

# Cyclone: Setup and Analysis

CPFD Software

[www.cpfd-software.com](http://www.cpfd-software.com)

# Cyclone

This training example demonstrates how to simulate a lightly loaded cyclones.

## Features used in this example:

- Merge and remove in Setup Grid Advanced options
- Agglomeration model in Particle Species Editor
- Bin by particle size at flux planes

This knowledge base post contains additional discussion:

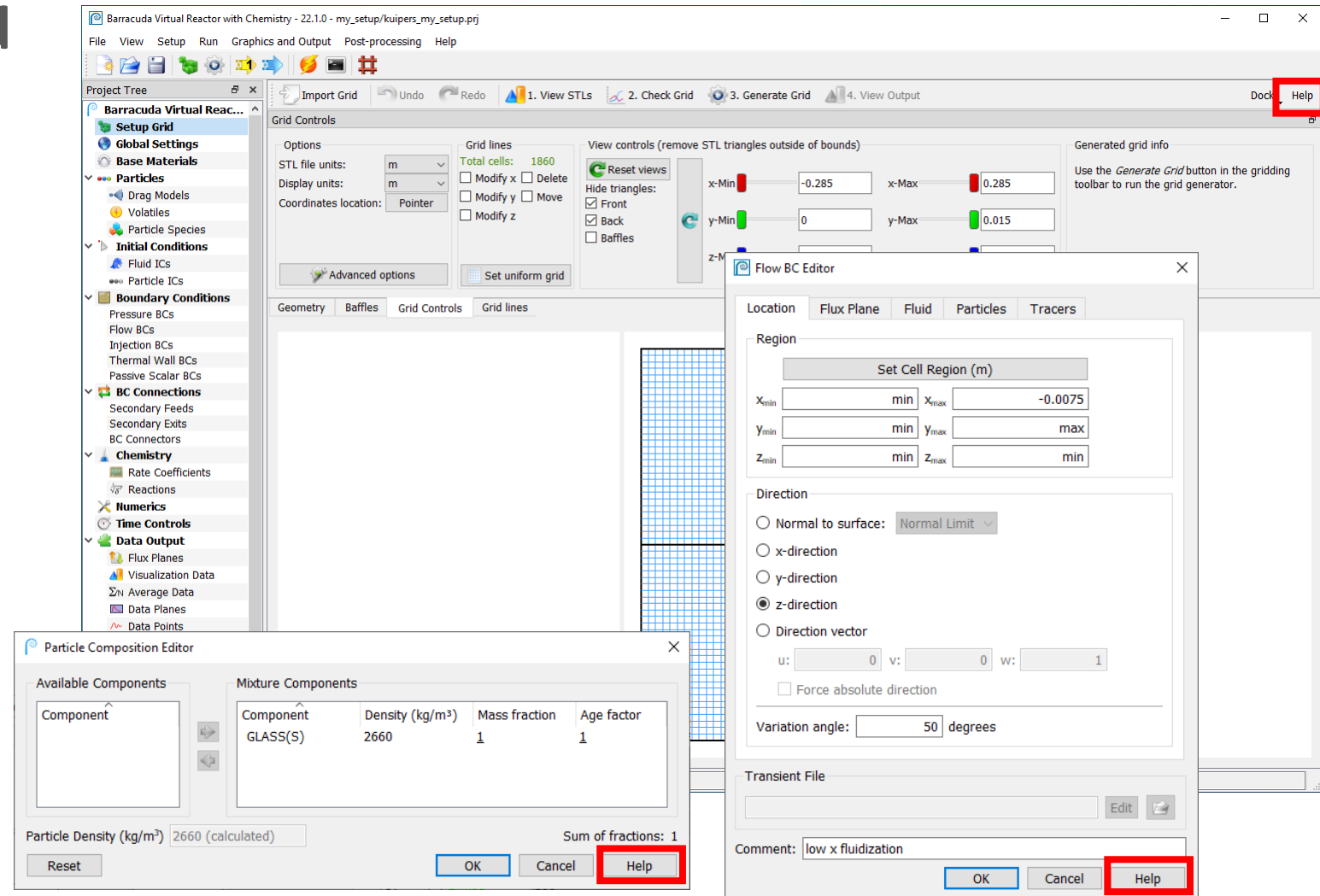
<https://cpfd-software.com/things-to-consider-when-simulating-cyclones/>



# How to Get More Information

All training materials have a limited amount of information about Barracuda and the GUI.

If you want to learn more, click on the Help button in the relevant dialog. This brings up the corresponding section of the User Manual.



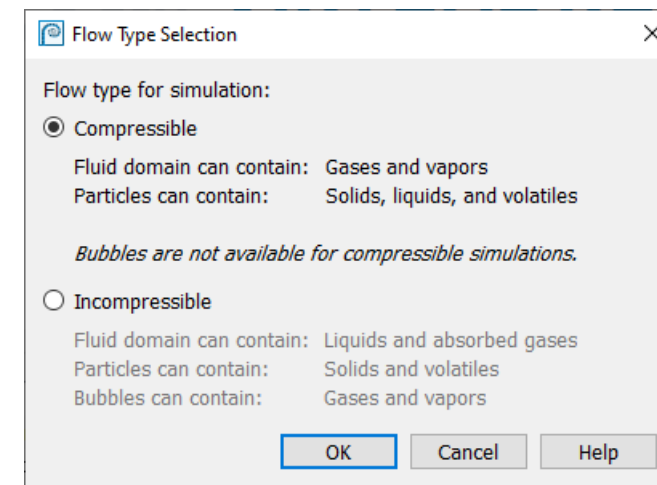
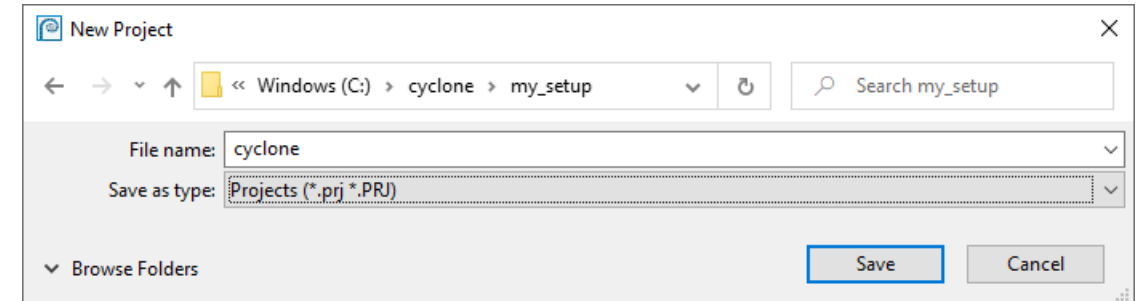
# Project File

Make a new compressible project file  
in the supplemental training directory:

`\cyclone\my_setup`

With the project name:

`cyclone.prj`



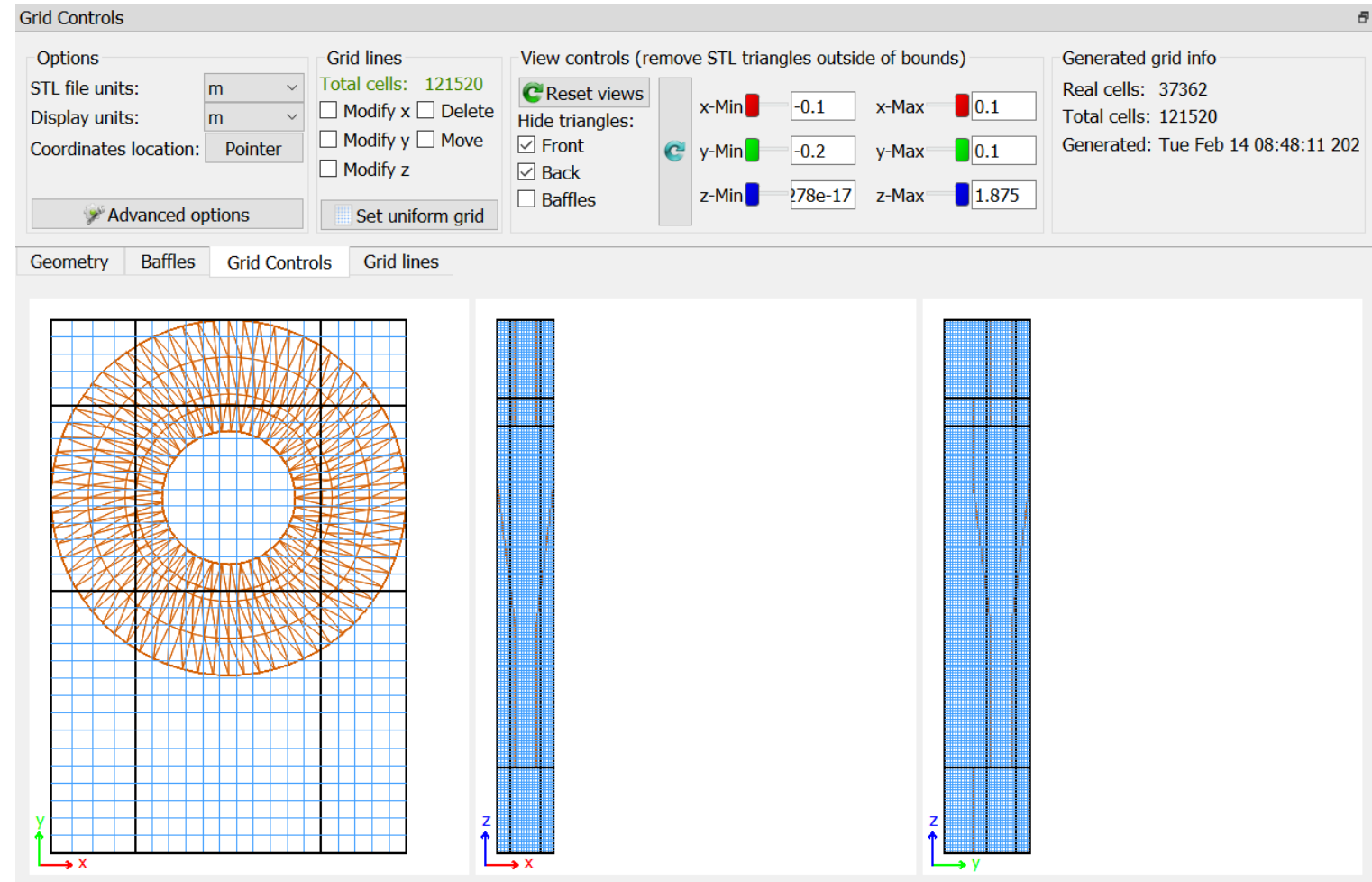
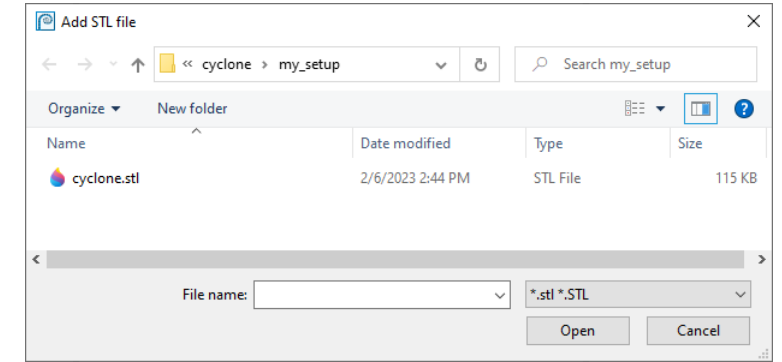
# Setup Grid

## Geometry tab

- Add cyclone.stl

## Grid Controls tab

- Set STL file units to m
- Set uniform grid to 130,000 cells
- Select Merge and remove small cells in the Advanced options dialog
- Modify x and y to add major grid lines to resolve vortex tube walls
- Modify z to add major grid lines for vortex tub, inlet horn, and dipleg discharge chamber



# Global Settings

Set Gravity in the z-direction

Select Isothermal at 300 K

Global Settings

Flow Type: Compressible

Fluid domain can contain: Gases and vapors  
Particles can contain: Solids, liquids, and volatiles

*Bubbles are not available for compressible simulations.*

Gravity Settings

x-direction:  m/s<sup>2</sup>    y-direction:  m/s<sup>2</sup>    z-direction:  m/s<sup>2</sup>

Thermal Settings

☒ Isothermal  
Temperature:  K

☐ Thermal

Heat Transfer Coefficients

Radiation Model

☒ None    ☐ Near wall    ☐ P-1    ☒ Cap exposed particle area

Temperature Warning Limits

Minimum:  K    Maximum:  K

☐ Record minimum and maximum temperatures in MinMaxTemp.data log file

Simulation Start Options

Help

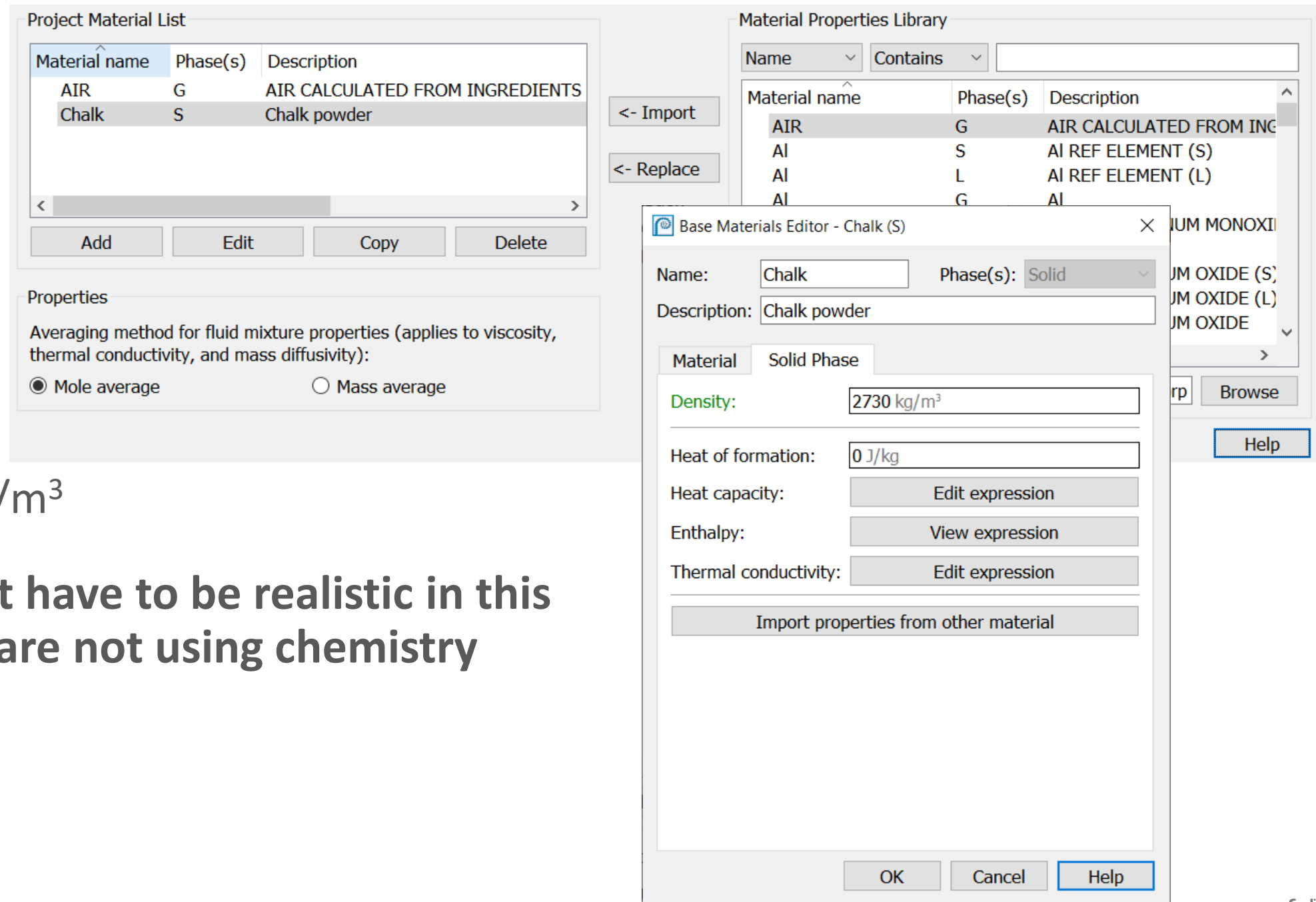
# Base Materials

## Import AIR

## Add Chalk

- Phase: Solid
- MW = 1 g/mol
- Density = 2730 kg/m<sup>3</sup>

MW of Chalk does not have to be realistic in this example because we are not using chemistry



The screenshot displays the software interface for managing materials. It includes a 'Project Material List' table, a 'Material Properties Library' table, and a 'Base Materials Editor' dialog for 'Chalk (S)'.

**Project Material List**

Material name	Phase(s)	Description
AIR	G	AIR CALCULATED FROM INGREDIENTS
Chalk	S	Chalk powder

Buttons: Add, Edit, Copy, Delete

**Properties**

Averaging method for fluid mixture properties (applies to viscosity, thermal conductivity, and mass diffusivity):

☒ Mole average ☐ Mass average

**Material Properties Library**

Name	Contains
AIR	G
Al	S
Al	L
Al	G

Buttons: <- Import, <- Replace

**Base Materials Editor - Chalk (S)**

Name: Chalk Phase(s): Solid

Description: Chalk powder

**Material** **Solid Phase**

Density: 2730 kg/m<sup>3</sup>

Heat of formation: 0 J/kg

Heat capacity: Edit expression

Enthalpy: View expression

Thermal conductivity: Edit expression

Import properties from other material

Buttons: OK, Cancel, Help

# Particles

**Set Close pack volume fraction: 0.5**

**Normal-to-wall momentum retention: 0.3**

**Tangent-to-wall momentum retention: 0.99**

- Using a very high value will allow the particles to slide around the cyclone barrel without losing too much speed

Particles

Contact and Collision Models

Close pack volume fraction:

Maximum momentum redirection from collision:

☐ Blended acceleration model for the contact force

☒ Transfer liquid mass on collision

[Stress Model Options](#)

Wall Interactions

Normal-to-wall momentum retention:

Tangent-to-wall momentum retention:

Diffuse bounce:

Cloud Options

☒ Allow clouds to represent fractional particles

Dense Fluid Forces

☐ Enable virtual mass force

☐ Enable lift force

[Help](#)



# Particle Species

## Create the chalk particle species:

- Chalk, 100% Chalk, psd\_chalk.sff, Agglomeration, WenYu-Ergun

PSD file is included  
in the supplemental  
training directory

Particle Species Manager							
Species-ID	Comment	Materials	Size	Sphericity	Emissivity	Drag model	Agglomeration
001	Chalk	Chalk	psd_chalk.sff	1	1	WenYu-Ergun	On
Add		Edit		Copy		Delete	


Particle Species Editor

Species-ID: 001

Comment: Chalk

Materials: Applied Materials

Size Distribution

☒ File: psd\_chalk.sff  

Import Preset Distribution:

☐ Size Range:

Minimum:  Maximum:

Surface and Shape


Sphericity:

Emissivity:

Scattering Factor:

☒ Agglomeration

Size Cut Point:

Effective Size Filename:   


Drag Model

Model Name:

Name	Link To Default	Value
c0	<input checked="" type="checkbox"/> Linked	1
c1	<input checked="" type="checkbox"/> Linked	0.15
c2	<input checked="" type="checkbox"/> Linked	0.44
c3	<input checked="" type="checkbox"/> Linked	2
c4	<input checked="" type="checkbox"/> Linked	180
n0	<input checked="" type="checkbox"/> Linked	-2.65

☒ Multiplier (constant):

☐ Multiplier (predefined):

☐ Multiplier (from file): 

# Fluid IC

## Fluid IC

- Fluid species = 100% AIR

The image shows two overlapping dialog boxes from a software application. The background dialog is the 'Fluid IC Editor', and the foreground dialog is the 'Mixture' dialog.

**Fluid IC Editor**

- ☒ Initial Conditions
  - Temperature: 300 K
  - Pressure: 101325 Pa
  - Velocity: 0 0 0 m/s
  - Fluid species: Define Fluids
- ☐ Initial Conditions from File
  - IC file:
- Region
  - Set Cell Region (m)
  - $x_{min}$  min  $x_{max}$  max
  - $y_{min}$  min  $y_{max}$  max
  - $z_{min}$  min  $z_{max}$  max
- Comment
  -

**Mixture**

- Available Components
  - Component
- Mixture
  - | Component | Fraction |
|-----------|----------|
| AIR(G)    | 1        |
- Specify mixture by: Mass fraction
- Sum of fractions: 1
- Buttons: Reset, OK, Cancel, Help

# Pressure BC

Add a pressure BC with information shown here for cyclone outlet

Use 100% AIR for Applied fluids

Pressure Boundary Conditions Editor

	Time (s)	Pressure (Pa)	Temperature (K)	Area Fraction	Particle Feed	K-Factor
1	0	101325	300	1	<input type="radio"/> Off	0
2					<input checked="" type="radio"/> On	

File:

Pressure BC Editor

Location Flux Plane Fluid Particles Tracers

Region

X<sub>min</sub>  X<sub>max</sub>   
Y<sub>min</sub>  Y<sub>max</sub>   
Z<sub>min</sub>  Z<sub>max</sub>

Direction

☐ x-direction  
☐ y-direction  
☒ z-direction

Comment:

Pressure BC Editor

Location Flux Plane Fluid Particles Tracers

Name:

Fluid species behavior:

☒ Bin by particle size  bins  
☐ Output raw particle data  
☐ Output tracer data

Pressure BC Editor

Location Flux Plane Fluid Particles Tracers

Flow Conditions

☒ Transient file:

☐ Specify values:

Area fraction:   
Pressure:  Pa  
Temperature:  K  
K-factor:

Fluid Composition

Fluid inflow properties:

Applied fluids:

Comment:

Pressure BC Editor

Location Flux Plane Fluid Particles Tracers

Behavior at Boundary

☐ No outflow  
☒ Outflow with size filtering:  
Minimum:   
Maximum:   
Units:

☐ Feed specified as volume fraction  
☐ Feed specified as mass flux  
☐ Feed specified as mass flow rate

Feed Settings

Comment:

# Flow BC

Add flow BC with information shown here for cyclone inlet

Flow BC Editor

Location Flux Plane Fluid Particles Tracers

Region

Set Cell Region (m)

X<sub>min</sub> min X<sub>max</sub> max

Y<sub>min</sub> min Y<sub>max</sub> min

Z<sub>min</sub> min Z<sub>max</sub> max

Direction

☐ Normal to surface: Normal Limit

☐ x-direction

☒ y-direction

☐ z-direction

☐ Direction vector

u: 0 v: 0 w: 1

☐ Force absolute direction

Variation angle: 15 degrees

Transient File

Comment:

OK Cancel Help

Flow BC Editor

Location Flux Plane Fluid Particles Tracers

Name: FLUXBC\_flow\_cyclone\_inlet

Fluid species behavior:

No output

☒ Bin by particle size 100 bins

☐ Output raw particle data

☐ Output tracer data

Transient File

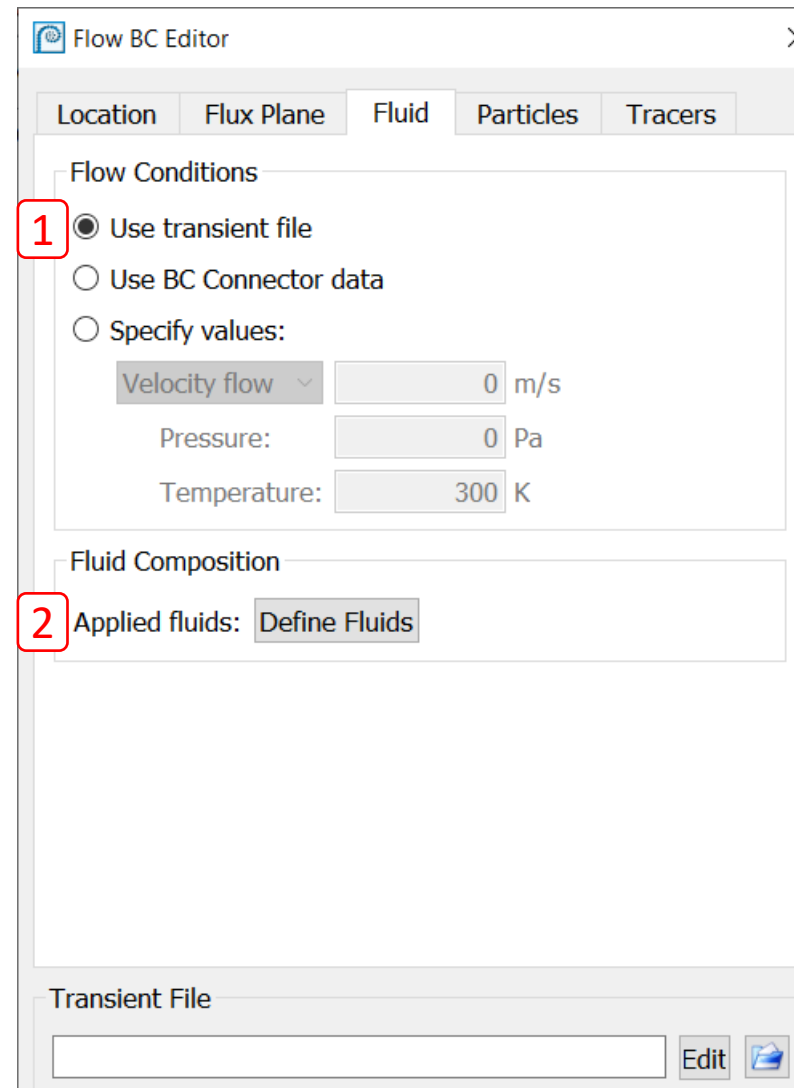
Comment:

OK Cancel Help

# Flow BC

Use 100% AIR for Applied fluids

Use 100% Chalk for Particle feed



Flow BC Editor

Location Flux Plane Fluid Particles Tracers

Flow Conditions

1 ☒ Use transient file

☐ Use BC Connector data

☐ Specify values:

Velocity flow  m/s

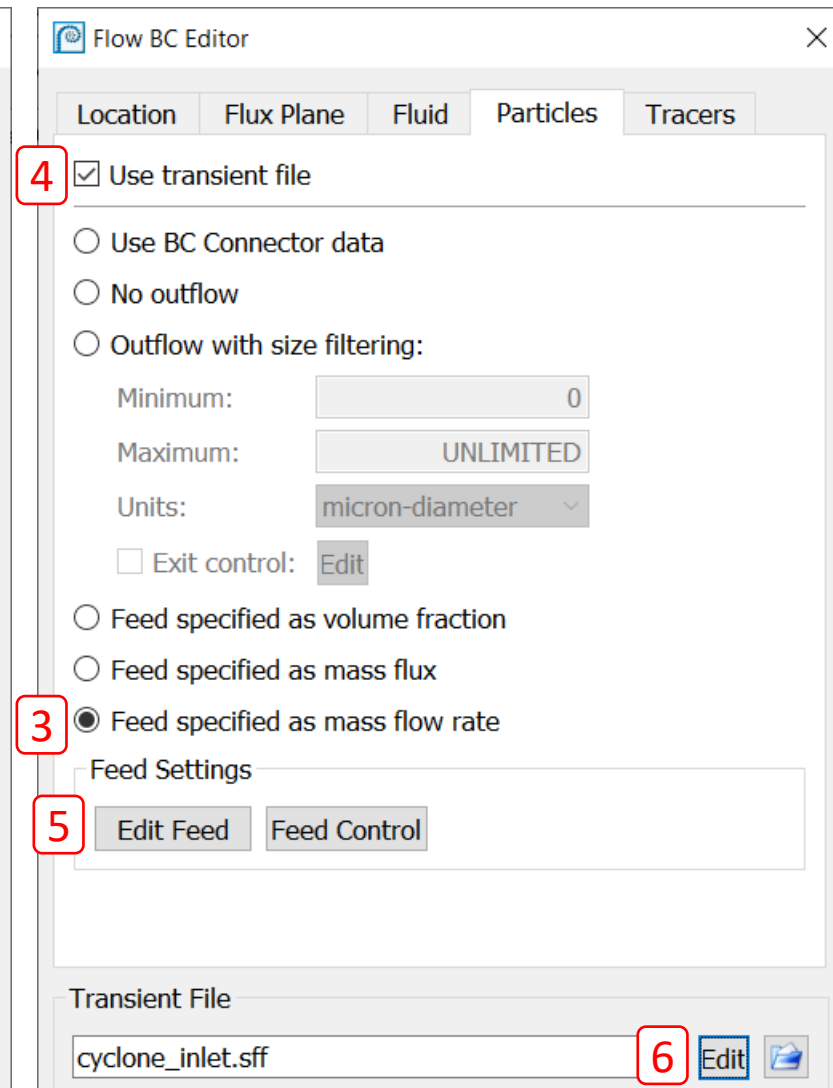
Pressure:  Pa

Temperature:  K

Fluid Composition

2 Applied fluids:

Transient File



Flow BC Editor

Location Flux Plane Fluid Particles Tracers

4 ☒ Use transient file

☐ Use BC Connector data

☐ No outflow

☐ Outflow with size filtering:

Minimum:

Maximum:

Units:

☐ Exit control:

☐ Feed specified as volume fraction

☐ Feed specified as mass flux

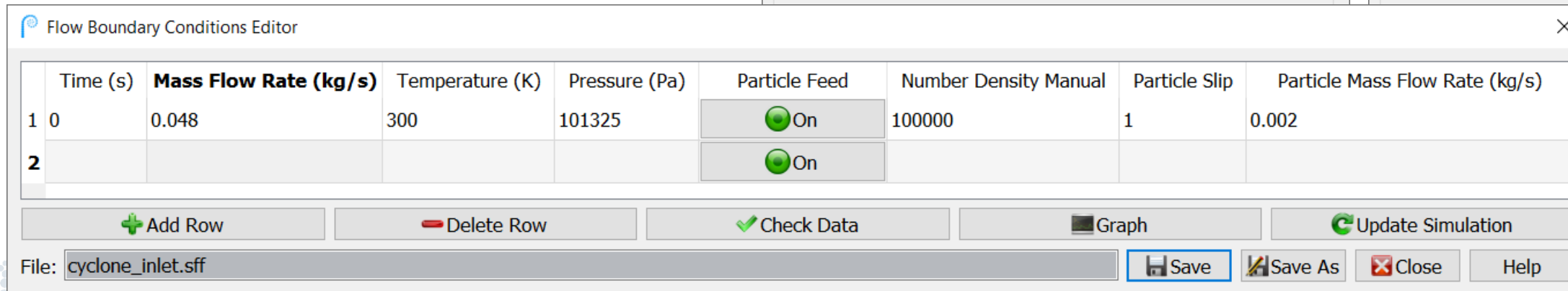
3 ☒ Feed specified as mass flow rate

Feed Settings

5

Transient File

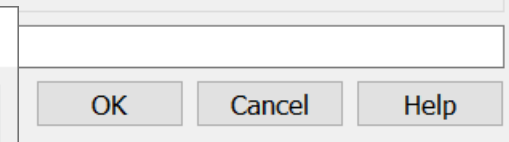
6



Flow Boundary Conditions Editor

	Time (s)	Mass Flow Rate (kg/s)	Temperature (K)	Pressure (Pa)	Particle Feed	Number Density Manual	Particle Slip	Particle Mass Flow Rate (kg/s)
1	0	0.048	300	101325	<input checked="" type="radio"/> On	100000	1	0.002
2					<input checked="" type="radio"/> On			

File:



# Time Controls

## Set Time step and End time

### Time Controls

This section allows configuration of the time step size to take during a period of time for the calculation. Only the first row is required. Subsequent rows can be entered to have different time steps for different time periods. For example, starting the calculation at a smaller time step is recommended, and then increasing the time step for rows 2-5 over simulation time.

#### Time step and duration settings

	Time step		End time	
1.	<input type="text" value="0.0005"/>	s	<input type="text" value="10"/>	s
2.	<input type="text"/>	s	<input type="text"/>	s
3.	<input type="text"/>	s	<input type="text"/>	s
4.	<input type="text"/>	s	<input type="text"/>	s
5.	<input type="text"/>	s	<input type="text"/>	s

[Advanced time step settings](#)

#### Restart file intervals

Restart interval (IC\_###)  simulation seconds

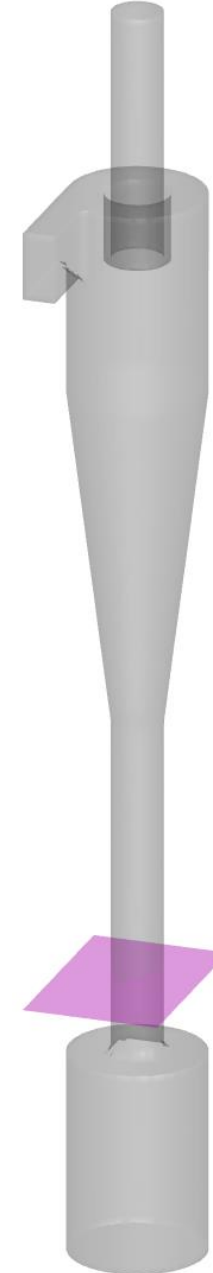
Backtrack interval (IC\_)  realtime minutes

[Help](#)

# Flux Planes

Define one flux plane to track flow through the dipleg

Select Bin by particle size



Flux Plane Editor

Location

Normal Direction: z

Select plane (m)

z: 0.42

x<sub>min</sub>: min x<sub>max</sub>: max

y<sub>min</sub>: min y<sub>max</sub>: max

Flux plane options

Name: FLUX\_dipleg

Fluid species behavior: No output

☒ Bin by particle size 100 bins

☐ Output raw particle data

☐ Output tracer data

☐ Reset particle residence time

☐ Reset tracer residence time

☐ Directional flux

Comment

Dipleg

OK Cancel Help

# Visualization Data

Set Output file interval and  
select the options shown for  
Visualization Data Output

Visualization Data Output

Output formats  
☒ Tecplot (\*.plt files) ☐ GMV (Gmv.\* files)

Output file interval  
Plot interval:  s Number of files produced using current end time of **10s**:

Cell Data

Available Data		Selected Data
Bulk density		Cell indices
Cell ID		Cell volume
Clouds per cell		CFL
Convective wall heat transfer		Fluid density
dp/dx	→	Fluid mass flux
dp/dy	←	Fluid velocity
dp/dz		Particle mass flux
Dynamic pressure		Particle velocity
Fluid composition mass concentration		Particle volume fraction
Fluid composition mass fraction		Pressure

Particle Data

Available Data		Selected Data
Cell ID		Cloud ID
Cloud mass		Particle size
Drag		Particle speed
Liquid fraction total		Particle velocity
Liquid mass total		Particle volume fraction
P1 radiation flux		Residence time
Particle density		
Particle mass		
Particle material		
Particle species		

Help



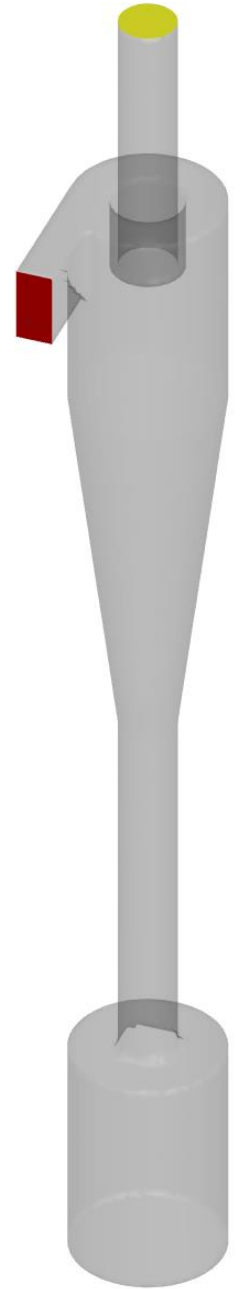
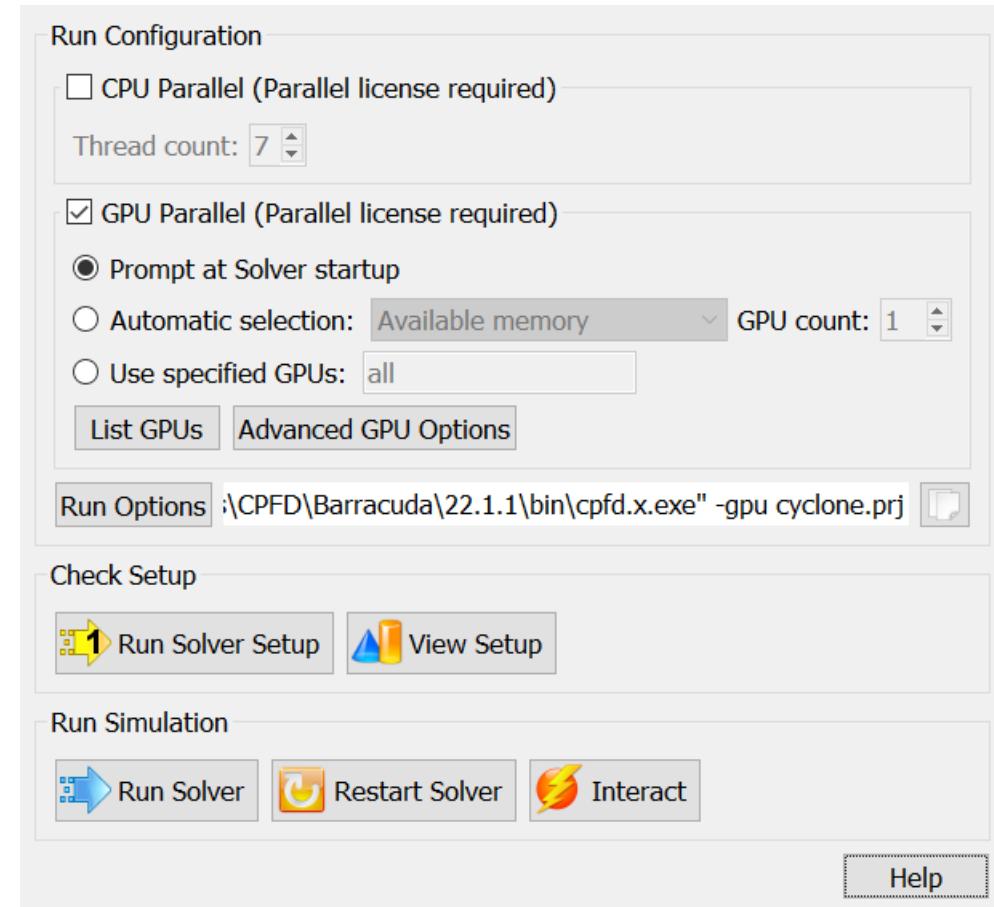
# Run

If NVIDIA GPU card is available,  
select GPU Parallel

Run Solver Setup and View Setup

Once you have checked the setup,  
Run Solver to start the simulation

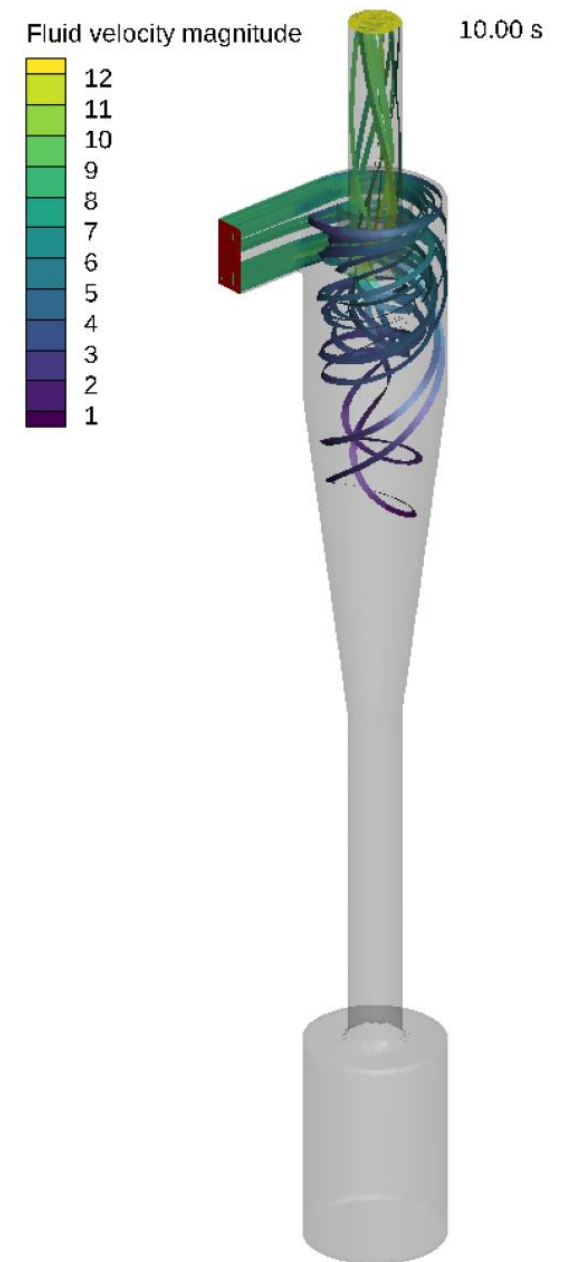
Wait until the simulation has  
reached at least 5 seconds before  
starting the post-processing  
exercises



# Post-Processing: Streamtraces

Follow along with this video to create a view of streamtraces in the cyclone

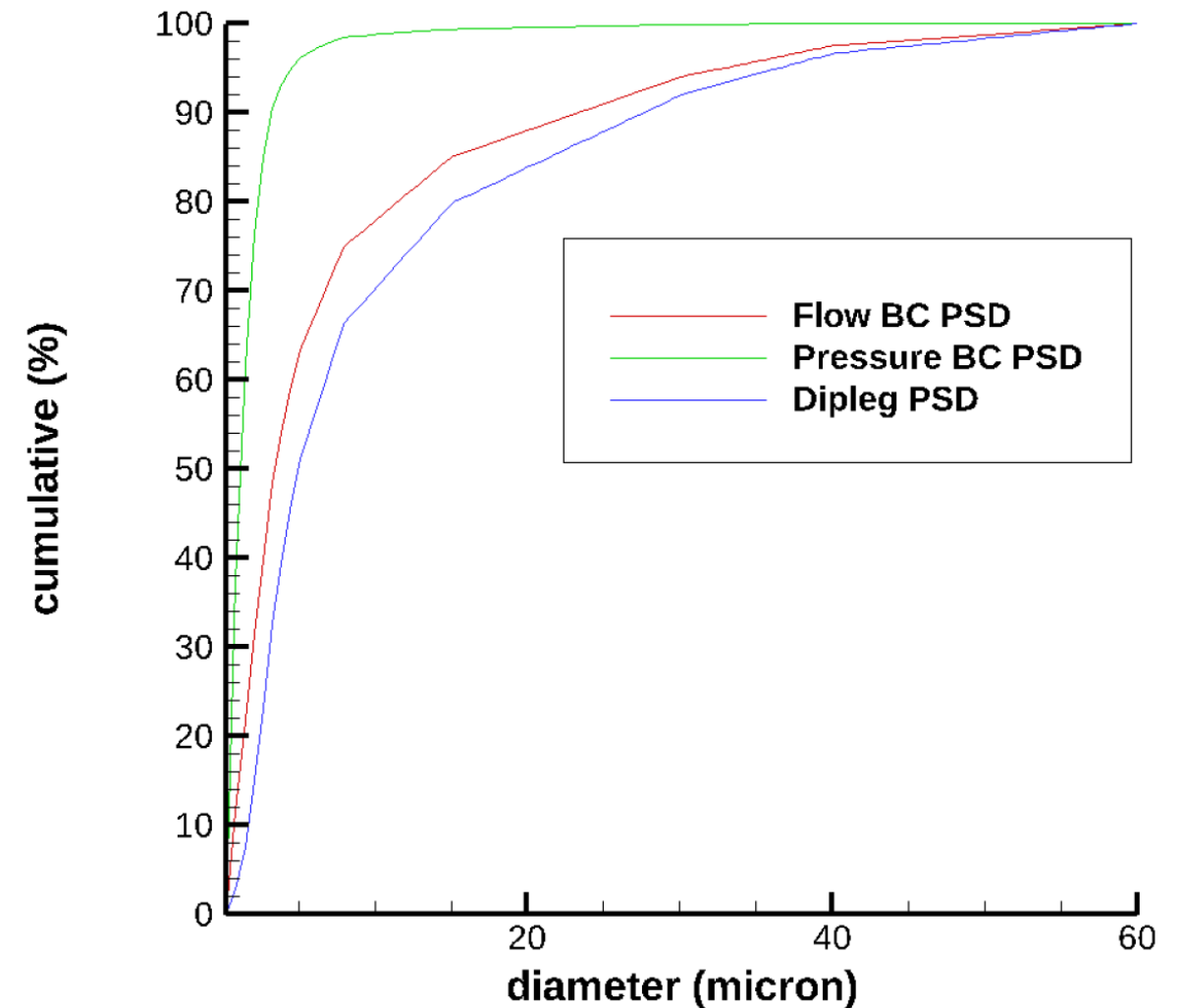
<https://cpfd-software.com/tecplot-for-barracuda-creating-streamtraces/>



# Post-Processing: Using flux2psd

Follow along with this Knowledge Base post to use flux2psd to compare the PSD of the chalk coming into the system at the Flow BC, to the PSD of the chalk leaving the system at the Pressure BC, and the PSD of the chalk going through the flux plane in the dipleg.

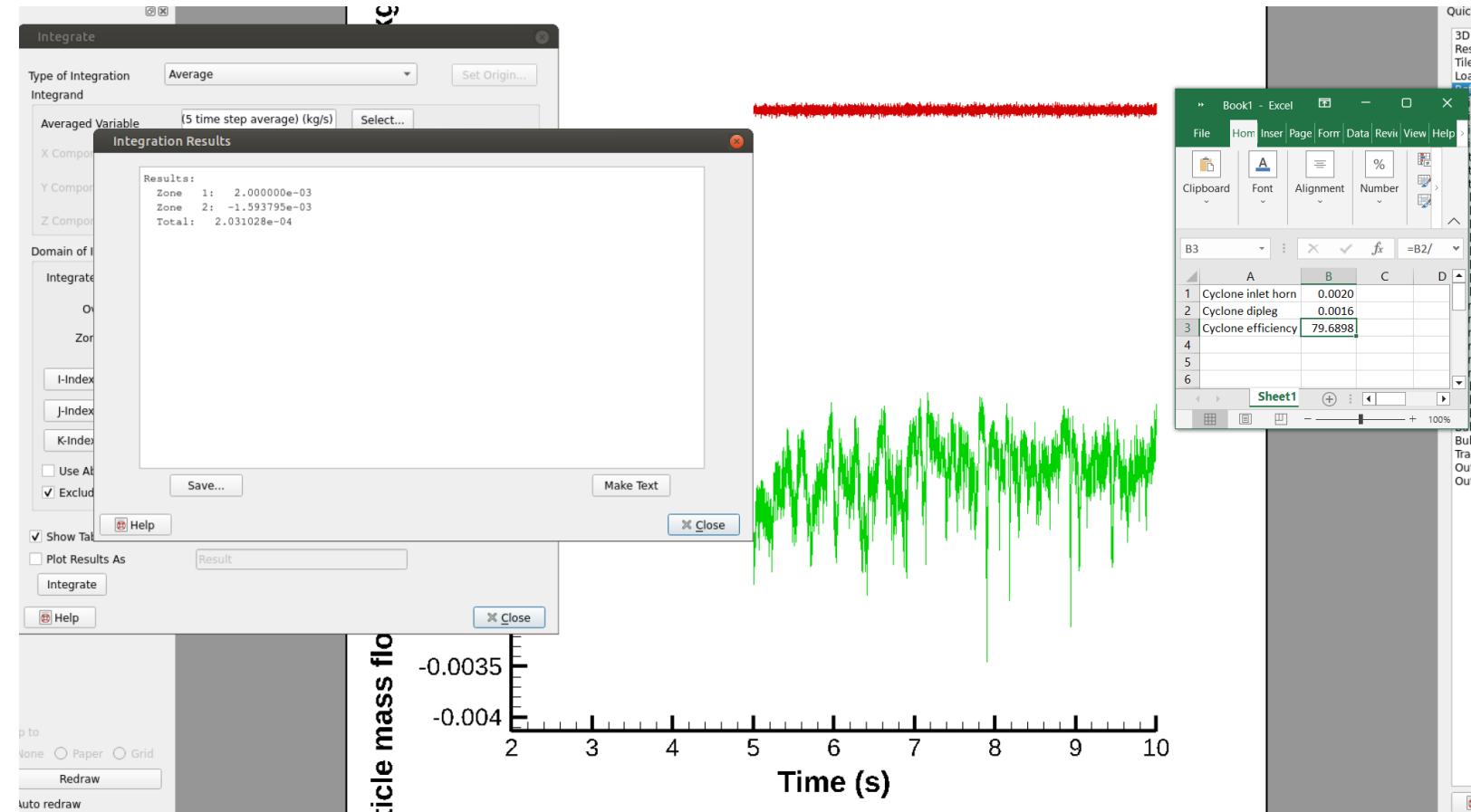
<https://cpfd-software.com/calculating-psd-at-a-flux-plane-using-flux2psd/>



# Post-Processing: Cyclone Efficiency

Follow along with this video and check the efficiency of the cyclone with an averaging time from 5-10 s

<https://cpfd-software.com/tecplot-for-barracuda-calculating-cyclone-efficiency/>



# Summary

**This model showed a lightly loaded cyclone based on literature.**

**Important setup parameters were highlighted:**

- Merge and remove small cells
- Agglomeration
- Bin by particle size

**Post-processing of the cyclone included:**

- Creating streamtraces to visualize the fluid flow path
- Using flux2psd to calculate the PSD of the particles entering and exiting the cyclone
- Calculating the efficiency of the cyclone