

CFD Simulation of Dispersed Flow, Mixing, Combustion and Exhaust Gas Dispersion

Dispersed flow modeling is an important and challenging analysis problem focused on mixing of different flow regimes or tracking discrete particles. Typically, the tracked flow regime is a small fraction of the whole. The applications for these analyses can include tracking dispersion of exhaust from diesel engines, particle laden flows, and more recently, dispersion of particulate and aerosol viruses such as COVID-19 within confined air spaces.

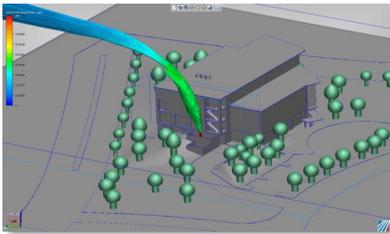
At Predictive Engineering, we developed our expertise in computational fluid dynamics (CFD) consulting with years of CFD project work in medical, aerospace, marine, HVAC, civil (e.g., gas turbine power plants) and automotive. Our work has been extensively benchmarked by experiments and in-service testing, giving us the necessary validation experience for world-class CFD service to our clients.

Our portfolio of case studies provides hard evidence of our many successful CFD consulting projects. These consulting endeavors include space-based communications equipment, hydroelectric spillways and HVAC air handling systems, to name just a few. We feel that our broad experience brings a fresh perspective to our clients' CFD challenges. This experience provides a cross-pollination between industries that have shared physics but different structures.

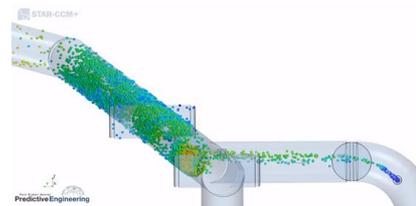
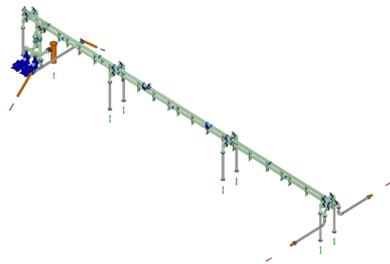
The following slides show a sample of CFD projects that are related to dispersion and particulate flow modeling. These projects span the range of applications from focused on exhaust emissions, gas dispersion, and particle flow. The primary goal in many of these analyses were to track specified minor species and ensure they were not getting drawn into inlets or to determine safe clearance spaces.

Computational Fluid Dynamics Engineering Simulation of Particulate and Smoke Dispersion for Improved Air Quality

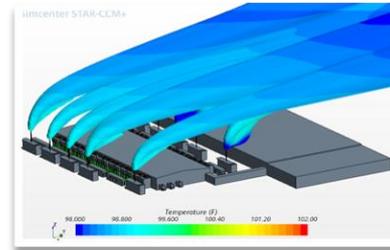
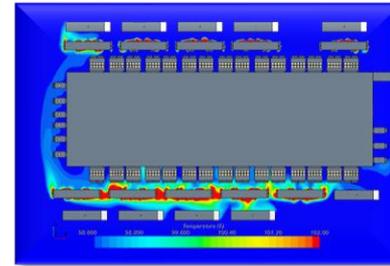
Exhaust Gas



Particulate Mixing



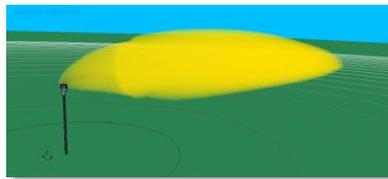
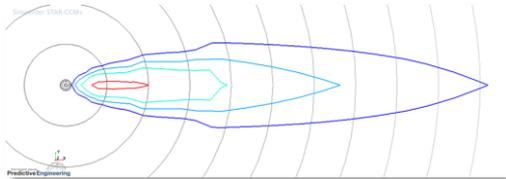
HVAC Air Quality



Boiler Optimization



Particulate Dispersion

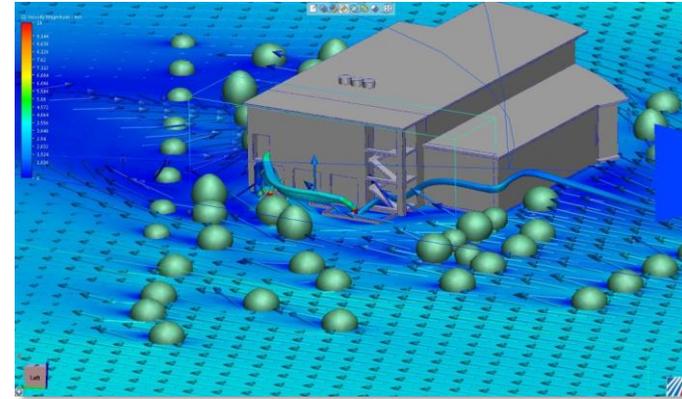


Diesel Generator Exhaust by Medical Facility

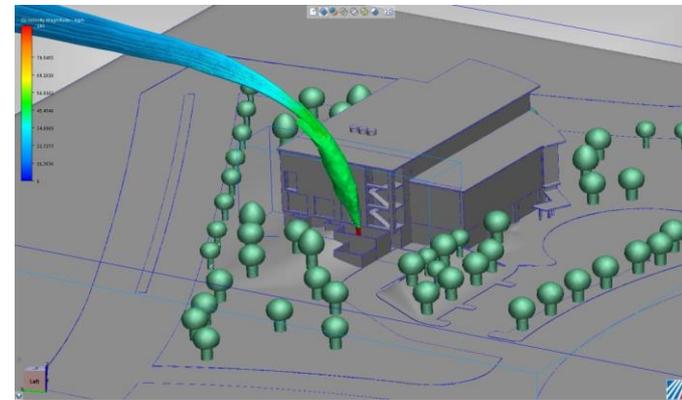
Geometry Definition



CFD Flow Results Showing Wind Patterns



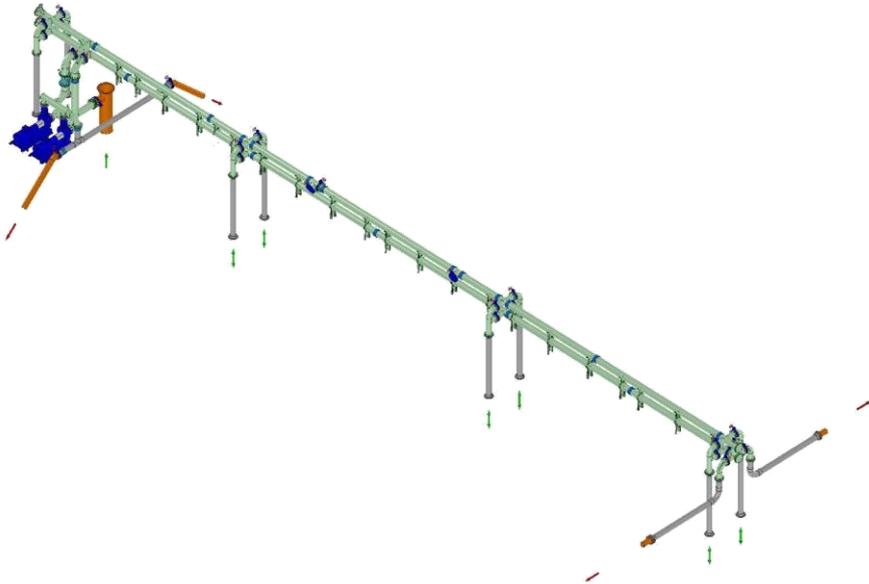
Flow Tracing of Generator Exhaust



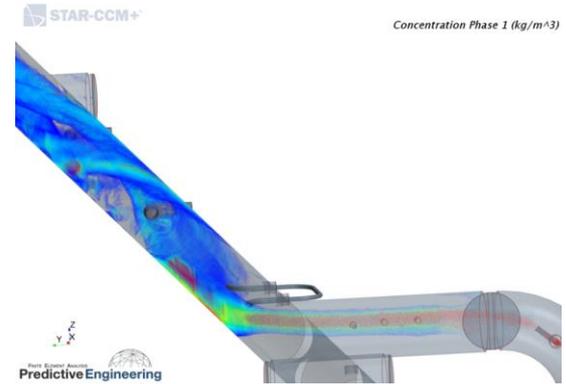
CFD simulation of air flow around the HVAC external air inlets during the emergency power supply generation (diesel engine). The flow simulation was based on prevailing wind conditions and full power generation. Results showed that the hospital's emergency room air supply would remain uncontaminated while on backup power and saved the client the expense of having to move the existing inlet.

Sediment Flow within Dredging System

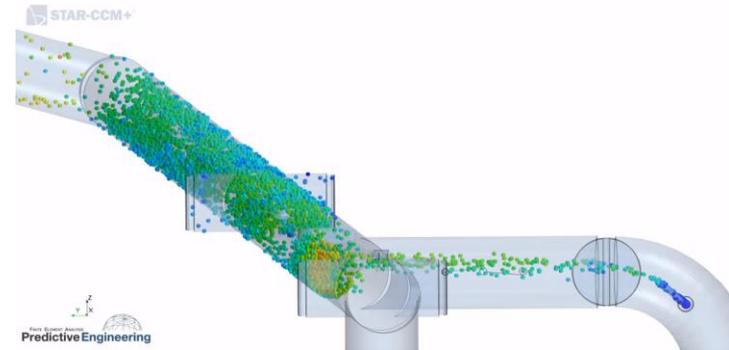
Dredging System



Particle Concentration



Flow Visualization

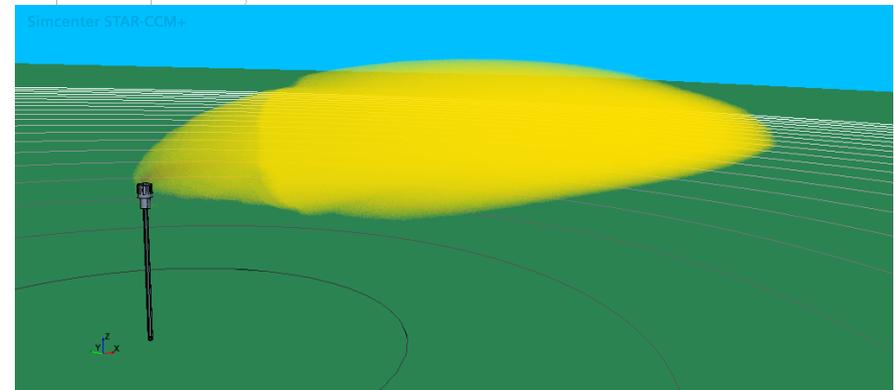
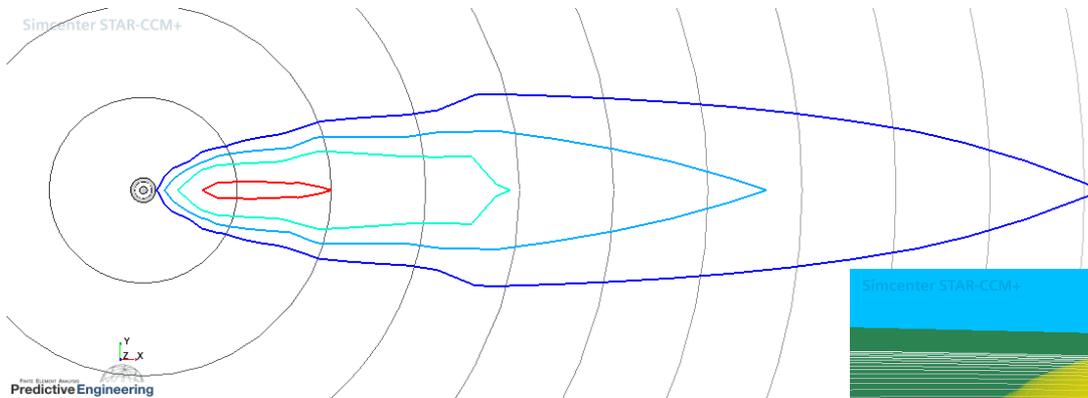
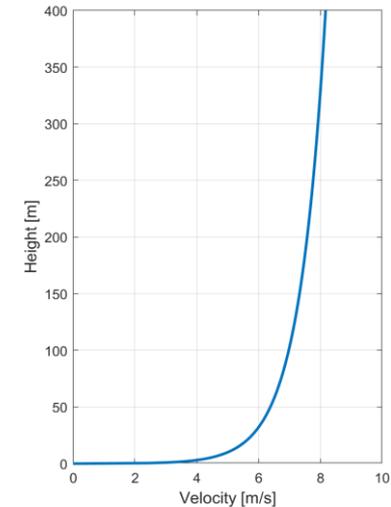


In this application we used Lagrangian multiphase models to simulate fine silt particles with sizes on the order of microns in a seawater dredging system. The Lagrangian models predict the path of the particles based on the drag and lift forces induced from the surrounding fluid. The fluid makes two 90° bends through a pipe coupling and a sharp bend through a tee, which causes a significant amount of swirl in the fluid. Our analysis showed much of the injected sediment was getting caught up in this swirl and pushed to the outside of the pipe walls. The results were able to clarify measurement observations the end-client had from test.

Flue Stack Gas Dispersion

Surface windspeed		Daytime incoming solar radiation			Nighttime cloud cover	
m/s	mi/h	Strong	Moderate	Slight	> 50%	< 50%
< 2	< 5	A	A – B	B	E	F
2 – 3	5 – 7	A – B	B	C	E	F
3 – 5	7 – 11	B	B – C	C	D	E
5 – 6	11 – 13	C	C – D	D	D	D
> 6	> 13	C	D	D	D	D

Note: Class D applies to heavily overcast skies, at any windspeed day or night

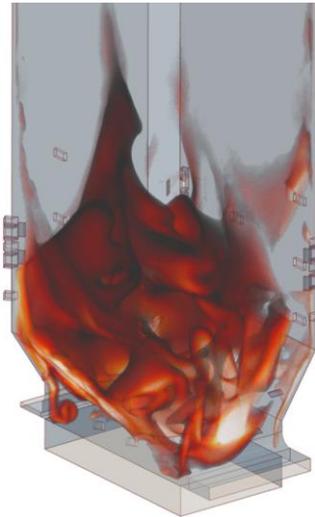


This analysis evaluated a flame out scenario where toxic gases are emitted from a flue rather than safely combusted. Different atmospheric conditions and wind speeds were evaluated to determine safe distances for locating structures and personnel so that their exposures would not exceed specified ppm levels as set by OSHA. The wind conditions were driven by Pasquill Stability class criteria which uses a logarithmic increase in wind velocity with respect to height, and linear slope on temperature to impact flow stability.

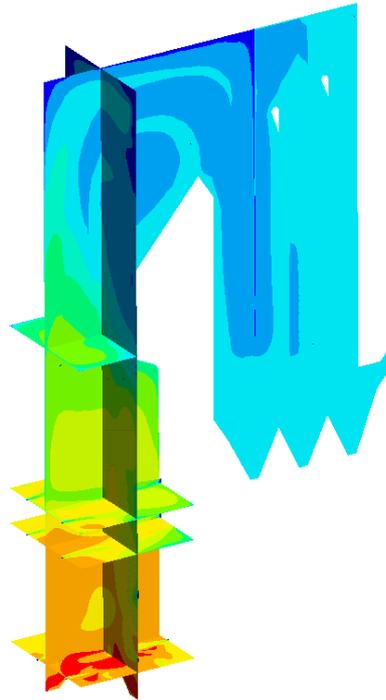
Solid Fuel Furnace Combustion

Rendered Flame in Wood Fueled Power Boiler

STAR-CCM+



CO Concentration in Recovery Boiler



Flame and Particle Tracing in Recovery Boiler

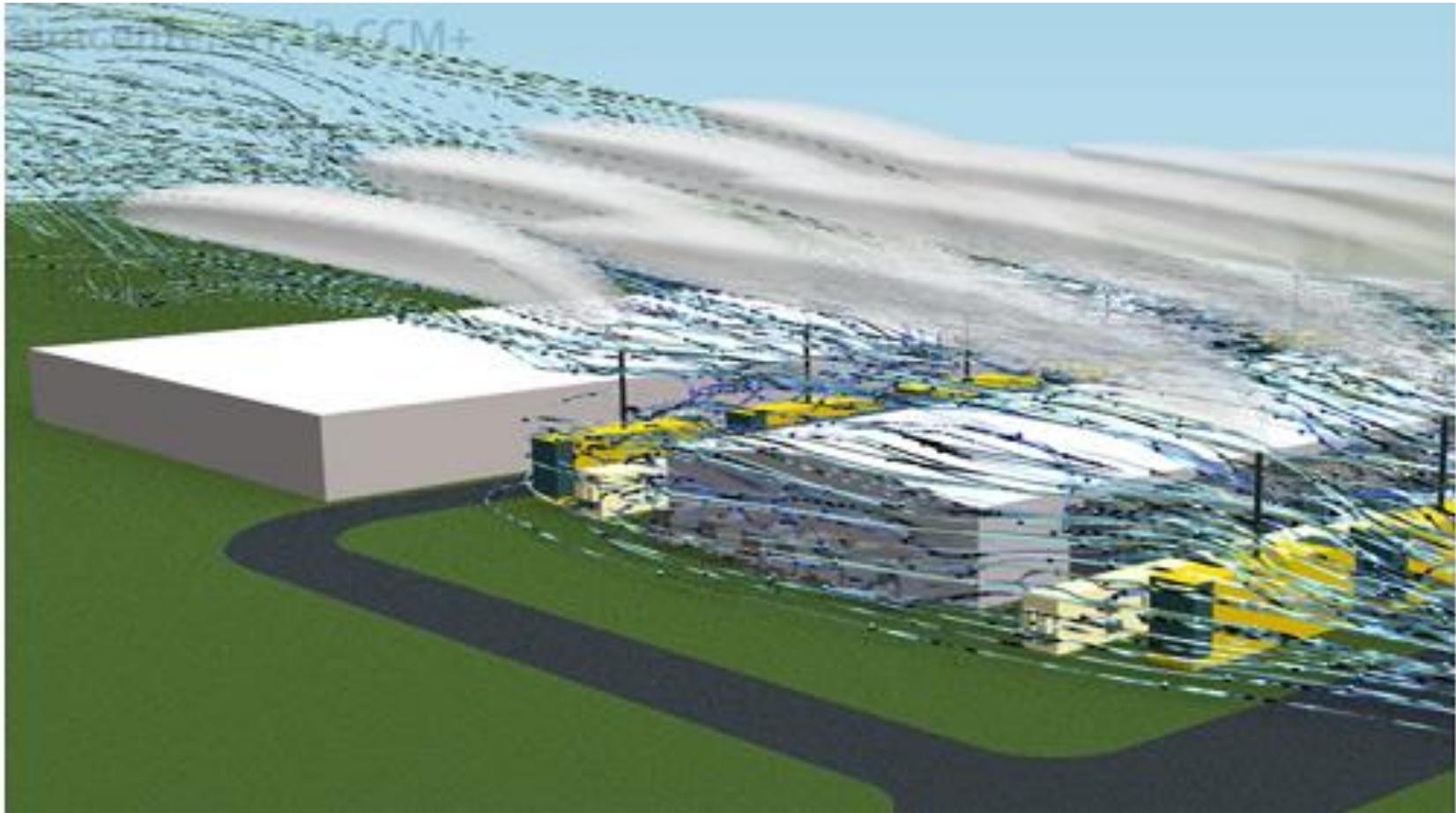
STAR-CCM+

FINITE ELEMENT ANALYSIS
Predictive Engineering



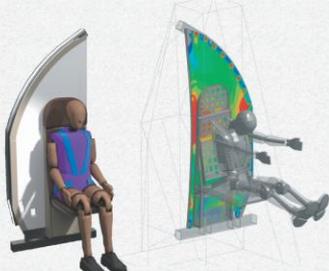
Predictive Engineering has extensive experience performing various analyses of power boilers and recovery boilers, fed by solid fuel particles. These boilers are typically fed with wood or block liquor, which can have significant moisture content. These models use reacting flow models coupled with Lagrangian particles to simulate the particle paths and the drying, devolatilization, and char burning process that occurs during combustion. The reacting flow mechanisms are coupled to radiative heat transfer to estimate flame temperatures and absorbed heat within the tube banks.

Data Center Exterior Generator Dispersion



This analysis investigated the exhaust plume of a series of backup generators for a data center. The goal was to determine if the exhaust fumes would contaminate the supply air of the cooling equipment in the data center and adjacent office building. By tracking the particulate matter in the hot exhaust air it was determined that the HVAC equipment was supplied with clean air.

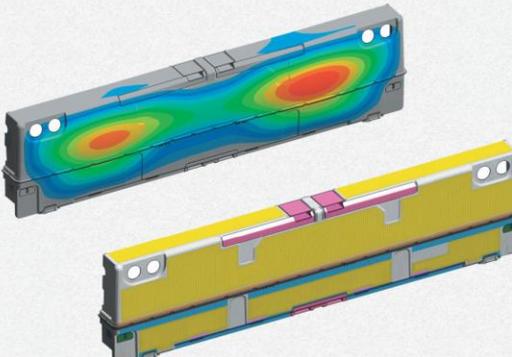
Predictive Engineering FEA and CFD Consulting Services, Portland, OR USA



FINITE ELEMENT ANALYSIS
PredictiveEngineering

Finite element analysis consulting services, software, training and technical support

- Composites, Pressure Vessels, Vibration
- NASTRAN: Linear Dynamics
- LS-DYNA: Drop-test, Impact, Burst Analysis
- STAR-CCM+: Thermal/Flow Analysis



PROJECT EXAMPLES

FAA 16g sled test validation

Femap FEA Model



FEA + LS-DYNA Model



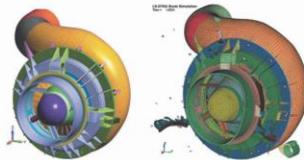
Validation is Gold



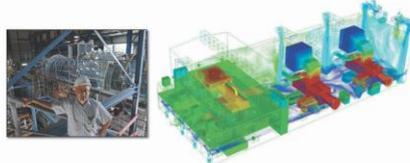
Stress and Vibration Analysis of Large Composite Container



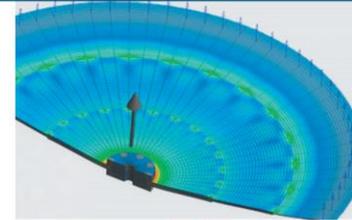
LS-DYNA turbine burst simulation



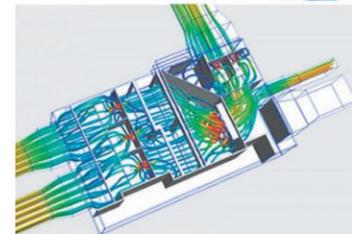
CFD study on co-generation power plant building



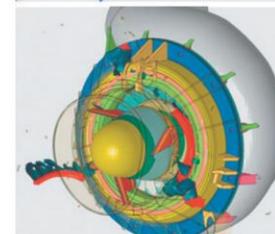
OUR SERVICES



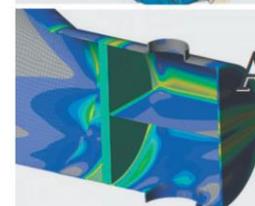
FEA



CFD



LS-DYNA



ASME BPVC

We welcome your inquiry about how we may digitally prototype your design from mechanical to thermal fluids simulation.