# THERM 8 <br> Moisture / Transient Modeling 

## Getting Started Guide

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## THERM 8: Transient Moisture model added

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.

## Changes from THERM 7 to THERM 8

- Version
- The latest version is THERM 8.0.10
- Simulation Engine Selection
- File / Properties / Calculation Options tab
- Simulation Engine
- Steady-State Thermal (ConRad)
- Transient Thermal + Moisture Engine (HygroThermFEM)
- Material Library and Boundary Condition Library
- When modeling transient/moisture
- XML file format for the libraries
- XML files for Boundary Condition timestep variables
- New grid view
- Results
- New visualization "window" for viewing the results

```
About THERM..
    THERM Finite Element Simulator
        OK
        Regents of the University of California
            Version 8.0.10.0
                10/30/20
            Conrad.dll: 7.0.3.0
            Viewer.obi: 7. 0.1.0
            LBLKeff.dll: 7.0.1.0
            gasses90.dll: 7.2.1.0
        Program Development Team
            Charlie Huizenga
            Dariush Arasteh
            Charlie Curciia
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            Christian Kohler
            Elizabeth Finlayson
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            KrystynaZelenay

\section*{File Properties: Calculation Options tab}

Applies to transient moisture \& heat transfer calculations

Applies to both simulation engines
Applies to Steady State (ConRad) engine only

The options on the left side of the THERM File Properties / Calculation Options tab are for the HygroThermFEM simulation engine


\section*{File Properties: Settings for Transient + Moisture (HygroThermFEM)}

\section*{Settings for the HygroThermFEM simulation engine}

These checkboxes determine what combination of heat transfer and moisture will be modeled

Select Transient to invoke the Transient model

These options are not yet implemented for the Transient model.

Only "User Defined" values can be used in this version

The Steady State option for the Transient model is not yet implemented

The Moisture calculation will take these options into account if checked.

These options are not yet implemented for the Transient model.


HygroThermFEM is the Transient Moisture \& Heat Transfer engine

3600 seconds = 1 hour

The default ": Number of Time Steps" is 8670 , which with the default Time Step of 3600 seconds, would model in 1 hour intervals for that many hours, approx 1 year.

If Number of Time Steps was set to 20 , the simulation would model 20 hours

Lowering the Mesh Parameter can sometimes help a transient model converge. The minimum value is 3 .

\section*{File Properties: Steady-State Thermal (ConRad)}

To use THERM 8 for Steady State Heat Transfer calculations (comparable to THERM 7) set these values


\section*{File Properties: Calculation Options tab}

This tab controls the type of model.

The Cross Section Type was moved here from the Therm File Properties tab


\section*{Material Library: Transient Thermal + Moisture Engine (Hygrothermfem)}


If you have a construction with an air cavity, you can use this material called
"Frame Cavity", which represents an air-filled cavity

\section*{Material Library: HygroThermFEM: Detail View}


\section*{Material Library: HygroThermFEM: XML file}

The Material Library for the Transient simulation engine is stored in an XML file called
\begin{tabular}{|c|c|c|c|}
\hline \multirow[b]{2}{*}{located here:} & \multicolumn{3}{|l|}{Local Disk (C:) , Users > Public > LBNL > THERM8.0 > lib} \\
\hline & Name & Date modified & Type \\
\hline C:\Users\Public\LBNL\THERM8.0\\ib & 2 Materials.xml & 11/1/2020 1:51 PM & XML Document \\
\hline & (eate BoundaryConditions.xml & 10/30/2020 5:59 PM & XML Document \\
\hline
\end{tabular}

The Materials.xml file


\section*{Boundary Condition Library: Transient Thermal + Moisture Engine (HygroThermfem)}

\begin{tabular}{|c|c|c|c|c|}
\hline \multirow[b]{4}{*}{Click the Detailed View button to see the record details (next page)} & \multicolumn{4}{|c|}{This Boundary Condition Library List View dialog box will appear} \\
\hline & \multicolumn{4}{|l|}{- Boundary Conditions Library} \\
\hline & Detailed View & Name & Type & Convection Model \\
\hline & New & & & \\
\hline \multirow[t]{6}{*}{Use New and Copy to make new records} & & Fixed film coefficient - Indoor & Transient & Fixed Convection Coefficient \\
\hline & Copy & Fixed film coefficient with fixed radiation coefficient & Transient & Fixed Convection Coefficient \\
\hline & Delete & ASHRAE Outside & Transient & ASHRAE/NFRC Outside \\
\hline & Import & Fixed temperature and humidity & Transient & ASHRAE/NFRC Outside \\
\hline & & ASHRAE Inside Convection Only & Transient & ASHRAE/NFRC Inside \\
\hline & Export & Constant Heat Flux Outside & Transient & ASHRAE/NFRC Outside \\
\hline \multirow[b]{4}{*}{In this version, these options are not available} & Report & Constant Heat Flux Inside & Transient & ASHRAE/NFRC Outside \\
\hline & & Fixed temperature & Transient & ASHRAE/NFRC Outside \\
\hline & Print & Kimura Only & Transient & Kimura \\
\hline & Save Lib As & Fixed film coefficient - Outdoor & Transient & Fixed Convection Coefficient \\
\hline
\end{tabular}

\section*{Boundary Condition Library: Transient Thermal + Moisture Engine (Hygrothermfem)}

When Boundary Conditions are applied to a boundary segment in a THERM model, a Time Step XML file is referenced. The Time Step values are not applied in the Boundary Condition Library itself.


\section*{Boundary Condition Library: Transient Thermal + Moisture Engine (Hygrothermfem)}

The Boundary Conditions Library for the Transient simulation engine is stored in an XML file called
\begin{tabular}{|c|c|c|c|}
\hline \multirow[t]{2}{*}{BoundaryConditions.xml} & \multicolumn{3}{|l|}{Local Disk (C:) > Users > Public > LBNL > THERM8.0 > lib} \\
\hline & Name & Date modified & Type \\
\hline & (98) Materials.xml & 11/1/2020 1:51 PM & XML Document \\
\hline C:\Users\Public\LBNL\THERM8.0\lib & (al) BoundaryConditions.xml & 10/30/2020 5:59 PM & XML Document \\
\hline
\end{tabular}
\begin{tabular}{|c|c|}
\hline & \(\square\) BoundaryConditions.xml \(\mathbb{Z}\) \\
\hline The BoundaryConditions.xml file contains a section for each record displayed in the library & ```
    <BoundaryConditionsType>
    <BoundaryConditionType>
        <UUID>62618ab2-b946-11e9-a2a3-2a2ae2dbcce4</UUID>
        <Name>Fixed film coefficient with fixed radiation coefficient</Name>
        <Protected>true</Protected>
        <BCType>Transient</BCType>
        <BCModel>Neumann</BCModel>
        <Convection>
            <Model>Fixed Convection Coefficient</Model>
        </Convection>
        <Radiation>
            <Model>Fixed Radiation Coefficient</Model>
        </Radiation>
        <UseHeatFlux>false</UseHeatFlux>
        <UseTemperature>false</UseTemperature>
        <UseHumidity>false</UseHumidity>
        <Color>0xFFO000</Color>
    </BoundaryConditionType>
<BoundaryConditionType>
        <UUID>d5bea3f2-b241-11e9-a2a3-2a2ae2dbcce4</UUID>
        <Name>ASHRAE Outside</Name>
        <Protected>true</Protected>
        <BCType>Transient</BCType>
        <BCModel>Neumann</BCModel>
        <Convection>
            <Model>ASHRAE/NFRC Outside</Model>
        </Convection>
        <UseHeatFlux>false</UseHeatFlux>
        <UseTemperature>false</UseTemperature>
        <UseHumidity>false</UseHumidity>
        <Color>0x0000FF</Color>
</BoundaryConditionType>
``` \\
\hline
\end{tabular}

\section*{Create a Model: Draw the polygons, Define the materials}
- When creating a model for THERM 8, it is advisable to draw it "from scratch".
- You can also import a file made from previous versions, which will set all the materials to black and they must be redefined for each polygon
- Draw polygons as you would normally do in THERM 7
- There is a sample file for the transient + moisture model in the "Samples" folder, called "stucco Wall - Moisture.THM"


You can also double click on a polygon to get to the Material Library List view to select the material.
\begin{tabular}{|c|c|c|c|}
\hline \multicolumn{4}{|l|}{- Material Definitions} \\
\hline Name Gypsum Board Interior & & & \(\checkmark\) \\
\hline \multicolumn{4}{|l|}{Material Type Liquid Transportation Redistribution \(\checkmark\)} \\
\hline Frame Cavity & Water Content \([\mathrm{b} / \mathrm{ft} 3]\) & Dl [ft2/s] & \\
\hline Glazing Cavity & 0 & 1.99132e-09 & \\
\hline External Radiation Enclosure & 0.593066 & 1.99132e-09 & \\
\hline Shading Material & 23.0984 & 1.71146e-06 & \\
\hline
\end{tabular}

\section*{Create a Model: Define Boundary Conditions}
- Click the BC toolbar button \(\square\)
- The boundary conditions will be defined as adiabatic (black)
- Double click on the interior and exterior boundary segments to set them to the correct Boundary Condition record from the Library
- With the Boundary Condition dialog box open, you also need to specify the Time Step XML file
- The color of the boundary condition segment will change based on the colors defined for each boundary condition


The Timestep Input File must also be specified. Click the elipses button to open a file browser dialog box, to select the appropriate Timestep XML file. Several example Timestep XML files are included in the installation, and stored in the Lib subfolder.
If a Timestep file is referenced from another directory, THERM will automatically copy it to the program Lib subfolder. If you select the same filename and changed something in the meantime, and stored somewhere else, the program, when it copies the file to the lib subfolder, will ask if you want to overwrite the older file that is in lib.
\begin{tabular}{|c|c|c|c|c|}
\hline \(\square\) < Users > Public > LBNL , THERM8.0 > lib & \(\checkmark\) & © & \(\bigcirc\) & rch lib \\
\hline New folder & & & & 盽三• - \\
\hline - Name & \multicolumn{3}{|l|}{\multirow[t]{2}{*}{Date modified 9/9/2020 2:02 PM}} & Type \\
\hline ] BC_TS_FixedHeatFluxExterior.xml & & & & XML Document \\
\hline BC_TS_FixedFilmInteriorWithLinerizedRadiation.xml & \multicolumn{3}{|l|}{9/18/2020 4:19 PM} & XML Document \\
\hline \(\square\) BC_TS_FixedFilminterior.xml & \multicolumn{3}{|l|}{9/8/2020 1:26 PM} & XML Document \\
\hline \(\square \mathrm{BC}\) _TS_FixedFilmExterior.xml & \multicolumn{3}{|l|}{9/8/2020 1:26 PM} & XML Document \\
\hline
\end{tabular}

\section*{Calculate the model}
- When the model is defined, click the Calc button \(\$\)

\section*{A Progress dialog box will be displayed}

It may go through several iterations, and take some time to finish the calculation


\section*{View Results: Temperatures}
- Once the model has finished simulating (which can take a while),
\begin{tabular}{|l|l|}
\hline Calculation & Window \\
\hline \multicolumn{1}{l}{ Help } & \\
\hline Calculation & F9 \\
\(\rightarrow\) Show Results & \\
\hline & Display Options \\
\hline
\end{tabular}
- BE PATIENT -- it will take several seconds for the visualization tool (THERMM-Viz) to appear


\section*{View Results: Humidity}

Humidity results
Humidity values are
being displayed

\section*{TPolygons TElements TNodes Reset Camera Data: Humidities}

This marker can be moved to show
the values over the timesteps


Humidity (\%)
\begin{tabular}{llllllllll}
1.0 & 2.1 & 3.2 & 4.3 & 5.4 & 6.6 & 7.7 & 8.8 & 9.9 & 11.0
\end{tabular}


\section*{View Results: Humidities over time}


\section*{View Results: Water Content}

Water Content Results
Water Content values
are being displayed

TPolygons TElements TNodes Reset Camera Data: WaterContent


This marker can be moved to show the values over the timesteps



\section*{Transient Thermal + Moisture Engine (Hygrothermfem) Libraries: XML files}

The Material Library, Boundary Condition Library and Boundary Condition Timestep files are XML files


\section*{Transient Thermal＋Moisture Engine（HygroThermFEM）Libraries Materials XML file}
\begin{tabular}{|c|c|}
\hline \multicolumn{2}{|l|}{\(\square\) Materials xml 区} \\
\hline 1 曰 & 回Materials＞ \\
\hline 2 ¢ & ＜SolidMaterial＞ \\
\hline 3 & ＜UUID＞8dd145d0－5f30－11ea－bc55－0242ac130003＜／UUID＞ \\
\hline 4 & ＜Name＞Laminated panel＜／Name＞ \\
\hline 5 & ＜Protected＞true＜／Protected＞ \\
\hline 6 & ＜DefaultThickness＞0．01＜／DefaultThickness＞ \\
\hline 7 & ＜MaterialInformation＞NA＜／MaterialInformation＞ \\
\hline 8 & ＜BulkDensity＞450＜／BulkDensity＞ \\
\hline 9 & ＜Porosity＞0．55＜／Porosity＞ \\
\hline 10 & ＜SpecificHeatCapacityDry＞1400＜／SpecificHeatCapacityDry＞ \\
\hline 11 & ＜ThermalConductivityDry＞0．125＜／ThermalConductivityDry＞ \\
\hline 12 & ＜Emissivity＞0．9＜／Emissivity＞ \\
\hline 13 & ＜WaterVaporDiffusionResistanceFactor＞203＜／WaterVaporDiffusionResistanceFactor＞ \\
\hline 14 & ＜Color＞0x008054＜／Color＞ \\
\hline 15 官 & ＜MoistureStorageFunction＞ \\
\hline 16 ¢ & ＜TableValue＞ \\
\hline 17 & ＜x＞0＜／x＞ \\
\hline 18 & ＜ \(\mathrm{y}>0</ \mathrm{y}>\) \\
\hline 19 & ＜／TableValue＞ \\
\hline 20 ® & ＜TableValue＞ \\
\hline 21 & ＜x＞0．1＜／x＞ \\
\hline 22 & ＜ \(\mathrm{y}>37</ \mathrm{y}>\) \\
\hline 23 & ＜／TableValue＞ \\
\hline 24 曰 & ＜TableValue＞ \\
\hline 25 & ＜x＞0．3＜／x＞ \\
\hline 26 & ＜y＞45＜／y＞ \\
\hline 27 & ＜／TableValue＞ \\
\hline 28 百 & ＜TableValue＞ \\
\hline 29 & ＜x＞0．5＜／x＞ \\
\hline 30 & ＜ \(\mathrm{y}>533</ \mathrm{y}>\) \\
\hline 31 － & ＜／TableValue＞ \\
\hline
\end{tabular}
```

＜LiquidTransportationCoefficientSuction＞ ＜TableValue＞
＜x＞0＜／x＞
＜y＞0＜／y＞
＜／TableValue＞
＜TableValue＞
＜x＞73＜／x＞
$\langle\mathrm{y}>4 \mathrm{e}-12</ \mathrm{y}\rangle$
＜／TableValue＞
＜TableValue＞
＜x＞534＜／x＞
$\langle\mathrm{y}>5 \mathrm{e}-12</ \mathrm{y}\rangle$
＜／TableValue＞

```
＜／LiquidTransportationCoefficientSuction＞
＜LiquidTransportationCoefficientRedistribution＞ ＜TableValue＞
＜x＞0＜／x＞
＜y＞0＜／y＞
＜／TableValue＞
＜TableValue＞
＜x＞57＜／x＞
＜y＞5．2e－11＜／y＞
＜／TableValue＞
＜TableValue＞
＜x＞65＜／x＞
\(\langle\mathrm{y}\rangle 7 \mathrm{e}-11</ \mathrm{y}\rangle\)
＜／TableValue＞
＜TableValue＞
＜x＞534＜／x＞
＜y＞1e－10＜／y＞
＜／TableValue＞
＜／LiquidTransportationCoefficientRedistribution＞
＜ThermalConductivityMoistureDependent＞
＜TableValue＞
＜x＞0＜／x＞
＜y＞0．12＜／y＞
＜／TableValue＞
＜TableValue＞
＜x＞534＜／x＞
＜y＞0．12＜／y＞
＜／TableValue＞
＜／ThermalConductivityMoistureDependent＞
＜ThermalConductivityTemperatureDependent＞
＜TableValue＞
＜x＞10＜／x＞
＜ \(\mathrm{y}>0.12</ \mathrm{y}>\)
＜／TableValue＞
＜／ThermalConductivityTemperatureDependent＞ ＜／SolidMaterial＞

\section*{Transient Thermal + Moisture Engine (Hygrothermfem) Libraries: Boundary Condition XML file}

BoundaryConditions.xml \(\boldsymbol{\boxed { }}\)
KBoundaryConditionsType>
<BoundaryConditionType>
<UUID>8a0494b0-d5ba-11ea-87d0-0242ac130003</UUID>
<Name>Fixed film coefficient - Indoor</Name>
<Protected>true</Protected>
<BCType>Transient</BCType>
<BCModel>Neumann</BCModel>
<Convection>
<Model>Fixed Convection Coefficient</Model>
</Convection>
<UseHeatFlux>false</UseHeatFlux>
<UseTemperature>false</UseTemperature>
<UseHumidity>false</UseHumidity>
<Color>0xFFO000</Color>
</BoundaryConditionType>
<BoundaryConditionType>
<UUID>62618ab2-b946-11e9-a2a3-2a2ae2dbcce4</UUID>
<Name>Fixed film coefficient with fixed radiation coefficient</Name>
<Protected>true</Protected>
<BCType>Transient</BCType>
<BCModel>Neumann</BCModel>
<Convection>
<Model>Fixed Convection Coefficient</Model>
</Convection>
<Radiation>
<Model>Fixed Radiation Coefficient</Model>
</Radiation>
<UseHeatFlux>false</UseHeatFlux>
<UseTemperature>false</UseTemperature>
<UseHumidity>false</UseHumidity>
<Color>0xFFO000</Color>
</BoundaryConditionType>

\section*{Transient Thermal + Moisture Engine (Hygrothermfem) Libraries: Boundary Condition Timestep XML file}
```

\#BC_TS_FixedFilminterior.xml 区
<?xml version="1.0"?>
<InputBoundaryConditionsData xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
        xsi:noNamespaceSchemaLocation="BoundaryConditionsInputFile.xsd">
<Name>Fixed Film Coefficient Interior</Name>
<BoundaryConditionTransient>
<ConvectionTimesteps>
<FixedConvectionFilmTimestep>
<Index>1</Index>
<Temperature>22</Temperature>
<Humidity>0.0</Humidity>
<FilmCoefficient>1.5</FilmCoefficient>
</FixedConvectionFilmTimestep>
<FixedConvectionFilmTimestep>
<Index>2</Index>
<Temperature>20.5</Temperature>
<Humidity>0.0</Humidity>
<FilmCoefficient>1.4</FilmCoefficient>
</FixedConvectionFilmTimestep>
<FixedConvectionFilmTimestep>
<Index>3</Index>
<Temperature>20</Temperature>
<Humidity>0.0</Humidity>
<FilmCoefficient>1.4</FilmCoefficient>
</FixedConvectionFilmTimestep>
<FixedConvectionFilmTimestep>
<Index>4</Index>
<Temperature>19</Temperature>
<Humidity>0.0</Humidity>
<FilmCoefficient>1.8</FilmCoefficient>
</FixedConvectionFilmTimestep>
<FixedConvectionFilmTimestep>
<Index>5</Index>
<Temperature>18.5</Temperature>
<Humidity>0.0</Humidity>
<FilmCoefficient>2.4</FilmCoefficient>
</FixedConvectionFilmTimestep>
</ConvectionTimesteps>
</BoundaryConditionTransient>
</InputBoundaryConditionsData>

```

\section*{Known Issues}
- Material Library
- Making a new record: Set the program units to SI and enter the values in the Material Library Detail view in SI units. The program doesn't properly convert the values if they are entered in IP units.
- Boundary Condition Library
- Detail View to List View: If you go from the List View to the Detail View, in some cases the program will display the details of the first record, not the record you had highlighted.```

