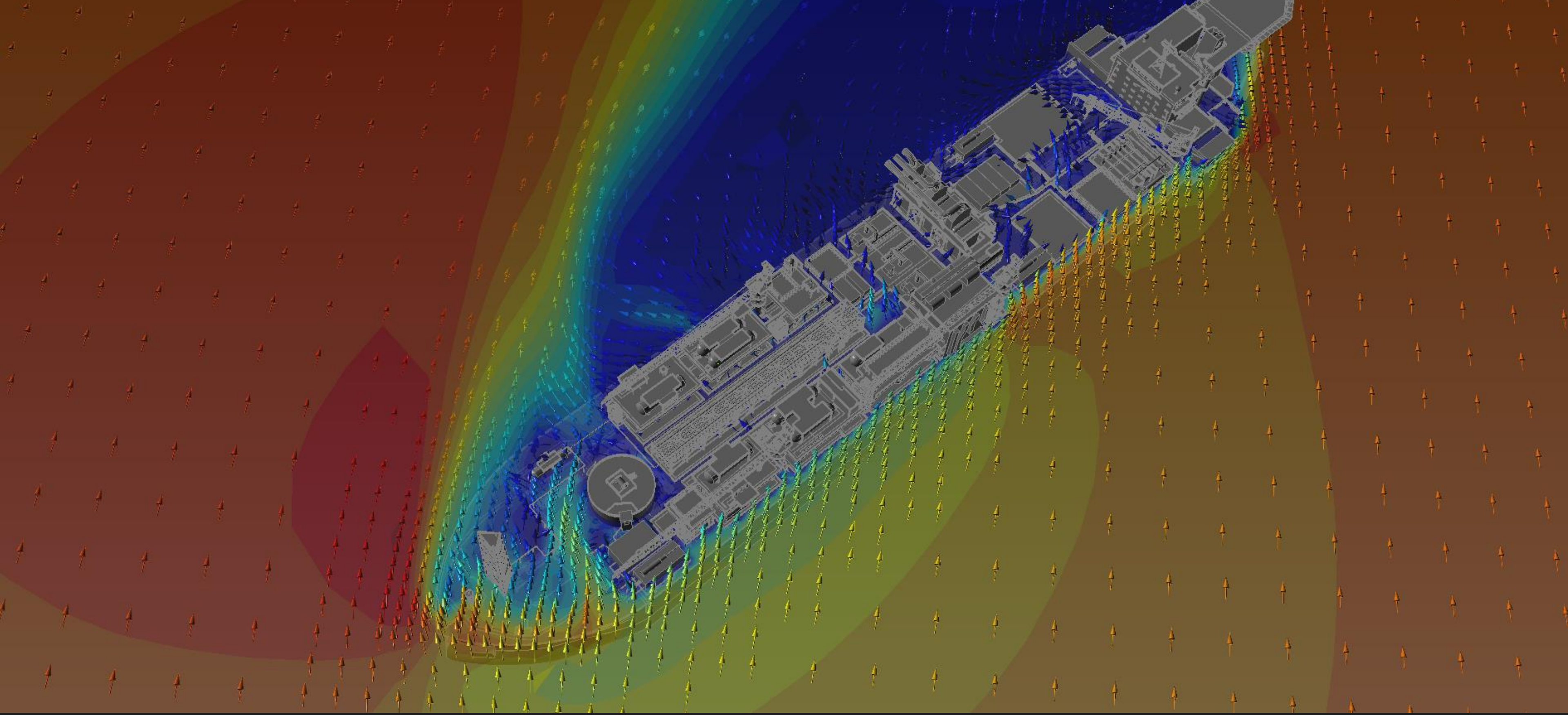


in:Flux for F&G Mapping

Developed by Insight Numerics

info@insightnumerics.com
www.insightnumerics.com

Implementation of in:Flux

- in:Flux has been designed to enable safety engineers to quickly and efficiently perform CFD studies for dispersion and ventilation analysis which can be used for F&G mapping (FGM).
  - Many performance standards are now requiring scenario or performance based methods for F&G mapping, e.g. TR84.00.07 and BP GP 30-85 (v2018).
- It is important to identify areas where gas clouds might accumulate when performing FGM analyses.
  - Ventilation simulations can assist in determining stagnant regions.
- Gas leaks can be simulated in any direction on flanges, valves, etc. to determine the resulting gas cloud.

Implementation of in:Flux

- Data such as %LFL, %UFL, %vol, and ppm of the gas cloud can be viewed at defined gas detector locations.

- Probability data can be associated with simulations to perform risk-based mapping. Detectors can be placed in optimal areas to reduce the overall risk of hazardous events.
  - Automatic optimization algorithms can be applied to maximize detector effectiveness.

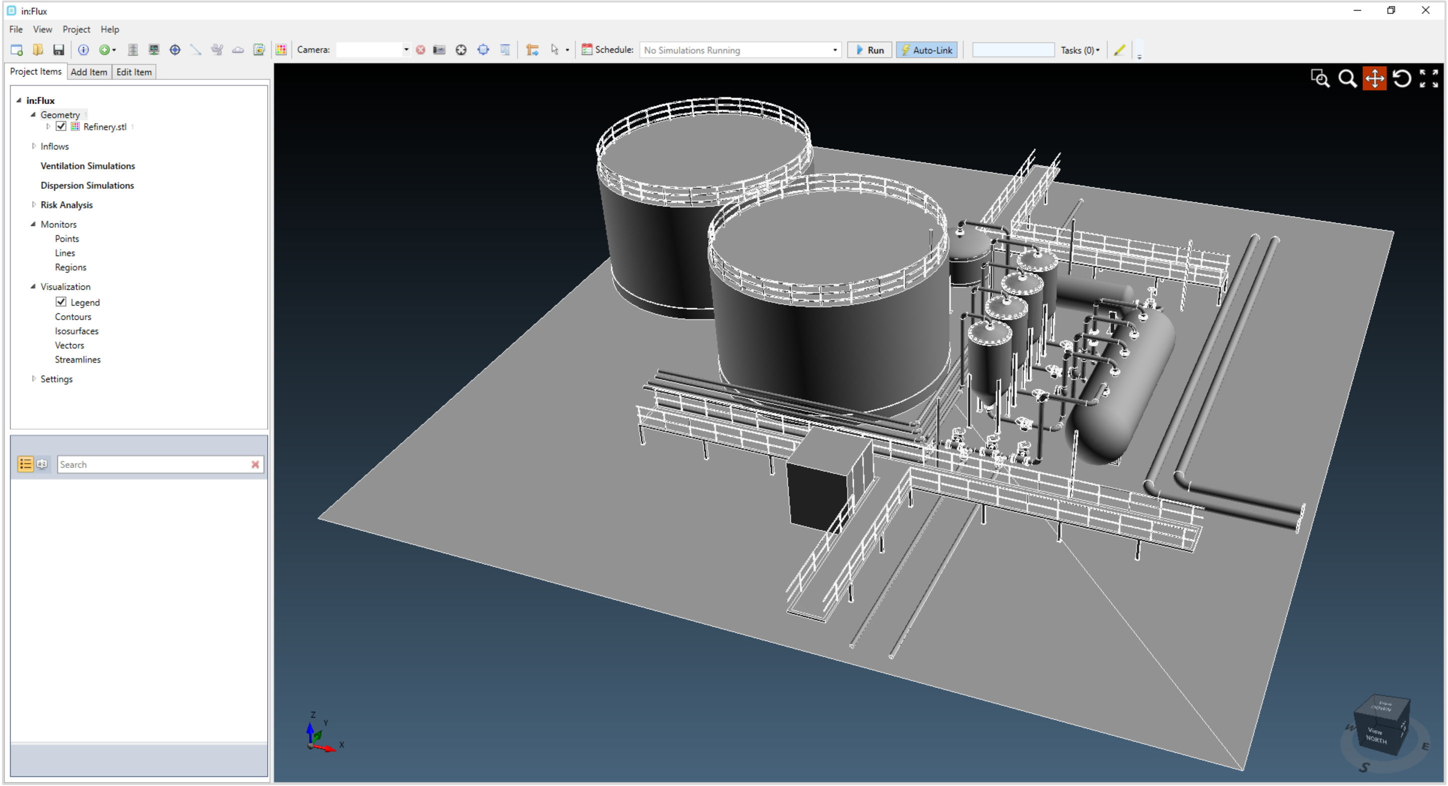
- Analyses can be combined with **Detect3D** to assess both flame detector and gas detectors using the geographic mapping method.

in:Flux FGM Analysis Steps

1. Import or create 3D model.
2. Create ventilation simulations to determine stagnant regions.
3. Define inventory (gas composition).
4. Define gas leaks (location, orientation, leak size, etc.).
5. Create dispersion simulations
6. Define monitor points (point gas detectors), monitor lines (open-path gas detectors), and monitor regions to analyze gas cloud volumes.
7. Review completed simulation data.
   a. 100% LFL gas cloud isosurface
   b. 10% LFL gas cloud isosurface
   c. LFL, %vol, and ppm data at Monitor Points
   d. LFL, %vol, and ppm data at Monitor Lines
   e. Stoichiometric Gas cloud volumes for Monitor Regions
8. Output results to Excel and screenshots of visuals.
9. (Optional) Implement risk data for simulations to generate risk matrix and optimize gas detector placements to reduce overall risk.

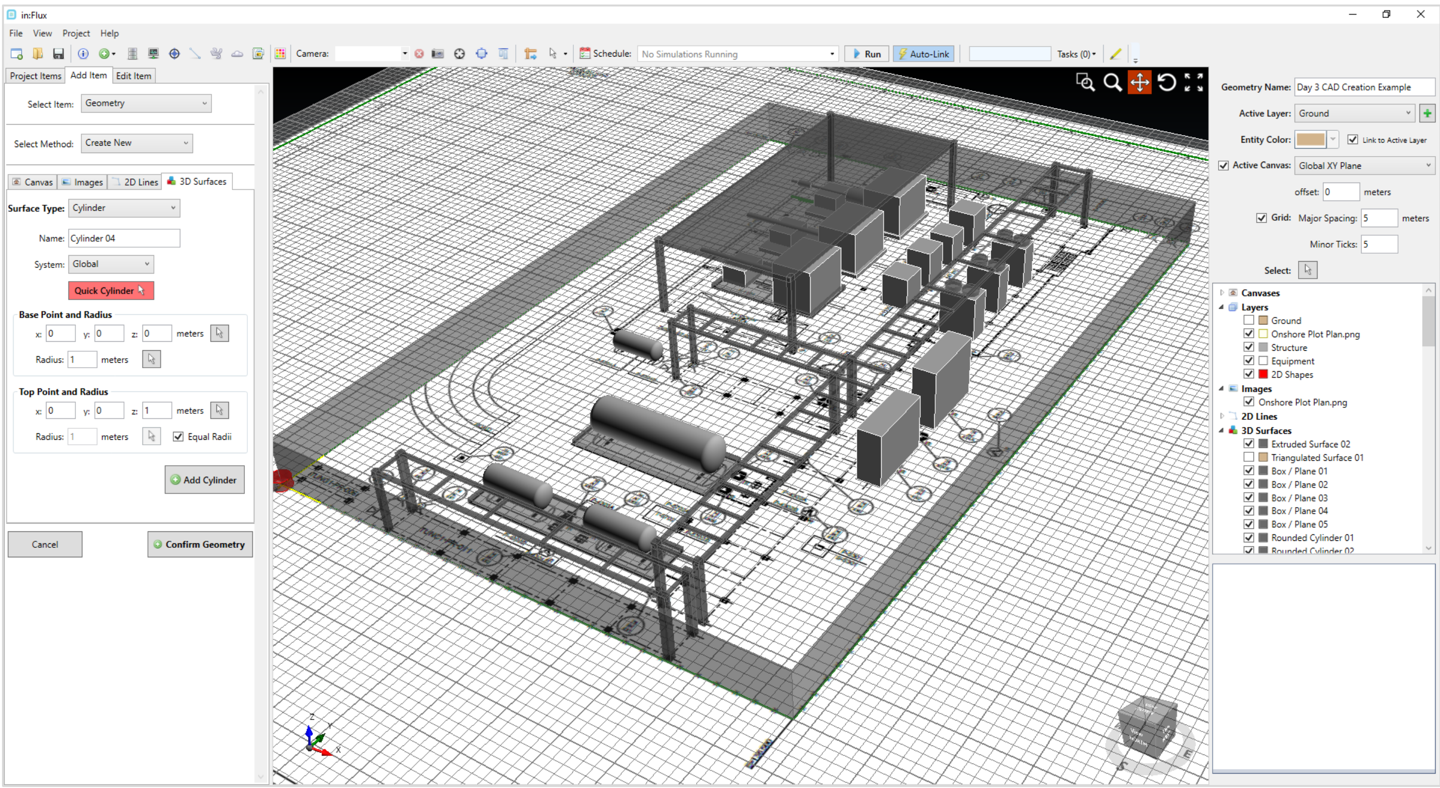
1. 3D Model Import

- Via the DGN file import, in:Flux can load **PDMS** and **SmartPlant3D** CAD models. **Navisworks (NWD)** files can be imported via DWF files. AutoCAD DWG, DXF and other standard CAD formats (STEP, IGES, OBJ and STL) are also accepted.



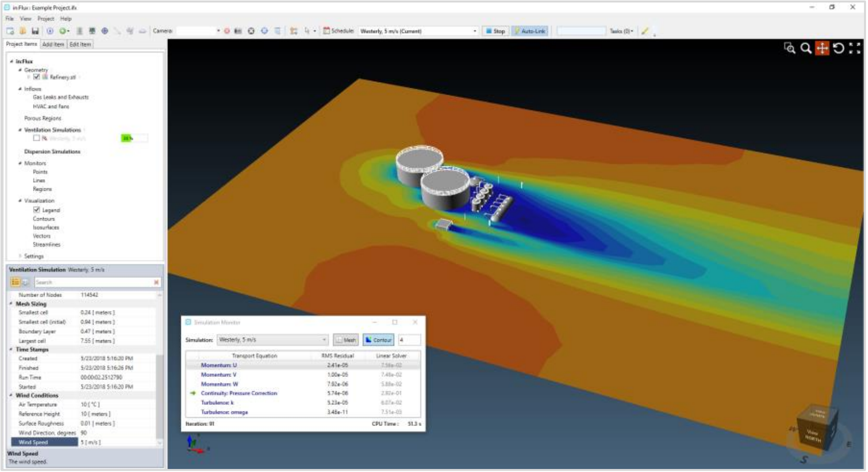
1. 3D Model Creation

- Geometry can be created directly in in:Flux – simple models can be built from drawings or plot plans when CAD files are not available. The created geometry can also be merged with CAD imported into the project.

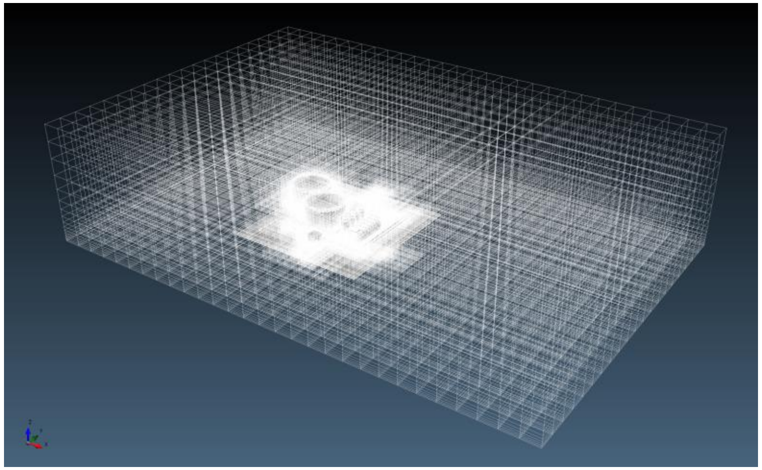


2. Ventilation Analysis

- Wind speed and direction are the only inputs necessary for ventilation simulations.
  - Complexities of the simulation are handled automatically (meshing, boundary conditions, numerical setup, etc.).



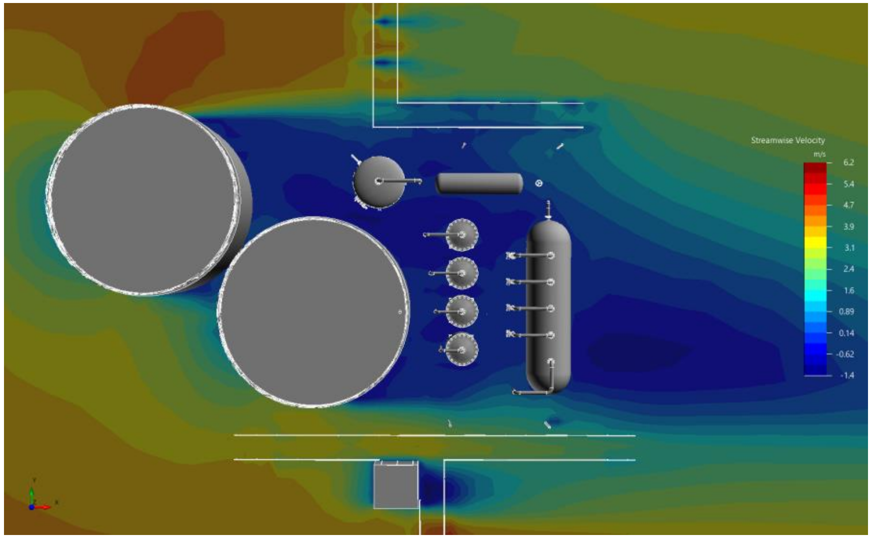
in:Flux interface displaying a contour and simulation monitor of the currently calculated ventilation for a westerly wind case.



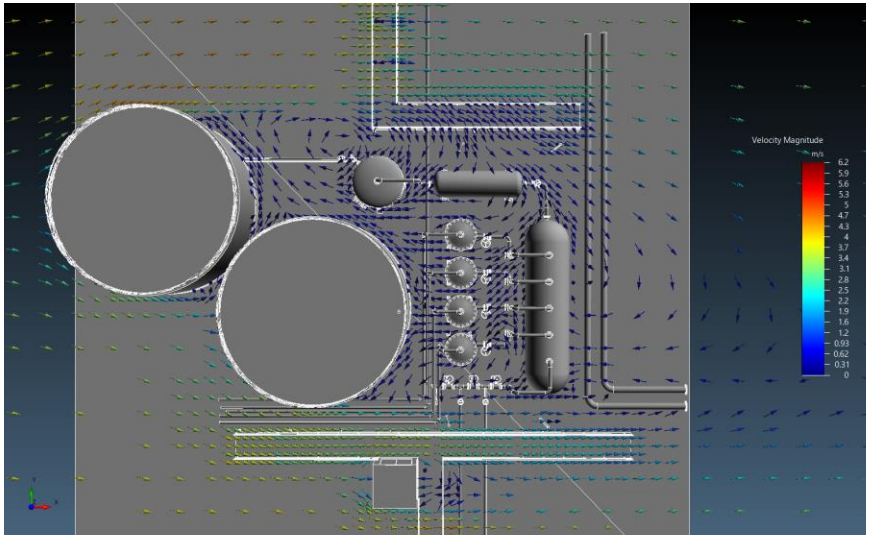
Isometric view of the automatically generated mesh around the CAD model

2. Ventilation Results

- Post processing visualization such as contours and vectors provide information on regions with low or stagnant wind speeds in the facility.
  - Stagnant regions are often good locations for detectors.



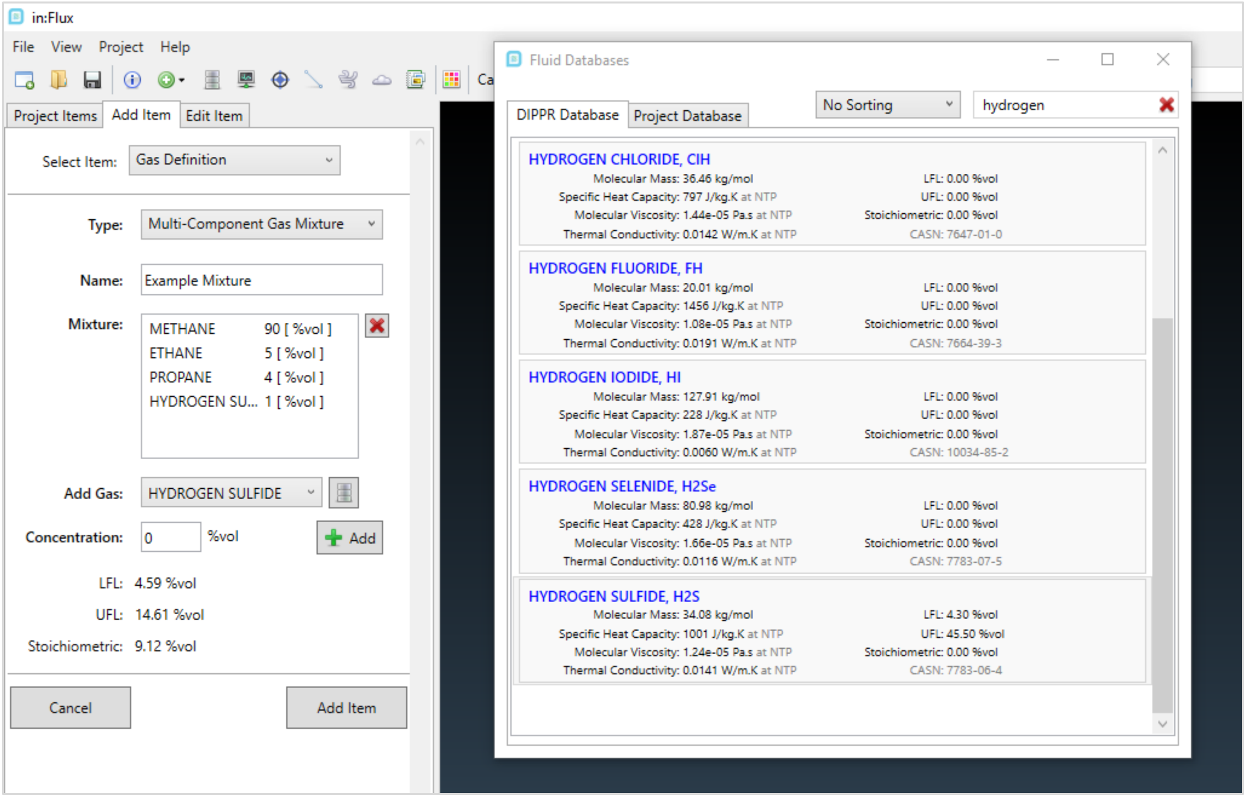
Contour showing the streamwise velocity at a 3m height across the facility for a westerly wind at 5m/s



Vectors indicating direction of the wind flow at a 3m height for a westerly wind at 5m/s

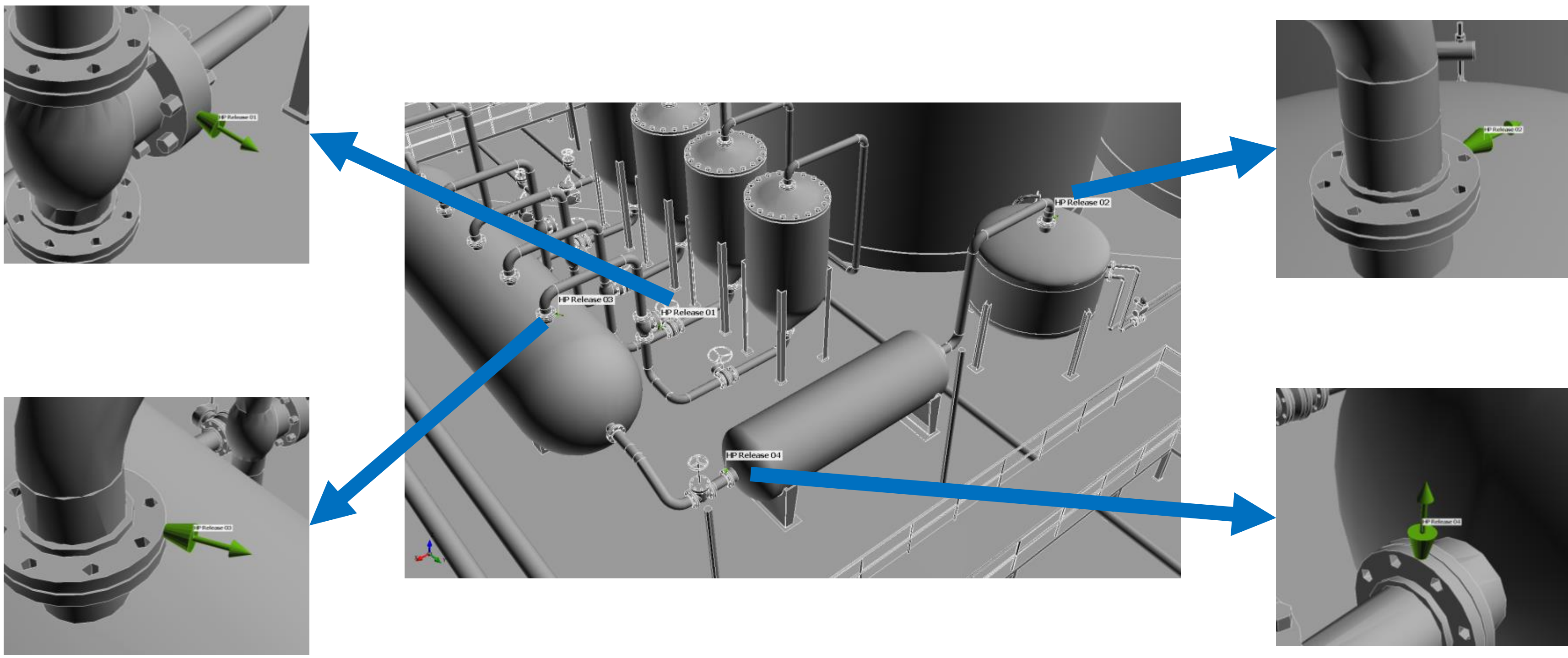
3. Gas Inventory Definition

- Many standard fluids are included from the AIChE DIPPR database.
- Custom gases and multi-component gases can also be defined.



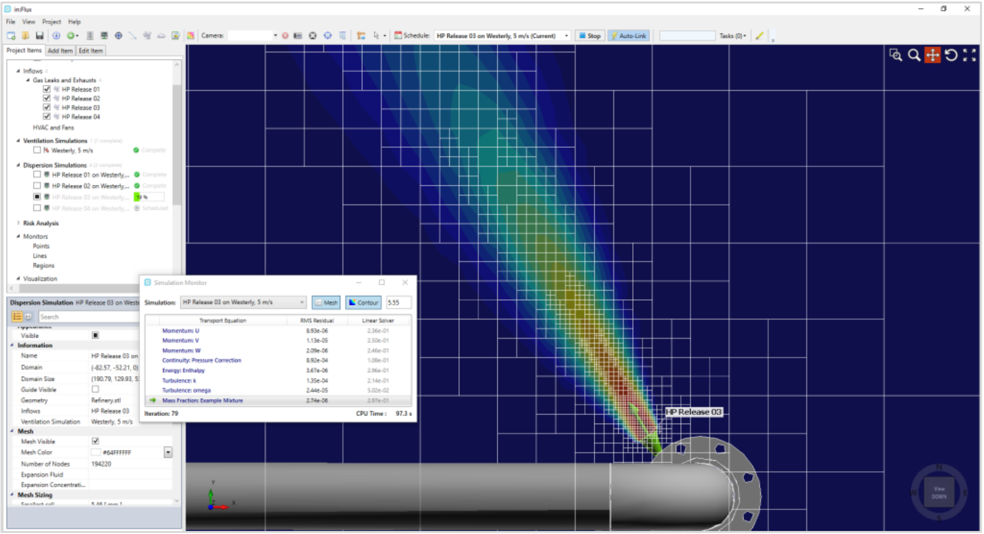
4. Definition of Gas Leak Locations

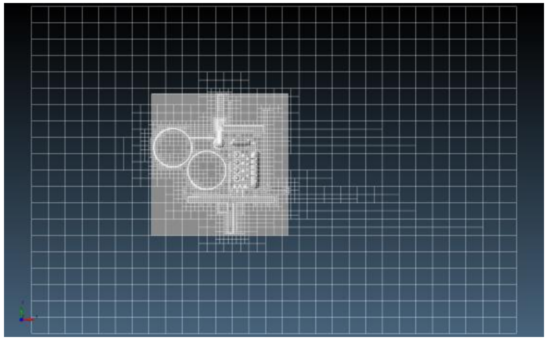
- Gas leaks are defined by clicking anywhere on the CAD model and entering an upstream pressure value, temperature and composition.
    - Leaks can be positioned in ANY direction or angle
- HVAC fans and emission sources such as exhaust plumes can also be set.

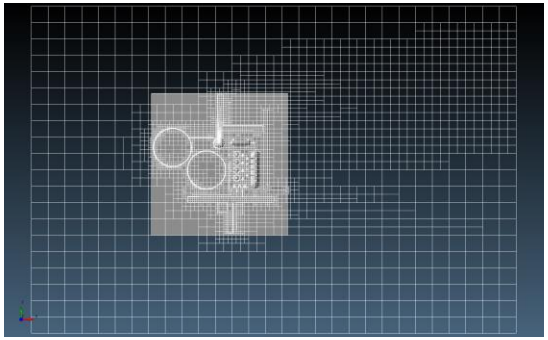


5. Dispersion Analysis – Setup and Calculation

- A dispersion simulation is created by combining a gas leak with a wind simulation. No further setup is required.
- The mesh will adapt itself throughout the domain and can be set to automatically expand to include certain concentrations.



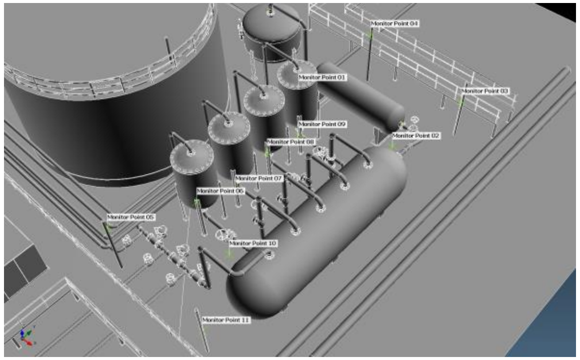


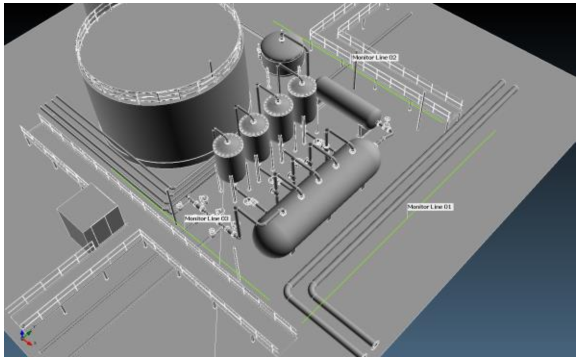


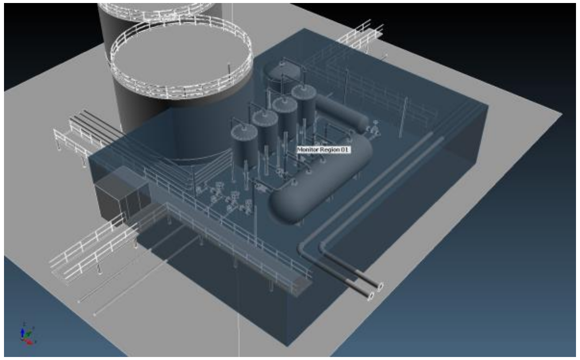
Above - Zoomed in view of mesh and mass fraction contour at a leak location. The mesh will refine itself as the calculation progresses

Upper Right and Right - Top view of the auto-generated mesh at start of dispersion simulation (upper right) and after the simulation has completed (right).

6. Monitor Definition



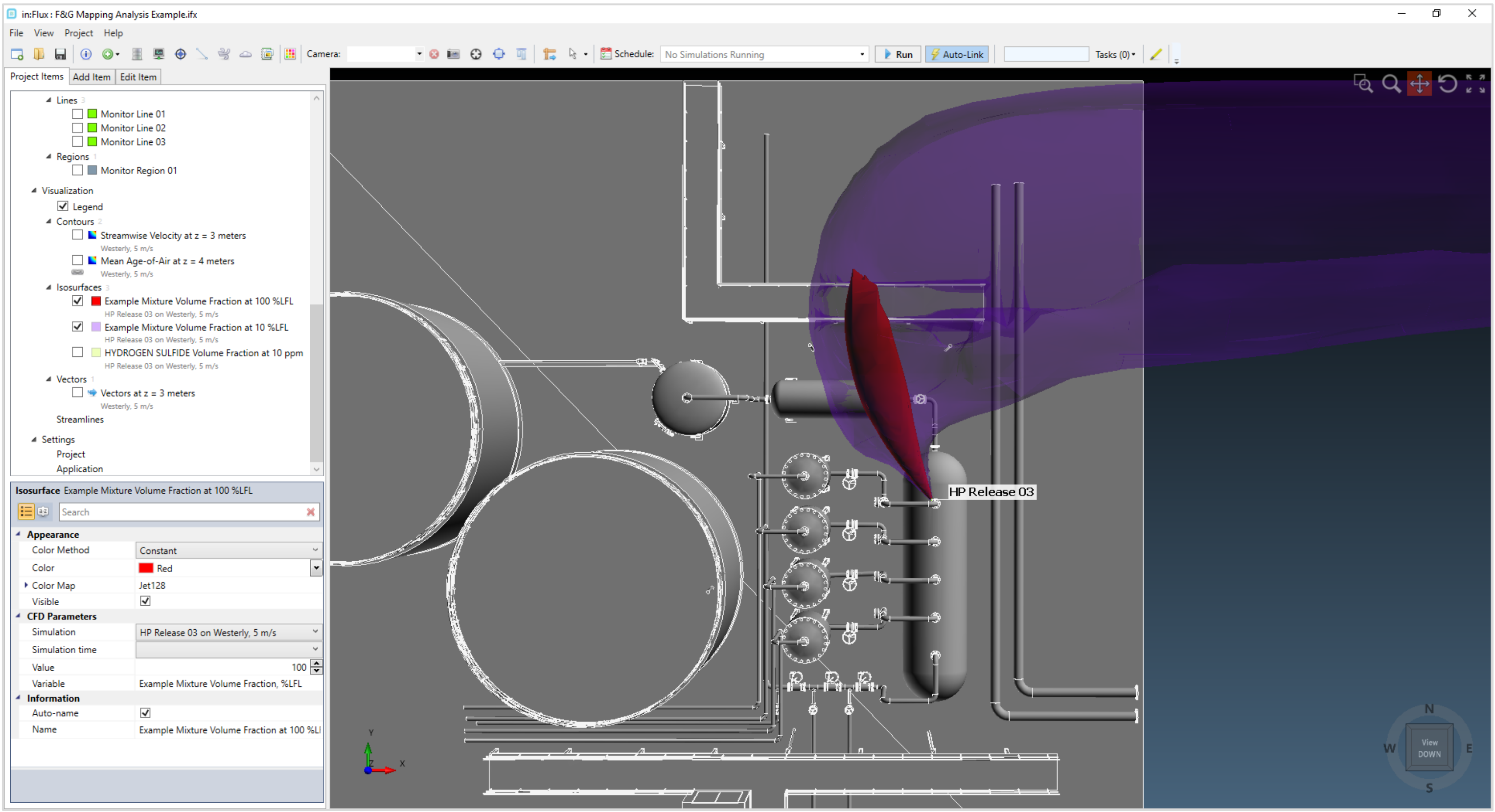




- Monitors provide measurements of concentrations and cloud volumes. All data is exportable to Excel. There is no limit to the number of monitors in an in:Flux project.
  - **Monitor Points** (top) can be used to represent point gas detectors and provide spot measurements of variables such as %LFL, %UFL, %vol, and ppm
  - **Monitor Lines** (middle) can be used to represent open-path gas detectors and provide min, max, averaged and integrated variable data such as LFL.m
  - **Monitor Regions** (bottom) provide stoichiometric gas cloud volumes as well as ventilation data such as air changes per hour
- Monitors can be added to the project before, during or after the dispersion calculation has finished.

7. Review Dispersion Data - Isosurface

- Isosurfaces are useful to show the dispersed gas clouds. These can be set up as concentrations of %volume, ppm, %LFL and %UFL.



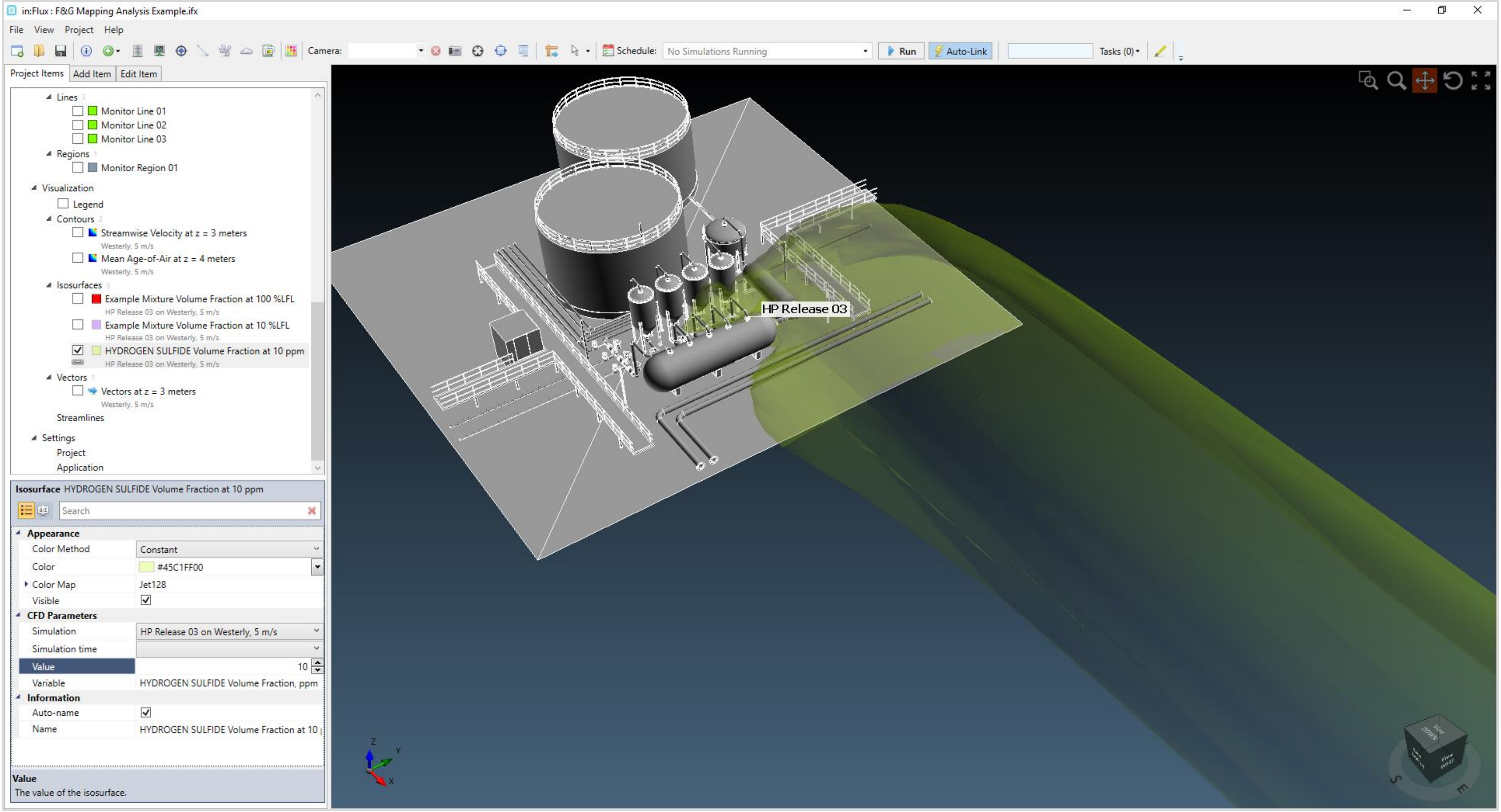
100% LFL cloud (red), 10%LFL cloud (blue)

Developed by Insight Numerics
www.insightnumerics.com

in:Flux INTELLIGENT CFD SOFTWARE

7. Review Dispersion Data - Isosurface

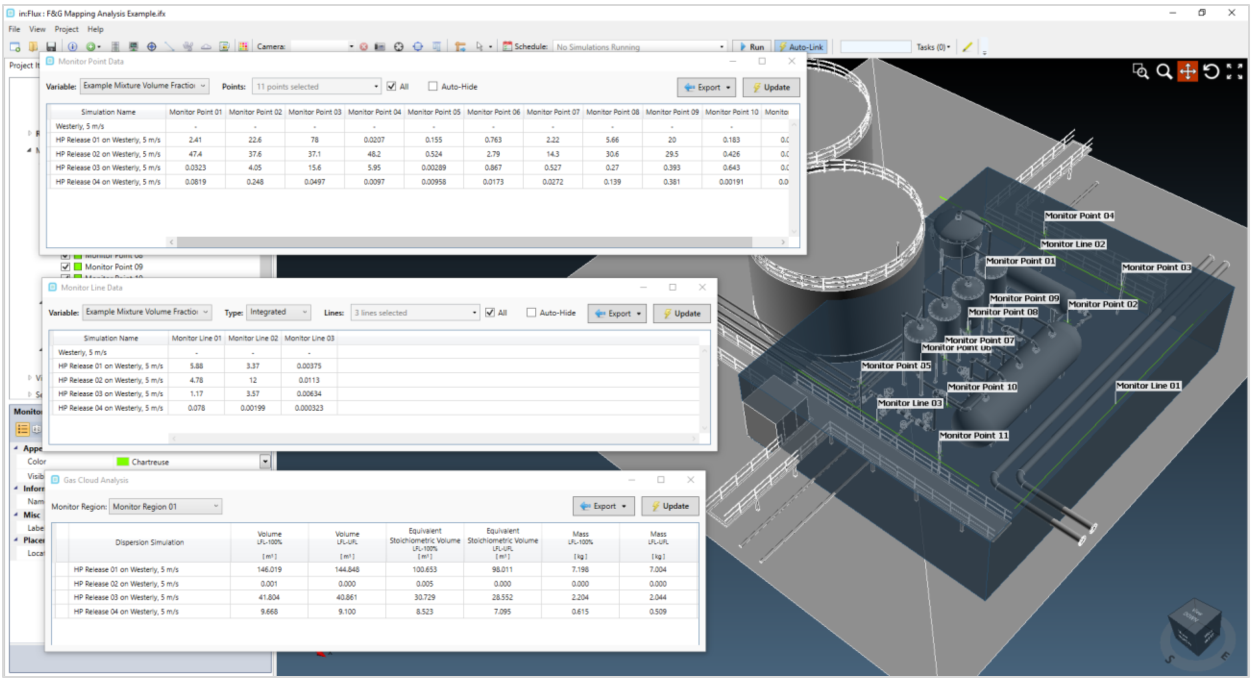
- For multi-component mixtures, isosurfaces can be generated for any component in the gas individually or as the bulk mixture.



10ppm H2S cloud

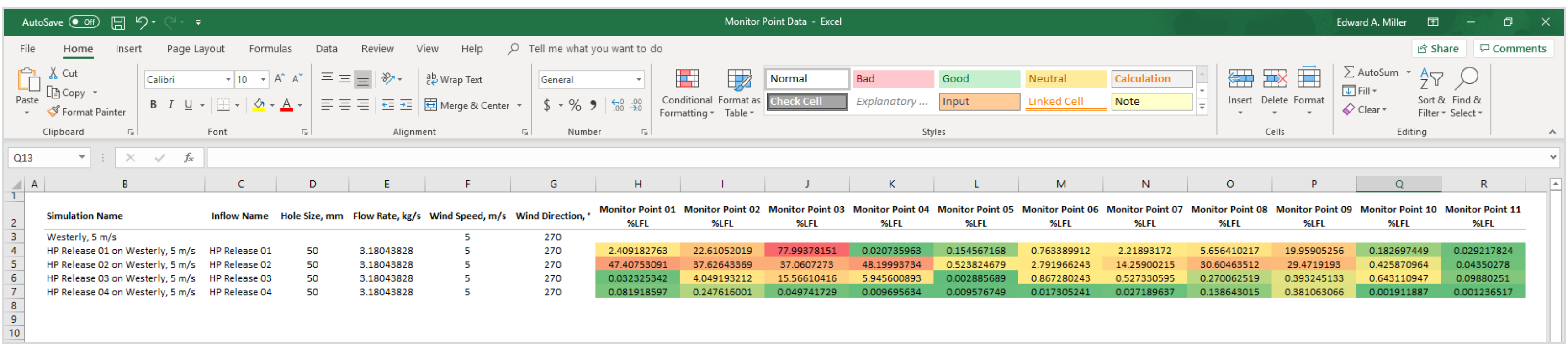
7. Review Dispersion Data - Monitors

- In addition to the visualizations, concentration and volume data (e.g. LFL, %vol, and ppm) at each of the monitors can be obtained and exported to Excel.
  - Monitor Point Data (top window) shows the bulk %LFL value at each point for each dispersion case completed
  - Monitor Line Data (middle window) shows the bulk LFL.m for each line and each case
  - Monitor Region Data (bottom window) shows the calculated gas cloud volumes



8. Output and Assess Results

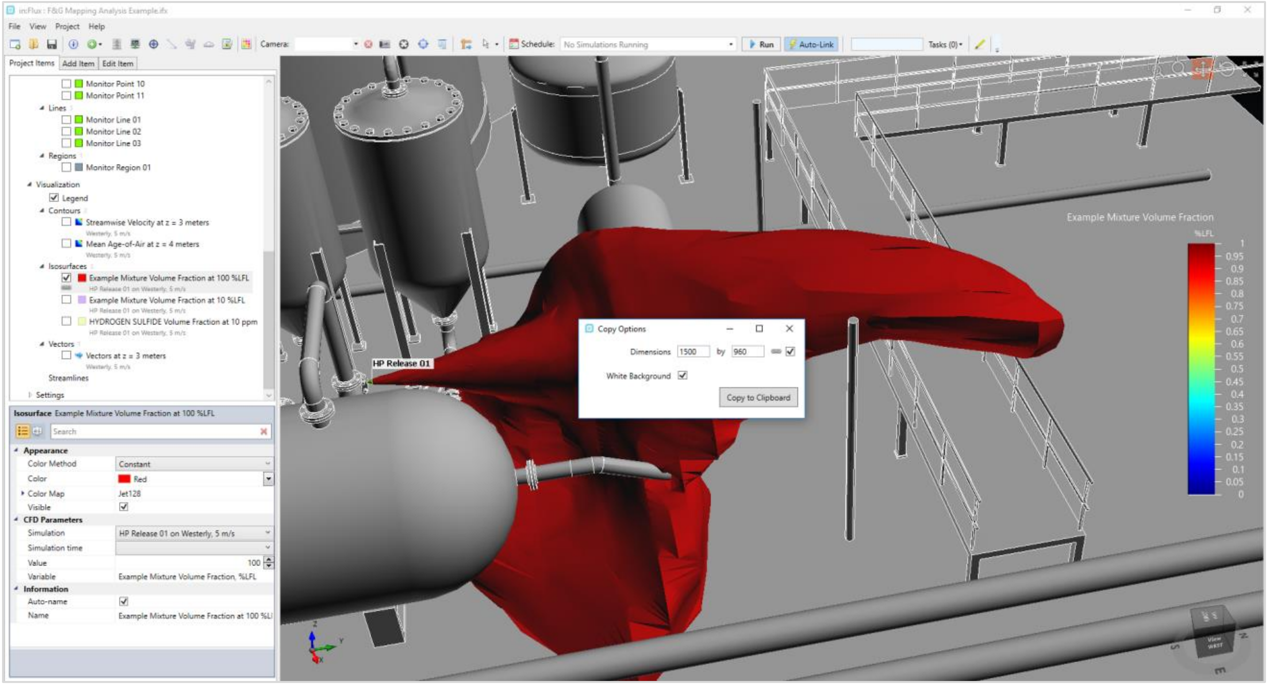
- Monitor Data exported to excel will display monitor information about each case simulated.
- Below shows conditional formatting applied to the Monitor Point data indicating which point detectors had the highest %LFL values for the cases simulated.
  - This information can then be used to run more cases and/or reposition monitor points to detect more cases.



Simulation Name	Inflow Name	Hole Size, mm	Flow Rate, kg/s	Wind Speed, m/s	Wind Direction, °	Monitor Point 01 %LFL	Monitor Point 02 %LFL	Monitor Point 03 %LFL	Monitor Point 04 %LFL	Monitor Point 05 %LFL	Monitor Point 06 %LFL	Monitor Point 07 %LFL	Monitor Point 08 %LFL	Monitor Point 09 %LFL	Monitor Point 10 %LFL	Monitor Point 11 %LFL
Westerly, 5 m/s				5	270											
HP Release 01 on Westerly, 5 m/s	HP Release 01	50	3.18043828	5	270	2.409182763	22.61052019	77.99378151	0.020735963	0.154567168	0.763389912	2.21893172	5.656410217	19.95905256	0.182697449	0.029217824
HP Release 02 on Westerly, 5 m/s	HP Release 02	50	3.18043828	5	270	47.40753091	37.62643369	37.0607273	48.19993734	0.523824679	2.791966243	14.25900215	30.60463512	29.4719193	0.425870964	0.04350278
HP Release 03 on Westerly, 5 m/s	HP Release 03	50	3.18043828	5	270	0.032325342	4.049193212	15.56610416	5.945600893	0.002885689	0.867280243	0.527330595	0.270062519	0.393245133	0.643110947	0.09880251
HP Release 04 on Westerly, 5 m/s	HP Release 04	50	3.18043828	5	270	0.081918597	0.247616001	0.049741729	0.009695634	0.009576749	0.017305241	0.027189637	0.138643015	0.381063066	0.001911887	0.001236517

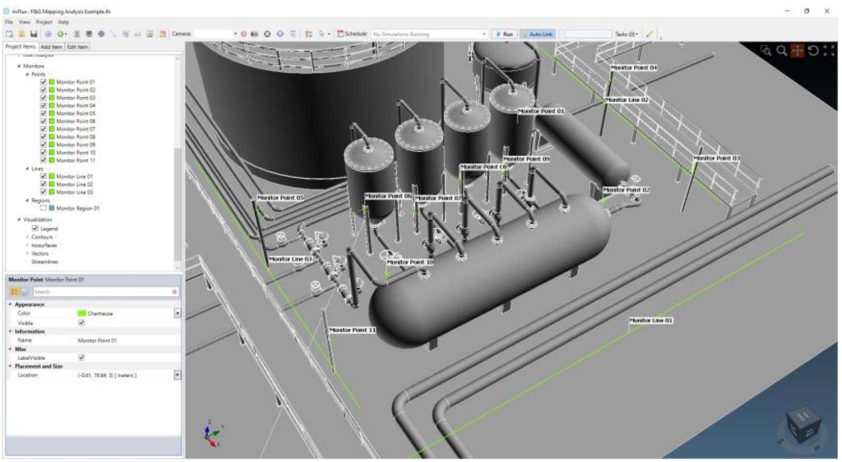
8. Output Screenshots

- Any view in the 3D window of Detect3D can be saved to the clipboard as a screenshot.
- Camera positions of the 3D window can be saved to quickly return to the exact views of exported figures or images.

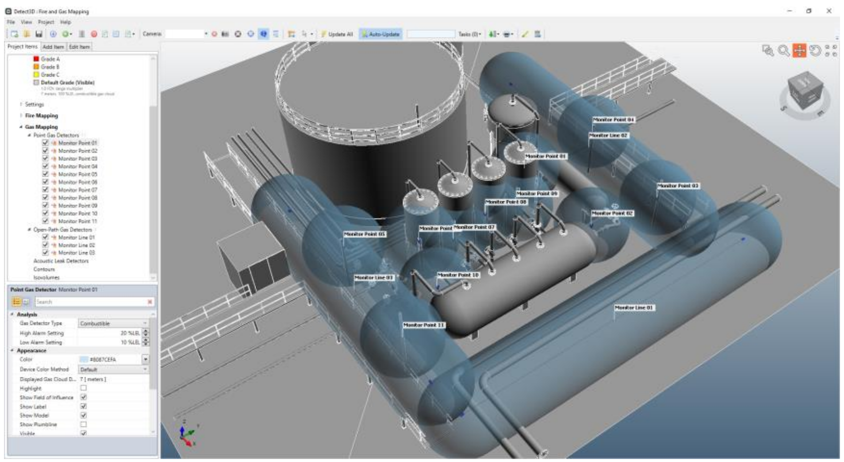


8. Output to Detect3D

- For comparison to geographic gas mapping, monitor points and monitor lines can be imported to Detect3D to view achieved coverage percentages.



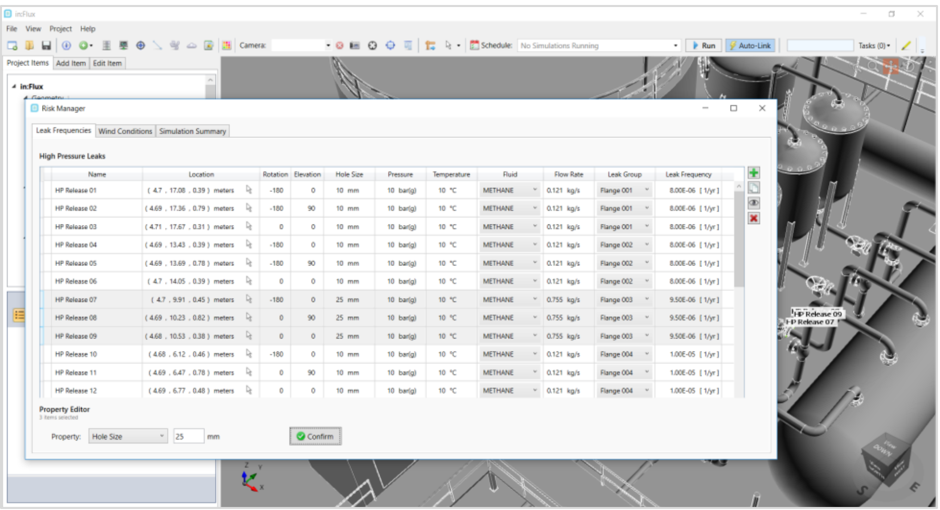
in:Flux – CAD model, monitor points, monitor lines, and monitor regions defined using in:Flux

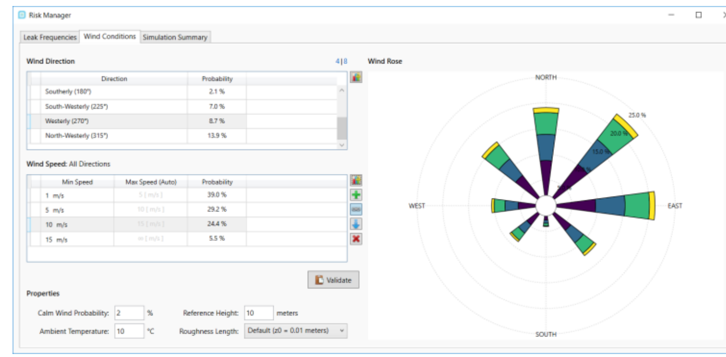


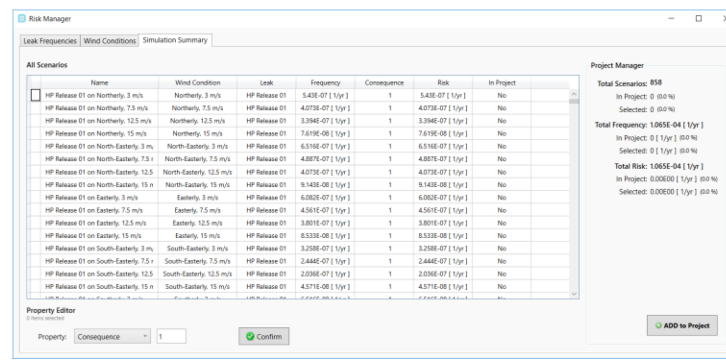
Detect3D – in:Flux project imported to Detect3D. Monitors now show up as point gas detectors, open-path gas detectors, and zones.

9. Risk Analysis and Gas Detector Optimization

- Use the Risk Manager to create all simulations needed for risk analysis:
  - Input wind data from the site (speed, direction, probability)
  - Create leaks and assign frequency data
  - Simulations will be automatically generated to cover all scenarios



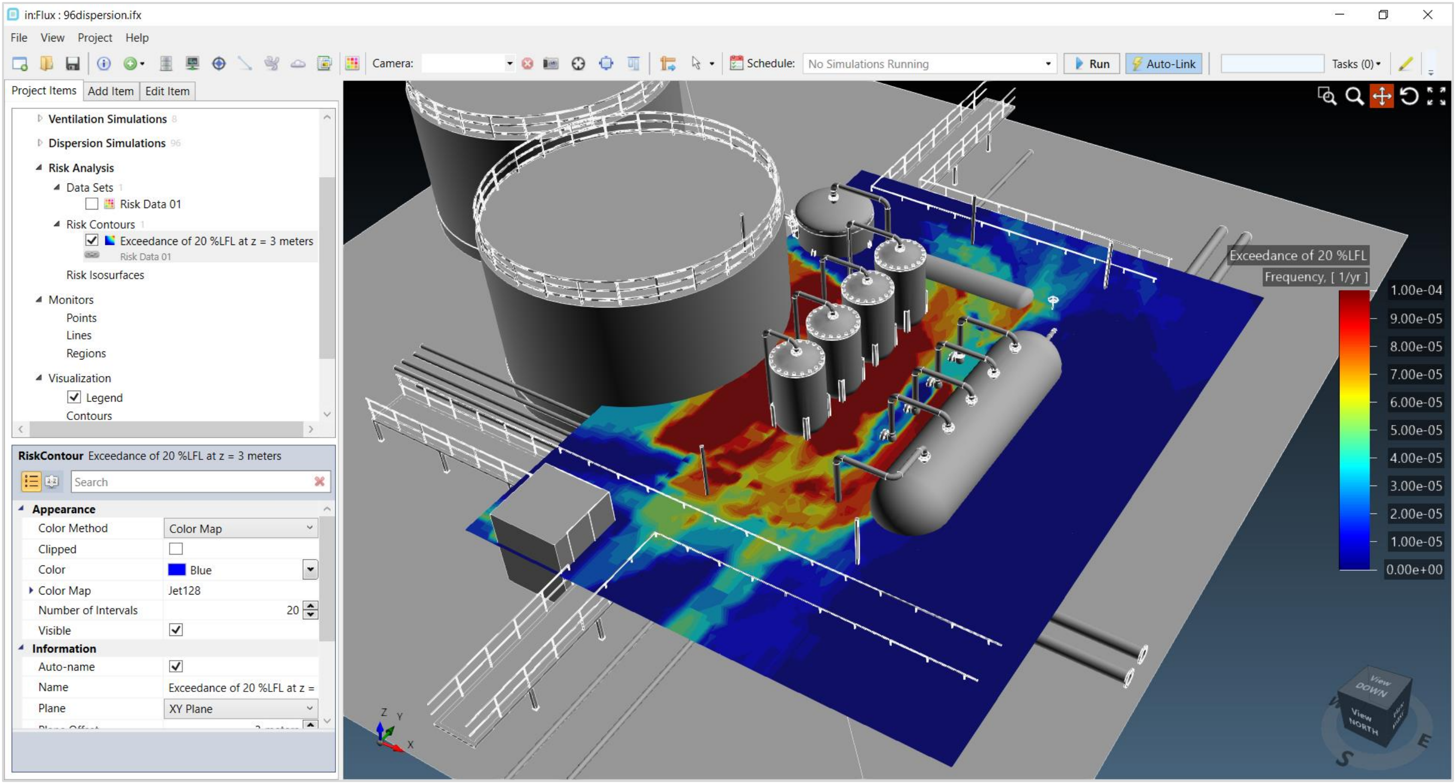




Above – Risk Manager Window showing a series of defined leaks, cases can be quickly duplicated and edited in bulk
Upper Right - The Wind Rose tab can be used to set the environmental conditions on the site.
Lower Right - The full scenario matrix combining all leaks and wind data is shown on the final tab. The example shows the 858 simulations to be run.

9. Risk Analysis and Gas Detector Optimization

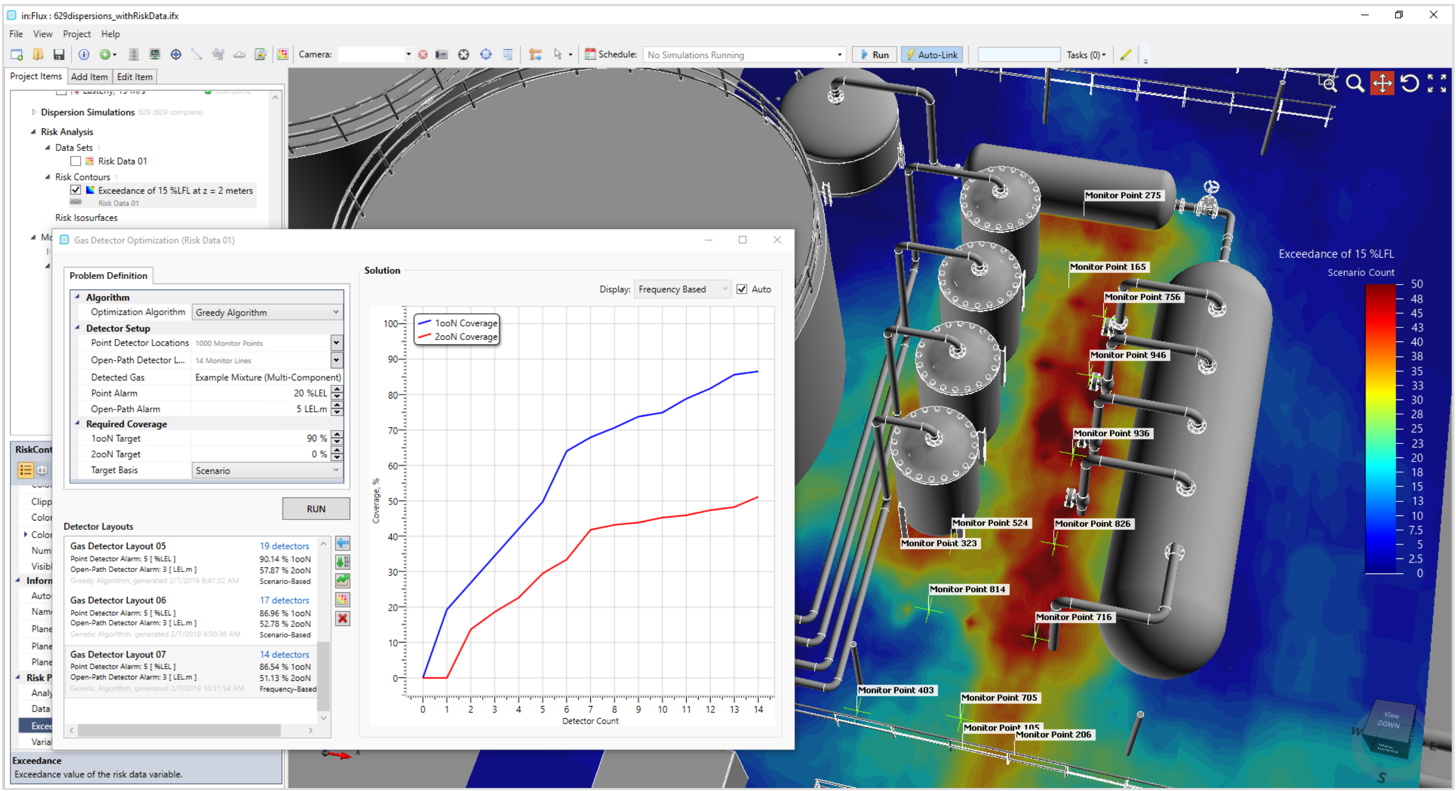
- Once the simulations have completed, risk-based visualizations such as exceedance of gas concentrations can be displayed with contours or isosurfaces.



20% LFL methane concentration by frequency

9. Risk Analysis and Gas Detector Optimization

- Optimal gas detector layouts are created using the optimization tool for a given zone.
  - Input alarm levels for point/open-path, coverage targets, and the basis for the optimization (scenario/frequency/risk)

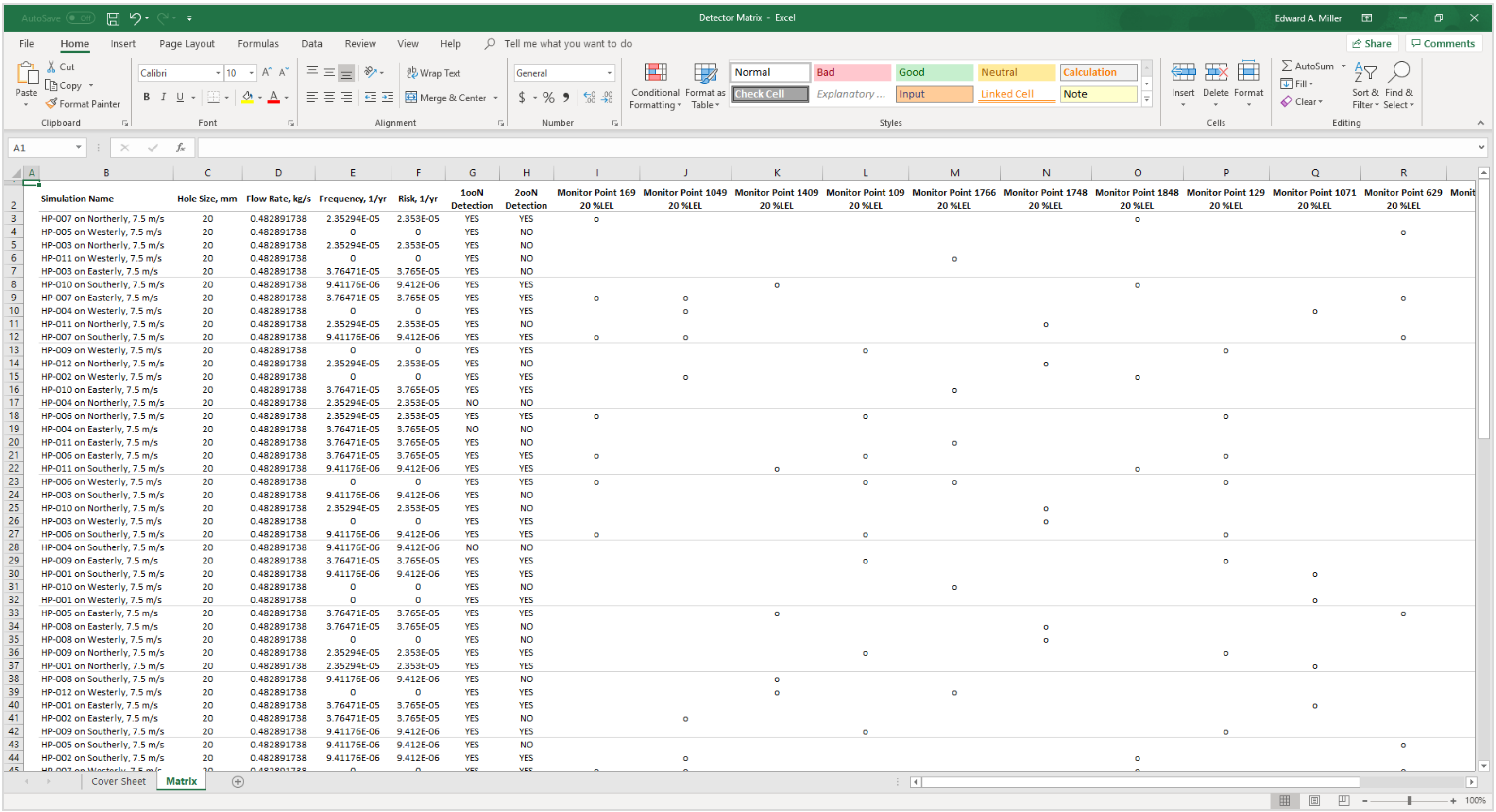


Optimized gas detector layout for specified alarm settings

Developed by Insight Numerics
www.insightnumerics.com

9. Risk Analysis and Gas Detector Optimization

- For each optimized layout, the associated detector matrix or Detect3D project file can be exported. The matrix shows which detectors go into alarm for each of the completed simulations in the in:Flux project.



	Simulation Name	Hole Size, mm	Flow Rate, kg/s	Frequency, 1/yr	Risk, 1/yr	1ooN Detection	2ooN Detection	Monitor Point 169 20 %LEL	Monitor Point 1049 20 %LEL	Monitor Point 1409 20 %LEL	Monitor Point 109 20 %LEL	Monitor Point 1766 20 %LEL	Monitor Point 1748 20 %LEL	Monitor Point 1848 20 %LEL	Monitor Point 129 20 %LEL	Monitor Point 1071 20 %LEL	Monitor Point 629 20 %LEL
3	HP-007 on Northerly, 7.5 m/s	20	0.482891738	2.35294E-05	2.353E-05	YES	YES	o						o			
4	HP-005 on Westerly, 7.5 m/s	20	0.482891738	0	0	YES	NO										o
5	HP-003 on Northerly, 7.5 m/s	20	0.482891738	2.35294E-05	2.353E-05	YES	NO										
6	HP-011 on Westerly, 7.5 m/s	20	0.482891738	0	0	YES	NO					o					
7	HP-003 on Easterly, 7.5 m/s	20	0.482891738	3.76471E-05	3.765E-05	YES	NO										
8	HP-010 on Southerly, 7.5 m/s	20	0.482891738	9.41176E-06	9.412E-06	YES	YES			o				o			
9	HP-007 on Easterly, 7.5 m/s	20	0.482891738	3.76471E-05	3.765E-05	YES	YES	o	o								o
10	HP-004 on Westerly, 7.5 m/s	20	0.482891738	0	0	YES	YES		o							o	
11	HP-011 on Northerly, 7.5 m/s	20	0.482891738	2.35294E-05	2.353E-05	YES	NO						o				
12	HP-007 on Southerly, 7.5 m/s	20	0.482891738	9.41176E-06	9.412E-06	YES	YES	o	o								o
13	HP-009 on Westerly, 7.5 m/s	20	0.482891738	0	0	YES	YES				o				o		
14	HP-012 on Northerly, 7.5 m/s	20	0.482891738	2.35294E-05	2.353E-05	YES	NO						o				
15	HP-002 on Westerly, 7.5 m/s	20	0.482891738	0	0	YES	YES		o					o			
16	HP-010 on Easterly, 7.5 m/s	20	0.482891738	3.76471E-05	3.765E-05	YES	YES					o					
17	HP-004 on Northerly, 7.5 m/s	20	0.482891738	2.35294E-05	2.353E-05	NO	NO										
18	HP-006 on Northerly, 7.5 m/s	20	0.482891738	2.35294E-05	2.353E-05	YES	YES	o			o				o		
19	HP-004 on Easterly, 7.5 m/s	20	0.482891738	3.76471E-05	3.765E-05	NO	NO										
20	HP-011 on Easterly, 7.5 m/s	20	0.482891738	3.76471E-05	3.765E-05	YES	NO					o					
21	HP-006 on Easterly, 7.5 m/s	20	0.482891738	3.76471E-05	3.765E-05	YES	YES	o			o				o		
22	HP-011 on Southerly, 7.5 m/s	20	0.482891738	9.41176E-06	9.412E-06	YES	YES			o				o			
23	HP-006 on Westerly, 7.5 m/s	20	0.482891738	0	0	YES	YES	o			o	o			o		
24	HP-003 on Southerly, 7.5 m/s	20	0.482891738	9.41176E-06	9.412E-06	YES	NO										
25	HP-010 on Northerly, 7.5 m/s	20	0.482891738	2.35294E-05	2.353E-05	YES	NO						o				
26	HP-003 on Westerly, 7.5 m/s	20	0.482891738	0	0	YES	YES						o				
27	HP-006 on Southerly, 7.5 m/s	20	0.482891738	9.41176E-06	9.412E-06	YES	YES	o			o				o		
28	HP-004 on Southerly, 7.5 m/s	20	0.482891738	9.41176E-06	9.412E-06	NO	NO										
29	HP-009 on Easterly, 7.5 m/s	20	0.482891738	3.76471E-05	3.765E-05	YES	YES				o				o		
30	HP-001 on Southerly, 7.5 m/s	20	0.482891738	9.41176E-06	9.412E-06	YES	YES									o	
31	HP-010 on Westerly, 7.5 m/s	20	0.482891738	0	0	YES	NO					o					
32	HP-001 on Westerly, 7.5 m/s	20	0.482891738	0	0	YES	YES									o	
33	HP-005 on Easterly, 7.5 m/s	20	0.482891738	3.76471E-05	3.765E-05	YES	YES			o							o
34	HP-008 on Easterly, 7.5 m/s	20	0.482891738	3.76471E-05	3.765E-05	YES	NO						o				
35	HP-008 on Westerly, 7.5 m/s	20	0.482891738	0	0	YES	NO						o				
36	HP-009 on Northerly, 7.5 m/s	20	0.482891738	2.35294E-05	2.353E-05	YES	YES				o				o		
37	HP-001 on Northerly, 7.5 m/s	20	0.482891738	2.35294E-05	2.353E-05	YES	YES									o	
38	HP-008 on Southerly, 7.5 m/s	20	0.482891738	9.41176E-06	9.412E-06	YES	NO			o							
39	HP-012 on Westerly, 7.5 m/s	20	0.482891738	0	0	YES	YES			o		o					
40	HP-001 on Easterly, 7.5 m/s	20	0.482891738	3.76471E-05	3.765E-05	YES	YES									o	
41	HP-002 on Easterly, 7.5 m/s	20	0.482891738	3.76471E-05	3.765E-05	YES	NO		o								
42	HP-009 on Southerly, 7.5 m/s	20	0.482891738	9.41176E-06	9.412E-06	YES	YES				o				o		
43	HP-005 on Southerly, 7.5 m/s	20	0.482891738	9.41176E-06	9.412E-06	YES	NO										o
44	HP-002 on Southerly, 7.5 m/s	20	0.482891738	9.41176E-06	9.412E-06	YES	YES		o					o			

Summary

- Ventilation simulations highlight stagnant regions in the facility – likely locations for gas accumulation.
- Dispersion simulations show gas cloud sizes and results for a specific leak.
- Monitor points, lines, and regions collect data at defined locations and can be exported to excel or Detect3D.
- Given risk data (leak frequency and consequence, wind probability, etc.), layouts can be created to mitigate risk throughout the site.
  - Using the gas detector optimization tool, these layouts can be generated automatically.

For questions about in:Flux or licensing options, please visit www.insightnumerics.com or email us at info@insightnumerics.com