PyroSim

Room Fire

THUNDERHEAD ENGINEERING

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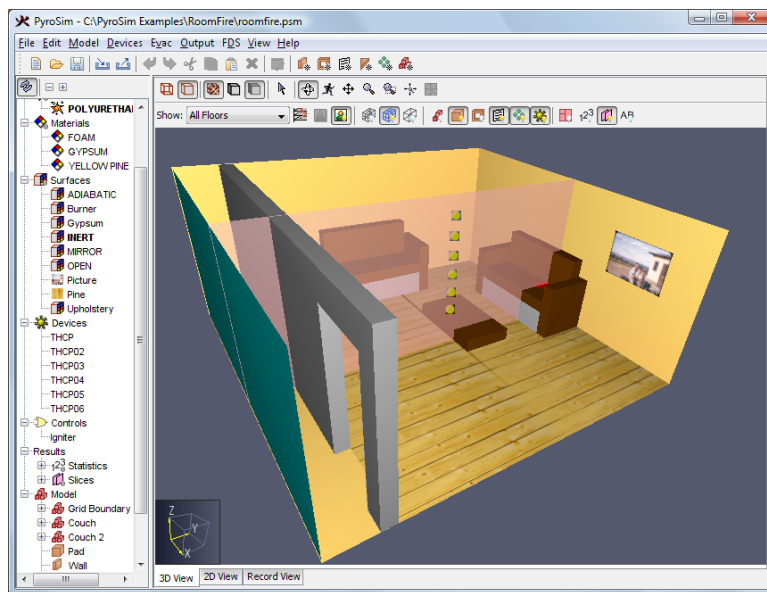
Room Fire

This is a more complex example. Although the geometry of the model is relatively simple, the fire is ignited by glowing particles that heat the sofa upholstery. The upholstery releases fuel and the fire results. As fuel is released, the sofa burns away.

This approach to modeling a fire pushes the limits of FDS capabilities and is beyond the usual heat release rate approach used by fire safety engineers. This detailed approach may be used by researchers or forensic investigators. The uncertainties in this detailed modeling are large.

This example is a simplification of the room fire problem provided by NIST as an FDS verification problem. The simplifications are in the geometry; the material properties and approach to modeling fire is the same as used by NIST.

Figure 1. Room fire in this example

This tutorial demonstrates how to:

- Import properties from a database.
- Define a combustion reaction.
- Replicate and rotate obstructions (furniture).
- Use a hole to represent an open door.
- Define an open surface on the exterior of the model.
- View 3D results using Smokeview.
- View 2D results using PyroSim.

The FDS input file listing for this model is provided at the end of this document. You can import this directly into PyroSim.

Brief Overview of Fire Modeling

In FDS/PyroSim, a fire is defined by a reaction, pyrolysis, and combustion:

1. Reaction – A reaction assumes a fuel vapor that reacts with oxygen to release energy and form combustion products.
2. Pyrolysis – This defines the rate at which solid or liquid surfaces generation fuel vapor. For example wood is heated and releases combustible gas or candle wax melts, is drawn up the wick, and vaporized.
3. Combustion – This is the reaction process by which fuel vapor mixes with oxygen and creates products based on the chemical reaction. The fuel vapor results from pyrolysis, oxygen is provided by air. The combustion process mixes fuel and oxygen and controls the reaction rate.

A more complete discussion of these processes is described in the FDS User Manual (Pyrolysis in Chapter 8 and Combustion in Chapter 12). On the PyroSim web site, the Resources also provide links to a set of videos that further explain the details (see PyroSim: Modeling Fire, Part 1 – Reactions, Part 2 - Heat Release Rate, and Part 3 - Combustion using HRR).

Standard Approach to Fire Modeling

The most frequently used approach to modeling a reaction in FDS/PyroSim assumes a single *fuel* species composed of C, H, O, and N that reacts with *air* to form *products* H_2O, CO_2, soot, and CO. The user specifies the chemical formula of the fuel (and the yields for soot and CO and hydrogen fraction in soot), and FDS/PyroSim calculates the stoichiometric coefficients and heat release rate.

The most common way to define pyrolysis in FDS/PyroSim is to specify a Heat Release Rate (HRR) on a surface. When HRR is specified, FDS uses the heat of combustion defined by the reaction to calculate the fuel vapor mass release rate that will result that will result in the desired energy release.

The most commonly used combustion model in FDS/PyroSim is the "simple chemistry" model, in which the reaction of fuel and oxygen is infinitely fast and controlled only by mixing.

More Complex Solid Phase Pyrolysis used in this Example

While this example uses the standard approach to define the reaction and combustion, it uses a much more complicated approach for the calculation of the solid phase pyrolysis (the conversion of the solid to fuel vapor).

In this example, fuel vapor mass release rate is calculated by actually simulating solid phase pyrolysis using a *layered* surface and a *pyrolysis rate* defined by the material properties. Layered surfaces are used so that a heat transfer calculation can be performed. The temperature is then used to calculate the solid phase pyrolysis rate. See the FDS User Manual (Pyrolysis in Chapter 8 and Combustion in Chapter 12) for more information.

Start a New Model

Run PyroSim.

1. To clear any open models, on the **File** menu, click **New**.
2. On the **View** menu, click **Units** and select **SI** to display values using the metric system.
3. Save the model. On the **File** menu, click **Save** and choose a folder. Name the file **roomfire.psm**.
4. Click **OK** to save the model.

Reaction

First we define the reaction for this simulation.

1. On the **Model** menu, click **Edit Reactions**.
2. Click the **Add From Library** button, select **POLYURETHANE** reaction, and move it to the **Current Model**. Click **Close**.
3. Click **OK** to close the dialog.

Create the Mesh

The mesh (or meshes) define the computational domain. It is convenient to define the mesh early and use it to help create geometry. You can always modify or refine the mesh later.

In this example we will use mesh cells with a size of 0.10 m. This is geometrically convenient and is somewhat smaller than 1/5 of the characteristic diameter (D*) for a 500 kW fire. In this simulation, the fire is ignited and grows, so there is not a single value of heat release rate with which to calculate D*.

It is the responsibility of the analyst to run verification calculations that show the mesh resolution is sufficiently small so that the results have converged. This is a compromise. Using mesh cells that are smaller by a factor of 2 should decrease error by a factor of 4, but will increase the simulation run time by a factor of 16.

1. On the **Model** menu, click **Edit Meshes**.
2. Click **New** and then **OK** to create a new mesh.
3. In the **Min X** box, type **0** and in the **Max X** box, type **5.2.**
4. In the **Min Y** box, type **-0.8** and in the **Max Y** box, type **4.6.**
5. In the **Min Z** box, type **0** and in the **Max Z** box, type **2.4.**
6. In the **X Cells** box, type **52.**
7. In the **Y Cells** box, type **54.**
8. In the **Z Cells** box, type **24.**
9. Click **OK** to save changes and close the **Edit Meshes** dialog.
10. On the **View** menu, click **Reset View to All Objects**.

Import Material Data

Materials are the building blocks for *Surfaces* that are used to define the geometry of the model. PyroSim includes a database file that provides data and references for the source of the data. We will import selected properties from this file.

1. On the **Model** menu, click **Edit Materials.**
2. Copy the **FOAM, GYPSUM, and YELLOW PINE** materials from the library into the **Current Model.**
3. Close the **PyroSim Libraries** dialog.
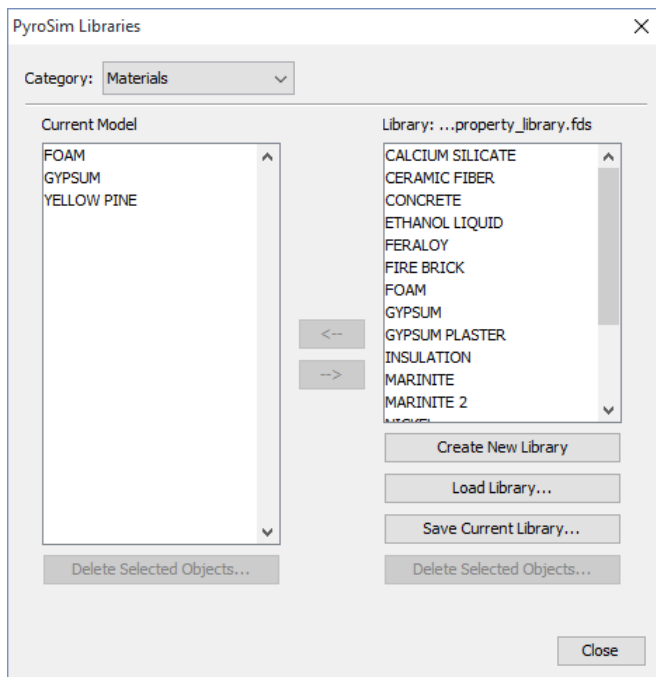
Figure 2. Copy the materials from the library into the current model

Because this ignition and burn-away simulation is sensitive to material properties, we will edit the imported FOAM material to have the same values as used in the NIST room fire example (the GYPSUM and YELLOW PINE do not affect the simulation, so we will leave them with the imported properties). To edit FOAM:

1. In the **Edit Materials** dialog, double-click on **FOAM**.
2. In the **Description** box, type **NIST – Completely Made Up**.
3. In the **Density** box, type **40**.
4. In the **Specific Heat** box, type **1**.
5. Click the **Pyrolysis** tab.
6. In the **Heat of Combustion** box, type **30000**.
7. Under **Reaction**, click **Edit**.
8. In the **Reference Temperature** box, type **300**.
9. Click the **Byproducts** tab.
10. In the **Heat of Reaction** box, type **800**.
11. In the **Composition** column, type **1**.
12. In the **Residue** column select **[Species: SPEC] REAC_FUEL**. This means that the pyrolysis byproducts will be the fuel.
13. Click **OK** to close the **Edit Pyrolysis Reaction** dialog.

14. Click **Apply** to save the changes.

The sofa cushions will be made of a thin layer of fabric that covers a foam pad. No default fabric is provided in the PyroSim libraries, so we will create one. The values used for this material are the same as used in the NIST model. Note – NIST clearly states the fabric properties are not realistic, so should not be used for other models without justification.

To add a new material:

1. In the **Edit Materials** click **New**.
2. In the **Name** box, type **Fabric**. Click **OK**.
3. In the **Density** box, type **100**. Do not change the default values for the other Thermal Properties.
4. Click the **Pyrolysis** tab.
5. Select the **Heat of Combustion** checkbox and in the value box type **15000**.
6. Under **Reaction**, click **Add**.
7. In the **Reference Temperature** box, type **280**.
8. Click the **Byproducts** tab.
9. Select the **Heat of Reaction** option and in the box, type **1000**. The reaction is Endothermic, that is, pyrolysis requires energy input to occur.
10. In the **Composition** column, type **1**.
11. In the **Residue** column select **[Species: SPEC] REAC_FUEL**. This means that the pyrolysis byproducts will be the fuel.
12. Click **OK** to close the **Edit Pyrolysis Reaction** dialog.
13. Click **OK** to close the **Edit Materials** dialog.

Create Surfaces

Materials define physical properties. Solid surfaces can use the material properties to calculate the thermal response.

The floor will be made of yellow pine material. To create the surface:

1. On the **Model** menu, click **Edit Surfaces**.
2. Click **New**, give the **Surface Name** as **Pine**, select the **Surface Type** as **Layered**, and click **OK**. A layered surface will calculate heat conduction into the surface.
3. Click on the **Appearance** box and select **psm_wood2.jpg**. Click **OK** to close the **Texture** dialog.
4. In the **Material Layers** tab, in the **Thickness** column, type **0.01.**
5. The material composition can be defined as a mixture. Click the **Edit** button. In the **Mass Fraction** column, type **1.0**. In the **Material** column, select **YELLOW PINE**. Click **OK** to close the **Composition** dialog.
6. In the **Edit Surfaces** dialog, click **Apply** to save the changes.
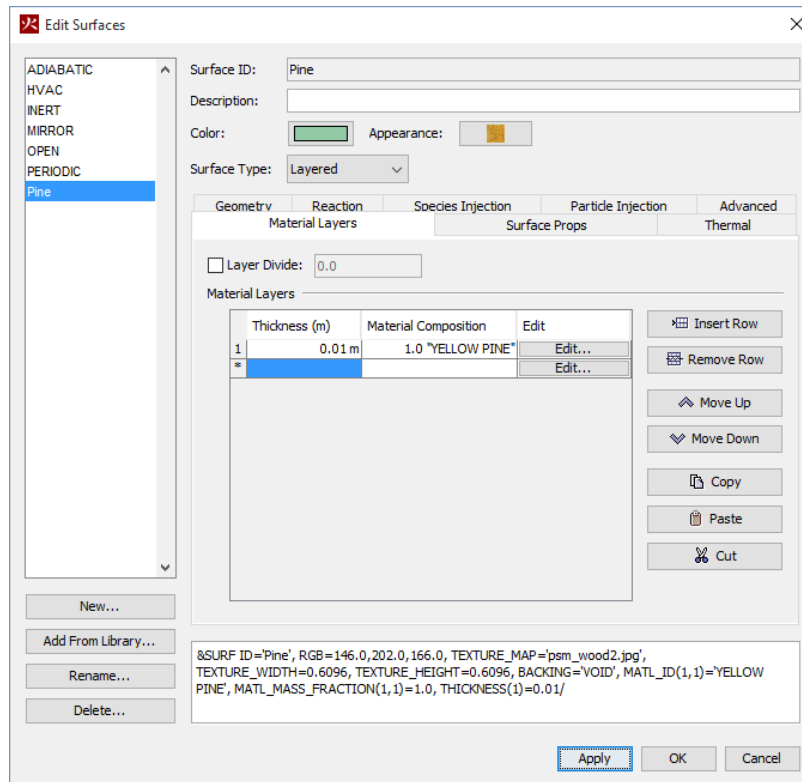
Figure 3. Creating the Pine floor surface

We will use gypsum for the walls:

1. In the **Edit Surfaces** dialog, click **New**. Give the **Surface Name** as **Gypsum**, select the **Surface Type** as **Layered**, and click **OK**.
2. Click on the **Color** box and define a neutral blue color (e.g. RGB of 198, 225, 230 and Alpha 255). Click **OK** to close the **Surface Color** dialog.
3. In the **Material Layers** panel, in the **Thickness** column, type **0.013.**
4. Click the **Edit** button. In the **Mass Fraction** column, type **1.0**. In the **Material** column, select **GYPSUM**. Click **OK** to close the **Composition** dialog.
5. In the **Edit Surfaces** dialog, click **Apply** to save the changes.

The upholstery will have a fabric surface and a foam core:

1. In the **Edit Surfaces** dialog, click **New**. Give the **Surface Name** as **Upholstery**, select the **Surface Type** as **Layered**, and click **OK**.
2. Click on the **Color** box and select a grey color (e.g. RGB of 120, 116, 110 and Alpha 255). Click **OK** to close the **Surface Color** dialog.
3. In the **Material Layers** we define the two materials for the upholstery. First the fabric. In the **Thickness** column, type **0.002**. Click the **Edit** button. In the **Mass Fraction** column, type **1.0**. In the **Material** column, select **Fabric**. Click **OK** to close the **Composition** dialog.

4. Now we add the foam. Click **Insert Row**. In the **Thickness** column, type **0.1**. Click the **Edit** button. In the **Mass Fraction** column, type **1.0**. In the **Material** column, select **FOAM**. Click **OK** to close the **Composition** dialog. You should now have two material layers in the upholstery surface.
5. Click on the **Surface Props** tab. In the **Backing** box, select **Insulated**.
6. Click on the **Reaction** tab. Select **Allow the Obstruction to Burn Away**. When this option is selected, the solid object disappears from the calculation cell by cell, as the mass contained by each mesh cells is consumed either by the pyrolysis reactions or by the prescribed HRR.
7. In the **Edit Surfaces** dialog, click **Apply** to save the changes.
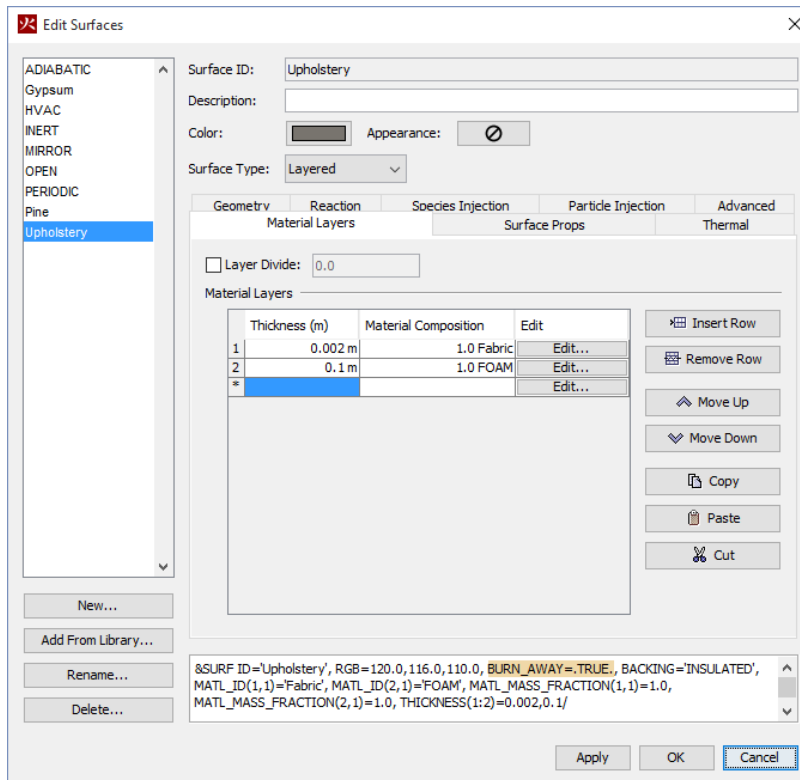
Figure 4: The upholstery has two material layers.

We will place an initial *ignitor* object on the sofa. This ignitor will be at a constant temperature of 1000 °C and will radiate heat that will ignite the upholstery. To create this burner surface:

1. In the **Edit Surfaces** dialog, click **New**. Give the **Surface Name** as **Ignitor**, select the **Surface Type** as **Heater/Cooler**, and click **OK**.
2. In the **Thermal** tab, in the **Boundary Condition Model**, select **Fixed Temperature**. This means the surface will stay at a constant temperature.
3. In the **Thermal** tab, in the **Surface Temperature** box, type **1000**. Leave the **Emissivity** at **0.9**.
4. Click the **Geometry** tab, in the **Geometry** list, select **Cylindrical**. In the **Radius** box, type **0.01**; in the **Length** box, type **0.15**.
5. In the **Edit Surfaces** dialog, click **OK** to save the changes and close the dialog.

Note that since the ignitor just keeps a constant surface temperature, we did not have to define any material properties for the surface.

Create Furniture (Obstructions)

We will now add furniture to the model.

Couch

The first will be a couch. Create a **Couch** group that will help us organize the input.

1. Right-click the **Model** category in the tree view.
2. On the **Model** menu, click **New Group**. The **Parent Group** will be **Model**.
3. In the **Group Name** box, type **Couch**.
4. Click **OK** to close the **Create Group** dialog.

To create the seat:

1. On the **Model** menu, click **New Obstruction**.
2. In the **Description** box, type **Seat cushion**.
3. In the **Group** list, select **Couch**.
4. On the **Geometry** tab, enter the values in Table 1.
5. On the **Surfaces** tab, select **Single** and select **Upholstery** from the list.
6. Click **OK** to close the **Obstruction Properties** dialog.

Table 1. Couch seat dimensions

	X	Y	Z
Min	1.5	3.8	0.2
Max	3.1	4.6	0.6

To create the right armrest:

1. On the **Model** menu, click **New Obstruction**.
2. In the **Description** box, type **Right armrest**.
3. In the **Group** list, select **Couch**.
4. On the **Geometry** tab, enter the values in Table 2.
5. On the **Surfaces** tab, select **Single** and select **Upholstery** from the list.
6. Click **OK** to close the **Obstruction Properties** dialog.

Table 2. Right armrest dimensions

	X	Y	Z
Min	1.3	3.8	0.0
Max	1.5	4.6	0.9

We will use the copy function to create the left armrest.

1. Right-click the **Right armrest** either in the Tree View or the 3D view.
2. Click **Copy/Move**.
3. In the **Mode** options, select **Copy** with **1** copy.
4. In the **Offset** boxes, enter **X = 1.8**, **Y = 0.0**, and **Z = 0.0**.
5. Click **OK** to close the **Translate** dialog.

To rename the copy, double-click on the **Right armrest** in the Tree view and change the **Description** to **Left armrest**. Click **OK**.

To create the back:

1. On the **Model** menu, click **New Obstruction**.
2. In the **Description** box, type **Back cushion**.
3. In the **Group** list, select **Couch**.
4. On the **Geometry** tab, enter the values in Table 3.
5. On the **Surfaces** tab, select **Single** and select **Upholstery** from the list.
6. Click **OK** to close the **Obstruction Properties** dialog.

Table 3. Couch back dimensions

	X	Y	Z
Min	1.5	4.4	0.6
Max	3.1	4.6	1.2

The display will appear as shown in Figure 5.
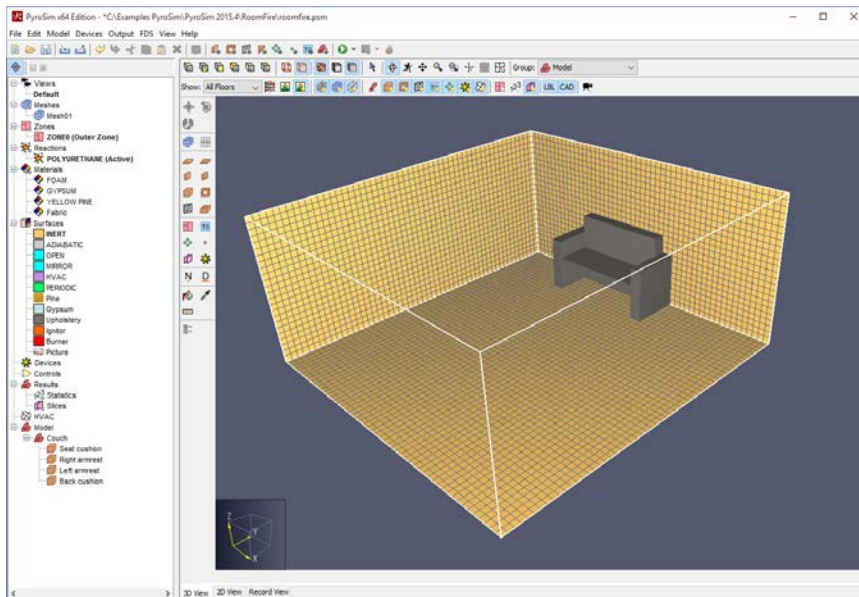
Figure 5. The room after the couch is added

Second Couch

We will now create a second couch using the copy function.

1. In the Tree View, right-click the **Couch** group.
2. Click **Copy/Move**.
3. In the **Mode** options, select **Copy** with **1** copy.
4. In the **Offset** boxes, enter **X = -1.3**, **Y = -3.6**, and **Z = 0.0**.
5. Click **OK** to close the **Translate** dialog.

Rotate the second couch to lie against the well.

1. In the Tree View, right-click the new **Couch** group.
2. Click **Rotate**.
3. In the **Mode** options, select **Move**.
4. In the **Angle** box, type **90**.
5. In the **Base Point** boxes, enter **X = 0.0** and **Y = 1.0**.
6. Click **OK** to close the **Rotate Objects** dialog.

Additional Furniture

Add a pad:

1. On the **Model** menu, click **New Obstruction**.
2. In the **Description** box, type **Pad**.
3. In the **Group** list, select **Model**.
4. On the **Geometry** tab, enter the values in Table 4.
5. On the **Surfaces** tab, select **Single** and select **Upholstery** from the list.
6. Click **OK** to close the **Obstruction Properties** dialog.

Table 4. Table dimensions

	X	Y	Z
Min	1.6	2.4	0.0
Max	3.0	3.2	0.2

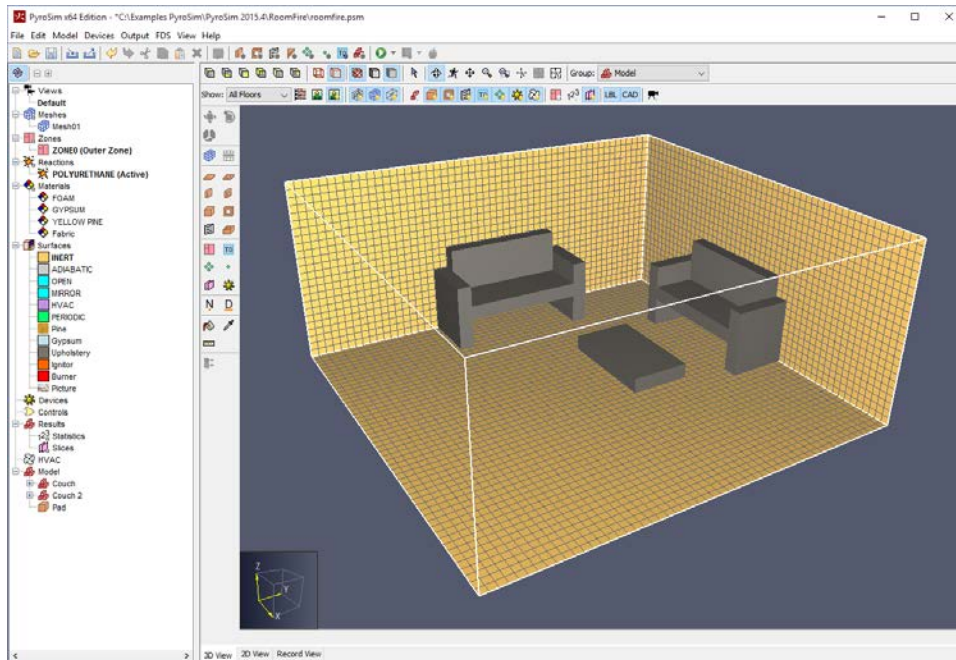The resulting room display is shown in Figure 6.

Figure 6. The resulting room display

Constructing complex objects can be time consuming and PyroSim supports several options. If your geometry is available in DXF, DWG, or STL format, PyroSim supports import. You can also import existing FDS models. For walls, PyroSim provides sketching on a background image. Alternately, if you use the same geometry in many models, you can create the geometry and save it. You can then copy any object from one model to another. You can even copy the text from an FDS input file and paste it into a PyroSim model.

Walls

We will add a wall using the 2D View. Since we will be adding only one interior wall, this wall could also be added quickly as a single obstruction. However, we will use the 2D view in order to demonstrate its use.

1. Select the **2D View**. Click the **Reset** tool.
2. Select the **Wall** ( ) Tool.
3. Click **Tool Properties** ( ). In the **Name** box, type **Wall**. Set the **Z Location** to **0.0**, the **Height** to **2.4**, the **Thickness** to **0.2**, and change the **Surface Prop** to **Gypsum**. Click **OK**.
4. With the wall tool draw the wall from left to right along the Y=0 line. Press the CTRL key to flip the wall to the lower part of the model, Figure 7.
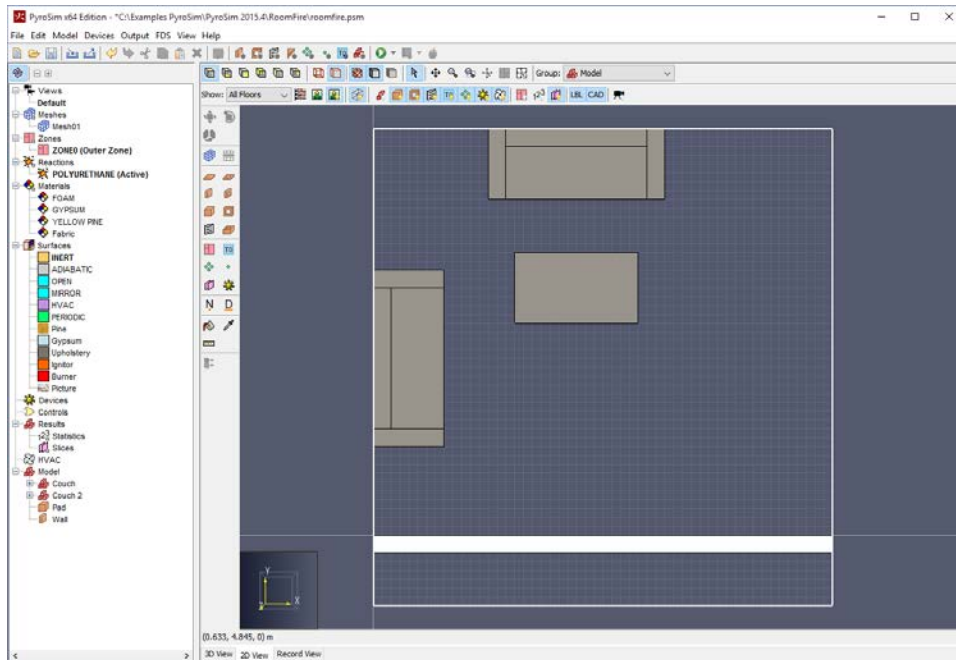
Figure 7. Drawing the wall

Create Door (Hole in Wall)

To add a door by creating a hole in the wall:

1. On the **Model** menu, click **New Hole**.
2. In the **Description** box, type **Door**.
3. In the **Group** list, select **Model**.
4. On the **Geometry** tab, enter the values in Table 5. Note that we extend the hole beyond the bounds of the wall it intersects. This ensures the hole will take priority over the wall.
5. Click **OK** to close the **Obstruction Properties** dialog.

Table 5. Door dimensions

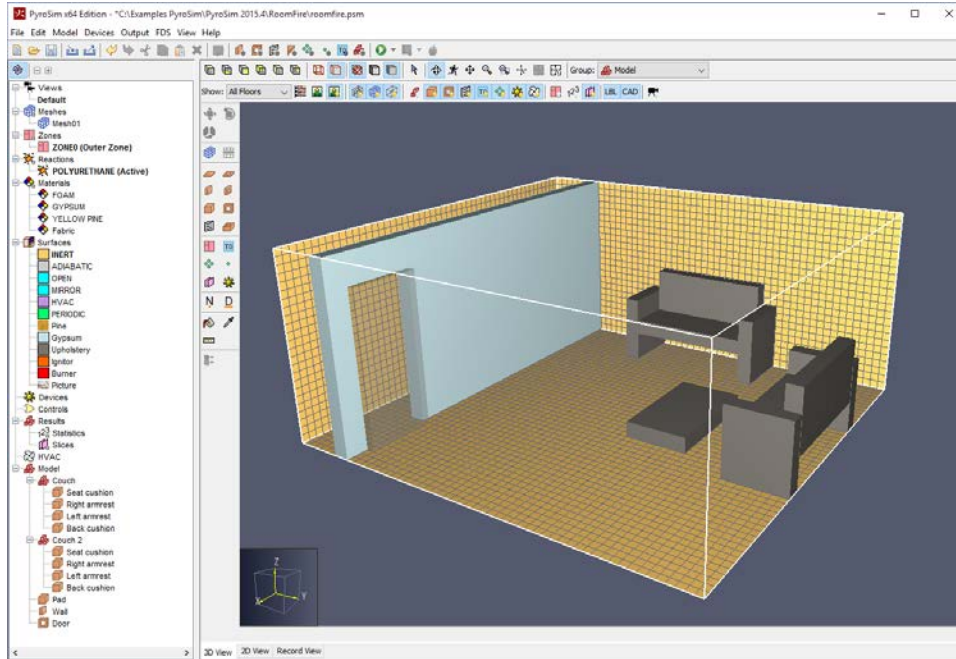|	X	Y	Z
Min	4.0	-0.3	0.0
Max	4.9	0.1	2.0

The model now looks like:

Figure 8. The model after adding the door

Use Vents to Define the Floor, Walls, and Ceiling

In FDS, *Vents* are used to describe 2D planar objects. In this example, we use vents to define the wood floor and the gypsum walls and ceiling. We do this because we want the walls and ceiling to heat up as a result of the fire. If we just used the default inert surface, they would stay at a constant temperature (20 °C by default).

To create the floor:

1. On the **Model** menu, click **New Vent**.
2. In the **Description** box, type **Floor**.
3. In the **Group** list, select **Model**.
4. In the **Surface** list, select **Pine**.
5. Click on the **Geometry** tab. In the **Plane** list, select **Z** and give the value as **0.001.**
6. In the **Bounds** boxes, enter the values in Table 6.
7. Click **OK** to close the **Vent Properties** dialog.

Table 6. Floor dimensions

	X	Y
Min	0.0	0.0
Max	5.2	4.6

Now we will define the walls and ceiling. These are created using vents and the Gypsum surface. To make these vents, use the information in Table 7.

Table 7. Wall and ceiling dimensions

Vent	Surface	Plane	Min X	Max X	Min Y	Max Y	Min Z	Max Z
Back Wall	Gypsum	Y=4.6	0	5.2			0	2.4
Left Wall	Gypsum	X=0			0	4.6	0	2.4
Right Wall	Gypsum	X=5.2			0	4.6	0	2.4
Ceiling	Gypsum	Z=2.4	0	5.2	0	4.6		

Create Ignitors that will light the Fire

In this model, we will define ignitors that will glow at a fixed temperature, heat the sofa, and ignite the sofa. Creating the ignitors is a two-step process: first we define particles, then we position them in the model.

To define the particles:

1. On the **Model** menu, click **Edit Particles**.
2. Click **New**. In the **Particle Name** box, type **Ignitor Particle**.
3. In the **Particle Type** list, select **Solid**.
4. Click **OK** to create the particle.
5. On the **Solid** tab, for **Surface**, select **Ignitor** (this is the fixed temperature surface we previously created.
6. In the **Movement** option, select **Particles are Stationary**.
7. Click the **Injection** tab. In the **Duration** box, type **1E5**. This means that the particle will remain in the model for the entire simulation.
8. Click **OK** to close the **Edit Particles** dialog.

Now we will create the actual ignitors. First create an Ignitor group:

1. Click the **Model** category in the tree view.
2. On the **Model** menu, click **New Group**. The **Parent Group** will be **Model**.
3. In the **Group Name** box, type **Ignitors**.
4. Click **OK** to close the **Create Group** dialog.

Now create the first ignitor:

1. On the **Model** menu, click **New Particle Location**.
2. In the **Description** box, type **Ignitor**.
3. In the **Group** list, select **Ignitors**.
4. In the **Particle** list, select **Ignitor Particle**.
5. In the **Droplet Count** select **Constant** and change the number to **1**.
6. Click the **Geometry** tab. In the **Location Properties** boxes, enter the values in Table 8.
7. Click **OK** to close the **Particle Cloud Properties** dialog.

Table 8. Ignitor location

X	Y	Z
2.45	4.35	0.65

Copy to create two more ignitors:

1. Right-click on the Ignitor and select **Copy/Move**.
2. In the **Model** options, select **Copy** and in the **Number of Copies** box, type **2**.
3. In the **Offset** boxes, enter the values in Table 9.
4. Click **OK** to close the **Translate** dialog.

Table 9. Ignitor Offsets

X	Y	Z
0.1	0.0	0.0

Add Open Boundary

We will add an open boundary on the model outside the door. PyroSim provides a shortcut that can create open vents on mesh boundaries.

1. In the navigation view, right-click on the **MESH01** and click **Open Mesh Boundaries**. This will add a group named **Vents for MESH** that includes vents on each grid boundary.
2. Delete four vents, the XMAX, XMIN, YMAX, and ZMIN vents.
3. Now double-click the **Mesh Vent: Mesh [ZMAX]** vent. Click the **Geometry** tab, and change **Max Y** to **0**. Click **OK**.

Now there are just two open vents. One opposite the door and one above the door. This will let smoke leave the door and flow up. It will also allow cold air to flow in the lower half of the door.

Create Thermocouple Records

We will first create one thermocouple near the ceiling and then replicate it to create a stack of thermocouples.

1. On the **Devices** menu, click **New Thermocouple.**
2. In the **Location** boxes, enter **X = 2.6**, **Y = 2.3**, and **Z = 2.1**.
3. Click **OK** to close the **Thermocouple** dialog.

To copy the thermocouple:

1. Right-click on **THCP** and click **Copy/Move**.
2. In the **Mode**, select **Copy** with the **Number of copies 5**.
3. In the **Offset** boxes, enter **X = 0.0**, **Y =0.0**, and **Z = -0.3**.
4. Click **OK** to close the **Translate** dialog.

5. Click the **LBL** icon to toggle labels off. Click the **Devices** icon to toggle devices off.

Create Layer Zoning Device

The upper and lower layers in the room can be calculated using the Layer Zone Device. To create this:

1. On the **Devices** menu, click **New Layer Zoning Device.**
2. Select the three checkboxes to enable, measuring of Layer Height, Upper Temperature, and Lower Temperature.
3. In the **End Point** boxes enter the data in Table 10.
4. Click **OK** to close the **Layer Zoning Device** dialog.

Table 10. Layer Zone Geometry

	X	Y	Z
End Point 1	2.6	2.3	0
End Point 2	2.6	2.3	2.4

Create Slice Records for Results Plotting

Slice planes can be used to display 2D contours in the Smokeview display of the results. In this analysis, we will save temperature and velocity data for future plotting. To define the slice plane:

1. On the **Output** menu, click **Slices.**
2. Fill the table by entering the values in Table 11.
3. Click **OK** to close the **Animated Planar Slices** dialog.

Table 11. Slice plane data

XYZ Plane	Plane Value (m)	Gas Phase Quantity	Use Vector?
X	2.6	Temperature	NO
X	4.45	Velocity	YES

Create Surface Plots

Temperatures (and other quantities) on the surface of objects can be plotted. To define the surface plots:

1. On the **Output** menu, click **Boundary Quantities**.
2. Click the **Wall Temperature** checkbox.
3. Click **OK** to close the **Animated Boundary Quantities** dialog.

Specify Simulation Properties

To define the end time:

1. On the **FDS** menu, click **Simulation Parameters**.
2. In the **Simulation Title** box, type **Room fire**.

3. In the **End Time** box, type **150** s.
4. Click **OK**.

Hang a Picture on the Wall

Let us fancy things up by hanging a picture on the wall. First decide what picture you want to hang.

1. On the **Model** menu, click **Edit Surfaces**.
2. In the **Edit Surfaces** dialog, click **New**. Give the **Surface Name** as **Picture**, select the **Surface Type** as **Basic** (this is just an INERT surface that you can name), and click **OK**.
3. Click on the **Appearance** box.
4. Click the **Import** button and select the image you want as a picture. In homage to my Dad and Brother, I used the image called <u>motorcycle.jpg</u>. That is me in the middle. Right-click the link and click **Save Link As** to download the image if you would like to use it.
5. The image you selected will be displayed. Set the **Width** to **1.0** and the **Height** to **0.675** (or whatever values are appropriate for your image.)
6. Click **OK** to close the **Textures** dialog.
7. Click **OK** to close the **Edit Surfaces** dialog.

We now create a vent that uses the texture.

1. On the **Model** menu, click **New Vent**.
2. In the **Description** box, type **Picture**.
3. In the **Group** list, select **Model**.
4. In the **Surface** list, select **Picture**.
5. Under **Texture Origin**, click to select **Relative to Object**.
6. Click the **Geometry** tab. In the **Plane** list, select **Y** and give the value as **4.599.**
7. In the **Bounds** boxes, enter the values in Table 12.
8. Click **OK** to close the **Vent Properties** dialog.

Table 12. Picture dimensions

	X	Z
Min	3.6	1.2
Max	4.6	1.875

The Model is Complete

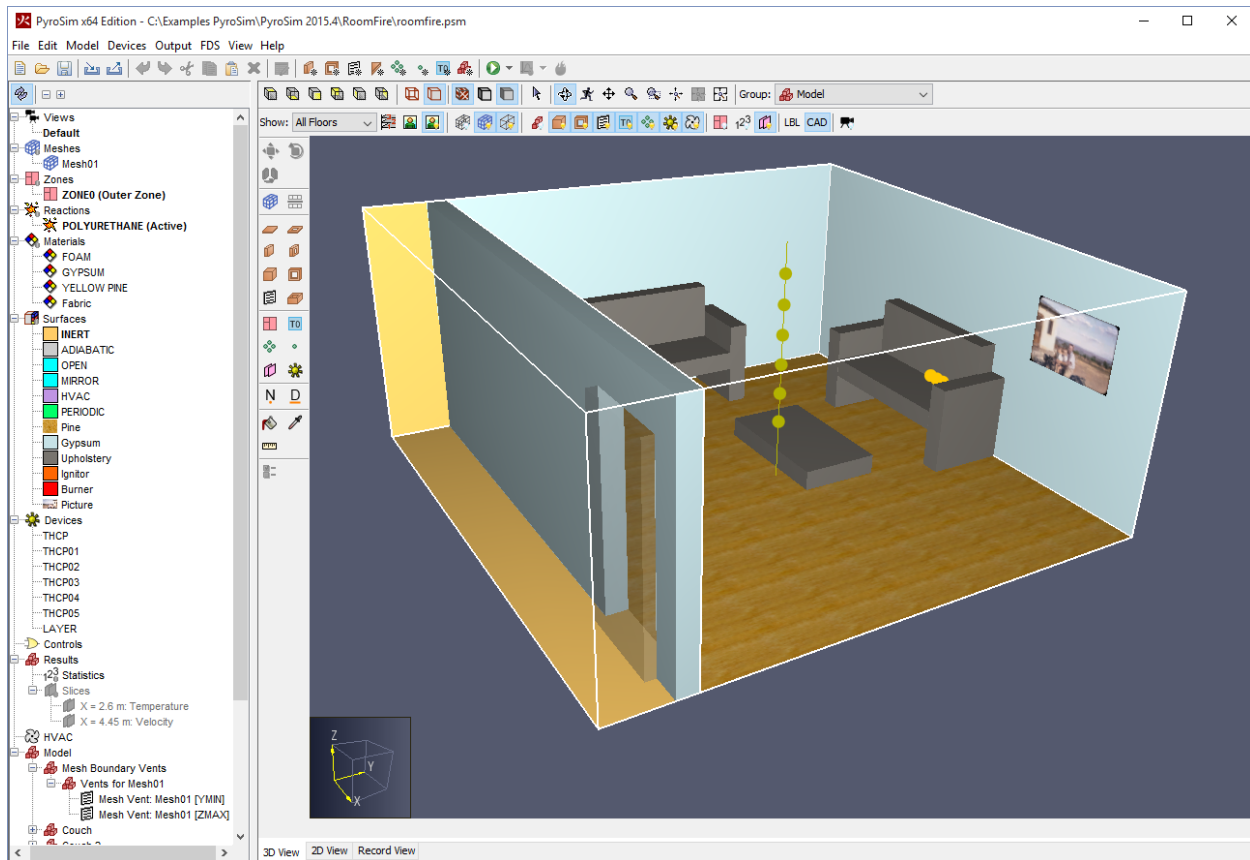Your model should now look like Figure 9. Save it.

Figure 9. Completed model

Run the Analysis

To run the analysis:

1. On the **FDS** menu, click **Run FDS**. If asked to expand holes, click **Yes**. You will receive a warning that two vents overlap. This is caused by the picture on the wall. The solution will use the gypsum wall vent and ignore the picture vent in the calculation.

View the Results

An image showing the smoke, heat release rate, and velocity vectors is shown in Figure 10. This is a time when the sofa has begun to burn, but the fire is still relatively small. You can clearly see the air circulation caused by the fire, with hot air flowing out the top half of the door and cold air flowing in the bottom half of the door. The smoke has formed a layer.
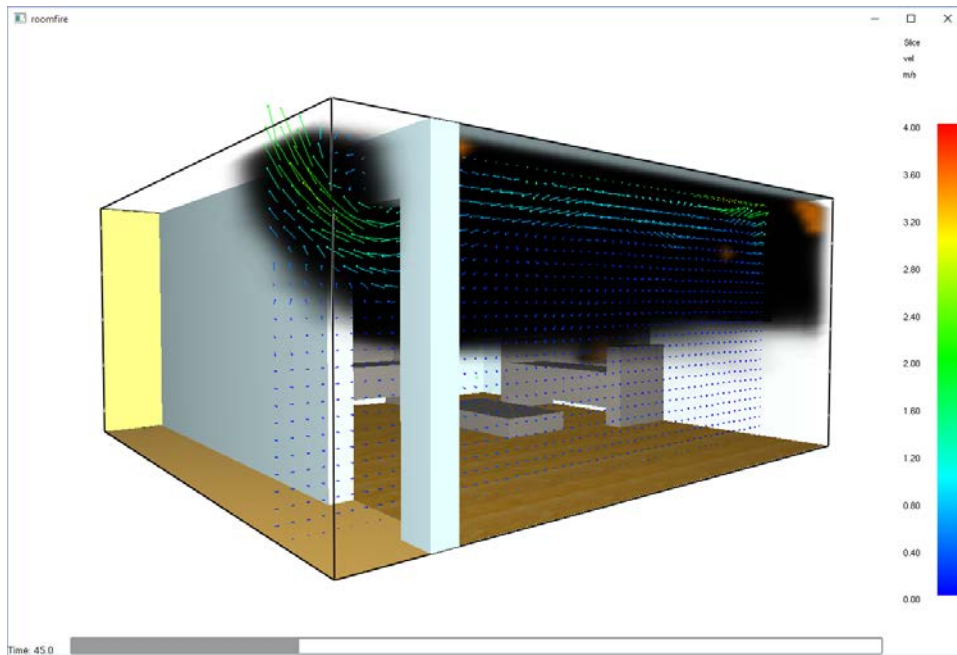
Figure 10. Plot showing smoke, heat release rate isosurface, and velocity vectors. You can see the formation of layers, the hot air and products flowing out the top of the door, and fresh air flowing in the bottom of the door.

A plot of surface temperature is given in Figure 11. Notice that parts of the sofa have burned away. To show this plot, in Smokeview, set the **Obstacles** location to **Actual**.
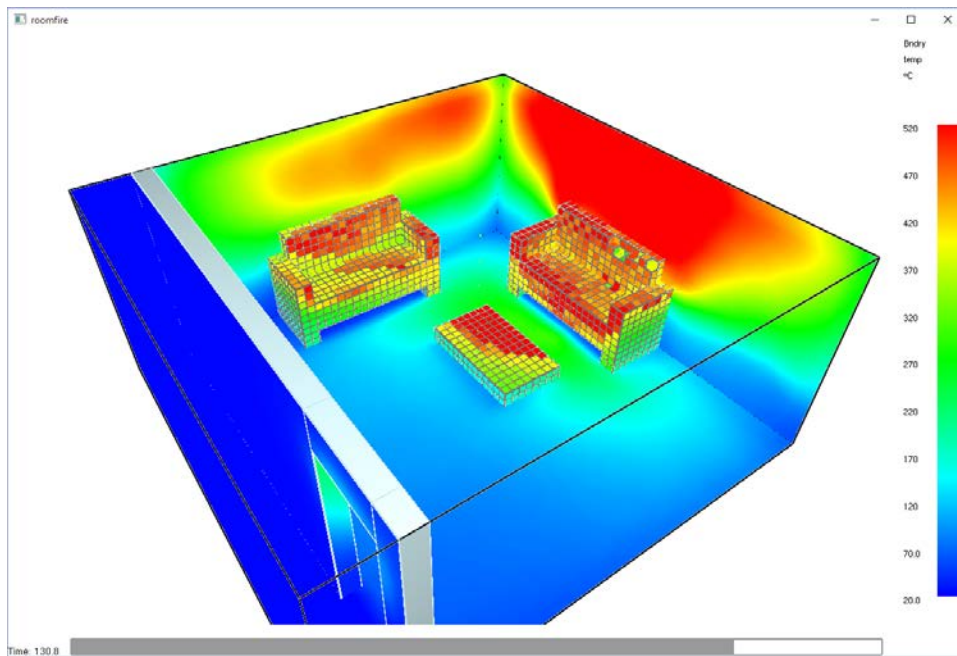

Figure 11: Plot of surface temperature. Notice that the sofa has burned away. In Smokeview, set the Obstacles location to Actual.

To view time history results

1. In the PyroSim toolbar, click **Plot Thermal Results**.
2. Plot the heat release rate as a function of time, Figure 12. This is an extreme fire with flashover.

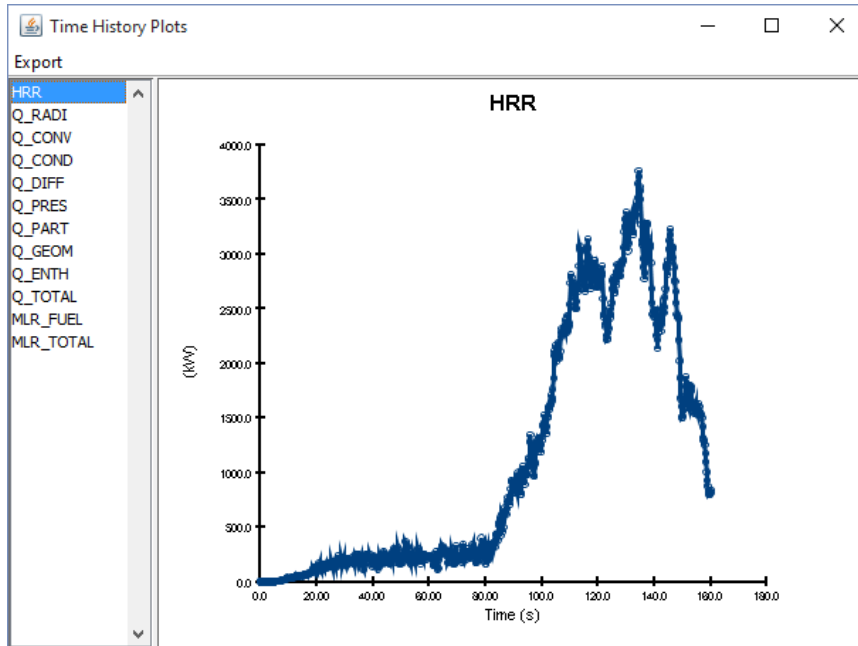You can also make plots of the thermocouple readings and the layer height.

Figure 12. Heat release rate.

References

FDS-SMV Official Website. *Fire Dynamics Simulator and Smokeview.* Gaithersburg, Maryland, USA : National Institute of Standards and Technology.

McGrattan, Kevin, et al. 2014. *Fire Dynamics Simulator Technical Reference Guide (Sixth Edition).* Gaithersburg, Maryland, USA, July 2014. NIST Special Publication 1018-6.

McGrattan, Kevin, et al. 2014. *Fire Dynamics Simulator User's Guide (Sixth Edition).* Gaithersburg, Maryland, USA, July 2014. NIST Special Publication 1019-6.

FDS Input File

Following is a listing of the FDS input file. You can either save this as a text file and import into PyroSim, or you can:

1. Open PyroSim and on the **File** menu, click **New**.
2. Select and copy the entire listing below.
3. On the PyroSim **Edit** menu, click **Paste**. You will receive two warnings. The first is related to textures. Since we are just pasting the FDS input data, we will lose the links to the wood floor and wall picture textures. You can go back and add those in PyroSim, if desired. Select **OK**. The second warning is that Simulation Parameters already exists in the model, click **Yes to All** to replace all existing data with the FDS file data.
4. Click the **Reset** tool.
5. Save and run.

```
roomfire.fds
Generated by PyroSim - Version 2015.4.1125
Nov 25, 2015 1:58:20 PM


&HEAD CHID='roomfire'/
&TIME T_END=200.0/
&DUMP RENDER_FILE='roomfire.ge1', COLUMN_DUMP_LIMIT=.TRUE., DT_RESTART=300.0/


&MESH ID='Mesh01', IJK=52,54,24, XB=0.0,5.2,-0.8,4.6,0.0,2.4/


&PART ID='Ignitor Particle',
      STATIC=.TRUE.,
      SURF_ID='Ignitor'/


&REAC ID='POLYURETHANE',
      FYI='NFPA Babrauskas',
      FUEL='REAC_FUEL',
      C=6.3,
      H=7.1,
      O=2.1,
      N=1.0,
      SOOT_YIELD=0.1/


&DEVC ID='THCP', QUANTITY='THERMOCOUPLE', XYZ=2.6,2.3,2.1/
&DEVC ID='THCP01', QUANTITY='THERMOCOUPLE', XYZ=2.6,2.3,1.8/
&DEVC ID='THCP02', QUANTITY='THERMOCOUPLE', XYZ=2.6,2.3,1.5/
&DEVC ID='THCP03', QUANTITY='THERMOCOUPLE', XYZ=2.6,2.3,1.2/
&DEVC ID='THCP04', QUANTITY='THERMOCOUPLE', XYZ=2.6,2.3,0.9/
&DEVC ID='THCP05', QUANTITY='THERMOCOUPLE', XYZ=2.6,2.3,0.6/
&DEVC ID='LAYER->HEIGHT', QUANTITY='LAYER HEIGHT', XB=2.6,2.6,2.3,2.3,0.0,2.4/
&DEVC ID='LAYER->LTEMP', QUANTITY='LOWER TEMPERATURE',
XB=2.6,2.6,2.3,2.3,0.0,2.4/
&DEVC ID='LAYER->UTEMP', QUANTITY='UPPER TEMPERATURE',
XB=2.6,2.6,2.3,2.3,0.0,2.4/
&MATL ID='Fabric',
```

```
      SPECIFIC_HEAT=1.0,
      CONDUCTIVITY=0.1,
      DENSITY=100.0,
      HEAT_OF_COMBUSTION=1.5E4,
      N_REACTIONS=1,
      HEAT_OF_REACTION=1000.0,
      SPEC_ID(1,1)='REAC_FUEL',
      NU_SPEC(1,1)=1.0,
      REFERENCE_TEMPERATURE=280.0/
&MATL ID='FOAM',
      FYI='Caution: Reaction Rate Not Validated, remaining data from Jukka
Hietaniemi, et al., "FDS simulation of fire spread..."',
      SPECIFIC_HEAT=1.0,
      CONDUCTIVITY=0.05,
      DENSITY=40.0,
      HEAT_OF_COMBUSTION=3.0E4,
      N_REACTIONS=1,
      HEAT_OF_REACTION=800.0,
      SPEC_ID(1,1)='REAC_FUEL',
      NU_SPEC(1,1)=1.0,
      REFERENCE_TEMPERATURE=300.0/
&MATL ID='GYPSUM',
      FYI='NBSIR 88-3752 - ATF NIST Multi-Floor Validation',
      SPECIFIC_HEAT=1.09,
      CONDUCTIVITY=0.17,
      DENSITY=930.0/
&MATL ID='YELLOW PINE',
      FYI='Quintiere, Fire Behavior - NIST NRC Validation',
      SPECIFIC_HEAT=2.85,
      CONDUCTIVITY=0.14,
      DENSITY=640.0/

&SURF ID='Upholstery',
      RGB=120.0,116.0,110.0,
      BURN_AWAY=.TRUE.,
      BACKING='INSULATED',
      MATL_ID(1,1)='Fabric',
      MATL_ID(2,1)='FOAM',
      MATL_MASS_FRACTION(1,1)=1.0,
      MATL_MASS_FRACTION(2,1)=1.0,
      THICKNESS(1:2)=0.002,0.1/
&SURF ID='Gypsum',
      RGB=198.0,225.0,230.0,
      BACKING='VOID',
      MATL_ID(1,1)='GYPSUM',
      MATL_MASS_FRACTION(1,1)=1.0,
      THICKNESS(1)=0.013/
&SURF ID='Pine',
      RGB=146.0,202.0,166.0,
      TEXTURE_MAP='psm_wood2.jpg',
      TEXTURE_WIDTH=0.6096,
      TEXTURE_HEIGHT=0.6096,
      BACKING='VOID',
      MATL_ID(1,1)='YELLOW PINE',
```

```
      MATL_MASS_FRACTION(1,1)=1.0,
      THICKNESS(1)=0.01/
&SURF ID='Ignitor',
      RGB=255.0,102.0,0.0,
      TMP_FRONT=1000.0,
      GEOMETRY='CYLINDRICAL',
      LENGTH=0.15,
      RADIUS=0.01/
&SURF ID='Picture',
      TEXTURE_MAP='motorcycle_1.jpg',
      TEXTURE_HEIGHT=0.675/

&INIT ID='Ignitor', PART_ID='Ignitor Particle', N_PARTICLES=1,
XYZ=2.45,4.35,0.65/
&INIT ID='Ignitor', PART_ID='Ignitor Particle', N_PARTICLES=1,
XYZ=2.55,4.35,0.65/
&INIT ID='Ignitor', PART_ID='Ignitor Particle', N_PARTICLES=1,
XYZ=2.65,4.35,0.65/

&OBST XB=1.5,3.1,3.8,4.6,0.2,0.6, SURF_ID='Upholstery'/ Seat cushion
&OBST XB=1.3,1.5,3.8,4.6,0.0,0.9, SURF_ID='Upholstery'/ Right armrest
&OBST XB=3.1,3.3,3.8,4.6,0.0,0.9, SURF_ID='Upholstery'/ Left armrest
&OBST XB=1.5,3.1,4.4,4.6,0.6,1.2, SURF_ID='Upholstery'/ Back cushion
&OBST XB=8.88178E-16,0.8,1.2,2.8,0.2,0.6, SURF_ID='Upholstery'/ Seat cushion
&OBST XB=4.44089E-16,0.8,1.0,1.2,0.0,0.9, SURF_ID='Upholstery'/ Right armrest
&OBST XB=8.88178E-16,0.8,2.8,3.0,0.0,0.9, SURF_ID='Upholstery'/ Left armrest
&OBST XB=8.88178E-16,0.2,1.2,2.8,0.6,1.2, SURF_ID='Upholstery'/ Back cushion
&OBST XB=1.6,3.0,2.4,3.2,0.0,0.2, SURF_ID='Upholstery'/ Pad
&OBST XB=0.0,5.2,-0.2,-1.94289E-16,0.0,2.4, SURF_ID='Gypsum'/ Wall

&HOLE XB=4.0,4.9,-0.3,0.1,-0.01,2.0/ Door

&VENT SURF_ID='OPEN', XB=0.0,5.2,-0.8,-0.8,0.0,2.4/ Mesh Vent: Mesh01 [YMIN]
&VENT SURF_ID='OPEN', XB=0.0,5.2,-0.8,0.0,2.4,2.4/ Mesh Vent: Mesh01 [ZMAX]
&VENT SURF_ID='Pine', XB=0.0,5.2,0.0,4.6,0.001,0.001/ Floor
&VENT SURF_ID='Gypsum', XB=0.0,5.2,4.6,4.6,0.0,2.4/ Back Wall
&VENT SURF_ID='Gypsum', XB=0.0,0.0,0.0,4.6,0.0,2.4/ Left Wall
&VENT SURF_ID='Gypsum', XB=5.2,5.2,0.0,4.6,0.0,2.4/ Right Wall
&VENT SURF_ID='Gypsum', XB=0.0,5.2,0.0,4.6,2.4,2.4/ Ceiling
&VENT SURF_ID='Picture', XB=3.6,4.6,4.599,4.599,1.2,1.875,
TEXTURE_ORIGIN=3.6,4.599,1.2/ Picture

&BNDF QUANTITY='WALL TEMPERATURE'/

&SLCF QUANTITY='TEMPERATURE', PBX=2.6/
&SLCF QUANTITY='VELOCITY', VECTOR=.TRUE., PBX=4.45/

&TAIL /
```

Original NIST FDS Verification Input File

This example we created is a simplification of the room fire problem provided by NIST as an FDS verification problem. You can download the complete original FDS verification file at:

https://github.com/firemodels/fds-smv/blob/development/Verification/Fires/room_fire.fds

To import the original FDS file into PyroSim, on the **File** menu, click **Import FDS/CAD File**. During import, specify that the NIST model was created using FDS 6.

The simplifications we made in the example are mostly related to geometry. You will notice that the default FOAM material properties we used are different than the NIST verification values (NIST specifically says their values are fabricated and not to be used for other simulations).