Trisco2D

computer program to calculate
2D steady state heat transfer
in rectangular objects

version 2.1

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physibel

This manual is intended as a complete reference for the Trisco2D application.

Example projects to get started are available as **Tutorials**
.../Documents/Physibel/Trisco2D2/Tutorials/

Documented software application examples, tutorials & exercises, short practical guides (How To's) and validation cases are accessible via the Physibel Knowledge base (www.physibel.be/en/knowledge).

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CHAPTER A INTRODUCTION

A.1. Short description of Trisco2D

Trisco2D is a thermal analysis program for steady state heat transfer in two-dimensional rectangular objects consisting of different materials and submitted to different boundary conditions. The geometry is described with a list of rectangular blocks, of which the vertices lie on grid points of a rectangular grid. The geometry can be created by intuitive drawing functions and/or loaded from a DXF file, automatically recognising vertical and horizontal object lines. Materials and surface boundary conditions with different thermal properties are identified using separate colours. Each geometry block is part of either a material or a surface boundary condition region, and has a reference to one of these colours.
After the input of geometry and thermal properties a system of linear equations is calculated based on the energy balance technique, and solved using a fast-iterative method.
The graphic and text output functions allow to generate thermal reports in line with the European standards.
Main applications of Trisco2D:

- Two-dimensional thermal bridges according to EN ISO 10211
- Surface condensation verification according to EN ISO 13788

A.2. Trisco2D: brief history and relation to other Physibel products

The first roots of Trisco2D (former KOBRU86) descend from research for a doctoral thesis on 2D and 3D heat transport in building physics (by Piet Standaert in 1984; cf. section A.7).
The first commercial version of TRISCO on PC was ready in 1989 and was continuously developed since then.
Trisco2D is the limited version of TRISCO which allows the full steady state thermal analysis of three-dimensional rectangular objects.
The table below provides a briefly comparison of the functionalities of the Physibel thermal steady-steady software tools:

	Trisco2D	TRISCO	BISCO	SOLIDO
dimensions	2D	3D	2D	3D
free form	in limited way	in limited way	✓	✓
rectangular	✓	✓		
extension	.tr2	.trc	.bsc	.sld
input formats	.dxf	.dxf, .sld, .bsc	.dxf	.stl, .trc, .bsc
detailed IR-radiation via view factors		✓	✓	✓
fixed field temperature/heat power		✓	✓	✓
optimised for use in according to	EN ISO 10211 EN ISO 6946 EN ISO 13788	EN ISO 10211 EN ISO 6946 EN ISO 13788 EN 673 EN ISO 1745	EN ISO 10077-2 EN ISO 12631 EN ISO 6946 EN ISO 10211 EN ISO 13788 EN 673 EN 1745	EN ISO 10211 EN ISO 6946 EN ISO 13788 EN 673 EN 1745

A.3. Technical specifications

- Trisco2D is a 64-bit Windows program. Trisco2D is installed in C:\Program Files (x86)\Physibel\Trisco2D2.
  In this folder the executable file is Trisco2D2.exe.
- The standard version of Trisco2D allows to solve systems with up to 30,000 nodes. An add-on feature to calculate an unlimited amount of nodes is available for purchase (feature Unlimited Nodes). The maximum number of nodes then depends on the RAM installed. For example, 8 Gb RAM allows to solve about 25,000,000 nodes, 16 Gb RAM allows to solve about 50,000,000 nodes.Trisco2D relies on OpenGL for use of hardware accelerated graphics.
- Trisco2D is protected is protected by either a hardware key, provided by Physibel, or a software licence (see A.4).

The Physibel 64-bit programs need several shared libraries (.dll files) from Microsoft.
The Microsoft Visual C++ 2017 Redistributable Package (x64) is included in the installation files of Trisco2D, but can also be downloaded from https://support.microsoft.com/en-us/help/2977003/the-latest-supported-visual-c-downloads.
This package installs mfc140.dll and other files in the directory C:\Windows\SysWOW64, required by 64-bit applications developed with Microsoft Visual C++ 2017.

A.4. Licence

The Physibel applications are protected by a licence, to prevent illegal use of the software. This can be either a hardware licence (Sentinel USB key) or a software licence.

A.4.1. Hardware licence

Perpetual licences are protected by a hardware licence (Sentinel USB key). The licence is locked to this dongle. It is strongly recommended to take a financial assurance for loss of the key by theft or any other incidence.

Before Trisco2D can be used, the driver (delivered with purchase) for the hardware key needs to be installed. Administrator rights are needed for this installation. It might be necessary to restart your computer after installing the driver.

During use of Trisco2D, the dongle needs to be attached to the computer at all times.

A.4.2. Software licence

Subscription licences are protected by a software licence. After first installation of Trisco2D, the user needs to activate the licence using the activation code received upon purchase of the software. When first opening Trisco2D, the Software Licence Manager will open automatically and prompt the user to activate the licence, or to register in the network floating database, depending on the licence type. The computer needs to be connected to the internet for this licence activation. Cloud-based floating licences are activated every time when opening the application.

After activation, the Software Licence Manager is available from the menu for stand-alone licences:
Help → Software Licence Manager...

Users with a floating network licence can check out a licence from the database for a maximum period of 3 days.

Help → Check out/in floating licence...

The software licence key for Trisco2D is linked to the computer where it was activated. When you want to move the application with a stand-alone licence to another computer, you can deactivate the licence in the Software Licence Manager. The licence can then be reactivated on a new computer.

If the Software Licence Manager is unavailable from the application itself, you can also open it from the command prompt. You need to first change directory to the Program Files folder where the application is installed. Then, open the Software Licence Manager with the following command:
QlmLicenseWizard.exe /settings "Trisco2D 2.1.lw.xml"

A.5. User Account Control (UAC)

Administrator rights are necessary to install Trisco2D on a computer.

The installation of the application is machine-level, meaning all user accounts can access the application after installation.

Each user account has its own copy of the colour database (see B.3.3) to work with. The colour database can be found in the user's application data directory (C:/Users/*username*/Appdata/Roaming/Physibel/Trisco2D2/).

In case of a software licence, the licence for Trisco2D is linked to the computer, but is stored at the user level. Each user account on a computer has to activate the licence in order to have access to the licence.

A.6. Overview of delivered files and file structure

Trisco2D is installed (when the user accepts the default destination) in the folder C:\Program Files (x86)\Physibel.

The following files are installed:

Folder	*File*	*Description*
...\Physibel\Trisco2D	Trisco2D2.exe	Trisco2D (64-bit) program
	*.dll, *.pat, *.rgb	Program resources
	QlmLicenseWizard	Software Licence Manager files
...\Physibel\Materials	*.phm	Material databases
...\Physibel\Manuals	Trisco2D2Manual.pdf	Trisco2D manual
	TR2***.pdf	Trisco2D How to's

Trisco2D tutorials are installed in Documents/Physibel/Trisco2D2/Tutorials.

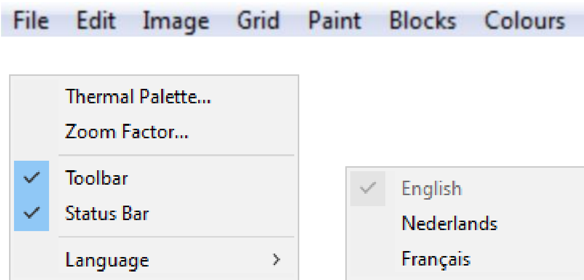
The colour database file ColourDatabase.tr2 and back-up ColourDatabase_Physibeldefault.tr2 (see B.3.3) together with the parameter file Trisco2D.prm (see A.8), are installed in C:/ProgramData/Physibel/Trisco2D2, (machine-level) and copied to each user account's application data folder when first opening Trisco2D (C:/Users/*username*/AppData/Roaming/Physibel/Trisco2D2).

A.7. References

- EN ISO 6946 (July 2017). Building components and building elements - Thermal resistance and thermal transmittance - Calculation methods.
- EN ISO 10211 (August 2017). Thermal bridges in building construction – Heat flows and surface temperatures – Detailed calculations
- EN 10456 (January 2008). Building materials and products – Hygrothermal properties – Tabulated design values and procedures for determining declared and design thermal values.
- Piet Standaert, Twee- en drie-dimensionale warmteoverdracht: numerieke methoden, experimentele studie en bouwfysische toepassingen. Doctoral dissertation, K.U. Leuven, 1984 (in Dutch).

A.8. Program settings

Global program settings can be edited via the main menu (*Settings → ...*).



- *Settings → Thermal Palette...*: select the colour palette for the visualisation of the resulting temperatures.
- *Settings → Zoom Factor...*: to customise the zooming factor of the mouse scroll wheel. The selected zoom factor is saved in the program parameter file (Trisco2D.prm).
- *Settings → Toolbar*: toggle to show or hide the graphic toolbar just below the menu bar.
- *Settings → Status Bar*: toggle to show or hide the text bar at the bottom of the Trisco2D application window (containing context depending information).
- *Settings → Language → ...*: to select the user interface language (English, Dutch, French). The selected language is saved in the parameter file (Trisco2D.prm). After exiting Trisco2D (*File → Exit*) and restarting Trisco2D, the new language is active.

Program default options (as set by the “Set As Default” button in several program dialog boxes) are saved in the parameter file (Trisco2D.prm) at program exit (*File → Exit*). The program parameters of the parameter file are loaded at program start up.

A.9. General editing commands

<u>Copy – paste</u>

- *Edit → Copy Value*: copies the value from the active input cell into the clipboard.
- *Edit → Paste Value*: copies the value from the clipboard into the active input cell.

<u>Undo – redo</u>

- *Edit → Undo*

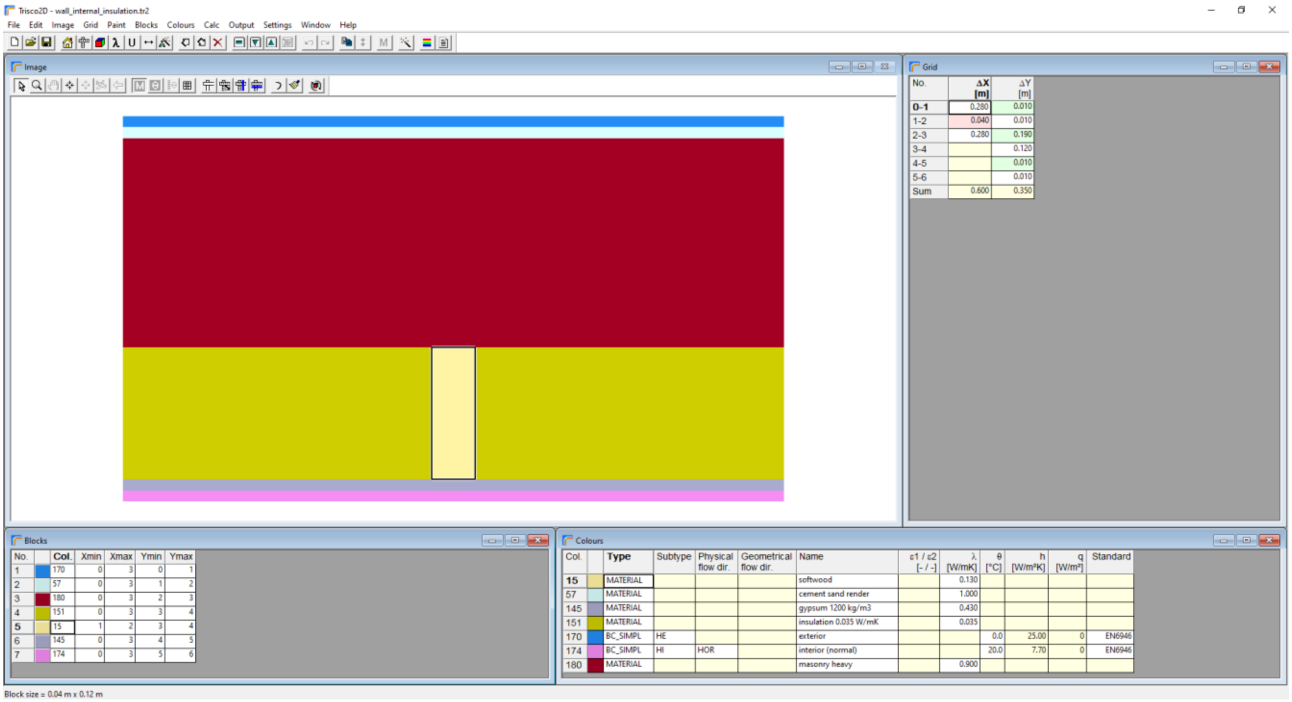
  Undoes the last edit action (e.g. to cancel a mistake).
  This command can be repeated to undo more previous edit actions.
  Only the last 100 edit actions are stored for undo.
  The undo command is impossible after saving a file (*File → Save* and *File → Save As...*),

closing the current file (*File → Close*, also *File → New*, *File → Open...*, *File → Import Data...*) or starting a calculation (*Calc → Calc System*).

– *Edit → Redo*
  Restores the previous edit action that was made undone using *Edit → Undo*.
  In other words: "redo" undoes "undo".
  This command can be repeated to restore more edit actions that were made undone.

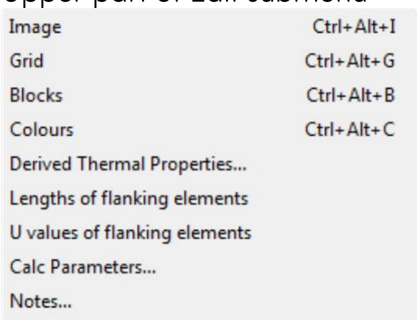
B.1. Trisco2D program layout

The input in Trisco2D is organised in several windows:
- **Image** window, with a graphical representation of the model.
- **Grid** window, with the distances along X and Y between the successive grid lines.
- **Blocks** window, with a list of all building blocks of the geometry.
  The coordinates refer to the grid numbers in the Grid window.
- **Colours** window, with the thermal data of the materials and boundary conditions.
  Each block in the Blocks window refers to a colour in the Colours window.



A window can be activated by clicking with the left mouse button on its title bar or in its client area (when the window is already open and visible on the screen), or the window can be opened and activated by selecting the corresponding command in the Edit submenu.

Upper part of Edit submenu



Other input windows:
- **Lengths of flanking elements** window, with lengths defined using grid number coordinates.
- **U values of flanking elements** window, with U values along lines parallel to X or Y.

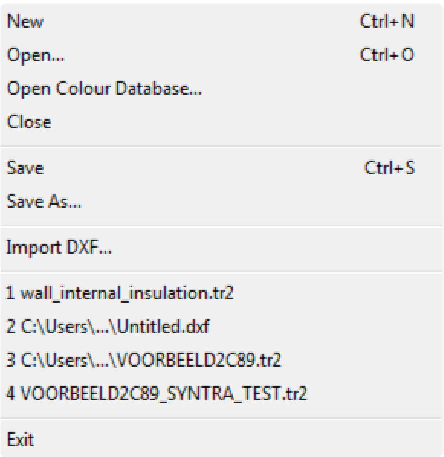
The following dialog boxes (also opened via the Edit submenu) contain additional input data:
- **Derived Thermal Properties** dialog box, to request output of temperature factor, linear thermal transmittance or equivalent thermal transmittance.
- **Calculation Parameters** dialog box.
- **Notes** dialog box, to enter text comments about the data.

B.2. Trisco2D start-up

When Trisco2D is launched, the parameter file Trisco2D.prm is read to load default program settings.
Then the colour database ColourDatabase.tr2 is read to initialise predefined material and boundary condition properties in the **Colours** window.

B.3. File functions

File submenu



B.3.1. New project

Menu command: *File → New*
This command opens a new project, after closing the current open project (if present).
The new project starts off with a single square block of size 1 m.
All parameters are reset to their default values (as stored in the parameter file Trisco2D.prm), except for the colour definitions. This allows to reuse the colour definitions of the previous open file (or of the colour database ColourDatabase.tr2 loaded at start up).

B.3.2. Open project

Menu command: *File → Open...*
After closing the current open project (if present), an Open dialog box appears.
Select a Trisco2D data file (with extension .tr2) from the list in the current folder or another folder.

When a file is opened, all parameters are reset to their default values (as stored in the parameter file Trisco2D.prm), except for the colour definitions. Then all data from the chosen Trisco2D data file are read and loaded into memory. The colour definitions in the data file overwrite existing colour definitions (e.g. of the colour database) with the same colour reference number. Colour definitions that are not present in the data file can be reused from the colour database or the previous project.
When a solution (.sol file) is present on disk (in the same folder as the data file), then this solution is automatically loaded after reading the .tr2 file.

B.3.3. Open Colour Database

Menu command: *File → Open Colour Database...*

The colour database contains predefined material and boundary condition properties (stored in the file ColourDatabase.tr2 in the application data folder), which is loaded at every Trisco2D start-up. It is advisable to add frequently used materials and boundary conditions to the colour database.
These predefined colours of the colour database are then available in any project, as far they are not overwritten by colour data of the current project or a previous project.

The command *File → Open Colour Database...* allows to modify the 256 available predefined colours of the colour database. After editing the colour data, the modified colours should then be saved (*File → Save*) to modify the colour database on disk.

Each user account on a computer has its own copy of the colour database (see A.5) to work with.

B.3.4. Import DXF

Menu command: *File → Import DXF...*

This function allows to create an object model from a DXF underlayer.
In the dialog box "Create DXF underlayer":
- Define the DXF unit considering the total object size.
  Press the <tab> key to view the unit modification in the total object size.
- Select whether horizontal and vertical grid lines should be added in the **Grid** window based on present DXF lines.
- Select in the list of DXF layers which layers should be skipped in the creation of the DXF underlayer.

New vertical or horizontal grid lines through DXF vertices can be added choosing the command *Grid → Set Vertical Grid Line* or *Grid → Set Horizontal Grid Line* and then using the mouse.
The DXF underlayer in the **Image** window can be shown or hidden via the toggle command *Image → Hide DXF Underlayer*.

B.4. Image window

Menu command: *Edit → Image*

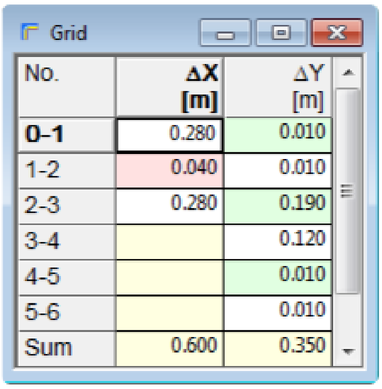
The **Image** window shows a graphical representation of the object model.
This window has its own toolbar.
The view functions are described in Chapter C.
The graphical grid functions are described in sections B.6.8 and B.6.9.
The paint functions are described in section B.7.

B.5. Grid window

Menu command: *Edit → Grid*

The **Grid** window is the input window for grid mesh sizes of a rectangular 2D grid.
Initially this is a *design grid* for the definition of the object geometry using blocks.

Finally, the grid should be refined to be used as a *calculation grid* with system nodes upon the grid nodes, for which the temperatures are calculated (with *Calc → Calc System*).



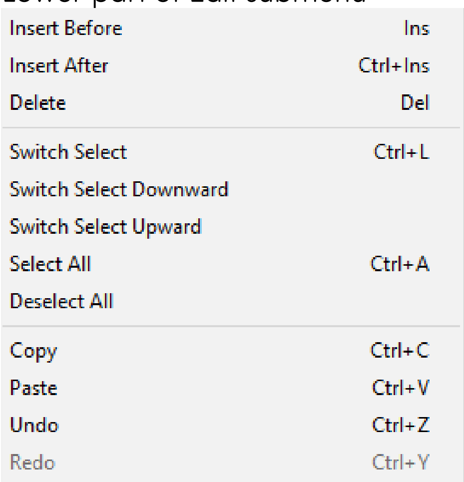
No.	ΔX [m]	ΔY [m]
0-1	0.280	0.010
1-2	0.040	0.010
2-3	0.280	0.190
3-4		0.120
4-5		0.010
5-6		0.010
Sum	0.600	0.350

<u>The grid</u>
The ΔX and ΔY columns in the **Grid** window correspond to the X and Y axes of the coordinate system. The X axis points to the right; the Y axis points downwards.
The positions Xmin, Xmax, Ymin and Ymax of the object blocks in the **Blocks** window are expressed as integer numbers (starting from 0) referring to the consecutive grid lines. As a result, material objects are always rectangular and bounded by grid lines parallel to X and Y.

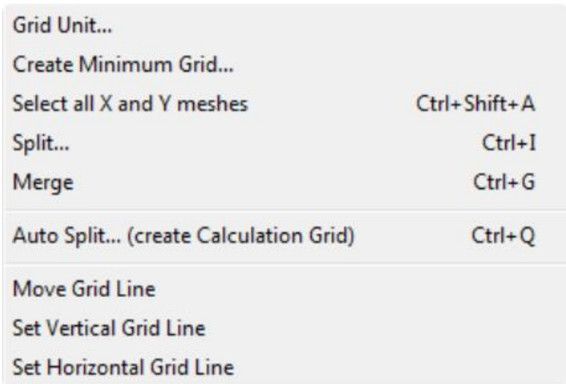
<u>Grid meshes</u>
The distances ΔX and ΔY between successive grid lines are the grid meshes and are editable in the **Grid** window. The corresponding bordering grid line numbers are in the first column ("No.").
The grid lines occurring as block borders (Xmin, Xmax, Ymin, Ymax) in the **Blocks** window are visible through background colour changes in the ΔX and ΔY columns (resp. white/red and white/green backgrounds).

B.6. Grid functions

Lower part of Edit submenu



Grid submenu

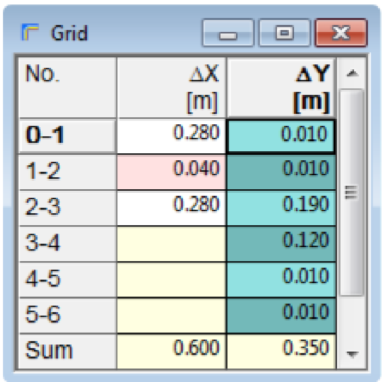


B.6.1. Insert mesh

– *Edit → Insert Before*
  Insert a new X or Y mesh (with size = 1 grid unit) before the active mesh.
– *Edit → Insert After*
  Insert a new X or Y mesh (with size = 1 grid unit) after the active mesh.

B.6.2. Grid mesh selections

Individual grid meshes can be selected to perform global actions (split, merge).
The selected meshes are marked in turquoise.



Meshes can be selected by clicking (left mouse button) the cell while holding the <Ctrl> key. A selection range can be defined by holding the <Shift> key. All meshes within the same column ΔX or ΔY can by selected by clicking (left mouse button) the column header.
Alternatively, menu functions can be used to select meshes.

From the Edit submenu:

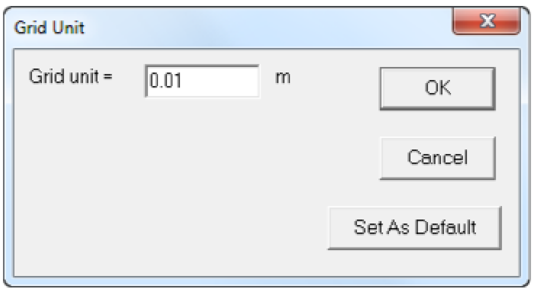
- *Edit → Switch Select*
  Switch on/off the selection for the active mesh.
- *Edit → Switch Select Downward*
  Switch on/off the selection of the active mesh and all next meshes (within the same column ΔX or ΔY) with equal selection mode.
- *Edit → Switch Select Upward*
  Switch on/off the selection of the active mesh and all previous meshes (within the same column ΔX or ΔY) with equal selection mode.
- *Edit → Select All*
  Select all meshes within the same column ΔX or ΔY.
- *Edit → Deselect All*
  Deselect all meshes (in both columns ΔX and ΔY).

From the Grid submenu:

- *Grid → Select all X and Y meshes*
  Select all meshes (in both columns ΔX and ΔY).

B.6.3. Grid unit

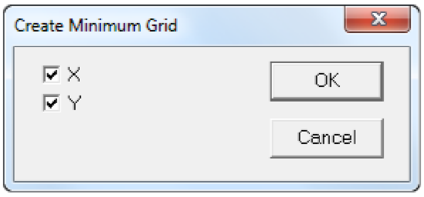
Menu command: *Grid → Unit...*



Input of the correct grid unit is important before starting the calculation of the system.

B.6.4. Create minimum grid

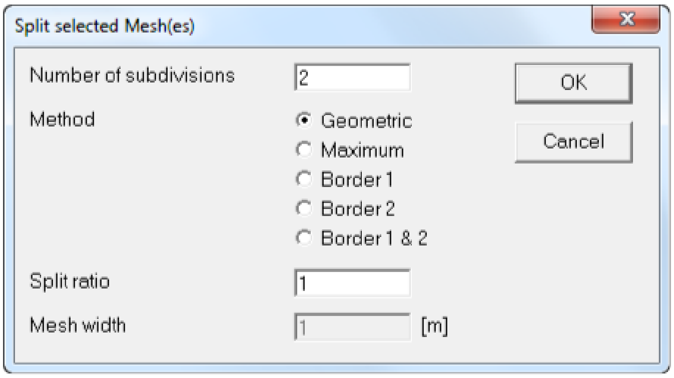
Menu command: *Grid → Create Minimum Grid*



Creates a minimum grid in the selected directions.
All grid meshes are rounded off to three decimal places.
The meshes of the *minimum grid* pass only through block borders.

B.6.5. Split (selected) mesh(es)

Menu command: *Grid → Split...*



Split either the selected meshes or the active mesh (when no selection is defined) into smaller parts according to one of the following methods:

- Geometric split
  Select method = geometric.
  Each mesh is split into the specified number of subdivisions using a geometric series with given ratio.
  When the split ratio = 1, then all created submeshes are equal.
  When the split ratio < 1, then the submeshes have decreasing mesh widths.
  When the split ratio > 1, then the submeshes have increasing mesh widths.
  A negative or zero split ratio is not allowed.
- Split using maximum mesh width
  Select method = maximum.
  All submeshes have a constant mesh width (as defined by the input field "mesh width"), except for the last submesh (width = remainder after division).
- Split using border size
  - Select method = border 1.
    Each mesh is split into two parts, when the original mesh size is greater than the given "mesh width". The first submesh (border 1) gets the size of the given mesh width, the second submesh gets the size of the difference.
  - Select method = border 2.
    Each mesh is split into two parts, when the original mesh size is greater than the given" mesh width". The second submesh (border 2) gets the size of the given mesh width, the first submesh gets the size of the difference.

– Select method = border 1 & 2.
  Calls successively: split using border 2, then split using border 1.
  So each mesh is split into three parts (when the original mesh size is large enough): both outer submeshes get the size of the given mesh width, the middle submesh gets the size of the difference.

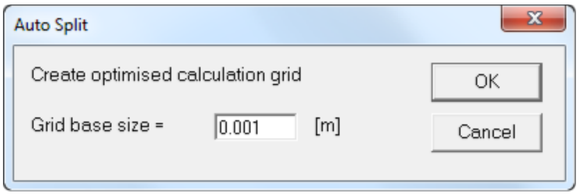
B.6.6. Merge selected meshes

Menu command: *Grid → Merge*

Merge each group of consecutive selected meshes into the largest possible union meshes.
Meshes at both sides of a block border cannot be merged (otherwise the block geometry would change).
When no grid meshes are selected, the active mesh is merged with the next mesh (if possible).
When all grid meshes are selected, then the merge function creates a *minimum grid*.

B.6.7. Auto split (create Calculation Grid)

Menu command: *Grid → Auto Split... (create Calculation Grid)*



The automatic split function creates an optimised calculation grid, e.g. starting from the *design grid* for the definition of the object blocks.
The "grid base size" is used as smallest subdivision of smaller grid meshes.
Larger grid meshes are split using geometric increasing submeshes (with constant split ratio = 1.5).

B.6.8. Move grid line

Menu command: *Grid → Move Grid Line*

The current grid over the object geometry in the **Image** window is now visualised, if not already visible (cf. *Image → Show Grid*).
The function enables to move an individual grid line to a new position by drag and drop using the left mouse button.
The X or Y coordinate of the new position is displayed on the status bar at the bottom of the application window (showing initial and final coordinates, as well as the new neighbouring mesh sizes).
A grid line that is moved beyond an adjacent grid line, will be removed after releasing the left mouse button.

B.6.9. Set vertical / horizontal grid line

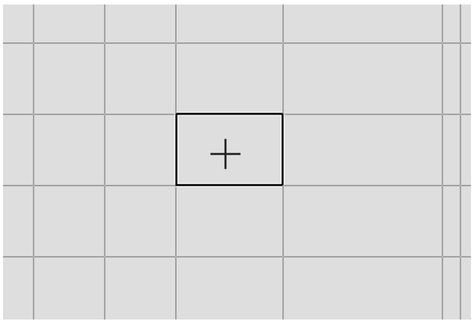
Menu commands: *Grid → Set Vertical Grid Line and Grid → Set Horizontal Grid Line*

The current grid and DXF underlayer over the object geometry in the **Image** window is now visualised, if not already visible (cf. *Image → Show Grid* and *Image → Hide DXF Underlayer*).
The functions enable to set a new vertical or horizontal grid line at the mouse cursor position

when the left mouse button is clicked.
The coordinates of the mouse cursor are displayed on the status bar at the bottom of the application window.
If a DXF underlayer is present, then the new grid line is snapped to the closest DXF vertex highlighted with a black square marker.

B.7. Paint functions

Painting allows to change the colours of grid cells in the **Image** window and modifies accordingly the blocks in the **Blocks** window. A grid cell in the **Image** window is a rectangle formed by two pairs of successive vertical and horizontal grid lines.
The paint colour is the current colour in the **Colours** window (i.e. the colour in the row in which the active input cell is located).
The current grid over the object geometry in the **Image** window is now visualised, if not already visible (cf. *Image → Show Grid*) and modify the mouse cursor into a crosshair cursor.



The figure above shows a grid cell around the crosshair mouse cursor within the grid in the **Image** window

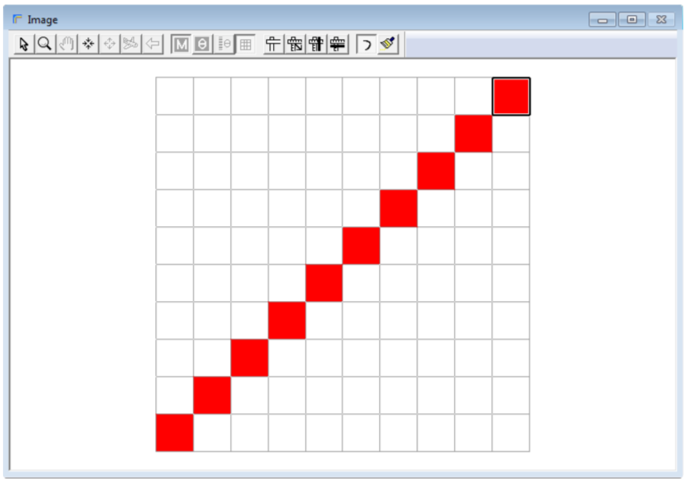
There are two paint functions:
– *Paint → Draw* to paint an individual grid cell or a line of grid cells 
– *Paint → Fill* to paint a connected region of identically coloured grid cells 

B.7.1. Draw

Menu command: *Paint → Draw*

This command enters the “draw modus”.
In the draw modus each click with the left mouse button paints the individual grid cell around the crosshair mouse cursor in the **Image** window using the active colour in the **Colours** window.
Hold the left mouse button down while moving the mouse to colour more individual grid cells.

<u>Draw line of grid cells</u>
First draw the start grid cell with the left mouse button.
Then hold the <Shift> key down, and click with the left mouse button at the end grid cell to draw all intermediate grid cells of the line of grid cells.



In the **Blocks** window new blocks are added at the end, corresponding to the new painted grid cells.
When the number of blocks grow, it may be useful to optimise the layout of blocks (using the function *Blocks → Optimise Blocks...*).

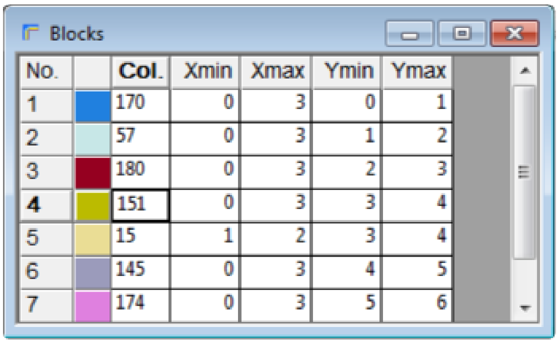
B.7.2. Fill

Menu command: *Paint → Fill*

This command enters the "fill modus".
In the fill modus each click with the left mouse button fills all connected grid cells with the same colour as the colour of the grid cell under the crosshair mouse cursor. The grid cells are filled up to the boundary of grid cells with a different colour, using a flood fill algorithm.
The layout of the blocks in the **Blocks** window are automatically optimised (using the function *Blocks → Optimise Blocks...*) allowing overlapping blocks.

B.8. Blocks window

Menu command: *Edit → Blocks*



The object geometry is defined by blocks in the **Blocks** window.
Each block has the following parameters:

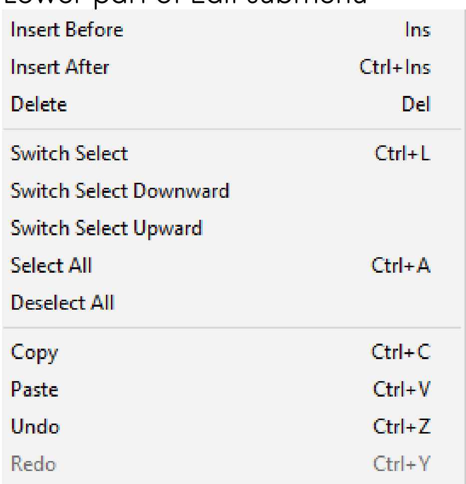
- *Colour number* (between 0 and 255) referring to a colour in the **Colours** window.
- *Block borders*: Xmin, Xmax, Ymin, Ymax.
  The block borders are grid line numbers along X and Y (integers starting from 0), which positions are defined in the **Grid** window.

The size of the active block (width x height) is shown in the status bar.

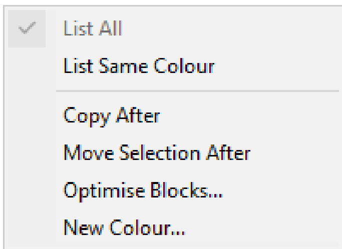
<u>Superposition rule</u>
Blocks with higher sequence number have priority over (i.e. overwrite the common parts of) blocks with lower sequence number.

B.9. Block functions

Lower part of Edit submenu



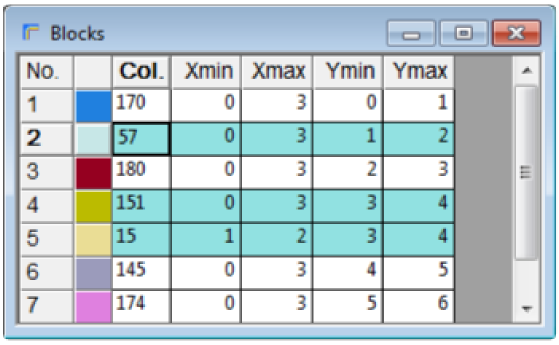
Blocks submenu



B.9.1. Insert block

- *Edit → Insert Before*
  Insert a new block before the active block.
- *Edit → Insert After*
  Insert a new block after the active block.

B.9.2. Block selections



No.		Col.	Xmin	Xmax	Ymin	Ymax
1		170	0	3	0	1
2		57	0	3	1	2
3		180	0	3	2	3
4		151	0	3	3	4
5		15	1	2	3	4
6		145	0	3	4	5
7		174	0	3	5	6

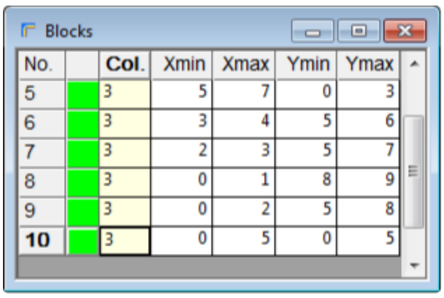
Individual blocks can be selected to perform global actions (delete, copy, move).
The selected blocks are marked in turquoise.
Blocks can be selected by clicking (left mouse button) the row number. Holding the <Shift> and <Ctrl> keys, a selection range can be defined.
Alternatively, menu functions can be used to select blocks.

<u>Block selection functions</u>:

- *Edit → Switch Select*
  Switch on/off the selection for the active block.
- *Edit → Switch Select Downward*
  Switch on/off the selection of the active block and all next blocks with equal selection mode.
- *Edit → Switch Select Upward*
  Switch on/off the selection of the active block and all previous blocks with equal selection mode.
- *Edit → Select All*
  Select all blocks.
- *Edit → Deselect All*
  Deselect all blocks.

B.9.3. Block list options

- *Blocks → List Same Colour*
  This function only shows in the **Blocks** window all blocks having the same colour as the active block.
  The block sequence numbers are the original sequence numbers (as in the normal view option *Blocks → List All*).
  The colour number cannot be edited.



No.		Col.	Xmin	Xmax	Ymin	Ymax
5		3	5	7	0	3
6		3	3	4	5	6
7		3	2	3	5	7
8		3	0	1	8	9
9		3	0	2	5	8
10		3	0	5	0	5

- *Blocks → List All*
  List all blocks again.

B.9.4. Delete, copy, move blocks

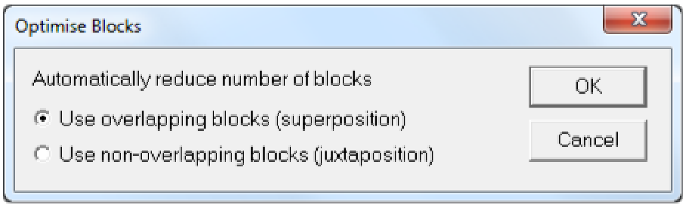
– *Edit → Delete*
  Delete selected block(s), or delete the active block (if no selection is made).

– *Blocks → Copy After*
  Copy selected block(s) to a new position in the blocks list.
  If there is no block selection, the active block is copied after itself.
  If there is a block selection, the selected block(s) are copied immediately after the active block.
  After the copy operation the copied block(s) become the new block selection.

– *Blocks → Move Selection After*
  Move selected block(s) to a new position in the blocks list.
  If there is no block selection, this function is disabled.
  If there is a block selection, the selected block(s) are moved immediately after the active block.
  After the move operation the selected block(s) remain selected.

B.9.5. Optimise blocks

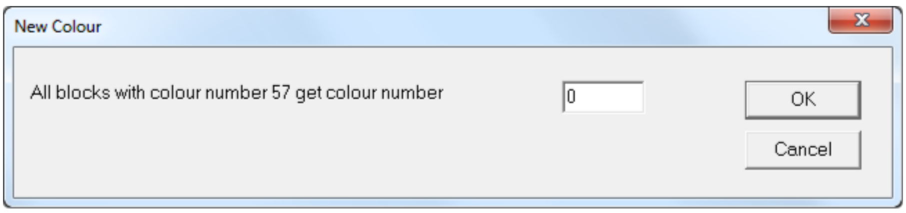
Menu command: *Blocks → Optimise Blocks...*



This function recalculates the list of blocks in the **Blocks** window based on the final object geometry in the **Image** window. The grid data in the **Grid** window remain unchanged.
The function tries to minimise the number of blocks.
There are two options:
– Use overlapping blocks (with possible superposition of blocks) in order to obtain a larger reduction in the final number of blocks.
– Use only non-overlapping blocks (without any superposition of blocks).

B.9.6. Redefine colour globally

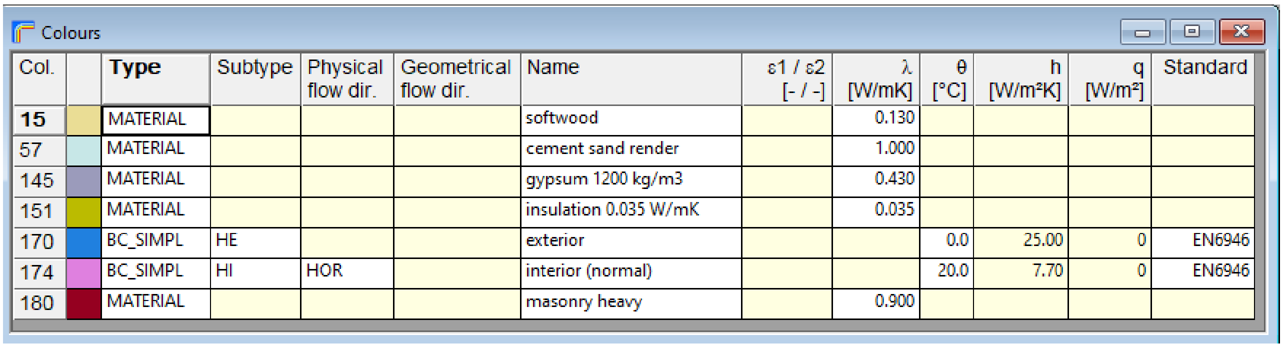
Menu command: *Blocks → New Colour...*



All blocks having the same colour number as the active block get a new colour number.

B.10. Colours window

Menu command: *Edit → Colours*



Colours

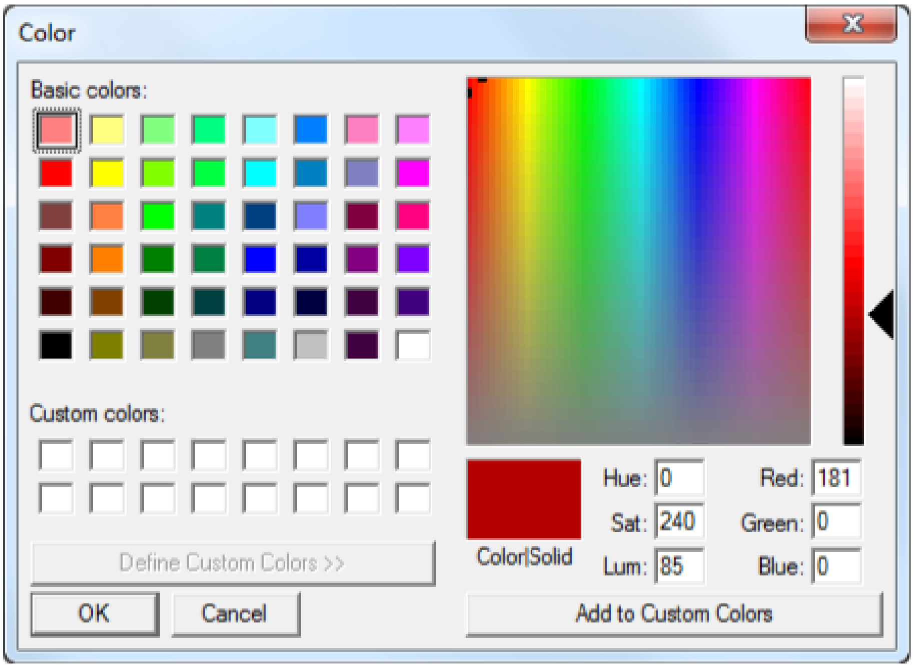
Col.		Type	Subtype	Physical flow dir.	Geometrical flow dir.	Name	ε1 / ε2 [- / -]	λ [W/mK]	θ [°C]	h [W/m²K]	q [W/m²]	Standard
15		MATERIAL				softwood		0.130				
57		MATERIAL				cement sand render		1.000				
145		MATERIAL				gypsum 1200 kg/m3		0.430				
151		MATERIAL				insulation 0.035 W/mK		0.035				
170		BC_SIMPL	HE			exterior			0.0	25.00	0	EN6946
174		BC_SIMPL	HI	HOR		interior (normal)			20.0	7.70	0	EN6946
180		MATERIAL				masonry heavy		0.900				

The **Colours** window defines the colours associated to the blocks in the **Blocks** window. Via the colours the thermal properties of the blocks are set.

B.10.1. Colour number

Each colour is identified by a *colour number* or *colour index*: an integer between 0 and 255. Therefore maximum 256 colours can occur in a project.

The fill colour belonging to each colour number can be changed. Position the active cell (surrounded by thick black lines) onto the second column (showing the actual colour), and double click (with the left mouse button) or press <Enter>. Choose a new colour in the standard Colour dialog box.



When Trisco2D is started up, the default colour values are loaded from the file MatColor.rgb in the application folder.
This file contains the red, green and blue components (as numbers between 0 and 255) for all 256 colour numbers.
The present colours in the blocks of a project are stored in the .tr2 data file (as RGB values), and are automatically loaded when the .tr2 data file is read.

B.10.2. Colour type and subtype

Each colour stands for a material or a boundary condition dependent on the colour type.

The following types are available:
- MATERIAL: material with fixed thermal conductivity.
  The material name and λ-value can be loaded from a material database
  (*Colours → Load Material...*).
- EQUIMAT: equivalent material with equivalent thermal conductivity defined by the subtype, physical flow direction and geometrical flow direction.
- BC_SIMPL: simplified surface boundary condition, defined by a surface heat transfer coefficient (for combined convection and radiation), boundary condition temperature and additional surface heat flux.
- BC_FRE_S: enclosure with unknown (free) internal temperature, simplified surface heat transfer (defined by a given surface heat transfer coefficient) and additional surface heat flux.

Possible standards (last column) for type BC_SIMPL and EQUIMAT:
- EN6946: thermal properties according to EN ISO 6946 (2017): Building components and building elements - Thermal resistance and thermal transmittance - Calculation methods.
- NIHIL: thermal properties not based on a standard.

Possible subtypes for type EQUIMAT:
- CAVITY: unventilated air cavity, defined by physical and geometrical heat flow direction.
- LAYER: unventilated air layer, defined by physical and geometrical heat flow direction.
  Choose LAYER when the cavity width (orthogonal to the heat flow direction) is at least 10 times the cavity thickness (in the heat flow direction).
- NIHIL: thermal properties defined by the user.

Possible subtypes for type BC_SIMPL and BC_FRE_S:
- HI: internal heat transfer, defined by physical flow direction.
- HE: external heat transfer.
- NIHIL: global surface heat transfer coefficient defined by the user.

Possible physical heat flows (with reference to the ground surface):
- HOR: horizontal heat flow.
- UP: upward heat flow.
- DOWN: downward heat flow.

Possible geometric heat flows (with reference to the X and Y directions of the screen):
- X: heat flow parallel to the X axis of the screen
- Y: heat flow parallel to the Y axis of the screen.

B.10.3. Colour name

Enter a name for the material or boundary condition.
The status bar shows the total area of all blocks having this colour.

B.10.4. Thermal properties

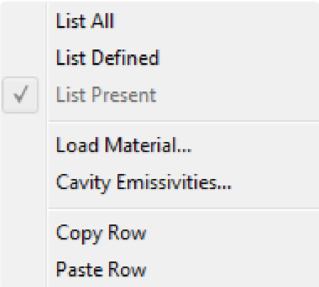
The relevant thermal properties for each colour type are shown in the **Colours** window.
Values on a white background can be edited. Values on a yellow background are automatically calculated. Empty cells refer to irrelevant properties for the active colour type.

The following thermal properties are possible:

– ε1/ε2 [-]: emissivities of the warm and cold side of the cavity or layer (EQUIMAT) (cf. section B.11.3).
– λ [W/(m.K)]: thermal conductivity of the material (MATERIAL, EQUIMAT).
– θ [°C]: boundary condition temperature (BC_SIMPL).
– h [W/(m^2.K)]: surface heat transfer coefficient (BC_SIMPL, BC_FRE_S).
– q [W/m^2]: surface heat flux (BC_SIMPL, BC_FRE_S).

B.11. Colour functions

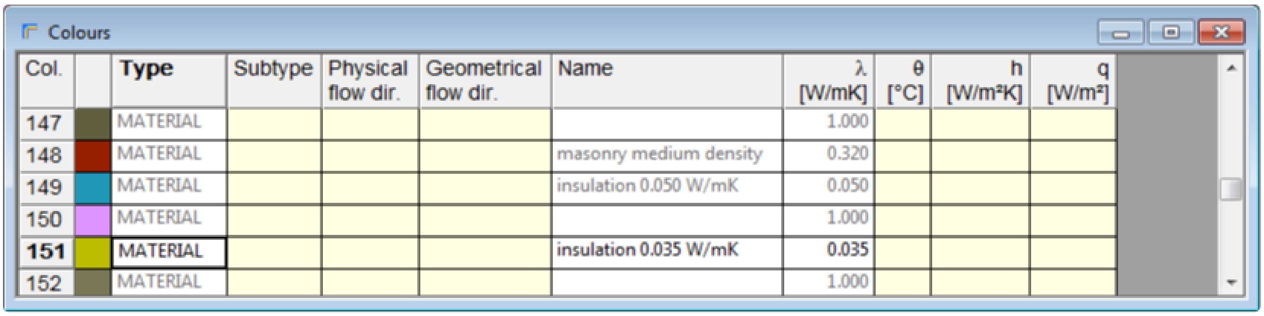
Colours submenu



B.11.1. List colours

All or part of the available 256 colours can be shown in the **Colours** window:

– *Colours → List All*
  List all 256 colours.
  The list is useful in choosing new colour numbers for blocks in the **Blocks** window.



Col.		Type	Subtype	Physical flow dir.	Geometrical flow dir.	Name	λ [W/mK]	θ [°C]	h [W/m²K]	q [W/m²]
147		MATERIAL					1.000			
148		MATERIAL				masonry medium density	0.320			
149		MATERIAL				insulation 0.050 W/mK	0.050			
150		MATERIAL					1.000			
151		MATERIAL				insulation 0.035 W/mK	0.035			
152		MATERIAL					1.000			

– *Colours → List Defined*
  List all defined colours.
  This option displays besides all present colours (referenced from the **Blocks** window) also other colour definitions of the colour database (and previous loaded data files), which are still present in memory.

– *Colours → List Present*
  List all colours referenced from the **Blocks** window.

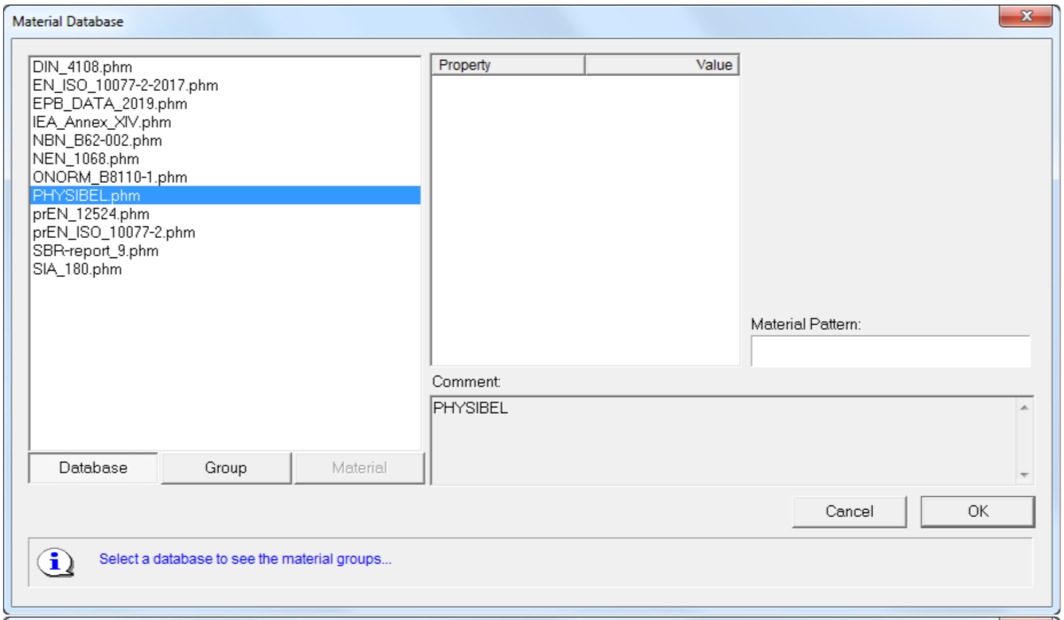
The edit fields for present colours have black text on a white background.
The edit fields for colours which are not present in the object model (not referenced from any block in the **Blocks** window) have grey text on a white background.
Only the properties of present colours are saved in the .tr2 data file (executing *File → Save*).

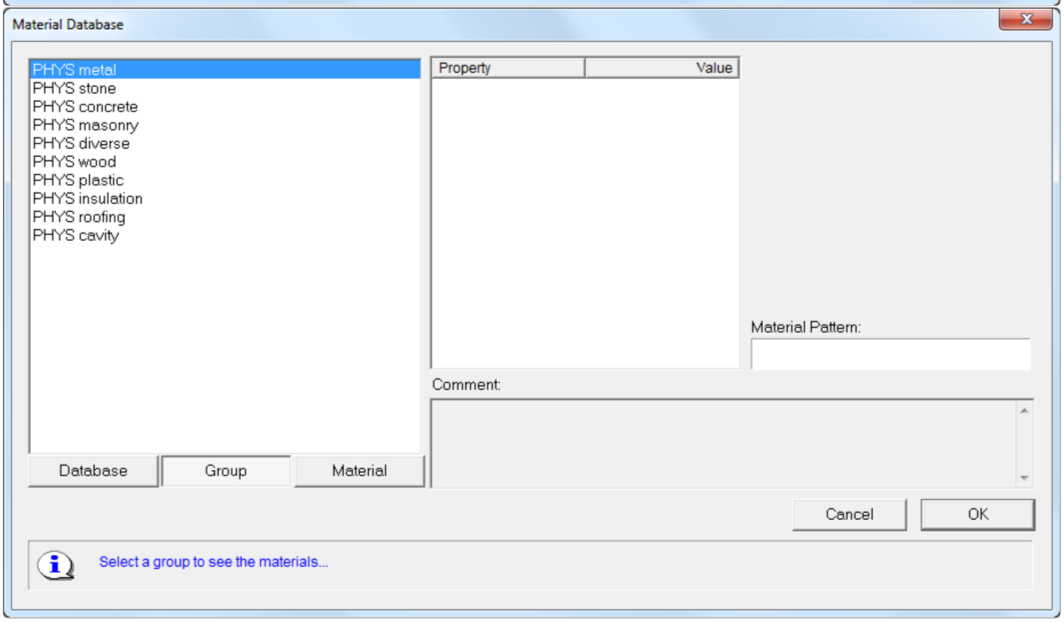
B.11.2. Load material properties

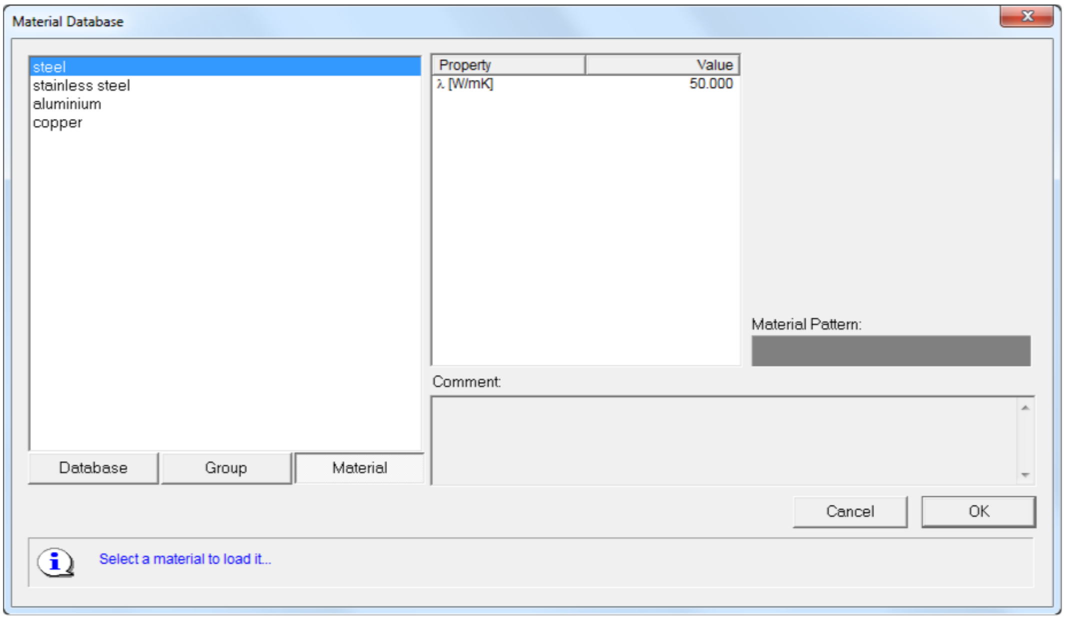
Menu command: *Colours → Load Material...*

The Material Database dialog box allows to select a material from a group of materials in a material database.
The available material databases contain the thermal conductivities of different materials according to several European standards, and are stored in the files with extension .phm in the Materials data folder (C:/Program Files(x86)/Physibel/Materials).

After selecting a material and pressing the OK button, the corresponding properties are loaded for the active colour number.



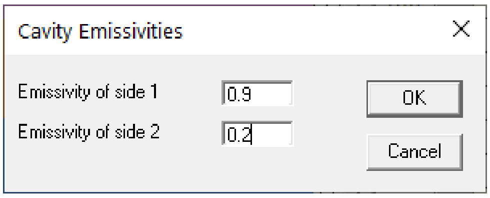




B.11.3. Cavity emissivities

Editing the grid cell of property 'ε1 / ε2 [- / -]' for colours of type EQUIMAT opens a dialog box for definition of the values.

The dialog box prompts for the emissivities of the cold and warm surfaces facing the heat flow.



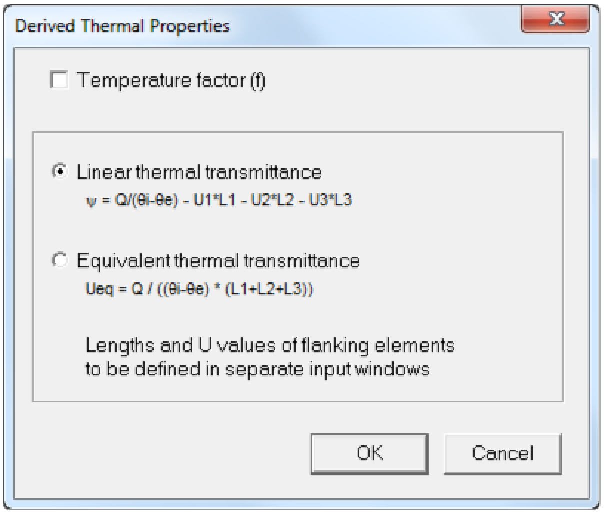
A valid emissivity lies between 0.001 and 1. (Otherwise the default value 0.9 is used.)
If any emissivity differs from 0.9 (the default value), the corresponding grid cell in the **Colours window** is highlighted in blue. The equivalent thermal conductivity is recalculated based on the new surface emissivities.
Calculation method: see section D.1.

B.11.4. Copy - paste

The functions *Colours → Copy Row* and *Colours → Paste Row* allow to copy all properties from one colour number to another colour number.

B.12. Derived thermal properties

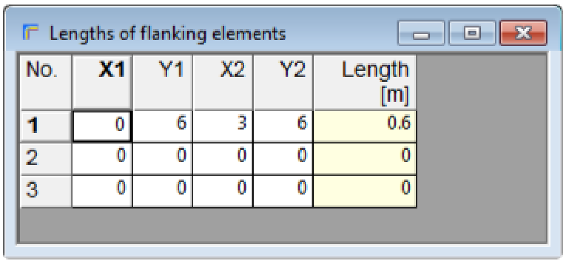
Menu command: *Edit → Derived Thermal Properties...*



This dialog box defines the desired derived thermal properties in the output after the system calculation.
The properties can only be evaluated if two boundary conditions with different temperatures occur (external and internal temperatures).

B.13. Lengths of flanking elements window

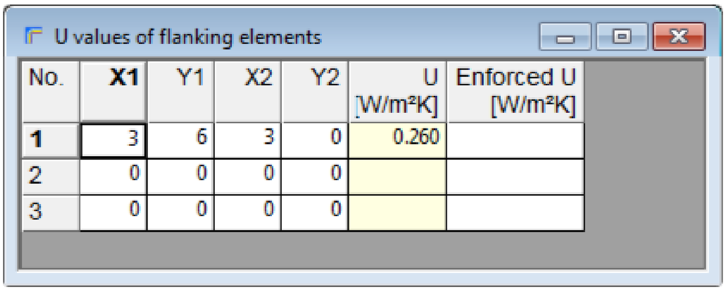
Menu command: *Edit → Lengths of flanking elements*



This window allows to define three lengths L1, L2 and L3.
Each length is defined between two nodes (X1,Y1) and (X2,Y2) in the grid.
The coordinates refer to grid numbers (starting from 0) in the **Grid** window.
The active line (defined by the input cell in the window) is highlighted in the **Image** window.
The grid coordinates of the active end point of the line (defined by the X1, Y1, X2 or Y2 position in the window) can also be set with the left mouse button, when the grid is made visible in the **Image** window (via the toggle command *Image → Show Grid*) and the mouse cursor is highlighted as a black square (i.e. when moved onto a grid node in the **Image** window).
The lengths are used in the calculation of derived thermal properties.

B.14. U values of flanking elements window

Menu command: *Edit → U values of flanking elements*



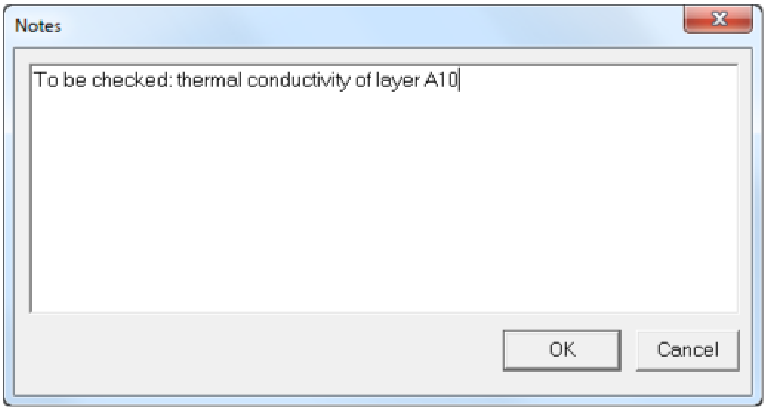
This window allows to define three lines along which the thermal transmittance (U1, U2, U3) is calculated.
Each line is defined between two nodes (X1,Y1) and (X2,Y2) in the grid.
The coordinates refer to grid numbers (starting from 0) in the **Grid** window.
The active line (corresponding to the input cell in the window) is highlighted in the **Image** window.
The grid coordinates of the active end point of the line (defined by the X1, Y1, X2 or Y2 position in the window) can also be set with the left mouse button, when the grid is made visible in the **Image** window (via the toggle command *Image → Show Grid*) and the mouse cursor is highlighted as a black square (i.e. when moved onto a grid node in the **Image** window).

The line must satisfy the following conditions, else the U value is unknown (with empty cell):
– The line must be parallel to a coordinate axis (X1 = X2 or Y1 = Y2).
– Both end points must lie in (or touch) different boundary conditions of type BC_SIMPL or BC_FRE_S with a surface heat transfer coefficient h > 0 W/(m^2.K).
– The line should only pass through material layers.
– The line must not lie on the boundary between different colour blocks to avoid any possible ambiguity in the traversed colour blocks.

The user can enter an enforced U value (in the last column), which always has precedence over the calculated U value.
The U values of flanking elements are used in the calculation of derived thermal properties.

B.15. Notes window

Menu command: *Edit → Notes...*

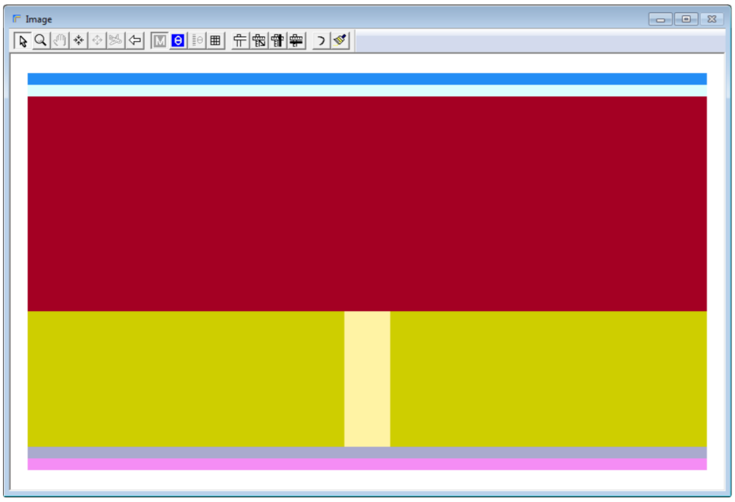


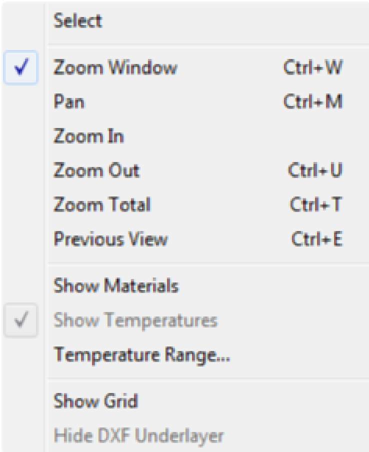
The entered text (max. 10 lines) is shown in the text output (*Output → Text Output*, then *View → Input Data*).

CHAPTER C VIEWING THE MODEL

C.1. Image submenu

The object model as defined in the **Blocks** window and **Colours** window is shown in the **Image** window. The view of the object in the **Image** window can be altered using image functions.





The current view mode (*Select, Zoom Window, Pan* or *Zoom In*), current object appearance (*Show Materials* or *Show Temperatures*) and view options (*Show Grid* and *Hide DXF Underlayer*) are checked in the Image submenu (see check mark in front of menu commands).

C.2. Select mode

Menu command: *Image → Select*

In Select mode an object can be selected from the **Image** window with the left mouse button. The selected object is highlighted in the **Image** window.
The kind of object (block, grid mesh, colour) is dependent on the active window (**Image** window, **Blocks** window, **Grid** window, **Colours** window).

Press <Esc> from any other command status (*Image → Zoom Window, Image → Pan, Image → Zoom In, Grid → Move Grid Line, Grid → Set Vertical Grid Line, Grid → Set Horizontal Grid Line, Paint → Draw, Paint → Fill*) to return to Select mode and move the focus to the **Image** window.

C.3. Zoom commands

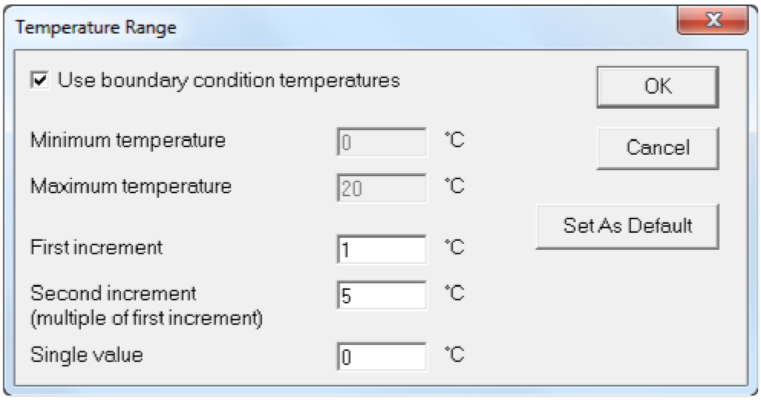
- *Image → Zoom Window*
  Enters "zoom window" mode. This allows to draw a zoom rectangle using the mouse in the Image window, which defines the borders of a zoomed view.
  Press <Esc> to cancel the current zoom rectangle (before releasing the left mouse button).
- *Image → Pan*
  Enters pan mode (only possible when the current view is already zoomed in). Mouse dragging or pressing arrow keys (with **Image** window active) moves the view over the object.
  Pan mode is activated automatically by holding down the mouse wheel.
- *Image → Zoom In*
  Enters "zoom in" mode. A following click using the left mouse button in the **Image** window

defines the centre point of the next zoomed view. The zoom factor is a program setting (see A.8). When in "zoom in" mode, a click using the right mouse button zooms out.
Zooming in is also possible using forward scrolling with the mouse wheel.

– *Image → Zoom Out*
  Zooms out using the current zoom factor (or restores the total zoom, when zoomed out enough).
  Zooming out is also possible using backward scrolling with the mouse wheel.
– *Image → Zoom Total*
  Shows total object.
– *Image → Previous View*
  Shows the previous zoom view. (More than one previous view cannot be recalled.)

C.4. Object appearance

– *Image → Show Materials*
  Shows the blocks of materials, cavities and boundary conditions.
– *Image → Show Temperatures*
  Shows the calculated temperatures on the material blocks in the object.
  This option is only available if a calculation solution is present.
  The colours of the temperature scale can be selected from different palettes (see A.8).
  The legend of used colours can only be made visible in the **Graphics Output** window (cf. section E.4).
  The temperature scale is defined in *Image → Temperature Range...*.
– *Image → Temperature Range...*
  Opens a dialog box to define the parameters of a temperature view.
  The option "Use boundary condition temperatures" initialises the minimum and maximum temperatures from the present boundary condition temperatures in the **Colours** window.
  The first increment is used as step value in *Image → Show Temperatures.*
  The second increment and single value are only used with isothermal lines in the **Graphics Output** window.
  This command is only enabled when the menu command *Image → Show Temperatures* is chosen.



– *Image → Show Grid*
  Show/hide the current grid in the **Image** window.
– *Image → Hide DXF Underlayer*
  Hide/show the DXF underlayer in the **Image** window (after *File → Import DXF...*).

C.5. Pick temperature using the mouse

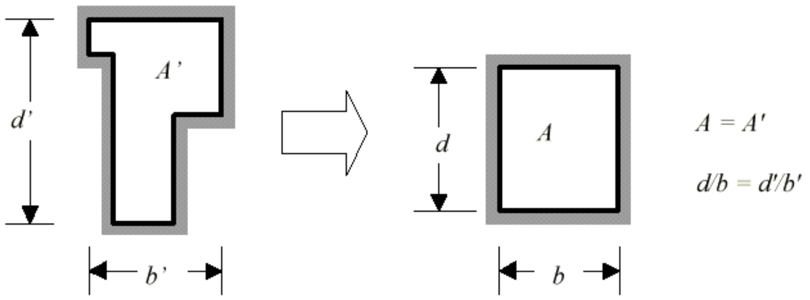
When the **Image** window is active (i.e. its title bar is blue) and the temperatures are shown (*Image → Show Temperatures*), then the surface temperature at the mouse cursor is displayed in the status bar (bottom left of the screen).
The number of decimals can be modified via *Settings → Decimals...* from the **Text Output** window (cf. section F.5 Chapter E).

CHAPTER D CALCULATION

D.1. Automatic calculation of equivalent thermal conductivity of EQUIMAT colour

The calculation of the equivalent thermal conductivity of a colour of type EQUIMAT in the **Colours** window is dependent on the subtype (CAVITY, LAYER), physical flow direction (HOR, UP, DOWN) and geometrical flow direction (X, Y). The calculation formula is based on the European standard EN ISO 6946, as indicated in the last column of the **Colours** window.

<u>Characteristic dimensions</u>
The characteristic dimensions are called *depth* (parallel to the heat flow direction) and *width* (orthogonal to the heat flow direction).
If the air cavity is not a rectangle, the depth d and width b are calculated from an equivalent rectangle (with sides parallel to X and Y) with the same aspect ratio:



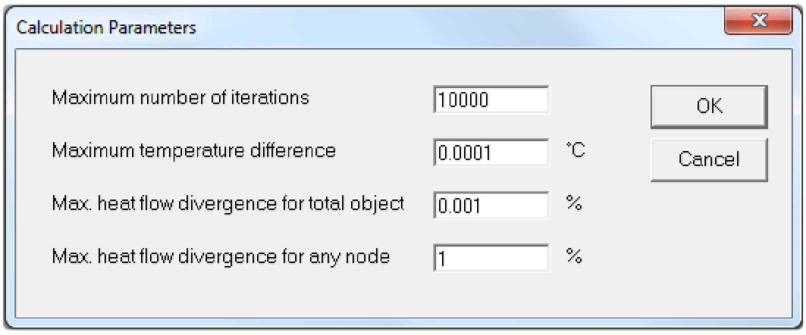
<u>Equivalent thermal conductivity of unventilated air cavity (CAVITY) or unventilated air layer (LAYER)</u>
$\lambda_{eq} = (h_c + h_r) \cdot d$

h_c = convective heat transfer coefficient (from warm surface to cold surface)
Horizontal heat flow: $h_c = max\left\{\frac{0.025}{d}, 1.25\right\}$
Upward heat flow: $h_c = max\left\{\frac{0.025}{d}, 1.95\right\}$
Downward heat flow: $h_c = max\left\{\frac{0.025}{d}, 0.12 \cdot d^{-0.44}\right\}$

h_r = radiative heat transfer coefficient
$$h_r = 4 \times 5.67 \times 10^{-8} \times (\theta_m + 273.16)^3 \times \frac{1}{\frac{1}{E} + \frac{1}{F} - 1}$$
θ_m = 10°C
$$E = \frac{1}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}$$
ε_1, ε_2 = emissivities at warm and cold sides of cavity (default values: ε_1 = ε_2 = 0.9)
$$F = \frac{1}{2} \cdot \left(1 + \sqrt{1 + \left(\frac{d}{b}\right)^2} - \frac{d}{b}\right)$$
For a layer (type = LAYER): F = 1 (since $d/b \approx 0$)

D.2. Calculation parameters

Menu command: *Edit → Calc Parameters...*



The calculation parameters control the calculation of the thermal system (*Calc → Calc System*), using iterations:
- *Maximum number of iterations*: maximum allowed number of iteration steps.
- *Maximum temperature difference*: maximum allowed temperature difference in any node between the previous and the current iteration step.
- *Maximum heat flow divergence for total object*: maximum allowed relative energy balance error for the total object (as union of all elementary control volumes).
- *Maximum heat flow divergence for any node*: maximum allowed relative energy balance error for the worst elementary control volume.

The iteration stops when the last three conditions are satisfied.
The first condition (maximum number of iterations) acts as an emergency break.

D.3. System calculation

Menu command: *Calc → Calc System*

A monitor shows the progress of the calculation.

First the input data are saved on disk (with file extension .tr2).
Then a system of linear equations is set up.
The equations express an energy balance for the control volume around each system node.
The extent of the control volume within the object is half the grid mesh along X and Y.
All heat flows in the energy balance are expressed as linear functions of neighbouring node temperatures.
Thereafter the linear system is solved using a fast and stable iterative method.
When the calculation is finished, the calculated node temperatures are saved in a file with extension .sol (same name as data file) in the same folder of the input data file.

<u>Memory requirement</u>
512 Mb RAM allows to solve a system of about 1,000,000 nodes.
1 Gb RAM allows to solve about 3,000,000 nodes.

<u>Interrupt calculation</u>
The calculations can be stopped at any time by pressing the <Esc> key. The obtained temperatures at that moment are saved in a .sol file. When restarting the calculation, the saved intermediate solution is loaded from the .sol file and the iteration restarts.

Temperatures out of range

Sometimes it is possible that some calculated node temperatures are outside the range of boundary condition temperatures. This is not a calculation error, but a “feature” of the solution technique: the energy balances are not applied for the isolated system nodes, but for the surfaces of a finite control volume around the nodes. Due to this discretisation such small overflows in calculated node temperatures may occur. The overflow is made smaller by refining the grid.

D.4. Heat flow divergences

The quality of the solution is mainly determined by the heat flow divergence of the total object, called in short *object divergence* (displayed in the calculation monitor). It is defined as the sum of all elementary heat flows entering the object (outgoing heat flows have a negative sign), divided by half the sum of the absolute values of all heat flows:

$$OD = \frac{|\Phi_{in,o} - \Phi_{out,o}|}{0.5 \cdot (|\Phi_{in,o}| + |\Phi_{out,o}|)} \cdot 100$$

with OD = object divergence [%]
$\Phi_{in,o}$ = total incoming heat flow for the object [W]
$\Phi_{out,o}$ = total outgoing heat flow for the object [W]

By using the factor 0.5 the denominator can be interpreted as the heat flow "passing" the object. The maximum possible object divergence is 200 %, i.e. when there are only incoming heat flows and no outgoing heat flows: $\Phi_{in,o}$ > 0 and $\Phi_{out,o}$ = 0 (or vice versa $\Phi_{in,o}$= 0 and $\Phi_{out,o}$> 0).
An object divergence tolerance of 0.001 % is recommended as reliable stopping criterion.
According to the standard ISO 10211 the object divergence should be less than 0.01 %.

Also a second heat flow divergence is used as additional stopping criterion: the maximum heat flow divergence for all nodes, called in short *node divergence* (also displayed in the calculation monitor). It is defined in a similar way as the object divergence:

$$ND = max_n\left(\frac{|\Phi_{in,n} - \Phi_{out,n}|}{0.5 \cdot (|\Phi_{in,n}| + |\Phi_{out,n}|)} \cdot 100\right)$$

with ND = node divergence [%]
$\Phi_{in,n}$= total incoming heat flow for the control volume around node n [W]
$\Phi_{out,n}$= total outgoing heat flow for the control volume around node n [W]

The default node divergence tolerance is 1 %.
Sometimes it happens that the node divergence does not decrease during the calculation. This is caused by an “unlucky” node, that is connected to its neighbouring nodes in an “unfavourable” way (due to strongly different mesh widths and/or strongly different thermal conductivities). Then a node divergence tolerance of 200 % (or a slightly higher value, to compensate for possible rounding errors) may be necessary to suppress the node divergence stopping criterion.

D.5. Derived thermal properties

The wanted derived thermal properties are defined using *Edit → Derived Thermal Properties...*
It is supposed that there are only two environments with different temperatures.

D.5.1. Temperature factor

The *temperature factor* is calculated using the following formula (cf. ISO 10211):

$$f = \frac{\theta_{si,min} - \theta_e}{\theta_i - \theta_e}$$

f = temperature factor [-]
θ_i = internal boundary condition temperature [°C]
θ_e = external boundary condition temperature [°C]
$\theta_{si,min}$ = minimum internal surface temperature [°C]

The output also reports:

- The internal heat transfer coefficient h_i [W/(m^2.K)] and internal surface resistance R_{si} [m^2.K/W] where $\theta_{si,min}$ applies.
- The relative humidity above which surface condensation occurs for the air at the internal boundary condition temperature.

D.5.2. Linear thermal transmittance

The *linear thermal transmittance* is calculated using the following formula (cf. ISO 10211):

$$\Psi = \frac{\Phi}{\theta_i - \theta_e} - U_1 * L_1 - U_2 * L_2 - U_3 * L_3$$

Ψ = linear thermal transmittance [W/(m.K)]
Ψ = total heat flow through object [W/m]
θ_i = internal boundary condition temperature [°C]
θ_e = external boundary condition temperature [°C]
U_1, U_2, U_3 = 1D thermal transmittances of flanking elements [W/(m^2.K)]
L_1, L_2, L_3 = lengths of flanking elements [m]
The lengths of the flanking elements are defined in the **Lengths of flanking elements** window.
The U values of the flanking elements are defined in the **U Values of flanking elements** window.

D.5.3. Equivalent thermal transmittance

The *equivalent thermal transmittance* is calculated using the following formula:

$$U_{eq} = \frac{\Phi}{(\theta_i - \theta_e) * (L_1 + L_2 + L_3)}$$

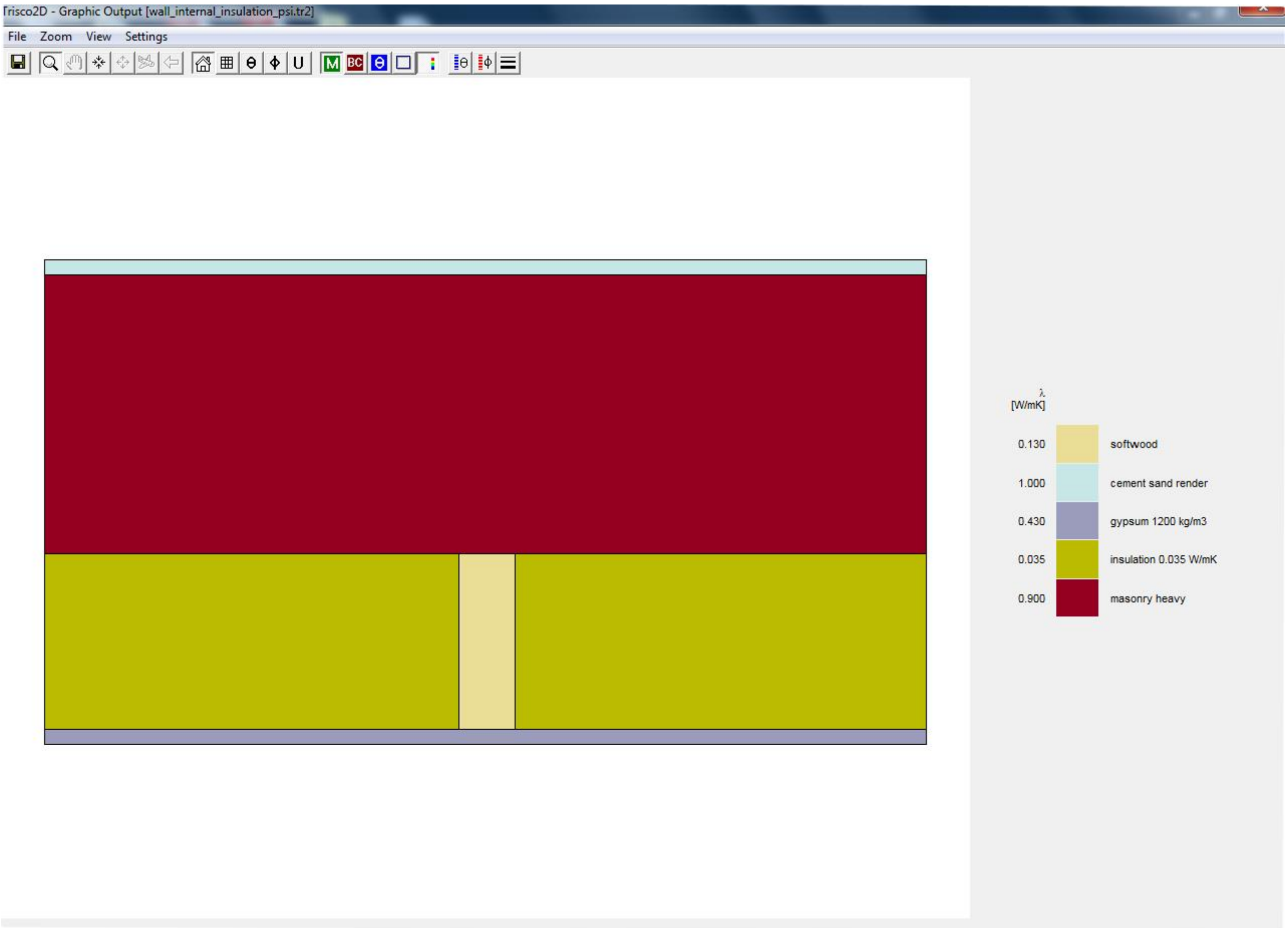
U_{eq} = equivalent thermal transmittance [W/(m^2.K)]
Φ = total heat flow through object [W/m]
θ_i = internal boundary condition temperature [°C]
θ_e = external boundary condition temperature [°C]
L_1, L_2, L_3 = lengths of flanking elements [m]
The lengths of the flanking elements are defined in the **Lengths of flanking elements** window.

CHAPTER E GRAPHIC OUTPUT

E.1. Graphic Output window

Menu command: *Output → Graphic Output*

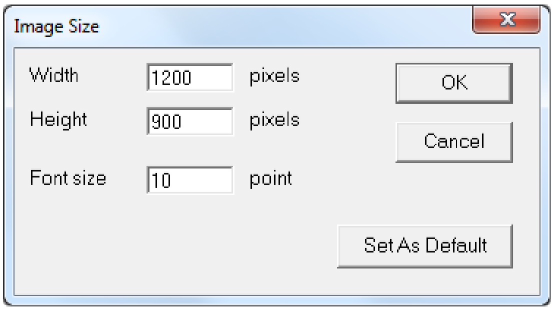
A new full-screen window with its own menu, toolbar and status bar are displayed.
To return to the main Trisco2D window, choose *File → Exit* or press the <Esc> key.



E.2. Save image

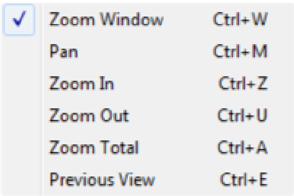
Menu command: *File → Save As...*

Save the current image as a .png file (in PNG format) on disk.
The image size (width and height) and font size for legend text are defined via the menu command
Settings → Image Size....



E.3. Zoom commands

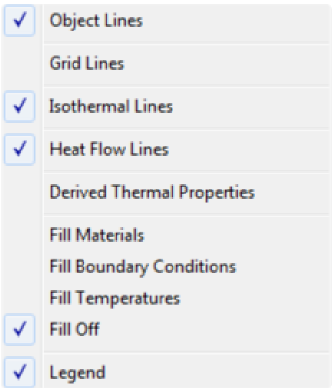
Zoom submenu



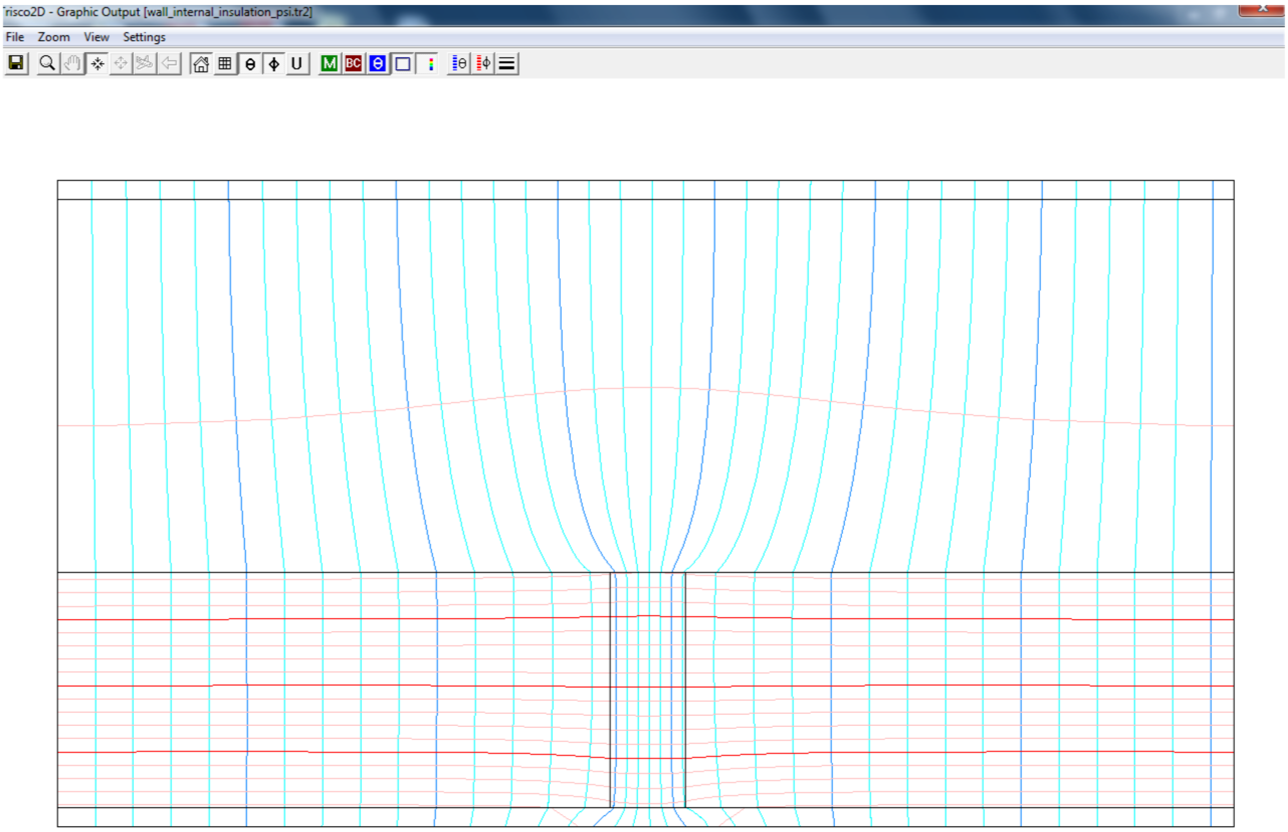
The zoom commands are identical to those of the **Image** window in the main menu.
Zooming in and out is also possible via scrolling forward and backward of the mouse wheel.

E.4. View options

View submenu



The check marks in front of the menu commands show the current view options.
Any change in the view options is immediately reflected in the image.



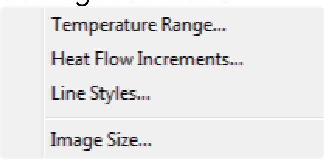
– *View* → *Object Lines*: show object contour lines.
– *View* → *Grid Lines*: show grid lines.
– *View* → *Isothermal Lines*: show isothermal lines conform to the temperature range parameters (*Settings* → *Temperature Range...*).
  Only possible when a calculation solution is available.
– *View* → *Heat Flow Lines*: show heat flow lines conform to the heat flow parameters (*Settings* → *Heat Flow Increments...*).
  Only possible when a calculation solution is available.
– *View* → *Derived Thermal Properties*: show linear thermal transmittance or equivalent thermal transmittance (dependent on chosen option from main menu *Edit* → *Derived Thermal Properties...*) as text in the legend at the right of the figure.
  The defined lengths and U values are indicated in the figure.
  Only possible when a calculation solution is available.
– *View* → *Fill Materials*: fill material blocks (of type MATERIAL or EQUIMAT) using the block colours.
– *View* → *Fill Boundary Conditions*: fill boundary condition blocks (of type BC_SIMPL or BC_FRE_S) using the block colours.
– *View* → *Fill Temperatures*: fill material blocks using temperature colours conform to the temperature range parameters (*Settings* → *Temperature Range...*). The colour palette for the temperatures can be selected in the main application (see A.8).
  Only possible when a calculation solution is available.
– *View* → *Fill Off*: switch off filling.
– *View* → *Legend*: show a legend at the right side of the figure.

<u>Heat flow lines</u>
Heat flow lines show the directions of the local heat flux vectors.
The density of the heat flow lines is proportional to the local heat flow magnitude.
The isotherms and heat flow lines form orthogonal fields.

The number of heat flow lines through a given line multiplied by the heat flow increment equals the total heat flow through that line.

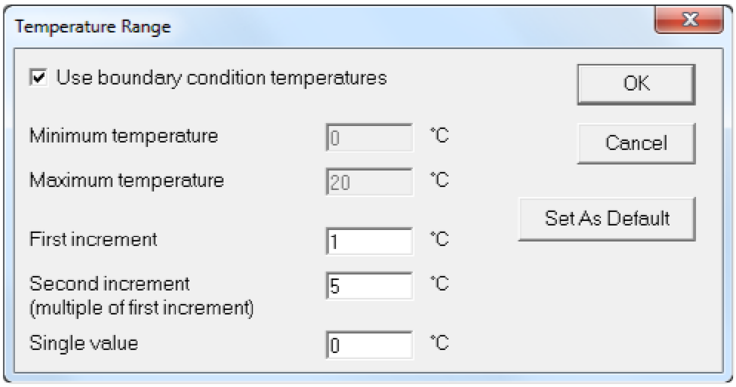
E.5. Settings

Settings submenu

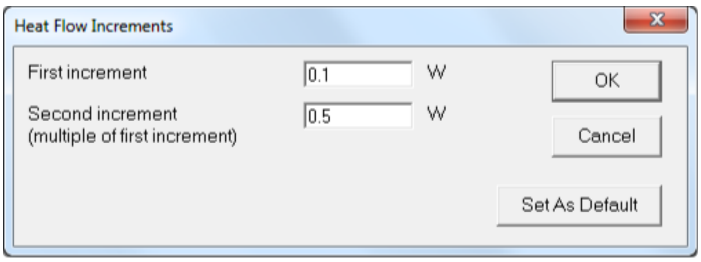


<u>*Settings → Temperature Range...*</u>

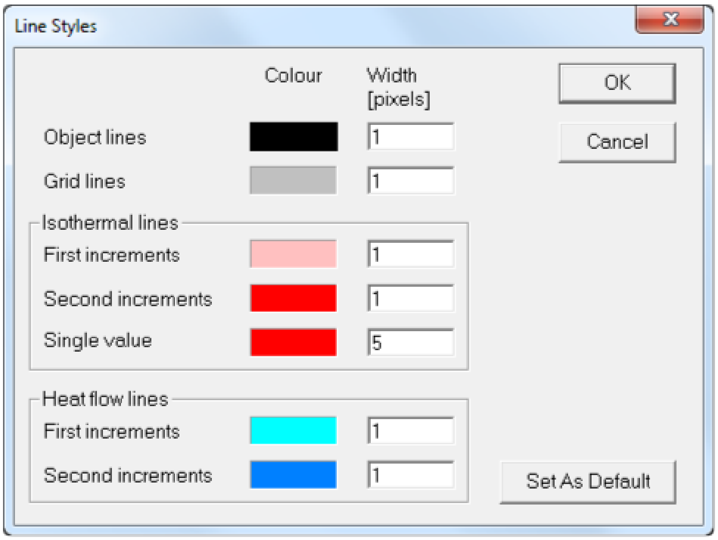
- Use boundary condition temperatures: initialise the minimum and maximum temperatures from the present boundary condition temperatures in the **Colours** window.
- Minimum temperature [°C] in graphic output.
- Maximum temperature [°C] in graphic output.
- First (or minor) increment [°C].
  Used for temperature filling (*View → Fill Temperatures*) and isothermal lines (*View → Isothermal Lines*).
- Second (or major) increment [°C] (must be a multiple of first increment).
  Only used with isothermal lines (*View → Isothermal Lines*).
- Single temperature value [°C] (e.g. dew point).
  Only used with isothermal lines (*View → Isothermal Lines*).



<u>*Settings → Heat Flow Increments...*</u>
Used with *View → Heat Flow Lines.*



Settings → Line Styles...



A colour field can be edited by double clicking on it with the left mouse button, which opens a Colour dialog box in which the colour value (RGB components) can be defined.
The width of isothermal lines and heat flow lines can be set to 0 pixels to cancel them. This is useful when e.g. only the second isothermal lines are desired in the figure.

Rainbow colours

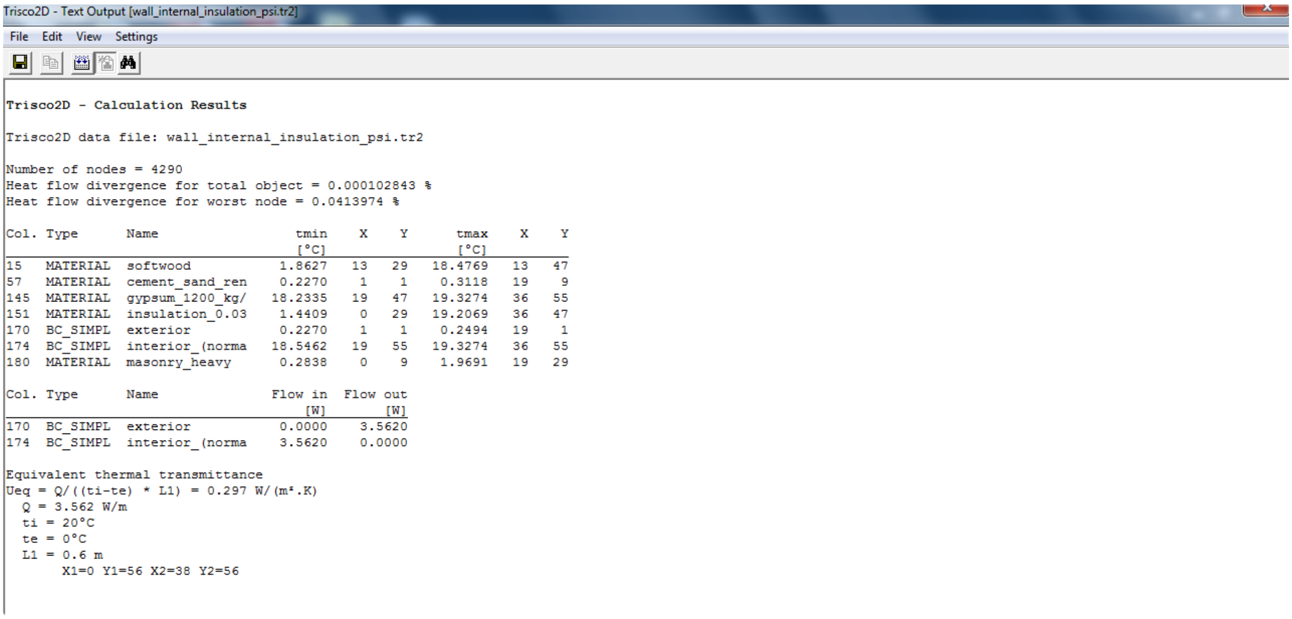
The filled isotherms are coloured using a rainbow scale interpolated from values defined in the a .rgb-file (a text file containing the red, green and blue components with values between 0 and 255 of the successive rainbow colours). The colours of the temperature scale can be selected from different palettes (see A.8).
The files RainbowColor.rgb and Ironbow.rgb are stored in the application folder.

CHAPTER F TEXT OUTPUT

F.1. Text Output window

Menu command: *Output → Text Output*

A new full-screen window with its own menu and toolbar are displayed.
To return to the main Trisco2D window, choose *File → Exit* or press the <Esc> key.




```
Trisco2D - Calculation Results

Trisco2D data file: wall_internal_insulation_psi.tr2

Number of nodes = 4290
Heat flow divergence for total object = 0.000102843 %
Heat flow divergence for worst node = 0.0413974 %

Col. Type      Name                tmin    X    Y      tmax    X    Y
                                   [°C]                [°C]
15   MATERIAL  softwood          1.8627   13   29   18.4769   13   47
57   MATERIAL  cement_sand_ren   0.2270    1    1    0.3118   19    9
145  MATERIAL  gypsum_1200_kg/  18.2335   19   47   19.3274   36   55
151  MATERIAL  insulation_0.03   1.4409    0   29   19.2069   36   47
170  BC_SIMPL  exterior          0.2270    1    1    0.2494   19    1
174  BC_SIMPL  interior_(norma  18.5462   19   55   19.3274   36   55
180  MATERIAL  masonry_heavy     0.2838    0    9    1.9691   19   29

Col. Type      Name             Flow in  Flow out
                                    [W]       [W]
170  BC_SIMPL  exterior          0.0000    3.5620
174  BC_SIMPL  interior_(norma   3.5620    0.0000

Equivalent thermal transmittance
Ueq = Q/((ti-te) * L1) = 0.297 W/(m².K)
  Q = 3.562 W/m
  ti = 20°C
  te = 0°C
  L1 = 0.6 m
       X1=0 Y1=56 X2=38 Y2=56
```

The text within the **Text Output** window can be edited.

F.2. Save text

Menu command: *File → Save As...*

Save the whole text in the current **Text Output** window into a Microsoft Word document (.doc) on disk.

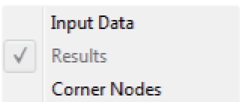
F.3. Copy text

Menu command: *Edit → Copy*

Copy the selected text (selected using the mouse or the arrow keys with the <Shift> key held down) into the clipboard (so that it can be pasted in an external text editor).

F.4. View options

View submenu



F.4.1. Input data

Menu command: *View → Input Data*

<u>Output</u>

- Document notes (defined with *Edit → Notes...* from the main menu)
- Trisco2D data file name
- Grid data: grid mesh widths along X and Y
- Blocks: block colour, block coordinates (as grid numbers, and absolute coordinates using the grid unit)
- Colours: all present colours with colour type and thermal properties
- Calculation parameters

<u>Example</u>

Trisco2D - Input Data

Trisco2D data file: wall_internal_insulation.tr2

GRID

No.	X [m]	Y [m]
0-1	0.074	0.010
1-2	0.076	0.010
2-3	0.051	0.010
3-4	0.034	0.015
4-5	0.022	0.022
5-6	0.015	0.012
6-7	0.010	0.012
7-8	0.010	0.022
8-9	0.010	0.015
9-10	0.010	0.010
10-11	0.008	0.010
11-12	0.010	0.015
12-13	0.015	0.022
13-14	0.022	0.034
14-15	0.034	0.014
15-16	0.051	0.014
16-17	0.076	0.034
17-18	0.072	0.022
18-19		0.015
19-20		0.010
20-21		0.010
21-22		0.010
Sum	0.600	0.350

BLOCKS

No.	Col.	Xmin	Xmax	Ymin	Ymax
1	170	0	24	0	1
2	57	0	24	1	3
3	180	0	24	3	15
4	151	0	24	15	25
5	15	9	15	15	25
6	145	0	24	25	27
7	174	0	24	27	28

No.	Col.	Xmin [m]	Xmax [m]	Ymin [m]	Ymax [m]
1	170	0.000	0.600	0.000	0.010
2	57	0.000	0.600	0.010	0.020
3	180	0.000	0.600	0.020	0.210
4	151	0.000	0.600	0.210	0.330
5	15	0.280	0.320	0.210	0.330
6	145	0.000	0.600	0.330	0.340
7	174	0.000	0.600	0.340	0.350

COLOURS

Col.	Type	Subtype	Phys. flow	Geom. flow	Name	lambda [W/mK]	t [°C]	h [W/m²K]	q [W/m²]
15	MATERIAL				softwood	0.130			
57	MATERIAL				cement_sand_render		1.000		
145	MATERIAL				gypsum_1200_kg/m³	0.430			
151	MATERIAL				insulation_0.035	0.035			
170	BC_SIMPL	HE			exterior		0.0	25.00	0
174	BC_SIMPL	HI	HOR		interior	20.0	7.70	0	
180	MATERIAL				masonry_heavy	0.900			

<u>CALCULATION PARAMETERS</u>

Maximum number of iterations = 10000
Maximum temperature difference = 0.0001°C

```
Heat flow divergence for total object = 0.001 %
Heat flow divergence for worst node = 1 %
```

F.4.2. Calculation results

Menu command: *View → Results*

<u>Output</u>

- Trisco2D data file name
- Number of nodes
- Iteration convergence quality numbers: heat flow divergence for total object and for worst node
- List of minimum and maximum temperatures per colour (and corresponding X, Y grid numbers)
- List of total heat flows (in and out of object) per boundary condition, and calculated internal temperature (for BC_FRE_S)
- Temperature factor (if requested in *Edit → Derived Thermal Properties...* from main menu)
- Linear thermal transmittance or equivalent thermal transmittance (cf. chosen option in *Edit → Derived Thermal Properties...*)

<u>Remark on listed heat flows</u>

The incoming and outgoing heat flows per boundary condition colour, as listed in the calculation results, are equal to the sums of elementary incoming and outgoing heat flows for all control areas around the system nodes touching that boundary condition colour. This is done this way because the system solution is also calculated from the energy balances containing these heat flows through the control areas.
Sometimes some system nodes belong to more than one boundary condition colour. This happens whenever two boundary condition colours touch each other. Trisco2D requires that those boundary condition colours must have the same type (BC_SIMPL or BC_FRE_S), otherwise an error message appears when starting the calculation. The control area of such a border node is assigned to one of the adjacent boundary conditions.
This implies the possibility that the total heat flow of such a boundary condition is underestimated or overestimated. Note however that the sums of the incoming and outgoing heat flows of all adjacent boundary condition colours are always correct. The underestimation or overestimation error can be decreased by applying smaller grid mesh widths at both sides of the contact nodes of the bordering boundary condition colours.

<u>Example</u>

```
Trisco2D - Calculation Results

Trisco2D data file: roofjunction.tr2

Number of nodes = 8100
Heat flow divergence for total object = 3.29652e-05 %
Heat flow divergence for worst node = 0.000565127 %

Linear thermal transmittance (EN ISO 10211)
psi = Q/(ti-te) - U1*L1 - U2*L2 = -0.008 W/(m.K)
  Q = 18.812 W/m
  ti = 20°C
  te = 0°C
  U1 = 0.365 W/(m².K)
       X1=5 Y1=88 X2=26 Y2=88
       interior_(norma   h=7.700 [(m².K)/W]
       gypsum_900_kg/m   d=0.010[cm]   lambda=0.300 [W/mK]
       masonry_medium_   d=0.140[cm]   lambda=0.320 [W/mK]
       insulation_0.03   d=0.060[cm]   lambda=0.030 [W/mK]
       masonry_heavy     d=0.090[cm]   lambda=0.900 [W/mK]
       exterior          h=25.000 [(m².K)/W]
  L1 = 1.3 m
       X1=1 Y1=88 X2=1 Y2=55
  U2 = 0.365 W/(m².K)
       X1=76 Y1=78 X2=76 Y2=55
       indoors,_upward   h=10.000 [(m².K)/W]
```

```
       gypsum_900_kg/m    d=0.010[cm]    lambda=0.300  [W/mK]
       reinforced_conc    d=0.140[cm]    lambda=2.500  [W/mK]
       concrete_densit    d=0.080[cm]    lambda=1.150  [W/mK]
       insulation_0.02    d=0.060[cm]    lambda=0.025  [W/mK]
       bitumen_sheet      d=0.010[cm]    lambda=0.230  [W/mK]
       exterior           h=25.000 [(m².K)/W]
  L2 = 1.3 m
       X1=5 Y1=15 X2=76 Y2=15
```

Col.	Type	Name	tmin [°C]	X	Y	tmax [°C]	X	Y
17	MATERIAL	limestone_hard	0.01	1	1	0.29	20	6
32	MATERIAL	bitumen_sheet	0.02	5	6	2.73	25	25
72	MATERIAL	concrete_densit	14.52	25	62	18.52	76	68
129	MATERIAL	gypsum_900_kg/m	16.94	25	76	19.22	76	77
133	MATERIAL	insulation_0.03	0.11	11	7	15.82	17	74
135	MATERIAL	insulation_0.02	0.45	43	42	18.02	76	62
136	MATERIAL	reinforced_conc	15.28	17	68	18.95	76	76
148	MATERIAL	masonry_medium_	0.19	25	7	18.81	25	88
170	BC_SIMPL	exterior	0.01	1	1	0.84	26	15
174	BC_SIMPL	interior_(norma	18.16	26	78	19.05	26	88
180	MATERIAL	masonry_heavy	0.03	5	7	1.02	11	88
190	BC_SIMPL	indoors,_upward	17.73	26	77	19.22	76	77

Col.	Type	Name	t [°C]	Flow in [W/m]	Flow out [W/m]
170	BC_SIMPL	exterior		0.00	18.81
174	BC_SIMPL	interior_(norma		7.72	0.00
190	BC_SIMPL	indoors,_upward		11.09	0.00

F.4.3. Temperatures in corner nodes

Menu command: *View → Corner Nodes* 

<u>Output</u>
Per object corner: X,Y grid numbers + calculated temperature

<u>Example</u>

Trisco2D - Temperatures in corner nodes

Trisco2D data file: wall_internal_insulation.tr2

X	Y	t [°C]
0	1	0.23
0	27	19.33
24	1	0.23
24	27	19.33

<u>List of all node temperatures</u>
See .sol file, lines starting with letter N: node temperature + X,Y grid numbers

F.5. Output decimals

Menu command: *Settings → Decimals...*