Effects of Intumescent Layering on Pyrolysis of FRP Systems

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Effects of Intumescent Layering on Pyrolysis of FRP Systems

A Major Qualifying Project Report
Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements for the
Degree of Bachelor of Science
By:

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Project: NAD FM15

Professor Nicholas Dembsey, Advisor
Abstract

Fiber Reinforced Polymers (FRPs) compose a versatile set of materials and offer several advantages over conventional materials in architectural applications such as exterior cladding and ornamental features. Manufacturers are developing a myriad of systems to improve these materials’ ability to meet fire safety regulations. Cone calorimetry is a bench-scale test whose results can be used to estimate an FRP system’s performance in a full-scale fire test, and can be used to compare intumescent layered systems to established systems. Simulating cone calorimeter experiments in Gpyro, a comprehensive pyrolysis modeling program, offers the possibility of predicting FRP systems’ performances before they are fabricated. However, use of Gpyro in this application is in its infancy and requires fine tuning to accurately predict test results. This project compared the effectiveness of different fire-resistant FRP systems in terms of meeting building regulations and tested the efficacy of Gpyro at predicting cone calorimeter test results from material properties.
Acknowledgements

We would like to thank the following individuals and sponsors, who provided us with the support and resources we needed to complete our project.

Professor Nicholas Dembsey – for providing us with resources, knowledge, and guidance throughout the course of the project.

Kreysler & Associates – for providing the opportunity to apply our engineering skills in a real world application and providing samples for testing.

Raymond Ranellone – for managing the time and equipment of the Fire Protection Lab and providing abundant help with calibration and testing procedures.

Chris Lautenberger – for developing Gpyro and providing resources and assistance to develop the use of Gpyro in cone calorimetry.
Authorship

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Standardized Testing Methods - AM
Cone Testing - AM ZH
Flammability Parameter – AM ZH
ASTM E84 Screening Tool – AM ZH
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Introduction

This project looked at three different batches of fiber reinforced polymer (FRP) systems and dissected and compared their differences with respect to fire performance and flame retardancy. Each FRP system was composed differently, specifically in terms of additives and layering. The samples were provided by Kreysler and Associates and were tested using an oxygen consumption cone calorimeter. Aside from the cone testing, there was also a computer simulation element to the project. These simulations were done in a pyrolysis simulator known as G-pyro, with the goal being to accurately model the experiments done in the calorimeter. Overall the testing and simulations were completed with the intention to investigate and demonstrate the efficacy of new FRPs in terms of their use as architectural composites, while simultaneously demonstrating the ability to predict performance through material analysis cost effectively and efficiently.
Background

In order to understand the relevance of this project, it is critical to be familiar with the importance of fiber reinforced polymers and their use in industry with regards to codes and test standards.

Fiber Reinforced Polymers

Fiber reinforced polymers are composite materials composed of strong fibers set in a polymer matrix. FRPs are widely used because they possess the strength of their fibers and the light weight and versatility of their resin. The fibers in FRPs are most commonly composed of glass, hence the name “fiberglass.” The FRP resin most often found in fiberglass is composed of unsaturated polyesters dissolved in styrene. The co-polymers set to form a hard, rigid substance, the properties of which can be manipulated during the manufacturing process to meet the requirements of the final material.1

Manufacturers use a myriad of additives in FRPs to adjust the materials’ various properties (e.g. antioxidants, foaming agents, fire retardants). Common fire retardant additives include halogen-containing fire retardants and alumina trihydrate1. Because of their light weight, corrosion resistance, and ability to be cast into a variety of shapes, FRPs have been used in architectural applications throughout the world, including, but not limited to: exterior cladding, acoustic panels, arches, balconies, and ornamental features. Kreysler & Associates2, a custom fabrication shop that works with FRPs, fabricated the rippled façade panels of the San Francisco Museum of Modern Art, which is the single largest architectural application of composites in the United States.

Standardized Testing Methods

The International Building Code (IBC) is a model building code developed by the International Code Council (ICC). The ICC was established in 1994 and acts as a non-profit organization that focuses on developing comprehensive sets of national model construction codes3. Namely, these codes and standards address issues of structural strength, sanitation, accessibility, lighting and ventilation, and energy conservation. Standards outlined by the IBC
that are essential to this project include the standard test ASTM E84 and the standard test ASTM E1354.

The ASTM E84\textsuperscript{[4]} is a full-scale test intended to provide comparative measurements of surface flame spread and smoke density measurements under specific fire exposure conditions. The test itself involves a noncombustible horizontal box or tunnel as the tunnel’s roof that is typically 24 ft long and 1.8 ft wide. The tunnel needs to be about as wide and long as the test specimen and about 1 ft high. The system is equipped with burners and a ventilation system. During the test the specimen is ignited and the progression of the flame front across the test material is measured by eye, while the smoke emitted from the end of the test is measured as a factor of optical density.

The ASTM E1354\textsuperscript{[5]} is a bench scale testing method that measures the response of materials exposed to desired levels of a radiant heat flux using an oxygen consumption cone calorimeter. All of our specimen testing was done on the cone calorimeter as it is much more economically convenient as opposed to using a full-scale test such as the ASTM E84. The actual procedure calls for the test specimen to be about 100x100 mm\textsuperscript{2} in area with a typical thickness of 50 mm. The specimen is wrapped in aluminum foil, placed in a holder and an edge frame. That system is then placed on the cone calorimeter load cell, which is situated directly below a conical heater and a spark ignitor. Next, the specimen is ignited and the actual test begins. Direct measurements that result from a cone test include initial and final mass of the specimen, temperature of flue gas at the orifice, O2, Co2, and CO readings, exhaust flow rate, time to ignition, time to flameout, test duration, total and peak heat released, cone irradiance, and photometric beam intensity.
Cone Testing

Cone Test Results

Altogether 18 different FRP systems (3 distinct batches) were tested using cone calorimetry in the last 6 months. Each FRP system was tested at both 50 and 78 kW/m². An initial heat flux (IHF) of 50 kW/m² was used in order to develop a baseline data set for the materials, while the 78 kW/m² was used to create a range of values. At these two incident heat fluxes, each system was tested four times, twice without thermocouples and twice with thermocouples. Four trials were conducted on each FRP system so that a certain degree of repeatability could be established. Thermocouples were used in this project in order to gain a more complete temperature history of the test specimen, so that accurate simulations of the theoretical test specimen in the Gpyro pyrolysis program could be run. However, it should be noted that the use of the thermocouples did interfere with the mass-related results of the specimen, but that as long as there was a common consistency between all four trials in terms of heat release rate then the differences in the mass histories’ were dismissed. The October batch (100515), consisting of 6 different FRP systems, would be specifically analyzed as the core of this project, while results from the remaining two batches can be found within the appendix.

Material description

The FRP systems in the October batch can be classified into three groups: FRP systems with no coating, coating with sand, and coating without sand. Specimen 4 is the only system without a coating. Specimens 5, 6 and 9 are systems that have a coating as well as sand. Specimens 7 and 8 are systems that have a coating without sand. In addition, specimens 8 and 9 have an added white base, which allows for further investigation into the effects of white layering compared to the previously established FRP systems.
<table>
<thead>
<tr>
<th>Series #</th>
<th>Description</th>
<th>Layers Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>100515-4</td>
<td>No Coating</td>
<td>2 layers of woven Roving</td>
</tr>
<tr>
<td>100515-5</td>
<td>Fireblock Polymer Concrete</td>
<td>2 layers of woven Roving</td>
</tr>
<tr>
<td>100515-6</td>
<td>Fireblock Polymer Concrete</td>
<td>3 layers of Carbon Fiber Cloth</td>
</tr>
<tr>
<td>100515-7</td>
<td>Fireblock Gelcoat-No sand</td>
<td>2 layers of woven Roving</td>
</tr>
<tr>
<td>100515-8</td>
<td>White Base Gelcoat-No sand</td>
<td>2 layers of woven Roving</td>
</tr>
<tr>
<td>100515-9</td>
<td>White Base Polymer Concrete</td>
<td>2 layers of woven Roving</td>
</tr>
</tbody>
</table>

*Table 1 - Description of October Specimens*

**Repeatability**

After cone testing was complete, data was distilled and the resulting graphs included Heat Release Rate (HRR), Mass Loss Rate (MLR), Effective Heat of Combustion (EHOC), Extinction Coefficient (EC), Smoke Production Rate (SPR), and Specific Extinction Area (SEA). For each set of graphs, it was found that there was good reproducibility as all trials would follow the same trend, excluding a few outliers. The other aspect of the graphs that should be observed is that the start of the second “peak” in the data is considered to be the start of edge burning. Edge burning occurs because of the edge frame that is placed on the specimen per the ASTM E1354 standard and does not fit within the paradigm of “1-dimensional” testing. This is to say that after edge burning occurs you lose the 1-dimensionality of pure surface burning as the flames propagate down the sides of the system and the subsequent ability to compare data to 1-dimensional models such as those in Gpyro is lost. Therefore, in terms of data analysis only the first peak in the graphs is considered to be relevant and the rest of the data can be either truncated or dismissed. Sample results, in terms of Heat Release Rate and Extinction Coefficient, for specimen 8 at both 50 and 78 kW/m^2 is detailed below:
Figure 1 - Extinction Coefficients of 100515-8 Samples at 78 kW/m²

Figure 2 - Heat Release Rates of 100515-8 Samples at 78 kW/m²
Comparisons using Tau

In order to compare FRP systems with different thicknesses at the same heat flux, the use of Tau was employed. Tau, which is defined as time divided by sample thickness squared, was applied so that the average of each FRP system could be plotted allowing for all 6 FRP systems
to be compared in one graph. Based off of the resulting tau graphs it was found that specimen 7 had the most favorable results in terms of potential use as an architectural composite. Its HRR was the lowest at both heat fluxes while also exhibiting the lowest smoke density. The white-based specimens (8 and 9) were found to have had the highest HRRs and smoke densities, while also exhibiting some of the shortest burn durations out of all of the systems. The use of sand/concrete in the FRP systems seemed to have no effect in terms of lowering peak HRR and ended up producing more smoke than specimens without sand. It should be noted that the data collected at 50 kw/m^2 is more chaotic in comparison to the data collected at 78 kW/m^2. This can be attributed to instrumentation drift, as there may have been data acquisition, circuitry, and or electrical/photodiode problems while testing occurred during this time period.

![Average HRR versus Tau (100515-78kW/m^2)](image)

*Figure 5 – Average Heat Release Rates vs Tau of October Specimens at 78 kW/m^2*
Figure 6 - Average Extinction Coefficients vs Tau of October Specimens at 78 kW/m²²

Figure 7 - Average Heat Release Rates vs Tau of October Specimens at 50 kW/m²²
Figure 8 - Average Extinction Coefficients vs Tau of October Specimens at 50 kW/m^2
Flammability Parameter

The flammability parameter, denoted by the Greek letter $\beta$ (Beta), is a term developed from the investigative work done on Cleary and Quintiere’s concurrent flow flame spread model by Mowrer and Williamson in 1991. Mowrer and Williamson defined the flammability parameter as a theoretical prediction of flame spread. If the flammability parameter has a positive value, it represents a degree of flame spread acceleration, while conversely, if the flammability parameter is negative, it represents a degree of flame spread deceleration.

The flammability parameter can be directly calculated from direct and indirect measurements from data output via the cone calorimeter:

$$\beta = k_f \dot{Q} - \frac{t_f}{t_{bo}} - 1$$

In the equation shown above, the parameter $k_f$ is a constant related to the flame length or forward heating distance and is assumed to be 0.01 (m$^2$/kW). $\dot{Q}$ (kW/m$^2$) is the Heat Release Rate Per Unit Area (HRRPUA), $t_f$ (seconds) is the time to ignition under the given Incident Heat Flux (IHF=50 kW/m$^2$), and $t_{bo}$ (seconds) is the burn duration.

B Parameter Table-100515 (October Batch)-50 kW/m$^2$ IHF

<table>
<thead>
<tr>
<th>Series #</th>
<th>AVG B Parameter</th>
<th>Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>100515-4</td>
<td>-0.96</td>
<td>± 0.13</td>
</tr>
<tr>
<td>100515-5</td>
<td>-0.67</td>
<td>± 0.057</td>
</tr>
<tr>
<td>100515-6</td>
<td>-0.64</td>
<td>± 0.067</td>
</tr>
</tbody>
</table>
In the table shown above, all FRP systems in the October batch showed decelerating flame spread. The sample 4 and 7 have the greatest decelerating flame spread, so they both show good fire retardancy and indicate that the flame spread less than other FPR systems. The gelcoat on sample 7 didn’t show a significant effect on flame spread compared to the sample 4. The sample 6 and 7 are both classified as fireblock polymer concrete. However, the sample 6 has 3 layers of carbon fiber cloth instead of 2 layers of woven roving. Interestingly, the sample 6 and 7 have comparable B parameter result, so they show similar level of flame spread. The sample 8 and 9 are the white base version of sample 7 and 5. The results indicate that the white base has a significant influence on flame spread. The white base obviously accelerate the flame spread by increasing b parameter from -0.67 to -0.41 and from -0.87 to -0.42 respectively. The uncertainties of each system were calculated using “Student T distribution” because 4 trials were tested for each of the FRP system. The FRP systems with similar B parameter also have similar uncertainty, which means no significant level of difference as they have overlapping range.

<table>
<thead>
<tr>
<th>Sample</th>
<th>B Parameter</th>
<th>±</th>
</tr>
</thead>
<tbody>
<tr>
<td>100515-7</td>
<td>-0.87</td>
<td>± 0.14</td>
</tr>
<tr>
<td>100515-8</td>
<td>-0.42</td>
<td>± 0.073</td>
</tr>
<tr>
<td>100515-9</td>
<td>-0.41</td>
<td>± 0.096</td>
</tr>
</tbody>
</table>

*Table 2 - Estimated B Parameters of October Specimens at 50 kW/m²*
As discussed in the previous term report, the ASTM E84 (The Tunnel Test) is the Standard Test Method for Surface Characteristics of Building Materials. The test method is intended to provide only comparative measurements of surface flame spread and smoke density measurements with that of select grade red oak and fiber-cement board surfaces under specific fire exposure conditions. During the test the progression of the flame front across the test material is measured by eye, while the smoke emitted from the end of the test is measured as a factor of optical density. The results of this test lead to the material being classified into a flame spread index (FSI) and a smoke-developed index (SDI). Both indices use an arbitrary scale in which asbestos-cement is has a value of 0 and red oak wood has a value of 100. The classification system most widely accepted is defined by the NFPA and is as follows:

Class A: flame spread index 0-25; smoke developed index 0-450
Class B: flame spread index 26-75; smoke developed index 0-450
Class C: flame spread index 76-200; smoke developed index 0-450

However, because of the extreme cost of this test, it is much more efficient to predict FSI and SDI values by using indirect measurements from a cone test instead. The method of extrapolating data from the cone calorimeter to predict FSI and SDI used in this report was developed by the 2013 MQP team (Acosta, et al). It is important to note that FSI and SDI prediction calculations are only valid at an incident heat flux of 50 kW/m².

**Flame Spread Index (FSI)**

In ASTM E84 tests, FSI is defined as a measure of a material’s propensity to burn and spread flame. Results from FSI calculations accompanied by their respective uncertainties for the October batch of specimen tested at an incident heat flux of 50 kw/m² can be seen below. FSI equations, sample calculations and interpretations can be found in the appendix.

<table>
<thead>
<tr>
<th>Series #</th>
<th>FSI</th>
<th>Uncertainty</th>
<th>Classification</th>
</tr>
</thead>
</table>
Table 3 - Estimated FSI and Classification of October Specimens

Samples (5,6 and 9) were found to be classified as “Class B” because the FSI values were slightly higher than 25. However, it is important to note that these FSI calculations carry an uncertainty of about ±2.0. Samples 5,6 and 9 can also be classified as “Class A” with that uncertainty. Interestingly, all the specimen that were classified as “B” had polymer concrete added to their system. So, it seems evident that sand/concrete will raise the FSI of an FRP, while coatings played a secondary effect that was not as apparent.

Smoke Developed Index (SDI)

In ASTM E84 tests, the SDI is defined as a measure of the intensity of smoke that is emitted from a material as it burns. Results from SDI calculations accompanied by their respective uncertainties for the October batch of specimen tested at an incident heat flux of 50 kw/m² can be seen below. SDI equations, sample calculations and interpretations can be found in the appendix.
The results show that all specimen are classified as class “A” in terms of SDI. However, the FSI of sample 5, 6 and 8 were calculated to be out of the range of class “A”, so these FRP systems need to be classified as class “B”.

<table>
<thead>
<tr>
<th>Series #</th>
<th>SDI</th>
<th>Uncertainty</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>100515-4</td>
<td>48</td>
<td>±16.98</td>
<td>A</td>
</tr>
<tr>
<td>100515-5</td>
<td>123</td>
<td>±3.95</td>
<td>A</td>
</tr>
<tr>
<td>100515-6</td>
<td>118</td>
<td>±2.55</td>
<td>A</td>
</tr>
<tr>
<td>100515-7</td>
<td>72</td>
<td>±5.37</td>
<td>A</td>
</tr>
<tr>
<td>100515-8</td>
<td>117</td>
<td>±10.23</td>
<td>A</td>
</tr>
<tr>
<td>100515-9</td>
<td>107</td>
<td>±10.22</td>
<td>A</td>
</tr>
</tbody>
</table>

*Table 4 - Estimated SDI and Classifications of October Specimens*
Gpyro

Gpyro is a comprehensive pyrolysis modeling software. It uses several input parameters to simulate materials’ behavior when exposed to specified conditions, such as a glass, resin, and ATH sample in a cone calorimeter. In the future, Gpyro may be able to predict a specimen’s cone calorimeter test performance before it is even fabricated. This work aims to identify how some of these parameters can be adjusted to more accurately simulate a cone calorimeter test.

Governing Equations

Gpyro simulates pyrolysis through the modeling of equations that describe mass conservation, species conservation, energy conservation, and reaction rates. When given material properties, reaction rates, and initial and boundary conditions through an input file, Gpyro uses these governing equations to simulate pyrolysis under the specified conditions. For a comprehensive guide of the governing equations of Gpyro, refer to the Gpyro Technical Reference Guide.

Parameters

Gpyro offers hundreds of parameters that can be adjusted to create a desired simulation. These parameters affect the general processes of the program, the properties of the components of the sample and gases they produce, how the solids react to form new solids, the composition of layers, how boundaries interact with the surroundings, and the geometry and layering of the sample. However, the vast majority of these variables are not changed from their defaults, either because they should never be changed by the recommendation of the program’s creator, Chris Lautenberger, or because they are not pertinent to the simulations we are running.

To produce an accurate simulation of a cone calorimeter test, we used a sample simulation from Gpyro of a 1D sample exposed to an incident heat flux on one face, then adjusted key parameters to match those of a real test.

General
The general settings of a Gpyro simulation affect the ambient conditions of the test and the equations for which Gpyro solves. Almost all of the general settings of the simulation are left at their defaults, which describe regular atmospheric conditions. The one parameter we adjusted was SOLVE_PRESSURE, which, when set as true, uses Darcy’s law to solve for gas pressure throughout the sample. This is because current simulations assume all gases instantaneously escape from the sample, and it is possible that this is partially responsible for the inaccurately high mass loss rate of the simulation.

Solid Properties

Each solid species has twenty-one parameters to describe material properties, but only six were specified for each material. This is because most of the parameters should never be changed, only matter in 2D or 3D simulations, or describe changes in material properties as a function of temperature. These six parameters for each material are thermal conductivity, density, specific heat, emissivity, opacity, and radiation across pores.

The Solid Properties for the species come from Esther Kim’s 2014 paper, “Parameter Estimation for Comprehensive Pyrolysis Modeling[^6],” operating under the assumption that the resin and glass present in the Kreysler specimens have comparable properties to those tested in Esther Kim’s work. A full table of these properties can be found in the Gpyro appendix.

Reaction Properties

Each reaction simulated in Gpyro has thirteen kinetic parameters used to describe it. However, all but five are used to either simulate oxygen-dependent reactions or to add an extra degree of complexity to the reaction. The remaining five parameters, used to describe the reactions, describe the rate at which the reactions occur, how much energy they absorb or release, and the degree to which the reaction causes intumescence. The kinetic parameters for the two reactions simulated in Gpyro, also obtained from Esther Kim’s 2014 paper, can be found in the Gpyro appendix.

Initial Conditions
Each layer of a simulated sample must have specified initial conditions, consisting of initial temperature and the composition of the layer. Initial temperature was kept at room temperature (300K). The composition of a glass and resin sample was determined by using the stated density of glass in the sample (two layers of 36 oz/yd² woven roving), area of the sample, and mass of the sample to find the mass fraction of glass in a typical glass and resin layer (45%). The remaining mass of a sample is a 50/50 mixture of hetron resin and ATH (27.5% each).

**Geometry**

Sample geometry specifies the size of each layer; which boundary conditions apply to each layer face; the number of cells in the x, y, and z directions; and the contact conductance between layers. For the sake of simulating an existing sample of glass, resin, and ATH, the geometry of the sample matched that of a typical sample: one 10cm x 10 cm x 3 mm layer. Because this simulation is only pertinent while behaving one-dimensionally (i.e. the side faces of the sample do not affect the burn so the depth of the sample is the only pertinent dimension), samples had one cell in the x and y directions, and 381 in the z direction. The boundary conditions for the different faces will be discussed in the next section.

**Boundary Conditions**

Each must have two faces with specified boundary conditions. Most of the parameters specified for boundary conditions are pertinent to gas momentum, energy, and species equations, which were not changed for the sake of these simulations. The boundary condition parameters manipulated in these simulations include incident heat flux and contact conductance to ambient solids. Because of the one dimensional nature of a cone calorimeter simulation, only the top and bottom faces have specified boundary conditions, and the side faces are assumed to be perfectly insulated.

Incident heat flux refers to the heat flux contributed by the cone heater. Because this varied between 50 kW/m² and 78 kW/m², we adjusted this parameter to fit the experimental data to which we compared simulated data.

Previous simulations of cone tests have specified a contact conductance on the bottom face of the sample as 0 W/m²-K. This is because an idealized cone calorimeter test assumes that
all faces except the top face are perfectly insulated to the ambient environment. However, because cone calorimeter tests do not have these idealized conditions, it is worth investigating if adjusting back face contact conductance to real world values will improve the reliability of Gpyro simulations.

**Results**

**Darcy’s Law**

Previous simulations of resin and glass systems have produced a simulated mass loss rate much greater than the experimental mass loss rate. Below is a comparison of simulated and test data; the simulation is a recreation of last year’s simulation.

![Figure 9 - Comparison of Mass Loss Rates of Last Year's Simulation and Test Data](image)

This may be because the default simulation assumes that all gases immediately leave the solid, rather than diffusing through the medium. A potential way of modeling the diffusion of gas through the solid is to set the SOLVE_PRESSURE variable as true in the input file, which allows GPyro to use Darcy’s Law to solve for pressure distribution in the solid. Darcy’s Law describes the movement of fluid through a permeable medium as a function of the permeability of the medium, cross-sectional area of the medium, pressure distribution along the length of the medium, viscosity of the fluid, and length of the medium.
Turning the pressure solving equation on and off, as well as manipulating the permeability of solids, produced no discernible difference in the samples tested.

**Back Face Contact Conductance**

Previous simulations of cone tests have specified a contact conductance on the bottom face of the sample as 0 W/m²·K. This is because an idealized cone calorimeter test assumes that all faces except the top face are perfectly insulated to the ambient environment. However, because cone calorimeter tests do not have these idealized conditions, it is worth investigating if adjusting back face contact conductance to real world values will improve the reliability of Gpyro simulations.

A sensitivity analysis of back face contact conductance was performed on a simulation of a glass and resin sample. Below is a comparison of the mass loss rate curves of a sample with a back face contact conductance of 0 W/m²·K (insulated), 50 W/m²·K (typical thermal contact conductance), 100 W/m²·K (typical thermal contact conductance), and 1000 W/m²·K (perfect thermal contact).

![Figure 10 - Simulated Mass Loss Rates of 100515-4 Samples with Varying Back Face Contact Conductances](image)

This comparison shows that specifying a back face thermal contact conductance of around 100 W/m²·K significantly decreases the mass loss rate of a simulated sample, bringing it much closer to the real values found in test data.
Top Face Convective Heat Transfer Coefficient

Previous simulations of cone tests have specified a convective heat transfer coefficient on the top face of 10 W/m$^2$-K. However, some research suggests that this parameter may in fact be around 30 W/m$^2$-K$^{[7]}$. In order to test the simulations’ sensitivity to changes in the convective heat transfer coefficient, a sample of 100515-4 was simulated with varying values. Below are comparisons between the mass loss rates and top face temperatures of samples with varying convective heat transfer coefficients at the top face.

![100515-4: Mass Loss Rate Comparison With Varying Convective Heat Transfer Coefficient](image)

*Figure 11 - Simulated Mass Loss Rates of 100515-4 Samples with Varying Convective Heat Transfer Coefficients*
It is evident that the convective heat transfer coefficient, when increased on the top face, has a significant effect on the mass loss rate and top face temperature of the sample. Therefore calibrating the back face contact conductance and top face convective heat transfer to match real world values may help improve the accuracy of cone simulations in GPyro.

**Comparing Simulations to Real Data**

To test the validity of this calibration exercise, we compared the mass loss rates and surface temperatures of a simulated sample under default boundary conditions, a “calibrated” simulated sample with a convective heat transfer coefficient of 30 W/m²-K and a back face contact conductance of 100 W/m²-K, and a real cone test. Note that graphs only include the first 100 seconds because edge burning occurs after this point.
Figure 13 - Comparison of Mass Loss Rates of Test Data and Simulations with Default and Calibrated Boundary Conditions

Figure 14 - Comparison of Top Face Temperatures of Test Data and Simulations with Default and Calibrated Boundary Conditions
These comparisons show that adjusting the boundary conditions in Gpyro simulations have greatly improved their prediction of cone calorimeter results.

**Conclusions**

Analysis of the use of pressure solving equations and permeability of solids in Gpyro has shown that these changes alone do not have any significant effect on the simulated pyrolysis of a glass and resin sample. However, by adjusting the contact conductance and convective heat transfer coefficient of a sample, we have been able to produce simulated data much closer to the actual data found in cone test results.

Currently, the most significant shortcoming of these simulations is that the sample is exposed to a single constant incident heat flux. However, in a real cone test, it is exposed to a second heat flux from the flame upon ignition. Future work could develop a method of simulating a secondary delayed flux upon ignition to further improve the accuracy of cone test simulations.
References


Appendices

Appendix A- Fiber Reinforced Polymers

Fiber reinforced polymers (FRP) are composite materials composed of strong fibers set in a polymer matrix. FRPs are widely used because they possess the strength of their fibers and the light weight and versatility of their resin.

The fibers in FRPs are most commonly composed of glass, hence the name “fiberglass.” Glass fibers have a tensile strength of approximately 2,000 MPa, a Young’s Modulus of approximately 80 GPa, and a density of approximately 2.5 g/cm³. Carbon fibers surpass glass fibers in all of these criteria, having a tensile strength of approximately 4,000 MPa, a Young’s Modulus of approximately 240 GPa, and a density of approximately 1.75 g/cm³, making it a stronger, lighter alternative to glass fiber. However, carbon fiber is much more expensive to produce than is glass fiber, so it is only used in high-performance applications.

The FRP resin most often found in fiberglass is composed of unsaturated polyesters dissolved in styrene. The co-polymers set to form a hard, rigid substance, the properties of which can be manipulated during the manufacturing process to meet the requirements of the final material. Vinyl ester resin can provide superior corrosion resistance than can polyester resin, but usually far in excess of what is required for building cladding. Phenolic resins have been shown to have superior fire, smoke, and toxicity properties relative to other resins. Because of this, phenolic resins are widely used in aircraft and mass transit applications.

Manufacturers use a myriad of additives in FRPs to adjust the materials’ various properties (e.g. antioxidants, foaming agents, fire retardants). Common fire retardant additives include halogen-containing fire retardants and alumina trihydrate. When exposed to high temperatures, halogen-containing fire retardants decompose to release halogen radicals, which then form
hydrogen halides, which then bond with high energy hydrogen and hydroxide radicals, replacing them with lower-energy halogen radicals. Alumina trihydrate, when exposed to high heat, releases the water to which it is bonded, which is an endothermic reaction. This causes the burning material to drop below its flash point and reduce the risk of fire.

Because of their light weight, corrosion resistance, and ability to be cast into a variety of shapes, FRPs have been used in architectural applications throughout the world, including, but not limited to: exterior cladding, acoustic panels, arches, balconies, and ornamental features. Kreysler & Associates, a custom fabrication shop that works with FRPs, fabricated the rippled façade panels of the San Francisco Museum of Modern Art, which is the single largest architectural application of composites in the United States.
Appendix B - The International Building Code

The 2012 International Building Code (IBC) is a model building code developed by the International Code Council (ICC). The ICC was established in 1994 and acts as a non-profit organization that focuses on developing comprehensive sets of national model construction codes. These construction and public safety codes are produced and developed through the governmental consensus process [1]. The IBC is the most commonly used building code in the United States. In terms of the IBC, this set of codes provides minimum requirements that aim to protect the public health, safety, and welfare of the occupants of buildings and structures. Namely, it addresses issues of structural strength, sanitation, accessibility, lighting and ventilation, and energy conservation. The codes are implemented and updated on a 3-year cycle to compensate for new construction methods and technologies. As far as scope is concerned, the IBC applies to all occupancies, including one- and two-family dwellings and any other type of building not under the umbrella of the International Residential Code (IRC) [2]. Certain chapters of the IBC have been identified as areas of interest to this MQP and have been thoroughly researched and dissected. These chapters that will be discussed include chapters 2, 3, 6, 8, 14, and 26.

Chapter 2 (Definitions) of the IBC defines terms heavily used and addressed in later chapters. Terms of significance, along with their respective definitions as defined verbatim in the IBC, in relation to applicability towards this MQP include: [2]

- **Backing**- The wall or surface to which the *veneer* is secured.
- **Building**- Any structure used or intended for supporting or sheltering any use or occupancy.
- **Building Area**- The area included within surrounding exterior walls (or exterior walls and fire walls) exclusive of vent shafts and courts. Areas of the building not provided with surrounding walls shall be included in the building area if such areas are included within the horizontal projection of the roof or floor above.
- **Exterior Insulation and Finish Systems (EIFS)**- EIFS are nonstructural, nonload-bearing, exterior wall cladding systems that consist of an insulation board attached either
adhesively or mechanically, or both, to the substrate; an integrally reinforced base coat and a textured protective finish coat.

- **Exterior Surfaces**- Weather-exposed surfaces.

- **Exterior Wall**- A wall, bearing or nonbearing, that is used as an enclosing wall for a building, other than a fire wall, and that has a slope of 60 degrees (1.05 rad) or greater with the horizontal plane.

- **Exterior Wall Covering**- A material or assembly of materials applied on the exterior side of exterior walls for the purpose of providing a weather-resisting barrier, insulation or for aesthetics, including but not limited to, veneers, siding, exterior insulation and finish systems, architectural trim and embellishments such as cornices, soffits, facias, gutters and leaders.

- **Exterior Wall Envelope**- A system or assembly of exterior wall components, including exterior wall finish materials, that provides protection of the building structural members, including framing and sheathing materials, and conditioned interior space, from the detrimental effects of the exterior environment.

- **F Rating**- The time period that the through-penetration firestop system limits the spread of fire through the penetration when tested in accordance with ASTM E 814 or UL 1479.

- **Fiber-reinforced Polymer (FRP)**- A polymeric composite material consisting of reinforcement fibers, such as glass, impregnated with a fiber-binding polymer, which is then molded and hardened. Fiber-reinforced polymers are permitted to contain cores laminated between fiber-reinforced polymer facings.

- **Fire Area**- The aggregate floor area enclosed and bounded by firewalls, fire barriers, exterior walls or horizontal assemblies of a building. Areas of the building not provided with surrounding walls shall be included in the fire area if such areas are included within the horizontal projection of the roof or floor next above.

- **Fire Barrier**- A fire-resistance-rated wall assembly of materials designed to restrict the spread of fire in which continuity is maintained.

- **Fire Protection Rating**- The period of time that an opening protective will maintain the ability to confine a fire as determined by certain tests. Ratings are stated in hours or minutes.
· **Fire Protection System**- Approved devices, equipment and systems or combinations of systems used to detect a fire, activate an alarm, extinguish or control a fire, control or manage smoke and products of a fire or any combination thereof.

· **Fire Resistance**- That property of materials or their assemblies that prevents or retards the passage of excessive heat, hot gases or flames under conditions of use.

· **Fire-resistance Rating**- The period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on certain tests.

· **Fire-resistant Joint System**- An assemblage of specific materials or products that are designed, tested and fire-resistance-rated in accordance with either ASTM E 1966 or UL 2079 to resist for a prescribed period of time the passage of fire through joints made in or between fire-resistance-rated assemblies.

· **Fire Wall**- A fire-resistance-rated wall having protected openings, which restricts the spread of fire and extends continuously from the foundation to or through the roof, with sufficient structural stability under fire conditions to allow collapse of construction on either side without collapse of the wall.

· **Flame Spread**- The propagation of flame over a surface.

· **Flame Spread Index**- A comparative measure, expressed as a dimensionless number, derived from visual measurements of the spread of flame versus time for a material tested in accordance with ASTM E 84 or UL 723.

· **Flash Point**- The minimum temperature in degrees Fahrenheit at which a liquid will give off sufficient vapors to form an ignitable mixture with air near the surface or in the container, but will not sustain combustion. Appropriate test procedure and apparatus as specified in ASTM D 56, ASTM D 93 or ASTM D 3278 shall determine the flash point of a liquid.

· **Interior Finish**- Interior finish includes interior wall and ceiling finish and interior floor finish.

· **Interior Floor Finish** - The exposed floor surfaces of buildings including coverings applied over a finished floor or stair, including risers.
- **Interior Floor-wall Base** - Interior floor finish trim used to provide a functional or decorative border at the intersection of walls and floors.

- **Interior Surfaces** - Surfaces other than weather-exposed surfaces.

- **Interior Wall and Ceiling Finish** - The exposed interior surfaces of buildings, including but not limited to: fixed or movable walls and partitions; toilet room privacy partitions; columns; ceilings; and interior wainscoting, paneling or other finish applied structurally or for decoration, acoustical correction, surface insulation, structural fire resistance or similar purposes, but not including trim.

- **Intumescent Fire-Resistant Coatings** - Thin film liquid mixture applied to substrates by brush, roller, spray or trowel which expands into a protective foamed layer to provide fire-resistant protection of the substrates when exposed to flame or intense heat.

- **Labeled** - Equipment, materials or products to which has been affixed a label, seal, symbol or other identifying mark of a nationally recognized testing laboratory, inspection agency or other organization concerned with product evaluation that maintains periodic inspection of the production of the above-labeled items and whose labeling indicates either that the equipment, material or product meets identified standards or has been tested and found suitable for a specified purpose.

- **Light-transmitting Plastic Roof Panels** - Structural plastic panels other than skylights that are fastened to structural members, or panels or sheathing and that are used as light-transmitting media in the plane of the roof.

- **Light-transmitting Plastic Wall Panels** - Plastic materials that are fastened to structural members, or to structural panels or sheathing, and that are used as light-transmitting media in exterior walls.

- **Masonry** - A built-up construction or combination of building units or materials of clay, shale, concrete, glass, gypsum, stone or other approved units bonded together with or without mortar or grout or other accepted methods of joining.

- **Metal Composite Material (MCM)** - A factory-manufactured panel consisting of metal skins bonded to both faces of a plastic core.
· **Plastic**- Any thermoplastic, thermosetting or reinforced thermosetting plastic material that conforms to combustibility classifications specified in the section applicable to the application and plastic type.

· **Plastic Glazing**- Plastic materials that are glazed or set in frame or sash and not held by mechanical fasteners that passes through the glazing material.

· **Smoke Barrier**- A continuous membrane, either vertical or horizontal, such as a wall, floor or ceiling assembly that is designed and constructed to restrict the movement of smoke.

· **Smoke Detector**- A listed device that senses visible or invisible particles of combustion.

· **Smoke-developed Index**- A comparative measure, expressed as a dimensionless number, derived from measurements of smoke obscuration versus time for a material tested in accordance with ASTM E 84.

· **Trim**- Picture molds, chair rails, baseboards, handrails, door and window frames and similar decorative or protective materials used in fixed applications.

· **Veneer**- A facing attached to a wall for the purpose of providing ornamentation, protection or insulation, but not counted as adding strength to the wall.

· **Vinyl Siding**- A shaped material, made principally from rigid polyvinyl chloride (PVC) that is used as an exterior wall covering.

· **Wall**- A vertical element with a horizontal length-to-thickness ratio greater than three, used to enclose space.

Chapter 3 (Use and Occupancy Classification) of the IBC details how structures are classified with respect to occupancy and usage. These classifications are used primarily for building and fire code enforcement. There are 10 types of occupancy classifications and they are defined by the IBC as follows: [2]

1. **Assembly (Group A)**- Occupancy includes, among others, the use of a building or structure, or a portion thereof, for the gathering of persons for purposes such as civic, social or religious functions; recreation, food or drink consumption or awaiting transportation.
2. **Business (Group B)** - Business Group B occupancy includes, among others, the use of a building or structure, or a portion thereof, for office, professional or service-type transactions, including storage of records and accounts.

3. **Educational (Group E)** - Educational Group E occupancy includes, among others, the use of a building or structure, or a portion thereof, by six or more persons at any one time for educational purposes through the 12th grade.

4. **Factory and Industrial (Group F)** - Factory Industrial Group F occupancy includes, among others, the use of a building or structure, or a portion thereof, for assembling, disassembling, fabricating, finishing, manufacturing, packaging, repair or processing operations that are not classified as a Group H hazardous or Group S storage occupancy.

5. **High Hazard (Group H)** - High-hazard Group H occupancy includes, among others, the use of a building or structure, or a portion thereof, that involves the manufacturing, processing, generation or storage of materials that constitute a physical or health hazard in quantities in excess of those allowed in control areas.

6. **Institutional (Group I)** - Institutional Group I occupancy includes, among others, the use of a building or structure, or a portion thereof, in which care or supervision is provided to persons who are or are not capable of self-preservation without physical assistance or in which persons are detained for penal or correctional purposes or in which the liberty of the occupants is restricted.

7. **Mercantile (Group M)** - Mercantile Group M occupancy includes, among others, the use of a building or structure or a portion thereof, for the display and sale of merchandise and involves stocks of goods, wares or merchandise incidental to such purposes and accessible to the public.

8. **Residential (Group R)** - Residential Group R includes, among others, the use of a building or structure, or a portion thereof, for sleeping purposes when not classified as an Institutional Group I or when not regulated by the International Residential Code.
9. **Storage (Group S)**- Storage Group S occupancy includes, among others, the use of a building or structure, or a portion thereof, for storage that is not classified as a hazardous occupancy.

10. **Utility and Mercantile (Group U)**- Buildings and structures of an accessory character and miscellaneous structures not classified in any specific occupancy shall be constructed, equipped and maintained to conform to the requirements of this code commensurate with the fire and life hazard incidental to their occupancy.

Chapter 6 (Types of Constructions) of the IBC deals with further classifications of buildings. Once a building has been assigned two one of the 10 occupancy groupings discussed in Chapter 3, the building is then classified into one of five construction types. Each construction type requires certain building elements such as exterior walls, floors, ceilings, etc. to have certain fire-resistance ratings. These fire-resistance ratings are based off the results of a Standard Fire Test (ASTM E 119). The construction classifications as defined by the IBC are as follows: [2] [3]

- **Types I and II**- Types I and II construction are those types of construction in which the building elements are of noncombustible materials, except as permitted.

- **Type III**- Type III construction is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by this code.

- **Type IV**- Type IV construction (Heavy Timber, HT) is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid or laminated wood without concealed spaces.

- **Type V**- Type V construction is that type of construction in which the structural elements, exterior walls and interior walls are of any materials permitted.

Chapter 8 (Interior Finishes) of the IBC describes allowable fire performances and smoke development from certain aspects of interior finishes. Interior finishes are defined as exposed surfaces of walls, ceilings, and floors within buildings. The two major dangers of unregulated interior finish are the rapid spread of fire and in the same vein, the production of large quantities of black smoke created by the combustion of materials. Unregulated finish material have the
potential to add to “fuel” to a fire, so their regulation is of critical importance. Allowable fire performances are based off of either the requirements set forth from the occupancy classifications or off of performance criteria from various fire tests. Sections in this chapter relating to fire tests or this MQP are as follows: [2]

· **Section 803.1.1** - Interior wall and ceiling finish should be classified in accordance with ASTM E 84 or UL 723. Interior finish materials should be grouped based on their flame spread and smoke developed indexes.

· **Section 803.1.2** - Specifies that interior wall or ceiling finish materials be in compliance with the room corner test NFPA 286 and have the following acceptance criteria:

· **Section 803.1.3** - Specifies that textile wall coverings and expanded vinyl wall coverings be in compliance with the room corner test NFPA 265 and have the following acceptance criteria:

· **Section 804.2** - Interior floor finish and floor covering materials are required to be of Class I of Class II materials in accordance with the NFPA 253. The NFPA 253 determines that a Class I material has a heat flux of 0.45 watts/cm² or greater, while a Class II material has a heat flux of 0.22 watts/cm² or greater.

· **Section 806.1** - Requires that decorative materials and trim in occupancies in Groups A, E, I and R meet the flame propagation performance criteria set forth by the NFPA 701.

Chapter 14 (Exterior Walls) of the IBC deals with exterior wall covering requirements and the ability to provide weather protection for the exterior of a building. The IBC heavily regulates exterior walls because of the potential for radiant heat exposure from one building to another. Wall coverings, flashing, and drainage methods all fall under this category. A limited amount of combustible materials are permitted on exterior walls of Type I, II, III, and IV buildings. Relevant requirements for exterior wall coverings, exterior wall openings, exterior windows and doors, architectural trim, balconies and similar projections, and bay and oriel windows are detailed by the IBC in the following sections: [2]

· **Section 1403.5** - Deals with vertical and lateral flame propagation. Exterior walls on buildings of Type I, II, III or IV construction that are greater than 40 feet (12 192 mm) in height
above grade plane and contain a combustible water-resistive barrier must be in accordance with the criteria of NFPA 285.

- **Section 1406.2.1.1** - Ignition resistance, in regards to combustible wall coverings, must be in accordance with NFPA 268.

- **Section 1406.2.1.1.2** - For fire separation distances greater than 5 feet (1524 mm), any exterior wall covering shall be permitted that has been exposed to a reduced level of incident radiant heat flux in accordance with the NFPA 268 test method without exhibiting sustained flaming. The minimum fire separation distance required for the exterior wall covering shall be determined from Table 1406.2.1.1.2 based on the maximum tolerable level of incident radiant heat flux that does not cause sustained flaming of the exterior wall covering.

- **Section 1407.9** - Unless otherwise specified, MCM shall have a flame spread index of 75 or less and a smoke-developed index of 450 or less when tested in the maximum thickness intended for use in accordance with ASTM E 84 or UL 723.

- **Section 1407.10** - Where installed on buildings of Type I, II, III and IV construction, MCM systems shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 450 when tested as an assembly in the maximum thickness intended for use in accordance with ASTM E 84 or UL 723. MCM shall be separated from the interior of a building by an approved thermal barrier consisting of 1/2-inch (12.7 mm) gypsum wallboard or a material that is tested in accordance with and meets the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of NFPA 275. The MCM system shall be tested in accordance with, and comply with, the acceptance criteria of NFPA 285. Such testing shall be performed on the MCM system with the MCM in the maximum thickness intended for use.

- **Section 1407.11.3.3** - MCM shall be required to comply with all of the following:

  1. MCM shall have a self-ignition temperature of 650°F (343°C) or greater when tested in accordance with ASTM D 1929.

  2. MCM shall conform to one of the following combustibility classifications when tested in accordance with ASTM D 635:
Class CC1: Materials that have a burning extent of 1 inch (25 mm) or less when tested at a nominal thickness of 0.060 inch (1.5 mm) or in the thickness intended for use.

Class CC2: Materials that have a burning rate of $2\frac{1}{2}$ inches per minute (1.06 mm/s) or less when tested at a nominal thickness of 0.060 inch (1.5 mm) or in the thickness intended for use.

- **Section 1409.9**- Unless otherwise specified, high-pressure decorative exterior-grade compact laminates (HPL) shall have a flame-spread index of 75 or less and a smoke-developed index of 450 or less when tested in the minimum and maximum thicknesses intended for use in accordance with ASTM E 84 or UL 723.

- **Section 1409.10**- Where installed on buildings of Type I, II, III and IV construction, HPL systems shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 450 when tested in the minimum and maximum thicknesses intended for use in accordance with ASTM E 84 or UL 723. HPL shall be separated from the interior of a building by an approved thermal barrier consisting of $\frac{1}{2}$-inch (12.7 mm) gypsum wallboard or equivalent thermal barrier material that will limit the average temperature rise of the unexposed surface to not more than 250°F (121°C) after 15 minutes of fire exposure in accordance with the standard time-temperature curve of ASTM E 119 or UL 263. The thermal barrier shall be installed in such a manner that it will remain in place for not less than 15 minutes based on a test conducted in accordance with UL 1715. The HPL system shall be tested in accordance with, and comply with, the acceptance criteria of NFPA 285. Such testing shall be performed on the HPL system with the HPL in the minimum and maximum thicknesses intended for use.

- **Section 1409.11.2.1**- HPL shall have a self-ignition temperature of 650°F (343°C) or greater when tested in accordance with ASTM D 1929.

Chapter 26 (Plastics) of the IBC sets forth the regulations that govern the materials, design, application, construction and installation of foam plastic, foam plastic insulation, plastic veneer, interior plastic finish and trim and light-transmitting plastics. Below are the types of plastics regulated along with pertinent code sections that govern their use by the IBC: [2]

- **Foam Plastic:**
Section 2603.3- Unless otherwise indicated in this section, foam plastic insulation and foam plastic cores of manufactured assemblies shall have a flame spread index of not more than 75 and a smoke-developed index of not more than 450 where tested in the maximum thickness intended for use in accordance with ASTM E 84 or UL 723. Loose fill-type foam plastic insulation shall be tested as board stock for the flame spread and smoke-developed indexes.

Section 2603.4- In certain provisions of the code, foam plastic shall be separated from the interior of a building by an approved thermal barrier of 1/2-inch (12.7 mm) gypsum wallboard or a material that is tested in accordance with and meets the acceptance criteria of both the Temperature Transmission Fire Test and the Integrity Fire Test of NFPA 275.

Section 2603.4.1.5- Foam plastic insulation under a roof assembly or roof covering that is installed in accordance with the code and the manufacturer’s instructions shall be separated from the interior of the building by wood structural panel sheathing not less than 0.47 inch (11.9 mm) in thickness bonded with exterior glue, with edges supported by blocking, tongue-and-groove joints or other approved type of edge support, or an equivalent material. A thermal barrier is not required for foam plastic insulation that is a part of a Class A, B or C roof-covering assembly, provided the assembly with the foam plastic insulation satisfactorily passes FM 4450 or UL 1256.

Section 2603.5- Exterior walls of buildings of Type I, II, III or IV construction of any height shall have a fire-resistance rating, data based on tests conducted in accordance with ASTM E 119 or UL 263 shall be provided to substantiate that the fire-resistance rating is maintained. The potential heat of foam plastic insulation in any portion of the wall or panel shall not exceed the potential heat expressed in Btu per square feet (mJ/m²) of the foam plastic insulation contained in the wall assembly tested in accordance with Section 2603.5.5. The potential heat of the foam plastic insulation shall be determined by tests conducted in accordance with NFPA 259 and the results shall be expressed in Btu per square feet (mJ/m²). Foam plastic insulation, exterior coatings and facings shall be tested separately in the thickness intended for use, but not to exceed 4 inches (102 mm), and shall each have a flame spread index of 25 or less and a smoke-developed index of 450 or less as determined in accordance with ASTM E 84 or UL 723. The exterior wall assembly shall be tested in accordance with and comply with the acceptance criteria of NFPA 285.
Section 2603.6- Foam plastic insulation meeting certain requirements shall be permitted as part of a roof-covering assembly, provided the assembly with the foam plastic insulation is a Class A, B or C roofing assembly where tested in accordance with ASTM E 108 or UL 790.

Section 2603.7- Foam plastic insulation used as interior wall or ceiling finish in plenums shall comply with one or more of the following:

1. The foam plastic insulation shall be separated from the plenum by a thermal barrier and shall exhibit a flame spread index of 75 or less and a smoke-developed index of 450 or less when tested in accordance with ASTM E 84 or UL 723 at the thickness and density intended for use.

2. The foam plastic insulation shall exhibit a flame spread index of 25 or less and a smoke-developed index of 50 or less when tested in accordance with ASTM E 84 or UL 723 at the thickness and density intended for use and shall meet the acceptance criteria when tested in accordance with NFPA 286.

3. The foam plastic insulation shall be covered by corrosion-resistant steel having a base metal thickness of not less than 0.0160 inch (0.4 mm) and shall exhibit a flame spread index of 75 or less and a smoke-developed index of 450 or less when tested in accordance with ASTM E 84 or UL 723 at the thickness and density intended for use.

· Plastic Interior Finish and Trim:

Section 2604.2.4- The flame-spread index shall not exceed 75 where tested in accordance with ASTM E 84 or UL 723. The smoke-developed index shall not be limited.

· Light-Transmitting Plastics:

Section 2604.4- Light-transmitting plastics, including thermoplastic, thermosetting or reinforced thermosetting plastic material, shall have a self-ignition temperature of 650°F (343°C) or greater where tested in accordance with ASTM D 1929; a smoke-developed index not greater than 450 where tested in the manner intended for use in accordance with ASTM E 84 or UL 723, or a maximum average smoke density rating not greater than 75 where tested in the thickness intended for use in accordance with ASTM D 2843 and shall conform to one of the following combustibility classifications:
Class CC1: Plastic materials that have a burning extent of 1 inch (25 mm) or less where tested at a nominal thickness of 0.060 inch (1.5 mm), or in the thickness intended for use, in accordance with ASTM D 635.

Class CC2: Plastic materials that have a burning rate of $2^{1/2}$ inches per minute (1.06 mm/s) or less where tested at a nominal thickness of 0.060 inch (1.5 mm), or in the thickness intended for use, in accordance with ASTM D 635.

Section 2610.2- The light-transmitting plastic shall be mounted above the plane of the roof on a curb constructed in accordance with the requirements for the type of construction classification, but at least 4 inches (102 mm) above the plane of the roof. Edges of the light-transmitting plastic skylights or domes shall be protected by metal or other approved noncombustible material, or the light transmitting plastic dome or skylight shall be shown to be able to resist ignition where exposed at the edge to a flame from a Class B brand as described in ASTM E 108 or UL 790. The Class B brand test shall be conducted on a skylight that is elevated to a height as specified in the manufacturer’s installation instructions, but not less than 4 inches (102 mm).

- **Fiber-reinforced plastic (FRP):** Fiber-reinforced plastic was permitted to be used in interior and exterior building construction, in the 2009 update of the ICC’s IBC. The IBC requires that for interior and exterior use, FRP must be fire tested and meet standard flame-spread and smoke-obscuration criteria laid forth in Chapters 8 and 14. Chapter 26 requires that FRP components carry an ICC-sanctioned label, which states the fire tests that have been passed. Ways to produce FRP so that they meet fire test criteria include adding specific additives to reduce the propensity of the finished material to combust. Or to add a fire reducing coated surfacing veil that suppresses smoke and reduces flame generation [4].

- **Reflective Plastic Core Insulation:**

Section 2613.3- Reflective plastic core insulation shall have a flame spread index of not more than 25 and a smoke-developed index of not more than 450 when tested in accordance with ASTM E 84 or UL 723. The reflective plastic core insulation shall be tested at the maximum thickness intended for use. Test specimen preparation and mounting shall be in accordance with ASTM E 2599
**Section 2613.4**- Reflective plastic core insulation shall comply with the acceptance criteria in accordance with NFPA 286 or UL 1715 in the manner intended for use and at the maximum thickness intended for use.

Fire Tests:

Fire tests allow for the determination of whether or not fire protection products meet performance criteria set forth in the IBC. There are various types of tests, each with different test methods and scales. These testing scales range from being full scale to small scale to bench scale. Most of these fire tests indicate the performance of a product in regards to its flame-spread, smoke obscuration, flammability, or fire-resistance. Fire tests that have pertinence to this MQP have been detailed and outlined, while others are mentioned for reference, as seen below:

Interior Tests:

- **ASTM E 84/UL 723 (Steiner Tunnel Test):** Standard Test Method for Surface Characteristics of Building Materials [5]. This test method is intended to provide only comparative measurements of surface flame spread and smoke density measurements with that of select grade red oak and fiber-cement board surfaces under the specific fire exposure conditions. Al Steiner of Underwriters Laboratories developed the Steiner Tunnel Test in 1944. The test itself involves a noncombustible horizontal box or tunnel as the tunnel’s roof that should be 24 ft long and 1.8 ft wide. The tunnel needs to be about as wide and long as the test specimen and about 1 ft high. The system is equipped with burners capable of providing 89 kilowatts of flame intensity and an air ventilation system controlled at a velocity of 240 ft per minute. The progression of the flame front across the test material is measured by eye, while the smoke emitted from the end of the test is measured as a factor of optical density. The results of this test lead to the material being classified into a flame spread index (FSI) and a smoke-developed index. Both indices use an arbitrary scale in which asbestos-cement is has a value of 0 and red oak wood has a value of 100. The classification system most widely accepted is defined by the NFPA and is as follows: [6]

Class A: flame spread index 0-25; smoke developed index 0-450

Class B: flame spread index 26-75; smoke developed index 0-450
Class C: flame spread index 76-200; smoke developed index 0-450

· **ASTM D 2859**: Standard Test Method for Ignition Characteristics of Finished Textile Floor Covering Materials. This standard tests and classifies finished textile floor covering materials in reference to their flame-resistance [7].

· **NFPA 253/ASTM E648 (Critical Radiant Heat Flux Test)**: Standard Method of Testing for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source. This test presents a method for evaluating critical radiant flux of floor coverings in corridors or exit-ways, providing a basis for estimating one aspect of the fire exposure behavior of floor covering systems. This Flooring Radiant Panel Test measure radiant energy. A specimen is mounted over a simulated concrete structural floor and is then exposed to a flaming ignition source. The test results indicate whether and how far the corridor flooring will spread the flame front and is given either a Class I or Class II rating. A Class I rating requires a minimum heat flux of 0.45 watts/cm², while a Class II rating has a minimum heat flux of 0.22 watts/cm² [8].

· **NFPA 265**: Standard Methods of Fire Tests for Evaluating Room Fire Growth Contribution of Textile or Expanded Vinyl Wall Coverings on Full Height Panels and Walls. This standard describes a method for determining the contribution of textile wall coverings to room fire growth during specified fire exposure conditions, thereby facilitating the selection of fire-resistant materials and increasing safety [9].

· **NFPA 268**: Standard Test Method for Determining Ignitability of Exterior Wall Assemblies Using a Radiant Heat Energy source. This test measures and describes the ignitability characteristics of exterior wall assemblies and their potential of contributing to fire growth [10].

· **NFPA 286 (Room Corner Test)**: Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth. This standard describes a method for determining the contribution of interior finish materials to room fire growth during specified fire exposure conditions. It is intended for the evaluation of the flammability characteristics of wall and ceiling interior finish, other than textile wall coverings, where such materials constitute the exposed interior surfaces of buildings. This test is also known as the “room corner” test. The test room is typical 8 feet wide, 12 feet deep, and 8 feet high. The test
also uses a 40-kilowatt gas diffusion fire for the first five minutes, followed by a 160-kilowatt gas diffusion fire for the next 10 minutes. Data such as heat-release rates, total heat released, oxygen depletion, carbon monoxide, carbon dioxide, and total smoke released are all measured [11] [12].

· **NFPA 701**: Standard Methods of Fire Tests for Flame Propagation of Textiles and Films. This test measures the flammability of a fabric when it is exposed to specific sources of ignition [13].

Exterior Tests:

· **ASTM E 119 (Standard Fire Test)**: Standard Test Methods for Fire Tests of Building Construction and Materials. This test sets forth a fire-resistance rating criteria based upon how long exterior wall construction can withstand fire exposure. A standard fire test is conducted in the following way: The wall, floor, or roof assembly (with thermocouples at a minimum of nine locations on its unexposed surface) is placed in a test furnace in a manner that subjects one of its surfaces to the heat prescribed by the test method. The temperature is then raised a 1,000 degrees F in the first five minutes of the test, to 1,300 degrees F by 10 minutes, 1,550 degrees F by one-half hour, 1,700 degrees F by the first hour, and to 2,000 degrees F in four hours. The temperature at eight hours or longer is 2,300 degrees F. A test is discontinued when one of the following things occurs: the unit no longer supports the load; flames or gases in sufficient volume and heat intensity to ignite cotton wastes; or transmission of heat through the unit is such that the average unexposed surface temperature rises by more than 250 degrees F. Fire ratings are generally assigned according to the last full hour successfully achieved under test conditions. Thus, normally if a floor slab fulfilled test conditions successfully for three hours 58 minutes it would be give a three-hour rating [14] [15].

· **ASTM E 1131**: Standard Test Method for Compositional Analysis by Thermogravimetry. This test is for use in quality control, material screening, and related problem solving where compositional analysis of a material is desired [16].

· **ASTM E 2707**: Standard Test Method for Determining Fire Penetration of Exterior Wall Assemblies Using a Direct Flame Impingement Exposure. This test measures the ability of
exterior wall covering material to resist fire penetration from the exterior to the unexposed side of the wall [17].

· **NFPA 268**: Standard Test method for Determining Ignitability of Exterior Wall Assemblies Using a Radiant Heat Energy Source. This fire test response standard details a method to determine the propensity of ignition of exterior wall assemblies from exposure to 12.5kW/m² radiant heat in the presence of a pilot ignition source [18].

· **NFPA 285 (Multiple-Story Test)**: Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-load-bearing Wall Assemblies Containing Combustible Components. This standard provides a standardized fire test procedure for evaluating the suitability of exterior, non-load bearing wall assemblies and panels on buildings where the exterior walls are required to be non-combustible. The test is on an intermediate-scale mockup and fabrication of the proposed assembly. The mockup is attached to a three-walled; two story structure, typically made of concrete, with an overall height of 15 feet 8 inches. Each story contains a test room, having dimensions of 10 feet wide by 10 feet deep by 7 feet high. The size of the mockup must be 17 feet 6 inches high by 13 feet 4 inches wide and must include a window opening approximately 30 inches high by 7 feet 8 inches wide that is centered horizontally in relation to the sidewalls. Thermocouples are attached to the exterior face of the mockup and to the interior of the mockup, to measure temperature throughout the test. The test procedure includes two burners: a fixed gas burner in the center of the first-story test room and a portable gas burner that is placed in the window opening. The room burner is ignited and must achieve a first-story room temperature of 1151 deg. F within the first 5 minutes. At that time, the window burner is ignited and both continue to burn for another 25 minutes for a total 30-minute test period and achieving an average first-story room temperature of 1648 deg. F. The assembly fails if flame propagation exceeds the limits indicated in the standard [19] [20].

· **UL 1040**: Standard for Fire Test of Insulated Wall Construction. This procedure determines the ability of field or prefabricated insulated wall panels to resist the spread of flame and fire exposure damage over a simulated interior wall surface of a building [21].

Plastic Tests:
· **ASTM D 635**: Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position. This test compares the relative linear rate of burning or extent and time of burning of plastics [22].

· **ASTM D 1929**: Standard Test Method for Determining Ignition Temperature of Plastics. This test’s results help compare the relative ignition characteristics of different materials [23].

· **ASTM D 2843**: Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics. This test allows for the comparison of relative smoke obscuration characteristics of plastics [24].

· **NFPA 259**: Standard Test Method for Potential Heat of Building Materials. This test method provides a means of determining the potential heat of building materials, such as plastics, subjected to a high-temperature exposure condition [25].

· **NFPA 275**: Standard Method of Fire Tests for the Evaluation of Thermal Barriers. This test method applies to construction materials intended to be used to protect foam insulation or MCM from fire exposure. The results of this test evaluate the ability of a material to prevent ignition from standard fire exposure [26].

Using The Cone Calorimeter Test To Predict Fire Test Values

The Cone Calorimeter test is a bench scale test that measures fire performance of a material specimen. For the sake of this MQP, it will be detailed how you can use results and measurements from the cone to predict how that same specimen tested would fair in a Tunnel Test or be classified. It was found that by finding the heat release rate, Q, of the specimen in the cone; you could then predict the flame height/length, the smoke developed index (SDI), and the flame spread index (FSI), which could then be used to predict if the specimen would pass or fail a NFPA 285 test and how it should be classified. Equations were derived from previous flame spread data and fire protection research.
From this model, Mowrer and Williamson [27] derived a pyrolysis front advance velocity equation:
Appendix C - Cone Calorimetry

Background of Cone Calorimetry

The cone calorimeter is the premier bench scale dynamic research tool in fire testing based on the principle of oxygen consumption calorimetry, which indicates that the oxygen consumption during combustion is proportional to the heat released (approximately 13.1 MJ per kg of oxygen consumed).

Figure 2: The cone calorimeter Schematic

In the figure shown above, the test apparatus mainly consist of the following components: a conical radiant electric heater, which is rated at 5000 W at 240 V and capable of producing irradiances on specimen surface up to 100 kW/m$^2$; a temperature controller, capable of receiving input from 0 to 1000°C and keeping temperature stable within +/- 2 °C; an exhaust gas system with oxygen and flow-measuring instrumentation, capable of producing flow from 0.012 to 0.035 m$^3$/s; a load cell with an accuracy of 0.1 g; an electric ignition spark plug; and a data collection and analysis system.

Test Specimen Preparation
The specimen is standardized to be 100x100 mm² in area and up to 50 mm in thickness. The specimen shall be conditioned to moisture equilibrium at an ambient temperature of 23 ± 3°C and a relative humidity of 50 ± 5%. The specimen is wrapped in aluminum foil so that only the top surface can be exposed and radiated by the conical heater and only through the top surface can gas escape.

Test operation

The aluminum-wrapped specimen is first placed on the sample holder and then covered by an edge frame. The sample holder is then installed on the load cell which is adjusted to be 25 mm below the conical heater. The spark igniter is placed between the specimen surface and cone after VI has runned for 180 seconds. The spark igniter ignites the flammable gases, and will be removed after the specimen surface starts to have visible flames. The time to ignition will be recorded in the VI. The smoke from the burning specimen is first collected by the hood above the conical heater and transported to the sampling ring where it passes through two filters to remove solid particles and water. A laser photometric beam between the gas sampling ring and the fan can determine the amount of produced smoke. The smoke measuring system is designed to be resiliently attached to the exhaust duct by means of refractory gasketing using a split yoke mounting. The meter is located in place by means of two small-diameter tubes welded onto each side of the exhaust duct, which serves as part of the light baffling for the air purging. In the exhaust system, the temperature of the gas stream is measured using a 1.0 to 1.6mm outside diameter sheathed-junction thermocouple. The flow rate is determined by measuring the differential pressure across a sharp-edged orifice in the exhaust stack. After the flame on the specimen surface is out, the operator need to remove the specimen holder and close the shutter. Another 180 seconds need to wait before we stop recording the data.

Important parameters and calculation derived from the Cone Results

**Cone Data Reproduction**

**Direct Measurements**
The cone calorimeter in WPI collects and records data via a system of sensors through the use of LabView. The data recorded by the cone calorimeter is series of voltages and temperature regarding to time. To gain a better understanding and mastery of the cone calorimeter and the data that is recorded, this MQP began by burning 5 random samples in the lab. These test samples included 2 samples of Pine, 2 samples of poly methyl methacrylate (PMMA), and 1 sample of an unknown FRP. The data from the unknown FRP was thrown out, because the cone was malfunctioning and producing faulty measurements during that particular test day. However, to demonstrate a complete understanding of the cone calorimeter and the cooperating software VI, direct and indirect measurements were reproduced in detail for the PMMA 2 sample. The overall goal was to see if reproduced results were similar to the results achieved through the VI. Also, all 4 samples were compared in terms of reproduced direct and indirect measurements for additional interpretation.

It was found that the voltages recorded in the VI by the sensors have a linear relationship with the actual magnitudes of useful measurements. Temperature was the one exception, as the VI recorded it in degrees Celsius. The following equation was found to be the most effective method in turning the recorded voltages into meaningful data:

\[ E = (V - V_{base}) \times C \]

In the above equation, \( E \) is the data in engineering units, \( V \) is the voltage, and \( V_{base} \) is the magnitude of the base condition voltage value, which accounts for any offset. \( C \) in the equation is the calibrations factor, which is generated by the VI during the process of calibration of the cone calorimeter. The last thing that needed to be accounted for, but was not factored into the equation, was the standard deviation. In most cases the standard deviation at the 0 starting point was within an acceptable range, so the base condition would remain valid and it could be ignored. As aforementioned, the temperature does not fit the linear relationship presented by the equation above. This is true, because the VI records it in engineering units by degrees Celsius rather than in a voltage. So, to convert it the only necessary step is outlined by the equation below:

\[ T (K) = T (^\circ C) + 273.15 \]

The following reproduced results were calculated from the burning of the PMMA 2 specimen:
The table above represents the magnitudes and the units of the calibration factors for all the direct measurements. Beam intensities are represented in units of percentage per volt, oxygen and carbon dioxide are in units of mole fraction per volt, mass is in units of grams per volt, carbon monoxide is in parts per million per volt, and pressure is in units of Pascal per volt. The temperature calibration factor is simply the conversion from Celsius to Kelvin and therefore has units of K.

**Oxygen Analyzer Reading**

For example, the oxygen analyzer recorded the oxygen as mole fraction per volt and spanned from 0 to 20.9% oxygen. The calibration factor C was 0.029 and the base-condition was 0.021 volts.
Figure 1: Reproduced data Versus VI result of Oxygen Analyzer Reading

Differential Pressure

The differential pressure was in units of Pascal per volt. The calibration factor was 100.00 and the base-condition was 0.6065 volts at the 0 point.

Temperature

Temperatures were recorded at the stack and reproduced. The temperatures recorded were converted to Kelvin using a calibration factor of 273.15. The VI result can barely see because it completely overlap with the calculated result.
Light Intensity

Photo Sensors on the cone calorimeter measured the light intensity before and after a laser passed through smoke. The subsequent readings were used to calculate smoke obscuration. The beam intensities were represented in units of percentage per volt. The calibration factors for Main and Comp were 1794.284 and 52.614 respectively. For this reproduced measurement the standard deviation was taken into account and added into the equation after the Main and Comp values were multiplied by the C-factor. Their respective standard deviations were -6.469 units and -1.256 units. However, it must be noted that the main photodiode calibration factor is too large for the PMMA tests, and thus our data for Light Intensity and subsequent Extinction Coefficient are unrealistic. This may be due to an alignment issue with the laser. Our pine tests had a reasonable extinction coefficient, so it looks like the issue with the PMMA test was limited to testing that day.
CO and CO2 Readings:

The composition of carbon dioxide are in units of mole fraction per volt, while carbon monoxide was measured in parts per million per volt. The calibration factors were 0.01075 and 318.494 and the base-condition voltages were -0.0063 volts and .0062 volts at the 0 point respectively.
Load Cell Measurement:

The load cell measurement was recorded in units of grams and the calibration factor was 43.842. There was no base condition to account for.

Indirect Measurements
Once the direct measurements were reproduced by converting the voltages measured in the cone calorimeter into engineering units, the result of the direct measurements were applied to reproduce indirect measurements by using certain established mathematical formulas. The comparison of the reproduced results and directs result from VI were created. If the graphs indicated that the two data sets were consistent and similar to each other, then the procedures and methods used to reproduce the indirect measurements were proved to be consistent with the VI. For example, heat release rate per unit area is considered to be the most important fire reaction property that affects fire growth caused by combustible material. The heat released rate is determined by the pressure difference, temperature and air concentration in the exhaust that recorded by the cone calorimeter using voltages. The equation and reproduction are further detailed below:

Heat Release Rate (HRR)

Heat release rate is considered the most important fire reaction property that affect fire growth caused by the combustible material. The heat released rate is determined by the pressure difference, temperature and air concentration in the exhaust that recorded by the cone calorimeter using voltages. The equation is described as follows:

\[
\dot{Q}(t) = \left( \frac{\Delta h_c}{r_o} \right) (1.10) C \sqrt{\frac{\Delta P}{T_c}} \left( X_{O_2}^0 - X_{O_2}(t) \right) \left( \frac{1.105 - 1.5 X_{O_2}(t)}{T_c} \right)
\]

\(\Delta h_c/r_0\) is specified to be 13.1 x 103 kJ/kg in general.

\(C\)=calibration constant for the oxygen consumption analysis, (m^1/2*kg^1/2*K^1/2)

\(T_c\)=absolute temperature at the orifice meter, (K)

\(\Delta P\): pressure drop through the orifice meter, (Pa)

\(X_{O_2}^0\)= initial value of oxygen analyzer reading (-)

\(X_{O_2}\)=oxygen analyzer reading, mole fraction (-)
As the graph shown above, the curve of calculated heat release rate match well with the results from VI despite of time delay of 221 seconds which is due to the fact that VI automatically filtrates the “inefficient “data. The Calibration factor used in the calculation is 0.045 and $X_{O_20}$ is 0.209.

Mass loss rate

The load cell of the cone calorimeter recorded the mass change every second during the whole test. Five-point numerical differentiation is used to compute the mass loss rate at each time interval. As the equation indicated below, there are four special cases in the calculation of the mass loss rate: the first scan, the second scan, the last scan but one, and the last scan. For any scan in between $(1 < i < n-1)$, the general equation is applied to compute the mass loss rate except four special cases.
The graph below is the comparison of the reproduced mass loss rate and VI results. The 9-point average method is applied to reduce the noise of the reproduced data. All invalid points out of the range from 0 to 0.4 g/s are also eliminated from the graph. Again, there is a time delay of 221 seconds between the reproduced graph and the VI result graph.

Figure 10: Reproduced data versus VI result of Mass Loss Rate using 9-pt average method

Effective Heat of Combustion
Effective heat of Combustion can be simply calculated by heat release rate over mass loss rate. The equation is shown below:

\[ q'(t) = \text{heat release rate at time } t, \text{ (kW)} \]

\[ m_i = \text{initial mass of specimen, (kg)} \]

\[ m_f = \text{final mass of specimen, (kg)} \]

\[ \frac{dm}{dt} = \text{heat release rate at time } t, \text{ (g/s)} \]

The graph below shows the comparison of reproduced effective heat of combustion and VI result. Most of the reproduced data points overlap with the VI result despite the deviation in the beginning and the end, which is caused by small mass loss rate. The data points are also restricted to the range of 0 to 40 kJ/g, which help eliminate the invalid points.

Figure 11: Reproduced data versus VI result of Effective Heat of Combustion

**Extinction Coefficient**

The smoke coefficient (k) and the specific extinction area (SEA) are basic measurements of smoke development in the fire, and they are calculated by the following equation:
In the reproduction of the smoke coefficient, \( L = 0.11 \text{m} \) is applied as extinction beam path length. The reproduction of beam intensities are also used to compute the smoke coefficient. The graph shown below indicates the consistency of reproduced data and VI results, but the time delay problem still exist in this comparison. Another issue is that the Extinction coefficient shouldn’t be negative numbers. The cause of it still need to be investigated.

**Smoke Production Rate**

\[ \text{SPR} = k \, \dot{V}_{\text{fuel}} \]

\[ \text{SEA}_{\text{fuel}} = \frac{\text{SPR}}{m_{\text{fuel}}} = k \, \dot{V}_{\text{fuel}} \, (\frac{dm}{dt}) \]

\( k = \text{smoke extinction coefficient, m}^{-1} \)

\( \text{SPR} = \text{smoke production rate, m}^2/\text{s} \)
$V' =$ volume exhaust flow rate, measured at the laser photometer, m$^3$/s

$SEA_{fuel} =$ specific extinction area, m$^2$/kg

$m'_{fuel} = (dm/dt) =$ mass loss rate at time t, kg/s

The reproduced extinction coefficient, volume flow rate measured at the exhaust and reproduced mass loss rate are used to compute the specific heat area. The data points are restricted to the range of 0 to 1 m$^2$/g in order to remove the invalid data. The time is also restricted to 220 to 370 second to get a better view of the comparison of reproduced SEA and VI results.
Appendix D - Cone Results and Graphs

100515 (October Batch)

Overall, the October batch results show a decent consistency with the 4 tested specimen. The specimen tested with thermocouples both on the surface and bottom seemed to cause the mass loss rate to have more variance and noise. In general, the specimen tested in IHF 78 kW/m\(^2\) have relative good repeatability and uniform results compared to the specimen tested in IHF 78 kW/m\(^2\). We checked the mass history of specimen tested in IHF 78 kW/m\(^2\), and found out that the mass curves recorded continuous noise (jump) during testing. The moving average method was applied to deal with the noise in the mass loss rate, but it didn’t seem to have big impact on reducing the noise. The team guess the issue was related to the instrument problem since we had this problem since D term begun. Another issue represented in the IHF 50 kW/m\(^2\) was the abnormity of recording extinction coefficient data (smoke obscuration). All data points were shown to be negative and keep decreasing over time. To fix the data, the team first shifted the data set to start from the zero point and then use the method of linear correction to adjust the trends. Once extinction coefficient data was corrected, the corrected data was applied to recalculate all indirect smoke measurement like smoke production rate and specific extinction area.

50 kW/m\(^2\) IHF

100515-4
Smoke Production Rate (100515-6)-50kW/m²

Specific Extinction Area (100515-6)-50kW/m²

Time [s]

SPECIMEN 1 (4.5 mm) WITH TC
SPECIMEN 2 (4.5 mm) WITH TC
SPECIMEN 3 (4.5 mm)
SPECIMEN 4 (4.3 mm)

100515-7
Specific Extinction Area (100515-9)-50 kW/m^2

Time (s)

SEA (m^2/kg)

SPECIMEN 1 (4.5 mm) WITH TC
SPECIMEN 2 (4.2 mm) WITH TC
SPECIMEN 3 (4.1 mm)
SPECIMEN 4 (4.2 mm)

78 kW/m^2 IHF

100515-4

Heat Release Rate / m^2 (100515-4)-78 kW/m^2

HRR PER UNIT AREA (KW/m^2)

Time (s)
Specific Extinction Area (100515-4)-78kW/m²

Heat Release Rate / m² (100515-5)-78kW/m²
Specific Extinction Area (100515-7)-78kW/m^2

Heat Release Rate / m^2 (100515-8)-78kW/m^2
In order to compare FRP systems with different thicknesses at the same heat flux, the use of Tau was employed. Tau is defined as time over thickness square. As we mentioned in the beginning the October batch section, the mass loss rate and smoke data acquired in IHF 50 kW/m^2 represented to be abnormal. Luckily, the data seemed to work very well in comparison after we correct the data. The specimen show similar behavior under either IHF 50 kW/m^2 or IHF 78 kW/m^2. Obviously, the specimen 8 and 9 have higher heat release rate per unit area than other systems in the October batch. In addition, specimen 4, 8 and 9 have greater extinction coefficient as we can tell clearly on the comparison graph. We can basically draw a preliminary conclusion that the white base cause a negative effect on the systems either with gelcoat of polymer concrete. The white base make the established system release a much higher heat and larger amount of smoke in a shorter period, so the white base is not recommended to put on the coating.

In terms of using white base, the specimen 8, fire block gelcoat, has a better fire performance than specimen 9 in general. Although specimen 8 and 9 have a similar level of HRRPUA, specimen 8 release less amount of smoke and take a longer burning duration.
Average Specific Extinction Area versus Tau (100515-50kW/m^2)

78 kw/m^2 IHF
Average Smoke Production Rate versus Tau (100515-78kW/m^2)
The November Batch are the two established system with sprayed white paint on the surface. We have tested each specimen for four times, two times in IHF 50 kW/m^2 and another two times in IHF 78 kW/m^2. Again, we encountered the issue of having lots of noise in mass measurement in 50 kW/m^2 than in 78 kW/m^2 because of the instrument issue. After the method of moving average was applied, the curves had clearer trends despite the noise. However, the smoke data in November Batch looked all fine besides the fact that the extinction coefficient showed mostly negative values. So the extinction coefficient data were corrected by shifting up the graph and ensuring the starting point to be zero.

112515-1

Fireblock Polymer Concrete

1:1 ratio by weight of Fireblock to #80 Fused White Aluminum Oxide

2 layers of 36oz. Woven Roving with 285 resin system
Lightly Sandblasted

112515-2

Fireblock Polymer Concrete

1:1 ratio by weight of Fireblock and MoMA sand

2 layers of 36oz. Woven Roving with 285 resin system

Regular MoMA sandblast once cured

112515-3

Fireblock Gelcoat

2 layers of 36oz. Woven Roving with 285 resin system

Lightly Sandblasted

Spray with 2 mils of Satin White Urethane Paint

112515-6

Fireblock Polymer Concrete

1:1 ratio by weight of Fireblock and MoMA sand

2 layers of 36 oz. Woven Roving with 285 resin system

Regular MoMA sandblast once cured

Spray with 2 mils of Satin White Urethane Paint

50 kW/m^2 IHF
78 kW/m^2 IHF

112515-1
Smoke Production Rate (112515-3) - 78kW/m²

Specific Extinction Area (112515-3) - 78kW/m²
The white paint on the specimen 6 is the only difference other than specimen 2. The white paint obliviously make the specimen release more heat in relative short period, but it is just slightly higher. The specimen 6 released little greater amount of smoke than specimen 2 did, but the burning duration was pretty similar. Overall, the white paint just make the specimen release relative more heat and little greater amount of smoke.
Specimen 2 has MoMA sand instead of fused white aluminum oxide that is used in specimen 1. The specimen 1 had a slightly higher heat release rate per unit area, but it last longer time and released smaller amount of smoke than specimen 2 did.

Specimen 3 has gelcoat and white paint on it. It had similar level HRRPUA as specimen 6 did, but it had longest burning duration and moderate amount of smoke. In general, the specimen 3 has a better fire performance than specimen 6 does if the white paint is needed.

50 kW/m²
78 kW/m²
## 011116 (January Batch)

<table>
<thead>
<tr>
<th>Series #</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>010816</td>
<td>HK Research Gelcoat lightly sandblasted</td>
</tr>
<tr>
<td>011116-1</td>
<td>Fireblock Gelcoat for comparison lightly sandblasted</td>
</tr>
<tr>
<td>011116-2</td>
<td>¾ Fireblock Gelcoat with ¼ White Base Gelcoat</td>
</tr>
<tr>
<td>011116-3</td>
<td>Fireblock MoMA style polymer concrete for comparison</td>
</tr>
<tr>
<td>011116-4</td>
<td>HK Research MoMA style polymer concrete</td>
</tr>
<tr>
<td>011116-5</td>
<td>Fireblock polymer concrete with Aluminum Oxide for comparison</td>
</tr>
<tr>
<td>011116-6</td>
<td>HK Research polymer concrete with Aluminum Oxide</td>
</tr>
</tbody>
</table>

The January batch was tested recently in March and April, during which time we had a lot of problems with data acquisition. Especially, the smoke data showed a slightly lower repeatability compared to the other batches. We encountered a problem with the exhausted system of the cone calorimetry that time. The smoke couldn’t be absorbed completely by the cone as ash from the specimen filled the surrounding air. However, as long as the first peak of the curve can match together, we don’t put too much concern on the repeatability. The laser system was still a little bit off, but we fixed the data by shifting the whole set of data and placing the first data point to the zero reading.

**50 kW/m^2 IHF**

010816
Heat of Combustion (011116-2)-50kW/m^2

Extinction Coefficient (011116-1)-50kW/m^2
Smoke Production Rate (011116-2)-50kW/m²

Specific Extinction Area (011116-2)-50KW/m²

SPECIMEN 1 (4.2mm)
SPECIMEN 2 (3.8mm)
Smoke Production Rate (011116-4)-50kW/m^2

Specific Extinction Area (011116-4)-50KW/m^2
Smoke Production Rate (011116-5)-50kW/m^2

Specific Extinction Area (011116-5)-50KW/m^2
Smoke Production Rate (011116-6)-50kW/m^2

Specific Extinction Area (011116-6)-50kW/m^2

78 kW/m^2 IHF

010816
Smoke Production Rate (011116-1)-78kW/m²

Specific Extinction Area (011116-1)-78kW/m²
Smoke Production Rate (011116-2)-78kW/m^2

Specific Extinction Area (011116-2)-78kW/m^2

011116-3
Smoke Production Rate (011116-6)-78kW/m^2

Specific Extinction Area (011116-6)-78kW/m^2

Tau Graph Comparison (011116)
From the observation on the Tau comparison graphs, HK research system released almost double HRRPUA than Fireblock system, and it also had obvious greater amount of smoke. The burning duration was shorter as well. In the HK research system, specimen 010816, 011116-4 and 01116-6 all have similar results on both HRRPUA and smoke data. It is difficult to compare them graphically.

For the comparison of Fireblock system (01116-1,2,3,5), the specimen (gelcoat white base) can be distinguished to have higher HRRPUA and extinction coefficient. However, the difference was not obvious and could be neglected when compared to specimen 3 and 5 (gelcoat with sand and gelcoat with white aluminum oxide). No doubt, the specimen 1 had a best fire performance because its lowest HRRPUA and Extinction Coefficient, and it had a slower reaction process as its burning duration was the longest.

50 kW/m^2

![Average HRR versus Tau (011116-50kW/m^2)](image)
Average Specific Extinction Area versus Tau (011116-50kW/m^2)

78 kW//m^2
Appendix E - Flammability Parameter Summary

Sample Calculation

Procedure

As mentioned previously, the flammability parameter is a very useful tool to predict flame spread. If the flammability parameter has a positive value, it represents a degree of flame spread acceleration, while conversely, if the flammability parameter is negative, it represents a degree of flame spread deceleration. The formula listed below is the equation used in the calculation of the flammability parameter, and it has only one independent variable, which is heat release rate per unit area.

\[
\beta = k_f \cdot \dot{Q} - \frac{t_f}{t_{bo}} - 1
\]

- \( k_f = 0.01 \ m^2/kW \)
- \( \dot{Q} \) is the heat release rate per unit area (HRRPUA)
- \( t_f \) is the ignition time subtracted by the shutter opening time
- \( t_{bo} \) is the flame out time subtracted by the time to ignition

Take 100515-4 as an example.

Shutter open: 198 seconds;
Ignition time: 140 seconds;
Flameout time: 714 seconds;
\( \dot{Q} = 21.625 \ kW/m^2 \) at 640 seconds;
\[
\beta = k_f \cdot \dot{Q} - \frac{t_f}{t_{bo}} - 1 = 0.01 \times 21.625 - \frac{198 - 140}{714 - 198} - 1 = -0.872
\]

In the example shown above, the flammability parameter was -0.872 after the shutter had been opened for 440 seconds. Thus, the flammability parameter for this specimen represented flame deceleration during the test.

Uncertainty
The Student’s t-distribution was applied to calculate the uncertainty for the average flammability parameter of each FRP system. The Student’s t-distribution was used as it requires estimating the mean of a normally distributed population in situations where the sample size is relatively small. A 70% confidence level was determined because there was only one standard deviation calculation involved in this process.

\[
(2) \quad \bar{X}_n \pm t \cdot \frac{S_n}{\sqrt{n}}
\]

- \(\bar{X}_n\) is mean value
- \(t = 1.25\), chosen based on 70% confidence and 3 degrees of freedom.
- \(S_n\) is standard deviation
- \(n = 4\), 4 trials have been tested for each specimen

### Summary Table-100515-50 kW/m^2

<table>
<thead>
<tr>
<th>Series #</th>
<th>AVG B Parameter</th>
<th>UNC</th>
</tr>
</thead>
<tbody>
<tr>
<td>100515-4</td>
<td>-0.96</td>
<td>± 0.17</td>
</tr>
<tr>
<td>100515-5</td>
<td>-0.67</td>
<td>± 0.075</td>
</tr>
<tr>
<td>100515-6</td>
<td>-0.64</td>
<td>± 0.087</td>
</tr>
<tr>
<td>100515-7</td>
<td>-0.87</td>
<td>± 0.18</td>
</tr>
<tr>
<td>100515-8</td>
<td>-0.42</td>
<td>± 0.096</td>
</tr>
<tr>
<td>100515-9</td>
<td>-0.41</td>
<td>± 0.13</td>
</tr>
</tbody>
</table>

At 50 kW/m^2 the October batch of specimen displayed negatively trending flammability parameters. Specimen 4, which had no coating displayed the greatest degree of flame
deceleration, while specimen 7 (Fireblock Gelcoat, no sand) had the second greatest deceleration. The only difference separating specimens 5 and 6 was that 6 had a third layer composed of Carbon Fiber cloth, which seemed to have no real effect in changing the flammability parameter results as it’s true value was only .03 lower than specimen 5’s. White based specimens 8 and 9 displayed very similar results with no degree of significant difference as their range of values overlapped when taking uncertainties into account. So, it remains unclear as to whether the addition of sand (specimen 9 has sand, 8 does not) has any effect on flammability parameter.

**Summary Table-100515-78 kW/m^2**

<table>
<thead>
<tr>
<th>Series #</th>
<th>AVG B Parameter</th>
<th>UNC</th>
</tr>
</thead>
<tbody>
<tr>
<td>100515-4</td>
<td>-0.49</td>
<td>±    0.022</td>
</tr>
<tr>
<td>100515-5</td>
<td>-0.29</td>
<td>±    0.038</td>
</tr>
<tr>
<td>100515-6</td>
<td>-0.35</td>
<td>±    0.026</td>
</tr>
<tr>
<td>100515-7</td>
<td>-0.42</td>
<td>±    0.047</td>
</tr>
<tr>
<td>100515-8</td>
<td>-0.26</td>
<td>±    0.028</td>
</tr>
<tr>
<td>100515-9</td>
<td>-0.29</td>
<td>±    0.047</td>
</tr>
</tbody>
</table>

Interestingly enough, the October batch at 78 kW/m^2 displayed a similar trend in results as when tested at 50 kW/m^2. Specifically, the specimens acted the same as they did at 50 kW/m^2, but in terms of actual flammability parameter value, where about half as large. So, it seems that an increase in incident heat flux will tend to cause an increase in flame acceleration, as all the specimen in this batch had become more positive than when tested at 50 kW/m^2.
### Summary Table-112515-50 kW/m^2

<table>
<thead>
<tr>
<th>Series #</th>
<th>AVG B Parameter</th>
<th>UNC</th>
</tr>
</thead>
<tbody>
<tr>
<td>112515-1</td>
<td>-0.64</td>
<td>± 0.16</td>
</tr>
<tr>
<td>112515-2</td>
<td>-0.59</td>
<td>± 0.086</td>
</tr>
<tr>
<td>112515-3</td>
<td>-0.58</td>
<td>± 0.0059</td>
</tr>
<tr>
<td>112515-6</td>
<td>-0.62</td>
<td>± 0.12</td>
</tr>
</tbody>
</table>

At 50 kW/m² the November batch of specimen displayed all negatively trending flammability parameters. Specimen 1, which had a white aluminum oxide element, displayed the greatest degree of flame deceleration, while specimen 3 (Fireblock Gelcoat system) had least negative flame deceleration. The only difference separating specimens 2 and 3 was that 2 had was composed of concrete, which seemed to have no real effect in changing the flammability parameter results as both specimen’s values overlapped when taking into account of uncertainties. However, as a whole, this group did not display a great difference in significance, which can be attributed to their composition being not wholly dissimilar.

### Summary Table-112515-78 kW/m^2

<table>
<thead>
<tr>
<th>Series #</th>
<th>AVG B Parameter</th>
<th>UNC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Once again as was seen with the October batch, this November batch at 78 kW/m² displayed a similar trend in results as when tested at 50 kW/m². Specifically, the specimens acted the same as they did at 50 kW/m², but in terms of actual flammability parameter value, where about half as large.

Summary Table-011116-50 kW/m²

<table>
<thead>
<tr>
<th>Series #</th>
<th>AVG B Parameter</th>
<th>UNC</th>
</tr>
</thead>
<tbody>
<tr>
<td>010816</td>
<td>-0.40</td>
<td>± 0.10</td>
</tr>
<tr>
<td>011116-1</td>
<td>-0.54</td>
<td>± 0.027</td>
</tr>
<tr>
<td>011116-2</td>
<td>-0.73</td>
<td>± 0.065</td>
</tr>
<tr>
<td>011116-3</td>
<td>-0.51</td>
<td>± 0.020</td>
</tr>
<tr>
<td>011116-4</td>
<td>-0.52</td>
<td>± 0.025</td>
</tr>
<tr>
<td>011116-5</td>
<td>-0.83</td>
<td>± 0.10</td>
</tr>
</tbody>
</table>
At 50 kW/m$^2$ the January batch of specimen also displayed all negatively trending flammability parameters. Specimen 5, which had an aluminum oxide element with Fireblock polymer concrete, displayed the greatest degree of flame deceleration. Specimen 010816, which was the HK Research Gelcoat with a light sandblast had the least negative flammability parameter.

Summary Table-011116-78 kW/m$^2$

<table>
<thead>
<tr>
<th>Series #</th>
<th>AVG B Parameter</th>
<th>UNC</th>
</tr>
</thead>
<tbody>
<tr>
<td>010816</td>
<td>-0.36</td>
<td>± 0.010</td>
</tr>
<tr>
<td>011116-1</td>
<td>-0.46</td>
<td>± 0.071</td>
</tr>
<tr>
<td>011116-2</td>
<td>-0.28</td>
<td>± 0.18</td>
</tr>
<tr>
<td>011116-3</td>
<td>-0.29</td>
<td>± 0.091</td>
</tr>
<tr>
<td>011116-4</td>
<td>-0.25</td>
<td>± 0.086</td>
</tr>
<tr>
<td>011116-5</td>
<td>-0.35</td>
<td>± 0.19</td>
</tr>
<tr>
<td>011116-6</td>
<td>-0.18</td>
<td>± 0.075</td>
</tr>
</tbody>
</table>

Again as was seen with the October and November batch, this January batch at 78 kW/m$^2$ displayed a similar trend in results as when tested at 50 kW/m$^2$. Specifically, the specimens acted the same as they did at 50 kW/m$^2$, but in terms of actual flammability parameter value, where about half as large.
Appendix F - FSI

Sample Calculation

The Flame Spread Index (FSI) is a measure of a material’s propensity to burn and spread flame that is used by the International Building Code (IBC), specifically in industry standard tests such as the ASTM E84. It is important for any material used as an interior finish or on exterior walls to meet the IBC standards for safety. So the results of the ASTM E84 are critical to where or not a material system will be up to code.

In the standard tests, FSI is calculated from the time integral of the flame extension utilizing the following equations:

\[
FSI = 0.515 \times A_T \quad A_T \leq 97.5 \\
FSI = \frac{4900}{195 - A_T} \quad A_T > 97.5
\]

\(A_T\): time integral of flame extension, (ft*min)

As previously mentioned, the 2013 MQP team (Acosta, et al) developed a screening tool to simulate flame extension in the tunnel test. This tool works on the assumption that the fire produced during the ASTM E84 test can be modeled as a basic 2-D fire with a point source. This tool provides useful data, but is also limited, because the deviation of the resulting FSI can reach 30% of its real values. The 2013 MQP team developed two different versions of the tool, one to be used on an FRP system with a coating and the other to be used on an FRP system without a coating. It was assumed that flame extension before the time to ignition was zero. For each test sample, \(L_f\) was calculated for each recorded time step based on the Heat Release Rate Per Unit Area.

\[
L_{f-coated} = \left(0.2322 \times \left(\frac{0.6\dot{Q} + 88}{0.43}\right)^{0.6496}\right) - 4.5
\]

\[
L_{f-noncoated} = \left(0.1574 \times \left(\frac{0.6\dot{Q} + 88}{0.43}\right)^{0.6496}\right) - 4.5
\]
L_f: simulated flame extension measured, (ft)

\( \dot{Q} \): heat release rate per unit area (HRRPUA) from the cone calorimeter tests, (kW/m²)

After \( L_f \) is calculated, \( A_T \) was approximated by summing the calculated flame extensions at every time point from the time to ignition to the time of edge burning. \( A_T \) can be expressed by the following equation:

\[
A_T = \sum L_f \Delta t
\]

In the above equation, time interval is assumed to be one second while the heat flux at that second is also used. The resulting calculated flame extension has a similar shape to the HHRPUA when plotted versus time. The FSI is then calculated by integrating the curve of the flame extension graph. It is critical to note that the assumption has to be made that the flame extension is constant after its peak and any other subsequent peaks in the graph are taken to be effects of edge burning and are neglected. So, the FSI is really the integral of the curve up to the flame extension peak and then the straight line extending from the peak until the point of burnout. This assumption is made, because realistically a flash fire can generate the same damage as a sustained fire, because it would spread rather than burn out.

After values for FSI were established for all of FRP systems, uncertainty was calculated using the law of propagation of uncertainty. This was done, because it is assumed that the FSI results stemming from the experimental measurements of the cone testing yield a “true value”. This “true value” actually falls within a range of values that accounts for random fluctuations that might alter data output during data acquisition. To account for this range of possible data discrepancy, the uncertainty in the measurements of our data points was calculated. The first step in this process was isolating the measurements or independent variables inherent to the FSI calculation. In the case, the only independent variable critical to the FSI equation is heat release rate per unit area (HRRPUA). So the first step, was to calculate the standard deviation on the average HRRPUA for each specific FRP system using the formula below:

\[
\sigma_x = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}
\]

Where:
\[ \bar{x} = \text{mean value of } x \]
\[ n = \text{number of measurements} \]

Since the FSI is a measurement of flame extension, and flame extension in turn is a measurement of heat release rate per unit area, the individual uncertainty of this HRRPUA term is needed to find the uncertainty of the flame extension and hence the corresponding FSI value using the law of propagation of uncertainty, which is defined by the following equation:

\[ \Delta R^2 = \left( \frac{\partial f}{\partial x} \right)^2 \cdot (\Delta x)^2 + \left( \frac{\partial f}{\partial y} \right)^2 \cdot (\Delta y)^2 + \left( \frac{\partial f}{\partial z} \right)^2 \cdot (\Delta z)^2 \]

Where:
\( \Delta x, \Delta y, \) and \( \Delta z \) are the individual uncertainties of possible variables governing an equation, which can be represented as the standard deviation of each variable. For FSI, there is just the one (HRRPUA) independent variable to consider.

In order to apply the law of propagation of uncertainty, the partial derivatives of the flame extension equations with respect to HRRPUA (or x for simplicity) had to be calculated. As previously mentioned, there are two flame extension models, one for materials with a coating and one with materials without a coating. Their respective derivatives are:

\[ \frac{\partial f}{\partial x} (L_{f\text{-coated}}) = \left( \frac{0.156588}{(0.6 \dot{Q} + 88)^{0.3504}} \right) \]

\[ \frac{\partial f}{\partial x} (L_{f\text{-noncoated}}) = \left( \frac{0.106145}{(0.6 \dot{Q} + 88)^{0.3504}} \right) \]

These equations are then factored into the propagation of uncertainty allowing for levels of significant difference between FRP systems to be ascertained:

\[ \Delta R^2_{\text{coated}} = \left( \frac{0.156588}{(0.6 \dot{Q} + 88)^{0.3504}} \right)^2 \cdot (\Delta x)^2 \]
\[ \Delta R^2_{_{\text{noncoated}}} = \left( \frac{0.106145}{(0.6Q + 88)^{0.3504}} \right)^2 \times (\Delta x)^2 \]

**Summary Table-100515-50 kW/m^2**

<table>
<thead>
<tr>
<th>Series #</th>
<th>FSI</th>
<th>Uncertainty</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>100515-4</td>
<td>4.8</td>
<td>±1.3</td>
<td>A</td>
</tr>
<tr>
<td>100515-5</td>
<td>27</td>
<td>±2.0</td>
<td>A/B</td>
</tr>
<tr>
<td>100515-6</td>
<td>26</td>
<td>±2.0</td>
<td>A/B</td>
</tr>
<tr>
<td>100515-7</td>
<td>20</td>
<td>±1.7</td>
<td>A</td>
</tr>
<tr>
<td>100515-8</td>
<td>20</td>
<td>±2.0</td>
<td>A</td>
</tr>
<tr>
<td>100515-9</td>
<td>26</td>
<td>±2.3</td>
<td>A/B</td>
</tr>
</tbody>
</table>

From comparison to the flammability parameter results from October, it seems that the higher the degree of flame deceleration, the lower the calculated FSI value. For example, specimen 4 had the highest degree of flame deceleration, but in regards to FSI it had the lowest value at 4.8. The other specimens all received a rating of 25 or below, allowing for every FRP system to be given a Class A rating defined by the ASTM standard.

**Summary Table-112515-50 kW/m^2**
This November batch of specimens were all calculated to have FSI’s of 21 or 22, giving the entire batch a Class A rating. They also had similar levels of uncertainty creating ranges of values that all overlapped, meaning the entire batch had no significant levels of difference in terms of FSI rating.

**Summary Table-011116-50 kW/m²**

<table>
<thead>
<tr>
<th>Series #</th>
<th>FSI</th>
<th>Uncertainty</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>010816</td>
<td>23</td>
<td>±2.0</td>
<td>A</td>
</tr>
<tr>
<td>011116-1</td>
<td>20</td>
<td>±1.4</td>
<td>A</td>
</tr>
<tr>
<td>011116-2</td>
<td>18</td>
<td>±1.9</td>
<td>A</td>
</tr>
<tr>
<td>011116-3</td>
<td>32</td>
<td>±2.0</td>
<td>B</td>
</tr>
</tbody>
</table>
This January batch produced all Class A ratings with the exception of specimen 3, which was classified as a Class B. As defined by the ASTM standard specimen 3 would not be allowed to be used in architectural applications. All remaining specimen had FSI values with no real levels of difference as their ratings tended to differ by about 1, when including uncertainty ranges.

### Appendix G - SDI

#### SDI SAMPLE CALCULATION

**Procedure**

In general, the ASTM E84 standard defines the smoke developed index of a material as the ratio of the integration of its light transmission over the integration of a reference red oak’s light transmission in 10 minutes. Thus, the first step of SDI calculation is to determine the light transmission percentage of the tested specimen. The light transmission percentage equation listed below is derived from two indirect measurements from cone calorimetry: extinction coefficient \( k \) and heat released rate per unit area \( \dot{Q}_{cone} \).

\[
T\% = \frac{100}{\exp\left(\frac{22.268 \times k}{0.645 \times \dot{Q}_{cone} + 125.6}\right)}
\]  

The second step is to determine the light transmission of red oak. A representative Time-Absorption Curve for smoke density of red oak under a burn duration of 10 minutes is referred to
below. A previous MQP (NAD_FQ13) digitized this graph and integrated the curve with the use of MATLAB, said integration led to a red oak light transmission value of 54.07. For the purposes of this MQP that obtained value was used to calculate SDI.

![Graph of light absorption percentage over time.](image)

The third step is to determine the light transmission of the tested specimen. As the T% has been calculated in the first step, it can then be substituted into the equation listed below to get the final SDI result.

\[
SDI = \frac{\int_{0}^{10 \text{ min}} (100 - T\%) \, dt}{\text{Test specimen}} \times \frac{\int_{0}^{10 \text{ min}} (100 - T\%) \, dt}{\text{Red Oak}}
\]

Where \(\int_{0}^{10 \text{ min}} (100 - T\%) \, dt\) Red Oak = 54.07

The fourth step is to classify the calculated value of the SDI. Referring to the tunnel test (ASTM E84), the smoke developed index should be less than 450 to be classified as Class A, B and C. For all the specimen tested in the past 6 months, the smoke developed index ranged from 5 to 150.

**SDI Uncertainty**
The uncertainty of SDI values needed to be determined for each FRP system in order to compare their differences more precisely. The uncertainty can give SDI values a range. Two different FRP system would be defined to have no significant difference in smoke obscuration if their SDI values with respective uncertainties overlap.

The law of propagation of uncertainty was used throughout all FSI and SDI calculations. Again, thanks to the previous MQP’s work (FQ13), time and effort on defining the final formula are saved. The uncertainty formula derived from MQP report NAD_FQ13 is listed below:

\[
\Delta R^2 = \left(\frac{-3452.4 \times e^{\left(-34.524x \frac{x}{y+194.729}\right)}}{y+194.729}\right)^2 \times \Delta x^2 + \left(\frac{-3452.4 \times x \times e^{\left(-34.524x \frac{x}{y+194.729}\right)}}{y+194.729}\right)^2 \times \Delta y^2
\]

- \(x\) is extinction coefficient
- \(\Delta x\) is standard deviation of extinction coefficient
- \(y\) is heat released rate per unit area
- \(\Delta y\) is standard deviation of heat released rate

The uncertainty (R) is then derived from \(\Delta R^2\) by taking its square root.

Summary Table-100515-50 kW/m^2

<table>
<thead>
<tr>
<th>Series #</th>
<th>SDI</th>
<th>Uncertainty</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>100515-4</td>
<td>48.4</td>
<td>±17.0</td>
<td>A</td>
</tr>
<tr>
<td>100515-5</td>
<td>123</td>
<td>±3.95</td>
<td>A</td>
</tr>
<tr>
<td>100515-6</td>
<td>118</td>
<td>±2.55</td>
<td>A</td>
</tr>
<tr>
<td>100515-7</td>
<td>72</td>
<td>±5.37</td>
<td>A</td>
</tr>
</tbody>
</table>
All specimen were given a Class A rating as all SDI values fell below 450. As far as actual smoke obscuration is concerned, specimen 4 and 7 produced the lowest levels of SDI, while specimens 5, 6, and 7 produced the highest.

### Summary Table-112515-50 kW/m^2

<table>
<thead>
<tr>
<th>Series #</th>
<th>SDI</th>
<th>Uncertainty</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>112515-1</td>
<td>64.5</td>
<td>±7.48</td>
<td>A</td>
</tr>
<tr>
<td>112515-2</td>
<td>105</td>
<td>±8.28</td>
<td>A</td>
</tr>
<tr>
<td>112515-3</td>
<td>112</td>
<td>±9.75</td>
<td>A</td>
</tr>
<tr>
<td>112515-6</td>
<td>119</td>
<td>±10.8</td>
<td>A</td>
</tr>
</tbody>
</table>

All systems in the November batch had a Class A rating with specimen 1 producing the lowest SDI value and thus the highest level of significant difference when compared to all other systems. The remaining systems were all within the same range of values when taking into account of uncertainty.

### Summary Table-011116-50 kW/m^2
<table>
<thead>
<tr>
<th>Series #</th>
<th>SDI</th>
<th>Uncertainty</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>010816</td>
<td>109</td>
<td>±13.6</td>
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</tr>
<tr>
<td>011116-1</td>
<td>164</td>
<td>±16.5</td>
<td>A</td>
</tr>
<tr>
<td>011116-2</td>
<td>87.8</td>
<td>±8.01</td>
<td>A</td>
</tr>
<tr>
<td>011116-3</td>
<td>128</td>
<td>±8.12</td>
<td>A</td>
</tr>
<tr>
<td>011116-4</td>
<td>148</td>
<td>±16.0</td>
<td>A</td>
</tr>
<tr>
<td>011116-5</td>
<td>89.4</td>
<td>±9.86</td>
<td>A</td>
</tr>
<tr>
<td>011116-6</td>
<td>89.9</td>
<td>±16.4</td>
<td>A</td>
</tr>
</tbody>
</table>

Once again, for this January batch all systems were found to have had SDI values below 450, so all were given a Class A rating. Specimens 2, 5, and 6 all had comparable ratings. 5 and 6 were essentially the same. 5 was composed of Fireblock polymer concrete with aluminum oxide, while 6 was composed of HK research polymer concrete with aluminum oxide. The highest ratings were given to specimens 1 and 4. Specimen 1 was composed of lightly sandblasted Fireblock Gelcoat, while specimen 4 was composed of HK research MoMA style polymer concrete.
Appendix H - Gpyro

Governing Equations

Gpyro simulates pyrolysis through the modeling of equations that describe mass conservation, species conservation, energy conservation, and reaction rates. When given material properties, reaction rates, and initial and boundary conditions through an input file, Gpyro uses these governing equations to simulate pyrolysis under the specified conditions. For a comprehensive guide of the governing equations of Gpyro, refer to the Gpyro Technical Reference Guide.

Parameters

Gpyro offers hundreds of parameters that can be adjusted to create a desired simulation. These parameters affect the general processes of the program, the properties of the components of the sample and gases they produce, how the solids react to form new solids, the composition of layers, how boundaries interact with the surroundings, and the geometry and layering of the sample. However, the vast majority of these variables are not changed from their defaults, either because they should never be changed by the recommendation of the program’s creator, Chris Lautenberger, or because they are not pertinent to the simulations we are running.

To produce an accurate simulation of a cone calorimeter test, we used a sample simulation from Gpyro of a 1D sample exposed to an incident heat flux on one face, then adjusted key parameters to match those of a real test.

General

The general settings of a Gpyro simulation affect the ambient conditions of the test and the equations for which Gpyro solves. Almost all of the general settings of the simulation are left at their defaults, which describe regular atmospheric conditions. The one parameter we adjusted was SOLVE_PRESSURE, which, when set as true, uses Darcy’s law to solve for gas pressure throughout the sample. This is because current simulations assume all gases instantaneously escape from the sample, and it is possible that this is partially responsible for the inaccurately high mass loss rate of the simulation.

Solid Properties
Each solid species has twenty-one parameters to describe material properties, but only six were specified for each material. This is because most of the parameters should never be changed, only matter in 2D or 3D simulations, or describe changes in material properties as a function of temperature. These six parameters for each material are thermal conductivity, density, specific heat, emissivity, opacity, and radiation across pores.

The Solid Properties for the species are listed below and come from Esther Kim’s 2014 paper, “Parameter Estimation for Comprehensive Pyrolysis Modeling,” operating under the assumption that the resin and glass present in the Kreysler specimens have comparable properties to those tested in Esther Kim’s work.

<table>
<thead>
<tr>
<th>Species</th>
<th>Resin</th>
<th>Resin Residue</th>
<th>ATH</th>
<th>ATH Residue</th>
<th>Glass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Conductivity (W/m-K)</td>
<td>0.230</td>
<td>0.190</td>
<td>1.220</td>
<td>0.240</td>
<td>0.180</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>1200</td>
<td>253</td>
<td>2300</td>
<td>1558</td>
<td>2600</td>
</tr>
<tr>
<td>Specific Heat (J/kg-K)</td>
<td>1400</td>
<td>1900</td>
<td>1200</td>
<td>1200</td>
<td>1400</td>
</tr>
<tr>
<td>Emissivity</td>
<td>0.840</td>
<td>0.900</td>
<td>0.810</td>
<td>0.810</td>
<td>0.880</td>
</tr>
<tr>
<td>Opacity (m⁻¹)</td>
<td>1*10⁶</td>
<td>1*10⁶</td>
<td>1*10⁶</td>
<td>1*10⁶</td>
<td>1*10⁶</td>
</tr>
<tr>
<td>Radiation Across Pores (m)</td>
<td>0</td>
<td>3.48*10⁻³</td>
<td>0</td>
<td>4.73*10⁻³</td>
<td>7.60*10⁻³</td>
</tr>
</tbody>
</table>

Table 1 - Solid Properties for Simulation

Reaction Properties

Each reaction simulated in Gpyro has thirteen kinetic parameters used to describe it. However, all but five are used to either simulate oxygen-dependent reactions or to add an extra degree of complexity to the reaction. The remaining five parameters, used to describe the reactions describe the rate at which the reactions occur, how much energy they absorb or release, and the
degree to which the reaction causes intumescence. Below are the kinetic parameters for the two reactions simulated in Gpyro, also obtained from Esther Kim’s 2014 paper.

<table>
<thead>
<tr>
<th>Reaction</th>
<th>n</th>
<th>Z (s⁻¹)</th>
<th>E (J/mol)</th>
<th>ΔHᵥ (kJ/kg)</th>
<th>Degree of Intumescence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resin to Resin Residue</td>
<td>1.13</td>
<td>5×10¹³</td>
<td>195</td>
<td>1.72×10⁵</td>
<td>1</td>
</tr>
<tr>
<td>ATH to ATH Residue</td>
<td>1.24</td>
<td>2.5×10¹¹</td>
<td>140</td>
<td>1.00×10⁶</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2 - Kinetic Properties for Simulation

Initial Conditions

Each layer of a simulated sample must have specified initial conditions, consisting of initial temperature and the composition of the layer. Initial temperature was kept at room temperature (300K). The composition of a glass and resin sample was determined by using the stated density of glass in the sample (two layers of 36 oz/yd² woven roving), area of the sample, and mass of the sample to find the mass fraction of glass in a typical glass and resin layer (45%). The remaining mass of a sample is a 50/50 mixture of hetron resin and ATH (27.5% each).

Geometry

Sample geometry specifies the size of each layer; which boundary conditions apply to each layer face; the number of cells in the x, y, and z directions; and the contact conductance between layers. For the sake of simulating an existing sample of glass, resin, and ATH, the geometry of the sample matched that of a typical sample: one 10cm x 10 cm x 3 mm layer. Because this simulation is only pertinent while behaving one-dimensionally (i.e. the side faces of the sample do not affect the burn so the depth of the sample is the only pertinent dimension), samples had one cell in the x and y directions, and 381 in the z direction. The boundary conditions for the different faces will be discussed in the next section.

Boundary Conditions

Each must have two faces with specified boundary conditions. Most of the parameters specified for boundary conditions are pertinent to gas momentum, energy, and species equations, which were not changed for the sake of these simulations. The boundary condition parameters
manipulated in these simulations include incident heat flux and contact conductance to ambient solids. Because of the one dimensional nature of a cone calorimeter simulation, only the top and bottom faces have specified boundary conditions, and the side faces are assumed to be perfectly insulated.

Incident heat flux refers to the heat flux contributed by the cone heater. Because this varied between 50 kW/m² and 78 kW/m², we adjusted this parameter to fit the experimental data to which we compared simulated data.

Previous simulations of cone tests have specified a contact conductance on the bottom face of the sample as 0 W/m²-K. This is because an idealized cone calorimeter test assumes that all faces except the top face are perfectly insulated to the ambient environment. However, because cone calorimeter tests do not have these idealized conditions, it is worth investigating if adjusting back face contact conductance to real world values will improve the reliability of Gpyro simulations.

Results

Darcy’s Law

Previous simulations of resin and glass systems have produced a simulated mass loss rate much greater than the experimental mass loss rate. Below is a comparison of simulated and test data; the simulation is a recreation of last year’s simulation, but with the incident heat flux and sample size changed to match those of the testing we conducted in December 2015.
This may be because the default simulation assumes that all gases immediately leave the solid, rather than diffusing through the medium. A potential way of modeling the diffusion of gas through the solid is to set the SOLVE_PRESSURE variable as true in the input file, which allows GPyro to use Darcy’s Law to solve for pressure distribution in the solid. Darcy’s Law describes the movement of fluid through a permeable medium as a function of the permeability of the medium, cross-sectional area of the medium, pressure distribution along the length of the medium, viscosity of the fluid, and length of the medium. Below is a comparison of a resin and glass sample with Darcy’s Law turned on and off.
It is apparent that turning Darcy’s Law on has no significant effect on the mass loss rate in this particular simulation. Next, we simulated samples with differing degrees of permeability: 1E-8, 1E-13, and 1E-17 m² to signify pervious, semi-pervious, and impervious materials, respectively[1].

It is also apparent that the permeability of the solids has no significant effect on the mass loss rate in this simulation.

To explore the full effects of turning Darcy’s Law on and off and adjusting permeability, we made the same changes to a simulation of the 100515-7 sample, in which a resin and glass mixture composes a bottom layer and an intumescent resin composes a top layer. Below is a graph comparing four simulations in which Darcy’s Law is turned off and Darcy’s Law is turned on with pervious, semi-pervious, and impervious permeability values for solid materials.
Although turning Darcy’s Law on had no evident effect on the previous simulation, it did have a significant effect on the mass loss rate of the layered sample, but adjusting the permeability of the solids had no measurable effect. This may indicated that in GPyro, turning Darcy’s Law on only affects gas permeation across layer boundaries, rather than through the sample itself.

Back Face Contact Conductance

Previous simulations of cone tests have specified a contact conductance on the bottom face of the sample as 0 W/m²-K. This is because an idealized cone calorimeter test assumes that all faces except the top face are perfectly insulated to the ambient environment. However, because cone calorimeter tests do not have these idealized conditions, it is worth investigating if adjusting back face contact conductance to real world values will improve the reliability of Gpyro simulations.

A sensitivity analysis of back face contact conductance was performed on a simulation of a glass and resin sample. Below is a comparison of the mass loss rate curves of a sample with a back face contact conductance of 0 W/m²-K (insulated), 50 W/m²-K (typical thermal contact conductance), 100 W/m²-K (typical thermal contact conductance), and 1000 W/m²-K (perfect thermal contact).
This comparison shows that specifying a back face thermal contact conductance of around 100 W/m²-K significantly decreases the mass loss rate of a simulated sample, bringing it much closer to the real values found in test data.

Top Face Convective Heat Transfer Coefficient

Previous simulations of cone tests have specified a convective heat transfer coefficient on the top face of 10 W/m²-K. However, some research suggests that this parameter may in fact be around 30 W/m²-K. In order to test the simulations’ sensitivity to changes in the convective heat transfer coefficient, a sample of 100515-4 was simulated with varying values. Below are comparisons between the mass loss rates and top face temperatures of samples with varying convective heat transfer coefficients at the top face.
It is evident that the convective heat transfer coefficient, when increased on the top face, has a significant effect on the mass loss rate and top face temperature of the sample. Therefore calibrating the back face contact conductance and top face convective heat transfer to match real world values may help improve the accuracy of cone simulations in GPyro.

Comparing Simulations to Real Data

To test the validity of this calibration exercise, we compared the mass loss rates and surface temperatures of a simulated sample under default boundary conditions, a “calibrated”
simulated sample with a convective heat transfer coefficient of 30 W/m^2·K and a back face contact conductance of 100 W/m^2·K, and a real cone test. Note that graphs only include the first 100 seconds because edge burning occurs after this point.
These comparisons show that adjusting the boundary conditions in Gpyro simulations have greatly improved their prediction of cone calorimeter results.

Conclusions

Analysis of the use of pressure solving equations and permeability of solids in Gpyro has shown that these changes alone do not have any significant effect on the simulated pyrolysis of a glass and resin sample. However, by adjusting the contact conductance and convective heat transfer coefficient of a sample, we have been able to produce simulated data much closer to the actual data found in cone test results.

Currently, the most significant shortcoming of these simulations is that the sample is exposed to a single constant incident heat flux. However, in a real cone test, it is exposed to a second heat flux from the flame upon ignition. Future work could develop a method of simulating a secondary delayed flux upon ignition to further improve the accuracy of cone test simulations.
Darcy’s Law Sensitivity Analysis

Darcy’s Law Off

100515-4 Mass Loss Rate vs. Time - Darcy’s Law Off

100515-4 - Temperature Profiles - Darcy’s Law Off
ATH Mass Fraction Profiles - Darcy's Law Off

ATH Residue Mass Fraction Profiles - Darcy's Law Off
100515-4 - Resin to Residue Reaction Rate Profiles - Darcy's Law Off

100515-4 - ATH to ATH Residue Reaction Rate Profiles - Darcy's Law Off
Darcy’s Law On, Pervious Solids (kz = 1E-8 m²)

100515-4 - Mass Loss Rate vs Time - Darcy's Law on, Pervious Solids

100515-4 - Temperature Profiles - Darcy's Law on, Pervious Solids
100515-4 - Resin Residue Mass Fraction Profiles - Darcy's Law on, Pervious Solids

100515-4 - ATH Mass Fraction Profiles - Darcy's Law On, Pervious Solids
Darcy’s Law on, Semi-Pervious Solids ($kz = 1 \times 10^{-13}$ m$^2$)

![Mass Loss Rate](image1)

![Temperature Profiles](image2)
100515-4 - Pressure Profile - Darcy's Law On, Semi-Pervious Solids

100515-4 - Resin Mass Fraction Profiles - Darcy's Law On, Semi-Pervious Solids
100515-4 - ATH to ATH Resin Reaction Rate Profiles - Darcy's Law On, Semi-Pervious Solids

Reaction Rate (kg/m³·s) vs. Depth (m)
Darcy’s Law on, Impervious Solids ($k_z = 1E^{-17} \text{ m}^2$)

100515-4 - Mass Loss Rate vs. Time - Darcy's Law On, Impervious Solids

100515-4 - Temperature Profiles - Darcy's Law On, Impervious Solids
100515-4 - Pressure Profiles - Darcy's Law On, Impervious Solids

100515-4 - Resin Mass Fraction Profiles - Darcy's Law on, Impervious Solids
100515-4 - Resin Residue Mass Fraction Profiles - Darcy's Law On, Impervious Solids

100515-4 - ATH Mass Fraction Profiles - Darcy's Law On, Impervious Solids
100515-4 - ATH Residue Mass Fraction Profiles - Darcy's Law On, Impervious Solids

100515-4 - Resin to Resin Residue Reaction Rate Profiles - Darcy's Law On, Impervious Solids
100515-4 - ATH to ATH Residue Reaction Rate Profiles - Darcy's Law On, Impervious Solids
Top Face Convective Heat Transfer Coefficient Sensitivity Analysis

$H_c = 10 \text{ W/m}^2\text{-K}$
100515-4 - Resin Mass Fraction Profiles - Hc = 10 W/m^2-K

100515-4 - Resin Residue Mass Fraction Profiles - Hc = 10 W/m^2-K
Hc = 30 W/m²-K

100515-4 - Mass Loss Rate vs Time - Hc = 30 W/m²-K

100515-4 - Temperature Profiles - Top Face Hc = 30 W/m²-K
$H_c = 50 \text{ W/m}^2\text{-K}$
100515-4 - Resin Mass Fraction Profiles - Top Face Hc = 50 W/m^2-K

100515-4 - Resin Residue Mass Fraction Profiles - Top Face Hc = 50 W/m^2-K
ATH to ATH Residue Reaction Rate Profiles - Top Face Hc = 50 W/m^2-K
Bottom Face Contact Conductance Sensitivity Analysis

\( H_c = 0 \text{ W/m}^2\text{-K} \)

100515-4 Mass Loss Rate vs. Time - Back Face Hc = 0 W/m\(^2\)K

100515-4 - Temperature Profiles - Back Face Hc = 0 W/m\(^2\)K
100515-4 - Resin Mass Fraction Profiles - Back Face
Hc = 0 W/m²-K

100515-4 - Resin Residue Mass Fraction Profiles - Back Face Hc = 0 W/m²-K
100515-4 - Resin to Residue Reaction Rate Profiles  
- Back Face Hc = 0 W/m^2-K

100515-4 - ATH to ATH Residue Reaction Rate Profiles - Back Face Hc = 0 W/m^2-K
Hc = 50 W/m²-K

100515-4 - Mass Loss Rate vs Time - Bottom Face
Hc = 50 W/m²-K

100515-4 - Temperature Profiles - Back Face Hc = 50 W/m²-K
100515-4 - Resin to Resin Residue Reaction Rate Profiles - Back Face Hc = 50 W/m^2-K

100515-4 - ATH to ATH Residue Reaction Rate Profiles - Back Face Hc = 50 W/m^2-K
Hc = 100 W/m²-K
100515-4 - ATH Mass Fraction Profiles - Back Face
Hc = 100 W/m^2-K

100515-4 - ATH Residue Mass Fraction Profiles - Back Face Hc = 100 W/m^2-K
100515-4 - Resin to Resin Residue Reaction Rate Profiles - Back Face Hc = 100 W/m^2-K

100515-4 - ATH to ATH Residue Reaction Rate Profiles - Back Face Hc = 100 W/m^2-K
\[ H_c = 1000 \text{ W/m}^2\text{-K} \]

100515-4 - Mass Loss Rate vs Time - Back Face Hc = 1000 W/m^2-K

100515-4 - Temperature Profiles - Back Face Hc = 1000 W/m^2-K
100515-4 - Resin Mass Fraction Profiles - Back Face Hc = 1000 W/m^2-K

100515-4 - Resin Residue Profiles - Back Face Hc = 1000 W/m^2-K
Calibrated Boundary Conditions

100515-4 - Mass Loss Rate vs Time - Calibrated Boundary Conditions

100515-4 - Temperature Profiles - Calibrated Boundary Conditions
Darcy’s Law Sensitivity Analysis
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TREF = 300,
P0 = 101300,
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GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIESITERNS = 1,
NCONTINUITYITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOL = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .FALSE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSMODE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
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FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_TSOLID = .FALSE.,
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N_SMOKEVIEW_QUANTITIES = 0,
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DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REDUCED_DTDUMP = 5000,
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DTMIN_KILL = 0.0000001,
POINT_QUANTITY(1) = 'MLR',
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POINT_IMESH(1) = 0,
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POINT_Y(5) = 0,
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PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
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PROFILE_COORD1(4) = 0,
PROFILE_COORD2(4) = 0,
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PROFILE_QUANTITY_INDEX(5) = 1,
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PROFILE_COORD1(5) = 0,
PROFILE_COORD2(5) = 0,
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PROFILE_COORD2(6) = 0,
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PROFILE_IMESH(7) = 0,
PROFILE_COORD1(7) = 0,
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PROFILE_QUANTITY(8) = 'YI',
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PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILE_COORD1(8) = 0,
PROFILE_COORD2(8) = 0,
PROFILE_ISKIP(8) = 1,
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PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILE_COORD1(9) = 0,
PROFILE_COORD2(9) = 0,
PROFILE_ISKIP(9) = 1,
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PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILECOORD1(10) = 0,
PROFILECOORD2(10) = 0,
PROFILEISKIP(10) = 1,
/

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NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 10000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.000000000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 0.000000000000001,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000000000001,
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PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
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NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 0.0000000000001,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,
NKX(4) = 0,
PERMX(4) = 1D-10,
K0Y(4) = 0.2,
NKY(4) = 0,
PERMY(4) = 1D-10,
NAME(5) = 'fireblock',
K0Z(5) = 0.23,
NKZ(5) = 0,
R0(5) = 1200,
NR(5) = 0,
C0(5) = 1400,
NC(5) = 0,
EMIS(5) = 0.84,
KAPPA(5) = 1000000,
TMELT(5) = 3000,
DHMELT(5) = 0,
SIGMA2MELT(5) = 0,
GAMMA(5) = 0.000068,
PERMZ(5) = 0.0000000000001,
RS0(5) = 1100,
PORE_DIAMETER(5) = 0.0005,
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHEMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.0000000000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 0.0000000000001,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(7) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.0000000000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPYRO_RXNS
NRXNS = 3,
CFROM(1) = 'resin',
CTO(1) = 'residue',
Z(1) = 500000000000000,
E(1) = 195,
DHS(1) = 0,
DHV(1) = 172000,
CHI(1) = 1,
ORDER(1) = 1.125,
ORDERO2(1) = 0,
IKINETICMODEL(1) = 0,
IO2TYPE(1) = 0,
M(1) = 0,
KCAT(1) = 0,
ICAT(1) = 0,
CFROM(2) = 'fireblock',
CTO(2) = 'fireblock residue',
Z(2) = 3200000000000000,
E(2) = 183,
DHS(2) = 0,
DHV(2) = 2500000,
CHI(2) = 1.5,
ORDER(2) = 1.3,
ORDERO2(2) = 0,
IKINETICMODEL(2) = 0,
IO2TYPE(2) = 0,
M(2) = 0,
KCAT(2) = 0,
ICAT(2) = 0,
CFROM(3) = 'ATH',
CTO(3) = 'ATH residue',
Z(3) = 250000000000,
E(3) = 140.1,
DHS(3) = 0,
DHV(3) = 1000000,
CHI(3) = 1,
ORDER(3) = 1.24,
ORDERO2(3) = 0,
IKINETICMODEL(3) = 0,
IO2TYPE(3) = 0,
M(3) = 0,
KCAT(3) = 0,
ICAT(3) = 0,
/
&GPYRO_HGRXNS
NHGRXNS = 0,
/
&GPYRO_GPROPS
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate' ,
M(1) = 44 ,
SIGMA(1) = 5.061 ,
EPSOK(1) = 254 ,
C0(1) = 1000 ,
NC(1) = 0 ,
/

&GPyRO_GYIELDS
GYIELDS(1,1) = 1,
GYIELDS(1,2) = 1,
GYIELDS(1,3) = 1,
GYIELDS(1,3) = 1,
/

&GPyRO_HGYIELDS
/

&GPyRO_CASES
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZEROD(1) = .FALSE.,
BETA(1) = 5,
IMESH(2) = 2,
TSTOP(2) = 400,
ZEROD(2) = .FALSE.,
BETA(2) = 10,
&GA_GENINPUT NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXPONENT = 2,
WHOLEGENEFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/ &GPYRO_IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YJO(1,1) = 1,
TMP_INITIAL(2) = 300,
TMPG_INITIAL(2) = 300,
P_INITIAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJO(2,1) = 1,
/

&GPYRO_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,
QE(1) = 78000,
HC(1) = 10,
NHC(1) = 0,
TINF(1) = 300,
RERADIATION(1) = .TRUE.,
TFIXED(1) = -1,
MDOTPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 0,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .FALSE.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,
/

&GPyro_Geom
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
NCELLY(1) = 1,
GEOMETRY_FILE(1) = 'null',
DEFAULT_SURF_IDX(1,1) = 0,
DEFAULT_SURF_IDX(1,2) = 0,
DEFAULT_SURF_IDX(1,3) = 0,
DEFAULT_SURF_IDX(1,4) = 0,
DEFAULT_SURF_IDX(1,5) = 1,
DEFAULT_SURF_IDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/

&GA_PHI
NPHI = 0,
/

&GA_VARS
NGENE = 0,
/
Darcy’s Law On, Pervious Solids

&GPYRO_GENERAL
DT0 = 0.1,
TAMB = 300,
TREF = 300,
P0 = 101300,
GX = 0,
GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIESITERNS = 1,
NCONTINUITYITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOL = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .TRUE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSMODE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DH VOL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_TSOLID = .FALSE.,
/

&GPYRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 11,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REduced_DTDump = 5000,
REDUCED_DTDUMP = 0.0001,
DTMIN_KILL = 0.0000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILE_COORD1(1) = 0,
PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE_IMESH(2) = 0,
PROFILE_COORD1(2) = 0,
PROFILE_COORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE_IMESH(3) = 0,
PROFILE_COORD1(3) = 0,
PROFILE_COORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE_IMESH(4) = 0,
PROFILE_COORD1(4) = 0,
PROFILE_COORD2(4) = 0,
PROFILE_ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'YI',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE_IMESH(5) = 0,
PROFILE_COORD1(5) = 0,
PROFILE_COORD2(5) = 0,
PROFILE_ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'YI',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILE_COORD1(6) = 0,
PROFILE_COORD2(6) = 0,
PROFILE_ISKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILE_COORD1(7) = 0,
PROFILE_COORD2(7) = 0,
PROFILE_ISKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILE_COORD1(8) = 0,
PROFILE_COORD2(8) = 0,
PROFILE_ISKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILE_COORD1(9) = 0,
PROFILE_COORD2(9) = 0,
PROFILE_ISKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILE_COORD1(10) = 0,
PROFILE_COORD2(10) = 0,
PROFILE_ISKIP(10) = 1,
PROFILE_QUANTITY(11) = 'PRESSURE',
PROFILE_QUANTITY_INDEX(11) = 0,
PROFILE_DIRECTION(11) = 'z',
PROFILE_IMESH(11) = 0,
PROFILE_COORD1(11) = 0,
PROFILE_COORD2(11) = 0,
PROFILE_ISKIP(11) = 1,
/

&GPYRO_SPROPS
NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.00000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 0.00000001,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000001,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000, 
DHMELT(4) = 0, 
SIGMA2MELT(4) = 0, 
GAMMA(4) = 0.00769, 
PERMZ(4) = 0.00000001, 
RS0(4) = 1100, 
PORE_DIAMETER(4) = 0.0005, 
K0X(4) = 0.2, 
NKX(4) = 0, 
PERMXX(4) = 1D-10, 
K0Y(4) = 0.2, 
NKY(4) = 0, 
PERMY(4) = 1D-10, 
NAME(5) = 'fireblock', 
K0Z(5) = 0.23, 
NKZ(5) = 0, 
R0(5) = 1200, 
NR(5) = 0, 
C0(5) = 1400, 
NC(5) = 0, 
EMIS(5) = 0.84, 
KAPPA(5) = 1000000, 
TMELT(5) = 3000, 
DHMELT(5) = 0, 
SIGMA2MELT(5) = 0, 
GAMMA(5) = 0.000068, 
PERMZ(5) = 0.00000001, 
RS0(5) = 1100, 
PORE_DIAMETER(5) = 0.0005, 
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.00000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 0.00000001,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(8) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.00000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPyRO_RXNS
NRXNS = 3,
CFROM(1) = 'resin',
CTO(1) = 'residue',
Z(1) = 5000000000000000,
E(1) = 195,
DHS(1) = 0,
DHV(1) = 172000,
CHI(1) = 1,
ORDER(1) = 1.125,
ORDERO2(1) = 0,
IKINETICMODEL(1) = 0,
IO2TYPE(1) = 0,
M(1) = 0,
KCAT(1) = 0,
ICAT(1) = 0,
CFROM(2) = 'fireblock',
CTO(2) = 'fireblock residue' ,
Z(2) = 3200000000000 ,
E(2) = 183 ,
DHS(2) = 0 ,
DHV(2) = 2500000 ,
CHI(2) = 1.5 ,
ORDER(2) = 1.3 ,
ORDERO2(2) = 0 ,
IKINETICMODEL(2) = 0 ,
IO2TYPE(2) = 0 ,
M(2) = 0 ,
KCAT(2) = 0 ,
ICAT(2) = 0 ,
CFROM(3) = 'ATH' ,
CTO(3) = 'ATH residue' ,
Z(3) = 2500000000000 ,
E(3) = 140.1 ,
DHS(3) = 0 ,
DHV(3) = 1000000 ,
CHI(3) = 1 ,
ORDER(3) = 1.24 ,
ORDERO2(3) = 0 ,
IKINETICMODEL(3) = 0 ,
IO2TYPE(3) = 0 ,
M(3) = 0 ,
KCAT(3) = 0 ,
ICAT(3) = 0 ,
/

&GPYRO_HGRXNS
NHGRXNS = 0,
/

&GPyRO_GPROPS
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44,
SIGMA(1) = 5.061,
EPSOK(1) = 254,
C0(1) = 1000,
NC(1) = 0,
/

&GPyRO_GYIELDS
GYIELDS(1,1) = 1,
GYIELDS(1,2) = 1,
GYIELDS(1,3) = 1,

&GPyRO_HGYIELDS
/

&GPyRO_CASES
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZEROD(1) = .FALSE.,
BETA(1) = 5,
IMESH(2) = 2,
TSTOP(2) = 400,
ZEROD(2) = .FALSE.,
BETA(2) = 10,
/

&GA_GENINPUT NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXPONENT = 2,
WHOLEGENEFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&G PYRO_IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YJ0(1,1) = 1,
TMP_INITIAL(2) = 300,
TMPG_INITIAL(2) = 300,
P_INITIAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJ0(2,1) = 1,
/

&GPYRO_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,
QE(1) = 78000,
HC(1) = 10,
NHC(1) = 0,
TINF(1) = 300,
RERADIATION(1) = .TRUE.,
TFIXED(1) = -1,
MDOTPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 0,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .FALSE.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,
/

&GPyro_GEOM
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
GEOMETRY_FILE(1) = 'null',
DEFAULT_SURF_IDX(1,1) = 0,
DEFAULT_SURF_IDX(1,2) = 0,
DEFAULT_SURF_IDX(1,3) = 0,
DEFAULT_SURF_IDX(1,4) = 0,
DEFAULT_SURF_IDX(1,5) = 1,
DEFAULT_SURF_IDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/

&GA_PHI
NPHI = 0,
/

&GA_VARS
NGENE = 0,
/
Darcy’s Law On, Semi-Pervious Solids

&GPYRO_GENERAL
DT0 = 0.1,
TAMB = 300,
TREF = 300,
P0 = 101300,
GX = 0,
GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIESITERNS = 1,
NCONTINUITYITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOL = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .TRUE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSTYPE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DH VOL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_T SOLID = .FALSE.,
/

&GPYRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 11,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REduced_DT DUMP = 5000,
REDUCED_DT DUMP = 0.0001,
DTMIN_KILL = 0.00000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILE_COORD1(1) = 0,
PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE_IMESH(2) = 0,
PROFILECOORD1(2) = 0,
PROFILECOORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE_IMESH(3) = 0,
PROFILECOORD1(3) = 0,
PROFILECOORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE_IMESH(4) = 0,
PROFILECOORD1(4) = 0,
PROFILECOORD2(4) = 0,
PROFILE_ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'YI',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE_IMESH(5) = 0,
PROFILECOORD1(5) = 0,
PROFILECOORD2(5) = 0,
PROFILE_ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'YI',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILE_COORD1(6) = 0,
PROFILE_COORD2(6) = 0,
PROFILE_ISKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILE_COORD1(7) = 0,
PROFILE_COORD2(7) = 0,
PROFILE_ISKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILE_COORD1(8) = 0,
PROFILE_COORD2(8) = 0,
PROFILE_ISKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILE_COORD1(9) = 0,
PROFILE_COORD2(9) = 0,
PROFILE_ISKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE.IMESH(10) = 0,
PROFILE.COORD1(10) = 0,
PROFILE.COORD2(10) = 0,
PROFILE.ISKIP(10) = 1,
PROFILE.QUANTITY(11) = 'PRESSURE',
PROFILE.QUANTITY_INDEX(11) = 0,
PROFILE.DIRECTION(11) = 'z',
PROFILE.IMESH(11) = 0,
PROFILE.COORD1(11) = 0,
PROFILE.COORD2(11) = 0,
PROFILE.ISKIP(11) = 1,
/

&GPyro_SProps
NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.0000000000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 0.000000000000001,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000000000001,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 0.0000000000001,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,
NKX(4) = 0,
PERMX(4) = 1D-10,
K0Y(4) = 0.2,
NKY(4) = 0,
PERMY(4) = 1D-10,
NAME(5) = 'fireblock',
K0Z(5) = 0.23,
NKZ(5) = 0,
R0(5) = 1200,
NR(5) = 0,
C0(5) = 1400,
NC(5) = 0,
EMIS(5) = 0.84,
KAPPA(5) = 1000000,
TMELT(5) = 3000,
DHMELT(5) = 0,
SIGMA2MELT(5) = 0,
GAMMA(5) = 0.000068,
PERMZ(5) = 0.0000000000001,
RS0(5) = 1100,
PORE_DIAMETER(5) = 0.0005,
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.0000000000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
\[\begin{align*}
R0(7) &= 2300, \\
NR(7) &= 0, \\
C0(7) &= 1200, \\
NC(7) &= 0, \\
EMIS(7) &= 0.81, \\
KAPPA(7) &= 1000000, \\
TMELT(7) &= 3000, \\
DHMELT(7) &= 0, \\
SIGMA2MELT(7) &= 0, \\
GAMMA(7) &= 0, \\
PERMZ(7) &= 0.0000000000001, \\
RS0(7) &= 1100, \\
PORE\_DIAMETER(7) &= 0.0005, \\
K0X(7) &= 0.2, \\
NKX(7) &= 0, \\
PERMX(7) &= 1D-10, \\
K0Y(7) &= 0.2, \\
NKY(7) &= 0, \\
PERMY(7) &= 1D-10, \\
NAME(8) &= 'ATH residue', \\
K0Z(8) &= 0.24, \\
NKZ(8) &= 0, \\
R0(8) &= 1558, \\
NR(8) &= 0, \\
C0(8) &= 1200, \\
NC(8) &= 0, \\
EMIS(8) &= 0.89, \\
KAPPA(8) &= 1000000, \\
TMELT(8) &= 3000, \\
DHMELT(8) &= 0.
\end{align*}\]
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.0000000000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPyro_rxns
NRXNS = 3,
CFROM(1) = 'resin',
CTO(1) = 'residue',
Z(1) = 500000000000000,
E(1) = 195,
DHS(1) = 0,
DHV(1) = 172000,
CHI(1) = 1,
ORDER(1) = 1.125,
ORDERO2(1) = 0,
IKINETICMODEL(1) = 0,
IO2TYPE(1) = 0,
M(1) = 0,
KCAT(1) = 0,
ICAT(1) = 0,
CFROM(2) = 'fireblock',
CTO(2) = 'fireblock residue',
Z(2) = 3200000000000,
E(2) = 183,
DHS(2) = 0,
DHV(2) = 2500000,
CHI(2) = 1.5,
ORDER(2) = 1.3,
ORDERO2(2) = 0,
IKINETICMODEL(2) = 0,
IO2TYPE(2) = 0,
M(2) = 0,
KCAT(2) = 0,
ICAT(2) = 0,
CFROM(3) = 'ATH',
CTO(3) = 'ATH residue',
Z(3) = 2500000000000,
E(3) = 140.1,
DHS(3) = 0,
DHV(3) = 1000000,
CHI(3) = 1,
ORDER(3) = 1.24,
ORDERO2(3) = 0,
IKINETICMODEL(3) = 0,
IO2TYPE(3) = 0,
M(3) = 0,
KCAT(3) = 0,
ICAT(3) = 0,
/

&GPYRO_HGRXNS
NHGRXNS = 0,
/

&GPyro_GProps
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44,
SIGMA(1) = 5.061,
EPSOK(1) = 254,
C0(1) = 1000,
NC(1) = 0,
/

&GPyro_GYields
GYIELDS(1,1) = 1,
GYIELDS(1,2) = 1,
GYIELDS(1,3) = 1,
/

&GPyro_HYields
/

&GPyro_Cases
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZEROD(1) = .FALSE.,
BETA(1) = 5,
IMESH(2) = 2,
TSTOP(2) = 400,
ZEROD(2) = .FALSE.,
BETA(2) = 10,
/

&GA_GENINPUT NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXPO = 2,
WHOLEGENEFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&GPYRO_IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YJ0(1,1) = 1,
TMP_INITIAL(2) = 300,
TMPG_INITIAL(2) = 300,
P_INITIAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJ0(2,1) = 1,
/

&GPyro_allbc
NSURF_idx = 2,
SURF_idx(1) = 1,
T(1) = 0,
QE(1) = 78000,
HC(1) = 10,
NHC(1) = 0,
TINF(1) = 300,
Reradiation(1) = .true.,
TFixed(1) = -1,
MDotPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 0,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .false.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,
/

&GPyRO_GEOM
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
GEOMETRY_FILE(1) = 'null',
DEFAULT_SURFIDX(1,1) = 0,
DEFAULT_SURFIDX(1,2) = 0,
DEFAULT_SURFIDX(1,3) = 0,
DEFAULT_SURFIDX(1,4) = 0,
DEFAULT_SURFIDX(1,5) = 1,
DEFAULT_SURFIDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/

&GA_PHI
NPHI = 0,
/

&GA_VARS
NGENE = 0,
/

Darcy’s Law On, Impervious Solids

&GPyro_General
DT0 = 0.1,
TAMB = 300,
TREF = 300,
P0 = 101300,
GX = 0,
GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIES ITERNS = 1,
NCONTINUITY ITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOL = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .TRUE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSMODE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DHVL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_TSOlid = .FALSE.,
/

&GPYRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 11,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REDUCED_DTDUMP = 5000,
REDUCED_DTDUMP = 0.0001,
DTMIN_KILL = 0.0000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILE_COORD1(1) = 0,
PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE_IMESH(2) = 0,
PROFILE_COORD1(2) = 0,
PROFILE_COORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE_IMESH(3) = 0,
PROFILE_COORD1(3) = 0,
PROFILE_COORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE_IMESH(4) = 0,
PROFILE_COORD1(4) = 0,
PROFILE_COORD2(4) = 0,
PROFILE_ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'YI',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE_IMESH(5) = 0,
PROFILE_COORD1(5) = 0,
PROFILE_COORD2(5) = 0,
PROFILE_ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'YI',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILECOORD1(6) = 0,
PROFILECOORD2(6) = 0,
PROFILE_SKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILECOORD1(7) = 0,
PROFILECOORD2(7) = 0,
PROFILE_SKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILECOORD1(8) = 0,
PROFILECOORD2(8) = 0,
PROFILE_SKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILECOORD1(9) = 0,
PROFILECOORD2(9) = 0,
PROFILE_SKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILE_COORD1(10) = 0,
PROFILE_COORD2(10) = 0,
PROFILE_ISKIP(10) = 1,
PROFILE_QUANTITY(11) = 'PRESSURE',
PROFILE_QUANTITY_INDEX(11) = 0,
PROFILE_DIRECTION(11) = 'z',
PROFILE_IMESH(11) = 0,
PROFILE_COORD1(11) = 0,
PROFILE_COORD2(11) = 0,
PROFILE_ISKIP(11) = 1,
/

&GPYRO_SPROPS
NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 1E-17,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 1E-17,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 1E-17,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 1E-17,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,
NKX(4) = 0,
PERMX(4) = 1D-10,
K0Y(4) = 0.2,
NKY(4) = 0,
PERMY(4) = 1D-10,
NAME(5) = 'fireblock',
K0Z(5) = 0.23,
NKZ(5) = 0,
R0(5) = 1200,
NR(5) = 0,
C0(5) = 1400,
NC(5) = 0,
EMIS(5) = 0.84,
KAPPA(5) = 1000000,
TMELT(5) = 3000,
DHMELT(5) = 0,
SIGMA2MELT(5) = 0,
GAMMA(5) = 0.000068,
PERMZ(5) = 1E-17,
RS0(5) = 1100,
PORE_DIAMETER(5) = 0.0005,
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 1E-17,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 1E-17,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(8) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 1E-17,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPYRO_RXNS
NRXNS = 3,
CFROM(1) = 'resin',
CTO(1) = 'residue',
Z(1) = 50000000000000 ,
E(1) = 195 ,
DHS(1) = 0 ,
DHV(1) = 172000 ,
CHI(1) = 1 ,
ORDER(1) = 1.125 ,
ORDERO2(1) = 0 ,
IKINETICMODEL(1) = 0 ,
IO2TYPE(1) = 0 ,
M(1) = 0 ,
KCAT(1) = 0 ,
ICAT(1) = 0 ,
CFROM(2) = 'fireblock',

CTO(2) = 'fireblock residue',
Z(2) = 3200000000000 ,
E(2) = 183 ,
DHS(2) = 0 ,
DHV(2) = 2500000 ,
CHI(2) = 1.5 ,
ORDER(2) = 1.3 ,
ORDERO2(2) = 0 ,
IKINETICMODEL(2) = 0 ,
IO2TYPE(2) = 0 ,
M(2) = 0 ,
KCAT(2) = 0 ,
ICAT(2) = 0 ,
CFROM(3) = 'ATH' ,
CTO(3) = 'ATH residue' ,
Z(3) = 25000000000000 ,
E(3) = 140.1 ,
DHS(3) = 0 ,
DHV(3) = 1000000 ,
CHI(3) = 1 ,
ORDER(3) = 1.24 ,
ORDERO2(3) = 0 ,
IKINETICMODEL(3) = 0 ,
IO2TYPE(3) = 0 ,
M(3) = 0 ,
KCAT(3) = 0 ,
ICAT(3) = 0 ,
/ 

&GPyro_HGRXNS
NHGRXNS = 0,
/

&GPyro_GProps
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44,
SIGMA(1) = 5.061,
EPSOK(1) = 254,
C0(1) = 1000,
NC(1) = 0,
/

&GPyro_GYields
GYIELDS(1,1) = 1,
GYIELDS(1,2) = 1,
GYIELDS(1,3) = 1,
/

&GPyro_HGyields
/

&GPyro_Cases
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZEROD(1) = .FALSE.,
BETA(1) = 5,
IMESH(2) = 2,
TSTOP(2) = 400,
ZEROD(2) = .FALSE.,
BETA(2) = 10,

&GA_GENINPUT NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXPONENT = 2,
WHOLEGENEFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&GPYRO_IC
NIC = 2,
TMP_INITAL(1) = 300,
TMPG_INITAL(1) = 300,
P_INITAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YI0(1,9) = 1,
TMP_INITAL(2) = 300,
TMPG_INITAL(2) = 300,
P_INITAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJ0(2,1) = 1,
/

&GPyRo_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,
QE(1) = 78000,
HC(1) = 10,
NHC(1) = 0,
TINF(1) = 300,
RERADIATION(1) = .TRUE.,
TFIXED(1) = -1,
MDOTPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 0,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .FALSE.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,
/

&GPYRO_GEOM
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
GEOMETRY_FILE(1) = 'null',
DEFAULT_SURF_IDX(1,1) = 0,
DEFAULT_SURF_IDX(1,2) = 0,
DEFAULT_SURF_IDX(1,3) = 0,
DEFAULT_SURF_IDX(1,4) = 0,
DEFAULT_SURF_IDX(1,5) = 1,
DEFAULT_SURF_IDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/

&GA_PHI
NPHI = 0,
/

&GA_VARS
NGENE = 0,
/

Convective Heat Transfer Coefficient Sensitivity Analysis

\[ H_c = 10 \text{ W/m}^2\cdot\text{K} \]

\&GPYRO_GENERAL

DT0 = 0.1,
TAMB = 300,
TREF = 300,
P0 = 101300,
GX = 0,
GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIESITERNS = 1,
NCONTINUITYITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOT = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .FALSE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSMODE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DHVOL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_TSOLID = .FALSE.,
/

&GPYRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 10,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REduced_DTDUMP = 5000,
REDUCED_DTDUMP = 0.0001,
DTMIN_KILL = 0.0000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILE_COORD1(1) = 0,
PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE_IMESH(2) = 0,
PROFILECOORD1(2) = 0,
PROFILECOORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE_IMESH(3) = 0,
PROFILECOORD1(3) = 0,
PROFILECOORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE_IMESH(4) = 0,
PROFILECOORD1(4) = 0,
PROFILECOORD2(4) = 0,
PROFILE_ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'YI',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE_IMESH(5) = 0,
PROFILECOORD1(5) = 0,
PROFILECOORD2(5) = 0,
PROFILE_ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'YI',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILE_COORD1(6) = 0,
PROFILE_COORD2(6) = 0,
PROFILE_ISKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILE_COORD1(7) = 0,
PROFILE_COORD2(7) = 0,
PROFILE_ISKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILE_COORD1(8) = 0,
PROFILE_COORD2(8) = 0,
PROFILE_ISKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILE_COORD1(9) = 0,
PROFILE_COORD2(9) = 0,
PROFILE_ISKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILE_COORD1(10) = 0,
PROFILE_COORD2(10) = 0,
PROFILE_ISKIP(10) = 1,
/

&GPyro_Sprops
NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.0000000000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0, PERMY(1) = 1D-10, NAME(2) = 'residue', K0Z(2) = 0.19, NKZ(2) = 0, R0(2) = 253, NR(2) = 0, C0(2) = 1900, NC(2) = 0, EMIS(2) = 0.9, KAPPA(2) = 1000000, TMELT(2) = 3000, DHMELT(2) = 0, SIGMA2MELT(2) = 0, GAMMA(2) = 0.00348, PERMZ(2) = 0.0000000000001, RS0(2) = 1100, PORE_DIAMETER(2) = 0.0005, K0X(2) = 0.2, NKX(2) = 0, PERMX(2) = 1D-10, K0Y(2) = 0.2, NKY(2) = 0, PERMY(2) = 1D-10, NAME(3) = 'glass', K0Z(3) = 0.18, NKZ(3) = 0, R0(3) = 2600, NR(3) = 0, C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000000000000001,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 0.0000000000001,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,
NKX(4) = 0,
PERMX(4) = 1D-10,
K0Y(4) = 0.2,
NKY(4) = 0,
PERMY(4) = 1D-10,
NAME(5) = 'fireblock',
K0Z(5) = 0.23,
NKZ(5) = 0,
R0(5) = 1200,
NR(5) = 0,
C0(5) = 1400,
NC(5) = 0,
EMIS(5) = 0.84,
KAPPA(5) = 1000000,
TMELT(5) = 3000,
DHMELT(5) = 0,
SIGMA2MELT(5) = 0,
GAMMA(5) = 0.000068,
PERMZ(5) = 0.0000000000001,
RS0(5) = 1100,
PORE_DIAMETER(5) = 0.0005,
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.0000000000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 0.0000000000001,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(8) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.0000000000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPyro_RXNS
NRXNS = 3,
CFROM(1) = 'resin',
CTO(1) = 'residue',
Z(1) = 5000000000000000,
E(1) = 195,
DHS(1) = 0,
DHV(1) = 172000,
CHI(1) = 1,
ORDER(1) = 1.125,
ORDERO2(1) = 0,
IKINETICMODEL(1) = 0,
IO2TYPE(1) = 0,
M(1) = 0,
KCAT(1) = 0,
ICAT(1) = 0,
CFROM(2) = 'fireblock',
CTO(2) = 'fireblock residue',
Z(2) = 3200000000000000,
E(2) = 183,
DHS(2) = 0,
DHV(2) = 2500000,
CHI(2) = 1.5,
ORDER(2) = 1.3,
ORDERO2(2) = 0,
IKINETICMODEL(2) = 0,
IO2TYPE(2) = 0,
M(2) = 0,
KCAT(2) = 0,
ICAT(2) = 0,
CFROM(3) = 'ATH',
CTO(3) = 'ATH residue',
Z(3) = 250000000000,
E(3) = 140.1,
DHS(3) = 0,
DHV(3) = 1000000,
CHI(3) = 1,
ORDER(3) = 1.24,
ORDERO2(3) = 0,
IKINETICMODEL(3) = 0,
IO2TYPE(3) = 0,
M(3) = 0,
KCAT(3) = 0,
ICAT(3) = 0,
/

&GPYRO_HGRXNS
NHGRXNS = 0,
/

&GPYRO_GPROPS
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44,
SIGMA(1) = 5.061,
EPSOK(1) = 254,
C0(1) = 1000,
NC(1) = 0,
/

&G PYRO_GYIELDS
GYIELDS(1,1) = 1,
GYIELDS(1,2) = 1,
GYIELDS(1,3) = 1,
GYIELDS(1,3) = 1,
/

&G PYRO_HGYIELDS
/

&G PYRO_CASES
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZEROD(1) = .FALSE.,
BETA(1) = 5,
IMESH(2) = 2,
TSTOP(2) = 400,
ZEROD(2) = .FALSE.,
BETA(2) = 10,
&GA_GENINPUT NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXponent = 2,
WHOLEGENEFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&GPyro_IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YJ0(1,1) = 1,
TMP_INITIAL(2) = 300,
TMPG_INITIAL(2) = 300,
P_INITIAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJ0(2,1) = 1,
/

&GPyro_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,
QE(1) = 78000,
HC(1) = 10,
NHC(1) = 0,
TINF(1) = 300,
RERADIATION(1) = .TRUE.,
TFIXED(1) = -1,
MDOTPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 0,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .FALSE.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,
/

&GPyRO_GEOM
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
NCELLY(1) = 1,
GEOMETRY_FILE(1) = 'null',
DEFAULT_SURF_IDX(1,1) = 0,
DEFAULT_SURF_IDX(1,2) = 0,
DEFAULT_SURF_IDX(1,3) = 0,
DEFAULT_SURF_IDX(1,4) = 0,
DEFAULT_SURF_IDX(1,5) = 1,
DEFAULT_SURF_IDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/

&GA_PHI
NPHI = 0,
/

&GA_VARS
NGENE = 0,
/
Hc = 30 W/m²-K

&GPyro_General
DT0 = 0.1,
TAMB = 300,
TREF = 300,
P0 = 101300,
GX = 0,
GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIESITERNS = 1,
NCONTINUITYITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOL = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .FALSE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSTYPE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DHVOL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_TSOLID = .FALSE.,

/&GPYRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 10,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REDUCEDDTDUMP = 5000,
REDUCEDDTDUMP = 0.0001,
DTMIN_KILL = 0.00000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILE_COORD1(1) = 0,
PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE_IMESH(2) = 0,
PROFILE_COORD1(2) = 0,
PROFILE_COORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE_IMESH(3) = 0,
PROFILE_COORD1(3) = 0,
PROFILE_COORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE_IMESH(4) = 0,
PROFILE_COORD1(4) = 0,
PROFILE_COORD2(4) = 0,
PROFILE_ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'YI',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE_IMESH(5) = 0,
PROFILE_COORD1(5) = 0,
PROFILE_COORD2(5) = 0,
PROFILE_ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'YI',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILECOORD1(6) = 0,
PROFILECOORD2(6) = 0,
PROFILE_SKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILECOORD1(7) = 0,
PROFILECOORD2(7) = 0,
PROFILE_SKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILECOORD1(8) = 0,
PROFILECOORD2(8) = 0,
PROFILE_SKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILECOORD1(9) = 0,
PROFILECOORD2(9) = 0,
PROFILE_SKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILECOORD1(10) = 0,
PROFILECOORD2(10) = 0,
PROFILEISKIP(10) = 1,
/

&GYPyro_Sprops
NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.0000000000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 0.0000000000001,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000000000001,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 0.0000000000001,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,
NKX(4) = 0,
PERMX(4) = 1D-10,
K0Y(4) = 0.2,
NKY(4) = 0,
PERMY(4) = 1D-10,
NAME(5) = 'fireblock',
K0Z(5) = 0.23,
NKZ(5) = 0,
R0(5) = 1200,
NR(5) = 0,
C0(5) = 1400,
NC(5) = 0,
EMIS(5) = 0.84,
KAPPA(5) = 1000000,
TMELT(5) = 3000,
DHMELT(5) = 0,
SIGMA2MELT(5) = 0,
GAMMA(5) = 0.000068,
PERMZ(5) = 0.0000000000001,
RS0(5) = 1100,
PORE_DIAMETER(5) = 0.0005,
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.0000000000000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 0.0000000000001,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(8) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.0000000000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPyRO_RXNS
NRXNS = 3,
CFROM(1) = 'resin',
CTO(1) = 'residue',
Z(1) = 50000000000000000000,
E(1) = 195,
DHS(1) = 0,
DHV(1) = 172000,
CHI(1) = 1,
ORDER(1) = 1.125,
ORDERO2(1) = 0,
IKINETICMODEL(1) = 0,
IO2TYPE(1) = 0,
M(1) = 0,
KCAT(1) = 0,
ICAT(1) = 0,
CFROM(2) = 'fireblock',
CTO(2) = 'fireblock residue',
Z(2) = 32000000000000000000,
E(2) = 183,
DHS(2) = 0,
DHV(2) = 2500000,
CHI(2) = 1.5,
ORDER(2) = 1.3,
ORDERO2(2) = 0,
IKINETICMODEL(2) = 0,
IO2TYPE(2) = 0,
M(2) = 0,
KCAT(2) = 0,
ICAT(2) = 0,
CFROM(3) = 'ATH',
CTO(3) = 'ATH residue',
Z(3) = 25000000000000,
E(3) = 140.1,
DHS(3) = 0,
DHV(3) = 1000000,
CHI(3) = 1,
ORDER(3) = 1.24,
ORDERO2(3) = 0,
IKINETICMODEL(3) = 0,
IO2TYPE(3) = 0,
M(3) = 0,
KCAT(3) = 0,
ICAT(3) = 0,
/

&GPYRO_HGRXNS
NHGRXNS = 0,
/

&GPYRO_GPROPS
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44,
SIGMA(1) = 5.061,
EPSOK(1) = 254,
C0(1) = 1000,
NC(1) = 0,
/

&GPYRO_GYIELD
GYIELD(1,1) = 1,
GYIELD(1,2) = 1,
GYIELD(1,3) = 1,
/

&GPYRO_HGYIELD
/

&GPYRO_CASES
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZEROD(1) = .FALSE.,
BETA(1) = 5,
IMESH(2) = 2,
TSTOP(2) = 400,
ZEROD(2) = .FALSE.,
BETA(2) = 10,
/
&GA_GENINPUT
NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXponent = 2,
WHOLEGENEFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&GPyRO_IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YJO(1,1) = 1,
TMP_INITIAL(2) = 300,
TMPG_INITIAL(2) = 300,
P_INITIAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJO(2,1) = 1,
/

&GPYRO_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,
QE(1) = 78000,
HC(1) = 30,
NHC(1) = 0,
TINF(1) = 300,
RERADIATION(1) = .TRUE.,
TFIXED(1) = -1,
MDOTPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 0,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .FALSE.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,
/

&GPYRO_GEOM
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
DEFAULT_SURF_IDX(1,1) = 0,
DEFAULT_SURF_IDX(1,2) = 0,
DEFAULT_SURF_IDX(1,3) = 0,
DEFAULT_SURF_IDX(1,4) = 0,
DEFAULT_SURF_IDX(1,5) = 1,
DEFAULT_SURF_IDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/

&GA_PHI
NPHI = 0,
/

&GA_VARS
NGENE = 0,
/
\[ H_c = 50 \text{ W/m}^2\cdot\text{K} \]

&GPyro_General

DT0 = 0.1,
TAMB = 300,
TREF = 300,
P0 = 101300,
GX = 0,
GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIESITERNS = 1,
NCONTINUITYITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOL = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .FALSE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSMODE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DHVOL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_TSOLID = .FALSE.,
/

&GPYRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 10,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REDUCED_DTDUMP = 5000,
REDUCED_DTDUMP = 0.0001,
DTMIN_KILL = 0.0000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILE_COORD1(1) = 0,
PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE_IMESH(2) = 0,
PROFILE_COORD1(2) = 0,
PROFILE_COORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE_IMESH(3) = 0,
PROFILE_COORD1(3) = 0,
PROFILE_COORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE_IMESH(4) = 0,
PROFILE_COORD1(4) = 0,
PROFILE_COORD2(4) = 0,
PROFILE_ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'YI',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE_IMESH(5) = 0,
PROFILE_COORD1(5) = 0,
PROFILE_COORD2(5) = 0,
PROFILE_ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'YI',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILECOORD1(6) = 0,
PROFILECOORD2(6) = 0,
PROFILESKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILECOORD1(7) = 0,
PROFILECOORD2(7) = 0,
PROFILESKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILECOORD1(8) = 0,
PROFILECOORD2(8) = 0,
PROFILESKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILECOORD1(9) = 0,
PROFILECOORD2(9) = 0,
PROFILESKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILE_COORD1(10) = 0,
PROFILE_COORD2(10) = 0,
PROFILE_ISKIP(10) = 1,
/

&GPyro_Sprops
NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
Kappa(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.0000000000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 0.0000000000001,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000000000001,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 0.0000000000001,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,  
NKX(4) = 0,  
PERMX(4) = 1D-10,  
K0Y(4) = 0.2,  
NKY(4) = 0,  
PERMY(4) = 1D-10,  
NAME(5) = 'fireblock',  
K0Z(5) = 0.23,  
NKZ(5) = 0,  
R0(5) = 1200,  
NR(5) = 0,  
C0(5) = 1400,  
NC(5) = 0,  
EMIS(5) = 0.84,  
KAPPA(5) = 1000000,  
TMELT(5) = 3000,  
DHMELT(5) = 0,  
SIGMA2MELT(5) = 0,  
GAMMA(5) = 0.000068,  
PERMZ(5) = 0.000000000001,  
RS0(5) = 1100,  
PORE_DIAMETER(5) = 0.0005,  
K0X(5) = 0.2,  
NKX(5) = 0,  
PERMX(5) = 1D-10,  
K0Y(5) = 0.2,  
NKY(5) = 0,  
PERMY(5) = 1D-10,  
NAME(6) = 'fireblock residue',  
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.0000000000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 0.0000000000001,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(8) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.0000000000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPYRO_RXNS
NRXNS = 3,
CFROM(1) = 'resin',
CTO(1) = 'residue',
Z(1) = 50000000000000 ,
E(1) = 195 ,
DHS(1) = 0 ,
DHV(1) = 172000 ,
CHI(1) = 1 ,
ORDER(1) = 1.125 ,
ORDERO2(1) = 0 ,
IKINETICMODEL(1) = 0 ,
IO2TYPE(1) = 0 ,
M(1) = 0 ,
KCAT(1) = 0 ,
ICAT(1) = 0 ,
CFROM(2) = 'fireblock',
CTO(2) = 'fireblock residue',
Z(2) = 3200000000000 ,
E(2) = 183 ,
DHS(2) = 0 ,
DHV(2) = 2500000 ,
CHI(2) = 1.5 ,
ORDER(2) = 1.3 ,
ORDERO2(2) = 0,
IKINETICMODEL(2) = 0,
IO2TYPE(2) = 0,
M(2) = 0,
KCAT(2) = 0,
ICAT(2) = 0,
CFROM(3) = 'ATH',
CTO(3) = 'ATH residue',
Z(3) = 250000000000,
E(3) = 140.1,
DHS(3) = 0,
DHV(3) = 1000000,
CHI(3) = 1,
ORDER(3) = 1.24,
ORDERO2(3) = 0,
IKINETICMODEL(3) = 0,
IO2TYPE(3) = 0,
M(3) = 0,
KCAT(3) = 0,
ICAT(3) = 0,
/

&GPYRO_HGRXNS
NHGRXNS = 0,
/

&GPYRO_GPROPS
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44,
SIGMA(1) = 5.061,
EPSOK(1) = 254,
C0(1) = 1000,
NC(1) = 0,
/

&GPYRO_GYIELDs
GYIELDs(1,1) = 1,
GYIELDs(1,2) = 1,
GYIELDs(1,3) = 1,
/

&GPYRO_HGYIELDs
/

&GPYRO_CASES
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZEROD(1) = .FALSE.,
BETA(1) = 5,
IMESH(2) = 2,
TSTOP(2) = 400,
ZEROD(2) = .FALSE.,
BETA(2) = 10,
/
&GA_GENINPUT NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXPONENT = 2,
WHOLEGENEFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&GPYRO_IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YJ0(1,1) = 1,
TMP_INITIAL(2) = 300,
TMPG_INITIAL(2) = 300,
P_INITIAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJ0(2,1) = 1,
/

&GPYRO_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,
QE(1) = 78000,
HC(1) = 50,
NHC(1) = 0,
TINF(1) = 300,
RERADIATION(1) = .TRUE.,
TFIXED(1) = -1,
MDOTPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 0,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .FALSE.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,
/

&GPyro_Geom
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
GEOMETRY_FILE(1) = 'null',
DEFAULT_SURF_IDX(1,1) = 0,
DEFAULT_SURF_IDX(1,2) = 0,
DEFAULT_SURF_IDX(1,3) = 0,
DEFAULT_SURF_IDX(1,4) = 0,
DEFAULT_SURF_IDX(1,5) = 1,
DEFAULT_SURF_IDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/

&GA_PHI
NPHI = 0,
/

&GA_VARS
NGENE = 0,
/
Contact Conductance Sensitivity Analysis

\[ H_c = 0 \text{ W/m}^2\text{-K} \]

&GPyro_GENERAL

DT0 = 0.1,
TAMB = 300,
TREF = 300,
P0 = 101300,
GX = 0,
GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIESITERNS = 1,
NCONTINUITYITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOL = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .FALSE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSMODE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DH VOL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_TSOLID = .FALSE.,
/

&GPYRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 10,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REduced_DTDUMP = 5000,
REduced_DTDUMP = 0.0001,
DTMIN_KILL = 0.0000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILE_COORD1(1) = 0,
PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE_IMESH(2) = 0,
PROFILECOORD1(2) = 0,
PROFILECOORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE_IMESH(3) = 0,
PROFILECOORD1(3) = 0,
PROFILECOORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE_IMESH(4) = 0,
PROFILECOORD1(4) = 0,
PROFILECOORD2(4) = 0,
PROFILE_ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'YI',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE_IMESH(5) = 0,
PROFILECOORD1(5) = 0,
PROFILECOORD2(5) = 0,
PROFILE_ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'YI',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILE_COORD1(6) = 0,
PROFILE_COORD2(6) = 0,
PROFILE_ISKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILE_COORD1(7) = 0,
PROFILE_COORD2(7) = 0,
PROFILE_ISKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILE_COORD1(8) = 0,
PROFILE_COORD2(8) = 0,
PROFILE_ISKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILE_COORD1(9) = 0,
PROFILE_COORD2(9) = 0,
PROFILE_ISKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILECOORD1(10) = 0,
PROFILECOORD2(10) = 0,
PROFILEISKIP(10) = 1,
/

&GPyro_Sprops
NSSpec = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.00000000000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 0.0000000000001,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000000000001,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 0.0000000000001,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,
NKX(4) = 0,
PERMX(4) = 1D-10,
K0Y(4) = 0.2,
NKY(4) = 0,
PERMY(4) = 1D-10,
NAME(5) = 'fireblock',
K0Z(5) = 0.23,
NKZ(5) = 0,
R0(5) = 1200,
NR(5) = 0,
C0(5) = 1400,
NC(5) = 0,
EMIS(5) = 0.84,
KAPPA(5) = 1000000,
TMELT(5) = 3000,
DHMELT(5) = 0,
SIGMA2MELT(5) = 0,
GAMMA(5) = 0.000068,
PERMZ(5) = 0.000000000001,
RS0(5) = 1100,
PORE_DIAMETER(5) = 0.0005,
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHEMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.000000000000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 0.0000000000001,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(8) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.0000000000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPyro_RXNS
NRXNS = 3,
CFROM(1) = 'resin' ,
CTO(1) = 'residue' ,
Z(1) = 50000000000000 ,
E(1) = 195 ,
DHS(1) = 0,
DHV(1) = 172000 ,
CHI(1) = 1 ,
ORDER(1) = 1.125 ,
ORDERO2(1) = 0 ,
IKINETICMODEL(1) = 0 ,
IO2TYPE(1) = 0 ,
M(1) = 0,
KCAT(1) = 0 ,
ICAT(1) = 0 ,
CFROM(2) = 'fireblock' ,
CTO(2) = 'fireblock residue' ,
Z(2) = 32000000000000 ,
E(2) = 183 ,
DHS(2) = 0 ,
DHV(2) = 2500000 ,
CHI(2) = 1.5,
ORDER(2) = 1.3,
ORDERO2(2) = 0,
IKINETICMODEL(2) = 0,
IO2TYPE(2) = 0,
M(2) = 0,
KCAT(2) = 0,
ICAT(2) = 0,
CFROM(3) = 'ATH',
CTO(3) = 'ATH residue',
Z(3) = 250000000,
E(3) = 140.1,
DHS(3) = 0,
DHV(3) = 1000000,
CHI(3) = 1,
ORDER(3) = 1.24,
ORDERO2(3) = 0,
IKINETICMODEL(3) = 0,
IO2TYPE(3) = 0,
M(3) = 0,
KCAT(3) = 0,
ICAT(3) = 0,
/

&GPyRO_HGRXNS
NHGRXNS = 0,
/

&GPyRO_GPROPS
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44,
SIGMA(1) = 5.061,
EPSOK(1) = 254,
C0(1) = 1000,
NC(1) = 0,
/

&GPYRO_GYIELDS
GYIELDS(1,1) = 1,
GYIELDS(1,2) = 1,
GYIELDS(1,3) = 1,
GYIELDS(1,3) = 1,
/

&GPYRO_HGYIELDS
/

&GPYRO_CASES
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZEROD(1) = .FALSE.,
BETA(1) = 5,
IMESH(2) = 2,
TSTOP(2) = 400,
ZEROD(2) = .FALSE.,
BETA(2) = 10,
&GA_GENINPUT
NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXPONENT = 2,
WHOLEGENEFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&GPyro_IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
Y10(1,1) = 0.275,
Y10(1,2) = 0,
Y10(1,3) = 0.45,
Y10(1,4) = 0,
Y10(1,5) = 0,
Y10(1,6) = 0,
Y10(1,7) = 0.275,
Y10(1,8) = 0,
YJ0(1,1) = 1,
TMP_INITIAL(2) = 300,
TMPG_INITIAL(2) = 300,
P_INITIAL(2) = 101300,
Y10(2,1) = 0.25,
Y10(2,2) = 0,
Y10(2,3) = 0,
Y10(2,4) = 0.5,
Y10(2,5) = 0,
Y10(2,6) = 0,
Y10(2,7) = 0.25,
Y10(2,8) = 0,
YJ0(2,1) = 1,
/

&GPyro_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,
QE(1) = 78000,
HC(1) = 10,
NHC(1) = 0,
TINF(1) = 300,
RERADIATION(1) = .TRUE.,
TFIXED(1) = -1,
MDOTPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 0,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .FALSE.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,
/

&G PYRO_GEOM
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
NCELLY(1) = 1,
GEOMETRY_FILE(1) = 'null',
DEFAULT_SURF_IDX(1,1) = 0,
DEFAULT_SURF_IDX(1,2) = 0,
DEFAULT_SURF_IDX(1,3) = 0,
DEFAULT_SURF_IDX(1,4) = 0,
DEFAULT_SURF_IDX(1,5) = 1,
DEFAULT_SURF_IDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/

&GA_PHI
NPHI = 0,
/

&GA_VARS
NGENE = 0,
/
Hc = 50 W/m²-K

&GPyro_General
DT0 = 0.1,
TAMB = 300,
TREF = 300,
P0 = 101300,
GX = 0,
GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIESITERNS = 1,
NCONTINUITYITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOL = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .FALSE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSMODE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DH VOL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_T SOLID = .FALSE.,
/

&GPYRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 10,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_RE DUCED_DTDUMP = 5000,
REDUCED_DTDUMP = 0.0001,
DTMIN_KILL = 0.00000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILE_COORD1(1) = 0,
PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE_IMESH(2) = 0,
PROFILE_COORD1(2) = 0,
PROFILE_COORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE_IMESH(3) = 0,
PROFILE_COORD1(3) = 0,
PROFILECOORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE_IMESH(4) = 0,
PROFILE_COORD1(4) = 0,
PROFILE_COORD2(4) = 0,
PROFILE_ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'YI',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE_IMESH(5) = 0,
PROFILE_COORD1(5) = 0,
PROFILE_COORD2(5) = 0,
PROFILE_ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'YI',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILE_COORD1(6) = 0,
PROFILE_COORD2(6) = 0,
PROFILE_ISKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILE_COORD1(7) = 0,
PROFILE_COORD2(7) = 0,
PROFILE_ISKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILE_COORD1(8) = 0,
PROFILE_COORD2(8) = 0,
PROFILE_ISKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILE_COORD1(9) = 0,
PROFILE_COORD2(9) = 0,
PROFILE_ISKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILE_COORD1(10) = 0,
PROFILE_COORD2(10) = 0,
PROFILE_ISKIP(10) = 1,
/

&GPyro_sprops
NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.000000000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 0.0000000000000001,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000000000001,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 0.0000000000001,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,
NKX(4) = 0,
PERMX(4) = 1D-10,
K0Y(4) = 0.2,
NKY(4) = 0,
PERMY(4) = 1D-10,
NAME(5) = 'fireblock',
K0Z(5) = 0.23,
NKZ(5) = 0,
R0(5) = 1200,
NR(5) = 0,
C0(5) = 1400,
NC(5) = 0,
EMIS(5) = 0.84,
KAPPA(5) = 1000000,
TMELT(5) = 3000,
DHMELT(5) = 0,
SIGMA2MELT(5) = 0,
GAMMA(5) = 0.000068,
PERMZ(5) = 0.0000000000001,
RS0(5) = 1100,
PORE_DIAMETER(5) = 0.0005,
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.0000000000000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 0.0000000000001,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(8) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.0000000000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPyRO_RXNS
NRXNS = 3,
CFROM(1) = 'resin',
CTO(1) = 'residue',
Z(1) = 50000000000000,
E(1) = 195,
DHS(1) = 0,
DHV(1) = 172000,
CHI(1) = 1,
ORDER(1) = 1.125,
ORDERO2(1) = 0,
IKINETICMODEL(1) = 0,
IO2TYPE(1) = 0,
M(1) = 0,
KCAT(1) = 0,
ICAT(1) = 0,
CFROM(2) = 'fireblock',
CTO(2) = 'fireblock residue',
Z(2) = 32000000000000,
E(2) = 183,
DHS(2) = 0,
DHV(2) = 2500000,
CHI(2) = 1.5,
ORDER(2) = 1.3,
ORDERO2(2) = 0 ,
IKINETICMODEL(2) = 0 ,
IO2TYPE(2) = 0 ,
M(2) = 0 ,
KCAT(2) = 0 ,
ICAT(2) = 0 ,
CFROM(3) = 'ATH' ,
CTO(3) = 'ATH residue' ,
Z(3) = 250000000000 ,
E(3) = 140.1 ,
DHS(3) = 0 ,
DHV(3) = 1000000 ,
CHI(3) = 1 ,
ORDER(3) = 1.24 ,
ORDERO2(3) = 0 ,
IKINETICMODEL(3) = 0 ,
IO2TYPE(3) = 0 ,
M(3) = 0 ,
KCAT(3) = 0 ,
ICAT(3) = 0 ,
/

&GPYRO_HGRXNS
NHGRXNS = 0 ,
/

&GPYRO_GPROPS
NGSPEC = 1 ,
IBG = 1 ,
IO2 = 2 ,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44 ,
SIGMA(1) = 5.061 ,
EPSOK(1) = 254 ,
C0(1) = 1000 ,
NC(1) = 0 ,
/

&GPYRO_GYIELDS
GYIELDS(1,1) = 1,
GYIELDS(1,2) = 1,
GYIELDS(1,3) = 1,
/

&GPYRO_HGYIELDS
/

&GPYRO_CASES
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZEROD(1) = .FALSE.,
BETA(1) = 5 ,
IMESH(2) = 2,
TSTOP(2) = 400,
ZEROD(2) = .FALSE.,
BETA(2) = 10 ,
/
&GA_GENINPUT NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXPONENT = 2,
WHOLEGENEFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&GPyRO_IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YJ0(1,1) = 1,

TMP_INITIAL(2) = 300,
TMPG.Initial(2) = 300,
P_INITIAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJ0(2,1) = 1,
/

&GPYRO_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,
QE(1) = 78000,
HC(1) = 10,
NHC(1) = 0,
TINF(1) = 300,
RERADIATION(1) = .TRUE.,
TFIXED(1) = -1,
MDOTPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 50,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .FALSE.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,

&GPyRO_GEOM
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
DEFAULT_SURF_IDX(1,1) = 0,
DEFAULT_SURF_IDX(1,2) = 0,
DEFAULT_SURF_IDX(1,3) = 0,
DEFAULT_SURF_IDX(1,4) = 0,
DEFAULT_SURF_IDX(1,5) = 1,
DEFAULT_SURF_IDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURFIDX2D(1,1) = 2,
SURFIDX2D(1,2) = 2,
SURFIDX2D(1,3) = 2,
SURFIDX2D(1,4) = 2,
SURFIDX2D(1,5) = 1,
SURFIDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/
"GA_PHI"
NPHI = 0,
/
"GA_VARS"
NGENE = 0,
\[ H_c = 100 \text{ W/m}^2\text{-K} \]

\[ &\text{GPyro_General} \]
\[ DT0 = 0.1, \]
\[ TAMB = 300, \]
\[ TREF = 300, \]
\[ P0 = 101300, \]
\[ GX = 0, \]
\[ GZ = 0, \]
\[ GY = 0, \]
\[ \text{THERMAL\_EQUILIBRIUM} = .TRUE., \]
\[ \text{VHLC} = 0, \]
\[ HCV = 1000000, \]
\[ NU\_A = 2, \]
\[ NU\_B = 1, \]
\[ NU\_C = 0.5, \]
\[ \text{NTDMA\_ITERATIONS} = 1000, \]
\[ \text{NSSPECIESITERNS} = 1, \]
\[ \text{NCONTINUITYITERNS} = 1, \]
\[ ALPHA = 1, \]
\[ \text{TMPTOL} = 0.0001, \]
\[ \text{HTOL} = 0.00000001, \]
\[ \text{YITOL} = 0.0001, \]
\[ \text{PTOL} = 0.0001, \]
\[ \text{YJTOL} = 0.0001, \]
\[ \text{HGTOL} = 0.1, \]
\[ \text{EXPLICIT\_T} = .FALSE., \]
\[ \text{SOLVE\_GAS\_YJ} = .FALSE., \]
\[ \text{SOLVE\_GAS\_ENERGY} = .FALSE., \]
\[ \text{SOLVE\_PRESSURE} = .FALSE., \]
\[ \text{USE\_TOFH\_NEWTON} = .FALSE., \]
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSMODE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DHVOL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_TSOLID = .FALSE.,
/

&GPyRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 10,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REDUCED_DTDUMP = 5000,
REDUCED_DTDUMP = 0.0001,
DTMIN_KILL = 0.00000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILE_COORD1(1) = 0,
PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE.IMESH(2) = 0,
PROFILE_COORD1(2) = 0,
PROFILE_COORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE.IMESH(3) = 0,
PROFILE_COORD1(3) = 0,
PROFILE_COORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE.IMESH(4) = 0,
PROFILE_COORD1(4) = 0,
PROFILE_COORD2(4) = 0,
PROFILE.ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'Y_I',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE.IMESH(5) = 0,
PROFILE_COORD1(5) = 0,
PROFILE_COORD2(5) = 0,
PROFILE.ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'Y_I',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILECOORD1(6) = 0,
PROFILECOORD2(6) = 0,
PROFILE_SKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILECOORD1(7) = 0,
PROFILECOORD2(7) = 0,
PROFILE_SKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILECOORD1(8) = 0,
PROFILECOORD2(8) = 0,
PROFILE_SKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILECOORD1(9) = 0,
PROFILECOORD2(9) = 0,
PROFILE_SKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILE_COORD1(10) = 0,
PROFILE_COORD2(10) = 0,
PROFILE_ISKIP(10) = 1,
/

&GPyro_sprops
NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.0000000000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 0.0000000000001,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000000000001,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 0.0000000000001,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,
NKX(4) = 0,
PERMX(4) = 1D-10,
K0Y(4) = 0.2,
NKY(4) = 0,
PERMY(4) = 1D-10,
NAME(5) = 'fireblock',
K0Z(5) = 0.23,
NKZ(5) = 0,
R0(5) = 1200,
NR(5) = 0,
C0(5) = 1400,
NC(5) = 0,
EMIS(5) = 0.84,
KAPPA(5) = 1000000,
TMELT(5) = 3000,
DHMELT(5) = 0,
SIGMA2MELT(5) = 0,
GAMMA(5) = 0.000068,
PERMZ(5) = 0.0000000000001,
RS0(5) = 1100,
PORE_DIAMETER(5) = 0.0005,
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.00000000000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 0.0000000000001,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(8) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.0000000000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPYRO_RXNS
NRXNS = 3,
CFROM(1) = 'resin',
CTO(1) = 'residue',
Z(1) = 50000000000000,
E(1) = 195,
DHS(1) = 0,
DHV(1) = 172000,
CHI(1) = 1,
ORDER(1) = 1.125,
ORDERO2(1) = 0,
IKINETICMODEL(1) = 0,
IO2TYPE(1) = 0,
M(1) = 0,
KCAT(1) = 0,
ICAT(1) = 0,
CFROM(2) = 'fireblock',
CTO(2) = 'fireblock residue',
Z(2) = 32000000000000,
E(2) = 183,
DHS(2) = 0,
DHV(2) = 2500000,
CHI(2) = 1.5,
ORDER(2) = 1.3,
ORDERO2(2) = 0,
IKINETICMODEL(2) = 0,
IO2TYPE(2) = 0,
M(2) = 0,
KCAT(2) = 0,
ICAT(2) = 0,
CFROM(3) = 'ATH',
CTO(3) = 'ATH residue',
Z(3) = 250000000000,
E(3) = 140.1,
DHS(3) = 0,
DHV(3) = 1000000,
CHI(3) = 1,
ORDER(3) = 1.24,
ORDERO2(3) = 0,
IKINETICMODEL(3) = 0,
IO2TYPE(3) = 0,
M(3) = 0,
KCAT(3) = 0,
ICAT(3) = 0,
/

&GPyro_HGRXNS
NHGRXNS = 0,
/

&GPyro_GPROPS
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44 ,
SIGMA(1) = 5.061 ,
EPSOK(1) = 254 ,
C0(1) = 1000 ,
NC(1) = 0 ,
/

&GPyro_GYields
GYields(1,1) = 1,
GYields(1,2) = 1,
GYields(1,3) = 1,
GYields(1,3) = 1,
/

&GPyro_HYields
/

&GPyro_Cases
NCases = 2,
IMesh(1) = 1,
TStop(1) = 900,
Zerod(1) = .FALSE.,
Beta(1) = 5,
IMesh(2) = 2,
TStop(2) = 400,
Zerod(2) = .FALSE.,
Beta(2) = 10,
/
&GA_GENINPUT NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXPONENT = 2,
WHOLEGENEFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&GPyRO IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YJ0(1,1) = 1,
TMP_INITIAL(2) = 300,
TMPG_INITIAL(2) = 300,
P_INITIAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJ0(2,1) = 1,
/

&GPYRO_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,
QE(1) = 78000,
HC(1) = 10,
NHC(1) = 0,
TINF(1) = 300,
RERADIATION(1) = .TRUE.,
TFIXED(1) = -1,
MDOTPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 100,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .FALSE.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,
/

&GPYRO_GEOM
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
NCELLY(1) = 1,
GEOMETRY_FILE(1) = 'null',
DEFAULT_SURF_IDX(1,1) = 0,
DEFAULT_SURF_IDX(1,2) = 0,
DEFAULT_SURF_IDX(1,3) = 0,
DEFAULT_SURF_IDX(1,4) = 0,
DEFAULT_SURF_IDX(1,5) = 1,
DEFAULT_SURF_IDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/

&GA_PHI
NPHI = 0,
/

&GA_VARS
NGENE = 0,
/
$$H_c = 1000 \text{ W/m}^2\text{-K}$$

&GPyro_General
DT0 = 0.1,
TAMB = 300,
TREF = 300,
P0 = 101300,
GX = 0,
GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIESITERNS = 1,
NCONTINUITYITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOL = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .FALSE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSMODE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DHVOL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_TSOlid = .FALSE.,
/
&GPYRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 10,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REDUCED_DTDUMP = 5000,
REduced_DTDUMP = 0.0001,
DTMIN_KILL = 0.00000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILECOORD1(1) = 0,
PROFILECOORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE_IMESH(2) = 0,
PROFILECOORD1(2) = 0,
PROFILECOORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE_IMESH(3) = 0,
PROFILECOORD1(3) = 0,
PROFILECOORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE_IMESH(4) = 0,
PROFILECOORD1(4) = 0,
PROFILECOORD2(4) = 0,
PROFILE_ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'YI',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE_IMESH(5) = 0,
PROFILECOORD1(5) = 0,
PROFILECOORD2(5) = 0,
PROFILE_ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'YI',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILECOORD1(6) = 0,
PROFILECOORD2(6) = 0,
PROFILE_ISKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILECOORD1(7) = 0,
PROFILECOORD2(7) = 0,
PROFILE_ISKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILECOORD1(8) = 0,
PROFILECOORD2(8) = 0,
PROFILE_ISKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILECOORD1(9) = 0,
PROFILECOORD2(9) = 0,
PROFILE_ISKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILECOORD1(10) = 0,
PROFILECOORD2(10) = 0,
PROFILEISKIP(10) = 1,
/

&GPyro_SProps
NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.0000000000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 0.0100000000000001,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000000000001,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 0.0000000000001,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,
NKX(4) = 0,
PERMX(4) = 1D-10,
K0Y(4) = 0.2,
NKY(4) = 0,
PERMY(4) = 1D-10,
NAME(5) = 'fireblock',
K0Z(5) = 0.23,
NKZ(5) = 0,
R0(5) = 1200,
NR(5) = 0,
C0(5) = 1400,
NC(5) = 0,
EMIS(5) = 0.84,
KAPPA(5) = 1000000,
TMELT(5) = 3000,
DHMELT(5) = 0,
SIGMA2MELT(5) = 0,
GAMMA(5) = 0.000068,
PERMZ(5) = 0.00000000000001,
RS0(5) = 1100,
PORE_DIAMETER(5) = 0.0005,
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.0000000000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 0.0000000000001,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(8) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.0000000000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPYRO_RXNS
NRXNS = 3,
CFROM(1) = 'resin',
CTO(1) = 'residue',
Z(1) = 50000000000000,
E(1) = 195,
DHS(1) = 0,
DHV(1) = 172000,
CHI(1) = 1,
ORDER(1) = 1.125,
ORDERO2(1) = 0,
IKINETICMODEL(1) = 0,
IO2TYPE(1) = 0,
M(1) = 0,
KCAT(1) = 0,
ICAT(1) = 0,
CFROM(2) = 'fireblock',
CTO(2) = 'fireblock residue',
Z(2) = 32000000000000,
E(2) = 183,
DHS(2) = 0,
DHV(2) = 2500000,
CHI(2) = 1.5,
ORDER(2) = 1.3,
ORDERO2(2) = 0,
IKINETICMODEL(2) = 0,
IO2TYPE(2) = 0,
M(2) = 0,
KCAT(2) = 0,
ICAT(2) = 0,
CFROM(3) = 'ATH',
CTO(3) = 'ATH residue',
Z(3) = 2500000000000,
E(3) = 140.1,
DHS(3) = 0,
DHV(3) = 1000000,
CHI(3) = 1,
ORDER(3) = 1.24,
ORDERO2(3) = 0,
IKINETICMODEL(3) = 0,
IO2TYPE(3) = 0,
M(3) = 0,
KCAT(3) = 0,
ICAT(3) = 0,
/

&GPYRO_HGRXNS
NHGRXNS = 0,
/

&GPYRO_GPROPS
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44,
SIGMA(1) = 5.061,
EPSOK(1) = 254,
C0(1) = 1000,
NC(1) = 0,
/

&GPYRO_GYIELDS
GYIELDS(1,1) = 1,
GYIELDS(1,2) = 1,
GYIELDS(1,3) = 1,
/

&GPYRO_HGYIELDS
/

&GPYRO_CASES
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZEROD(1) = .FALSE.,
BETA(1) = 5,
IMESH(2) = 2,
TSTOP(2) = 400,
ZEROD(2) = .FALSE.,
BETA(2) = 10,
/
&GA_GENINPUT
NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXponent = 2,
WHOLEGENERFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&GPyRO_IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YJ0(1,1) = 1,
TMP_INITIAL(2) = 300,
TMPG_INITIAL(2) = 300,
P_INITIAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJ0(2,1) = 1,
/

&GPYRO_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,  
QE(1) = 78000,  
HC(1) = 10,  
NHC(1) = 0,  
TINF(1) = 300,  
RERADIATION(1) = .TRUE.,  
TFIXED(1) = -1,  
MDOTPP(1) = 0,  
PRES(1) = 101300,  
QEG(1) = 0,  
HCG(1) = 15,  
TINFG(1) = 300,  
TFIXEDG(1) = -1000,  
HM(1) = 0.01,  
YJINF(1,1) = 1,  
SURF_IDX(2) = 2,  
T(2) = 0,  
QE(2) = 0,  
HC(2) = 1000,  
NHC(2) = 0,  
TINF(2) = 300,  
RERADIATION(2) = .FALSE.,  
TFIXED(2) = -1,  
MDOTPP(2) = 0,  
PRES(2) = -1000,  
QEG(2) = 0,  
HCG(2) = 15,  
TINFG(2) = 300,  
TFIXEDG(2) = -1000,  
HM(2) = 0,
YJINF(2,1) = 1,
/

&GPYRO_GEOM
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
NCELLY(1) = 1,
GEOMETRY_FILE(1) = 'null',
DEFAULT_SURF_IDX(1,1) = 0,
DEFAULT_SURF_IDX(1,2) = 0,
DEFAULT_SURF_IDX(1,3) = 0,
DEFAULT_SURF_IDX(1,4) = 0,
DEFAULT_SURF_IDX(1,5) = 1,
DEFAULT_SURF_IDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/

&GA_PHI
NPHI = 0,
/

&GA_VARS
NGENE = 0,
/
Calibrated Boundary Conditions

Heat Flux 50 W/m²

&GPYRO_GENERAL
DT0 = 0.1,
TAMB = 300,
TREF = 300,
P0 = 101300,
GX = 0,
GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIESITERNS = 1,
NCONTINUITYITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOL = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .FALSE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSTYPE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DHVOL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PRODUCED_AT_TSOLID = .FALSE.,
/

&GPYRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 10,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REduced_DTDUMP = 5000,
REDUCED_DTDUMP = 0.0001,
DTMIN_KILL = 0.00000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILE_COORD1(1) = 0,
PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE_IMESH(2) = 0,
PROFILE_COORD1(2) = 0,
PROFILE_COORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE_IMESH(3) = 0,
PROFILE_COORD1(3) = 0,
PROFILE_COORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE_IMESH(4) = 0,
PROFILE_COORD1(4) = 0,
PROFILE_COORD2(4) = 0,
PROFILE_ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'YI',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE_IMESH(5) = 0,
PROFILE_COORD1(5) = 0,
PROFILE_COORD2(5) = 0,
PROFILE_ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'YI',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILECOORD1(6) = 0,
PROFILECOORD2(6) = 0,
PROFILE_ISKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILECOORD1(7) = 0,
PROFILECOORD2(7) = 0,
PROFILE_ISKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILECOORD1(8) = 0,
PROFILECOORD2(8) = 0,
PROFILE_ISKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILECOORD1(9) = 0,
PROFILECOORD2(9) = 0,
PROFILE_ISKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILE_COORD1(10) = 0,
PROFILE_COORD2(10) = 0,
PROFILE_ISKIP(10) = 1,
/

&GPYRO_SPROPS
NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.0000000000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 0.0000000000001,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000000000001,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 0.0000000000001,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,
NKX(4) = 0,
PERMX(4) = 1D-10,
K0Y(4) = 0.2,
NKY(4) = 0,
PERMY(4) = 1D-10,
NAME(5) = 'fireblock',
K0Z(5) = 0.23,
NKZ(5) = 0,
R0(5) = 1200,
NR(5) = 0,
C0(5) = 1400,
NC(5) = 0,
EMIS(5) = 0.84,
KAPPA(5) = 1000000,
TMELT(5) = 3000,
DHMELT(5) = 0,
SIGMA2MELT(5) = 0,
GAMMA(5) = 0.000068,
PERMZ(5) = 0.0000000000001,
RS0(5) = 1100,
PORE_DIAMETER(5) = 0.0005,
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.0000000000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 0.0000000000001,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(8) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.0000000000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,
K0Y(8) = 0.2,
NKY(8) = 0,
PERMY(8) = 1D-10,
/

&GPYRO_RXNS
NRXNS = 3,
CFROM(1) = 'resin',
CTO(1) = 'residue',
Z(1) = 5000000000000000000,
E(1) = 195,
DHS(1) = 0,
DHV(1) = 172000,
CHI(1) = 1,
ORDER(1) = 1.125,
ORDERO2(1) = 0,
IKINETICMODEL(1) = 0,
IO2TYPE(1) = 0,
M(1) = 0,
KCAT(1) = 0,
ICAT(1) = 0,
CFROM(2) = 'fireblock',
CTO(2) = 'fireblock residue',
Z(2) = 320000000000000000,
E(2) = 183,
DHS(2) = 0,
DHV(2) = 2500000,
CHI(2) = 1.5,
ORDER(2) = 1.3,
ORDERO2(2) = 0,
IKINETICMODEL(2) = 0,
IO2TYPE(2) = 0,
M(2) = 0,
KCAT(2) = 0,
ICAT(2) = 0,
CFROM(3) = 'ATH',
CTO(3) = 'ATH residue',
Z(3) = 250000000000,
E(3) = 140.1,
DHS(3) = 0,
DHV(3) = 1000000,
CHI(3) = 1,
ORDER(3) = 1.24,
ORDERO2(3) = 0,
IKINETICMODEL(3) = 0,
IO2TYPE(3) = 0,
M(3) = 0,
KCAT(3) = 0,
ICAT(3) = 0,
/

&GPYRO_HGRXNS
NHGRXNS = 0,
/

&GPYRO_GPROPS
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44,
SIGMA(1) = 5.061,
EPSOK(1) = 254,
C0(1) = 1000,
NC(1) = 0,
/

&GPYRO_GYIELDS
GYIELDS(1,1) = 1,
GYIELDS(1,2) = 1,
GYIELDS(1,3) = 1,
GYIELDS(1,3) = 1,
/

&GPYRO_HGYIELDS
/

&GPYRO_CASES
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZEROD(1) = .FALSE.,
BETA(1) = 5,
IMESH(2) = 2,
TSTOP(2) = 400,
ZEROD(2) = .FALSE.,
BETA(2) = 10,
&GA_GENINPUT NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXponent = 2,
WHOLEGENEFRAc = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&GPyRO_IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YJ0(1,1) = 1,
TMP_INITIAL(2) = 300,
TMPG_INITIAL(2) = 300,
P_INITIAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJ0(2,1) = 1,
/

&GPyRO_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,
QE(1) = 50000,
HC(1) = 30,
NHC(1) = 0,
TINF(1) = 300,
RERADIATION(1) = .TRUE.,
TFIXED(1) = -1,
MDOTPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 100,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .FALSE.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,
/

&GPYRO_GEOM
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
NCELLY(1) = 1,
GEOMETRY_FILE(1) = 'null',
DEFAULT_SURFIDX(1,1) = 0,
DEFAULT_SURFIDX(1,2) = 0,
DEFAULT_SURFIDX(1,3) = 0,
DEFAULT_SURFIDX(1,4) = 0,
DEFAULT_SURFIDX(1,5) = 1,
DEFAULT_SURFIDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,

&GA_PHI
NPHI = 0,

&GA_VARS
NGENE = 0,
Heat Flux 78 W/m²

&G_PYRO_GENERAL
DT0 = 0.1,
TAMB = 300,
TREF = 300,
P0 = 101300,
GX = 0,
GZ = 0,
GY = 0,
THERMAL_EQUILIBRIUM = .TRUE.,
VHLC = 0,
HCV = 1000000,
NU_A = 2,
NU_B = 1,
NU_C = 0.5,
NTDMA_ITERATIONS = 1000,
NSSPECIESITERNS = 1,
NCONTINUITYITERNS = 1,
ALPHA = 1,
TMPTOL = 0.0001,
HTOL = 0.00000001,
YITOL = 0.0001,
PTOL = 0.0001,
YJTOL = 0.0001,
HGTOL = 0.1,
EXPLICIT_T = .FALSE.,
SOLVE_GAS_YJ = .FALSE.,
SOLVE_GAS_ENERGY = .FALSE.,
SOLVE_PRESSURE = .FALSE.,
USE_TOFH_NEWTON = .FALSE.,
SHYI_CORRECTION = .TRUE.,
NCOEFF_UPDATE_SKIP = 1,
FDSMODE = .FALSE.,
CONVENTIONAL_RXN_ORDER = .FALSE.,
NOCONSUMPTION = .FALSE.,
EPS = 0.0000000001,
BLOWING = .FALSE.,
CONSTANT_DHVOL = .TRUE.,
FULL_QSG = .FALSE.,
GASES_PROroduced_AT_TSOLID = .FALSE.,
/

&GPYRO_OUTPUT
CASENAME = 'sample_03',
N_POINT_QUANTITIES = 5,
N_PROFILE_QUANTITIES = 10,
N_SMOKEVIEW_QUANTITIES = 0,
DTDUMP_GA = 1,
DTDUMP_POINT = 1,
DTDUMP_PROFILE = 1,
DTDUMP_SMOKEVIEW = 1,
TMP_REduced_DTDUMP = 5000,
REDUCED_DTDUMP = 0.0001,
DTMIN_KILL = 0.00000001,
POINT_QUANTITY(1) = 'MLR',
POINT_QUANTITY_INDEX(1) = 0,
POINT_IMESH(1) = 0,
POINT_Z(1) = 0,
POINT_X(1) = 0,
POINT_Y(1) = 0,
POINT_QUANTITY(2) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(2) = 0,
POINT_IMESH(2) = 0,
POINT_Z(2) = 0,
POINT_X(2) = 0,
POINT_Y(2) = 0,
POINT_QUANTITY(3) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(3) = 0,
POINT_IMESH(3) = 0,
POINT_Z(3) = 0.001,
POINT_X(3) = 0,
POINT_Y(3) = 0,
POINT_QUANTITY(4) = 'TEMPERATURE',
POINT_QUANTITY_INDEX(4) = 0,
POINT_IMESH(4) = 0,
POINT_Z(4) = 0.002,
POINT_X(4) = 0,
POINT_Y(4) = 0,
POINT_QUANTITY(5) = 'N_ITERATIONS',
POINT_QUANTITY_INDEX(5) = 0,
POINT_IMESH(5) = 0,
POINT_Z(5) = 0,
POINT_X(5) = 0,
POINT_Y(5) = 0,
PROFILE_QUANTITY(1) = 'TEMPERATURE',
PROFILE_QUANTITY_INDEX(1) = 0,
PROFILE_DIRECTION(1) = 'z',
PROFILE_IMESH(1) = 1,
PROFILE_COORD1(1) = 0,
PROFILE_COORD2(1) = 0,
PROFILE_ISKIP(1) = 1,
PROFILE_QUANTITY(2) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(2) = 1,
PROFILE_DIRECTION(2) = 'z',
PROFILE_IMESH(2) = 0,
PROFILE_COORD1(2) = 0,
PROFILE_COORD2(2) = 0,
PROFILE_ISKIP(2) = 1,
PROFILE_QUANTITY(3) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(3) = 2,
PROFILE_DIRECTION(3) = 'z',
PROFILE_IMESH(3) = 0,
PROFILE_COORD1(3) = 0,
PROFILE_COORD2(3) = 0,
PROFILE_ISKIP(3) = 1,
PROFILE_QUANTITY(4) = 'REACTION_RATE_K',
PROFILE_QUANTITY_INDEX(4) = 3,
PROFILE_DIRECTION(4) = 'z',
PROFILE_IMESH(4) = 0,
PROFILE_COORD1(4) = 0,
PROFILE_COORD2(4) = 0,
PROFILE_ISKIP(4) = 1,
PROFILE_QUANTITY(5) = 'YI',
PROFILE_QUANTITY_INDEX(5) = 1,
PROFILE_DIRECTION(5) = 'z',
PROFILE_IMESH(5) = 0,
PROFILE_COORD1(5) = 0,
PROFILE_COORD2(5) = 0,
PROFILE_ISKIP(5) = 1,
PROFILE_QUANTITY(6) = 'YI',
PROFILE_QUANTITY_INDEX(6) = 2,
PROFILE_DIRECTION(6) = 'z',
PROFILE_IMESH(6) = 0,
PROFILE_COORD1(6) = 0,
PROFILE_COORD2(6) = 0,
PROFILE_ISKIP(6) = 1,
PROFILE_QUANTITY(7) = 'YI',
PROFILE_QUANTITY_INDEX(7) = 5,
PROFILE_DIRECTION(7) = 'z',
PROFILE_IMESH(7) = 0,
PROFILE_COORD1(7) = 0,
PROFILE_COORD2(7) = 0,
PROFILE_ISKIP(7) = 1,
PROFILE_QUANTITY(8) = 'YI',
PROFILE_QUANTITY_INDEX(8) = 6,
PROFILE_DIRECTION(8) = 'z',
PROFILE_IMESH(8) = 0,
PROFILE_COORD1(8) = 0,
PROFILE_COORD2(8) = 0,
PROFILE_ISKIP(8) = 1,
PROFILE_QUANTITY(9) = 'YI',
PROFILE_QUANTITY_INDEX(9) = 7,
PROFILE_DIRECTION(9) = 'z',
PROFILE_IMESH(9) = 0,
PROFILE_COORD1(9) = 0,
PROFILE_COORD2(9) = 0,
PROFILE_ISKIP(9) = 1,
PROFILE_QUANTITY(10) = 'YI',
PROFILE_QUANTITY_INDEX(10) = 8,
PROFILE_DIRECTION(10) = 'z',
PROFILE_IMESH(10) = 0,
PROFILE_COORD1(10) = 0,
PROFILECOORD2(10) = 0,
PROFILE_ISKIP(10) = 1,
/

&GPyro_sprops
NSSPEC = 8,
NAME(1) = 'resin',
K0Z(1) = 0.23,
NKZ(1) = 0,
R0(1) = 1200,
NR(1) = 0,
C0(1) = 1400,
NC(1) = 0,
EMIS(1) = 0.84,
KAPPA(1) = 1000000,
TMELT(1) = 3000,
DHMELT(1) = 0,
SIGMA2MELT(1) = 0,
GAMMA(1) = 0,
PERMZ(1) = 0.0000000000001,
RS0(1) = 1100,
PORE_DIAMETER(1) = 0.0005,
K0X(1) = 0.2,
NKX(1) = 0,
PERMX(1) = 1D-10,
K0Y(1) = 0.2,
NKY(1) = 0,
PERMY(1) = 1D-10,
NAME(2) = 'residue',
K0Z(2) = 0.19,
NKZ(2) = 0,
R0(2) = 253,
NR(2) = 0,
C0(2) = 1900,
NC(2) = 0,
EMIS(2) = 0.9,
KAPPA(2) = 1000000,
TMELT(2) = 3000,
DHMELT(2) = 0,
SIGMA2MELT(2) = 0,
GAMMA(2) = 0.00348,
PERMZ(2) = 0.0000000000001,
RS0(2) = 1100,
PORE_DIAMETER(2) = 0.0005,
K0X(2) = 0.2,
NKX(2) = 0,
PERMX(2) = 1D-10,
K0Y(2) = 0.2,
NKY(2) = 0,
PERMY(2) = 1D-10,
NAME(3) = 'glass',
K0Z(3) = 0.18,
NKZ(3) = 0,
R0(3) = 2600,
NR(3) = 0,
C0(3) = 400,
NC(3) = 0,
EMIS(3) = 0.88,
KAPPA(3) = 1000000,
TMELT(3) = 3000,
DHMELT(3) = 0,
SIGMA2MELT(3) = 0,
GAMMA(3) = 0.00769,
PERMZ(3) = 0.0000000000001,
RS0(3) = 1100,
PORE_DIAMETER(3) = 0.0005,
K0X(3) = 0.2,
NKX(3) = 0,
PERMX(3) = 1D-10,
K0Y(3) = 0.2,
NKY(3) = 0,
PERMY(3) = 1D-10,
NAME(4) = 'sand',
K0Z(4) = 0.2,
NKZ(4) = 0,
R0(4) = 1682,
NR(4) = 0,
C0(4) = 1500,
NC(4) = 0,
EMIS(4) = 0.65,
KAPPA(4) = 1000000,
TMELT(4) = 3000,
DHMELT(4) = 0,
SIGMA2MELT(4) = 0,
GAMMA(4) = 0.00769,
PERMZ(4) = 0.0000000000001,
RS0(4) = 1100,
PORE_DIAMETER(4) = 0.0005,
K0X(4) = 0.2,
NKX(4) = 0,
PERMX(4) = 1D-10,
K0Y(4) = 0.2,
NKY(4) = 0,
PERMY(4) = 1D-10,
NAME(5) = 'fireblock',
K0Z(5) = 0.23,
NKZ(5) = 0,
R0(5) = 1200,
NR(5) = 0,
C0(5) = 1400,
NC(5) = 0,
EMIS(5) = 0.84,
KAPPA(5) = 1000000,
TMELT(5) = 3000,
DHMELT(5) = 0,
SIGMA2MELT(5) = 0,
GAMMA(5) = 0.000068,
PERMZ(5) = 0.00000000000001,
RS0(5) = 1100,
PORE_DIAMETER(5) = 0.0005,
K0X(5) = 0.2,
NKX(5) = 0,
PERMX(5) = 1D-10,
K0Y(5) = 0.2,
NKY(5) = 0,
PERMY(5) = 1D-10,
NAME(6) = 'fireblock residue',
K0Z(6) = 0.19,
NKZ(6) = 0,
R0(6) = 253,
NR(6) = 0,
C0(6) = 1900,
NC(6) = 0,
EMIS(6) = 0.9,
KAPPA(6) = 1000000,
TMELT(6) = 3000,
DHMELT(6) = 0,
SIGMA2MELT(6) = 0,
GAMMA(6) = 0.00348,
PERMZ(6) = 0.0000000000001,
RS0(6) = 1100,
PORE_DIAMETER(6) = 0.0005,
K0X(6) = 0.2,
NKX(6) = 0,
PERMX(6) = 1D-10,
K0Y(6) = 0.2,
NKY(6) = 0,
PERMY(6) = 1D-10,
NAME(7) = 'ATH',
K0Z(7) = 1.22,
NKZ(7) = 0,
R0(7) = 2300,
NR(7) = 0,
C0(7) = 1200,
NC(7) = 0,
EMIS(7) = 0.81,
KAPPA(7) = 1000000,
TMELT(7) = 3000,
DHMELT(7) = 0,
SIGMA2MELT(7) = 0,
GAMMA(7) = 0,
PERMZ(7) = 0.0000000000001,
RS0(7) = 1100,
PORE_DIAMETER(7) = 0.0005,
K0X(7) = 0.2,
NKX(7) = 0,
PERMX(7) = 1D-10,
K0Y(7) = 0.2,
NKY(7) = 0,
PERMY(7) = 1D-10,
NAME(8) = 'ATH residue',
K0Z(8) = 0.24,
NKZ(8) = 0,
R0(8) = 1558,
NR(8) = 0,
C0(8) = 1200,
NC(8) = 0,
EMIS(8) = 0.89,
KAPPA(8) = 1000000,
TMELT(8) = 3000,
DHMELT(8) = 0,
SIGMA2MELT(8) = 0,
GAMMA(8) = 0.00475,
PERMZ(8) = 0.0000000000001,
RS0(8) = 1100,
PORE_DIAMETER(8) = 0.0005,
K0X(8) = 0.2,
NKX(8) = 0,
PERMX(8) = 1D-10,  
K0Y(8) = 0.2,  
NKY(8) = 0,  
PERMY(8) = 1D-10,  
/

&GPyro_Rxns  
NRXNS = 3,  
CFROM(1) = 'resin',  
CTO(1) = 'residue',  
Z(1) = 50000000000000000000,  
E(1) = 195,  
DHS(1) = 0,  
DHV(1) = 172000,  
CHI(1) = 1,  
ORDER(1) = 1.125,  
ORDERO2(1) = 0,  
IKINETICMODEL(1) = 0,  
IO2TYPE(1) = 0,  
M(1) = 0,  
KCAT(1) = 0,  
ICAT(1) = 0,  
CFROM(2) = 'fireblock',  
CTO(2) = 'fireblock residue',  
Z(2) = 32000000000000000000000000,  
E(2) = 183,  
DHS(2) = 0,  
DHV(2) = 2500000,  
CHI(2) = 1.5,  
ORDER(2) = 1.3,  

ORDERO2(2) = 0,
IKINETICMODEL(2) = 0,
IO2TYPE(2) = 0,
M(2) = 0,
KCAT(2) = 0,
ICAT(2) = 0,
CFROM(3) = 'ATH',
CTO(3) = 'ATH residue',
Z(3) = 250000000000,
E(3) = 140.1,
DHS(3) = 0,
DHV(3) = 1000000,
CHI(3) = 1,
ORDER(3) = 1.24,
ORDERO2(3) = 0,
IKINETICMODEL(3) = 0,
IO2TYPE(3) = 0,
M(3) = 0,
KCAT(3) = 0,
ICAT(3) = 0,
/

&GPYRO_HGRXNS
NHGRXNS = 0,
/

&GPYRO_GPROPS
NGSPEC = 1,
IBG = 1,
IO2 = 2,
CPG = 1000,
NAME(1) = 'pyrolysate',
M(1) = 44 ,
SIGMA(1) = 5.061 ,
EPSOK(1) = 254 ,
C0(1) = 1000 ,
NC(1) = 0 ,
/

&GPYRO_GYIELDS
GYIELDS(1,1) = 1,
GYIELDS(1,2) = 1,
GYIELDS(1,3) = 1,
/

&GPYRO_HGYIELDS
/

&GPYRO_CASES
NCASES = 2,
IMESH(1) = 1,
TSTOP(1) = 900,
ZERO(1) = .FALSE.,
BETA(1) = 5,
IMESH(2) = 2,
TSTOP(2) = 400,
ZERO(2) = .FALSE.,
BETA(2) = 10,
/
&GA_GENINPUT NGEN = 200,
NINDIV = 500,
MAXCOPIES = 10,
SIMULATED_EXPERIMENTAL_DATA = .FALSE.,
RESTART = .FALSE.,
FITMIN = 0,
FITCLIP = 0,
FITEXponent = 2,
WHOLEGENEFRAC = 0.8,
BRUTE_FORCE = .FALSE.,
KILL_NONCONVERGED_SOLNS = .TRUE.,
ASA = 1,
BSA = 20,
OPTIMIZATION_TYPE = 'SCE',
ISOTROPIC_THERMAL_CONDUCTIVITY = .FALSE.,
ISOTROPIC_PERMEABILITY = .FALSE.,
DUMP_INTERMEDIATE_TRIALS = .FALSE.,
DUMP_ALL_RESULTS_BEST = .FALSE.,
MAXN = 1000000,
KSTOP = 100,
PCENTO = 0.00001,
NGS = 8,
ISEED = 1969,
NPG = 17,
NPS = 9,
NSPL = 17,
MINGS = 8,
NOPT = 8,
/
&GPyro_IC
NIC = 2,
TMP_INITIAL(1) = 300,
TMPG_INITIAL(1) = 300,
P_INITIAL(1) = 101300,
YI0(1,1) = 0.275,
YI0(1,2) = 0,
YI0(1,3) = 0.45,
YI0(1,4) = 0,
YI0(1,5) = 0,
YI0(1,6) = 0,
YI0(1,7) = 0.275,
YI0(1,8) = 0,
YJ0(1,1) = 1,

TMP_INITIAL(2) = 300,
TMPG_INITIAL(2) = 300,
P_INITIAL(2) = 101300,
YI0(2,1) = 0.25,
YI0(2,2) = 0,
YI0(2,3) = 0,
YI0(2,4) = 0.5,
YI0(2,5) = 0,
YI0(2,6) = 0,
YI0(2,7) = 0.25,
YI0(2,8) = 0,
YJ0(2,1) = 1,
/

&GPYRO_ALLBC
NSURF_IDX = 2,
SURF_IDX(1) = 1,
T(1) = 0,
QE(1) = 78000,
HC(1) = 30,
NHC(1) = 0,
TINF(1) = 300,
RERADIATION(1) = .TRUE.,
TFIXED(1) = -1,
MDOTPP(1) = 0,
PRES(1) = 101300,
QEG(1) = 0,
HCG(1) = 15,
TINFG(1) = 300,
TFIXEDG(1) = -1000,
HM(1) = 0.01,
YJINF(1,1) = 1,
SURF_IDX(2) = 2,
T(2) = 0,
QE(2) = 0,
HC(2) = 100,
NHC(2) = 0,
TINF(2) = 300,
RERADIATION(2) = .FALSE.,
TFIXED(2) = -1,
MDOTPP(2) = 0,
PRES(2) = -1000,
QEG(2) = 0,
HCG(2) = 15,
TINFG(2) = 300,
TFIXEDG(2) = -1000,
HM(2) = 0,
YJINF(2,1) = 1,
/

&GPyro_Geom
NMESH = 1,
NOBST = 1,
ZDIM(1) = 0.003,
NCELLZ(1) = 381,
XDIM(1) = 0.1,
NCELLX(1) = 1,
YDIM(1) = 0.1,
NCELLY(1) = 1,
NCELLY(1) = 1,
GEOMETRY_FILE(1) = 'null',
DEFAULT_SURF_IDX(1,1) = 0,
DEFAULT_SURF_IDX(1,2) = 0,
DEFAULT_SURF_IDX(1,3) = 0,
DEFAULT_SURF_IDX(1,4) = 0,
DEFAULT_SURF_IDX(1,5) = 1,
DEFAULT_SURF_IDX(1,6) = 2,
DEFAULT_IC(1) = 1,
OFFSETZ(1) = 0,
OFFSETX(1) = 0,
OFFSETY(1) = 0,
IMESH(1) = 1,
Z1(1) = 0,
Z2(1) = 0.003,
X1(1) = 0,
X2(1) = 0.1,
Y1(1) = 0,
Y2(1) = 0.1,
ICNUM(1) = 1,
SURF_IDX2D(1,1) = 2,
SURF_IDX2D(1,2) = 2,
SURF_IDX2D(1,3) = 2,
SURF_IDX2D(1,4) = 2,
SURF_IDX2D(1,5) = 1,
SURF_IDX2D(1,6) = 2,
HCR(1,1) = 9d9,
HCR(1,2) = 9d9,
HCR(1,3) = 9d9,
HCR(1,4) = 9d9,
HCR(1,5) = 9d9,
HCR(1,6) = 9d9,
/

&GA_PHI
NPHI = 0,
/

&GA_VARS
NGENE = 0,
/