THERM 8 Moisture / Transient Modeling

Getting Started Guide

Lawrence Berkeley National Laboratory

Updated November 7, 2020

THERM 8: Transient Moisture model added

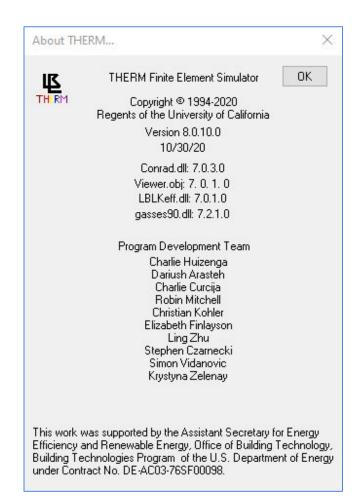
The THERM simulation engine been extended to model time dependent (transient) simulations (a "time domain" has been added to THERM's original 2-D Finite Element Numerical Model (FEM)), and a moisture transfer model has been added.

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

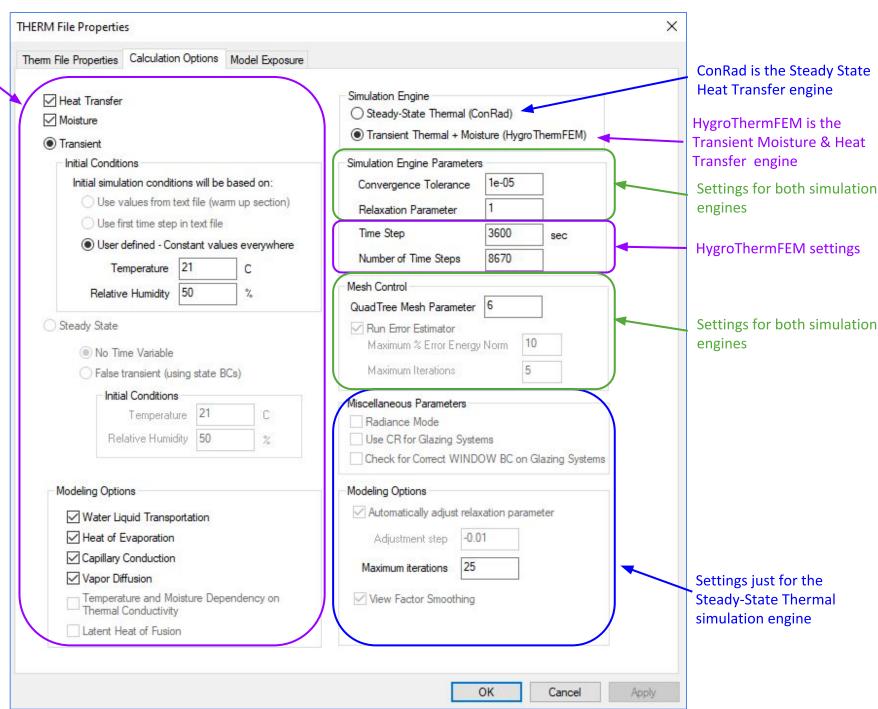


File Properties: Calculation Options tab

Applies to transient moisture & heat transfer calculations

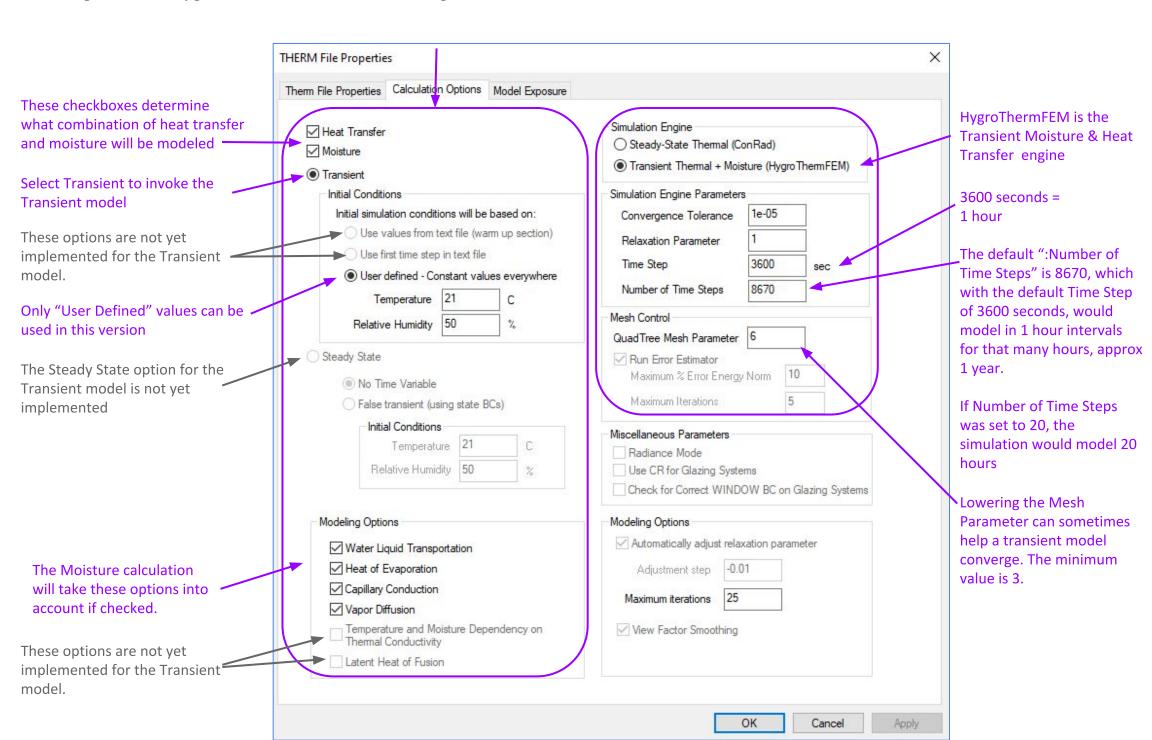
Applies to both simulation enginesApplies to Steady State (ConRad) engine only

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



File Properties: Settings for Transient + Moisture (HygroThermFEM)

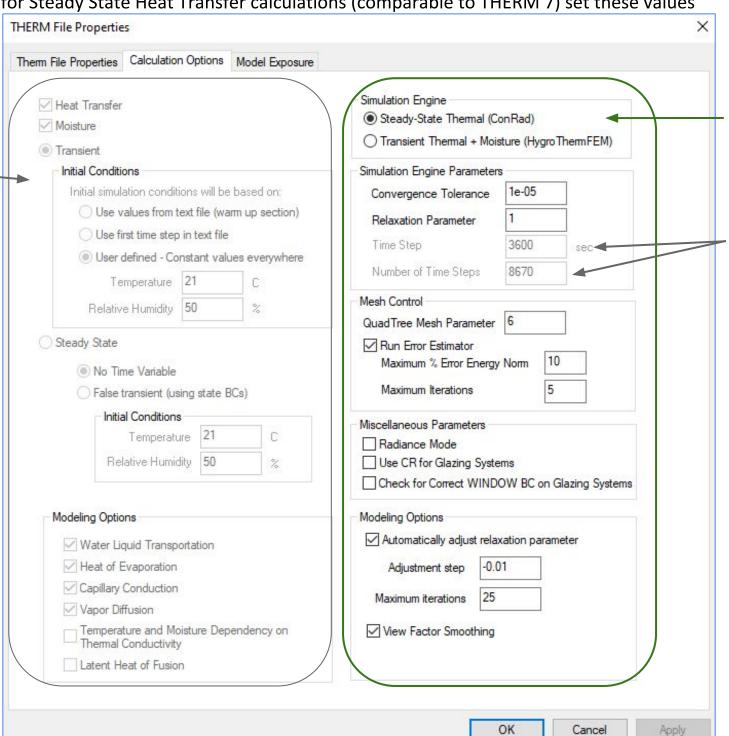
Settings for the HygroThermFEM simulation engine



File Properties: Steady-State Thermal (ConRad)

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

When the ConRad Simulation Engine is selected, all the input parameters on the left side of the tab will be grayed out (they are only relevant for the HyrgroThermFEM engine)



Select the ConRad radio button

When ConRad is selected, the Time Step and Number of Time Steps input boxes are grayed out (they are only for the transient model)

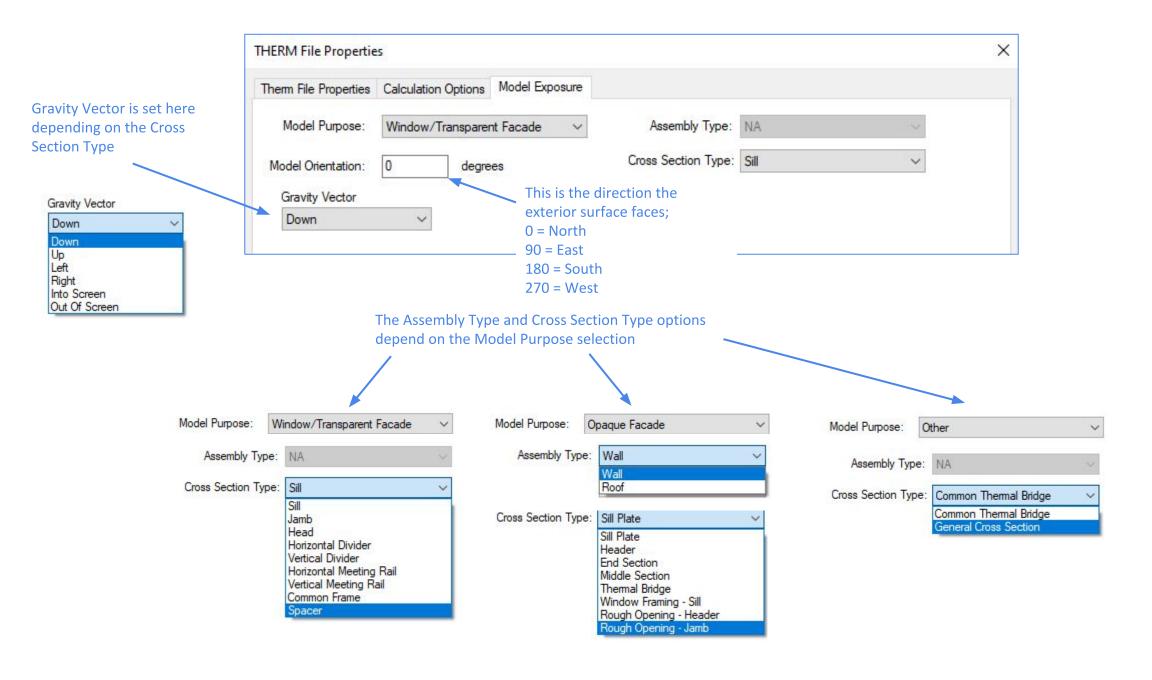
All the other values on the right hand side of this tab are settings that can be used with the ConRad engine for steady state heat transfer modeling

They are the same values as in previous versions of THERM

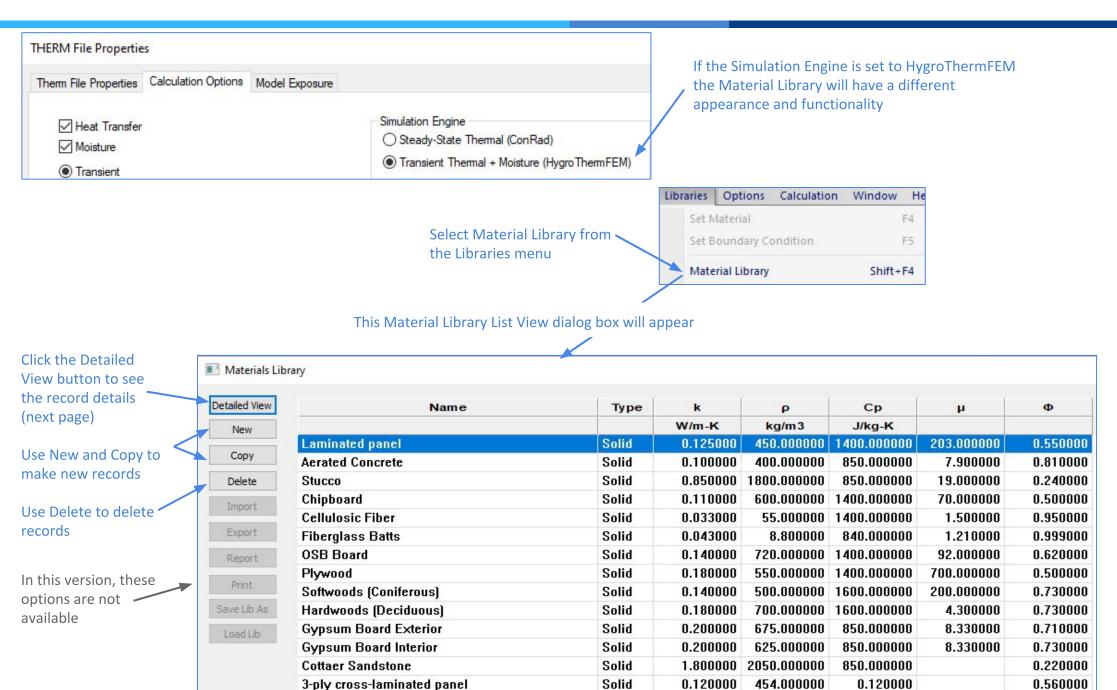
File Properties: Calculation Options tab

This tab controls the type of model.

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



Material Library: Transient Thermal + Moisture Engine (HygroThermFEM)

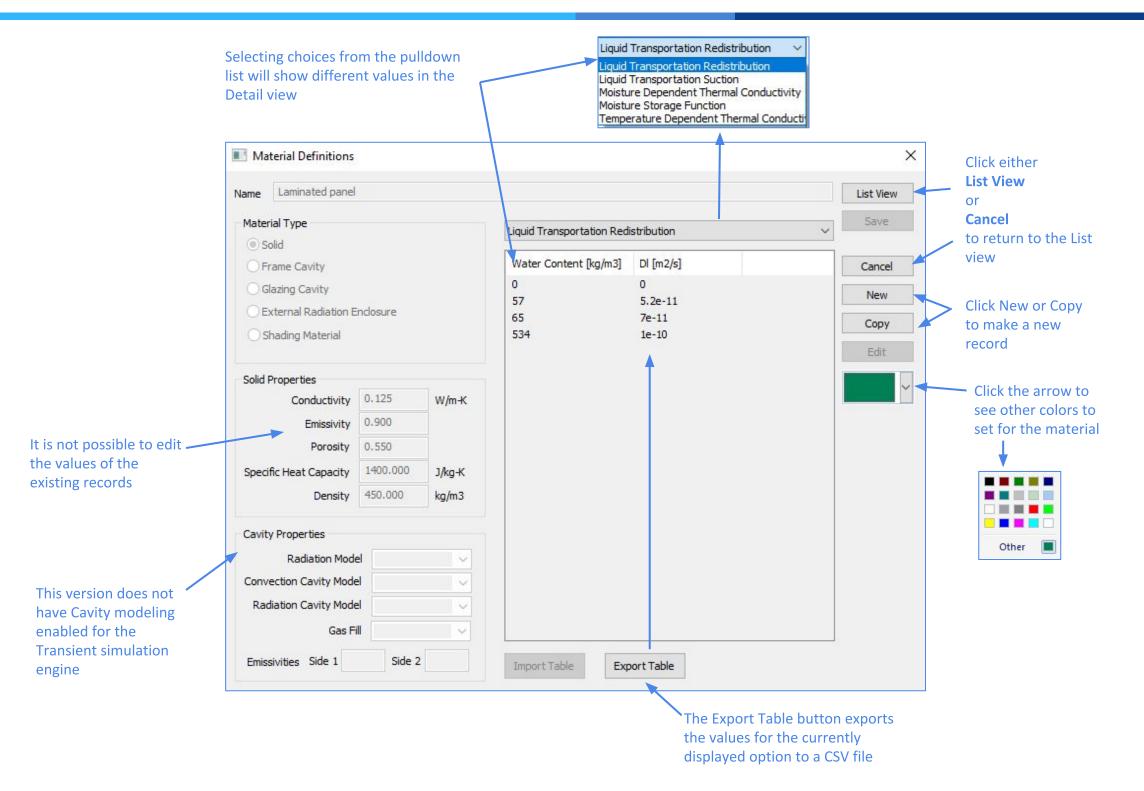


Frame Cavity

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

Cavity

Material Library: HygroThermFEM: Detail View



Material Library: HygroThermFEM: XML file

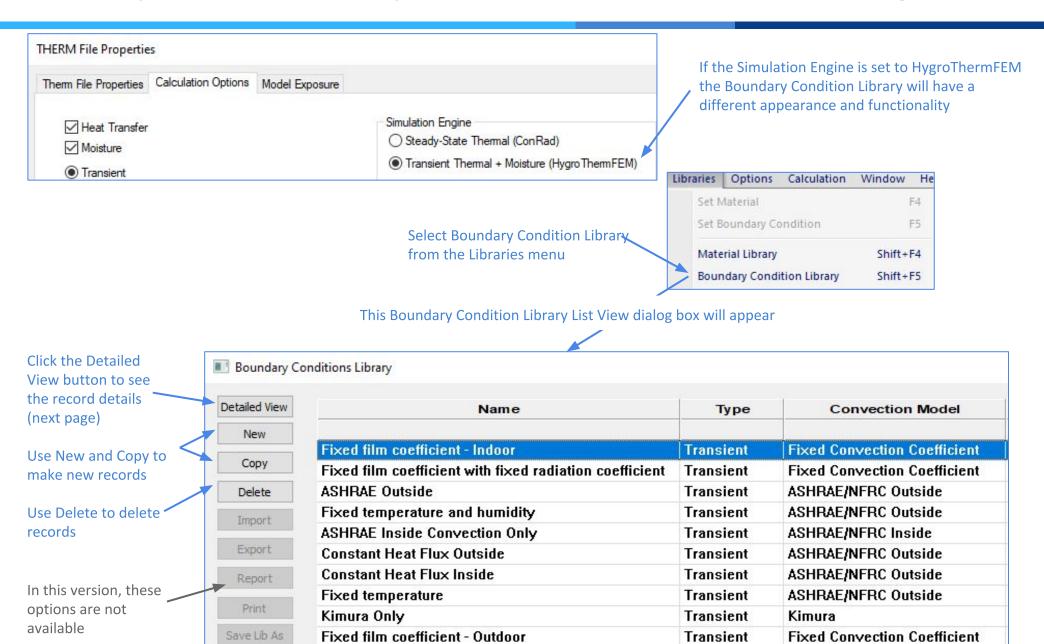
The Material Library for the Transient simulation engine is stored in an XML file called



The Materials.xml file contains a section for each record displayed in the library

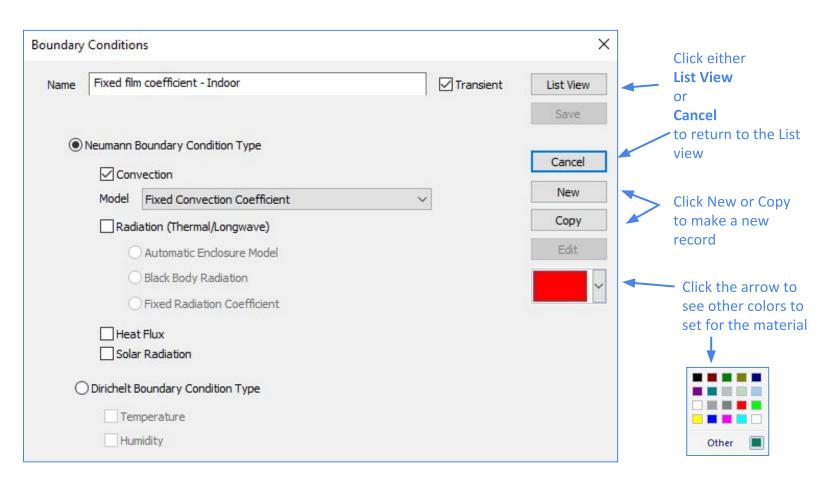
```
Materials.xml
     -<Materials>
  2
         <SolidMaterial>
  3
           <UUID>8dd145d0-5f30-11ea-bc55-0242ac130003</UUID>
  4
          <Name>Laminated panel
  5
           <Protected>true</Protected>
  6
           <DefaultThickness>0.01
  7
           <MaterialInformation>NA</MaterialInformation>
  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
           <MoistureStorageFunction>
 16
             <TableValue>
 17
               <x>0</x>
 18
               <y>0</y>
 19
             </TableValue>
 20
             <TableValue>
 21
               <x>0.1</x>
 22
               <y>37</y>
 23
             </TableValue>
 24
             <TableValue>
 25
               < x > 0.3 < /x >
 26
               <y>45</y>
 27
             </TableValue>
 28
             <TableValue>
 29
               < x > 0.5 < / x >
 30
               <v>53</v>
 31
             </TableValue>
```

Boundary Condition Library: Transient Thermal + Moisture Engine (HygroThermFEM)



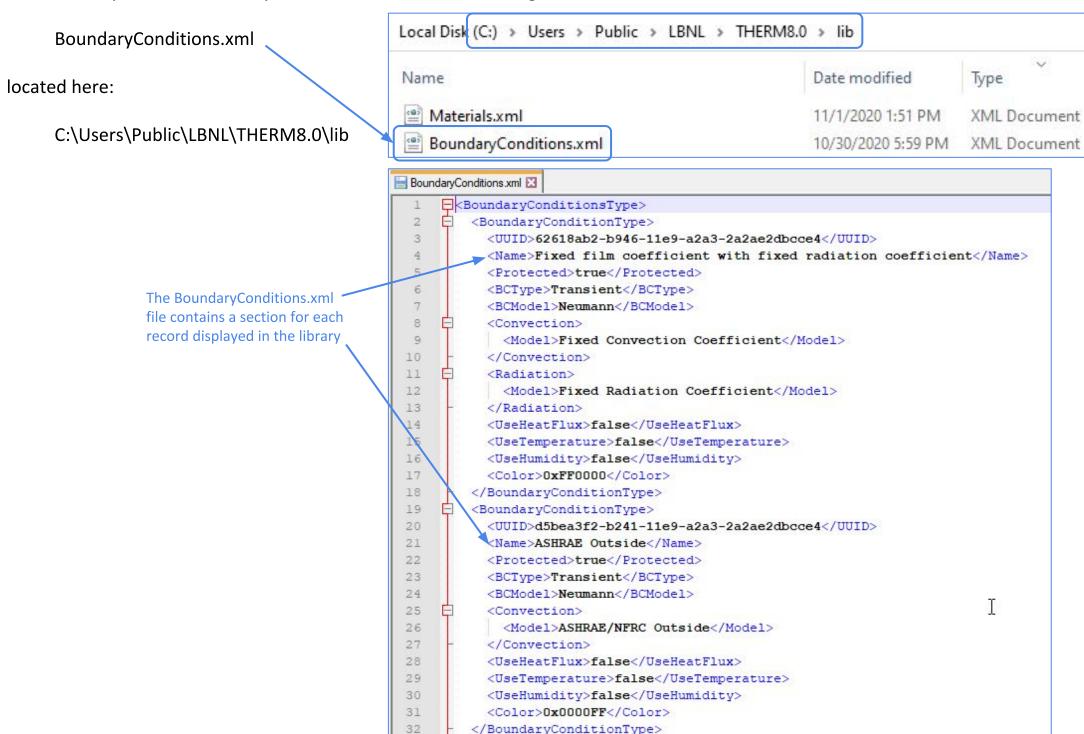
Boundary Condition Library: Transient Thermal + Moisture Engine (HygroThermFEM)

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.



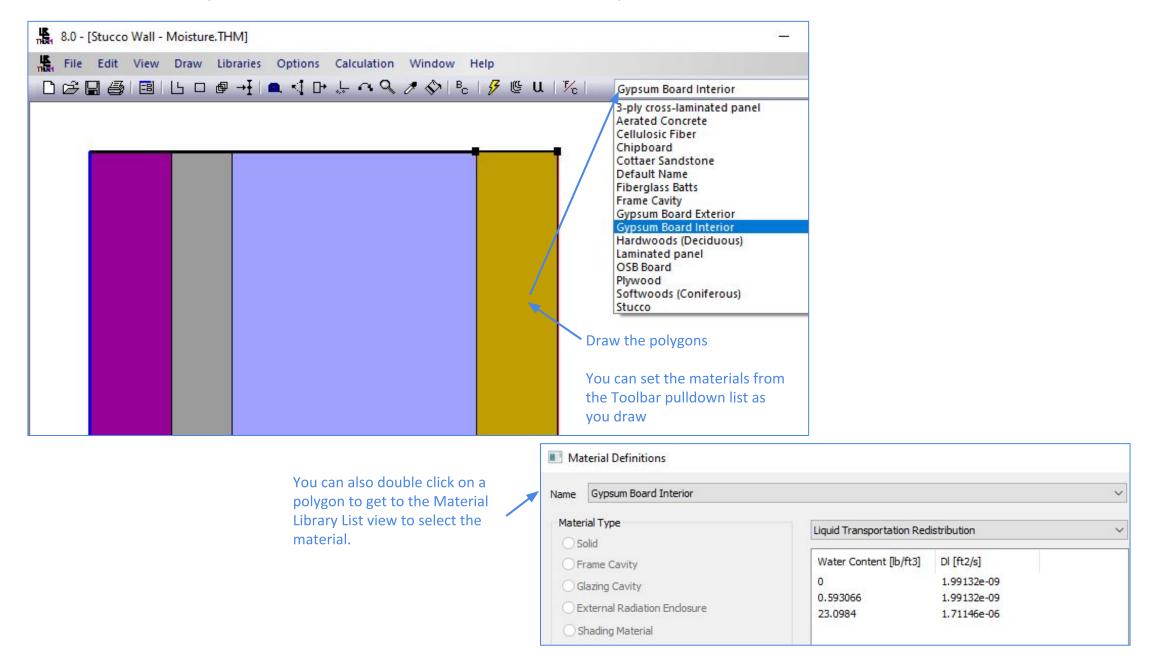
Boundary Condition Library: Transient Thermal + Moisture Engine (HygroThermFEM)

The Boundary Conditions Library for the Transient simulation engine is stored in an XML file called



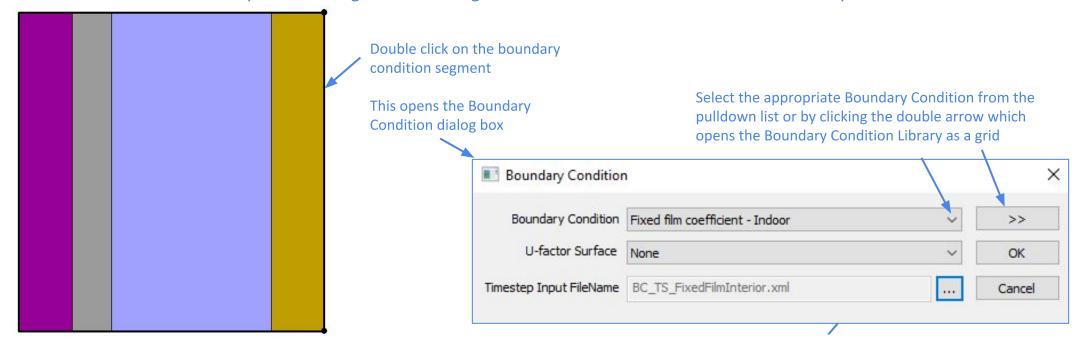
Create a Model: Draw the polygons, Define the materials

- 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"



Create a Model: Define Boundary Conditions

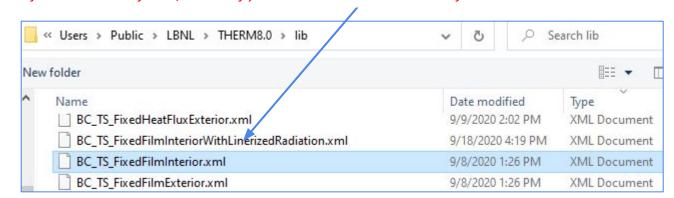
- Click the BC toolbar button
- The boundary conditions will be defined as adiabatic (black)
- Double click on the interior and exterior boundary segments to set them to the correct Boundary Condition record from the Library
- With the Boundary Condition dialog box open, you also need to specify the **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.

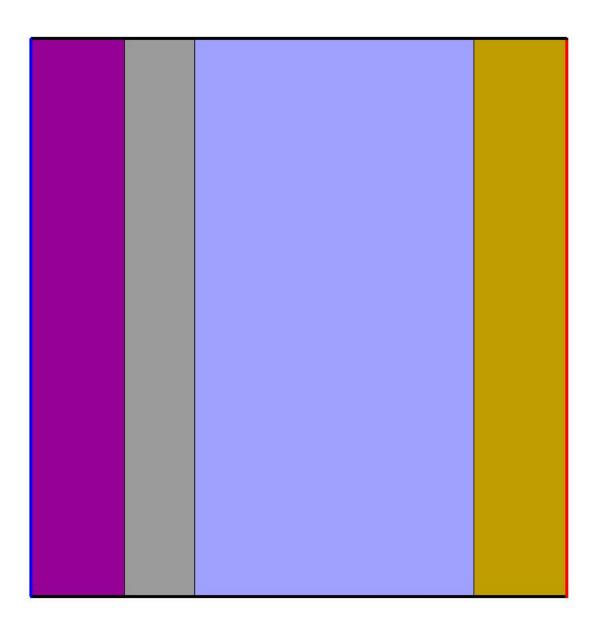
NOTE: If the timestep value set in File / Properties is different than the timesteps in the Timestep XML files, the program will pick the smallest timestep between all the values.



Calculate the model

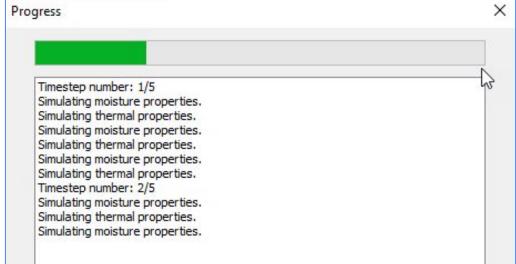
When the model is defined, click the Calc button





A Progress dialog box will be displayed

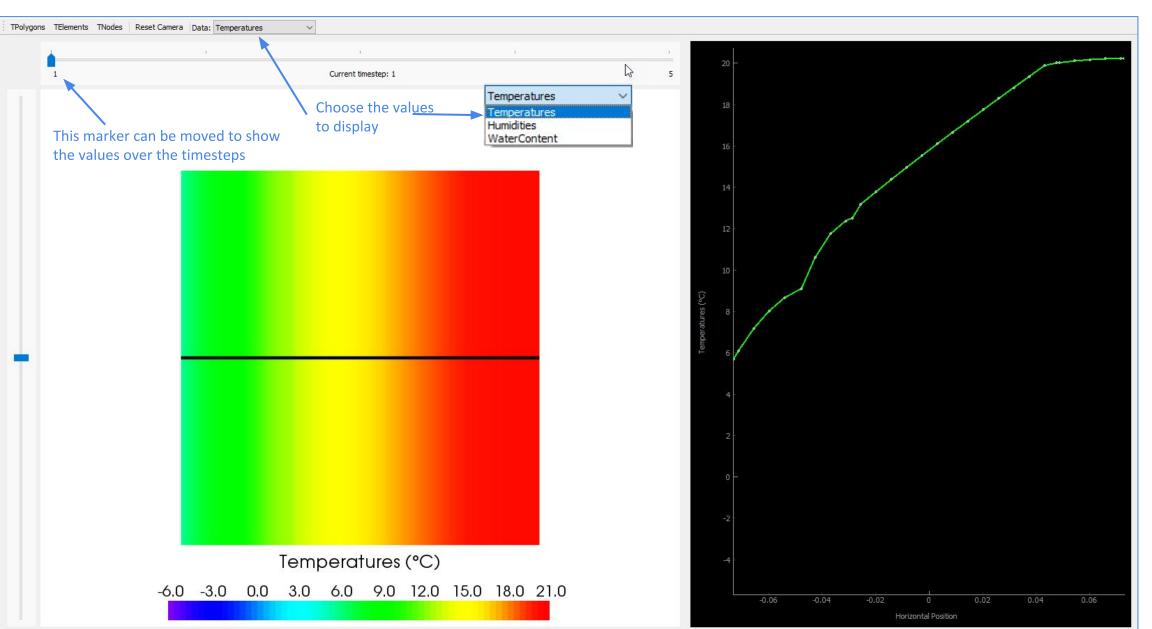
It may go through several iterations, and take some time to finish the calculation



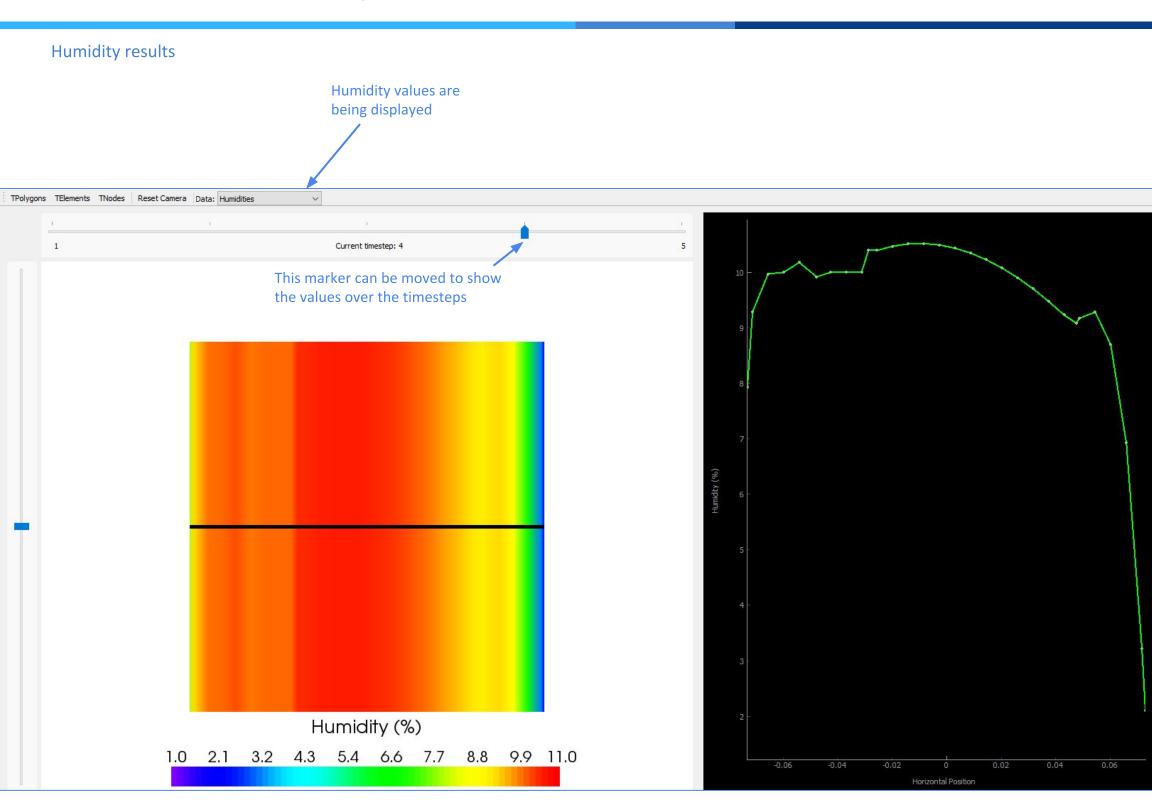
View Results: Temperatures

Once the model has finished simulating (which can take a while),
 click on either the Results toolbar icon
 Or the Calculation / Show Results menu option
 Calculation Window Help
 Calculation Window Help
 Calculation F9
 Show Results
 Display Options Shift+F9

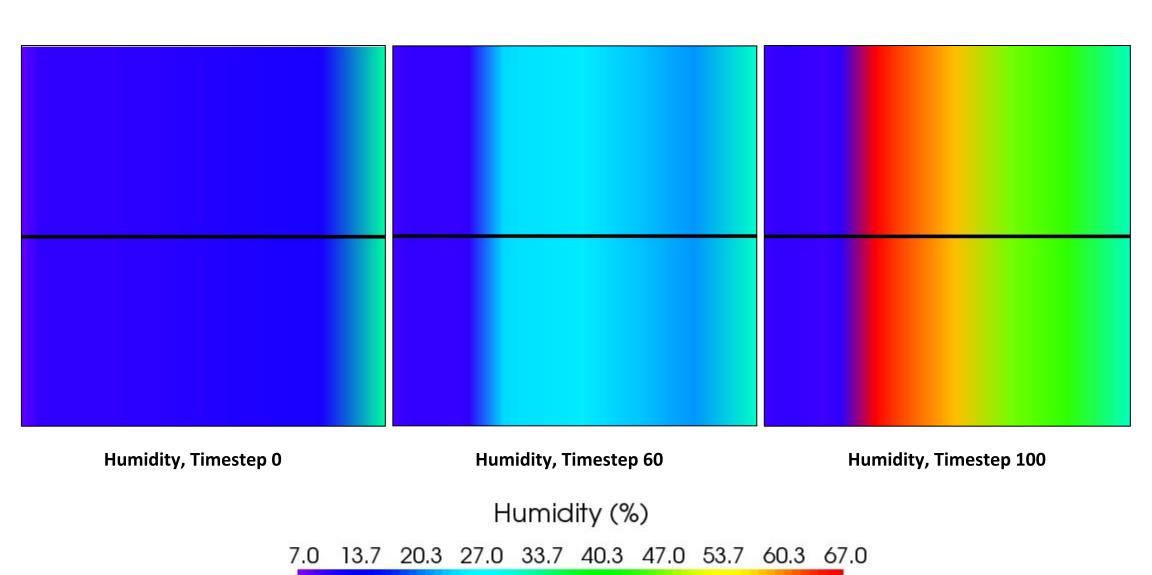
BE PATIENT -- it will take several seconds for the visualization tool (THERMM-Viz) to appear



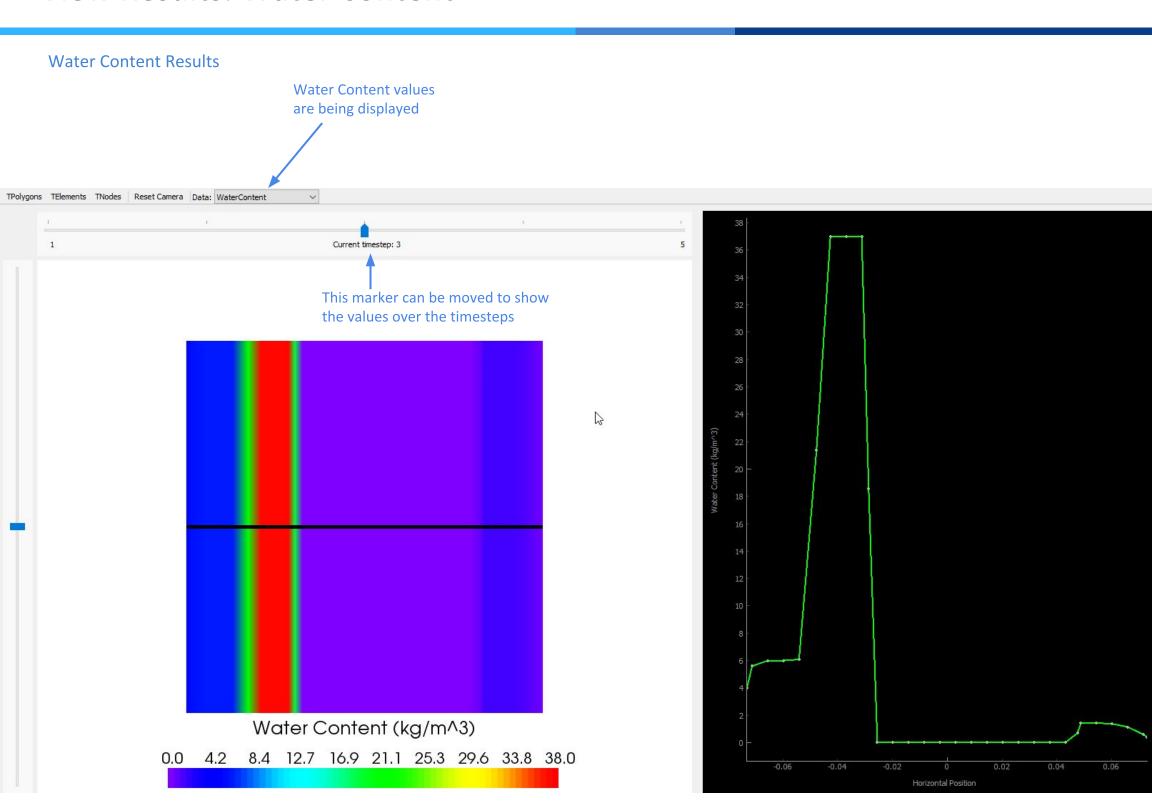
View Results: Humidity



View Results: Humidities over time

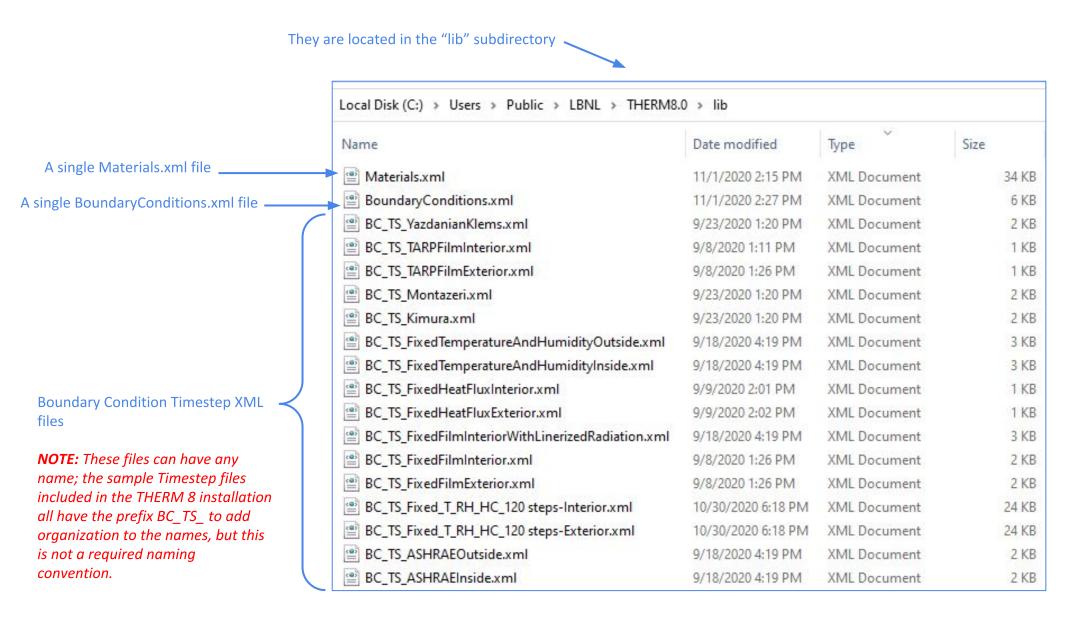


View Results: Water Content



Transient Thermal + Moisture Engine (HygroThermFEM) Libraries: XML files

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



Transient Thermal + Moisture Engine (HygroThermFEM) Libraries: Materials XML file

```
Materials.xml 🔀
     -Materials>
  2
         <SolidMaterial>
  3
           <UUID>8dd145d0-5f30-11ea-bc55-0242ac130003</UUID>
  4
           <Name>Laminated panel</Name>
  5
           <Protected>true</Protected>
           <DefaultThickness>0.01
  6
  7
           <MaterialInformation>NA</MaterialInformation>
  8
           <BulkDensity>450</BulkDensity>
  9
           <Porosity>0.55</Porosity>
           <SpecificHeatCapacityDry>1400</SpecificHeatCapacityDry>
 10
 11
           <ThermalConductivityDry>0.125</ThermalConductivityDry>
 12
           <Emissivity>0.9</Emissivity>
 13
           <WaterVaporDiffusionResistanceFactor>203</WaterVaporDiffusionResistanceFactor>
 14
           <Color>0x008054</Color>
           <MoistureStorageFunction>
 15
 16
             <TableValue>
 17
               <x>0</x>
 18
               <y>0</y>
 19
             </TableValue>
             <TableValue>
 20
 21
               <x>0.1</x>
 22
               <y>37</y>
 23
             </TableValue>
 24
             <TableValue>
 25
               < x > 0.3 < / x >
 26
               <v>45</v>
             </TableValue>
 28
             <TableValue>
 29
               < x > 0.5 < / x >
 30
               <v>53</v>
 31
             </TableValue>
```

```
<LiquidTransportationCoefficientSuction>
    <TableValue>
      <x>0</x>
      <v>0</v>
    </TableValue>
    <TableValue>
      <x>73</x>
      <v>4e-12</v>
    </TableValue>
    <TableValue>
      <x>534</x>
      <v>5e-12</v>
   </TableValue>
  </LiquidTransportationCoefficientSuction>
  <LiquidTransportationCoefficientRedistribution>
    <TableValue>
      <x>0</x>
      <v>0</v>
    </TableValue>
    <TableValue>
      <x>57</x>
      <y>5.2e-11</y>
    </TableValue>
    <TableValue>
      <x>65</x>
     <v>7e-11</v>
   </TableValue>
    <TableValue>
      <x>534</x>
      <v>1e-10</v>
   </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>
      <y>0.12</y>
   </TableValue>
  </ThermalConductivityTemperatureDependent>
</SolidMaterial>
```

Transient Thermal + Moisture Engine (HygroThermFEM) Libraries: Boundary Condition XML file

```
BoundaryConditions.xml
      ── <BoundaryConditionsType>
  2
         <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>
  9
             <Model>Fixed Convection Coefficient</Model>
 10
           </Convection>
 11
           <UseHeatFlux>false</UseHeatFlux>
 12
           <UseTemperature>false</UseTemperature>
 13
           <UseHumidity>false</UseHumidity>
 14
           <Color>0xFF0000</Color>
 15
         </BoundaryConditionType>
 16
         <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>
           <BCModel>Neumann</BCModel>
 22
           <Convection>
              <Model>Fixed Convection Coefficient</Model>
 23
 24
           </Convection>
 25
           <Radiation>
 26
             <Model>Fixed Radiation Coefficient</Model>
 27
           </Radiation>
           <UseHeatFlux>false</UseHeatFlux>
 28
 29
           <UseTemperature>false
 30
           <UseHumidity>false</UseHumidity>
 31
           <Color>0xFF0000</Color>
 32
         </BoundaryConditionType>
```

Transient Thermal + Moisture Engine (HygroThermFEM) Libraries: Boundary Condition Timestep XML file

```
BC_TS_FixedFilmInterior.xml
       <?xml version="1.0"?>
       <InputBoundaryConditionsData xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"</pre>
  2
  3
         xsi:noNamespaceSchemaLocation="BoundaryConditionsInputFile.xsd">
  4
          <Name>Fixed Film Coefficient Interior</Name>
         <BoundaryConditionTransient>
  6
                <ConvectionTimesteps>
  7
                    <FixedConvectionFilmTimestep>
  8
                        <Index>1</Index>
  9
                        <Temperature>22</Temperature>
                        <Humidity>0.0</Humidity>
 10
 11
                        <FilmCoefficient>1.5</FilmCoefficient>
 12
                    </FixedConvectionFilmTimestep>
 13
                    <FixedConvectionFilmTimestep>
 14
                        <Index>2</Index>
 15
                        <Temperature>20.5</Temperature>
 16
                        <Humidity>0.0</Humidity>
 17
                        <FilmCoefficient>1.4</FilmCoefficient>
 18
                    </FixedConvectionFilmTimestep>
 19
                    <FixedConvectionFilmTimestep>
 20
                        <Index>3</Index>
 21
                        <Temperature>20</Temperature>
 22
                        <Humidity>0.0</Humidity>
 23
                        <FilmCoefficient>1.4</FilmCoefficient>
 24
                    </FixedConvectionFilmTimestep>
 25
                    <FixedConvectionFilmTimestep>
                        <Index>4</Index>
 26
 27
                        <Temperature>19</Temperature>
 28
                        <Humidity>0.0</Humidity>
 29
                        <FilmCoefficient>1.8</FilmCoefficient>
                    </FixedConvectionFilmTimestep>
 30
 31
                    <FixedConvectionFilmTimestep>
 32
                        <Index>5</Index>
 33
                        <Temperature>18.5</Temperature>
                        <Humidity>0.0</Humidity>
 34
 35
                        <FilmCoefficient>2.4</FilmCoefficient>
                    </FixedConvectionFilmTimestep>
 36
 37
                </ConvectionTimesteps>
 38
          </BoundaryConditionTransient>
       </InputBoundaryConditionsData>
 39
```

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.