A PC Program

THERM 8



for Analyzing Two-Dimensional Heat and Moisture Transfer Through Building Products

Windows and Daylighting Group Building Technologies Department Environmental Energy Technologies Division Ernest Orlando Lawrence Berkeley National Laboratory Berkeley CA 94720 USA

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THERM 8: Program Description

A PC Program for Analyzing the Two-Dimensional Heat Transfer Through Building Products

Christian Kohler, Charlie Curcija, Robin Mitchell, Dariush Arasteh Stephen Czarnecki, Simon Vidanovic, Ling Zhu Windows and Daylighting Group Building Technologies Department Environmental Energy Technologies Division Lawrence Berkeley National Laboratory Berkeley, California 94720 http://windows.lbl.gov/software/software.html

> Charlie Huizenga Center for Environmental Design Research University of California Berkeley, California

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1.1. Overview

THERM is a Microsoft Windows[™]-based computer program developed at Lawrence Berkeley National Laboratory (LBNL) for use by building component manufacturers, engineers, educators, students, architects, and others interested in two-dimensional heat transfer. Using THERM, you can model two-dimensional heat-transfer effects in building components such as windows, walls, foundations, roofs, and doors, appliances, and other products where thermal bridges are of concern. THERM's heat-transfer analysis allows you to evaluate a product's energy efficiency and local temperature patterns, which may relate directly to problems with condensation, moisture damage, and structural integrity.

THERM's two-dimensional conduction heat-transfer analysis is based on the finite-element method, which can model the complicated geometries of building products. The program's graphic interface allows you to draw cross sections of products or components to be analyzed. To create the cross sections, you can trace imported files in DXF or bitmap format, or input the geometry from known dimensions. Each cross section is represented by a combination of polygons. The material properties are defined for each polygon and the environmental conditions to which the component is exposed are defined by the boundary conditions surrounding the cross section. Once the model is created, the remaining analysis (mesher and heat transfer) is automatic. You can view results from THERM in several forms, including U-factors, isotherms, heat-flux vectors, and local temperatures.

THERM's results can be used to define the frame elements in the Berkeley Lab WINDOW program's centerof-glass optical and thermal models to determine total window product U-factors and Solar Heat Gain Coefficients.

Program downloads, update information, and Knowledge Base articles about THERM and the other software tools from the Windows and Daylighting Group at LBNL can be found at: <u>windows.lbl.gov</u>. If you have questions or problems about using the program, email <u>ThermHelp@lbl.gov</u> or go to the THERM Forum (Google Group) at <u>https://groups.google.com/forum/#!forum/lbnl-therm</u> where you can post and reply to questions about the program.

1.2. THERM 8 Transient Moisture Model

The THERM simulation engine been extended to model time dependent (transient) simulations (a "time domain" has been added to THERM's original 2-D Finite Element Numerical Model (FEM)), and a moisture transfer model has been added.

The transient thermal and moisture simulation engine in THERM (called HygroThermFEM) allows modeling of thermal bridges and non-homogeneities in building construction without approximation. Such elements are primary pathways and causes for condensation and moisture in building and it is important to model them correctly in a thermal/moisture analysis. By failing to account for the moisture characteristics in the thermal envelope, designers and building can introduce problems that endanger the health and safety of building occupants as well as the durability of the building itself.

The HygroTHERMFEM model in THERM8 will allow building simulation practitioners to accurately model wall, roof, foundation constructions taking into account both the thermal and moisture characteristics of those constructions.

1.3. Changes from THERM 7 to THERM 8

The following are the changes made to THERM 8 to accommodate the new moisture model:

- Simulation engine options (File / Properties)
 - Steady-state without moisture (THERM 7)
 - Transient/moisture
- Material and Boundary Condition Libraries
 - The Material and Boundary Condition Libraries for the transient / moisture model are stored in the XML file format and have a new grid view
- Visualization "window" for viewing the moisture results

This document is not a complete THERM user manual, but instead contains the changes made to THERM 8 for the Transient Moisture Model.

2.1. Overview

THERM allows modeling both transient moisture and thermal simulations, as well as stead-state thermal simulations.

The sections below describe the settings for transient moisture and thermal simulations.

2.2. File / Properties

The File / Properties dialog box controls what model is used for a given file. All the settings in the three tabs of the File / Properties dialog box are saved with individual files, not as program-level settings.

Calculation Options tab

Below is a description of the fields in the File / Properties / Calculation Options tab.

File Properties Calculation Option	Model Exposure			
Heat Transfer		Simulation Engine		
Z Moisture		◯ Steady-State Thermal (C	onRad)	
Transient		Transient Thermal + Mois	sture (HygroTi	hermFEM)
Initial Conditions		Simulation Engine Parameter	s	
Initial simulation conditions w	ill be based on:	Convergence Tolerance	0.01	1
O Use values from text file	e (warm up section)	Polavation Parameter	1]
OUse first time step in tex	t file]
User defined - Constant	values everywhere	Time Step	360	sec
Temperature 69.8	F	Number of Time Steps	100	
Relative Humidity 10	%	Mesh Control		
		QuadTree Mesh Parameter	6	
Steady State		Run Error Estimator		
No Time Variable		Maximum % Error Energy	Norm 10	
 False transient (using state BCs) 		Maximum Iterations	5	
Initial Conditions		Miscellaneous Parameters		
Temperature 6	9.8 F	Radiance Mode		
Relative Humidity 5	i0 %	Use CR for Glazing Systems		
		Check for Correct WIND	OW BC on Gl	azing Systems
Modeling Options		Modeling Options		
Water Liquid Transportatio	n	Automatically adjust rela	xation parame	ter
Heat of Evaporation		Adjustment step -0.0)1	
Capillary Conduction				
Vapor Diffusion		Maximum iterations 25		
Temperature and Moisture Thermal Conductivity	Dependency on	View Factor Smoothing		
Latent Heat of Fusion				

Figure 2-1. File/Properties contains settings for both the steady-state and transient models.

Heat Transfer	Check this box to model heat transfer.
	Checking this box is appropriate for
	 Simulation engine = Steady-State Thermal (ConRad) Simulation engine = Transient Therm + Moisture (HygroThermFEM)
Moisture	Check this box to model moisture.

	Checking this box is appropriate for				
	 Simulation engine = Transient Therm + Moisture (HygroThermFEM) 				
Transient					
Initial Conditions	 Initial simulation conditions will be based on either: User values from text file (warm up section): <i>currently not implemented</i> Use first time step in text file: <i>currently not implemented</i> User defined – Constant values everywhere Temperature: Default: 21 C. Relative Humidity: Default: 50. Units: percentage (%) 				
Steady State (f Currently not in	for HygroThermFEM engine) nplemented in THERM 8				
No Time Variable	This uses the same steady state equation to calculation heat transfer as ConRad, and there is no time variable. See technical documentation				
False transient (using state BCs)	 This runs a transient simulation until it reaches a steady state solution. Initial Conditions: this sets the temperature and relative humidity of the entire mode to start the simulation. It is also necessary to have transient-style Boundary Conditions (ie, XML file) that have contant temperature and relative humidity values over the timesteps. 				
Modeling Opt For the HygorT	cions hermFEM simulation engine				
	 These are modeling options to set when modeling moisture using the HygroThermFEM engine: Water Liquid Transportation: Models transport of water in a liquid state. If this is not checked, then only water vapor is modeled. Heat of Evaporation: Models phase change of water. Capilary Conduction: Models capillary transport through Vapor Diffusion Conduction: Models diffusion of vapor thorugh material. Temperature and Moisture Dependency on Thermal Conductivity: <i>Currently not available</i> Latent Heat of Fusion: <i>Currently not available</i> 				
	Default: All options are selected by default.				
Simulation En	lgine				
Steady-State Thermal (ConRad)	Steady-state thermal simulation				

Transient Therm + Moisture (HygroTherm FEM)	Transient thermal and moisture simulation engine
Simulation En	igine Parameters
Convergence Tolerance	This controls the simulation error norm tolerance. If the error norm calculation is greater than this value, the program will display an "non-convergence" error message. If using the transient moisture model and it doesn't converge, this value could be reduced to 1e-02. Used in both the ConRad and HygroThermFEM simulation engines.
Relaxation	This is the initial value for relayation parameter used in iterations
Parameter	
	Used in both the ConRad and HygroThermFEM simulation engines.
	Default: 1.
Time Step	This parameter is used by the HygroThermFEM transient model to set the length of the time step. The default value of 3600 seconds equals 1 hour. Default: 3600. Units: seconds.
Number of Time Steps	This parameter determines how many times steps are calculated when the HygroThermFEM engine is selected. It works in conjunction with the Time Step value. The default Time Step value of 3600 seconds (1 hour) used with the default value of the Number of Time Steps (8670) would result in a simulation at 1 hour intervals for a year. Default: 8670. Units: unitless
Mesh Control For both the Hy	gorThermFEM and ConRad simulation engines
Quad Tree Mesh Parameter	The relative size of the finite element mesh created for the model. The larger the number the finer the mesh. The upper limit of the mesh parameter is usually 9. Increasing this value may help mesh files that return "mesh errors". Default: 6.
Run Error Estimator	If this option is checked, the program will perform the calculation of the error energy norm. If the simulation does not meet the value in Maximum % Error Energy Norm, the program will increment the Quadtree Mesh Parameter (if Automatically increment mesh parameter is checked on the Simulation tab), until the Maximum Iteration value is reached. Default: checked.
Maximum % Error Energy Norm	THERM incorporates a local error estimator and subsequent local mesh refinement. The error estimator is based on a published and well regarded methodology based on the estimate of Error Energy Norm (EEN). In this technique,

	only regions with an EEN larger than the threshold value are refined, resulting in optimum mesh size. An EEN value of 10% is chosen for the default because it results in overall computational accuracy of well below 1%, which is the ISO 10211 requirement. Default: 10%				
Maximum Iterations	The number of iterations for the program to run in an attempt to meet the Maximum % Error Energy Norm specified. Default: 5				
Miscellanceou For the ConRad	s Parameters simulation engine				
Radiance Mode	If this option is checked, THERM will use Radiance to model the optical properties of a THERM model. This is used for modeling shading systems whose geometry is modeled in THERM. The THERM background will turn gray when this option is checked, to indicate that this option is selected, because this is not an option that would normally be used.				
Use CR for	If this option is shocked. THERM will perform a Condensation Resistance simulation				
Glazing Sustems	as well as the standard U-factor calculation.				
e getenite	This option only applies to the ConRad Simulation Engine.				
	Default: unchecked.				
Check for Correct WINDOW BC on Glazing Systems	If this option is checked, THERM will check to see that the Boundary Conditions applied to an imported WINDOW glazing system match those that were imported with that glazing system. Default: unchecked.				
Modeling Opt	ions				
Automatically adjust relaxation parameter	When equations are not converging, the relaxation parameter modifies previous iteration result in order to better converge. The values are from 0 to 1. The solver starts from a value of 1 and reduces it from there.				
	For ConRad simulation engine.				
	Detault: checked				
Adjustment step	Incremental reduction of the relaxation parameter from 1 to 0.				
	For ConRad simulation engine.				
	Default: -0.01				

Maximum iterations	Number of iterations to apply the automatic relaxation parameter adjustment to. <i>For both the HygorThermFEM and ConRad simulation engines</i> Default: 25
View Factor	This is used for gray body radiation calculation. If the view factors (surfaces being viewed) are very different, such as blocking surfaces, the view factor smoothing helps accuracy of results. See TARCOG technical documentation on the THERM documentation webpage.
Smoothing	<i>For ConRad simulation engine.</i>

Typical settings for a transient thermal and moisture simulation (HygroThermFEM)

Heat Transfer			Simulation Engine		
Moisture			◯ Steady-State Thermal (0	ConRad)	
Transient			Transient Thermal + Mo	isture (Hygro	ThemFEM)
Initial Conditions			Simulation Engine Paramete	rs	
Initial simulation condition	ns will be b	ased on:	Convergence Tolerance	0.01	
 Use values from tex 	t file (warm	up section)	Relaxation Parameter	1	
Use first time step in	n text file		Time Step	360	
User defined - Cons	stant value:	s everywhere	Number of Time Steps	100	
Temperature	59.8	F	Number of Time Steps	100	
Relative Humidity	10	%	Mesh Control	C	_
O Standy State		-	Quad Iree Mesh Parameter	0	
Steady State		Maximum & Error Energy	u Norm	0	
No Time Variable		Manimum Reactions	,		
 False transient (using state BCs) 		Maximum Iterations	0		
Initial Conditions	69.9		Miscellaneous Parameters		
Temperature 69.8 F		Radiance Mode			
Relative Humidity	, 50	%	Use CR for Glazing Systems		
				OW BC on	Glazing Systems
Modeling Options			Modeling Options		
Water Liquid Transpor	tation		Automatically adjust relation	axation parar	meter
Heat of Evaporation			Adjustment step -0.	01	
Capillary Conduction			Maximum iterations		
Vapor Diffusion	_				
Temperature and Mois Thermal Conductivity	ture Deper	ndency on	View Factor Smoothing		
Latent Heat of Fusion					

Figure 2-2. Typical File/Properties settings for a transient thermal and moisture model.

Typical settings for	a steady-state thermal	calculation	(ConRad)
<i>J</i> 0	5		· /

THERM File Properties	×
Therm File Properties Calculation Options Model Exposure	
 ✓ Heat Transfer ✓ Moisture Transient Initial Conditions Initial simulation conditions will be based on: Use values from text file (warm up section) Use first time step in text file User defined - Constant values everywhere 	Simulation Engine Steady-State Thermal (ConRad) Transient Thermal + Moisture (HygroThermFEM) Simulation Engine Parameters Convergence Tolerance 0.01 Relaxation Parameter Time Step 360 sec Sec
Temperature69.8FRelative Humidity10%	Number of Time Steps 100 Mesh Control
 Steady State No Time Variable False transient (using state BCs) Initial Conditions Temperature 69.8 F Relative Humidity 50 % 	Run Error Estimator 10 Maximum % Error Energy Norm 10 Maximum Iterations 5 Miscellaneous Parameters 5 Radiance Mode Use CR for Glazing Systems Check for Correct WINDOW BC on Glazing Systems
Modeling Options Water Liquid Transportation Heat of Evaporation Capillary Conduction Vapor Diffusion Temperature and Moisture Dependency on Thermal Conductivity Latent Heat of Fusion	Modeling Options Automatically adjust relaxation parameter Adjustment step -0.01 Maximum iterations 25 View Factor Smoothing
	OK Cancel Apply

Figure 2-3. Typical File/Properties settings for a steady-state thermal model.

Model Exposure tab

Below is a description of the fields in the File / Properties / Model Exposure tab.

Therm File Properties	Calculation Options Model Exposure		
Model Purpose:	Opaque Facade 🗸 🗸	Assembly Type:	Wall \checkmark
Model Orientation:	0 degrees	Cross Section Type:	Header ~
Gravity Vector Down	~		



Model Purpose	<i>e</i> This pulldown list consists of the following options				
	 Window / Transparent Façade Opaque Façade Other 				
	Outer				
Assembly Type	If Model Purpose is set to Opaque Façade , this pulldown list becomes active with the following choices:				
	WallRoof				
	If Model Purpose is set to either Window/Transparent Façade or Other , this value is set to " N/A ".				
Model Orientation	The direction the exterior surface of the model faces. This orientation of the exterior surface is used to determine the wind direction for the simulation.				
	Below are the standard Cardinal orientations, but any value from 0 – 360 may be entered.				
	• North = 0				
	East = 90				
	 South = 180 West = 270 				
	Legal values: 0 – 360.				
	Units: degrees				
Cross Section	The values in this pulldown depend on the Model Purpose selection.				
туре	 If Model Purpose = Window / Transparent Façade, the choices are 				



2.3. Material Library

The Material Library is different depending on the Simulation Engine selected.

- ConRad: If the ConRad simulation engine is selected, the Material library is the same as in previous versions of THERM.
- HygroThermFEM: If the HygroThermFEM simulation engine is selected, the Material library is much different.

2.3.1. Material Library List View

Selecting the Material choice from the Libraries menu when the HygroThermFEM simulation model is selected displays the Materials in "List View".

Materials Libr	ary						
Detailed View	Name	Туре	k	ρ	Ср	μ	Φ
New			Btu/h-ft-F	lb/ft3	Btu/lb-F		
	Laminated panel	Solid	0.072224	28.092588	0.334384	203.000000	0.550000
Сору	Aerated Concrete	Solid	0.057779	24.971189	0.203019	7.900000	0.810000
Delete	Stucco	Solid	0.491121	112.370353	0.203019	19.000000	0.240000
Import	Chipboard	Solid	0.063557	37.456784	0.334384	70.000000	0.500000
impore	Cellulosic Fiber	Solid	0.019067	3.433539	0.334384	1.500000	0.950000
Export	Fiberglass Batts	Solid	0.024845	0.549366	0.200631	1.210000	0.999000
Report	OSB Board	Solid	0.080890	44.948141	0.334384	92.000000	0.620000
	Plywood	Solid	0.104002	34.335386	0.334384	700.000000	0.500000
Print	Softwoods (Coniferous)	Solid	0.080890	31.213987	0.382153	200.000000	0.730000
Save Lib As	Hardwoods (Deciduous)	Solid	0.104002	43.699582	0.382153	4.300000	0.730000
Load Lib	Gypsum Board Exterior	Solid	0.115558	42.138882	0.203019	8.330000	0.710000
	Gypsum Board Interior	Solid	0.115558	39.017484	0.203019	8.330000	0.730000
	Cottaer Sandstone	Solid	1.040021	127.977346	0.203019		0.220000
	3-ply cross-laminated panel	Solid	0.069335	28.342300	0.000029		0.560000
	Frame Cavity	Cavity					

Figure 2-9. Material List View.

Buttons

The buttons on the left hand side of the List View have the following functions:

Detailed View	Used to access the detailed view of the record, where the input values can be edited.
New	Used to make a new record, based on a default record. Click the New button, and the program will create a new record at the bottom of the list called "Default Name". Highlight that record and click the Detailed View button to edit the new record as needed.
Сору	Used to copy an existing record (including name and all associated input values) into a new record. Highlight the record to be copied and click the Copy button. The new record will be added to the bottom of the list. Highlight that record and click the Detailed View button to edit the new record as needed.
Delete	Used to delete a record. Highlight the record to delete and click the Delete button.

Import	Currently disabled.
Export	Currently disabled.
Report	Currently disabled.
Print	Currently disabled.
Save Lib As	Currently disabled.
Load Lib	Currently disabled.

Column Headings

The List view contains columns with selected results (from the Detail view) for each record, as described below.

Name	The name of the material.
Туре	The material type, from the options of Solid Frame Cavity Glazing Cavity External Radiation Enclosure Shading Material
k	Conductivity of the material. Units: Btu/h-ft-F (IP); W/m-K (SI)
ρ	Density of the material. Units: lb/ft3 (IP); kg/m3 (SI)
Ср	Specific heat of the material. Units: Btu/lb-F (IP);J/kg-K (SI)
μ	Water Vapor Diffusion Resistance Factor. Units : unitless
Φ	Porosity of the material. Units: unitless

2.3.1. Material Library Detail View

Name	Laminated panel					List Vi
Mate	rial Type					Sav
٥s	olid			Liquid Transportation Red	listribution	~
OF	rame Cavity			Water Content [lb/ft3]	DI [ft2/s]	Cano
G	lazing Cavity			0	0	No
OE	xternal Radiation Er	ndosure		3.55839	5.59723e-10	IVEV
Os	hading Material			33.3365	1.07639e-09	Сор
	2					Edi
Solid	Properties					
	Conductivity	0.072	Btu/h-ft-F			
	Emissivity	0.900				
	Porosity	0.550				
Speci	fic Heat Capacity	0.334	Btu/lb-F			
	Density	Density 28.093 lb/ft3				
Cavit	y Properties					
	Radiation Mode	9	~			
Conv	ection Cavity Mode	1	~			
Rad	diation Cavity Mode	1	~			
	Cas Fil					

In the List View, highlight a record and click the Detailed View button to see the detailed input values for each material.

Figure 2-10. Material Detail View.

Buttons

The buttons on the right hand side of the Detail View have the following functions:

List View	Used to access the List view of the Material Library.
Save	Saves any changes made to the Materials XML file.
Cancel	Cancels any changes and returns to the List View.
New	Used to make a new record.
Сору	Used to copy an existing record (including name and all associated input values) into a new record. Highlight the record to be copied and click the Copy button. The new record will be added to the bottom of the list. Highlight that record and click the Detailed View button to edit

	the new record as needed.
Edit	Currently not implemented.
Color	The color assigned to the material. It can be changed by clicking on the arrow to the right of the color box, selecting another color, and then clicking Save to save the changes to the record. $ \begin{array}{c} \hline \\ \hline $

Input Values

The List view contains columns with selected results (from the Detail view) for each record, as described below.

Name	The name of the material.				
Material Type					
	 The material type, from the options of Solid Frame Cavity Glazing Cavity (currently not implemented for HygroThermFEM) External Radiation Enclosure (currently not implemented for HygroThermFEM) 				
	 Shading Material (currently not implemented for HygroThermFEM) 				
Solid Proper <i>These input va</i>	ties ilues are for Material Type = Solid				
Conductivity	Conductivity of the material.				
	Units: Btu/h-ft-F (IP); W/m-K (SI).				
Emissivity	Emissivity of the material.				
	Units: unitless				
Porosity	Porosity of the material.				
	Units: unitless				
Specific Heat Capacity	Specific Heat Capacity of the material.				
	Units: Btu/lb-F (IP); J/kg-K (SI).				
Density	Density of the material.				

	Units: lb/ft3 (IP); kg/m3 (SI).					
Cavity Prop <i>These input v</i>	erties alues are for Material Type = Frame Cavity					
Radiation	The Frame Cavity Radition Model, from the following choices:					
Iviouer	CENISO 15099					
Convection Cavity Model	Currently not implemented for HygroThermFEM.					
Radiation Cavity Model	Currently not implemented for HygroThermFEM.					
Gas Fill	The gas fill in the cavity, from the following choices: Air Argon Krypton Yonon 					
Emissivites Side 1	Currently not implemented for HygroThermFEM.					
Emissivities Side 2	Currently not implemented for HygroThermFEM.					
Liquid Tran	sportation Redistribution					
	Material Type					
	Solid Frame Cavity Water Content [kg/m3] DI [m2/s]					
	O Glazing Cavity 0 0					
	External Radiation Endosure 20 1e-10 210 7e-09					
	Figure 2-12. Liquid Transportation Redistribution variables for Stucco material.					
Water Content	Water content.					
	Units: lb/ft3 (IP); kg/m3 (SI).					
Dl	Liquid transportation coefficient.					
	Units: ft2/s (IP); m2/s (SI).					
Import File	To import data into this function, create a CSV file with the two values separated by a					

Format	comma. The values (always in SI units) are:
	 Water Content
	 Dl (liquid transportation coefficient)
	I HERM8-stucco-liquid IransportationRedistribution.csv 🔀
	2 20,1e-10
	3 210,78-09
	<i>Figure 2-13. Import CSV file format for Liquid Transportation Redistribution variables, always in SI units.</i>
Liquid Trans	sportation Suction
	Name 3-ply cross-laminated panel
	Material Tuna
	Solid
	Frame Cavity Water Content [kg/m3] DI [m2/s]
	Glazing Cavity 0 0 73 4e-12
	External Radiation Enclosure 534 5e-12
F	Figure 2-14. Liquid Transportation Suction variables for 3-ply cross-laminated panel material.
Water	Water content.
Content	Unite: $\frac{1}{4}$ (IP): $\frac{1}{4}$ (SI)
Dl	Liquid transportation coefficient.
	Units: $ft2/s$ (IP); m2/s (SI).
Import File Format	To import data into this function, create a CSV file with the two values separated by a comma. The values (always in SI units) are:
	 Water Content (kg/m3)
	 Dl (liquid transportation coefficient, m2/s)
	THERMS 2nhanned liquidTransportation Station pay
	2 73,4e-12 3 534.5e-12
	Figure 2-15. Import CSV file format for Liquid Transportation Suction variables for 3-ply cross- laminated panel material, always in SI units.
Moisture De	ependent Thermal Conductivity

	Name Laminated panel					
	Material Type			Moisture Dependent There	mal Conductivity	
	Solid			Water Content [kg/m2]	Thermal Conductivity DW/m-k	1
	Frame Cavity			0	0 12	
				534	0.12	
l	External Radiation Enclo	osure				
F	igure 2-16. Moisture De	ependent Th	hermal Cor	nductivity variables fo	r Laminated Panel mater	rial.
Water Content	Water content.					
	Units: lb/ft3 (IP);	kg/m3 (S	5I).			
Thermal Conductivity	Thermal conducti	vity.				
contractions	Units: Btu/h-ft-F	(IP); W/1	m-K (SI).			
Import File Format	To import data in comma. The value	to this fu es (alway	nction, ci s in SI ur	reate a CSV file wi nits) are:	th the two values se	parated by a
	■ Water Co	ntont (ka	(m3)			
	 Water Co. Thermal (Conductiv	/1113) witty (W//1	m-K)		
	 Thermal Conductivity (W/m-K) 					
		conducti	vity (**/1	,		
		HERM8	Haminated Pa	nel-MoistureDependentTher	malConductivity.csv 🔀	
		THERMS	HaminatedPa	nel-MoistureDependentTher	malConductivity.csv 🔀	
		THERM8	HaminatedPa ,0.12 34,0.12	nel-MoistureDependentTher	malConductivity.csv 🗵	
		THERM8	HaminatedPa ,0.12 34,0.12	nel-MoistureDependentTher	malConductivity.csv 🗵	
	Figure 2-17. Imp	THERMS	BlaminatedPa , 0.12 34, 0.12 le format forma	nel-MoistureDependentTher or Moisture Dependen	malConductivity.csv ⊠ t Thermal Conductivity in SI units	variables for
	Figure 2-17. Imp	THERME 1 0, 2 53 Port CSV fil La	HaminatedPa , 0.12 34, 0.12 le format fo mianted P	nel-MoistureDependentTher or Moisture Dependen anel material, always i	t Thermal Conductivity.csv 🛛	variables for
Moisture St	Figure 2-17. Imp orage Function	THERME	HaminatedPa , 0.12 34, 0.12 Ile format fo mianted P	nel-MoistureDependentTher or Moisture Dependen anel material, always a	t Thermal Conductivity.csv 🔀	variables for
Moisture St	Figure 2-17. Imp orage Function	THERME THERME 2 53 port CSV fil La	HaminatedPa , 0.12 34, 0.12 le format fa mianted P	nel-MoistureDependentTher or Moisture Dependen anel material, always a	t Thermal Conductivity in SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function	THERMS	HaminatedPa , 0.12 34, 0.12 le format fa mianted P	nel-MoistureDependentTher	malConductivity.csv 🛛 t Thermal Conductivity in SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid	THERME	HaminatedPa , 0.12 34, 0.12 le format fa mianted P	nel-MoistureDependentTher or Moisture Dependen anel material, always a Moisture Storage Func	t Thermal Conductivity t SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid	Dort CSV fi	HaminatedPa , 0.12 34, 0.12 le format fu mianted P	nel-MoistureDependentTher for Moisture Dependen anel material, always a Moisture Storage Func Humidity [-]	t Thermal Conductivity t Thermal Conductivity in SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid Frame Cavity Glazing Cavity	THERMS	HaminatedPa , 0.12 34, 0.12 le format fa mianted P	nel-MoistureDependentTher or Moisture Dependen anel material, always a Moisture Storage Func Humidity [-] 0	t Thermal Conductivity in SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid Frame Cavity Glazing Cavity External Radiation F	THERME	HaminatedPa , 0.12 34, 0.12 le format fo mianted P	nel-MoistureDependentTher or Moisture Dependent anel material, always of Moisture Storage Func Humidity [-] 0 0.1	t Thermal Conductivity in SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid Frame Cavity Glazing Cavity External Radiation E Shading Material	THERME	HaminatedPa , 0.12 34, 0.12 le format for mianted P	nel-Moisture Dependent Ther or Moisture Dependent anel material, always in Moisture Storage Func Humidity [-] 0 0.1 0.3 0.5	t Thermal Conductivity in SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid Frame Cavity Glazing Cavity External Radiation E Shading Material	THERMS	HaminatedPa , 0.12 34, 0.12 le format fo mianted P	nel-Moisture Dependent Ther or Moisture Dependent anel material, always a Moisture Storage Func Humidity [-] 0 0.1 0.3 0.5 0.7	t Thermal Conductivity t Thermal Conductivity in SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid Frame Cavity Glazing Cavity External Radiation E Shading Material	THERMS	34aminatedPa , 0.12 34, 0.12 le format fa mianted P	nel-MoistureDependentTher or Moisture Dependent anel material, always of Humidity [-] 0 0.1 0.3 0.5 0.7 0.8	t Thermal Conductivity.csv X t Thermal Conductivity in SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid Frame Cavity Glazing Cavity External Radiation E Shading Material Solid Properties	THERME	HaminatedPa , 0.12 34, 0.12 le format fa mianted P	mel-Moisture Dependent Ther or Moisture Dependent anel material, always a Moisture Storage Func Humidity [-] 0 0.1 0.3 0.5 0.7 0.8 0.9 0.9 0.9	t Thermal Conductivity in SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid Frame Cavity Glazing Cavity Shading Material Solid Properties Conductivity	indosure	W/m-K	Moisture Dependent Ther anel material, always a Moisture Storage Func Humidity [-] 0 0.1 0.1 0.3 0.5 0.7 0.8 0.9 0.93 0.95	t Thermal Conductivity in SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid Frame Cavity Glazing Cavity External Radiation E Shading Material Solid Properties Conductivity Emissivity	indosure	W/m-K	mel-Moisture Dependent Ther or Moisture Dependent anel material, always in Moisture Storage Funct Humidity [-] 0 0.1 0.3 0.5 0.7 0.8 0.9 0.93 0.95 0.99	t Thermal Conductivity in SI units.	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid Frame Cavity Glazing Cavity External Radiation E Shading Material Solid Properties Conductivity Emissivity Porosity	Image: Contract of the	W/m-K	mel-Moisture Dependent Ther anel material, always a Moisture Storage Func Humidity [-] 0 0.1 0.3 0.5 0.7 0.8 0.9 0.93 0.95 0.99 0.995	t Thermal Conductivity.csv 🔀	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid Frame Cavity Glazing Cavity External Radiation E Shading Material Solid Properties Conductivity Emissivity Porosity Specific Heat Capacity	THERME 1 0, 2 53 port CSV fill La indosure 0.125 0.900 0.550 1400.000 1400.000	W/m-K	Moisture Dependent Ther anel material, always a Moisture Storage Func Humidity [-] 0 0.1 0.1 0.3 0.5 0.7 0.8 0.9 0.93 0.95 0.99 0.995 0.999	t Thermal Conductivity.csv 🔀	variables for
Moisture St	Figure 2-17. Imp orage Function Name Laminated panel Material Type Solid Frame Cavity Glazing Cavity External Radiation E Shading Material Solid Properties Conductivity Emissivity Porosity Specific Heat Capacity Density	THERME 1 0, 2 53 port CSV fill La 0.125 0.900 0.550 1400.000 450.000 450.000	W/m-K J/kg-K kg/m3	Moisture Dependent Ther anel material, always a Moisture Storage Func Humidity [-] 0 0.1 0.3 0.5 0.7 0.8 0.9 0.93 0.95 0.99 0.995 0.999 0.995 0.999 0.995 0.999 0.995 0.999 0.995	t Thermal Conductivity in SI units.	variables for

Humidity	Humidity fraction.					
	Legal values: 0 – 1.					
	Units: unitless.					
Water	Water content.					
content	Units: lb/ft3 (IP); kg/m3 (SI).					
Import File Format	To import data into this function, create a CSV file with the two values separated by a comma. The values (always in SI units) are:					
	Humidity (fraction, 0-1)Water Content (kg/m3)					
	HERM8-LaminatedPanel-MoistureStorageFunction.csv					
	1 0,0 2 0.1,37 3 0.3 45					
	4 0.5,53 5 0.7,64					
	6 0.8,73 7 0.9,89					
	9 0.95,107 10 0.99,159					
	11 0.995,185 12 0.999,251					
	13 0.9995,281 14 0.9999,347 15 1,534					
	Figure 2-19. Import CSV file format for Moisture Storage Function variables for Lamianted Panel material, always in SI units.					
Temperature	Dependent Thermal Conductivity					
٩	Name Laminated panel					
	Material Type Temperature Dependent Thermal Conductivity					
	Solid Frame Cavity Temperature [C] Thermal Conductivity [W/m-K]					
	Glazing Cavity 10 0.12					
Figu	re 2-20. Temperature Dependent Thermal Conductivity variables for Laminated Panel material.					
Temperature	Temperature.					
	Units: F (IP); C (IP).					
Thermal Conductivity	Thermal conductivity.					
Conductiony	Units: Btu/h-ft-F (IP); W/m-K (SI).					

Import File Format	To import data into this function, create a CSV file with the two values separated by a comma. The values (always in SI units) are:
	Temperature (C)Thermal Conductivity (W/m-K)
	THERM8-LaminatedPanel-TemperatureDependentThermalConductivity.csv I
	Figure 2-21. Import CSV file format for Temperature Dependent Thermal Conductivity variables for Lamianted Panel material, always in SI units.

File Format and Location

The Material Library is stored in an XML file called "Materials.xml" which is located in the "lib" subfolder of the THERM working directory.

C:\Users\Public\LBNL\THERM8.0\lib

Local Disk (C:) > Users > Public > LBNL > THERM8.0 > lib				
Name	Date modified	Туре	Size	
Materials.xml	11/1/2020 1:51 PM	XML Document	34 KB	
BoundaryConditions.xml	10/30/2020 5:59 PM	XML Document	6 KB	

Figure 2-22. The Materials.xml file is located in the "lib" subfolder of the THERM working directory.

The definitions of all the materials displayed in the THERM Material Library are stored in this XML file.

🔚 Mate	erials.xm	
1	₽ <ŀ	laterials>
2	¢	<solidmaterial></solidmaterial>
3		<uuid>8dd145d0-5f30-11ea-bc55-0242ac130003</uuid>
4		<name>Laminated panel</name>
5		<protected>true</protected>
6		<defaultthickness>0.01</defaultthickness>
7		<materialinformation>NA</materialinformation>
8		<bulkdensity>450</bulkdensity>
9		<porosity>0.55</porosity>
10		<specificheatcapacitydry>1400</specificheatcapacitydry>
11		<thermalconductivitydry>0.125</thermalconductivitydry>
12		<emissivity>0.9</emissivity>
13		<watervapordiffusionresistancefactor>203</watervapordiffusionresistancefactor>
14		<color>0x008054</color>
15	Ę	<moisturestoragefunction></moisturestoragefunction>
16	Ę.	<tablevalue></tablevalue>
17		<x>0</x>
18		<y>0</y>
19		
20	Þ	<tablevalue></tablevalue>
21		<x>0.1</x>
22		<y>37</y>
23	-	

Figure 2-23. The Materials.xml file contains all the values for all the material records in the Material Library.

Making New Material Library Records

Using either the New or the Copy buttons in either the List or Detail View, it is possible to create new records. In the Detail View, the new or copied record value can be changes, and then those changes saved by clicking the Save button. Those changes are then made in the Material.xml file.

For example, if a new "solid" material record is created, and values added for the Solid Properties section as well as the different functions on the right side, all those changes are then saved in the Materials.xml file.



Figure 2-24. Make a new material using either New or Copy and change the input values as needed.

2.4. Boundary Condition Library

The Boundary Condition Library is different depending on the Simulation Engine selected.

- ConRad: If the ConRad simulation engine is selected, the Material library is the same as in previous versions of THERM.
- HygroThermFEM: If the HygroThermFEM simulation engine is selected, the Material library is much different.

2.4.1. Boundary Condition Library List View

Selecting the Boundary Condition choice from the Libraries menu when the HygroThermFEM simulation model is selected displays the Boundary Condition records in "List View".

🔳 Boundary Co	onditions Library		
Detailed View	Name	Туре	Convection Model
New			
	Fixed film coefficient - Indoor	Transient	Fixed Convection Coefficient
Сору	Fixed film coefficient with fixed radiation coefficient	Transient	Fixed Convection Coefficient
Delete	ASHRAE Outside	Transient	ASHRAE/NFRC Outside
Import	Fixed temperature and humidity	Transient	ASHRAE/NFRC Outside
ampore	ASHRAE Inside Convection Only	Transient	ASHRAE/NFRC Inside
Export	Constant Heat Flux Outside	Transient	ASHRAE/NFRC Outside
Report	Constant Heat Flux Inside	Transient	ASHRAE/NFRC Outside
	Fixed temperature	Transient	ASHRAE/NFRC Outside
Print	Kimura Only	Transient	Kimura
Save Lib As	Fixed film coefficient - Outdoor	Transient	Fixed Convection Coefficient

Figure 2-25. Boundary Condition List View.

Buttons

The buttons on the left hand side of the List View have the following functions:

Detailed Viscon	Used to access the detailed view of the record, where the input values can be edited.
View	
New	Used to make a new record, based on a default record. Click the New button, and the program will create a new record at the bottom of the list called "Default Name". Highlight that record and click the Detailed View button to edit the new record as needed.
Сору	Used to copy an existing record (including name and all associated input values) into a new record. Highlight the record to be copied and click the Copy button. The new record will be added to the bottom of the list. Highlight that record and click the Detailed View button to edit the new record as needed.
Delete	Used to delete a record. Highlight the record to delete and click the Delete button.
Import	Currently disabled.
Export	Currently disabled.

Report	Currently disabled.
Print	Currently disabled.
Save Lib As	Currently disabled.
Load Lib	Currently disabled.

Column Headings

The List view contains columns with selected results (from the Detail view) for each record, as described below.

Name	The name of the boundary condition.
Туре	 The boundary condition type, from the options of Transient Steady State (this is for the case where the transient moisture model is used with steady state algorithms, not currently implemented)
Convection Model	Options are: ASHRAE/NFRC Outside ASHRAE/NFRC Inside Fixed Convection Coefficient TARP Yazdanian Klems Kimura Montazeri
Temperature	<pre>For Type = Steady State, Convection Model Air Temperature. Steady State is not currently implemented for HygroThermFEM. Units: F (IP); C (SI)</pre>
Film Coefficient	For Type = Steady State, Convection Model Film Coefficient. <i>Steady State is not currently implemented for HygroThermFEM</i> . Units: Btu/h-ft2-F (IP); W/m2-K (SI)
Heat Flux	For Type = Steady State, Convection Model Heat Flux. <i>Steady State is not currently implemented for HygroThermFEM</i> . Units: Btu/h-ft2 (IP); W/m2 (SI)

Solar Padiation	For Type = Steady State, Convection Model Solar Radiation.
Ruutution	Steady State is not currently implemented for HygroThermFEM.
	Units: Btu/h-ft2 (IP); W/m2 (SI)
Radiation Model	For the Neumann Boundary Condition Type, if the Radiation Checkbox is checked, the Radiation model will be one of the following:
	 Automatic Enclosure Model Black Body Radiation Fixed Radiation Coefficient
Film	For Type = Steady State, Radiation Model Film Coefficient.
Coefficient	Steady State is not currently implemented for HygroThermFEM.
	Units: Btu/h-ft2-F (IP); W/m2-K (SI)
Temperature	For Type = Steady State, Radiation Model Radiation Surface Temperature.
	Steady State is not currently implemented for HygroThermFEM.
	Units: F (IP); C (SI)
Humidity	For Type = Steady State, Radiation Model Humidity fraction.
	Steady State is not currently implemented for HygroThermFEM.
	Legal Values: 0-1
	Units: unitless

2.4.1. Boundary Condition Library Detail View

In the List View, highlight a record and click the Detailed View button to see the detailed input values for each boundary condition.

Boundary	Conditior	ns	×
Name	Fixed film	n coefficient - Indoor	List View Save
	Neumann B	Boundary Condition Type	Cancel
	Model	Fixed Convection Coefficient \checkmark	New
	Radia	ation (Thermal/Longwave)	Сору
	0	Automatic Endosure Model	Edit
	0) Black Body Radiation) Fixed Radiation Coefficient	\sim
	Heat	t Flux r Radiation	
С	Dirichelt B	Boundary Condition Type	
	Tem	Iperature	
	Hum	nidity	

Figure 2-26. Boundary Condition Detail View.

Buttons

The buttons on the right hand side of the Detail View have the following functions:

List View	Used to access the List view of the Boundary Condition Library.
Save	Saves any changes made to the BoundaryConditions XML file. If changes are made to a field, move off the field in order for the Save button to become activated.
Cancel	Cancels any changes and returns to the List View.
New	Used to make a new record.
Сору	Used to copy an existing record (including name and all associated input values) into a new record. Highlight the record to be copied and click the Copy button. The new record will be added to the bottom of the list. Highlight that record and click the Detailed View button to edit the new record as needed.
Edit	Currently not implemented.



Input Values

The List view contains columns with selected results (from the Detail view) for each record, as described below.

Name	The name of the boundary condition.		
Transient	This is selected by default, and not editable in this version. The non-transient boundary conditions would be for the Steady State mode for the HygroThermFEM simulation engine, which has not been implemented yet.		
Neumann Bo	oundary Condition Type		
Convection	This option is checked if the boundary condition will include convection modeling.		
Model	 The Model pulldown list pertains to the type of convection model to be used, from the following choices: ASHRAE/NFRC Outside ASHRAE/NFRC Inside Fixed Convection Coefficient TARP Yazdanian Klems Kimura Montazeri For the Montazeri Convection Model, extra input values will be entered when assigning those to a specific boundary condition segment, which are Building Width Building Height 		

	Boundary Condition X		
	Boundary Condition Montezeri ~ >>		
	U-factor Surface None V OK		
	Timestep Input FileName Cancel		
	Neumann Boundary Condition Type		
	Convertion Model Montazeri		
	Surface Length 1000 mm Building Height 5 m		
	Radiation Model NA		
	Emissivity 0.84		
	Blocking Surface		
	Solar Absorptance 0		
	when they are assigned the Boundary Condition Type = Montezeri.		
Radiation	 This option is checked if the boundary condition will include Radiation modeling The Radiation model options are: Automatic Enclosure Model Black Body Radiation Fixed Radiation Coefficient 		
Heat Flux	This option is checked if the boundary condition will include Heat Flux modeling		
Solar Radiation	This option is checked if the boundary condition will include Solar Radiation modeling		
Dirichelt Bo	undary Condition Type		
Temperature	Check this option to include Temperature in this Boundary Condition Type		
Humidity	Check this option to include Humidity in this Boundary Condition Type		

File Format and Location

The Boundary Condition Library is stored in an XML file called "BoundaryConditions.xml" which is located in the "lib" subfolder of the THERM working directory.

C:\Users\Public\LBNL\THERM8.0\lib

Local Disk (C:) > Users > Public > LBNL > THERM8.0 > lib					
Name	Date modified	Туре	Size		
🔮 Materials.xml	11/1/2020 1:51 PM	XML Document	34 KB		
BoundaryConditions.xml	10/30/2020 5:59 PM	XML Document	6 KB		

Figure 2-29. The BoundaryConditions.xml file is located in the "lib" subfolder of the THERM working directory.

The definitions of all the boundary conditions displayed in the THERM Boundary Condition Library are stored in this XML file.

🔚 Bour	ndaryC	Conditions xml 🔀
1	Ðk	BoundaryConditionsType>
2	¢.	<boundaryconditiontype></boundaryconditiontype>
3		<uuid>8a0494b0-d5ba-11ea-87d0-0242ac130003</uuid>
4		<name>Fixed film coefficient - Indoor</name>
5		<protected>true</protected>
6		<bctype>Transient</bctype>
7		<bcmodel>Neumann</bcmodel>
8	¢	<convection></convection>
9		<model>Fixed Convection Coefficient</model>
10	-	
11		<useheatflux>false</useheatflux>
12		<usetemperature>false</usetemperature>
13		<usehumidity>false</usehumidity>
14		<color>0xFF0000</color>
15	-	
16	Ę.	<boundaryconditiontype></boundaryconditiontype>
17		<uuid>62618ab2-b946-11e9-a2a3-2a2ae2dbcce4</uuid>
18		<name>Fixed film coefficient with fixed radiation coefficient</name>
19		<protected>true</protected>
20		<bctype>Transient</bctype>
21		<bcmodel>Neumann</bcmodel>
22	Ę	<convection></convection>
23		<model>Fixed Convection Coefficient</model>
24	-	
25	Ę	<radiation></radiation>
26		<model>Fixed Radiation Coefficient</model>
27	-	
28		<useheatflux>false</useheatflux>
29		<usetemperature>false</usetemperature>
30		<usehumidity>false</usehumidity>
31		<color>0xFF0000</color>
32	-	

Figure 2-30. The BoundaryConditions.xml file contains all the values for all the material records in the Material Library.

Making New Boundary Condition Library Records

Using either the New or the Copy buttons in either the List or Detail View, it is possible to create new records. In the Detail View, the new or copied record value can be changes, and then those changes saved by clicking the Save button. Those changes are then made in the BoundaryCondition.xml file.

For example, if a new boundary condition record is created, all the settings for that boundary condition are saved in the BoundaryConditions.xml file.



Figure 2-31. Make a new boundary condition using either New or Copy and change the input values as needed. The changes will be saved into the BoundaryConditions.xml file.

file

Time Step Boundary Condition Files

In addition to specifying a standard Boundary Condition for a boundary condition segment when using the transient simulation engine (HygroThermFEM), it is also necessary to specify a Time Step Boundary Condition, which are stored in separate XML files.

There are several examples of Time Step files that are installed with THERM 8, and they are found in the "lib" subfolder of the THERM working directory.

C:\Users\Public\LBNL\THERM8.0\lib

(C:) > Users > Public > LBNL > THERM8.0 > lib		~
Name	Date modified	Туре
🔮 Materials.xml	11/2/2020 6:23 PM	XML Document
BoundaryConditions.xml	11/3/2020 6:05 PM	XML Document
BC_TS_YazdanianKlems.xml	9/23/2020 1:20 PM	XML Document
BC_TS_TARPFilmInterior.xml	9/8/2020 1:11 PM	XML Document
BC_TS_TARPFilmExterior.xml	9/8/2020 1:26 PM	XML Document
BC_TS_Montazeri.xml	9/23/2020 1:20 PM	XML Document
BC_TS_Kimura.xml	9/23/2020 1:20 PM	XML Document
BC_TS_FixedTemperatureAndHumidityOutside.xml	9/18/2020 4:19 PM	XML Document
BC_TS_FixedTemperatureAndHumidityInside.xml	9/18/2020 4:19 PM	XML Document
BC_TS_FixedHeatFluxInterior.xml	9/9/2020 2:01 PM	XML Document
BC_TS_FixedHeatFluxExterior.xml	9/9/2020 2:02 PM	XML Document
BC_TS_FixedFilmInteriorWithLinerizedRadiation.xml	9/18/2020 4:19 PM	XML Document
BC_TS_FixedFilmInterior.xml	9/8/2020 1:26 PM	XML Document
BC_TS_FixedFilmExterior.xml	9/8/2020 1:26 PM	XML Document
BC_TS_Fixed_T_RH_HC_120 steps-Interior.xml	10/30/2020 6:18 PM	XML Document
BC_TS_Fixed_T_RH_HC_120 steps-Exterior.xml	10/30/2020 6:18 PM	XML Document
BC_TS_ASHRAEOutside.xml	9/18/2020 4:19 PM	XML Document
BC_TS_ASHRAEInside.xml	9/18/2020 4:19 PM	XML Document

Figure 2-32. The Boundary Condition Time Step files are located in the "lib" subfolder of the THERM working directory.

These example files have a common naming convention of "BC_TS_" to indicate that they are **B**oundary Condition Time Step files, but the files can have any name desired.

The Time Step files contain values for as many time steps as are being defined in each.

For example, the example file "BS_TS_FixedFilmInterior.xml" file has 5 timestep sections, with definitions for Temperature, Humidity and Film Coefficient for each time step.

📄 BC_	TS_Fb	edFilmInterior.xml		
1	<		on="1.0"?>	
2	<	InputBound	aryConditionsData xmlns:xsi=" <u>http://www.w3.or</u>	rg/2001/XMLSchema-instance"
3	Ę	xsi:noNam	espaceSchemaLocation="BoundaryConditionsInput	File.xsd">
4		<name>Fix</name>	ed Film Coefficient Interior	
5	白	<boundary< td=""><td>ConditionTransient></td><td></td></boundary<>	ConditionTransient>	
6	þ	<co< td=""><td>nvectionTimesteps></td><td>In each TimeStep section,</td></co<>	nvectionTimesteps>	In each TimeStep section,
7	白		<pre><fixedconvectionfilmtimestep></fixedconvectionfilmtimestep></pre>	there are values for
8			<index>1</index>	
9		TimeStep	<temperature>22</temperature>	• Temperature
10		section 1	<humidity>0.0</humidity>	 Humidity
11			<filmcoefficient>1.5</filmcoefficient>	 FilmCoefficient
12	-			
13	白		<fixedconvectionfilmtimestep></fixedconvectionfilmtimestep>	
14			<index>2</index>	
15			<temperature>20.5</temperature>	
16			<humidity>0.0</humidity>	
17			<filmcoefficient>1.4</filmcoefficient>	There are 5 time steps
18	-			in this file, each with a
19	白		<fixedconvectionfilmtimestep></fixedconvectionfilmtimestep>	different value for
20			<index>3</index>	different value for
21			<temperature>20</temperature>	Temperature, Humidity
22			<humidity>0.0</humidity>	and Film Coefficient
23			<filmcoefficient>1.4</filmcoefficient>	
24	-			
25	白		<fixedconvectionfilmtimestep></fixedconvectionfilmtimestep>	
26			<index>4</index>	
27			<temperature>19</temperature>	
28			<humidity>0.0</humidity>	
29			<filmcoefficient>1.8</filmcoefficient>	
30	-			
31	₽		<fixedconvectionfilmtimestep></fixedconvectionfilmtimestep>	
32			<index>5</index>	
33			<temperature>18.5</temperature>	
34			<humidity>0.0</humidity>	
35			<filmcoefficient>2.4</filmcoefficient>	
36	F			
37	-	<td>onvectionTimesteps></td> <td></td>	onvectionTimesteps>	
38	-	<td>yConditionTransient></td> <td></td>	yConditionTransient>	
39		/InputBoun	daryConditionsData>	

Figure 2-33. The Boundary Condition Time Step file format.

Applying Boundary Conditions to a Model

Applying boundary conditions to a model is similar to how they are applied in previous versions of THERM, with a few exceptions.

• After the model is completed, click the BC toolbar button to assign the boundary conditions. Intially, all the boundary conditions for the model will be set to "Adiabatic".



Figure 2-34. Click the BC toolbar icon to generate the initial boundary conditions for the model, which will initially all be set to Adiabatic (with a black color0.

- Select the desired boundary condition segments to assign boundary conditions to and either double click the left mouse button or press the Enter key, in order to open the Boundary Condition selection dialog box.
- Select the Boundary Condition from the pulldown list which displays the records from the Boundary Condition Library
- Select the U-factor Surface tag as applicable
- Select the Timestep Input Filename as applicable. The OK button will not be activated until a Timestep Input Filename has been specified

Select the Boundary Condition from the Library		×	Double click on a boundary condition segment to open the Boundary Condition dialog box
Bunden: Condition			
H factor Surface	a him coefficient - Indoor	>>	
Non	2		
Timestep Input FileName BC_	TS_Fixed_T_RH_HC_120 steps-Interior.xml	Cancel	
Neumann Boundary Cond	lition Type		
Convection Model	Fixed Convection Coefficient		
Surface Tilt	90 deg Building Width 20	m	Select the Timestep file to use for
Surface Length	1000 mm Building Height 5	n	this boundary condition segment
Radiation Model	NA	(C:) > V	sers > Public > LBNL > THERM8.0 > lib
Emissivity	0.84	Name	
	Blocking Surface	BC T	S FixedFilmExterior.xml
Solar Absorptance	0	 @ BC_T	S_Fixed_T_RH_HC_120 steps-Interior.xml
O Dirichelt Boundary Cond	ition Type	🔮 BC_T	S_Fixed_T_RH_HC_120 steps-Exterior.xml

Figure 2-35. Specify both a Boundary Condition and a Timestep File for each boundary segment in a model.

2.5. Simulate the Model

When the model has been drawn, and materials and boundary conditions assigned, the model can be simulated by clicking the Calc toolbar icon, or selecting the Calculation/Calculation (F9) menu option.

In the example file below (from the sample file called "Stucco Wall – Moisture.thm"), the **File/Properties Time Step** is set to **3600 seconds** (1 hour), the **Number of Time Steps** is set to **100**, and the **QuadTree Mesh Parameter** is set to **4**.



Figure 2-36. File/Properties setting for the sample file called "Stucco Wall – Moisture.thm".

The sample file Stucco Wall - Moisture.thm consists of five polygons.



Figure 2-37. Stucco Wall – Moisture.thm.

The boundary condition definitions are shown below. The Timestep Input files have a timestep of 120, and the File/Properties Time Step value is set to 100, so the lower of the two timestep settings will determine the time step for the simulation, in this case 100 timesteps.

		Boundary Condition	1		×
Exterior Bounda Conditions, — including a Time	ry estep	Boundary Condition U-factor Surface	Fixed film coefficient - Indoo None	or	~ >> ~ ОК
file with 120 timesteps define	ed	Timestep Input FileName	BC_TS_Fixed_T_RH_HC_12	20 steps-Interior.xml	Cancel
Boundary Condition			×	~	Conditions, including a
U-factor Surface	None BC_TS_Fixed_T_RH_HC_120 st	teps-Exterior.xml	OK Cancel		Timestep file with 120 timesteps defined

Figure 2-38. Boundary Condition definitions.

During the transient simulation, the program will display a small progress window showing the current timestep.

rogress	
T	
Timestep number: 1/100	
Simulating moisture properties.	13
Moisture simulation timestep division at level 1 simulating for timestep 1	
Moisture simulation timestep division at level 1 simulating for timestep 2	
Moisture simulation timestep division at level 1 simulating for timestep 3	
Moisture simulation timestep division at level 2 simulating for timestep 21	
Moisture simulation timestep division at level 2 simulating for timestep 22	
Moisture simulation timestep division at level 2 simulating for timestep 23	
Moisture simulation timestep division at level 2 simulating for timestep 24	
Moisture simulation timestep division at level 2 simulating for timestep 25	
Moisture simulation timestep division at level 2 simulating for timestep 26	
Moisture simulation timestep division at level 2 simulating for timestep 27	
Moisture simulation timestep division at level 2 simulating for timestep 28	
Moisture simulation timesten division at level 2 simulating for timesten 29	
Moisture simulation timestep division at level 2 simulating for timestep 30	
Moisture simulation timestep division at level 2 simulating for timestep 31	
Moisture simulation timestep division at level 2 simulating for timestep 32	
Moisture simulation timestep division at level 2 simulating for timestep 32	
Moisture simulation unestep division at level 2 simulating for timestep 33	× .

Figure 2-39. A progress window shows the status of the transient simulation.

2.6. View the Results

When the simulation has finished, the progress window will close.

To view the results, click the Calculation / Show Results menu option to open the THERM Visualization program. It may take a few seconds to appear.

This results visualization tool shows a color flooded image on the left and a graph of the results on the right.



Figure 2-40. The THERM Visualization tool.

The slider at the top of the visualization tool allows results to be viewed at each timestep. There are also three different values that can be displayed, chosen from the Data pulldown list:

- Temperatures
- Humidities
- Water Content

The slider on the left side allows placement of the horiztonal location line, which determines the values displayed in the graph on the right hand side. This is useful when viewing results for a non-symmetrical model.



Figure 2-41. The THERM Visualization tool control options



Figure 2-42. Temperatures over the timesteps



Figure 2-43. Humidities over the timesteps