Steady State heat flow with Simu-Therm 8.0

Hilger & Daniel Software GmbH
www.simu-therm.de

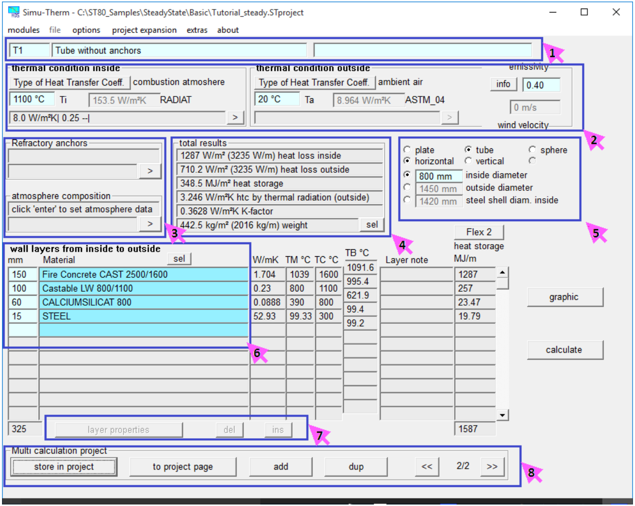
Contents

Structure of this tutorial

This tutorial gives an introduction to the basic functionality of the Simu-Therm 8.0 steady state heat flow calculation.
You learn step by step how to enter a plate calculation and a tube calculation, interpret the results and make printouts.
You can easily perform all of the described calculation examples on on your computer. We strongly recommend to do so.
After working through the tutorial up to the page "Printout example", you will be able to perform standard heat loss calculations.
If you also need to consider air spaces in your applications, you can find this in the last 4 sections.

Overview Steady State calculation page

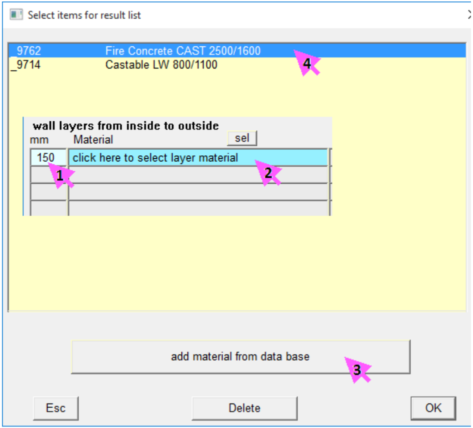
1. descriptions
2. ambient conditions
3. anchor + atmosphere
4. result block
5. geometric properties
6. enter layers
7. layer management
8. navigation in the project



Enter wall layers

Simu-Therm can prosess up to 30 layers in a wall. To add a layer, enter the thickness and select a layer material from the list of project materials.

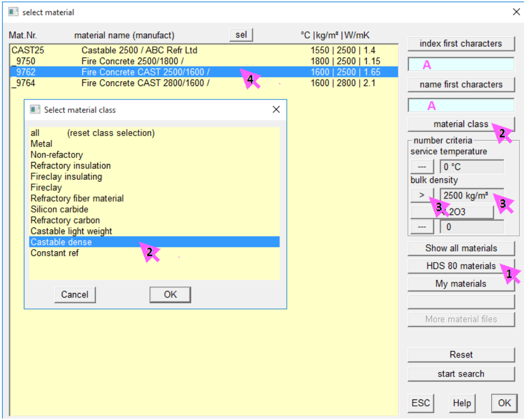
1. first layer: enter thickness **150**
2. to fetch a material from the project material page, use *click here to select material*
3. as there are no materials in the project yet, get one from the database with *add material from data base*. Proceed as shown on the following page to fetch two materals into the project
4. double click **Fire concrete CAST 2500/1600** to get it into the first layer



Add a material to the project

The criteria for material search are: Text search in material ID AND name (A), material class, service temperature, density, chem. analysis component

1. select the database *HDS 80 materials*
2. click on *material class* and select **Castable dense**
3. narrow the selction to density > **2500**
4. select **Fire concrete CAST 2500/1600**
5. as the second material select **Castable LW 800/1100**, using the criteria **Castable lightweight** and density < **1200**



Enter more layers

1. in the second layer line enter thickness **100** and select material **Castable LW 800/1100**
2. click *Reset* to remove the former selection
3. the next layer is 60 mm calcium-silicate: use the text search, select *name contains characters* and type **calc**
4. select **CALCIUMSILICAT 800**
5. the last layer is a 15 mm steel shell: use *name first characters* and type **steel**, then select **Steel**. Now the list of layers should look like **6**

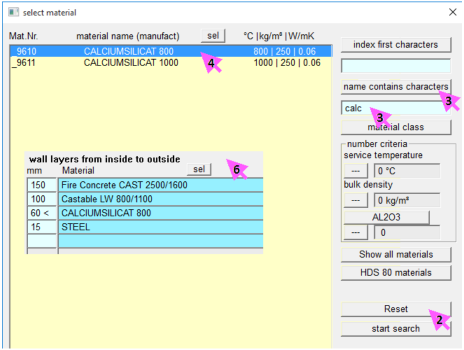
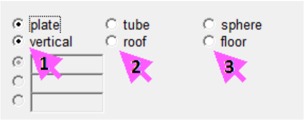


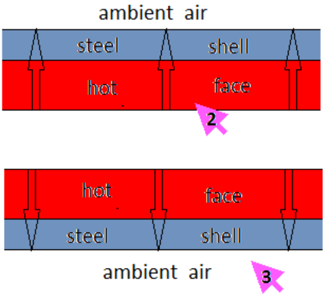
Plate calculation (plane wall)

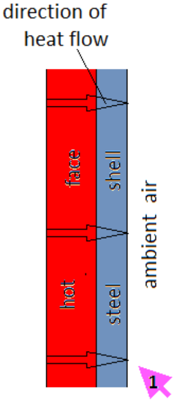
In Simu-Therm, three wall shapes are available: Plate, tube wall, sphere wall
Those are the shapes which can be computed by one-dimensional equations.



For a plate, heat flow is different for the following options:

1. vertical plate
2. roof plate
3. floor plate



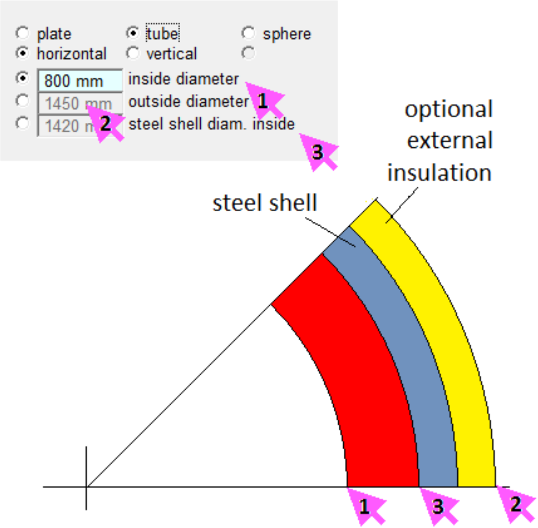


Tube and sphere wall calculation

The orientation of tubes can be horizontal or vertical

For tubes and spheres there are three ways to determine the diameter

1. inside diameter:
2. outside diameter
3. inside diameter of the steel shell (often given by design)

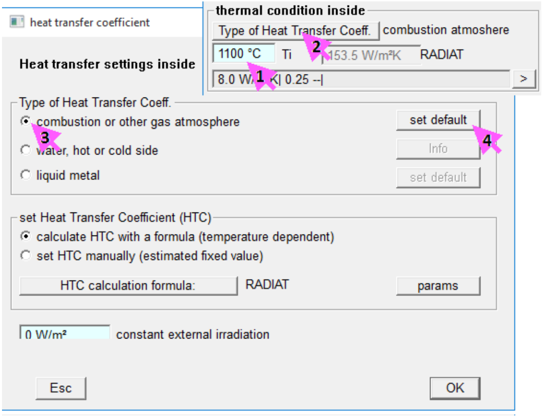


Thermal condition inside

In the block *Thermal condition inside* enter the inside temperature **1100°C in (1)** and select a heat transfer coefficient (= HTC, =film coefficient). You find details about the HTC in a special tutorial. For refractory design calculations just use the default feature, giving the worst case.

2. click on *Type of heat transfer coefficient* to open the HTC dialog
3. select *combustion or othe gas atmosphere*
4. click on *default*

Then the HTC is calculated temperature dependent with Simu-Therm's RADIAT formula assuming a typical combustion atmosphere.



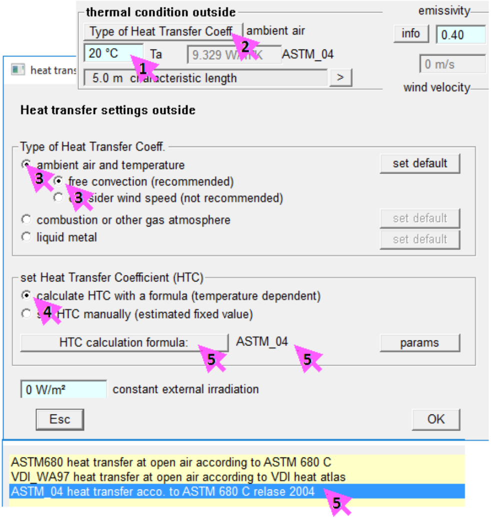
Thermal condition outside

Enter the ambient temperature **20°C in (1)** and select a HTC. The HTC outside usually is important because it controls the outside surface temperature.

2. click on *Type of heat transfer coefficient*
3. select *ambient air* and *free convection*

Free convection is recommended because it is 1.) the worst case and 2.) can be calculated more reliably.

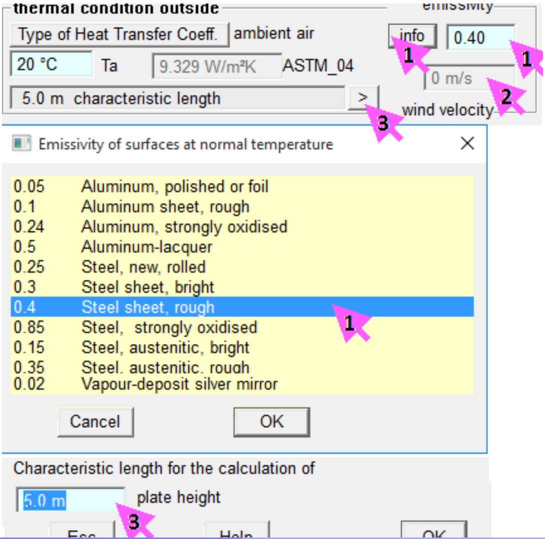
4. select *calculate htc*
5. click on *HTC calculation formula* and select the option **ASTM_04** *heat transfer according to ASTM 680 C release 2004*



Common parameters of the HTC outside

The HTC to ambient air mainly depends on the emissivity of the surface and the wind speed (= wind distant from the surface, **not** the thermal uplift movement)

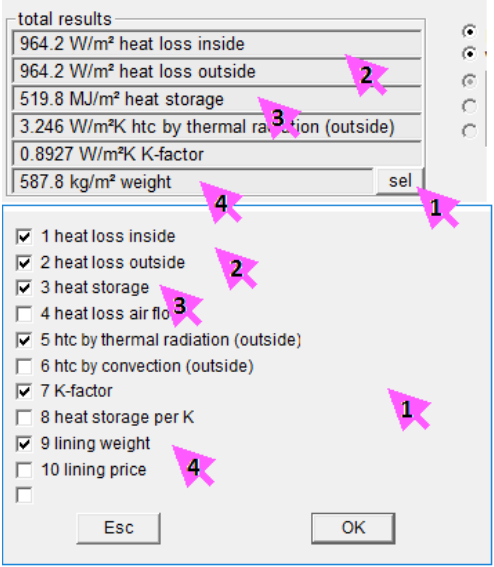
1. enter an emissivity or click on the *info* button to select it from a list of typical materials
2. if you chose *use wind speed* in the HTC dialog, you can enter a wind speed.
3. several calculation formulas need a *characteristic lenght*. Click on the right arrow to enter that figure. In case of a vertical plate it is the height of the plate. As the impact is small, Simu-Therm uses the default value 5 meters.



Results overview block

The results block shows a selection of figures of special interest for the user.

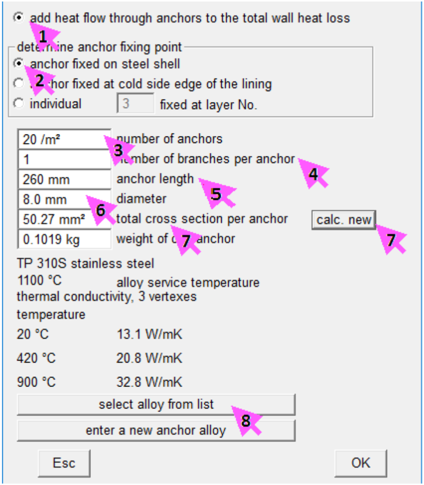
1. click on *sel* to open the selection dialog. Up to 6 selected items can be displayed in the block. The most important figures of a lining are:
2. heat loss (inside and/or outside)
3. heat storage
4. weight



Enter a refractory anchor

1. select *add heat flow through anchors...*
2. select *anchor fixed on steel shell*
3. enter the number of anchors
4. enter the number of branches of an anchor
5. enter the length
6. enter the diameter and click *calc. new* to compute the cross section of an anchor
7. in case of a flat anchor, omit the diameter and enter the cross section
8. select an anchor alloy

For more details about anchors see the special tutorial.

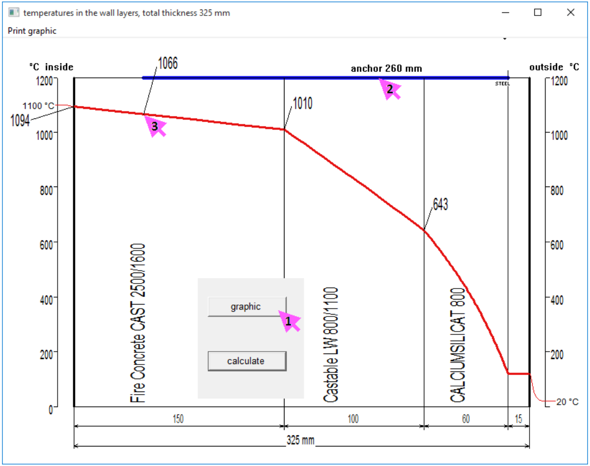


Graphic with refractory anchor

The graphic shows if the anchor was placed correctly.

1. click on *graphic*

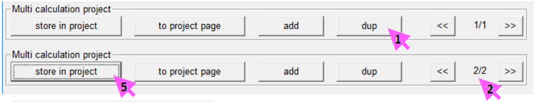
2. the blue line shows the range of the anchors
3. the temperature of the anchor tip is indicated

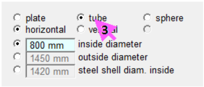


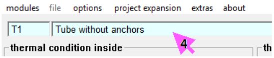
Create a modified copy

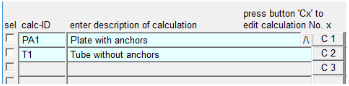
Create a copy of calc. 1, transform it to a tube wall and remove the anchors.

1. click on *dup* to duplicate the calculation
2. note that the project now contains two calculations and the new calculation is no. 2
3. transform to a tube with inside diameter 800 mm
4. change ID and description(s). Set the number and the length of anchors to zero
5. store the modifications in the project









view on the project page

Print calculations

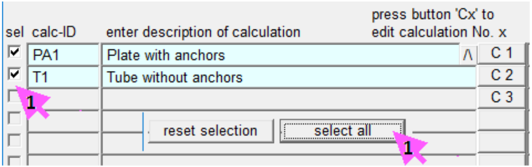
In order to print, switch to the project page

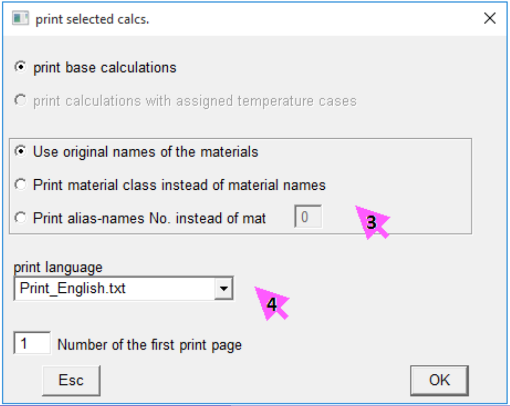
1. select the calculations you want to print, e.g. with *select all*
2. click on *print*

in the print dialog, you can specify details:

3. hide the original material names by replacing them by material groups or by alias names
4. select a language file with a translation list for the printout.

To add languages, you can create own language files





Printout example: Vertical wall

1. logo and page should be altered by the user
2. foot note can can be altered by the user
3. the graphic can be replaced by the standard Simu-Therm graphic, see above
4. the anchor block only appears if anchors are used

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02-16-19

1

SIMU-THERM
HEAT FLOW SIMULATION

1

Steady state heat transfer calculation plane wall - vertical

Offer/Order No.: Name: ®French
Customer: Date:
Project: Revis.Name:
Location: Revis.Date:

Calculation **PA1 // // Plate with anchors**

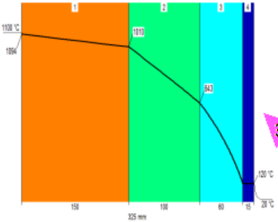
	inside	outside	unit
Ambient temperature	1100	20	°C
Surface temperature	1093.7	119.5	°C
Heat transition coefficient	153.8 (2)	9.677 (1)	W/m²K

(1) Calculation method ASTM C680, issue 2004 Emissivity=0.40 - wind =0 m/s
(2) Calculation method RADIAT / 8.0 W/m²K / 0.25 --

lining characteristics
325 mm total thickness
962.9 W/m² Heat loss inside
473 Heat content total kJ/K
0 price
962.9 W/m² Heat loss outside

wall layers from inside to outside

	Material	Thickn. mm	Density kg/m³	temperature border °C	temperature mean °C	K mean W/mK	Var
1	Fire Concrete CAST 2500/1600	150	2500	1093.7	1052	1.729	+0.023
2	Castable LW 800/1100	100	800	1010.2	829	0.2619	+0.031
3	CALCIUMSILICAT 800	60	250	642.7	415	0.1136	+0.021
4	STEEL	15	7850	119.8	120	52.29	
		325		119.5			



3

Metal anchors 20 /m²
anchor length 260 mm
tip temperature 1066 °C
TP 310S stainless steel service temperature 1100 °C
heat bridge effect considered in
calculation of total heat loss

4

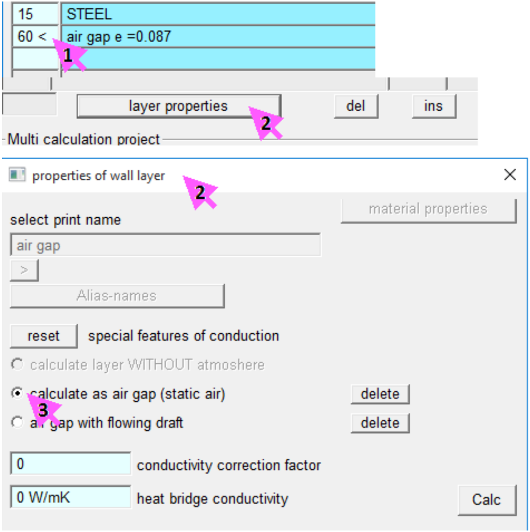
All data specified are calculated figures and are to be understood with the general tolerances.
Heat bridges are not considered in the calculation.

2

Add a static air gap

We add a 60 mm wide static air gap to a copy of the plate calculation. For details about air gaps see the special tutorial

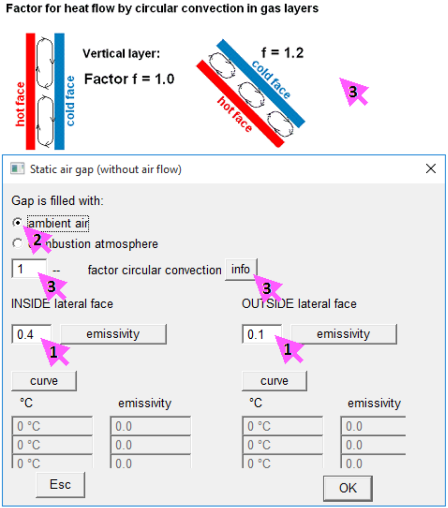
1. enter *60 mm* in the layer line below the steel shell
2. click on *layer properties*
3. in the layer property dialog select *calculate as air gap (static air)* to open the static air gap dialog.



Static air gap dialog

1. enter emissivities **0.4 and 0.1**
Assume that the air space is formed by an aluminum sheet with emissivity $= 0.1$ So the emissivity is 0.4 inside (steel) and 0.1 outside (aluminum). Note that the emissivity of the calculation has to be changed to 0.1

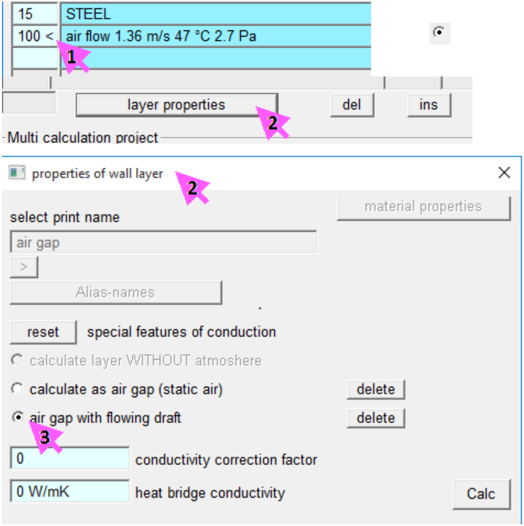
2. click on *ambient air*
3. click on *info* to open an information page about *factor circular convection*, then enter 1



Add a ventilated air gap

We add a 100 mm wide ventilated air gap to a copy of the plate calculation. For details about air gaps see the special tutorial

1. enter *100 mm* in the layer line below the steel shell
2. click on *layer properties*
3. in the layer property dialog select *air gat with flowing draft* to open the ventilated air gap dialog.



Ventilated air gap dialog

1. enter emissivities **0.4** (steel inside) and **0.1** (aluminum outside).
2. enter **5 m** both as uplift height and as flow length, because the height of our wall of 5 m
3. assume that the flow cross section is 50% of the air gap and enter **0.5** as the necking at outlet
4. select the flow type *free colvection*, because the air flow is driven by thermal uplift only, not by a fan
5. select the calculation position *outlet*, because this is the hottest point (possible: inlet, half length, outlet)