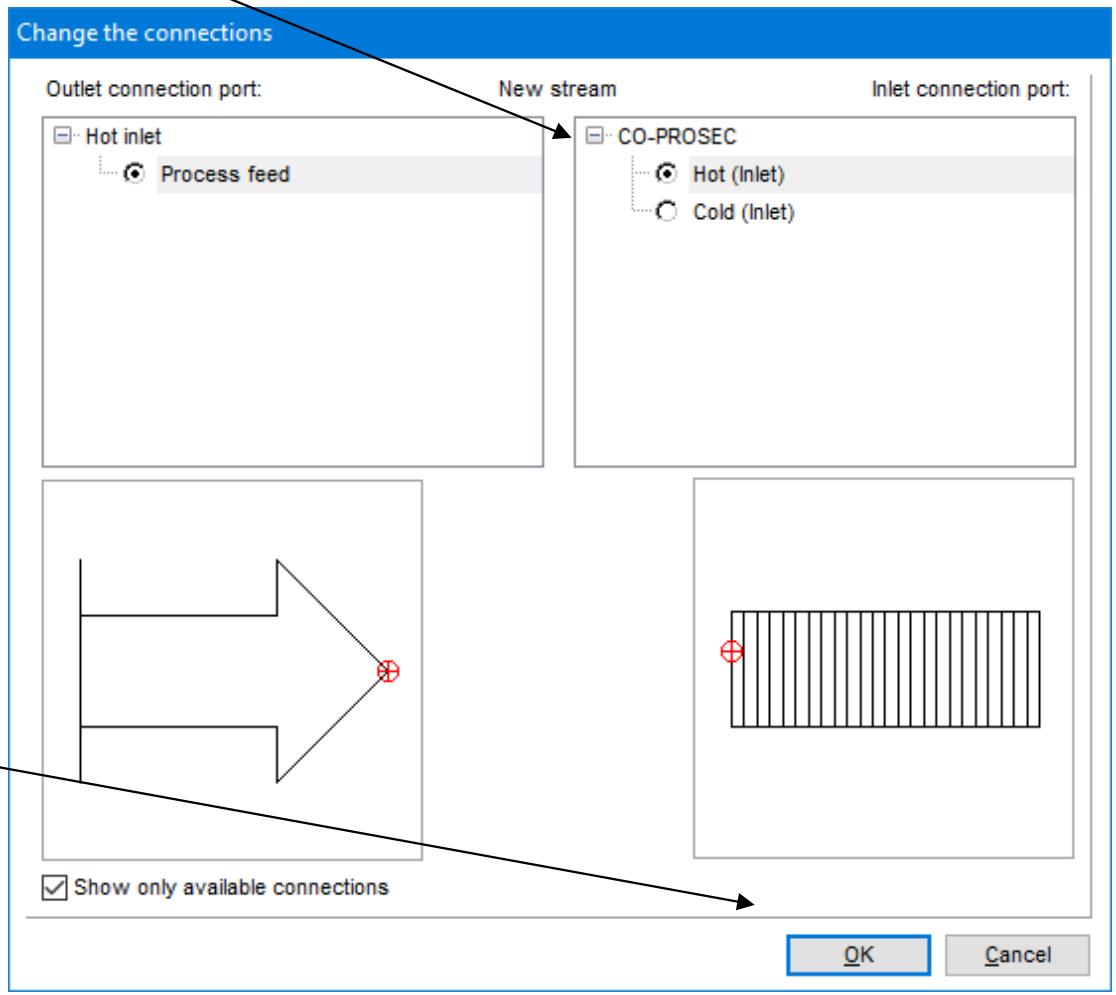
Step 3: Create the flowsheet
C- Connect unit operations

1. Select the “Create a material stream” icon
2. Select the first unit operation (source) by clicking on it
3. Select the connected unit operation (target) by clicking on it as well



Step 3: Create the flowsheet
C- Connect unit operations

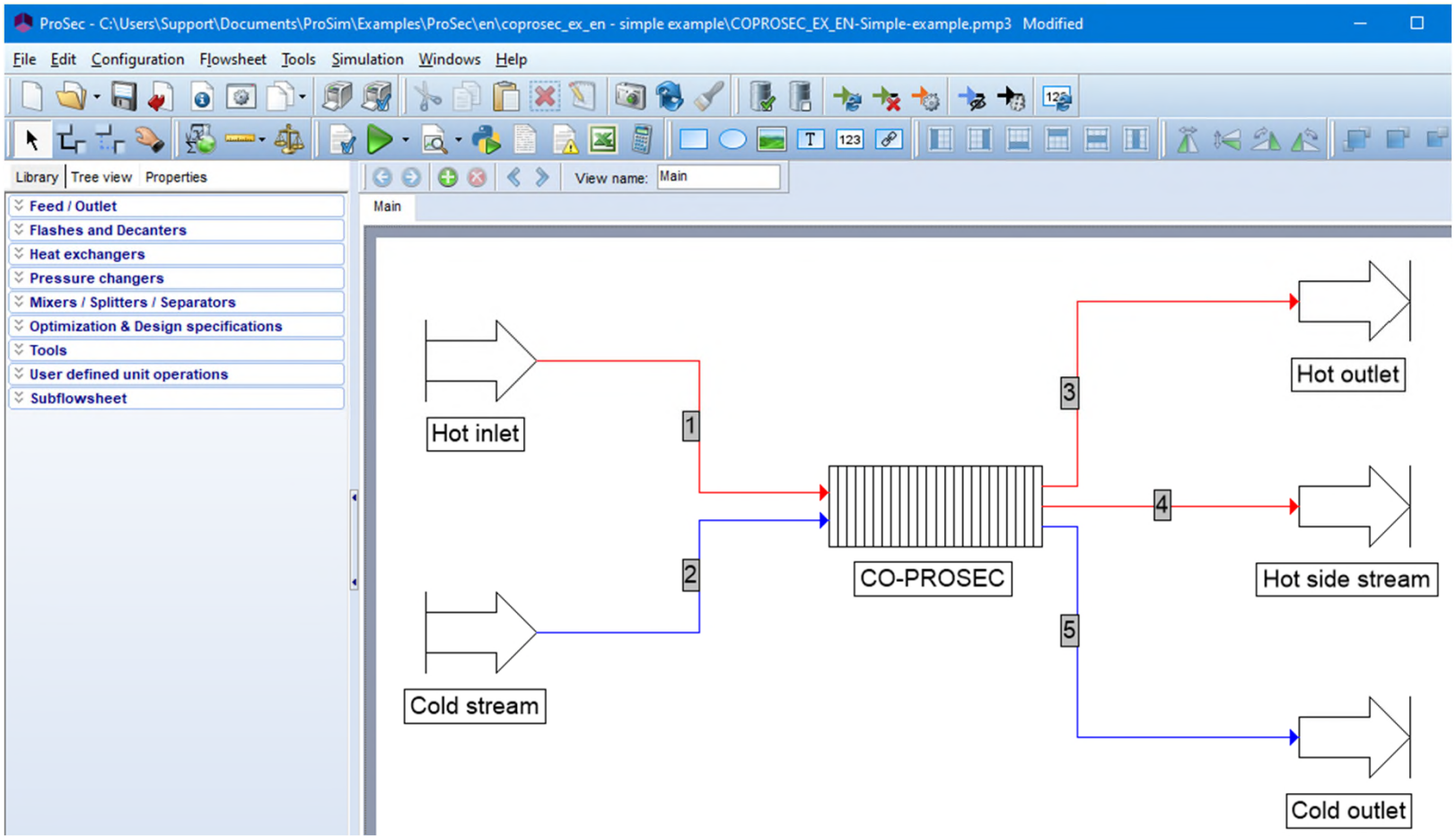
1. Select to which stream described in ProSec unit operation you want to connect the process feed. Here we connect the hot inlet to the hot stream described in ProSec unit operation.



2. Confirm by clicking on “OK”

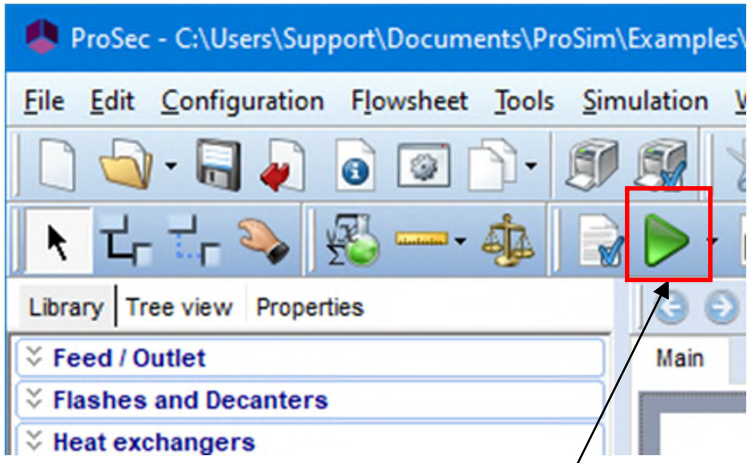
3. Repeat for the different material streams needed (5 streams)

Step 3: Create the flowsheet
C- Connect unit operations



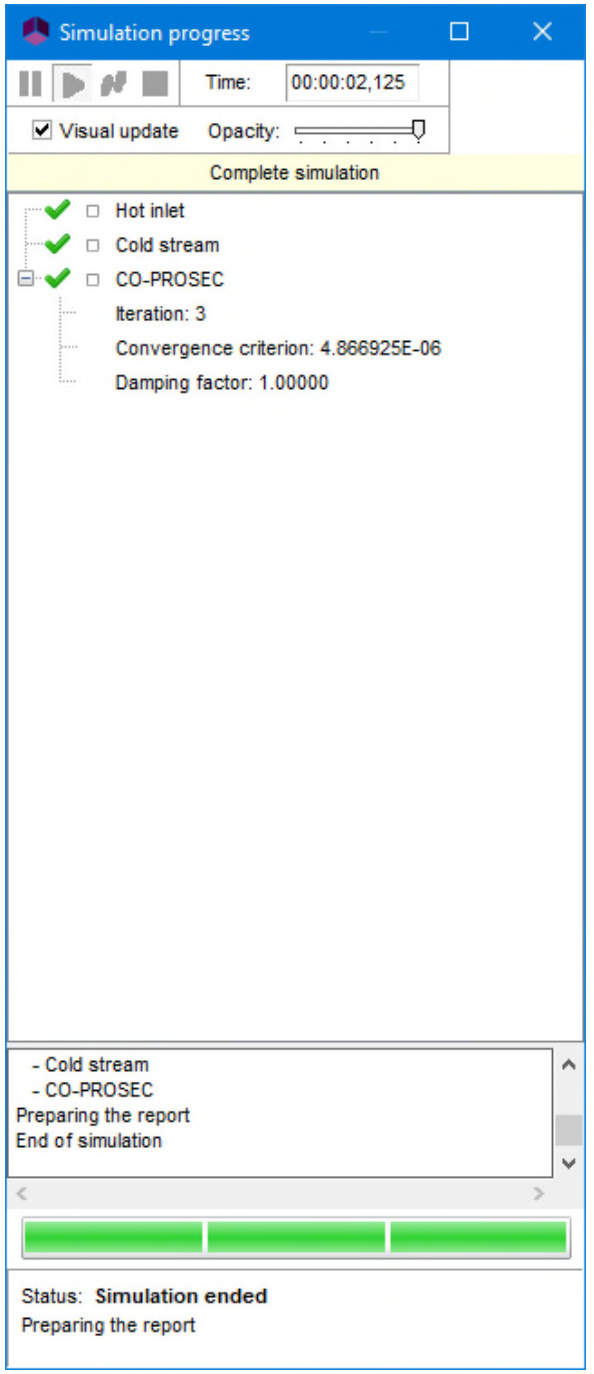
Material streams can be colored in order to ease the reading of the flowsheet. Simply right click on the stream to access the option.

Step 4: Running the simulation



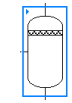
Click on the green arrow to start the simulation

When the simulation starts,
the “Simulation progress” window opens.



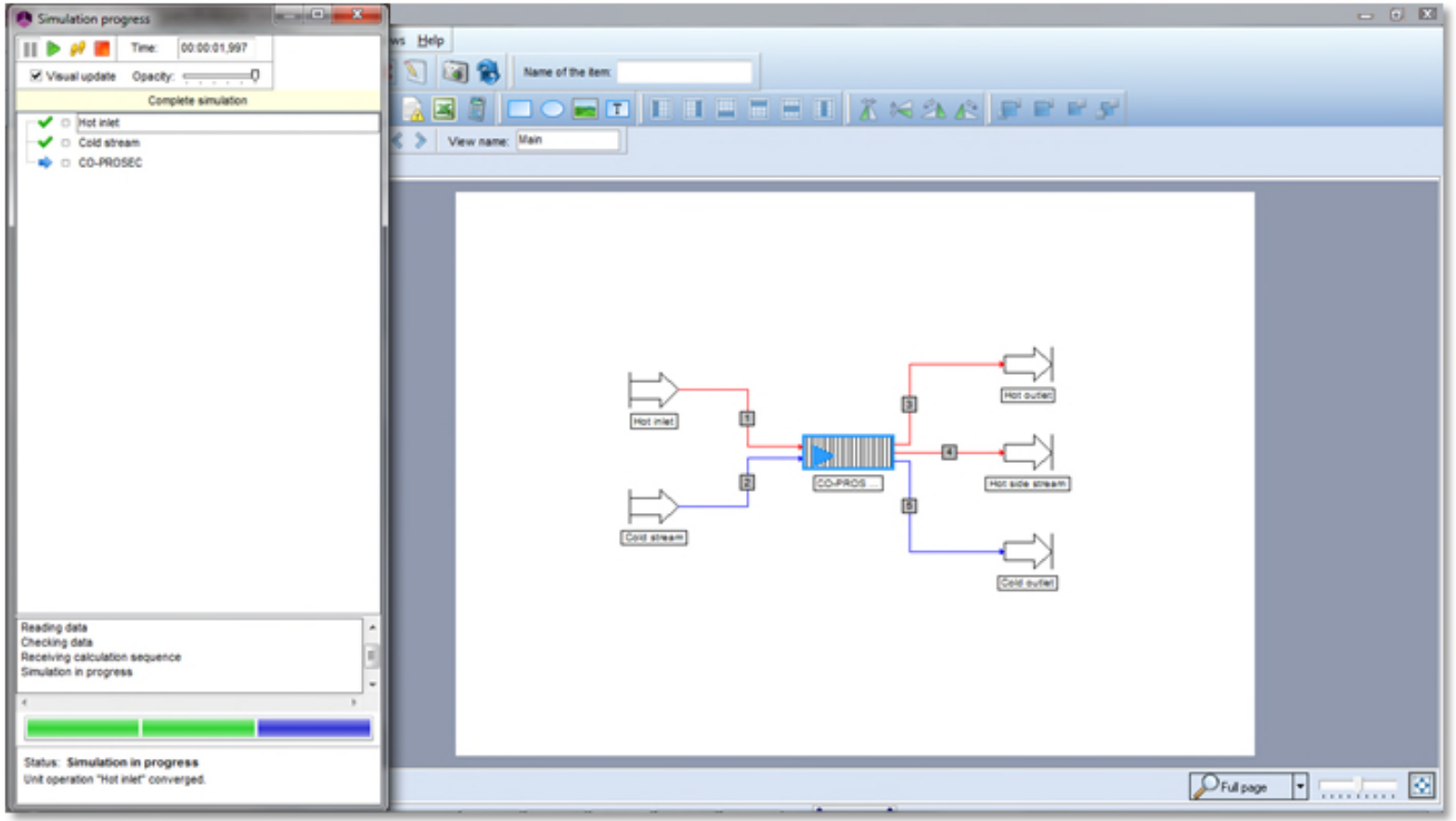
Step 4: Running the simulation

During the calculation, different symbols and indications will appear and disappear in the "Simulation progress" window and in the drawing area.



- A green validation mark indicates that the module has been correctly calculated
- A blue arrow indicates that calculation is in progress
- A blue question mark indicates that the module has not been calculated yet

- A red cross indicates a convergence error



Step 4: Running the simulation

When all the modules have been properly calculated, all the marks are in green. Your simulation is successful.

Check that all the criteria for convergence have been reached.

Closing the “Simulation progress” window will, by default, automatically open the simulation report.

Step 5: Reports generated

A. ProSec unit operation tabulated results

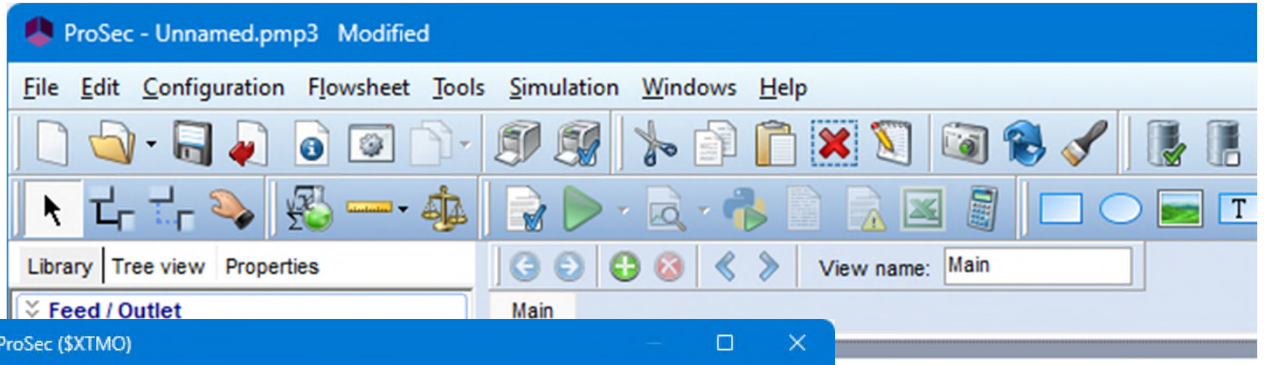
B. ProSec unit operation graphical results

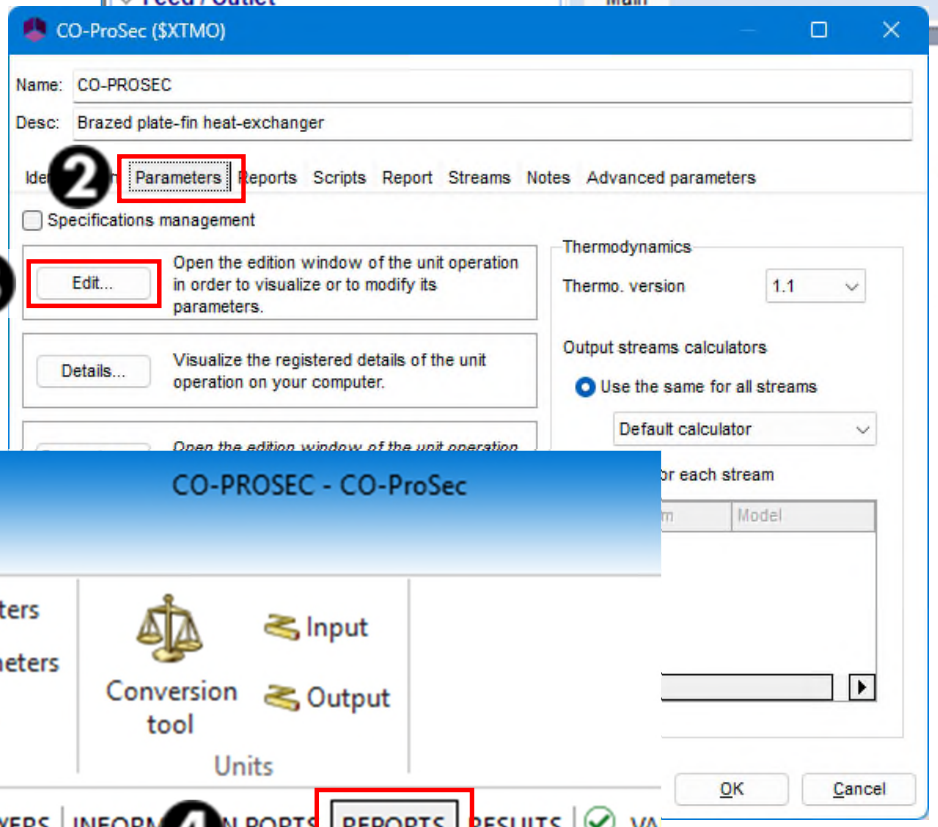
C. ProSimPlus general reports

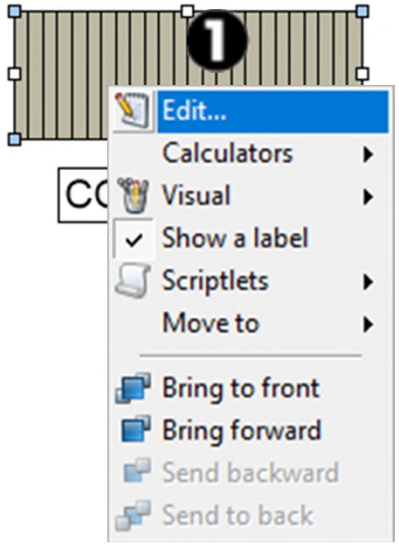
Step 5: Reports generated
A- ProSec tabulated results

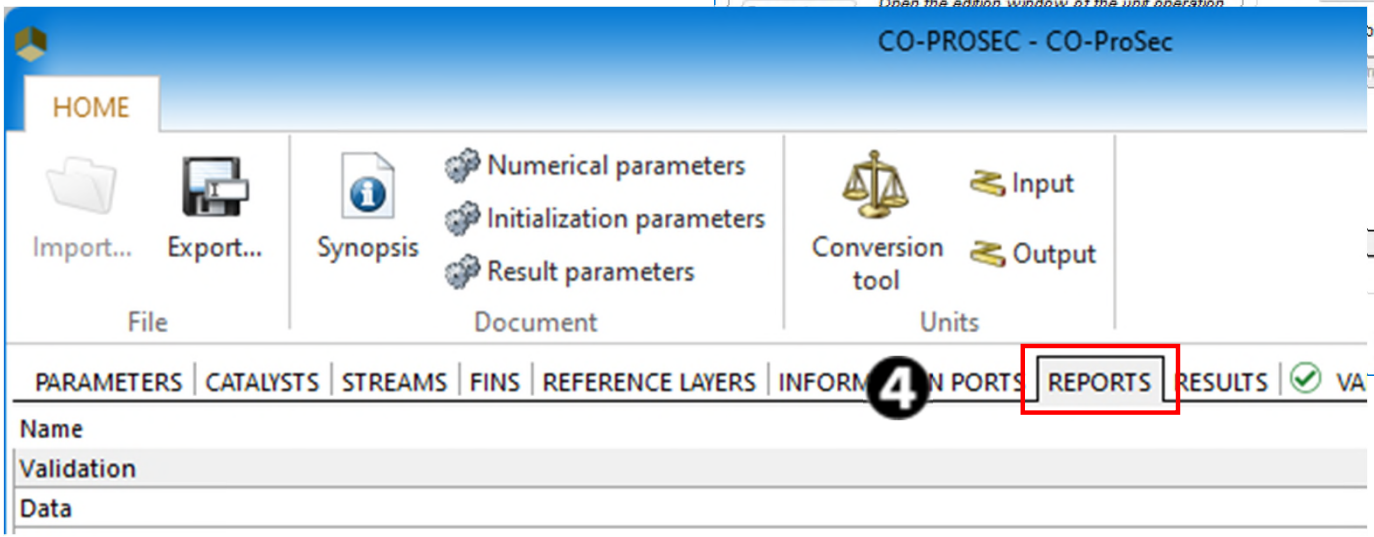
To consult the reports generated by ProSec unit operation:

1. Double-click on its icon on the flowsheet or select “Edit…” in the contextual menu
2. Press the “Parameters” tab
3. Press the “Edit…” button
4. Press the “Reports” tab



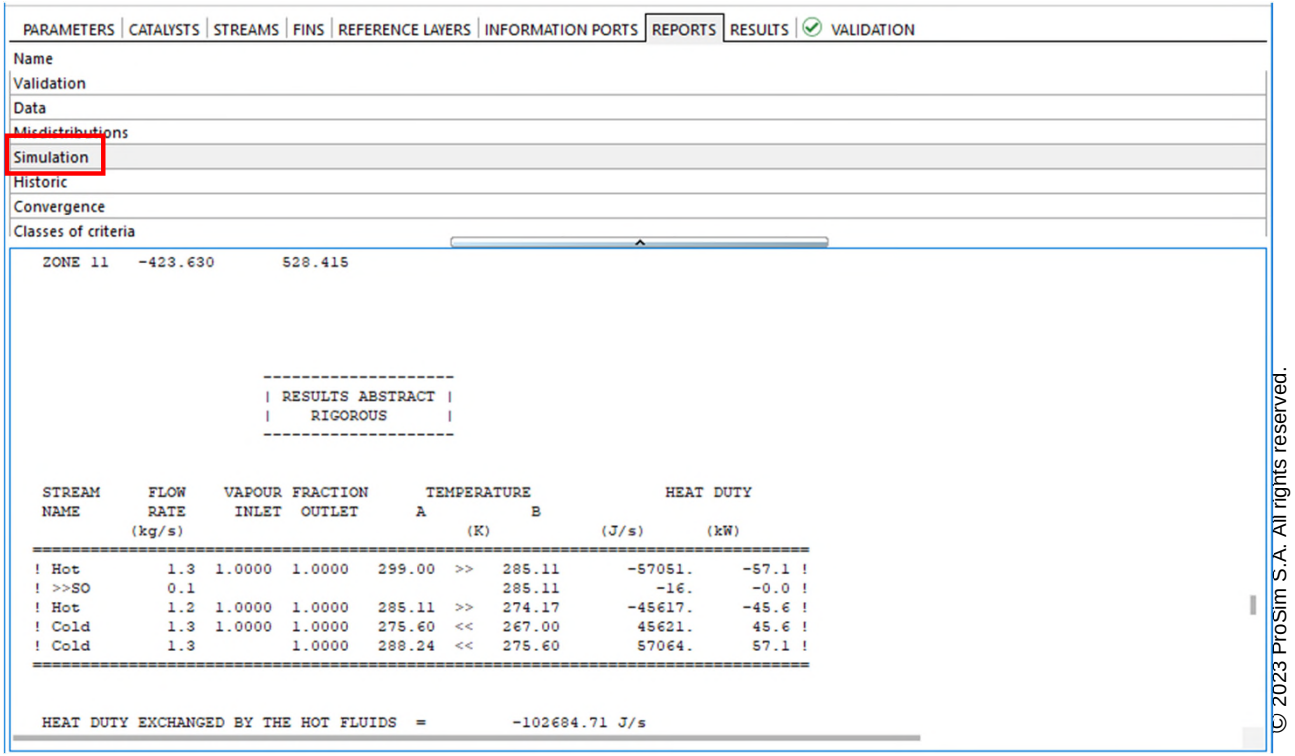






Step 5: Reports generated
A- ProSec tabulated results

- "Simulation" contains the main results:
  - ✓ Report on the input data
  - ✓ Results for the "Common Wall Temperature" calculation mode (initialization of ProSec rigorous calculations): inlet & outlet temperatures & vapor fraction, heat duty exchanged
  - ✓ ProSec results: inlet & outlet temperatures & vapor fraction, heat duty exchanged
  - ✓ Pressure drops calculation
  - ✓ …

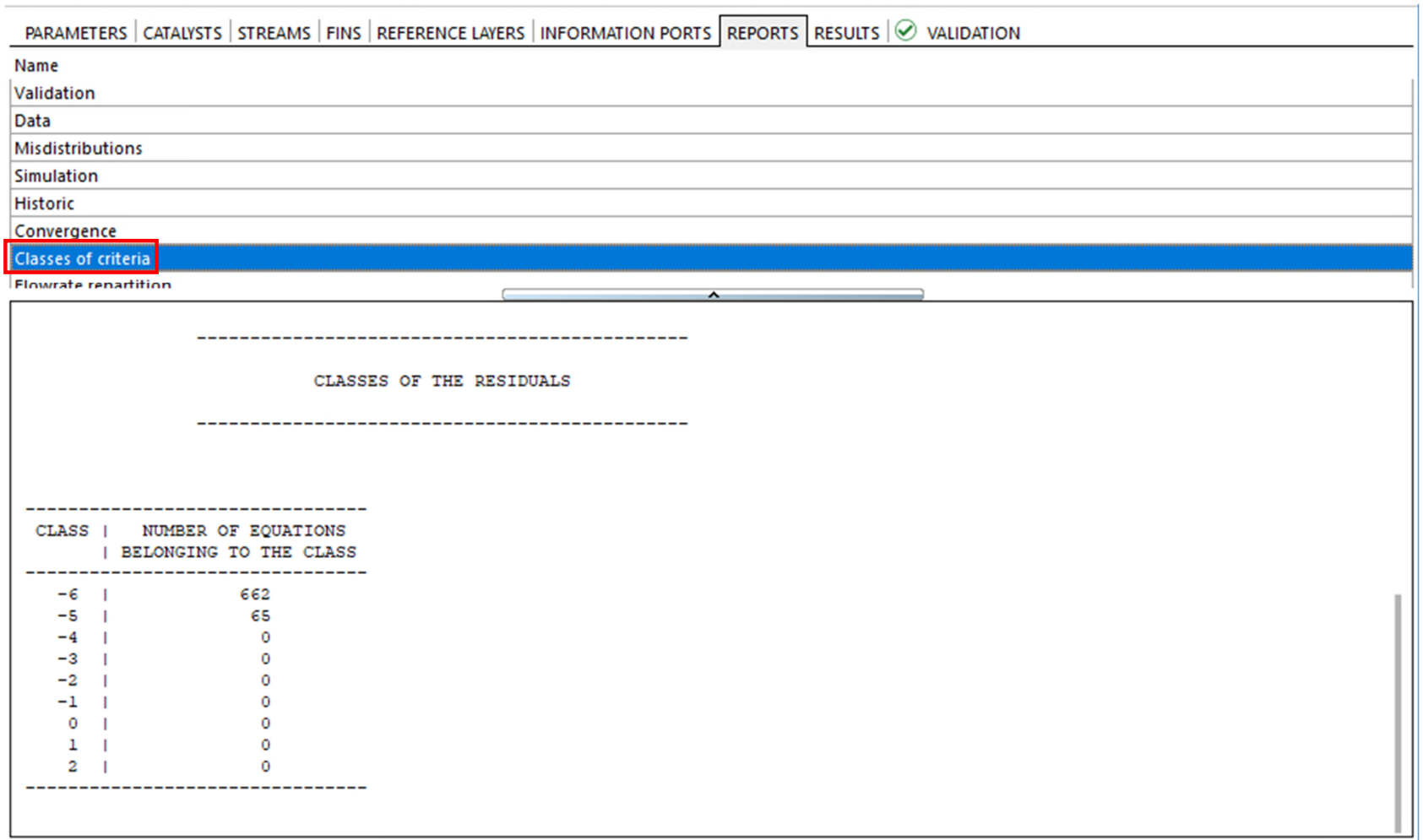


Step 5: Reports generated
A- ProSec tabulated results

- "Classes of criteria" shows the number of equations which have a convergence criterion belonging to the class:

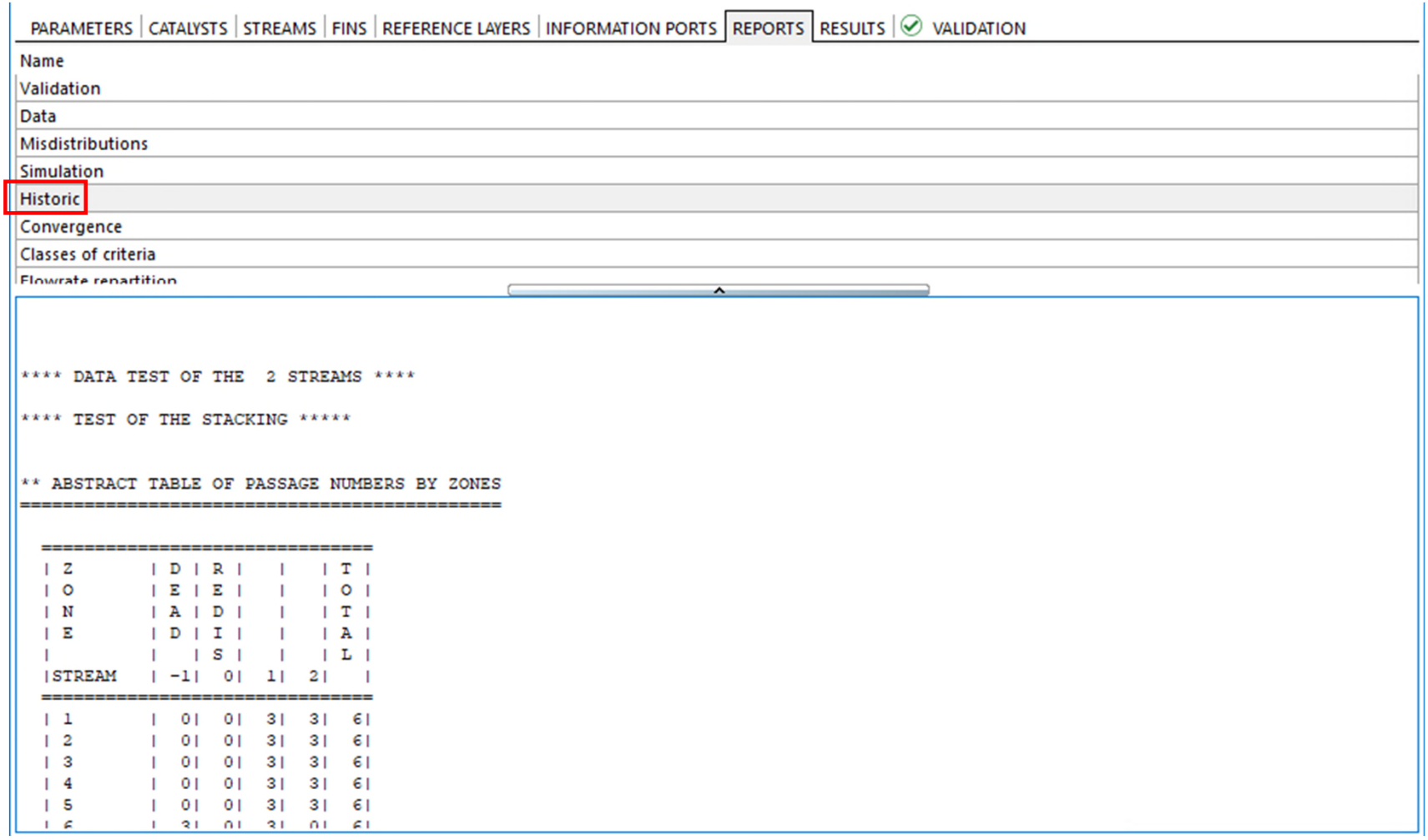
$$10^{Class+i} < \text{Criterion value} < 10^{Class}$$

- This indicates the level of convergence of ProSec.



Step 5: Reports generated
A- ProSec tabulated results

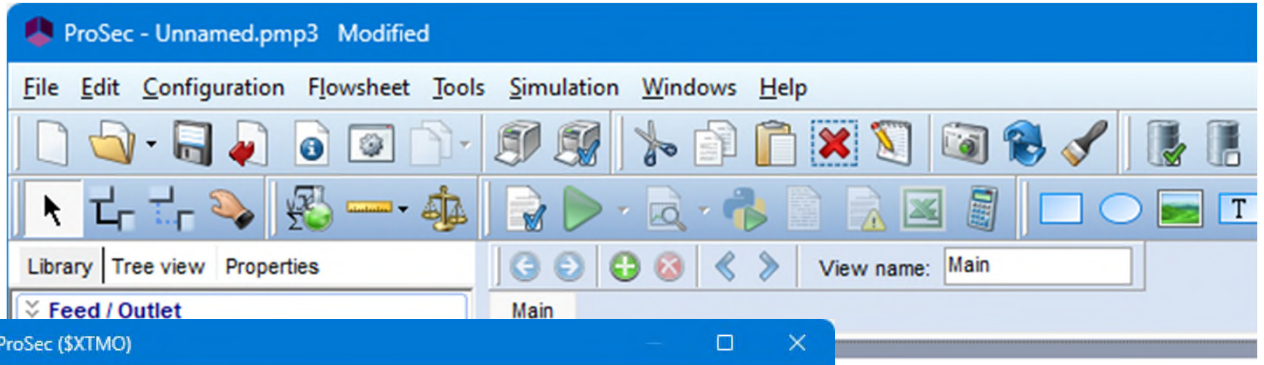
- "Historic" contains information about the errors (with help if any errors are present) and the topology analysis of the inlet data by the unit operation.

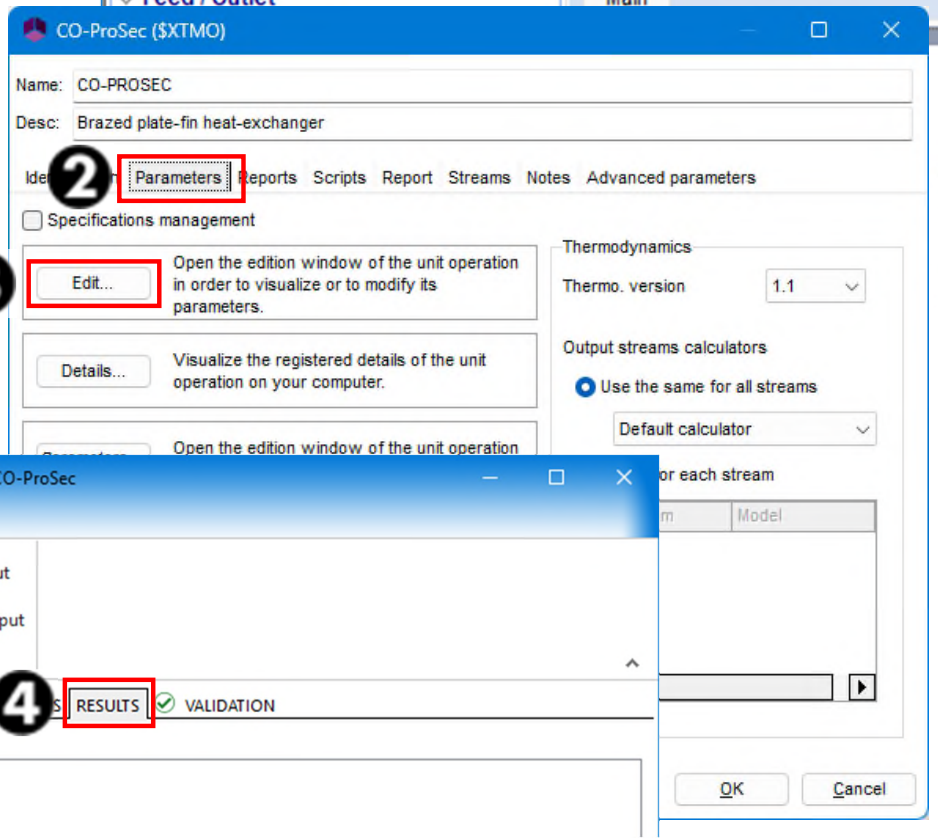


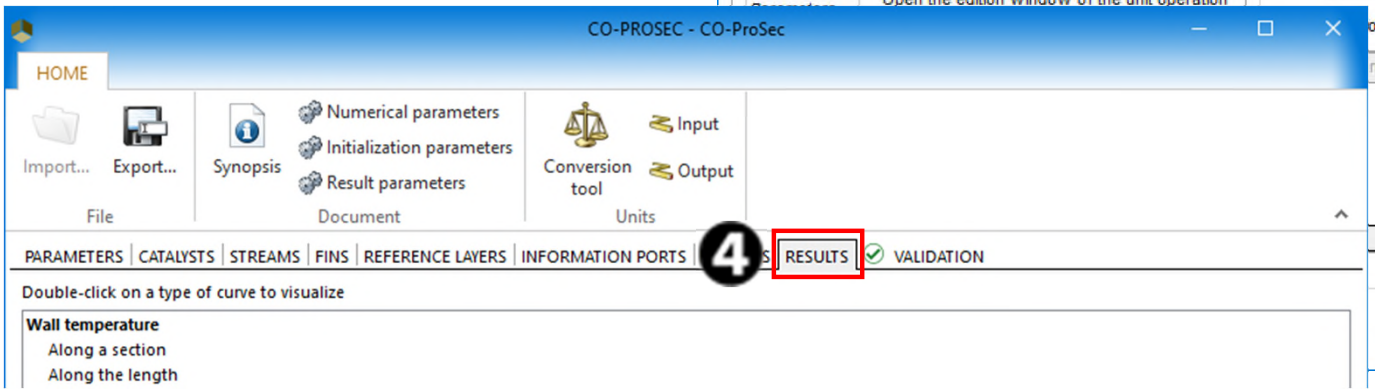
Step 5: Reports generated
B- ProSec graphical results

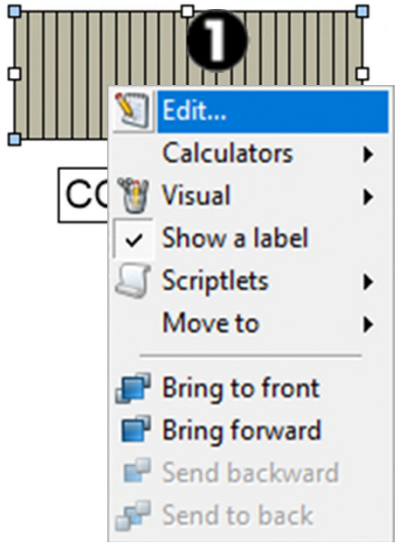
To consult the reports generated by ProSec unit operation:

1. Double-click on its icon on the flowsheet or select “Edit…” in the contextual menu
2. Press the “Parameters” tab
3. Press the “Edit…” button
4. Press the “Results” tab



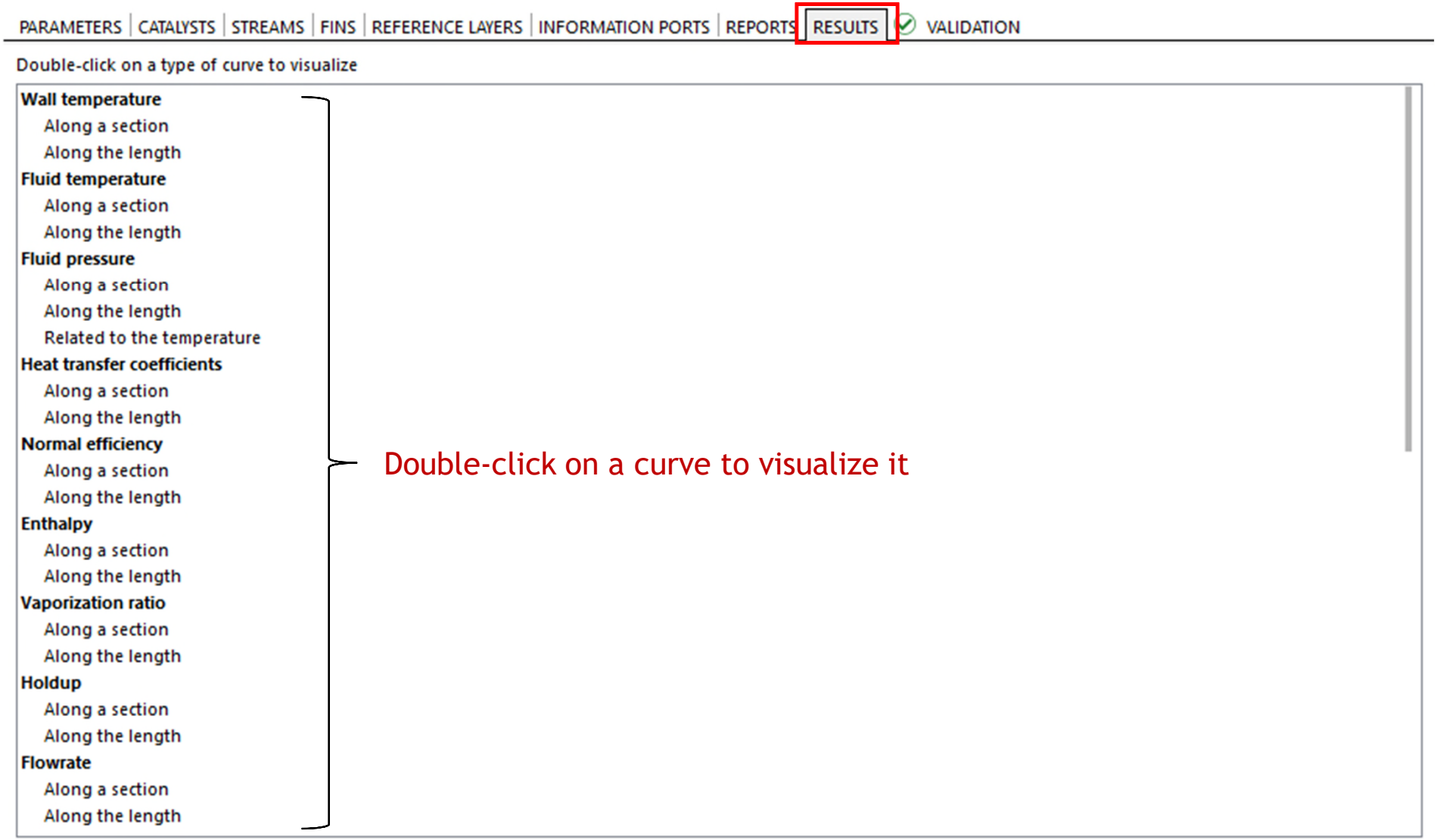






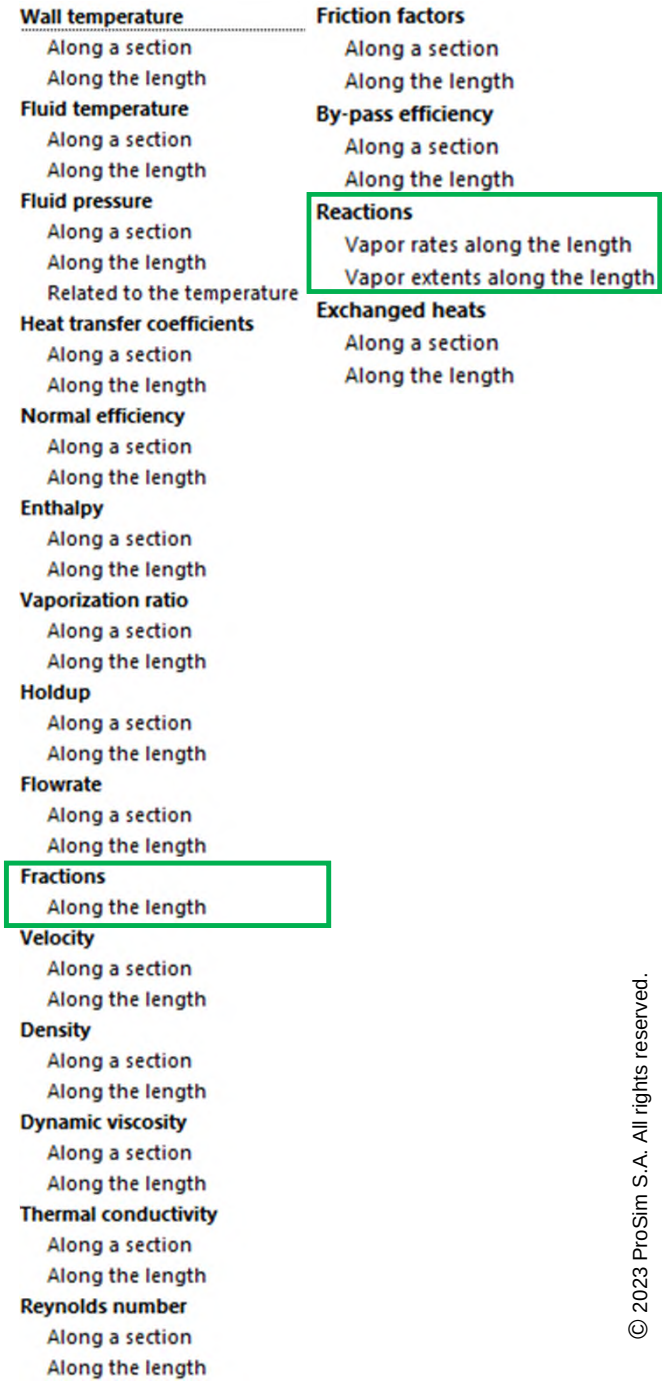
Step 5: Reports generated
B- ProSec graphical results

- "Results" tab
  - Graphical results



Step 5: Reports generated
B- ProSec graphical results

- "Results" tab
  - If at least one stream is vapor-liquid, the properties are displayed, if possible, for the vapor, the liquid and the global physical phase.
  - In green, available only for ProSec Reaction
  - In Prosec Reaction, the properties are displayed, if possible, in molar, mass and volume scale.



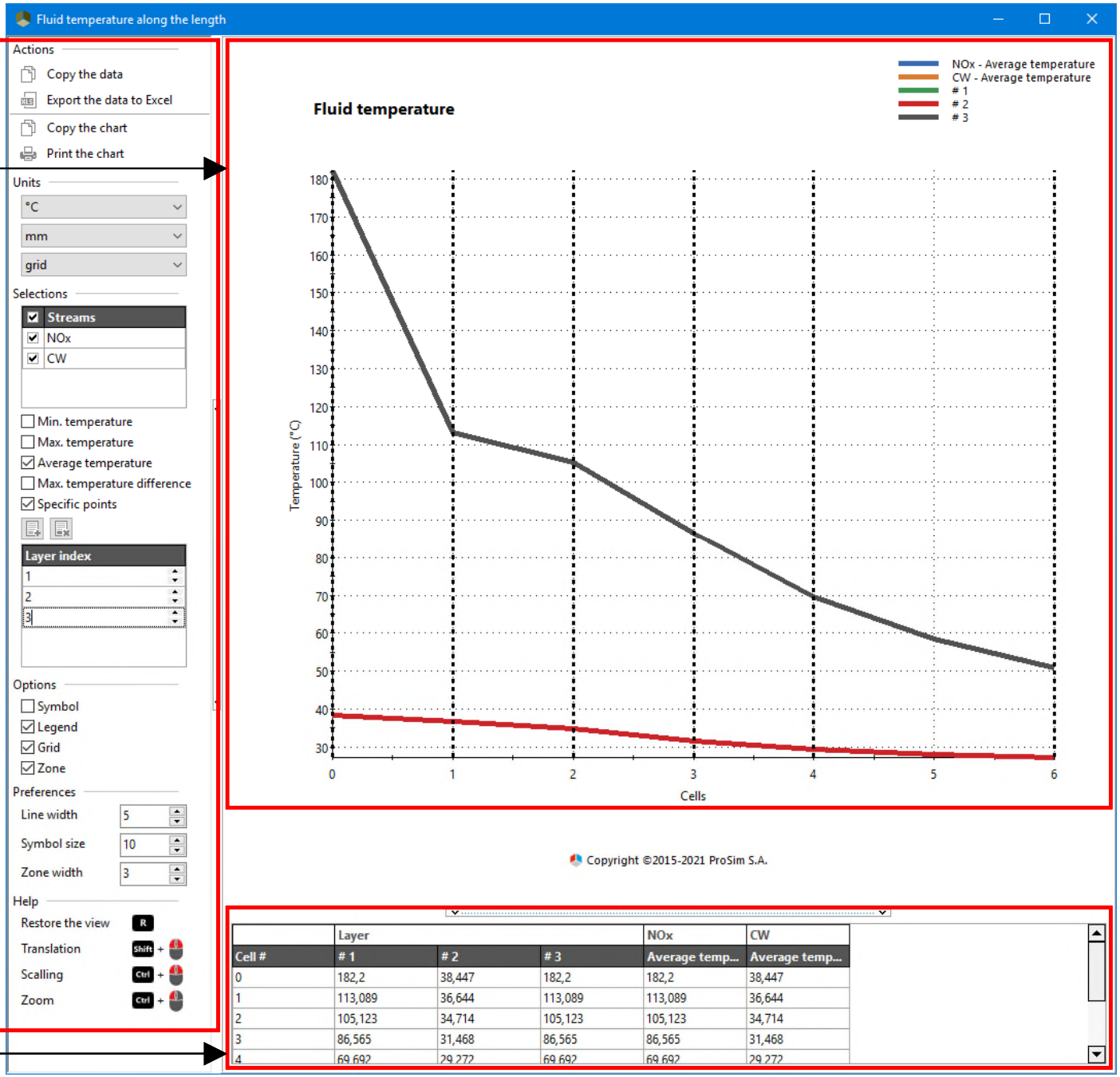
Step 5: Reports generated
B- ProSec graphical results

- "Results" tab

Graph visualization zone

Control panel

Corresponding tabulated values

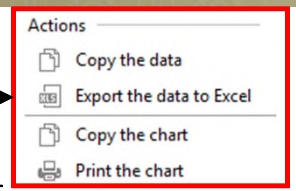


	Layer			NOx	CW
Cell #	# 1	# 2	# 3	Average temp...	Average temp...
0	182,2	38,447	182,2	182,2	38,447
1	113,089	36,644	113,089	113,089	36,644
2	105,123	34,714	105,123	105,123	34,714
3	86,565	31,468	86,565	86,565	31,468
4	69,692	29,272	69,692	69,692	29,272

Step 5: Reports generated
B- ProSec graphical results

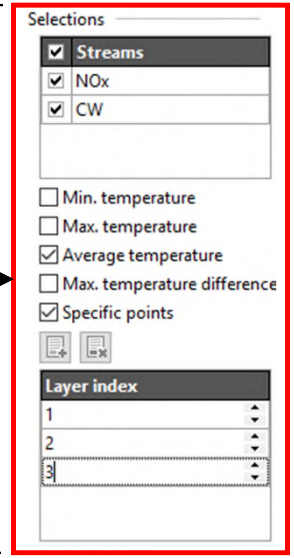
- "Results" tab

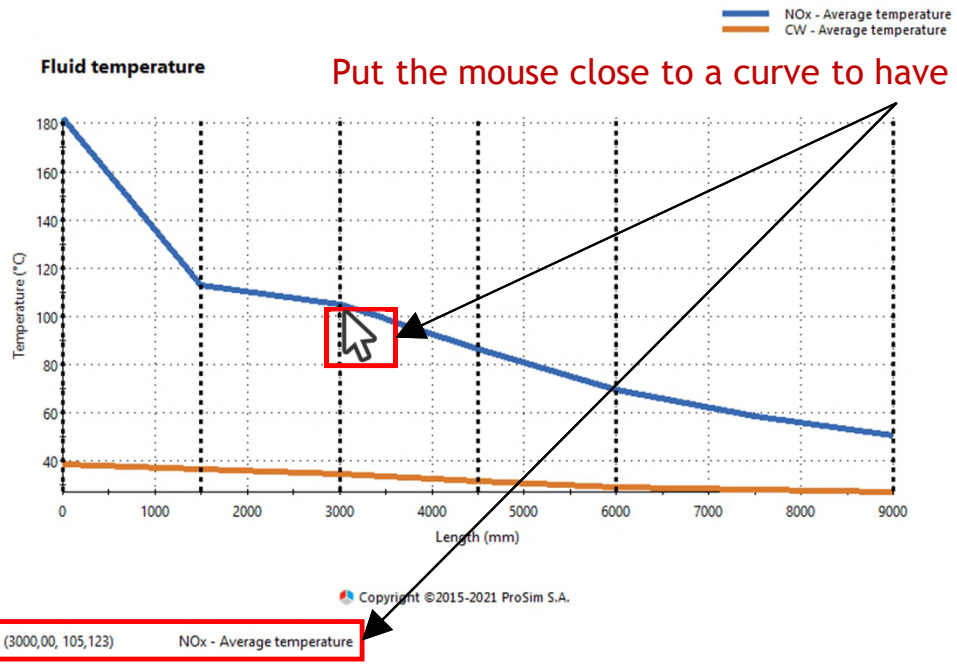
Copy/Export the values or the graph (e.g. in Excel)



Selection of the units of the axis, the X axis type (grid or length) and depending the curve: the physical state (vapor, liquid, global), the scale (molar, mass, volume).

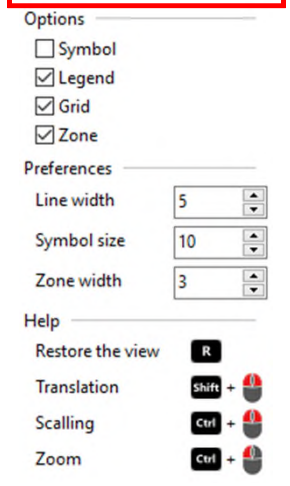
Selection of the type of curves to plot (several selection possible)





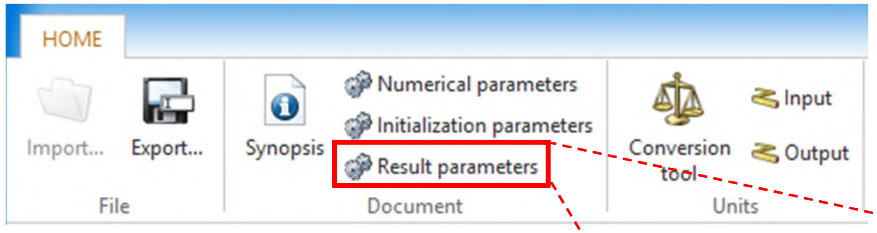
Put the mouse close to a curve to have the corresponding coordinates

Graphical option of the graph

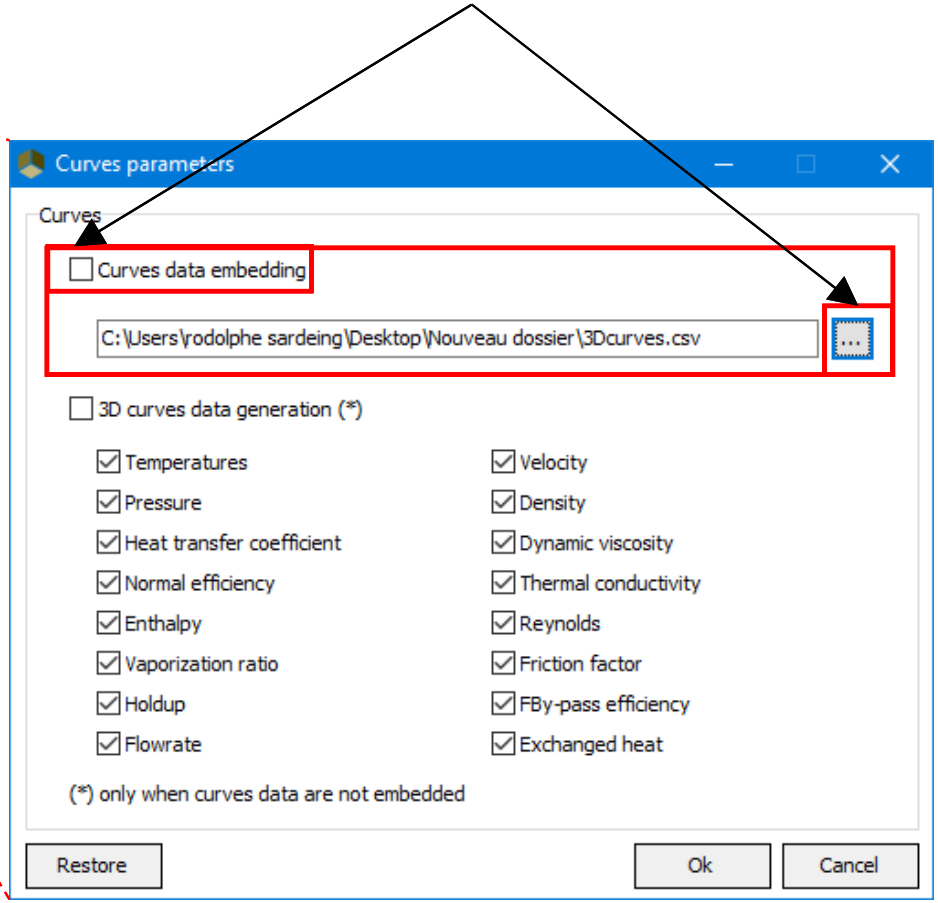


Step 5: Reports generated
B- ProSec graphical results

- "Results" tab
  - Display of 3D curves



Deactivate the "Curves data embedding" (in the simulation file) to have access to the 3D curves. All the data will be saved in the "csv" file you will specify.



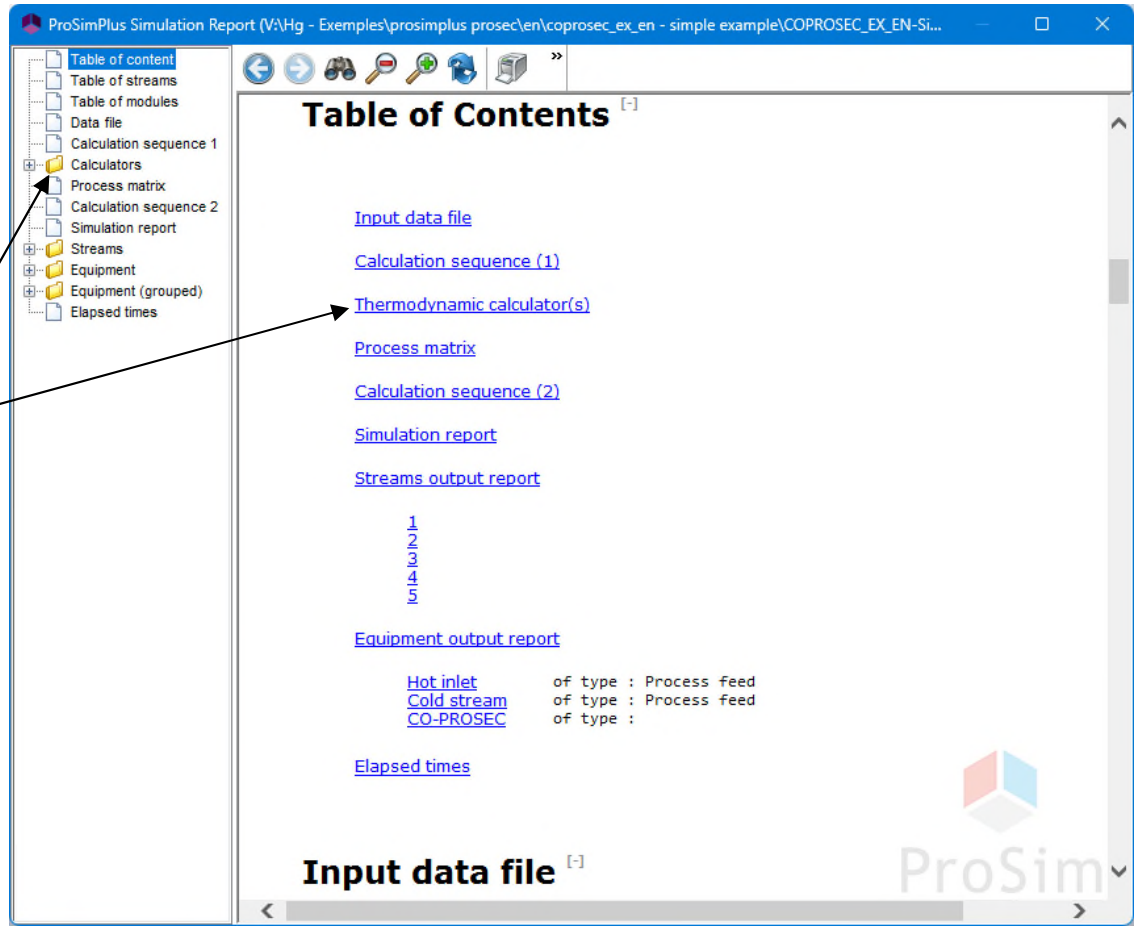
For simulations with a high number of streams and/or meshes, the curves could be not displayed. In that case, just decrease the number od 3D curves.

Step 5: Reports generated
C- ProSimPlus general reports

The HTML report is by default automatically displayed after each run.
It provides information about:

- Pure component properties and thermodynamic models
- List of equipment calculation
- Process streams characteristics
- Results for each process equipment
- Convergence and constraints

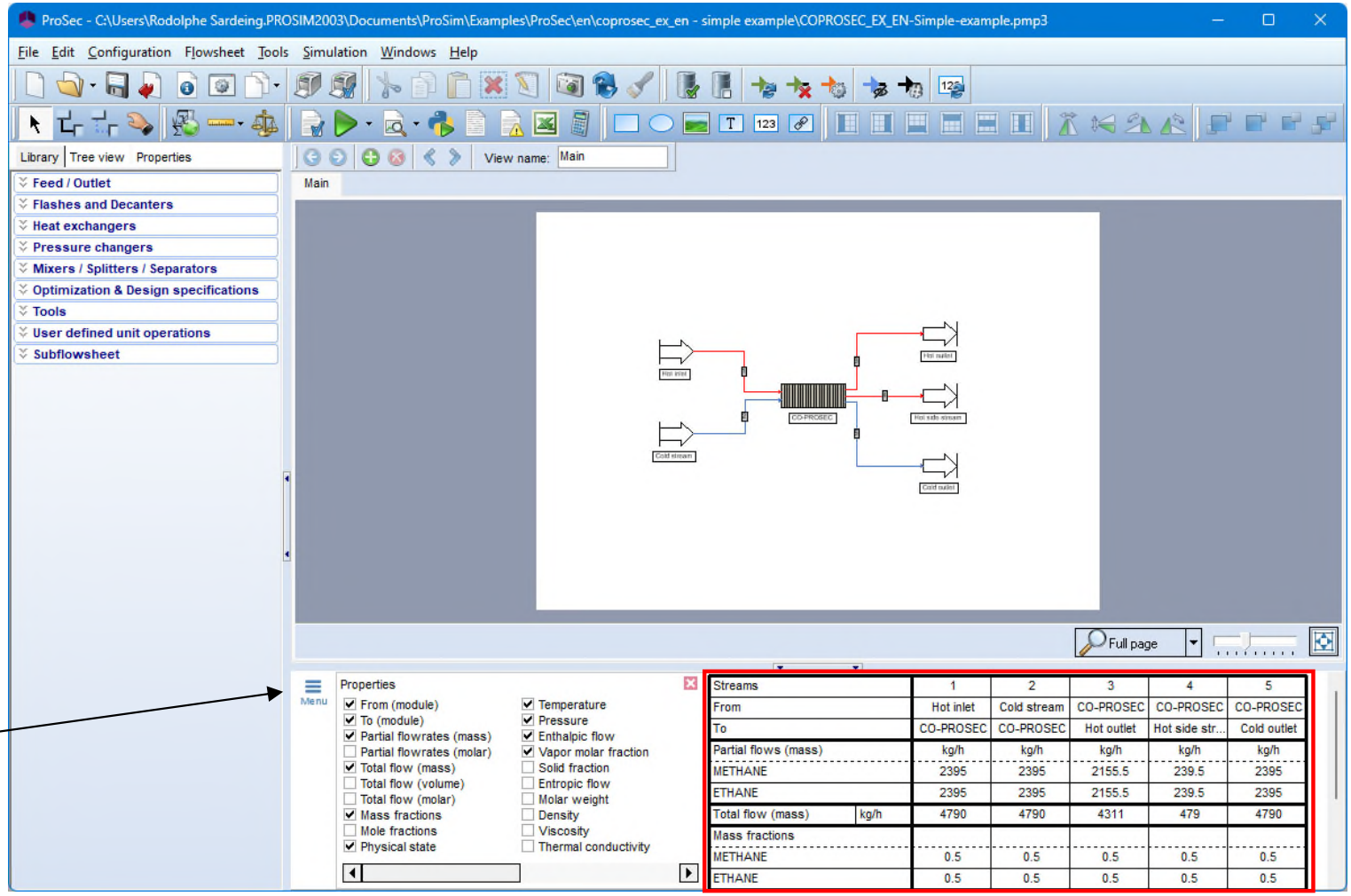
Hyperlinks give you direct access to detailed information on initial configuration, unit operations, calculation sequence and results.



All the reports are created in the folder where you saved your project.

Step 6: Analyze simulation results from the flowsheet

A table with selected results is automatically generated and located below the flowsheet.



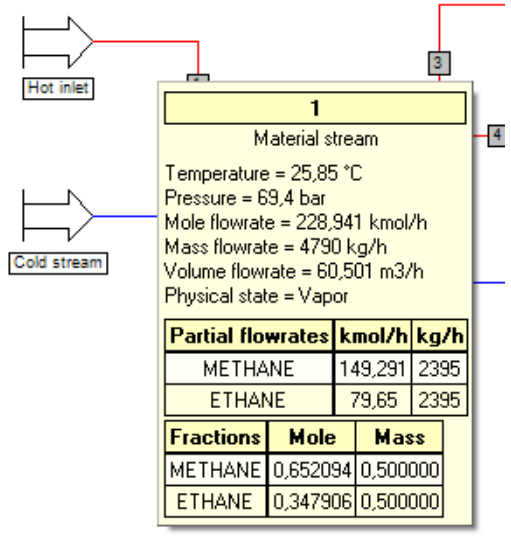
Streams		1	2	3	4	5
From		Hot inlet	Cold stream	CO-PROSEC	CO-PROSEC	CO-PROSEC
To		CO-PROSEC	CO-PROSEC	Hot outlet	Hot side str...	Cold outlet
Partial flows (mass)		kg/h	kg/h	kg/h	kg/h	kg/h
METHANE		2395	2395	2155.5	239.5	2395
ETHANE		2395	2395	2155.5	239.5	2395
Total flow (mass)	kg/h	4790	4790	4311	479	4790
Mass fractions						
METHANE		0.5	0.5	0.5	0.5	0.5
ETHANE		0.5	0.5	0.5	0.5	0.5

Click on Menu to configure the streams properties for the display and the export in MS-Excel

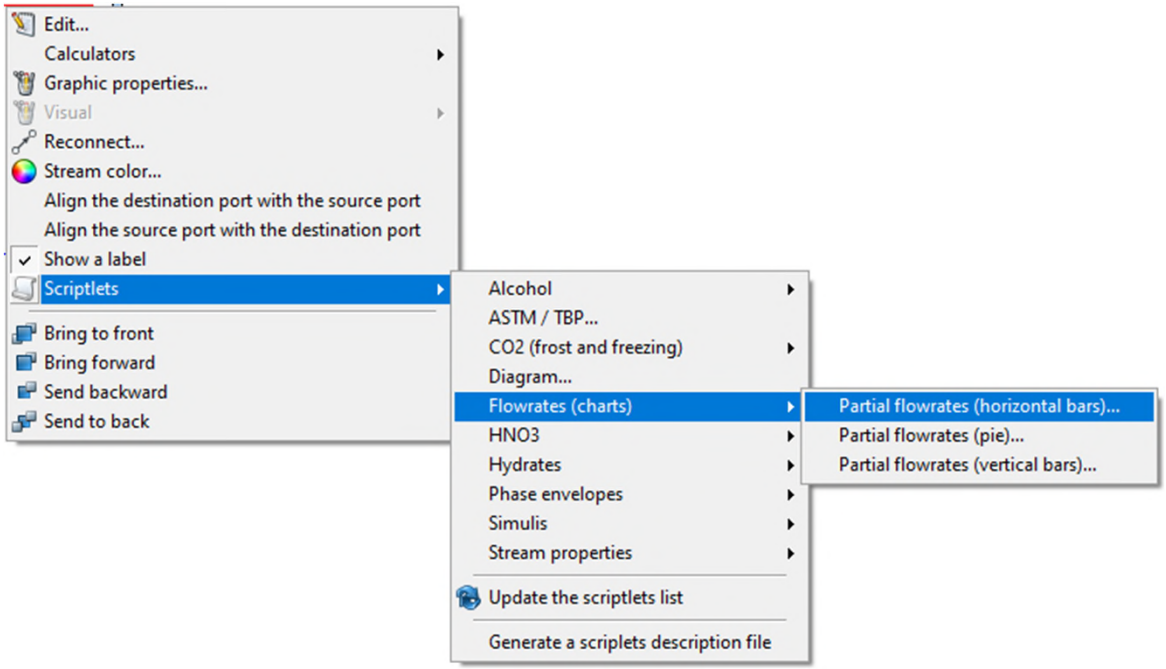
You can copy the grid to paste it in other documents or directly export it to an Excel file.

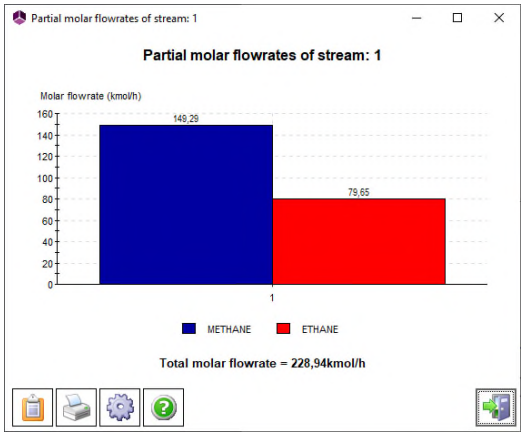
Step 6: Analyze simulation results from the flowsheet

In the drawing area, positioning the mouse on a stream displays its characteristics



Right click on a stream to access the contextual menu.
With Scritplets, you can analyze results through different types of charts.





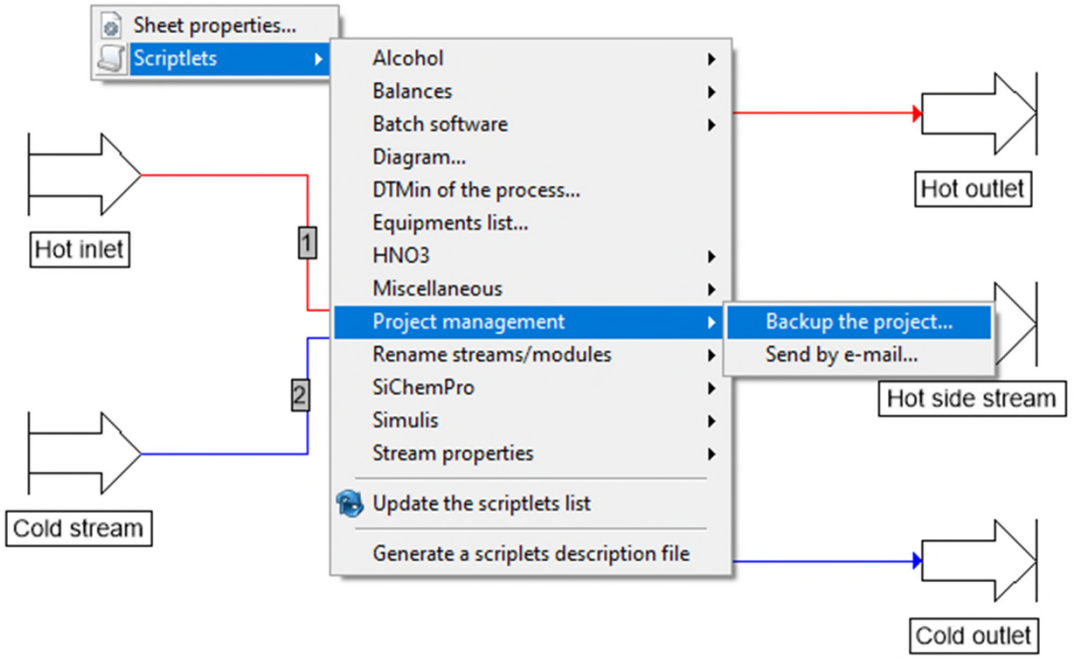
These charts can be copied and pasted in other documents

Step 7: Sharing the simulation

When you need to send the simulation to someone else, simply right click anywhere on the flowsheet, and select the Scriptlet “Send by e-mail…”.

This action will automatically create a zip file that will include among other:

- ✓ The “.pmp3” file (ProSimPlus file)
- ✓ The History file



ProSim

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