


# Generating Parametric Analyses & Using Variables Within Your FDS File

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**STREAMLINING WORKFLOWS**  
**and**  
**REDUCING ERRORS**  
**was more interesting than**  
**THE PROJECT ITSELF**

## Pop Quiz!

```
&MESH XB= 0.0, 6.096, 0.0, 3.658, 0.0, 2.438, IJK= 41, 24, 16/
```

```
&SURF ID='FIRE', HRRPUA=833.3, TAU_Q=-335.4/
```

```
&VENT XB= 0.638, 1.862, 1.138, 2.362, 0.0, 0.0, SURF_ID='FIRE' /
```

1. What is the mesh cell size?
2. What is the peak heat release rate?
3. Is the fire a fast, medium, or slow growth fire?



It takes  
**TIME**  
to understand  
**FDS Code**

# Life before xFDS

	A	B	C	D	E	F	G	H
	ID	X	Y	Z	Prefix	QUANTITY	SPEC_ID	SETPOINT
2	Stair1-1				CMO	VOLUME FRACTION	CARBON MONOXIDE	0.0014 &DEVC ID='CMO-Stair1-1', XYZ= 15.3
3	2				CO2	VOLUME FRACTION	CARBON DIOXIDE	0.06 &DEVC ID='CO2-Stair1-1', XYZ= 15.3
4		15.380 m	20.726 m	4.572 m	OXY	VOLUME FRACTION	OXYGEN	0.13 &DEVC ID='OXY-Stair1-1', XYZ= 15.3
5					TMP	TEMPERATURE		60 &DEVC ID='TMP-Stair1-1', XYZ= 15.3
6					VIS	VISIBILITY		4 &DEVC ID='VIS-Stair1-1', XYZ= 15.3
7	Stair1-2				CMO	VOLUME FRACTION	CARBON MONOXIDE	0.0014 &DEVC ID='CMO-Stair1-2', XYZ= 15.3
8	3				CO2	VOLUME FRACTION	CARBON DIOXIDE	0.06 &DEVC ID='CO2-Stair1-2', XYZ= 15.3
9		15.380 m	20.726 m	9.449 m	OXY	VOLUME FRACTION	OXYGEN	0.13 &DEVC ID='OXY-Stair1-2', XYZ= 15.3
10					TMP	TEMPERATURE		60 &DEVC ID='TMP-Stair1-2', XYZ= 15.3
11					VIS	VISIBILITY		4 &DEVC ID='VIS-Stair1-2', XYZ= 15.3
12	Stair1-3				CMO	VOLUME FRACTION	CARBON MONOXIDE	0.0014 &DEVC ID='CMO-Stair1-3', XYZ= 15.3
13	4				CO2	VOLUME FRACTION	CARBON DIOXIDE	0.06 &DEVC ID='CO2-Stair1-3', XYZ= 15.3
14		15.380 m	20.726 m	13.716 m	OXY	VOLUME FRACTION	OXYGEN	0.13 &DEVC ID='OXY-Stair1-3', XYZ= 15.3
15					TMP	TEMPERATURE		60 &DEVC ID='TMP-Stair1-3', XYZ= 15.3
16					VIS	VISIBILITY		4 &DEVC ID='VIS-Stair1-3', XYZ= 15.3
17	Stair1-4				CMO	VOLUME FRACTION	CARBON MONOXIDE	0.0014 &DEVC ID='CMO-Stair1-4', XYZ= 15.3
18	5				CO2	VOLUME FRACTION	CARBON DIOXIDE	0.06 &DEVC ID='CO2-Stair1-4', XYZ= 15.3
19		15.380 m	20.726 m	18.288 m	OXY	VOLUME FRACTION	OXYGEN	0.13 &DEVC ID='OXY-Stair1-4', XYZ= 15.3
20					TMP	TEMPERATURE		60 &DEVC ID='TMP-Stair1-4', XYZ= 15.3
21					VIS	VISIBILITY		4 &DEVC ID='VIS-Stair1-4', XYZ= 15.3
22	Stair1e-1				CMO	VOLUME FRACTION	CARBON MONOXIDE	0.0014 &DEVC ID='CMO-Stair1e-1', XYZ= 15.3
23	6				CO2	VOLUME FRACTION	CARBON DIOXIDE	0.06 &DEVC ID='CO2-Stair1e-1', XYZ= 15.3
24		15.380 m	22.860 m	4.572 m	OXY	VOLUME FRACTION	OXYGEN	0.13 &DEVC ID='OXY-Stair1e-1', XYZ= 15.3
25					TMP	TEMPERATURE		60 &DEVC ID='TMP-Stair1e-1', XYZ= 15.3
26					VIS	VISIBILITY		4 &DEVC ID='VIS-Stair1e-1', XYZ= 15.3
27	Stair1e-2				CMO	VOLUME FRACTION	CARBON MONOXIDE	0.0014 &DEVC ID='CMO-Stair1e-2', XYZ= 15.3
28	7				CO2	VOLUME FRACTION	CARBON DIOXIDE	0.06 &DEVC ID='CO2-Stair1e-2', XYZ= 15.3
29		15.380 m	22.860 m	9.449 m	OXY	VOLUME FRACTION	OXYGEN	0.13 &DEVC ID='OXY-Stair1e-2', XYZ= 15.3
30					TMP	TEMPERATURE		60 &DEVC ID='TMP-Stair1e-2', XYZ= 15.3
31					VIS	VISIBILITY		4 &DEVC ID='VIS-Stair1e-2', XYZ= 15.3
32	Stair1e-3				CMO	VOLUME FRACTION	CARBON MONOXIDE	0.0014 &DEVC ID='CMO-Stair1e-3', XYZ= 15.3
33	8				CO2	VOLUME FRACTION	CARBON DIOXIDE	0.06 &DEVC ID='CO2-Stair1e-3', XYZ= 15.3
34		15.380 m	22.860 m	13.716 m	OXY	VOLUME FRACTION	OXYGEN	0.13 &DEVC ID='OXY-Stair1e-3', XYZ= 15.3
35					TMP	TEMPERATURE		60 &DEVC ID='TMP-Stair1e-3', XYZ= 15.3
36					VIS	VISIBILITY		4 &DEVC ID='VIS-Stair1e-3', XYZ= 15.3

What if you want to add or remove new lines?



So many python files for one project!

Documentation is **separated** from the actual modeling files.

Spreadsheets and scripts may not be **user-friendly**.

# Introducing...



A ...

- free,
- open-source,
- progressive,
- extendable, and
- general purpose

... framework for rapid model development

Free

As in free beer!

Progressive

Start with the basics and expand as needed

Extendable

If a feature is missing, you can add it

# xFDS Philosophy

There should be a  
**single source of truth**  
for all data

The user should be able to  
**understand the differences**  
**between models**  
without navigating menus  
or opening every FDS file

The user should be  
**productive without**  
**being a developer**

# What is the Mesh Resolution?

```
&MESH XB= 0.0, 6.096, 0.0, 3.658, 0.0, 2.438, IJK= 41, 24, 16/
```

$$I = 6.096 \text{ m} / 41 = 0.15 \text{ m}$$

$$J = 3.658 \text{ m} / 24 = 0.15 \text{ m} \quad \Rightarrow 15 \text{ cm}$$

$$K = 2.438 \text{ m} / 16 = 0.15 \text{ m}$$



# What is the Mesh Resolution?

```
&MESH XB= 0.0, 6.096, 0.0, 3.658, 0.0, 2.438, IJK= 41, 24, 16/
```



```
{# Set outer mesh boundaries #}  
{% set dx = 20 |convert('ft', 'm') %}  
{% set dy = 12 |convert('ft', 'm') %}  
{% set dz = 8 |convert('ft', 'm') %}  
{# Set desired mesh resolution #}  
{% set res = 15 |convert('cm', 'm') %}
```

```
&MESH XB= 0.0, {{ dx }}, 0.0, {{ dy }}, 0.0, {{ dz }},  
IJK={{ (dx/res)|int }}, {{ (dy/res)|int }},{{ (dz/res)|int }}/
```

# What is the Mesh Resolution?

```
&MESH XB= 0.0, 6.096, 0.0, 3.658, 0.0, 2.438, IJK= 41, 24, 16/
```



```
{# Set outer mesh boundaries #}  
{% set dx = 20 |convert('ft', 'm') %}  
{% set dy = 12 |convert('ft', 'm') %}  
{% set dz = 8 |convert('ft', 'm') %}  
{# Set desired mesh resolution #}  
{% set res = 15 |convert('cm', 'm') %}  
  
{% set bounds = 0.0, dx, 0.0, dy, 0.0, dz %}  
&MESH XB={{ bounds|xb }}, IJK={{ bounds|ijk(res) }}/
```

# Need a Mesh Sensitivity Analysis?

pbdl.yml - Yaml Configuration File

```
xfds:  
  render:  
    - name: {{ Q }}kW@{{ res }}m  
      files:  
        - model.fds  
      variables:  
        dx: 20 # ft  
        dy: 12 # ft  
        dz: 8 # ft  
        area: 1.5 # m^2  
      parameters:  
        Q: [1000, 1500]  
        res: [0.10, 0.15, 0.20]
```

model.fds - FDS Template

```
{% set bounds = [  
  0.0, dx|convert('ft', 'm'),  
  0.0, dy|convert('ft', 'm'),  
  0.0, dz|convert('ft', 'm'),  
] %}  
&MESH XB= {{ bounds|xb }},  
      IJK={{ bounds|ijk(res) }}/  
&SURF ID='FIRE',  
      HRRPUA={{ Q / area }},  
      TAU_Q= {{ Q|t2(tg=300) }}/  
&VENT .../
```

# Need a Mesh Sensitivity Analysis?

pbd.yml - Yaml Configuration File

```
xfds:  
  render:  
    - name: {{ Q }}kW@{{ res }}m  
      files:  
        - model.fds  
      variables:  
        dx: 20 # ft  
        dy: 12 # ft  
        dz: 8 # ft  
        area: 1.5 # m^2  
      parameters:  
        Q: [1000, 1500]  
        res: [0.10, 0.15, 0.20]
```

Output Models

- 1000kW@0.10m.fds
- 1000kW@0.15m.fds
- 1000kW@0.20m.fds
- 1500kW@0.10m.fds
- 1500kW@0.15m.fds
- 1500kW@0.20m.fds

## What's the Peak HRR? Fast, Med, or Slow?

```
&SURF ID='FIRE', HRRPUA=833.3, TAU_Q=-335.4/  
&VENT XB=0.638, 1.862, 1.138, 2.362, 0.0, 0.0, SURF_ID='FIRE' /
```

$$dx = 1.862 \text{ m} - 0.638 \text{ m} = 0.612 \text{ m}$$

$$dy = 2.362 \text{ m} - 1.138 \text{ m} = 0.612 \text{ m}$$

$$\text{area} = dx * dy = 0.612 \text{ m} * 0.612 \text{ m} = 1.5 \text{ m}^2$$

$$Q = \text{HRRPUA} * \text{area} = 833.3 \text{ kW/m}^2 * 1.5 \text{ m}^2 = 1250 \text{ kW}$$

$$tg = \text{TAU}_Q / \text{sqrt}(Q / 1000) = 300 \text{ s} \Rightarrow \text{Medium Growth}$$

## What's the Peak HRR? Fast, Med, or Slow?

```
&SURF ID='FIRE', HRRPUA=833.3, TAU_Q=-335.4/  
&VENT XB=0.638, 1.862, 1.138, 2.362, 0.0, 0.0, SURF_ID='FIRE' /
```



```
{# Set fire size #}  
{% set Q = 1250 %}  
{# Set fire center #}  
{% set xc, yc, z = (1.25, 1.75, 0.00) %}  
  
{# Determine offsets from xc/yc to get desired area #}  
{% set area = 1.5 %}  
{% set s = (area ** 0.5) / 2 %}  
  
&SURF ID='FIRE', HRRPUA={{ Q / area }}, TAU_Q={{ Q|t2(tg=300) }}/  
&VENT XB={{ (xc-s, xc+s, yc-s, yc+s, z, z)|xb }}, SURF_ID='FIRE' /
```

# Other Features

## pbd.yml

- Generate a large number of scenarios
- Add information to only specific scenarios
- Exclude specific scenario combinations

## filters.py

- Program new filters to use in your template

## model.ini / model.ssf

- Smokeview config and scripts with each model

## model.fds

- Create reusable template blocks with macros
- Use if-statements to toggle records on and off
- Use for loops to quickly generate similar records

## units.txt

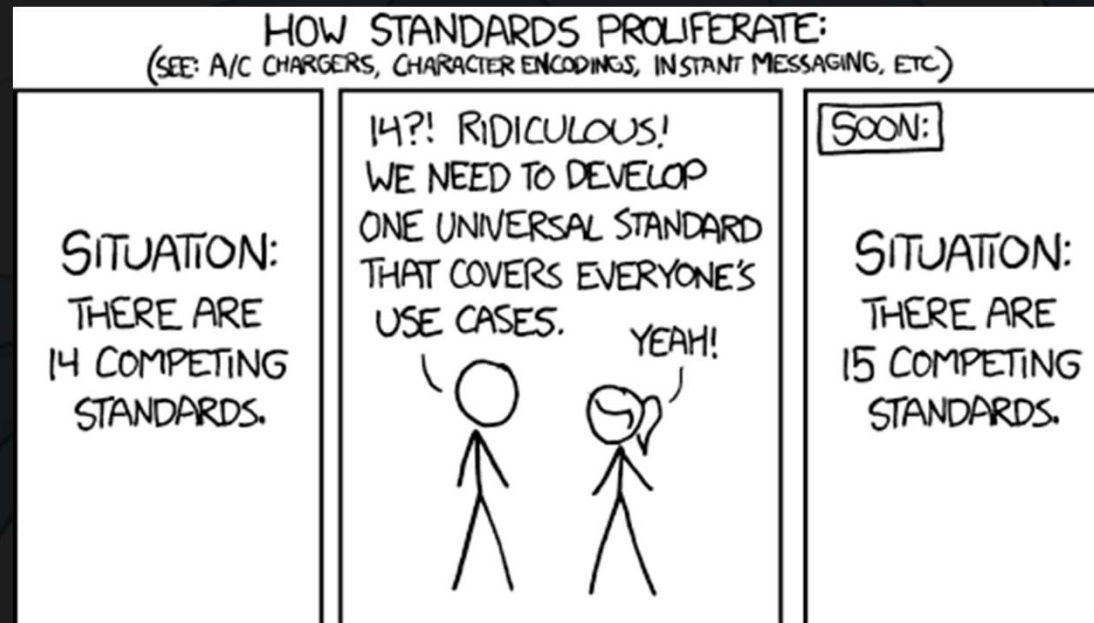
- Define new units for conversion if not available

## model.pbs

- Create PBS template files to match each model

# There are many ways to create an FDS File

**xFDS can improve your workflow**



<https://xkcd.com/927/>



# Pop Quiz!

```
{% set dx = 20|convert('ft', 'm') %}  
{% set dy = 12|convert('ft', 'm') %}  
{% set dz = 8|convert('ft', 'm') %}  
{% set res = 15|convert('cm', 'm') %}  
{% set bounds = 0.0, dx, 0.0, dy, 0.0, dz %}  
&MESH XB={{ bounds|xb }}, IJK={{ bounds|ijk(res) }}/
```

```
{% set Q = 1250 %}  
{% set xc, yc, z = (1.25, 1.75, 0.00) %}  
{% set area = 1.5 %}  
{% set s = (area ** 0.5) / 2 %}  
&SURF ID='FIRE', HRRPUA={{ Q / area }}, TAU_Q={{ Q|t2(tg=300) }}/
```

```
&VENT XB={{ (xc-s, xc+s, yc-s, yc+s, z, z)|xb }}, SURF_ID='FIRE' /
```

1. What is the mesh cell size?
2. What is the peak heat release rate?
3. Is the fire a fast, medium, or slow growth fire?

# Thank You!



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ACCELERATE YOUR MODELING

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Let's Connect!



<https://pbd.tools/connect>



Documentation at  
<https://xfds.pbd.tools>