

Refractory Lining Thermal Modeller

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What the Refractory Lining Thermal Modeller lets you do.

The Refractory Lining Thermal Modeller (RLTM) allows you to model linings made up of refractory and insulating materials for various furnace conditions. Materials can be dragged and dropped onto lining models, and dragged within them. Material thicknesses, hot face and ambient temperatures, and environmental factors can be adjusted and are reflected live in the model window. Multiple resizable windows can be open at one time, so that potential linings can be compared.

RLTM supports entry of materials in both ASTM and metric systems (or combinations), and produces results in either ASTM or metric.

Lining models can be printed, saved and exported as pdf.

RLTM includes a database structure to allow the easy addition and editing of lining materials. Materials can be exported and imported, and some manufacturers may provide data for their materials on their web sites.

RLTM is useful under steady state conditions for axial flow.

RLTM is available for Windows, and Macintosh OSX operating systems. In general the functionality of RLTM is the same under each operating system, but where differences apply they are noted here.

What RLTM does not do

Great care should be taken before applying the estimates obtained from RLTM to practical projects. Many factors can influence heat flow through a refractory lining including but not limited to; furnace pressure, furnace atmosphere, furnace geometry, gas turbulence. Estimates from RLTM should always be reviewed by a competent engineer.

RLTM does not model fluctuating conditions or complex geometry. It is of use for rapidly modelling axial flow through plane structures. Safe use temperatures for refractories, and their relation to classification temperatures, vary dependant on the application.

What you need

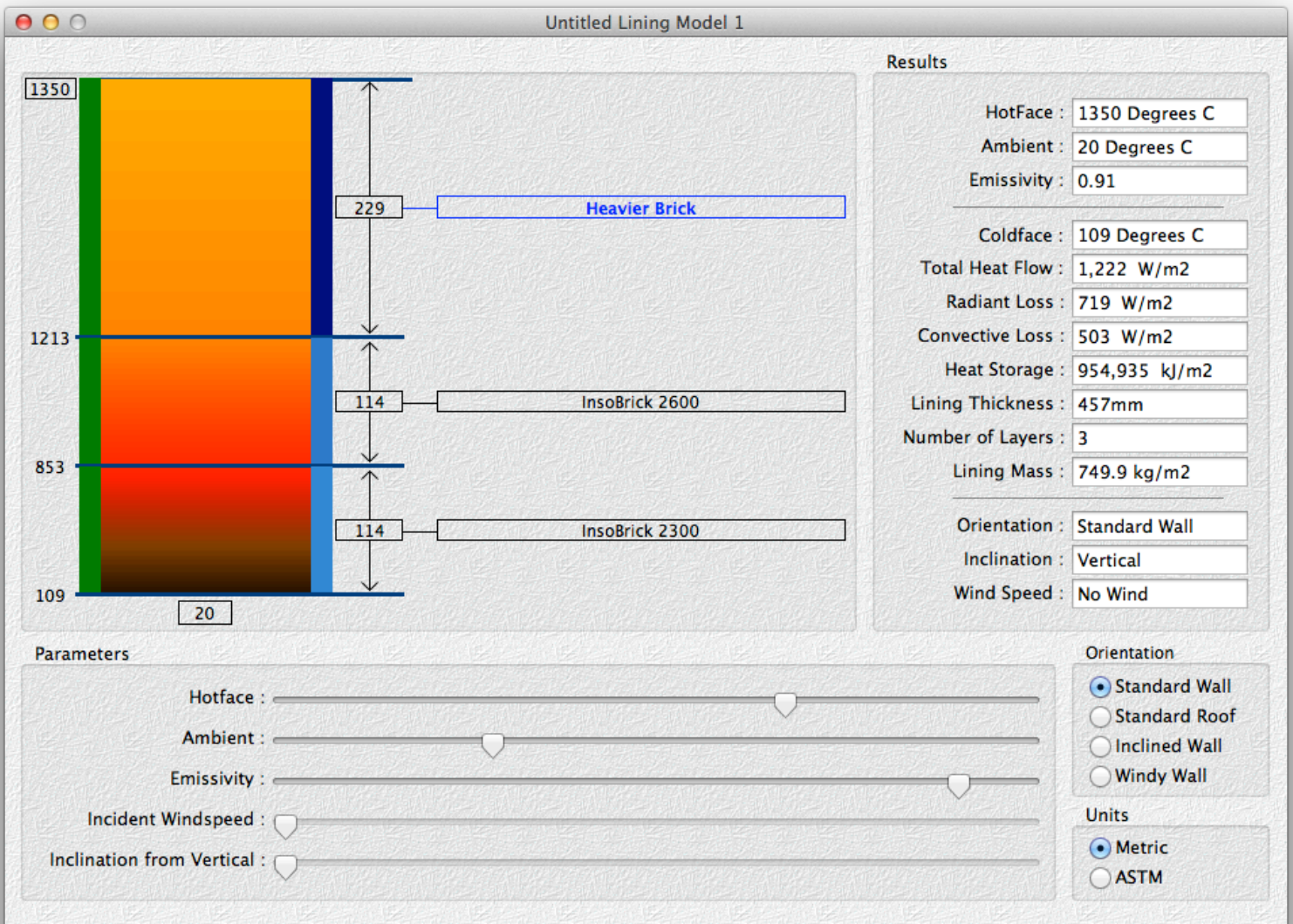
A Pentium or better Windows PC running Windows XP, Vista, 7 or 8.

or

Macintosh running OSX 10.5 or later.

Using RLTM

The main RLTM model window in Mac OSX.



The green bar on the left hand side shows whether materials are approaching or exceeding their classification temperature. As they approach the classification temperature the bar turns orange and then red when the classification temperature is exceeded. The point at which the bar section turns orange can be set as a preference.

The figures to the left of the green bar are the interface temperatures between lining layers. The top boxed figure is the lining hot-face temperature.

The main body is an approximation of a thermal chromatic scale. The boxed figure below it is the ambient temperature.

The blue bar on the right hand side indicates relative layer density. The lining layer name in blue is the selected lining layer.

Interpolated thermal conductivity values can be displayed or hidden by selection of a preference.

When starting up RLTM the about screen will appear giving details about the program and registration this will be visible for about six seconds or you can close this immediately by clicking on it.

On closing the about window, two windows will open “Available Materials” and a calculation window “Untitled Lining Model 1”. These are the main RLTM windows.

The Available Materials window in Mac OSX.

Material Name	Class Temp	Density	Thicknesses				Unit
DiatoVerm 1000	1000 C	360 kg/M3	1	2	3		ins
Dynatherm	800 C	258 kg/M3	1				ins
Heavier Brick	2800 F	2400 kg/M3	3	4.5	6	9	ins
Heavy Brick	1350 C	1800 kg/M3	76	114	230		mm
InsoBrick 2300	2300 F	50 lb/ft3	64	76	114	229	mm
InsoBrick 2600	2600 F	60 lb/ft3	2.5	3	4.5	6	ins
Mud-o-therm 1400	2600 F	120 lb/ft3	4.5	6	9	12	ins
Superfluff 1200	1200 C	145 kg/M3	12	25			mm

The Available Materials window displays a list of all materials in the database that can be added to a calculation.

You can add different thicknesses by editing the “Standard Thickness’es” field on the general pane of the Material Window. Click on the thickness you want and drag it to the Calculation window to add it to the calculation.

You can display all materials or just materials of a certain class by selecting options from the pop-up menu at the top of the Available Materials Window. See the paragraph below “Adding and Editing materials”.

You can alter the columns to be displayed by clicking on the View button.

You can alter the display order by clicking on the list titles. Sort orders on Classification Temperature and Density allow for unit differences.

Please note that the unregistered version of RLTM does not allow adding or editing or materials. Only the demonstration materials are available. (you can view materials in the “Edit Material” window but can’t save changes).

To Create a New Lining Model Select New from the File Menu.

To Open a Saved Lining Model select Open from the File menu.

To Save a Lining Model select Save from the File menu.

When a lining model is saved, the characteristics of the materials used in it are saved with it. If you change the properties of the materials used in the lining model, and then re-open the lining model, it will still use the old properties. The reason for this is to allow opening of models whose materials are not present in your database.

Note that the number of lining models open at one time is limited to eight.

Working with a Lining Model.

Adding Materials to a Lining Model

You add materials to a lining model by dragging them from the Available Materials window and dropping them on the graphic area of the Lining Model Window. You can select from up to four standard thicknesses by dragging from one of the columns.

To alter the Hot face Temperature either :

Adjust the slider below the calculation graphic, or
Click on the Hotface temperature (boxed at top left of the graphic) or
Click on the Hotface field at top right.
Press Ctrl - F (Fire Face - H is taken)

To alter the ambient temperature either,

Adjust the slider below the calculation graphic or,
Click on the Ambient Temperature (boxed below the lining graphic) or
Click on the Ambient field below the Hotface field.
Press Ctrl - A

To alter the thickness of a lining component either

Click on the Blue line at the back of the lining component and drag it to a new position.
(Note that if you drag it so that the thickness is zero the lining component is deleted)
Click on the lining component thickness box (beside the material name)

To delete a selected lining component either,

Press the delete or backspace key or
Reduce the lining component thickness to zero or
Drag the lining component out of the graphic.

To move a lining component :

Click on the lining component material name and drag it to the new position.

To duplicate an existing lining component :

Select the component to be duplicated and press Ctrl - D

To adjust the casing emissivity :

Adjust the slider below the calculation graphic.

To select one of the casing convection models :

Select the radio button beside the model you want. Note that a windy wall with a zero windspeed may give slightly different results to a standard wall.

In the axial steady state model that RLTM uses, heat flow through the lining is generally limited by the insulating properties of the lining components. This means that the calculations for radiant and convective loss will affect the casing plate temperature but will normally have slight impact on the heat flow.

RLTM uses the same temperature for both a background radiation temperature and an ambient air temperature. This can be adjusted by the means detailed above under 'To alter the ambient temperature' and is displayed in a box at the centre of the cold face side (bottom of the graphic) of the lining.

Radiant flux is modelled by RLTM as a straight application of the Stefan-Boltzmann Law.

$$q_{\text{rad}} = E\sigma (T_{\text{Case}}^4 - T_{\text{Ambient}}^4)$$

RLTM includes four models for convective flux from the casing:

1. Standard Wall

$$q_{\text{Conv}} = 1.842 (T_{\text{Case}} - T_{\text{Ambient}})^{1.25}$$

2. Standard Roof

$$q_{\text{Conv}} = 2.372 (T_{\text{Case}} - T_{\text{Ambient}})^{1.25}$$

3. Inclined Wall

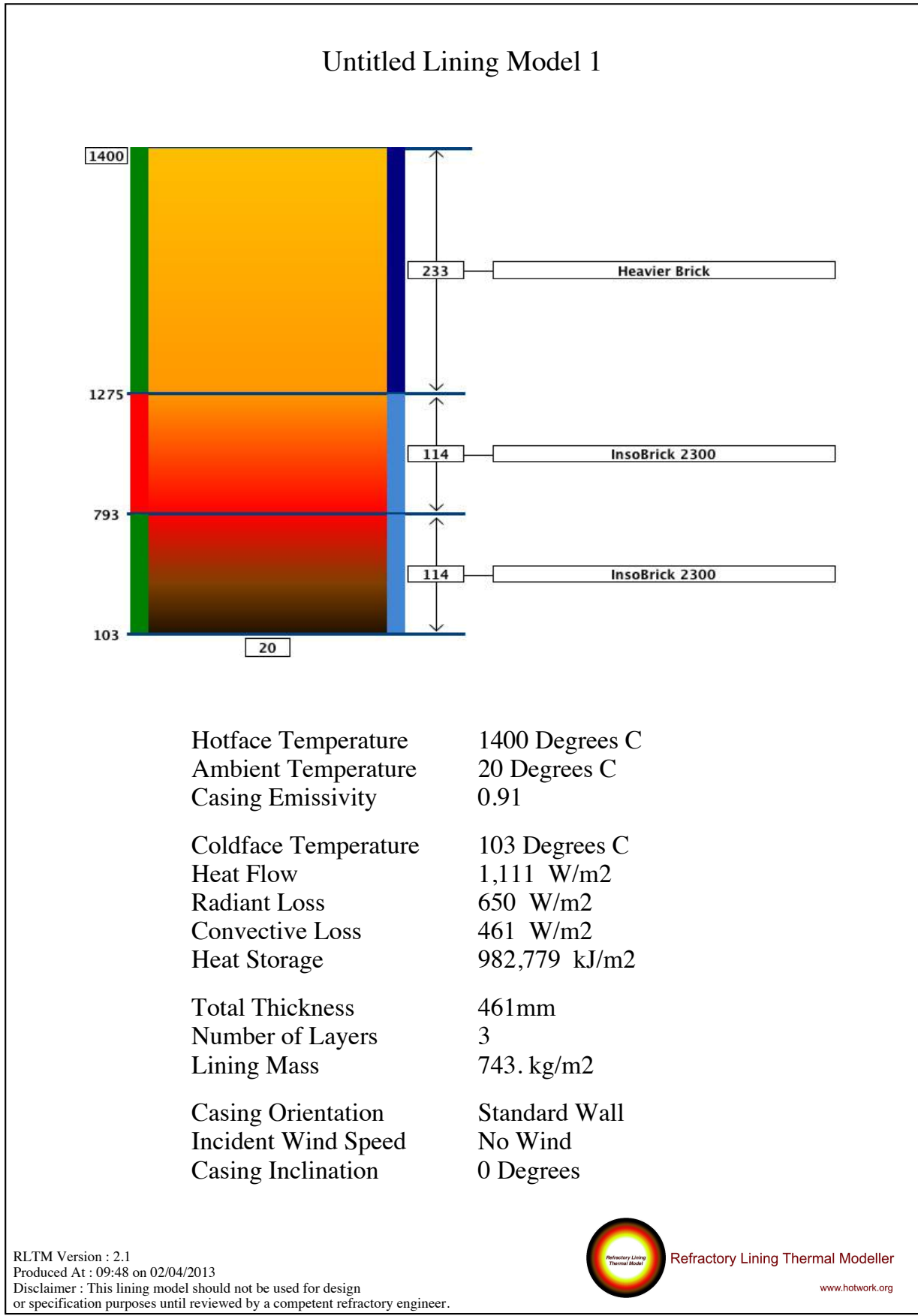
$$q_{\text{Conv}} = \text{Cos (Inclination)} \times 1.842 (T_{\text{Case}} - T_{\text{Ambient}})^{1.25}$$

4. Windy Wall

$$q_{\text{Conv}} = 1.07 \times (9.462 \times \sqrt{(.305 + .87 \times \text{Windspeed})} \times (T_{\text{Case}} - T_{\text{Ambient}})$$

Convective heat transfer is a black art, and difficult to model in practical environments. Where casing emissivity is high (normal), radiant flux will compensate for any shortcomings in the convection models. Where emissivity is low treat convection results with scepticism. There are many more complex expressions for convective loss involving dimensionless numbers, but where casing geometry is not ideal (flat with unobstructed air flow) I am not convinced they give more reliable results.

Printing



RLTM prints in both portrait and landscape orientations.

When you print, you will see a picture in the bottom right hand corner “Refractory Lining Thermal Modeller”. This is the default picture, you can replace it with your own which might include your company name or logo, or any additional standard text as a graphic.

To include your own graphic, open Options(Windows) or Preferences (Mac). Select the second pane - printing, and choose your file. RLTM can use jpeg, png, gif and tiff type graphic files. The file location will be saved, and the graphic included on the printout. If you move or delete the graphic file, you will revert to the default.

RLTM actually allows a space approximately 35 mm high by 140 mm for this graphic. Larger graphics will be scaled down in proportion. A graphic will probably look best if it is created at this 1:4 height to width ratio.

You can also copy either the graphic or the text result block from the front lining model window to the clipboard, and then paste them into your own documents. To do this select the option you require from the edit menu. The clipboard can hold either a picture or text, so if you want both you will have to do the procedure twice. The graphics are clipped at the same size as they are displayed in the lining model window, at screen resolution. Please note that the disclaimer is not displayed as a part of either graphic or text so you will need to include your own statement on this.

You can place a pdf of the calculation on the clipboard by selecting PDF to clipboard from the Edit menu. This can be pasted into emails or word documents.

Units in RLTM

RLTM can produce results in either Metric or ASTM units. It can accept material data in either Metric or ASTM units or in mixtures of the two.

To select output units :

Choose the appropriate radio button at the bottom right of the calculation window.

To set the initial value for output units, open Options(Windows) or Preferences (Mac). Select the Units pane and make your selection. When you open a new calculation window, this will be the default.

To select input units :

You can select units individually for each material property as you enter it, you can also select a unit preference that will switch all of the property units between the Metric and ASTM systems. No conversion takes place when you switch between units. In other words when you enter 40 lbs per cubic foot, and then switch to kg per cubic metre, the figure 40 is unchanged.

When you open a new material window the overall unit preference is set from the Input Unit preference selected in the preference window.

To set the input unit preference :

Open Options(Windows) or Preferences (Mac) Select the Units pane and make your selection.

The preference will apply the next time you open a new ‘New Material’ window.

Adding and editing Materials:

RLTM includes a relational database of materials, together with limited supplier information.

Please note that the unregistered version of RLTM does not permit saving of new or edited materials, or importing/exporting of materials. See the section on registering RLTM below for information on how to register.

RLTM requires certain information about a material in order to function. The required fields are :

- Our Name for Material
- Material Class
- Density
- Standard Thickness
- Classification Temperature
- Thermal Conductivity (at least one data point)
- Specific Heat (at least one data point)

Other properties are optional. You can enter materials without required properties, but they will appear in the list of available materials in italics and cannot be dragged to a calculation. If you attempt to drag an incomplete material a list of missing data will appear.

The screenshot shows a Mac OS X window titled "Material". At the top, there are three colored window control buttons (red, yellow, green). Below them, the window contains several input fields and buttons:

- "Our Name for Material": A text box containing "Heavy Brick".
- "Supplier": A text box containing "Brickworks" and a "Select" button to its right.
- "Supplier's Name For Material": A text box containing "Brick N°1".
- Below these fields are three tabs: "General" (selected), "Thermal Conductivity", and "Specific Heat".
- Under the "General" tab, there are several rows of input fields:
 - "Material Class": A dropdown menu showing "Dense Brick".
 - "Source Of Data": A dropdown menu showing "Supplier's Product Data".
 - "Unit Preference": A dropdown menu showing "Metric".
 - "Density": A text box with "1800" and a dropdown menu showing "kg per cubic metre".
 - "Standard Thickness,es": A text box with "76,114,230" and a dropdown menu showing "Millimetres".
 - "Classification Temperature": A text box with "1350" and a dropdown menu showing "Degrees Centigrade".
- On the right side of the "General" pane, there is a small rectangular image showing a glowing orange brick.
- At the bottom of the pane is a large empty text area labeled "Notes".
- At the bottom right of the window are two buttons: "Save" and "Cancel".

The General Pane of The Material Window (Mac OS X).

The Material window is based on three tab panes.

The following are common to all tab panes :

- Our Name For Material - this is the material name that will appear on all output.
- Supplier - The material's manufacturer or supplier - selected from an editable list.
- Supplier's name for material - provides a connection to the base product while protecting investment in specifications.

First Tab Pane

- Material Class - used mainly to prevent the available materials window becoming too clogged.
- Source of data - self explanatory
- Unit Preference - see above discussion on units.
- Density - used for heat storage and lining weight calculations.
- Standard Thickness - This is the thickness of material that is applied to the calculation when a material is first dragged from the Available Materials window to the Lining Model Window. You can enter a series of thicknesses separated by commas (12,25,50) and these will produce separate material listings in the available materials window.
- Classification Temperature - used to visually indicate when a lining material is close to or above it's classification temperature.
- Notes - self explanatory

Second Tab Pane.

Thermal Conductivity

You can add up to five thermal conductivity data points for any material. RLTM will try to fit a curve to the points that you enter either from your choice or by a best fit option. The resulting curve fit data will be used to interpolate/extrapolate values for lining models.

Materials with less than three data points will always be fitted to a straight line.

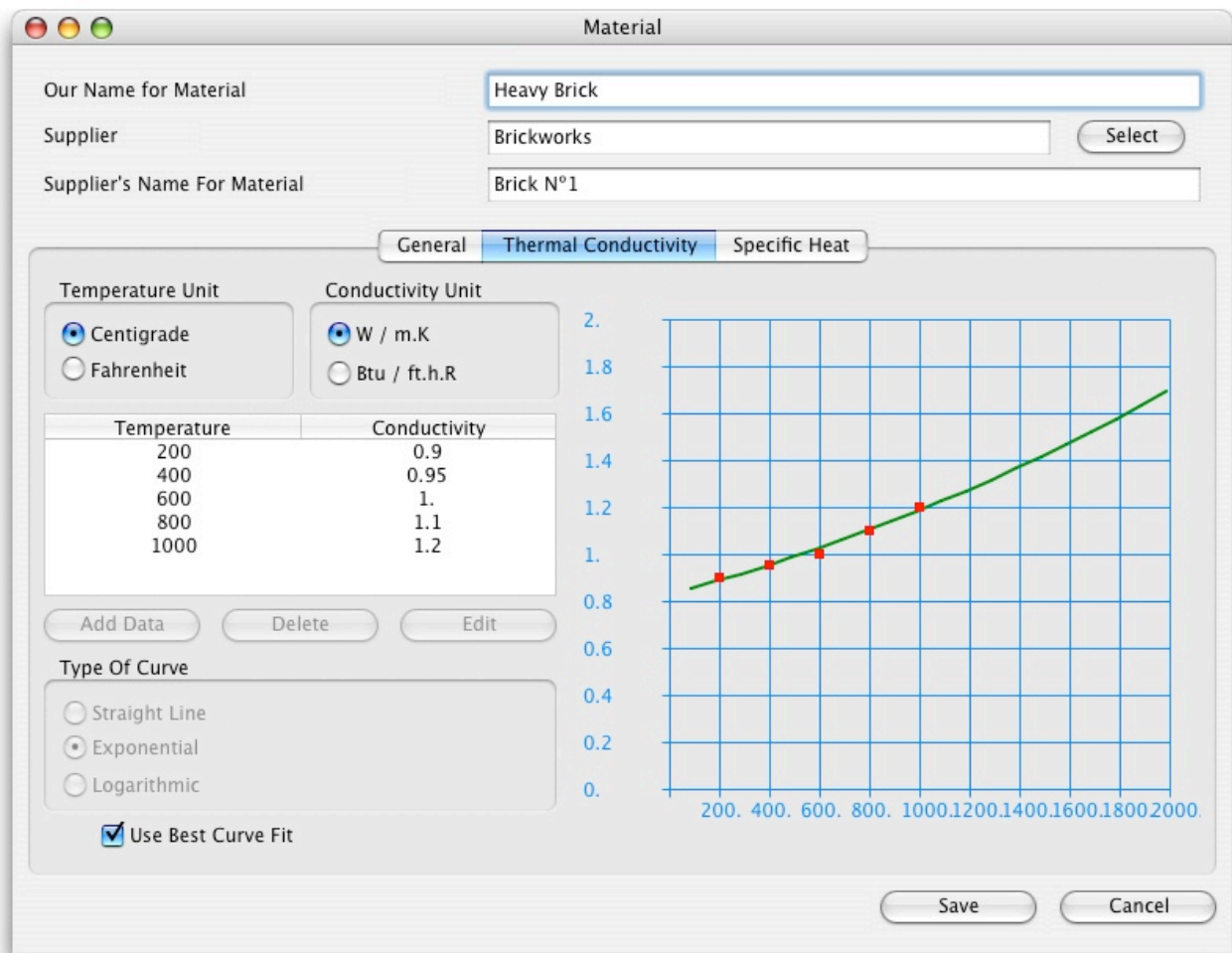
Most materials will be fitted to either a straight line or exponential curve.

Few refractory/insulating materials have thermal conductivity profiles that fit a logarithmic curve. If you see this it might be wise to check your data.

To add a new data point click on the add data button and enter the temperature and conductivity data in the window displayed.

To edit a data point, select it and click on the edit button, or double-click on the entry.

To delete a data point select it and click on the delete button.



The Thermal Conductivity Pane of the Material Window (Mac OSX)

Third Tab Pane

Specific Heat

You can add up to five specific heat data points for any material. RLTM will try to fit a curve to the points that you enter either from your choice or by a best fit option. The resulting curve fit data will be used to interpolate/extrapolate values for lining models.

Materials with less than three data points will always be fitted to a straight line.

Specific heat data is used to calculate the heat storage of a lining.

Manufacturers do not always print specific heat data on their literature, for most alumino silicate refractories a single value of 1.13 kJ / kg.C or 0.27 Btu / lb.F may give a coherent result.

To add a new data point click on the add data button and enter the temperature and conductivity data in the window displayed.

To edit a data point, select it and click on the edit button, or double-click on the entry.

To delete a data point select it and click on the delete button.

Importing and Exporting Materials

The registered version of RLTM can export and import materials from other users.

RLTM exports materials in specially formatted text files.

To Export Materials, select Export Materials from under the file menu. You can choose to export all classes of material or just one class. You can also choose to export materials from all suppliers or from just one. You may have to create more than one file to get all the materials that you want. When you have set up the export parameters that you desire, click on the Export Materials Now button. You will see the standard file save prompt.

To Import Materials, select "Import Materials from under the file menu. Then click on the "Select File From Which to Import Materials..." button. The standard file open dialog will appear allowing you to select an import file. RLTM checks to see that the file is a RLTM import file, if it is, the name of the file will appear in the edit field above the button, if not, a warning message will appear. If the file is the correct format, the Import Now button at bottom right will be enabled.

You can import in three different ways :

Import All Materials : All materials in the import file will be added to the database, if they already exist, the original data will not be disturbed but new copies with the same name will be appended to the database. You can select which to delete later.

Skip materials already in database : All materials in the import file are checked against the names of materials already in the database. If they are already present they are not imported and the existing data is not altered. If they are not present they are appended to the database. Note that only the name is checked, if a material has the same name as one already in the database, but other properties are different, it is still not imported.

Replace Materials already in database : All materials in the import file are checked against the names of materials already in the database. If a material with the same name is already present the existing data is overwritten with the new imported data. If it is not present the new material data is appended to the database.

General Notes about the calculation.

The conductivity calculation is based on the thermal resistance model. Thermal conductivity is interpolated from the data entered for a material at the arithmetic mean temperature in a layer. Since many materials have non linear thermal conductivity curves, some distortion can occur if large layer thickness values are used for materials of this type. You can test this yourself by creating two models, one with one layer of ceramic fibre blanket 300 mm thick and one with twelve layers of ceramic fibre blanket 25 mm thick. More thinner layers should give an answer closer to reality. Beware of using blanket data for folded ceramic fibre modules. Always remember that RLTM is only a model.

Version History

1.00 Original Version

1.01 Fixed Windows file suffix bug.

Added Menu Shortcuts

RLTM now remembers position and shape of Available Materials

Added view option to control displayed columns in Available Materials.

Added multiple thicknesses for materials

Name change to RLTM throughout.

Added Document Icons for saved models.

Available Materials now hides properly when RLTM is deactivated.

Print and Save menus now deactivate when there is nothing to print or save.

Stiff Warning added.

Notes Field in Material Window now works properly.

Supplier window now checks for non SQL compliant characters.

Added import/export capability.

Added Graphic/Text to clipboard.

1.02 Fixed bug in material selection.

RLTM can now handle internally generated RowIDs in 32 bit variables.

Splash screen now shows correct version.

1.03 Fixed bug in material selection as it related to material deletion.

KValues in Lining model now limited to four decimal places.

Revisions to this manual.

1.04 Fixed bug in conversion of doubles to strings on non-English platforms.

Fixed Import Export Bug.

Revised material validity format.

2.1 Windows 7/8 compatibility improved.

OSX version now contains no PPC code - compatible Lion and Mountain Lion.

Database standard updated to sqlite.

Calculation window reorganised for clarity.

Available Materials window updated.

Unit option added to Calculation window.

Printouts updated, logo issues addressed.

PDF output to clipboard and file.

Import/Export rewritten.

General appearance improvements and bug fixes.

Preferences/Options expanded and reorganised.

Esellerate licensing/activation.

Internet based Beta system.

Preferences/Options migrated to Mac pList/ Windows Registry.

How to Register RLTM

RLTM is limited to use of the initial fictional materials unless it is registered.
Registration costs \$399.00 (USD).

To register :

Select the “Purchase” from under the file menu in RLTM.
Click on the “Purchase” button in the new window.
This will take you to the Esellerate (Digital River) Site where you can complete payment.

You can deactivate a Serial Number and then use it on another computer.

To do this :

First export all your materials as described above.
Select “License and Updates...” from under the file menu in RLTM.
Click on the “Deactivate Serial Num..” button.
A warning appears - Click on the “Deactivate” button.
The Serial number is deactivated and can be used on another computer.

When you deactivate a copy of RLTM, the database reverts to its unregistered format with the seven sample materials. Your existing data is saved in the same folder with a series of numbers after the name “RLTMMaterials” - it will look something like “RLTMMaterials3449479147”.

RLTM requires an internet connection for registration, validation and activation.

Bug reports and support.

We would be glad to hear any comments regarding the software. You can contact hotwork by selecting the E-mail Hotwork option from under the file menu in RLTM or by e-mailing support@hotwork.org.

Legal Stuff

RLTM is licensed as a beta version and may contain bugs, errors and inaccuracies. It is for use by people wanting to rapidly model different refractory linings. All results should be checked before being applied to a project or specification. We have taken great care in writing RLTM, but can accept no liability for any losses arising from it's use, whether registered or unregistered.

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We hope you have a lot of fun with it.