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FINAL REPORT – Revision 3

Cuisine Solutions Ammonia Release Modeling

Prepared for:

United States Chemical Safety Board

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AcuTech PROCESS RISK MANAGEMENT

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5	August 15, 2025	Final Report w. Addendum	Addendum: Case 2 Building Wake Model added to the report

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1 Introduction

The United Sates Chemical Safety Board (CSB) requested that AcuTech complete a release and dispersion modeling analysis of the anhydrous ammonia release that occurred at Cuisine Solutions in Sterling, VA on July 31, 2024.

The scope of work was as follows:

1. Review information and evidence provided by the CSB to develop inputs for the release and dispersion modeling.
2. Develop and assess a range of release scenarios using the Phast consequence model to evaluate and consider the effects of release phase, flowrate, elevation, velocity, temperature, and orientation among other factors.

2 Background Information

AcuTech reviewed the exhibits provided by the CSB to inform the assessment. A full listing of the exhibits provided for review is provided in Appendix A. Based on the evidence review, the following was established as the basis for this assessment:

- The release originated from the discharge of a relief valve mounted on the HEX-5 surge drum.
  - The vessel MAWP is 300 psig and is 20" OD x 96" horizontal surge drum, with a flooded plate heat exchanger.
  - It appears the high level shutdown is defaulted to 52% level (10" above vessel bottom), with alarm at 42%. Operating level is 15%, and low level shutdown is at 5%.
- The relief valve that discharged was attached to a 1.5" vessel nozzle, and a ¾" three way valve was provided at the relief valve inlet.
  - The relief valve on the surge drum is a ½" x ¾" 800QR Cyrus Shank RV
- The relief discharge is located approximately 39 feet above ground level.
- Figure 1 illustrates the specification for the relief discharge to atmosphere.

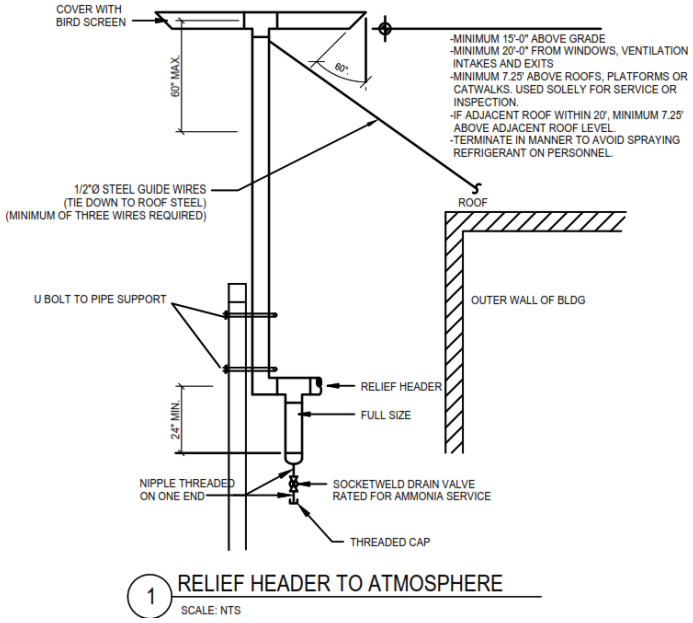


Figure 1 - Relief Valve Discharge Specification [Exhibit 130]

- Exhibit 143 video shows the immediate discharge orientation is at a downward angle. At the initial stage, the release is momentum driven. The video clearly illustrates a downward momentum resulting from the angular cut at the end of the tee diffuser. Visual centerline of the cloud is marked by a blue arrow in Figure 2. This evidence supports the theory that the bevel cut discharge on the tee caused a downward release angle, normal to the opening plane, which was identified to be 60 degrees downward.



Figure 2 - Snapshot from Release Video [Exhibit 143]

- Figure 3 illustrates the same angle of release on a side view photograph. The downward momentum of the release resulted in a cloud that was impinged by the momentum and wind against the building and rooftop air unit. The lack of open field dispersion in the downwind direction would also contribute to the downward trajectory continuing to the side of the building.



Figure 3 - Illustration of Release Orientation

- Based on information from Exhibit 147, the following timeline is considered:
  - The release started between 8:19 pm and 8:23 pm (based on reports of ammonia odor).
  - The release rate may have increased from initial to full flow at 8:27 pm (appears on security camera).
  - Visible release ends at 8:35 pm on security camera.
  - Compressors shutdown between 8:47 pm and 8:54 pm.
  - King Valve closed at approximately 8:53 pm to 8:55 pm.
- Based on Exhibit 046 timestamps, the release duration is approximately 9 minutes:
  - At 1:04:39 - Surveillance camera video shows the cloud first appear (must be 8:27 pm.)
  - At 1:05:17 - Cloud spreads at ground level
  - At 1:06:24 - Cloud is no longer spreading at ground level, visible vapors have dispersed completely
  - At 1:08:20 – Cloud is visible at ground level, evacuees egress rapidly
  - At 1:10:01- Cloud has grown more significant at ground
  - At 1:13:00- Cloud no longer visible, employee moves toward cloud from nearby door

Weather data from the nearest weather data station at the time of the incident was collected from the National Climactic Data Center at Washington Dulles Airport (IAD). The data is provided in Appendix B. The weather data indicated a wind speed of 3.3 meters per second and a direction of 160 degrees (SSE).

3 Models, Settings, and Source Term

A site-specific consequence analysis of the release cases was conducted using the commercially available Process Hazards Analysis Software Tool (Phast) consequence modeling software, version 9.0. Phast was utilized to determine the hazard zones. The Phast Unified Dispersion Model (UDM) was used to assess the impacts of the releases, including the downwind dispersion distance, the concentration profile, the width of dispersing clouds, and other factors.

Dispersion models use an averaging time to calculate the maximum concentration and the plume width. The averaging time is used to consider the effects of changes in the wind direction over the course of the release, as these changes can cause the dispersing cloud to meander from side to side, and reduce the concentration experienced at a given point below the full, centerline concentration. Typically, a short averaging time is used for flammable gas dispersion effects since the peak concentration is more important, and a longer averaging time is usually used for toxic dispersion effects since the long-term concentration is more important. For this project, an averaging time of 600 seconds is used for toxic results. These values are consistent with the Phast model default parameters.

3.1 General Model Settings and Inputs

The following model settings and inputs were used for the analysis:

Input	Value	Basis/Comment
Surface Roughness	1.0 m	Consistent with site location, forested areas and scattered large buildings
Averaging Time	600 s	Standard value for toxic vapor dispersion
Wind	7.5 mph, 160 deg, D Stability	Consistent with weather observations at IAD, see Appendix B
Material	100% Anhydrous Ammonia	

3.2 Relief Valve and Source Term

The Phast model was utilized to assess the relief and discharge of ammonia. Phast includes a “short pipe” model designed to assess the relief of pressurized vapor, or liquid through a rupture disc or relief valve. The model assesses the discharge of material through a relief orifice, flow of discharged material through discharge piping (including flashing and frictional flow losses), and the discharge of material to the atmosphere.

The model was first used to setup the PRV involved in the incident, a Cyrus Shank 800 QR set to relieve at 300 psig. Cyrus Shank provides the following capacity table for the 800 series relief devices.

800 Series Capacity Chart

Slope = 0.42 SCFM/PSIA
Standard Conditions [60 °F, 1 Atm]

Set Pressure (PSIG)	Air SCFM	Air lb/min	Air lb/hr	NH3 lb/min	NH3 lb/hr	R-22 lb/min	R-22 lb/hr	R-290 lb/min	R-290 lb/hr	R-404A lb/min	R-404A lb/hr
50	29.3	2.2	134.1	1.7	102.8	3.9	231.6	2.8	165.4	4.1	246.1
75	40.8	3.1	187.0	2.4	143.4	5.4	323.0	3.8	230.7	5.7	343.2
100	52.4	4.0	239.9	3.1	183.9	6.9	414.4	4.9	296.0	7.3	440.3
125	63.9	4.9	292.8	3.7	224.5	8.4	505.8	6.0	361.2	9.0	537.4
150	75.5	5.8	345.7	4.4	265.0	10.0	597.2	7.1	426.5	10.6	634.5
175	87.0	6.6	698.6	5.1	305.6	11.5	688.6	8.2	491.8	12.2	731.6
200	98.6	7.5	451.5	5.8	346.2	13.0	780.0	9.3	557.0	13.8	828.7
225	110.1	8.4	504.4	6.4	386.7	14.5	871.4	10.4	622.3	15.4	925.8
250	121.7	9.3	557.3	7.1	427.3	16.0	962.8	11.5	687.6	17.0	1022.9
275	133.2	10.2	610.2	7.8	467.8	17.6	1054.2	12.5	752.8	18.7	1120.0
300	144.8	11.1	663.1	8.5	508.4	19.1	1145.6	13.6	818.1	20.3	1217.1
325	156.3	11.9	716.0	9.1	548.9	20.6	1237.0	14.7	883.4	21.9	1314.2
350	167.9	12.8	768.9	9.8	589.5	22.1	1328.4	15.8	948.7	23.5	1411.3
375	179.4	13.7	821.8	10.5	630.1	23.7	1419.8	16.9	1013.9	25.1	1508.4
400	191.0	14.6	874.7	11.2	670.6	25.2	1511.2	18.0	1079.2	26.8	1605.5

Figure 4 - 800 QR Relief Valve Capacity Table[1]

To define the 800 QR orifice in the short pipe model, Phast was set to evaluate a 300 psig air relief through a relief valve with outlet of ¾" directly to atmosphere. The orifice size was back-calculated to match the 663.1 lb/hr release rate specified for the 800 QR valve. The equivalent orifice size was determined to be 0.175-inch diameter. At 300 psig, using saturated ammonia vapor, this orifice is predicted to relieve 485 lb/hr of ammonia, a deviation of -4.6% from the design value specified by Cyrus Shank. The anhydrous ammonia release rate from the Phast discharge model is within 5% of the design value given by Cyrus Shank; accordingly, the Phast discharge rate for the 0.175-inch relief valve orifice is used to predict the discharge rate for all release cases.

As the Phast model is not capable of evaluating multiple atmospheric discharges (as from a tee diffuser), therefore the short pipe model was used to assess the flow rate, then a separate user defined source model was initiated to assess a single discharge from a single side of the tee diffuser. The user defined source model used the flow rate and velocity predicted by the short pipe model to calculate the flow rate and velocity of the discharge from each side of the tee diffuser.

Accordingly, release models in this study that assess the near-field release dynamics consider a single discharge from one side of the tee diffuser: half of the total relief rate, oriented to the South. The near-field release dynamics are representative of discharge from both sides of the tee diffuser.

3.3 Building Wake Model

Because the wind dispersed ammonia vapor across the roof of the building, the Phast Building Wake Model (BWM) was used to consider the effects of the building wake, and uptake of vapor into the recirculation zone on the lee side of the building. The flow of wind past a building produces a zone of pressure-drop (or a "wake") in the area downwind of the building. A release in or near the wake can be entrained in the wake and experience a period of

[1] https://www.cyrusshank.com/product/800-series-relief-valve-800qr/

mixing within the wake. If the release is from a chimney on top of the building, the building wake will draw the plume closer to the ground, and if the plume is drawn very low, all or part of the plume may become entrained in the building lee.

The Phast BWM aims to provide a more realistic assessment of the consequences of releases in industrial facilities where buildings and other structures are present. It allows users to define the dimensions and location of buildings relative to the release source to understand how these obstructions might influence the dispersion of hazardous materials. The BWM is illustrated for reference in Figure 5.

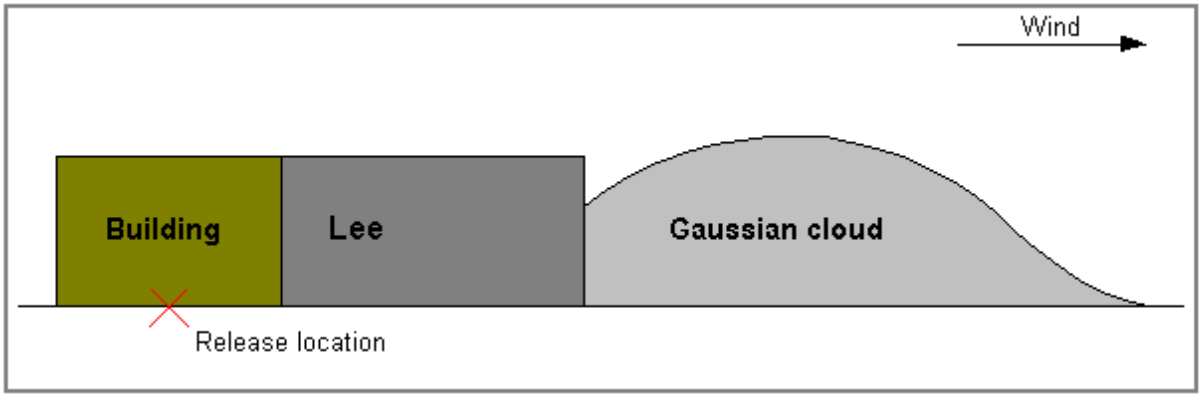


Figure 5 - Build Wake Model Illustration[2]

(Release location shown is an example only)

The BWM was used to assess the dispersion of vapors downwind of the building. These results are presented as downwind dispersion footprint contours and downwind concentration plots.

[2] Building Wake Model Theory, Phast Technical Reference Manual, Det Norske Veritas

4 Parameters Considered

The study was developed to assess a range of potential release conditions in order to evaluate possible outcomes of the actual release event, and the effects that changes in critical parameters would have. The variation of parameters between the cases is intended to inform the understanding of the incident, which parameters affected the outcome, and how different conditions could have contributed to increasing or reducing the hazards to people.

Based on the evidence reviewed, and the parameters which would affect the discharge and dispersion of the release, the following parameters were considered to define the range of cases evaluated in the study:

4.1 Phase or Liquid Fraction

The phase of the material at the relief valve inlet, and phase of the discharge (liquid, vapor, or two-phase) has a significant effect on the mass flow rate through the relief valve orifice, the release temperature, and the cloud density. A liquid flow or two-phase flow into the relief valve inlet results in higher mass flaw rates through the relief valve orifice, and accordingly, higher release rates to atmosphere than a vapor flow to the relief inlet.

Liquid or two-phase releases to the atmosphere form flashing droplets which are pulled toward the ground by gravity; the droplets flash to vapor as they travel through the air, but they may reach the ground as liquid rainout if there is insufficient time or heat input to flash completely. Droplet trajectories and flashing rates are affected by the release velocity, elevation and orientation of the discharge, as well as the atmospheric conditions (temperature and humidity).

Droplets increase the bulk cloud density, and droplets flash to form low temperature vapors, which also increase the cloud density. Dense clouds slump toward ground level due to gravity/buoyancy effects.

Vapor releases may be dense, neutral, or buoyant. The buoyancy is affected by the molecular weight, concentration, and temperature, with colder vapor temperatures resulting in denser, less-buoyant clouds.

Buoyant clouds will rise into the atmosphere, while dense clouds will slump down, and may become grounded.

In the scenarios assessed in the report, the phase of the relief valve inlet for the short pipe model was considered to be liquid or vapor for the range of scenarios assessed in the study. In addition, a hypothetical two-phase relief inlet scenario was considered by initiating a relief termination discharge model that used half of the discharge liquid fraction of the liquid relief inlet case.

4.2 Relief Pressure

The pressure in the vessel at the time of the release affects the pressure drop across the relief valve orifice, which affects the mass flow rate through the relief valve and the discharge velocity.

Spurious failure of relief valves can result in relief at normal operating pressures, which are below the relief pressure. Reduced pressure at the relief inlet results in reduced mass flow rates and reduced velocity. Low velocity clouds disperse more slowly and may readily slump more than high velocity clouds (for upward discharge orientations), and high velocity clouds have greater initial mixing/dilution. High relief velocities, when oriented upward, can be used to aid in jetting/dispersing material upward and away from areas where people may be present, but lower relief velocities (as in a spurious relief event) can cause the discharge not to be safely jetted upward, but rather slump downward.

In the scenarios assessed in this report, relief was considered at the relief valve set pressure, 300 psig, as well as the normal operating pressure, 45 psig. While the relief valve opened very close to the set pressure in laboratory testing, the normal operating pressure was considered as well to consider a credible spurious relief scenario that results in a lower mass flow rate and lower release momentum.

4.3 Orientation

The orientation of the discharge defines the initial direction of the release momentum and jetting. Downward angles will jet material toward ground level and are often avoided in relief discharge, while upward or vertical discharge will jet material upward into the atmosphere, which is generally safer for people on adjacent structures or at ground level. Beveled cuts at relief discharges can affect the discharge orientation of relief discharges, and it is known that relief discharge will be perpendicular to the plane of a bevel cut for certain relief scenarios[3].

In the scenarios assessed in this report, a range of relief orientations is considered, including: downward angle (-60 degrees) to represent a release angled downward, perpendicular to the bevel cuts on the tee diffuser; horizontal discharge (0 degrees) to represent a tee diffuser without beveled cuts; upward angle (45 degrees) to represent a bullhorn style discharge; and vertical discharge (90 degrees) to represent a vertical bullhorn or single point vertical discharge.

4.4 Discharge Diameter, Termination Type

The discharge diameter and termination type affect the relief velocity and the number of discharge points, which affects the mass flow rate from each discharge point. Smaller diameter discharges will result in higher release velocities. Higher jetting velocities can be used to aid in dispersing materials rapidly away from the discharge point towards safer areas (e.g. higher elevations and away from structures).

Single point discharges (e.g. open-ended lines), or tee diffusers affect the number of release points, the mass flow rate for each discharge, and the velocity of the discharge(s). Tee diffusers split the mass flow between two discharge points, and will halve the velocity of the discharge (assuming a constant piping diameter). Tee diffusers are commonly used to balance the reaction forces of horizontal or angled discharges to avoid excessive piping stress. Single point discharges will maintain the velocity of the relief discharge to the atmospheric discharge point, these are commonly used for horizontal or vertical discharge orientations.

[3] "What is a Safe Discharge Location?", American Institute of Chemical Engineers, AIChE, Presented by Georges A. Melhem Ph.D. FAICHE, Presented March 2020

In the scenarios assessed in this report, a range of discharges are considered, including: the 3-inch diameter tee diffuser observed in the incident, and a 1-inch diameter single point discharge to assess the dispersion of higher velocity releases by considering a credible minimum pipe diameter for the relief valve discharge.

4.5 Elevation

The elevation of a release affects the distance from the release to occupied structures, people, or other sensitive receptors. Increased discharge elevations can be used to separate dispersing clouds from adjacent structures or people at ground level to aid in safe dispersion of relief discharges. Elevation is a critical parameter in the design of relief disposal systems.

In the scenarios assessed in the report, the 39 foot release elevation observed for the incident was used. One alternate case was considered to evaluate a discharge elevation of 55 feet.

4.6 Illustration of the Model Components

Figure 6 and Figure 7 illustrate the components of the system in the context of the Phast model and the liquid and vapor phase scenarios considered in the study.

The vessel temperature and pressure, and the phase at the relief inlet are defined for each scenario, considering liquid or vapor flow to the relief valve. These inputs initiate the relief valve and relief discharge piping models in Phast, which assess the flow through the relief valve orifice, flashing in the discharge piping, mass flow rate, and velocity in the discharge piping.

The relief termination is considered to develop a discharge source for each scenario: single point discharge at discharge piping conditions, or tee diffuser termination with half of the mass flow rate directed to each discharge point from the tee. As noted in Section 3.2, the Phast model is not capable of evaluating multiple atmospheric discharges (as from a tee diffuser), therefore the release models in this study that assess the near-field release dynamics consider a single discharge from the tee diffuser, oriented to the South.

The Phast model then assesses atmospheric expansion from the relief termination, which feeds into the Phast unified dispersion model to assess jetting, flashing, rainout, and vapor dispersion.

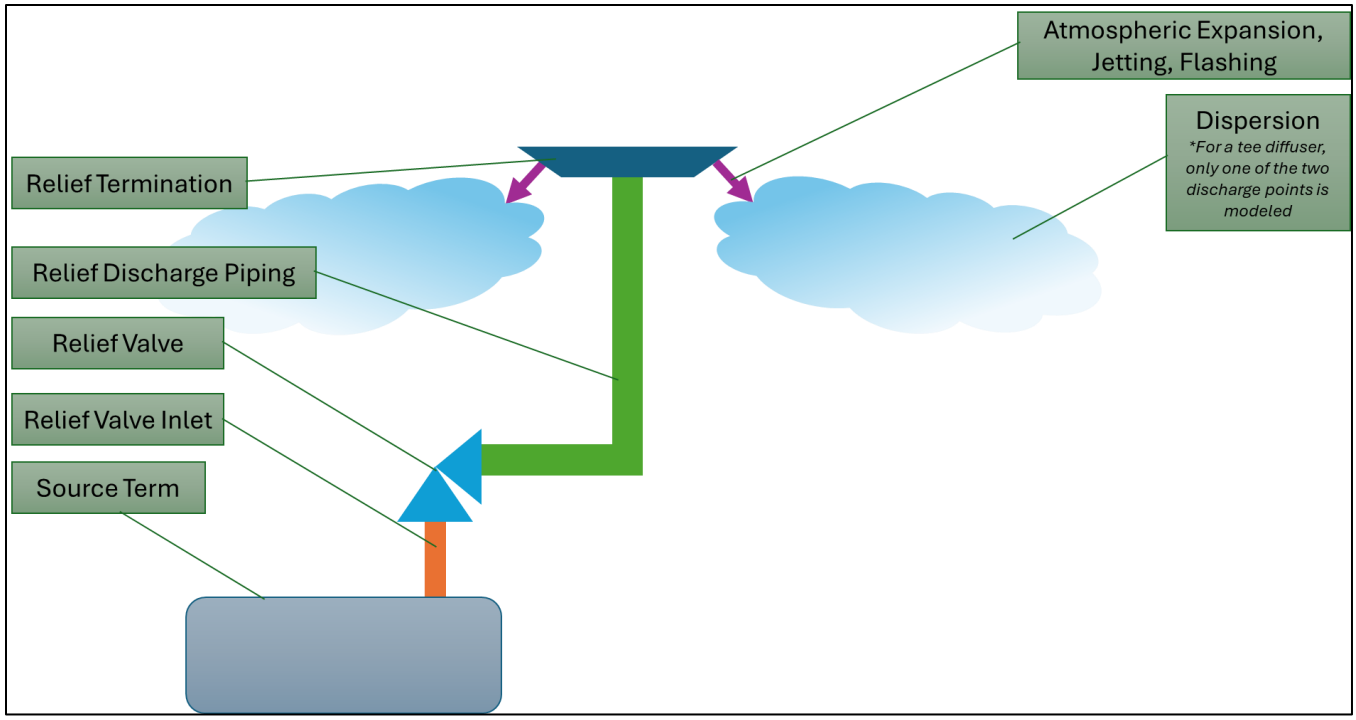


Figure 6 - Illustration of the Relief Scenario and Model Components (Tee Diffuser)

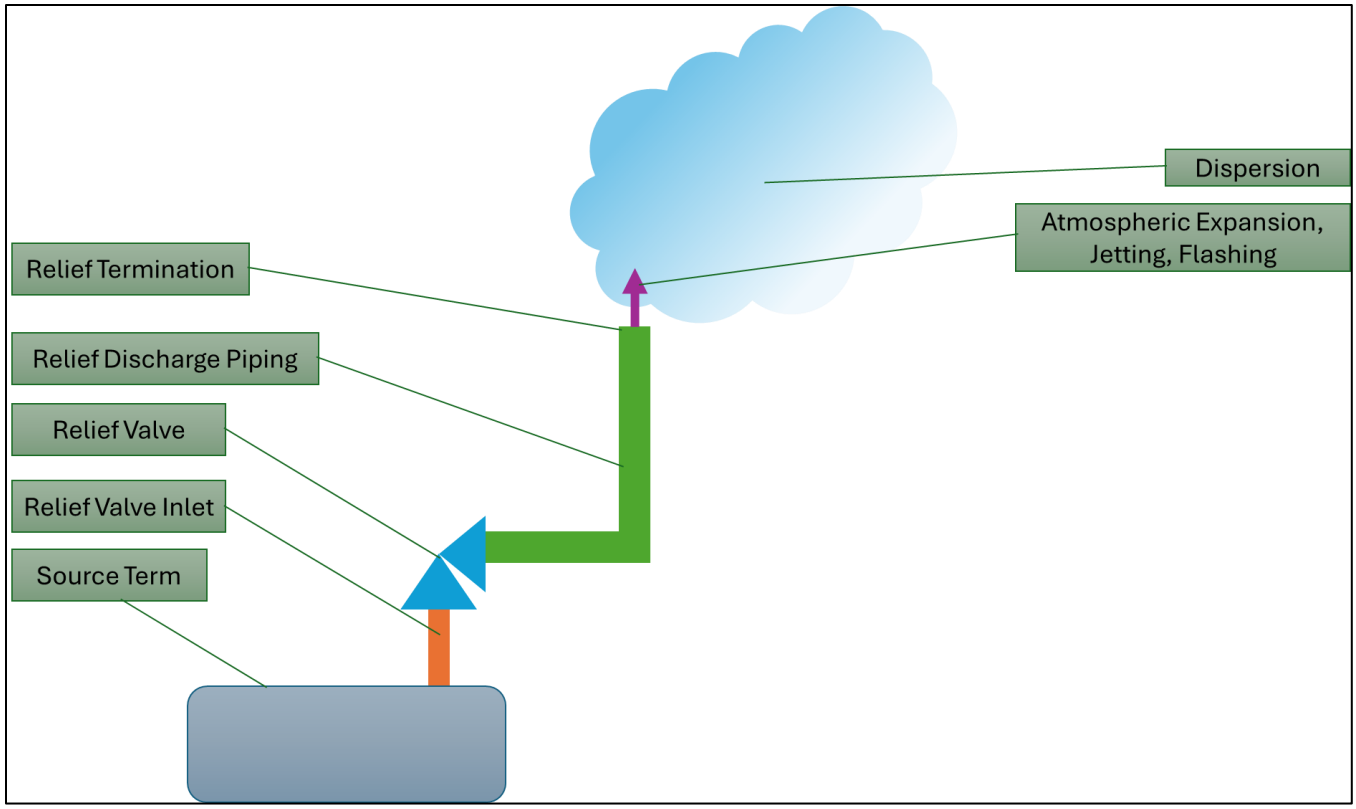


Figure 7 - Illustration of the Relief Scenario and Model Components (Single Point Discharge)

5 Scenarios and Results

5.1 Near-Field Release Models

To assess the parameters affecting the near-field release dynamics, a parametric assessment of release conditions was conducted. For each of the liquid and vapor relief inlet scenarios, the short pipe model was used to model the total relief rate from the PRV at the defined source term pressure. For the postulated two-phase inlet scenario, the discharge from the relief termination is considered directly as ½ of the mass flow rate and liquid fraction of the equivalent liquid relief scenario. The scenarios considered variations in parameters as shown in Table 1.

Table 1 - Scenarios Modeled to Assess Near-Field Release Dynamics

	Source (Relief Valve Inlet)			Discharge to Atmosphere			
Case	Phase	Pressure	Temperature	Termination Type	Elevation	Orientation	Discharge Diameter
#	-	psig	F	-	ft	degrees from horizontal	inches
1	Liquid	300	Saturation	Tee	39	-60	3
2	Vapor	300	Saturation	Tee	39	-60	3
3	Liquid	300	Saturation	Tee	39	0	3
4	Vapor	300	Saturation	Tee	39	0	3
5	Liquid	45	Saturation	Tee	39	-60	3
6	Vapor	45	Saturation	Tee	39	-60	3
7	Liquid	45	Saturation	Tee	39	0	3
8	Vapor	45	Saturation	Tee	39	0	3
9	Liquid	300	Saturation	Tee	39	45	3
10	Vapor	300	Saturation	Tee	39	45	3
11	Liquid	300	Saturation	Tee	39	90	3
12	Vapor	300	Saturation	Tee	39	90	3
13	Liquid	45	Saturation	Tee	39	45	3
14	Vapor	45	Saturation	Tee	39	45	3
15	Liquid	45	Saturation	Tee	39	90	3
16	Vapor	45	Saturation	Tee	39	90	3
17	Liquid	300	Saturation	Single Point	39	90	1
18	Vapor	300	Saturation	Single Point	39	90	1
19	Liquid	45	Saturation	Single Point	39	90	1
20	Vapor	45	Saturation	Single Point	39	90	1
21	Two-phase	-	-	Tee	39	-60	3
22	Two-phase	-	-	Single Point	39	90	1
23	Liquid	300	Saturation	Single Point	55	90	1

The results of the discharge modeling indicate the following atmospheric discharge parameters for the cases.

Table 2 - Discharge Results

Case	Source (Relief Valve Inlet)		Relief Valve Discharge		Discharge to Atmosphere	
	Phase	Pressure	Relief Rate*	Liq Fraction	Termination Type	Velocity
#	-	psig	lb/hr	fraction	-	ft/s
1	Liquid	300	1647.2	0.69	Tee	30.8
2	Vapor	300	485.1	0.00	Tee	26.4
3	Liquid	300	1647.2	0.69	Tee	30.8
4	Vapor	300	485.1	0.00	Tee	26.4
5	Liquid	45	479.1	0.89	Tee	5.3
6	Vapor	45	92.4	0.00	Tee	2.7
7	Liquid	45	479.1	0.89	Tee	5.3
8	Vapor	45	92.4	0.00	Tee	2.7
9	Liquid	300	1647.2	0.69	Tee	30.8
10	Vapor	300	485.1	0.00	Tee	26.4
11	Liquid	300	1647.2	0.69	Tee	30.8
12	Vapor	300	485.1	0.00	Tee	26.4
13	Liquid	45	479.1	0.89	Tee	5.3
14	Vapor	45	92.4	0.00	Tee	2.7
15	Liquid	45	479.1	0.89	Tee	5.3
16	Vapor	45	92.4	0.00	Tee	2.7
17	Liquid	300	1647.2	0.69	Single Point	464.9
18	Vapor	300	485.1	0.00	Single Point	542.3
19	Liquid	45	479.1	0.89	Single Point	49.1
20	Vapor	45	92.4	0.00	Single Point	95.5
21	Two-phase	NA	1066.1	0.34	Tee	28.6
22	Two-phase	NA	1066.1	0.34	Single Point	503.6
23	Liquid	300	1647.2	0.69	Single Point	464.9

**This rate represents the total relief rate, for tee diffuser scenarios, this rate is divided between two discharge points and only one discharge point is assessed in the model, as noted in Sections 3 and 4.*

The results of the models are presented as side-view dispersion contour plots, in order to provide an effective visual of the release dynamics and provide a clear comparison to visual observations from the event. In this section the plots may not illustrate the full extent of the cloud, as the focus of the models is the near-field discharge and cloud behavior. In these plots, the 300 ppm contour is given, this concentration corresponds to the IDLH ("Immediately Dangerous to Life and Health") level as defined by the National Institute for Occupational Safety and Health. Additional contour plots are given in Appendix C which illustrate the full cloud extent to 25 ppm, 200 ppm and 300 ppm concentrations for all cases.

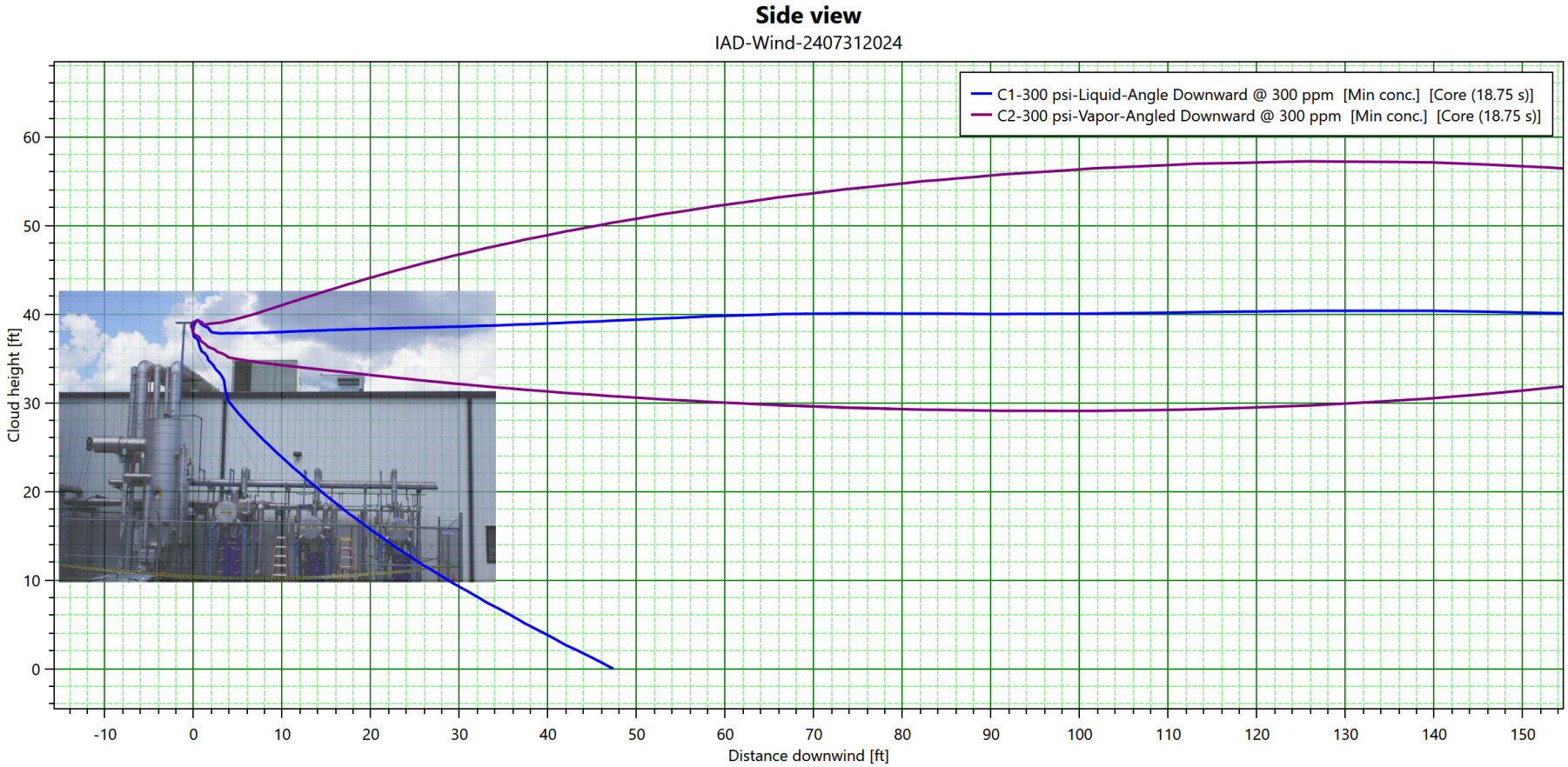


Figure 8 - Cases 1 and 2 - Liquid and Vapor Relief - 300 psig – Angled Downward

**This plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

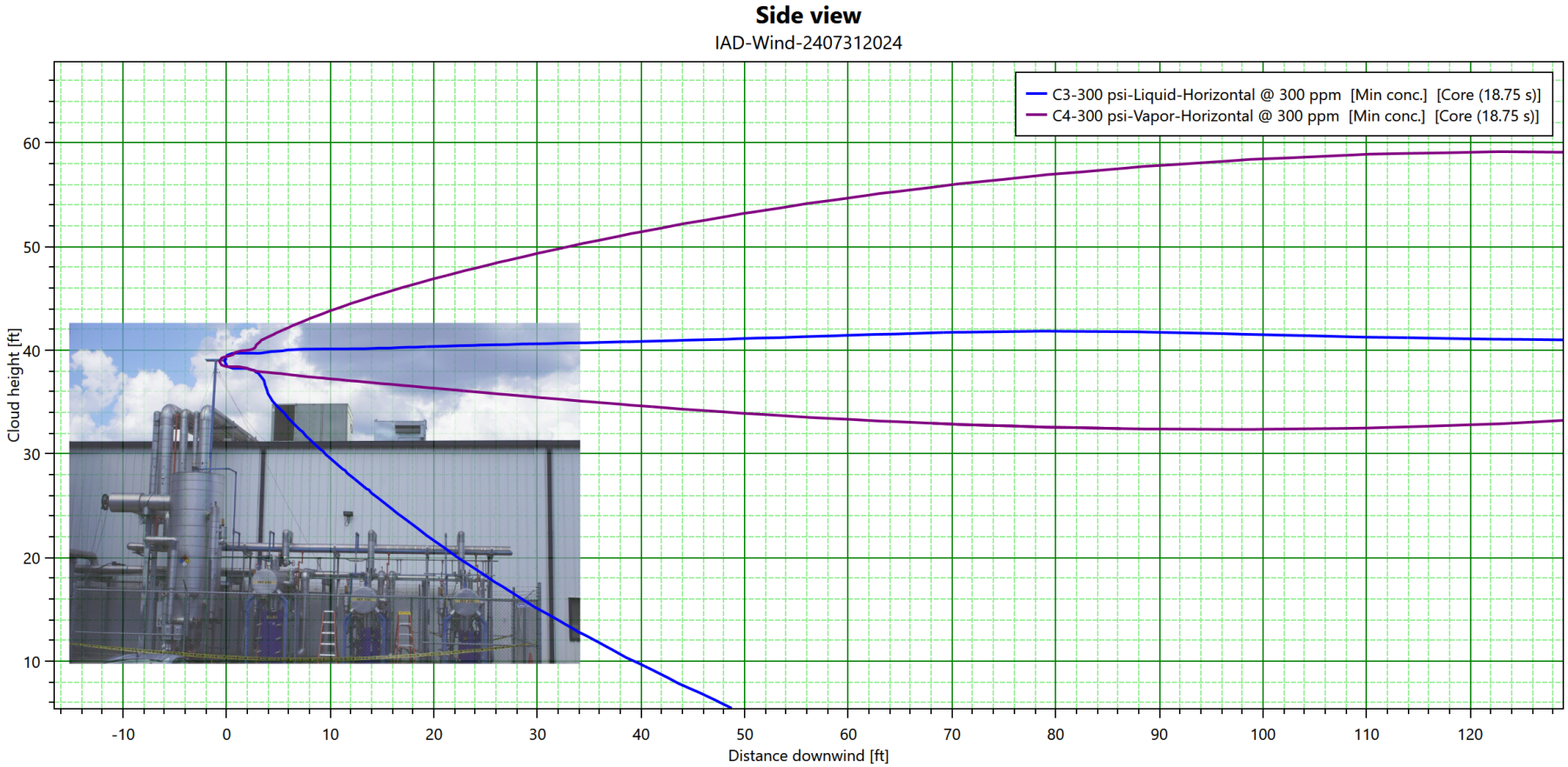


Figure 9 - Cases 3 and 4 – Liquid and Vapor Relief - 300 psig - Horizontal

**This plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

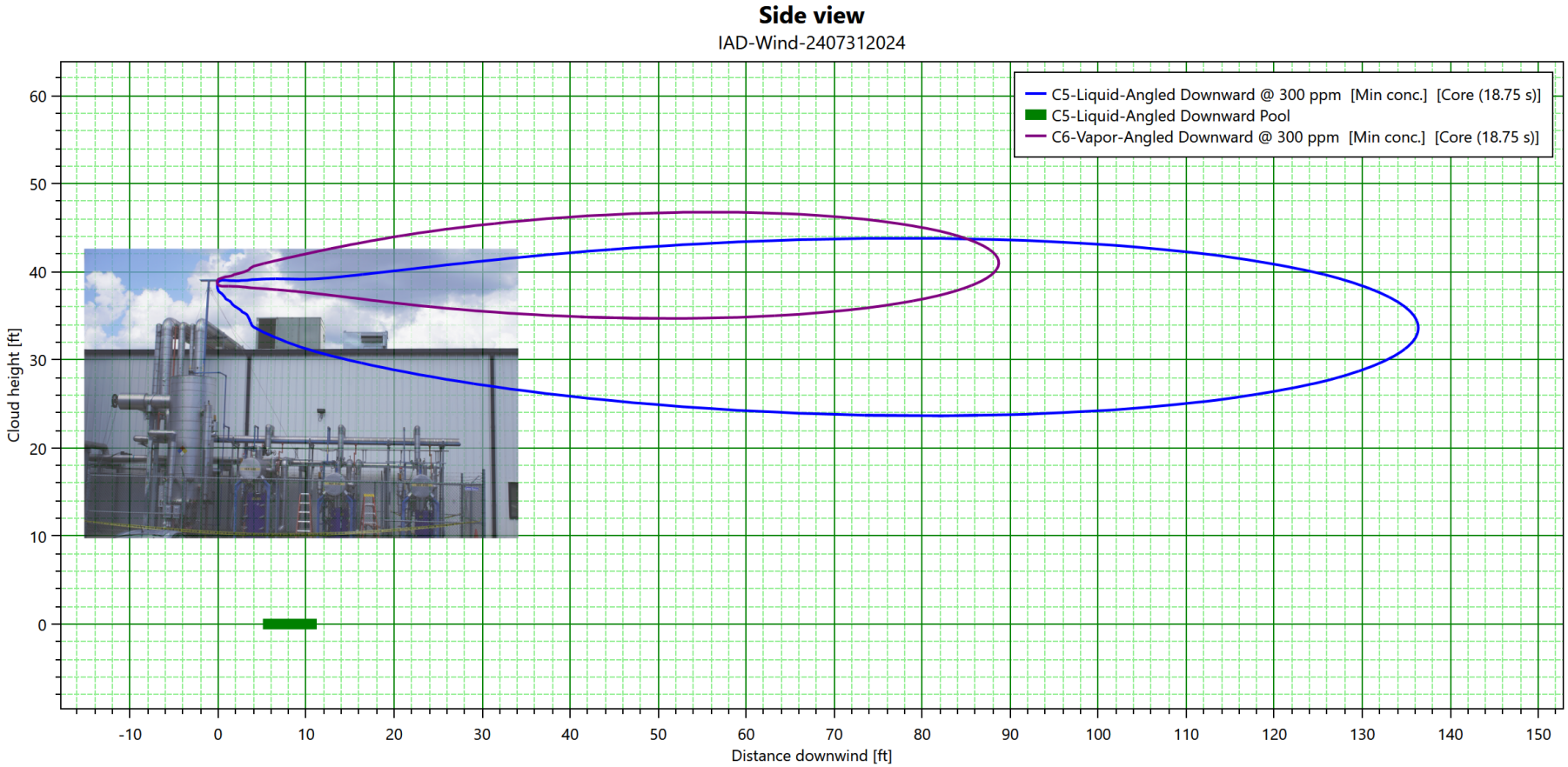


Figure 10 - Cases 5 and 6 - Liquid and Vapor Relief - 45 psig – Angled Downward

**This plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

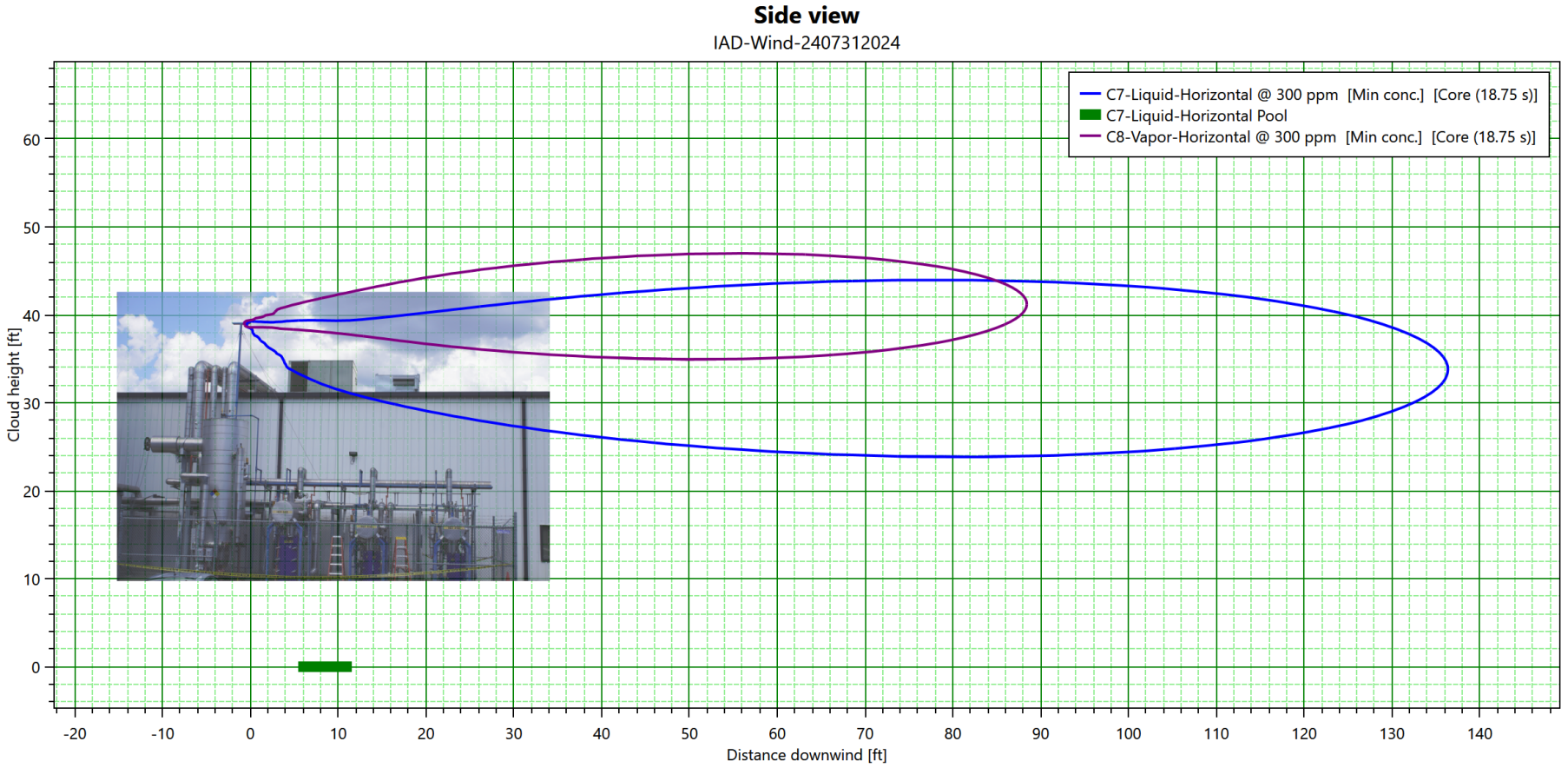


Figure 11 - Cases 7 and 8 – Liquid and Vapor Relief - 45 psig - Horizontal

**This plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

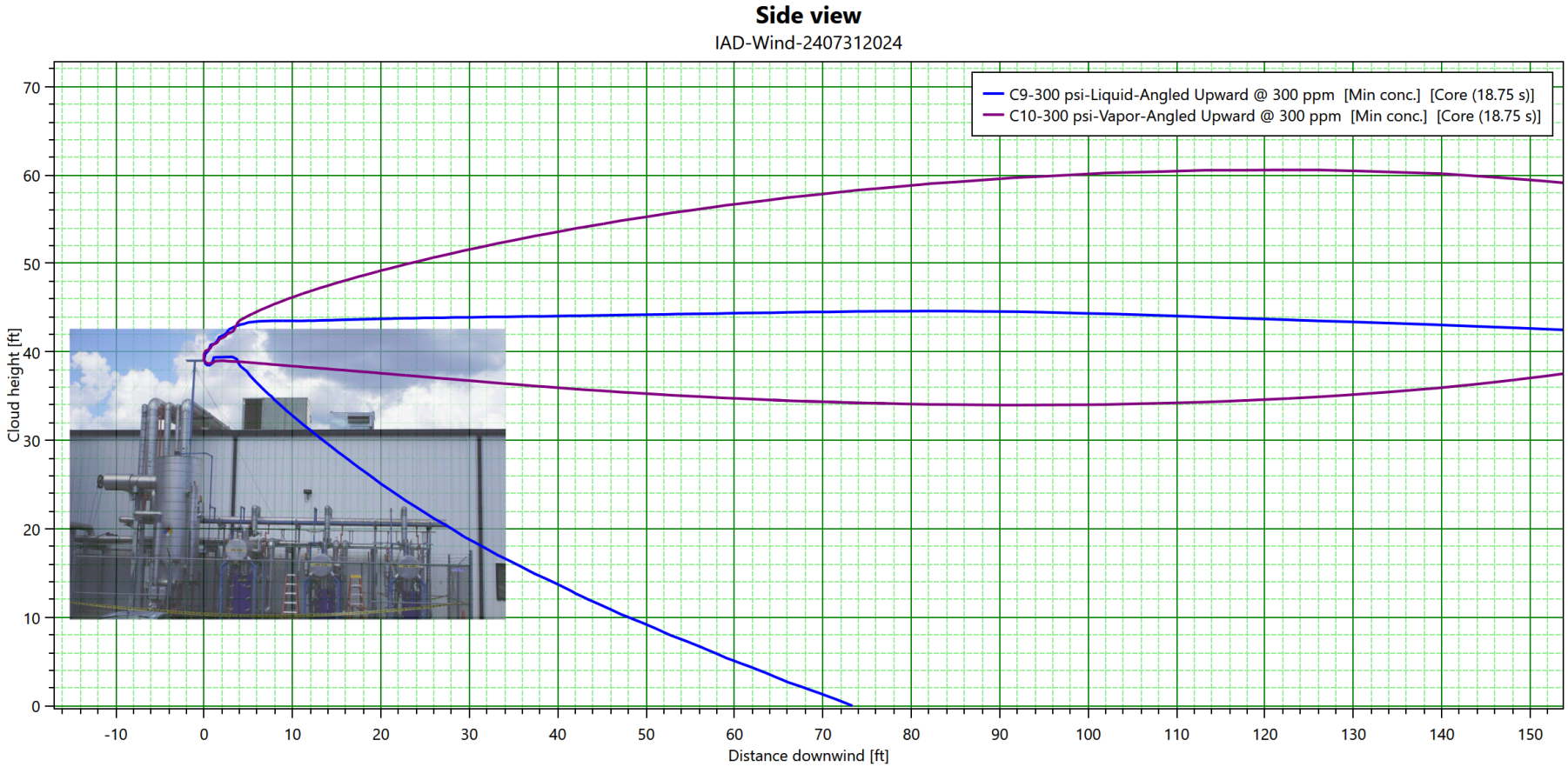


Figure 12 - Cases 9 and 10 - Liquid and Vapor Relief - 300 psig – Angled Upward

**This plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

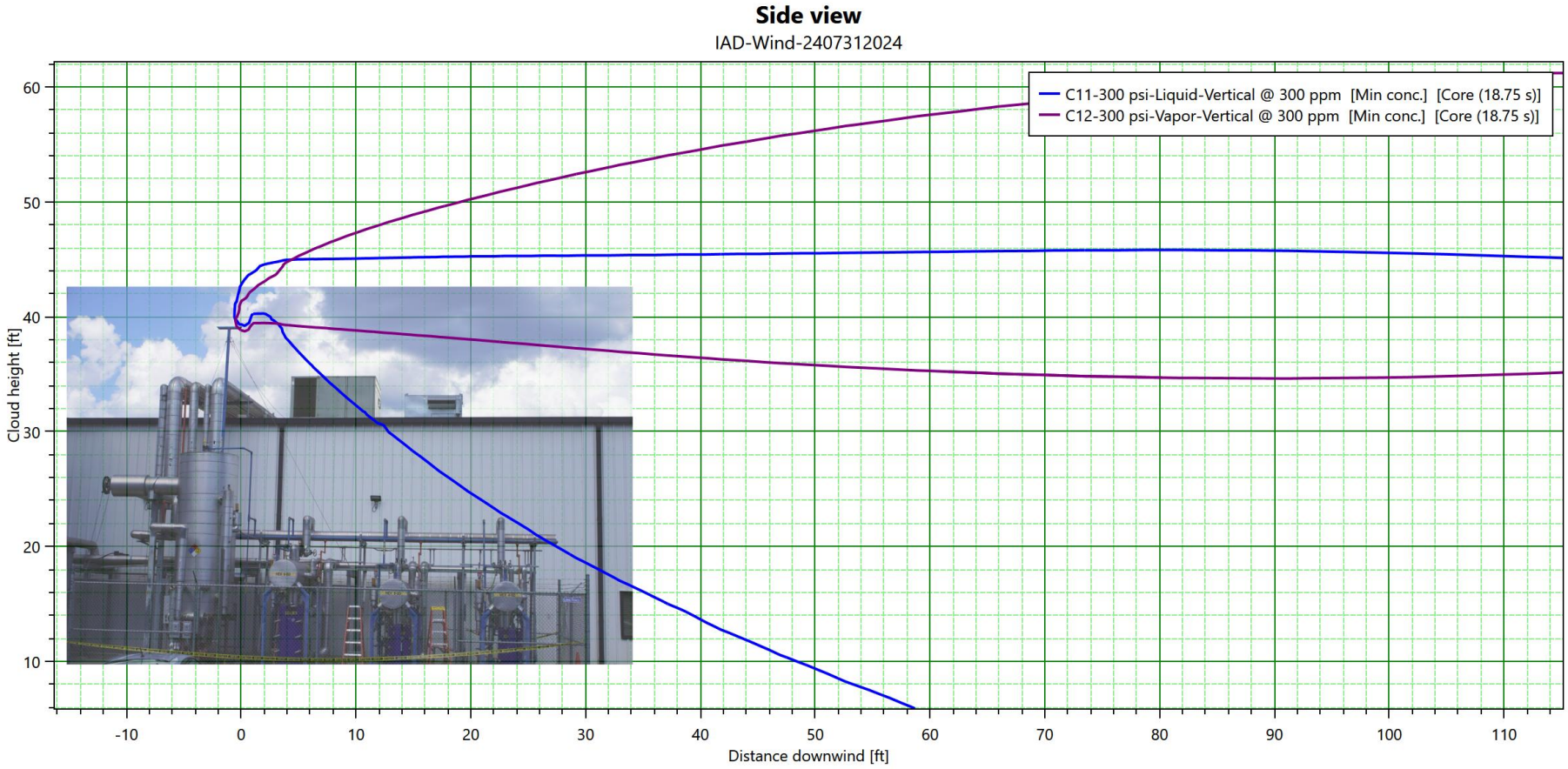


Figure 13 - Cases 11 and 12 – Liquid and Vapor Relief - 300 psig – Vertical

**This plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

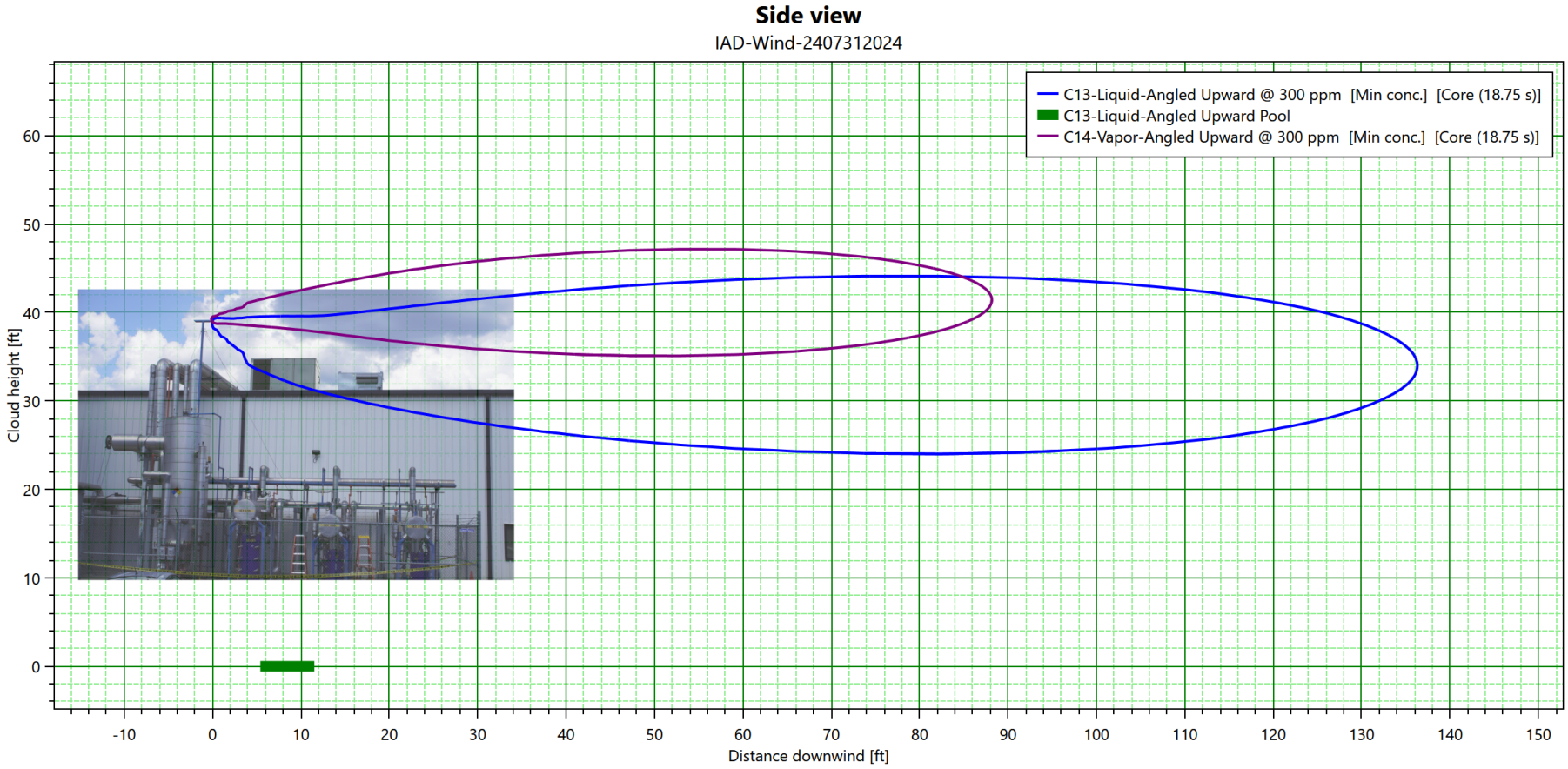


Figure 14 - Cases 13 and 14 - Liquid and Vapor Relief - 45 psig – Angled Upward

**This plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

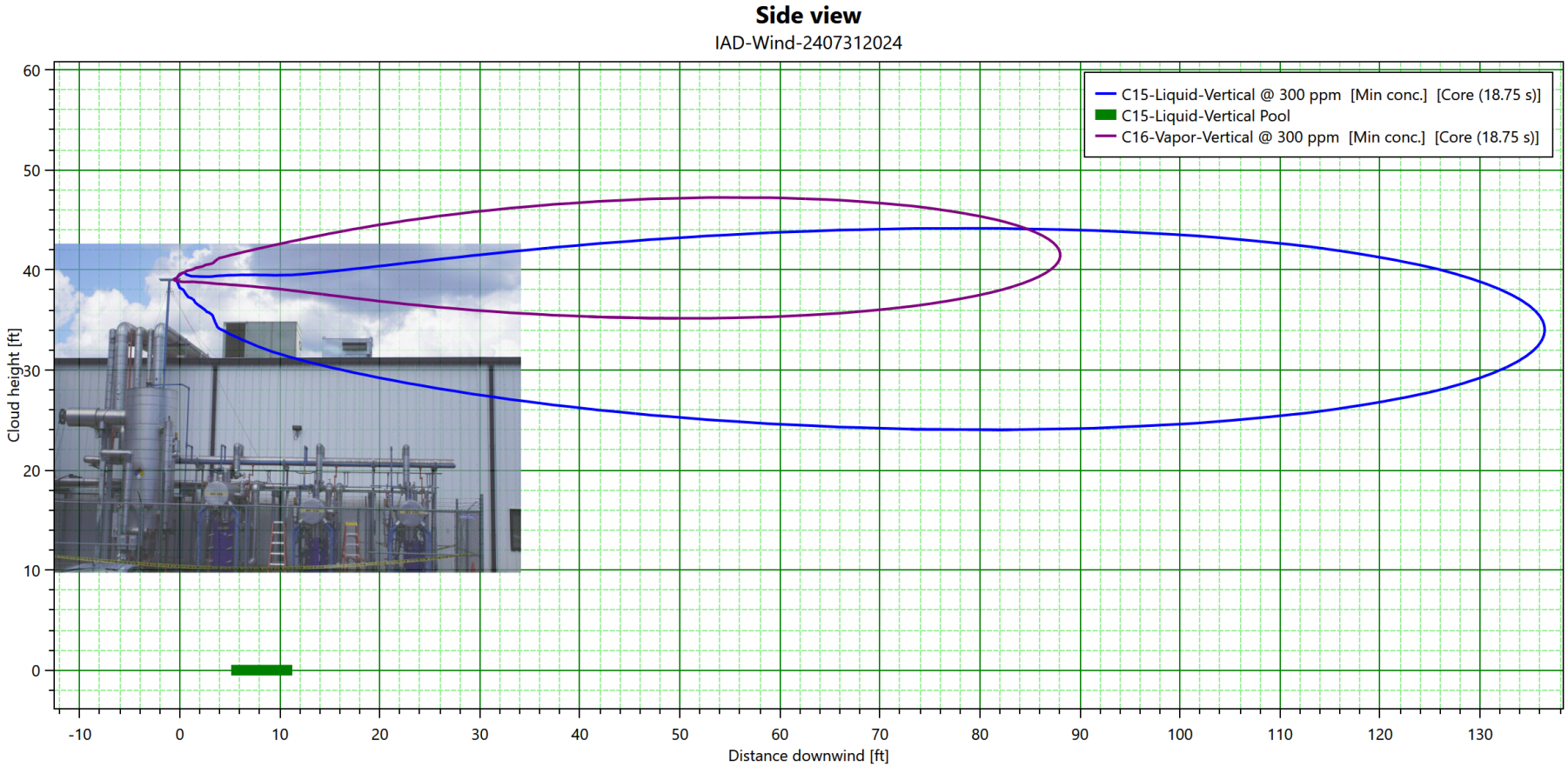


Figure 15 - Cases 15 and 16 – Liquid and Vapor Relief - 45 psig - Vertical

**This plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

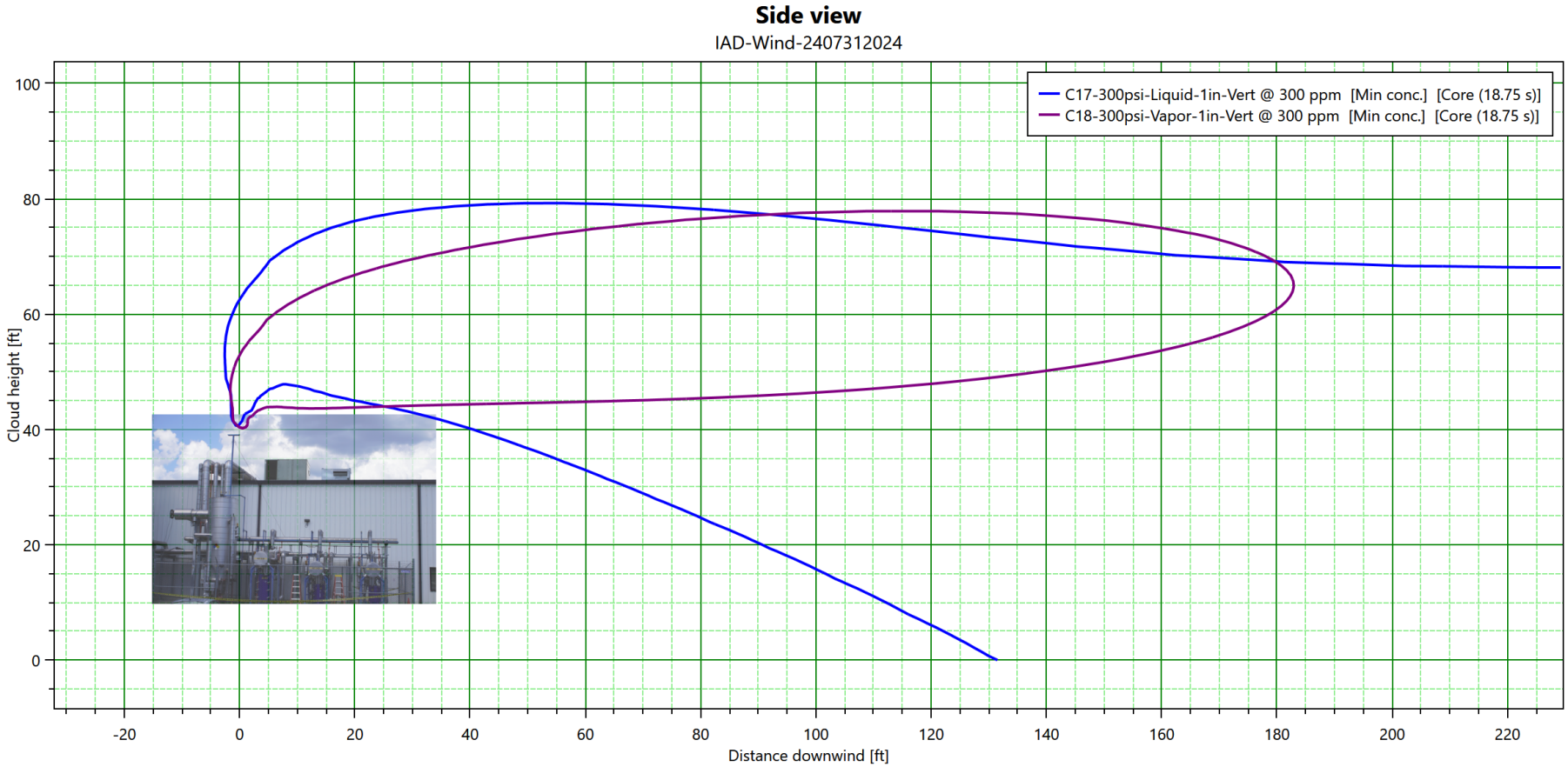


Figure 16 - Cases 17 and 18 – Liquid and Vapor Relief –300 psig - Vertical Discharge, 1-Inch Diameter

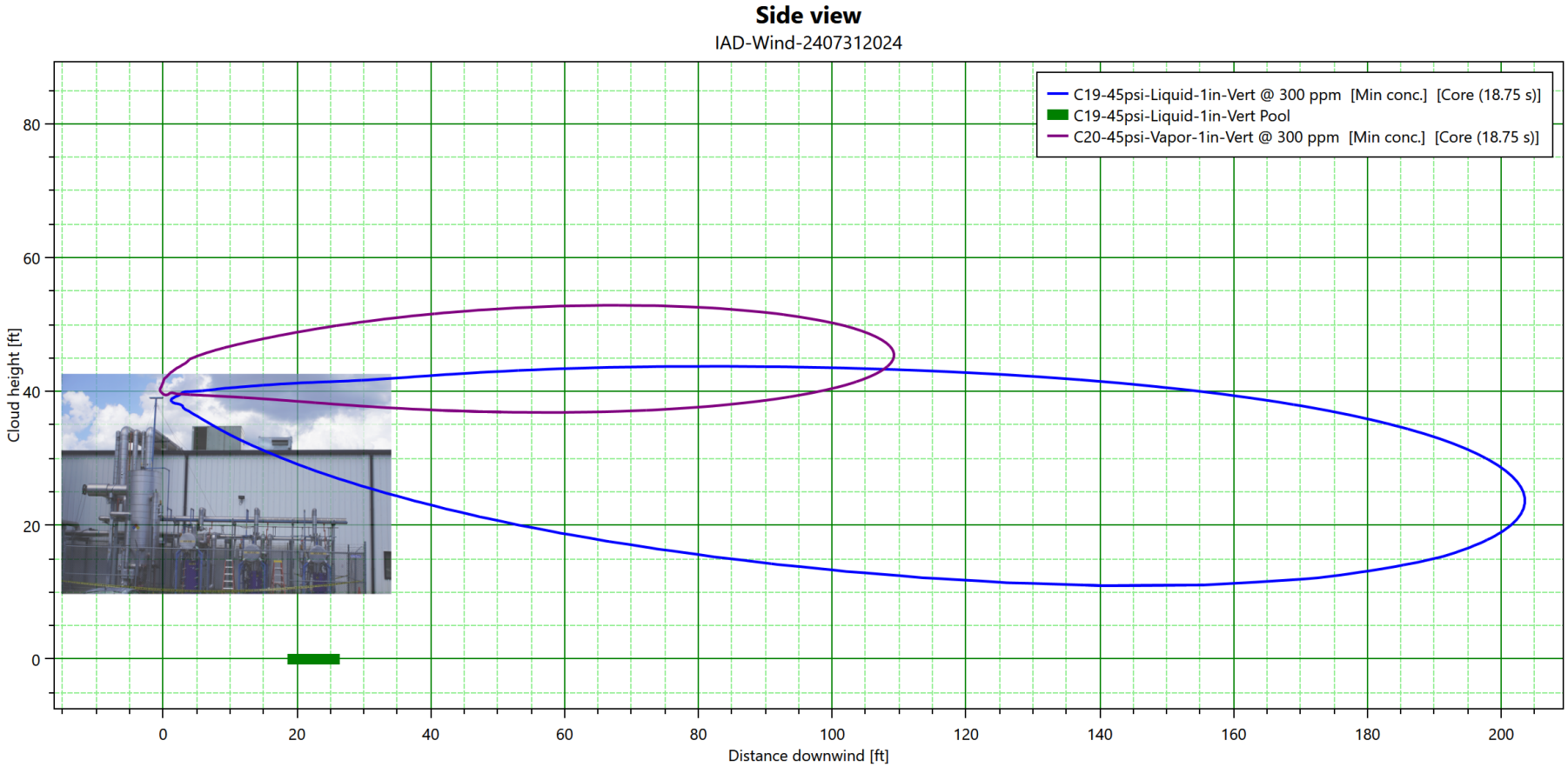


Figure 17 - Cases 19 and 20 – Liquid and Vapor Relief – 45 psig - Vertical Discharge, 1-Inch Diameter

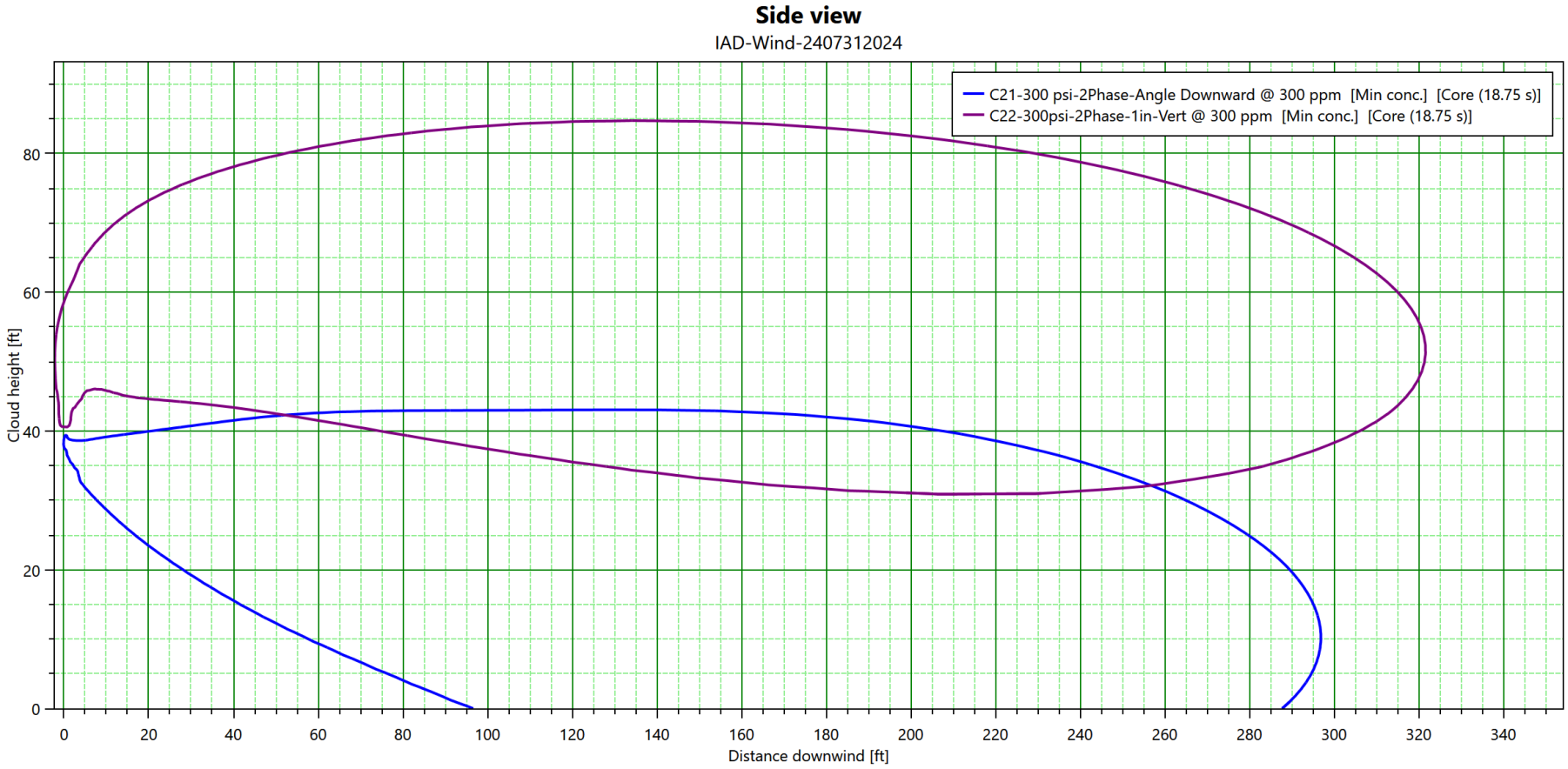


Figure 18 - Cases 21 and 22 – two-phase Relief – 300 psig – Angled Downward and Vertical 1-inch Diameter

**For Case 21, this plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

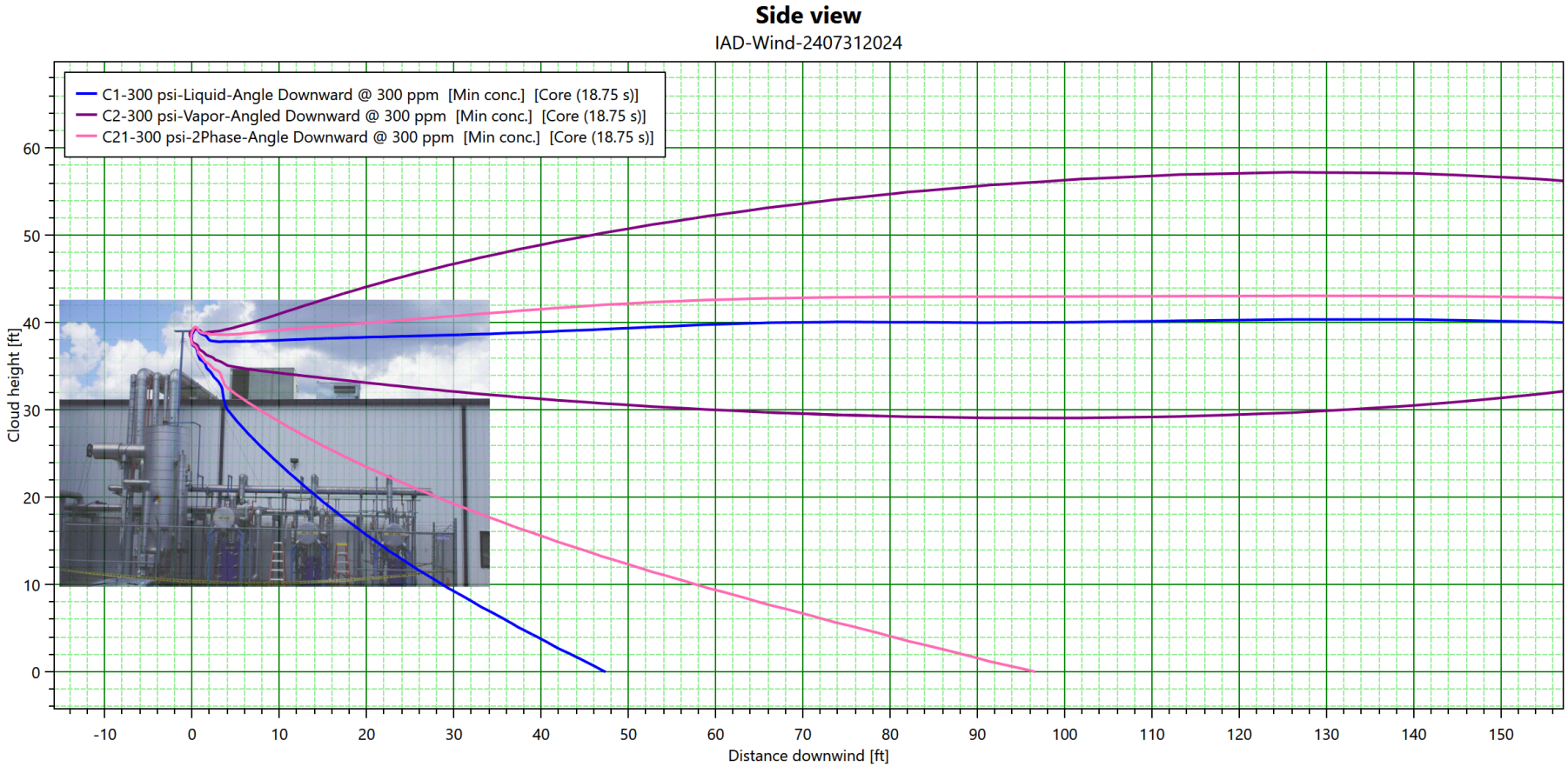


Figure 19 - Cases 1, 2, and 21 – Liquid, Vapor, and Two-Phase Relief – 300 psig – Angled Downward

**This plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

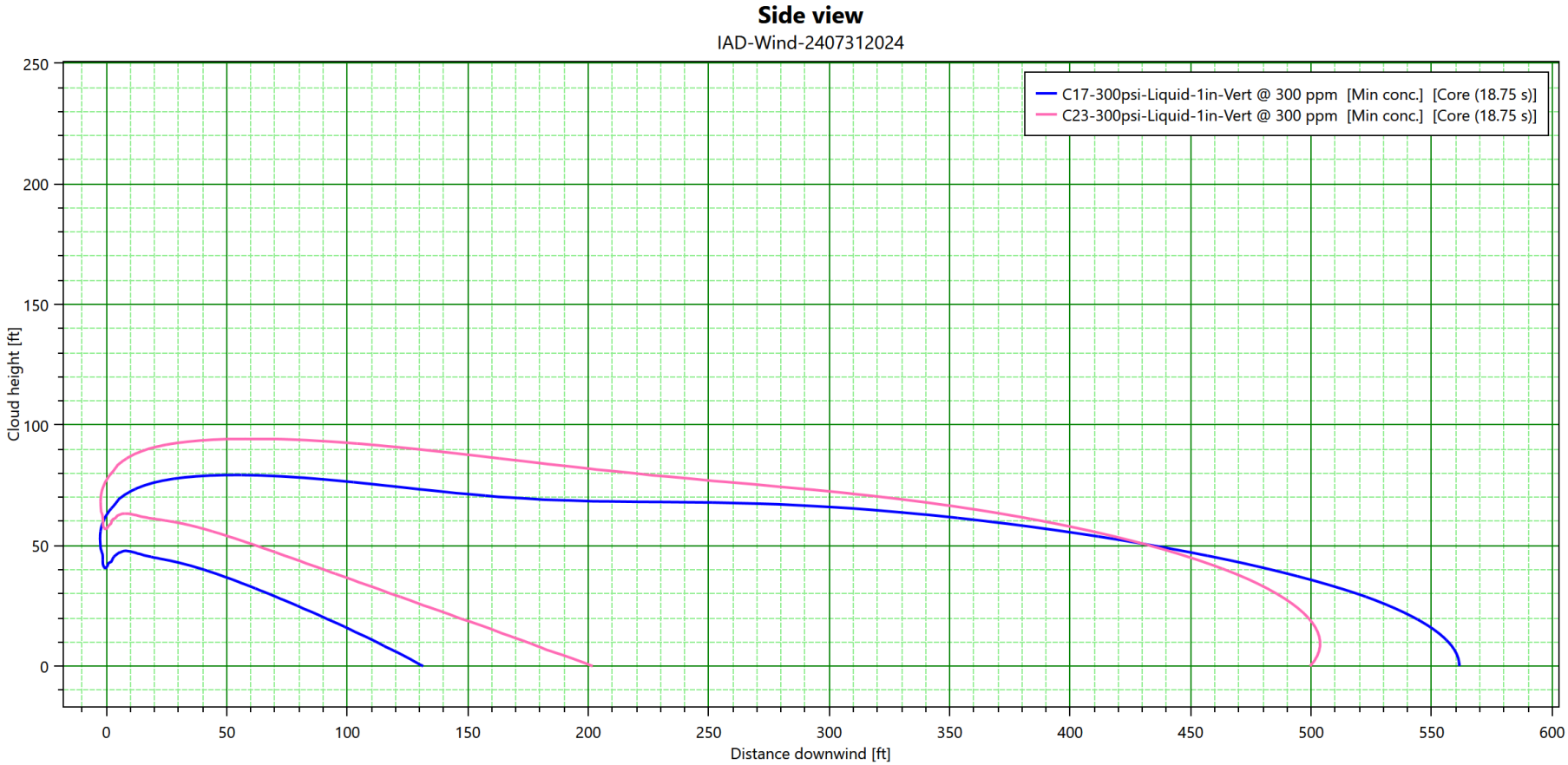


Figure 20 - Cases 17 and 23 – Liquid Relief – 300 psig – Vertical 1-inch Diameter – 39 feet and 55 feet

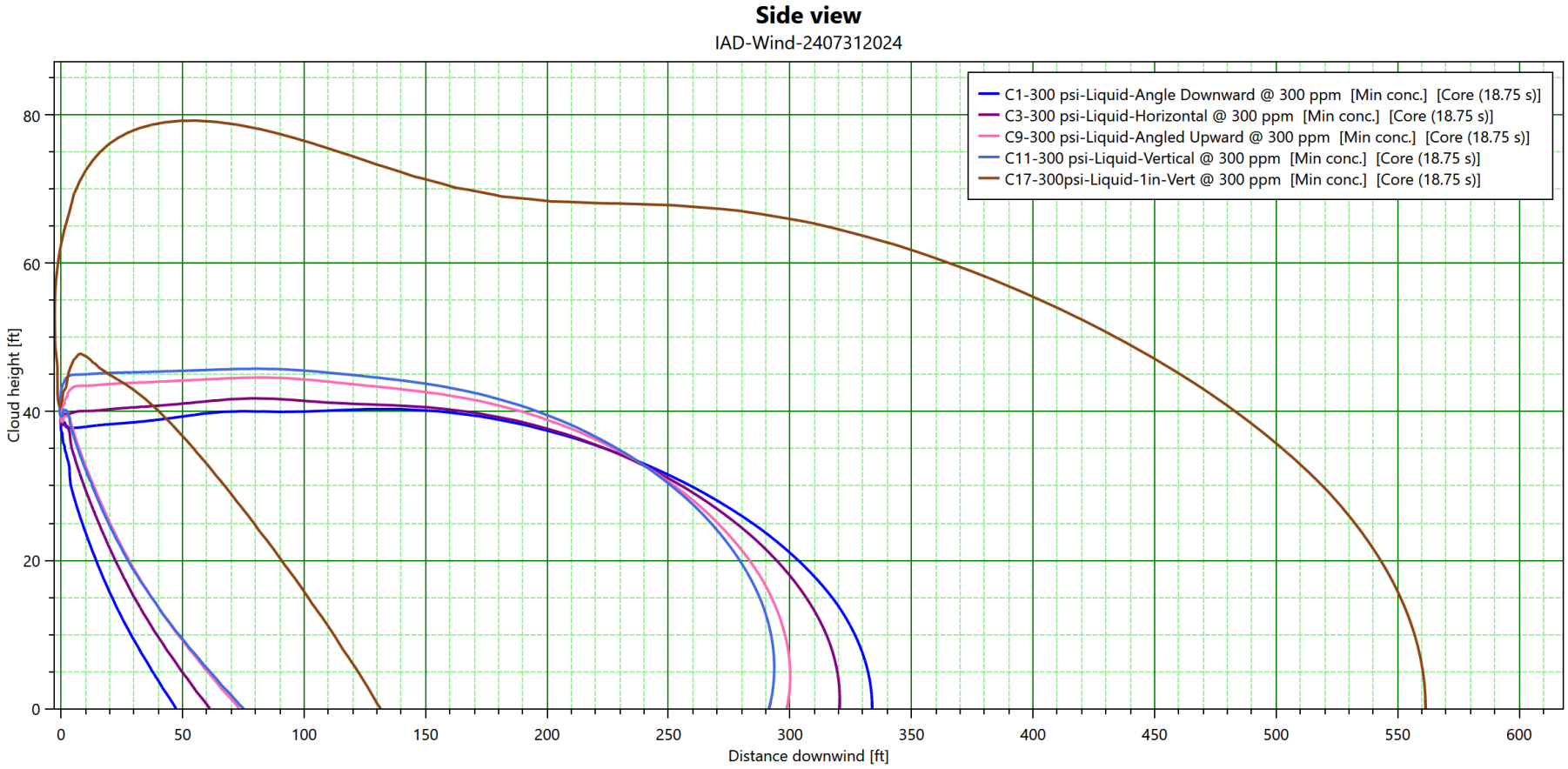


Figure 21 - Cases 1, 3, 9, 11 and 17 – Liquid Relief – 300 psig – Range of Orientations

**For Cases 1, 3, 9, and 11, this plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

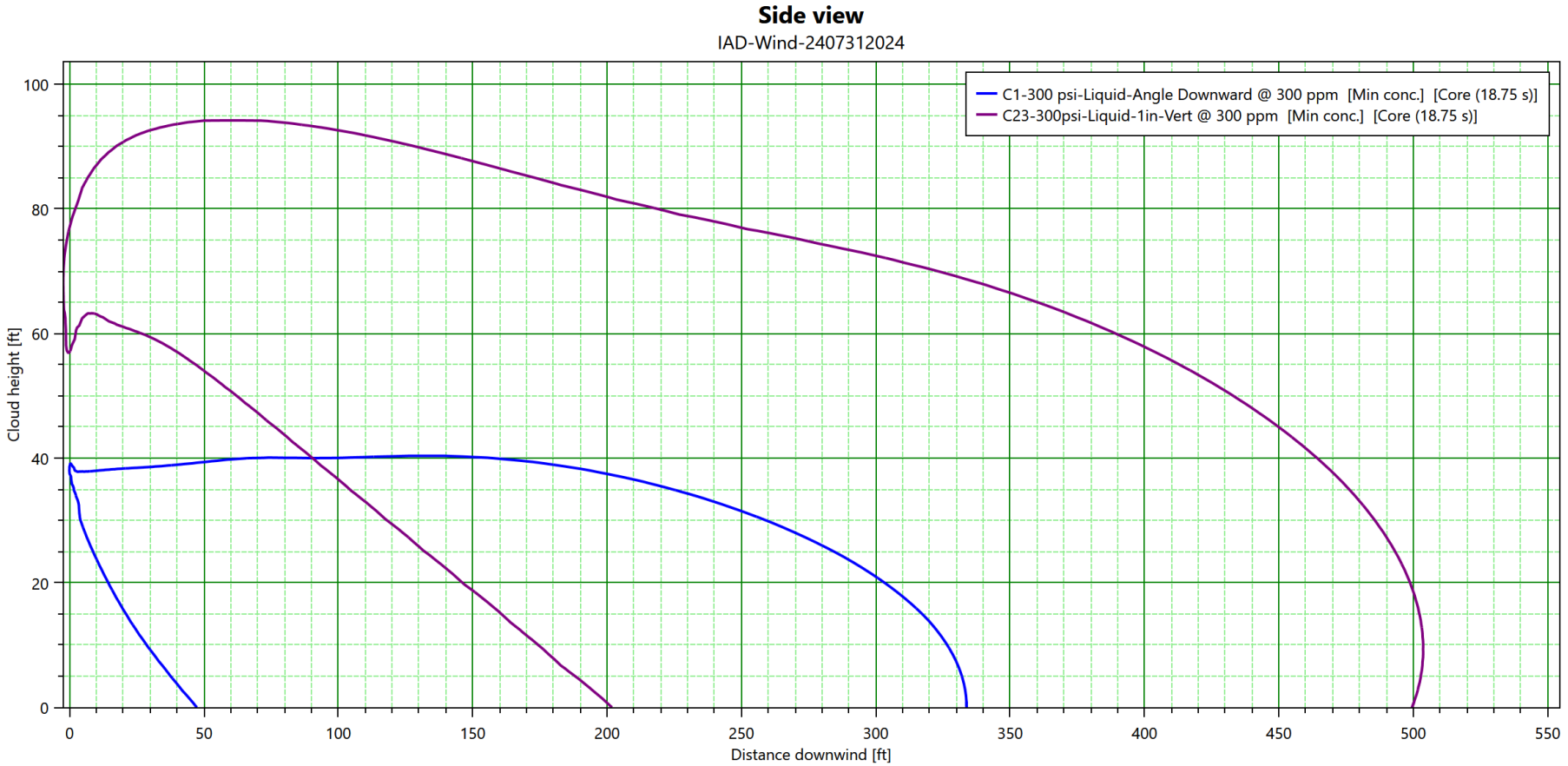


Figure 22 - Cases 1 and 23 – Liquid Relief – 300 psig – Angled Downward at 39 feet and Vertical 1-inch Diameter at 55 feet

**For Case 1, this plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

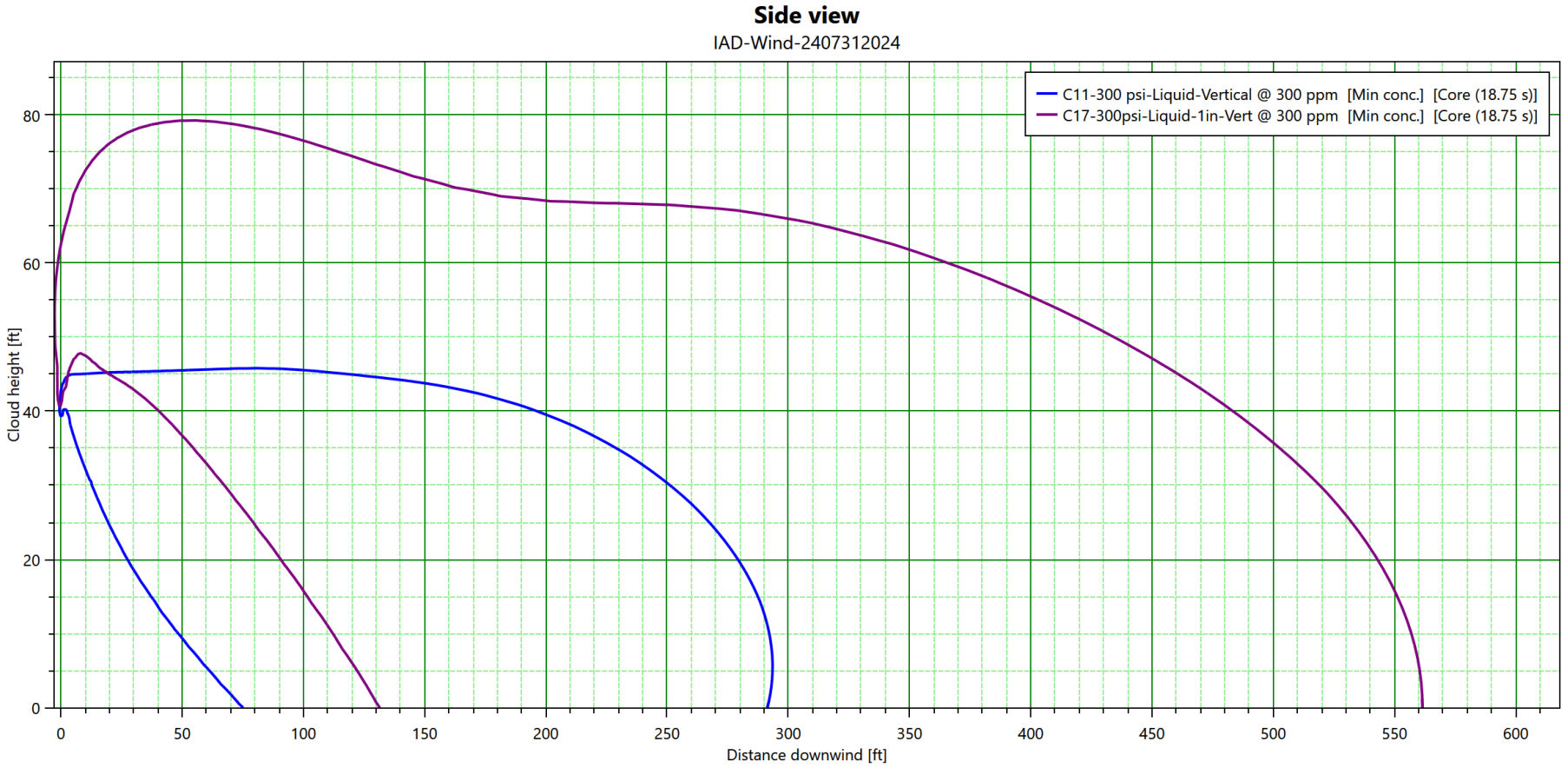


Figure 23 - Cases 11 and 17 – Liquid Relief – 300 psig – Vertical - 1-inch Diameter Single Point and 3-inch Tee Diffuser

**For Case 11, this plot illustrates discharge from the tee-diffuser oriented to the South, North discharge is not shown*

5.2 Far-Field Dispersion Models

The Phast dispersion model was used to assess the far-field dispersion of ammonia vapors from the discharge. For this assessment, the building wake model was employed. Accordingly, the model illustrates the downwind dispersion from the Northeast side of the building, dispersing in the Northwest direction. The results are illustrated using the 160 degree wind direction observed at the time of the event. The model did not explicitly model the dispersion of vapors over the roof, but rather initialized the dispersing cloud at the edge of the building as it is entrained into the building lee zone, as illustrated in Figure 5.

Case 1 from the near field release model scenario set was assessed as the basis of the dispersion model, and the downwind dispersion model considered the dispersion of a plume originating from one side of the discharge tee, at a rate of 823.6 lb/hr. In reality, additional vapor from the opposite side of the tee discharge would also contribute to the plume dispersion, but such effects are beyond the capability of the Phast model.

The results are illustrated as dispersion footprint contours, illustrating the extent of the dispersion at a height of 5 feet above ground level. The 300 ppm IDLH concentration was not exceeded at this height at any location; 25 ppm and 75 ppm concentrations contours are plotted. The highest concentration predicted in the building wake was 105 ppm.



Figure 24 - Dispersion Footprint Contours for Building Wake and Far Field Dispersion

6 Conclusions

The results of the study support several key conclusions:

1. None of the vapor relief cases evaluated in the study, including the case angled downward at 60 degrees, resulted in clouds that exceeded the IDLH (or even 25 ppm-See Appendix C) at ground level. The 300 psig and 45 psig vapor relief scenarios, even those angled downward (Case 2 and Case 6), were shown to result in buoyant clouds that rise after discharge. In comparison, all liquid and two-phase releases assessed in the study were shown to form dense clouds that slump to ground level. Accordingly, the modeling supports the conclusion that the relief discharge that occurred at Cuisine Solutions was a two-phase release with a significant liquid component that resulted from liquid or two-phase flow to the relief valve inlet. This conclusion is illustrated in Figure 8 and Figure 10.
2. Cases which consider a liquid flow to the relief valve inlet are predicted to result in significant two-phase discharge to the atmosphere, with liquid fractions of 69% or higher, depending on the relief pressure. Accordingly, it is concluded that a liquid or two-phase flow to the relief valve inlet was likely to have led to the significant liquid component in the relief discharge to atmosphere. This liquid or two-phase flow could have resulted from inadequate liquid disengagement in the vessel headspace during relief, a high liquid level, and/or overfill of the vessel. Vapor/liquid disengagement in pressure relief is a phenomenon that is not generally considered in the design of ammonia refrigeration relief systems, and the small vessel involved in this incident provided very limited distance for liquid disengagement. This conclusion is illustrated by the relief valve discharge modeling results in Table 2.
3. Case 1 most closely resembles the release dynamics observed in the incident. This case considers a liquid relief at 300 psig resulting in a two-phase discharge angled downward by the bevel cut tee. This conclusion is supported by the relief valve test data (Exhibit 129), video of the incident which illustrates the initial release angle, and dense cloud slumping to ground level (Exhibit 143), and the relief piping design (Exhibit 130). Case 21 considers a scenario similar to Case 1, a two-phase vapor-liquid mixture at the relief inlet, exhibiting similar cloud slumping. This conclusion is illustrated in Figure 19. Accordingly, it is considered that the following factors played a role in the incident:
    a. The relief discharge in the incident was angled downward by the bevel cut on the tee diffuser, as supported by the initial release angle observed in the video and seen in the Case 1 and Case 21 model results.
    b. The relief discharge in the incident contained a significant liquid component that contributed to the dense cloud slumping to ground level as observed in the video and seen in the Case 1 and Case 21 model results. Vapor releases were predicted to result in buoyant clouds which would not have reached ground level. This conclusion is further illustrated in Figure 8.
4. Liquid relief at 300 psig and 39 feet elevation, representative of the Cuisine Solutions incident, is shown to result in a two-phase discharge which exceeds the IDLH at ground level for any relief orientation. Modifying the discharge orientation alone would not have been sufficient to prevent an incident. This conclusion is illustrated clearly in Figure 21. Furthermore, increasing the elevation and reducing the discharge minimum credible 1-inch diameter, in order to jet the liquid relief scenario vertically upward at 55 feet above ground level with a maximum release velocity (Case 23), was shown to be insufficient to prevent the release from exceeding IDLH at ground level. This is illustrated in Figure 22.

5. A nine-minute discharge from a 300 psig liquid relief scenario, which is considered to best represent the scenario based on the observations and modeling, is predicted to release a total mass of 247.1 lbs of ammonia. This is a credible maximum release inventory for the incident, considering the relief valve inlet may have had some vapor component, which would reduce the relief rate. This conclusion is based on the discharge results provided in Table 2.
6. A spurious liquid relief scenario at 45 psig, at the observed release conditions of the incident, would have resulted in liquid ammonia rainout to ground level for any release orientation. The resulting liquid pool could have exposed people at ground level to both toxic vapor hazards and direct exposure to liquid ammonia droplets which present chemical burn hazards. This conclusion is illustrated in Figure 10, Figure 11, Figure 14, Figure 15, and Figure 17.
7. Ammonia vapors dispersing downwind across the building roof will be drawn toward the ground by the building wake effect on the downwind side of the building. This incident resulted in ammonia vapors dispersing across the roof, due to the release elevation, orientation, and cloud density. Ammonia vapors entered the recirculation zone downwind of the building. Modeling of the dispersion in the building wake predicts a plume exceeding 75 ppm on the northwest side of the building at ground level breathing height, and exceeding 25 ppm dispersing offsite. This is illustrated in Figure 24.
8. The design of a relief systems to safely discharge anhydrous ammonia to the atmosphere must consider the relief inlet phase and discharge phase, as well as the discharge height, discharge velocity, resulting cloud density, and potential building lee effects.
    a. The discharge of two-phase anhydrous ammonia relief streams to the atmosphere can cause dense-slumping clouds for many relief scenarios and liquid droplets can rainout to form liquid pools below the relief point.
    b. High velocity, elevated, vertical discharge is the best option to discharge vapor or two-phase anhydrous ammonia relief discharge to the atmosphere, but these parameters alone may not guarantee safe discharge is attained for all relief scenarios that must be considered.
    c. The credible range of relief rates, phase, and source conditions must be considered to ensure relief will be discharged to a safe location for all credible relief scenarios.

Appendix A: Exhibits Provided for Review

Exhibit 072
Exhibit 084
Exhibit 101
Exhibit 106
Exhibit 112
Exhibit 115
Exhibit 129
Exhibit 130
Exhibit 131
Exhibit 141
Exhibit 143
Exhibit 144
Exhibit 147
Exhibit 207
Exhibit 013
Exhibit 021
Exhibit 028
Exhibit 030
Exhibit 037
Exhibit 041
Exhibit 044
Exhibit 046
Exhibit 054
Exhibit 061
Exhibit 062
Exhibit 065

Appendix B: Weather Data Collected

station	valid	lon	lat	elevation	tmpf	relh	drct	sped	gust_mph	skyc1	skyc2	skyc3	skyl1	skyl2	skyl3
IAD	7/30/2024 0:52	-77.4473	38.9348	98	76	78.94	200	14.95	21.85	FEW	BKN		15000	25000	
IAD	7/30/2024 1:52	-77.4473	38.9348	98	75	81.62	200	12.65		FEW	BKN		15000	25000	
IAD	7/30/2024 2:39	-77.4473	38.9348	98	75	81.62	190	9.2		BKN			1500		
IAD	7/30/2024 2:50	-77.4473	38.9348	98	75.2	83.32	200	10.35		BKN			1300		
IAD	7/30/2024 2:52	-77.4473	38.9348	98	75	81.62	200	10.35		BKN			1300		
IAD	7/30/2024 3:52	-77.4473	38.9348	98	75	81.62	200	11.5		OVC			1100		
IAD	7/30/2024 4:52	-77.4473	38.9348	98	75	84.46	180	8.05		OVC			1200		
IAD	7/30/2024 5:52	-77.4473	38.9348	98	75	84.46	180	6.9		OVC			1100		
IAD	7/30/2024 6:52	-77.4473	38.9348	98	75	84.46	190	9.2		OVC			1100		
IAD	7/30/2024 7:52	-77.4473	38.9348	98	75	84.46	190	8.05		OVC			1100		
IAD	7/30/2024 8:52	-77.4473	38.9348	98	76	81.69	190	6.9		OVC			1200		
IAD	7/30/2024 9:52	-77.4473	38.9348	98	77	79.02	190	9.2		OVC			1300		
IAD	7/30/2024 10:52	-77.4473	38.9348	98	78	76.45	190	8.05		OVC			1500		
IAD	7/30/2024 11:52	-77.4473	38.9348	98	80	74.06	170	10.35		OVC			1700		
IAD	7/30/2024 12:52	-77.4473	38.9348	98	83	64.92	200	10.35		BKN	OVC		2200	3100	
IAD	7/30/2024 13:52	-77.4473	38.9348	98	85	60.87	170	10.35	20.7	BKN			2800		

station	valid	lon	lat	elevation	tmpf	relh	drct	sped	gust_mph	skyc1	skyc2	skyc3	skyl1	skyl2	skyl3
IAD	7/30/2024 14:27	-77.4473	38.9348	98	87	57.1	170	11.5	24.15	BKN	BKN		3000	15000	
IAD	7/30/2024 14:52	-77.4473	38.9348	98	86	58.95	160	13.8	23	BKN	BKN		3000	15000	
IAD	7/30/2024 15:52	-77.4473	38.9348	98	88	55.32	170	13.8	21.85	SCT	BKN		4100	5000	
IAD	7/30/2024 16:52	-77.4473	38.9348	98	86	60.99	190	10.35		SCT	BKN	BKN	3800	5500	20000
IAD	7/30/2024 17:52	-77.4473	38.9348	98	84	67.28	160	16.1	31.05	SCT	BKN	BKN	2700	3600	6500
IAD	7/30/2024 18:15	-77.4473	38.9348	98	79	84.69	170	5.75		SCT	BKN	BKN	3000	6000	12000
IAD	7/30/2024 18:34	-77.4473	38.9348	98	80	84.75	160	5.75		SCT	BKN	BKN	3000	6000	12000
IAD	7/30/2024 18:52	-77.4473	38.9348	98	80	81.96	200	6.9		SCT	BKN	BKN	3000	6000	12000
IAD	7/30/2024 19:52	-77.4473	38.9348	98	77	76.36	190	5.75		FEW	BKN	BKN	3600	10000	20000
IAD	7/30/2024 20:52	-77.4473	38.9348	98	77	73.78	180	6.9		FEW	BKN	BKN	4000	10000	20000
IAD	7/30/2024 21:52	-77.4473	38.9348	98	76	76.27	200	4.6		OVC			9000		
IAD	7/30/2024 22:52	-77.4473	38.9348	98	75	81.62	200	6.9		SCT	BKN		7000	10000	
IAD	7/30/2024 23:11	-77.4473	38.9348	98	75	81.62		3.45		FEW	OVC		1600	6500	
IAD	7/30/2024 23:24	-77.4473	38.9348	98	75	81.62	250	5.75		BKN	OVC		1600	6000	
IAD	7/30/2024 23:52	-77.4473	38.9348	98	75	84.46	190	3.45		OVC			1500		
IAD	7/31/2024 0:05	-77.4473	38.9348	98	75	84.46	210	5.75		OVC			1400		

station	valid	lon	lat	elevation	tmpf	relh	drct	sped	gust_mph	skyc1	skyc2	skyc3	skyl1	skyl2	skyl3
IAD	7/31/2024 0:12	-77.4473	38.9348	98	75	84.46	160	3.45		OVC			1400		
IAD	7/31/2024 0:52	-77.4473	38.9348	98	74	87.34	150	5.75		OVC			1200		
IAD	7/31/2024 1:52	-77.4473	38.9348	98	74	87.34	180	5.75		OVC			1100		
IAD	7/31/2024 2:31	-77.4473	38.9348	98	74	90.36	200	5.75		OVC			900		
IAD	7/31/2024 2:52	-77.4473	38.9348	98	74	90.36	190	5.75		OVC			800		
IAD	7/31/2024 3:08	-77.4473	38.9348	98	74	90.36	210	5.75		OVC			700		
IAD	7/31/2024 3:52	-77.4473	38.9348	98	74	90.36	220	4.6		OVC			600		
IAD	7/31/2024 4:49	-77.4473	38.9348	98	73.4	94.1	210	5.75		OVC			400		
IAD	7/31/2024 4:52	-77.4473	38.9348	98	73	93.45	210	5.75		OVC			400		
IAD	7/31/2024 5:52	-77.4473	38.9348	98	73	93.45	240	4.6		OVC			400		
IAD	7/31/2024 6:33	-77.4473	38.9348	98	73	96.68	180	3.45		OVC			300		
IAD	7/31/2024 6:42	-77.4473	38.9348	98	73	96.68	200	3.45		OVC			200		
IAD	7/31/2024 6:52	-77.4473	38.9348	98	73	96.68	180	3.45		OVC			200		
IAD	7/31/2024 7:35	-77.4473	38.9348	98	73	96.68	0	0		BKN	OVC		200	1000	
IAD	7/31/2024 7:52	-77.4473	38.9348	98	73	96.68	0	0		BKN	OVC		200	900	
IAD	7/31/2024 8:27	-77.4473	38.9348	98	76	87.43	200	3.45		BKN			500		

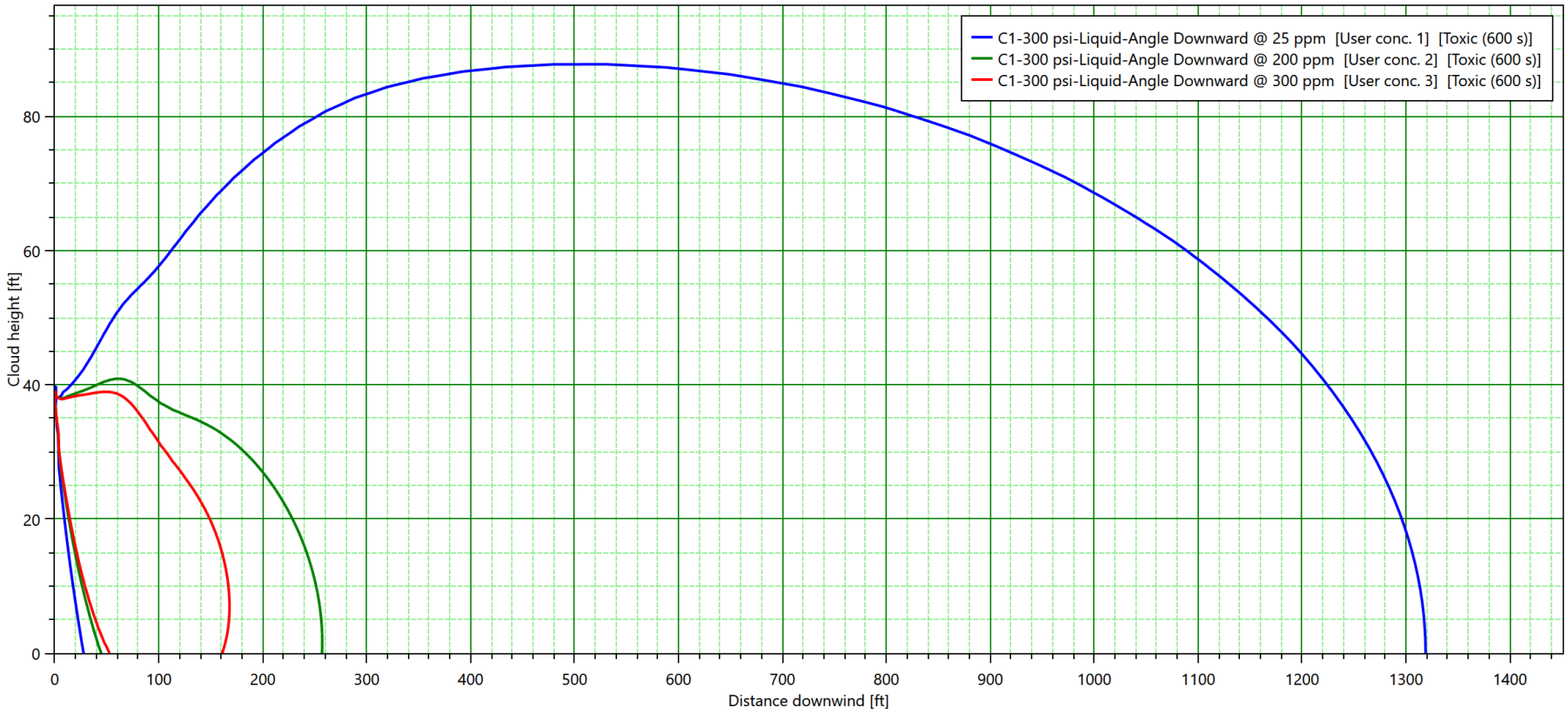
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IAD	7/31/2024 8:52	-77.4473	38.9348	98	78	81.82	200	4.6		SCT	SCT		500	8000	
IAD	7/31/2024 9:52	-77.4473	38.9348	98	84	65.04	0	0		FEW	FEW		10000	25000	
IAD	7/31/2024 10:52	-77.4473	38.9348	98	87	59.08		3.45		FEW			3500		
IAD	7/31/2024 11:52	-77.4473	38.9348	98	91	48.63		4.6		SCT			4800		
IAD	7/31/2024 12:52	-77.4473	38.9348	98	93	44.15	280	8.05	17.25	BKN	BKN		4800	25000	
IAD	7/31/2024 13:52	-77.4473	38.9348	98	94	41.35	290	6.9	17.25	SCT	BKN	BKN	5000	9000	25000
IAD	7/31/2024 14:52	-77.4473	38.9348	98	93	42.65	230	9.2		SCT	BKN	BKN	5000	10000	25000
IAD	7/31/2024 15:52	-77.4473	38.9348	98	96	38.88	280	10.35		FEW			6500		
IAD	7/31/2024 16:52	-77.4473	38.9348	98	94	39.94	260	10.35	18.4	FEW	BKN		5500	9000	
IAD	7/31/2024 17:52	-77.4473	38.9348	98	94	41.35	260	9.2		BKN	BKN		5500	10000	
IAD	7/31/2024 18:52	-77.4473	38.9348	98	88	57.23	160	5.75		FEW	FEW		6500	10000	
IAD	7/31/2024 19:52	-77.4473	38.9348	98	86	58.95	160	9.2		FEW	FEW		6500	10000	
IAD	7/31/2024 20:52	-77.4473	38.9348	98	84	60.74	160	5.75		FEW	FEW		6000	12000	
IAD	7/31/2024 21:52	-77.4473	38.9348	98	82	64.8	180	8.05		CLR					
IAD	7/31/2024 22:52	-77.4473	38.9348	98	80	69.17	190	5.75		CLR					

station	valid	lon	lat	elevation	tmpf	relh	drct	sped	gust_mph	skyc1	skyc2	skyc3	skyl1	skyl2	skyl3
IAD	7/31/2024 23:52	-77.4473	38.9348	98	78	73.87	0	0		CLR					

Appendix C: Supplementary Model Results

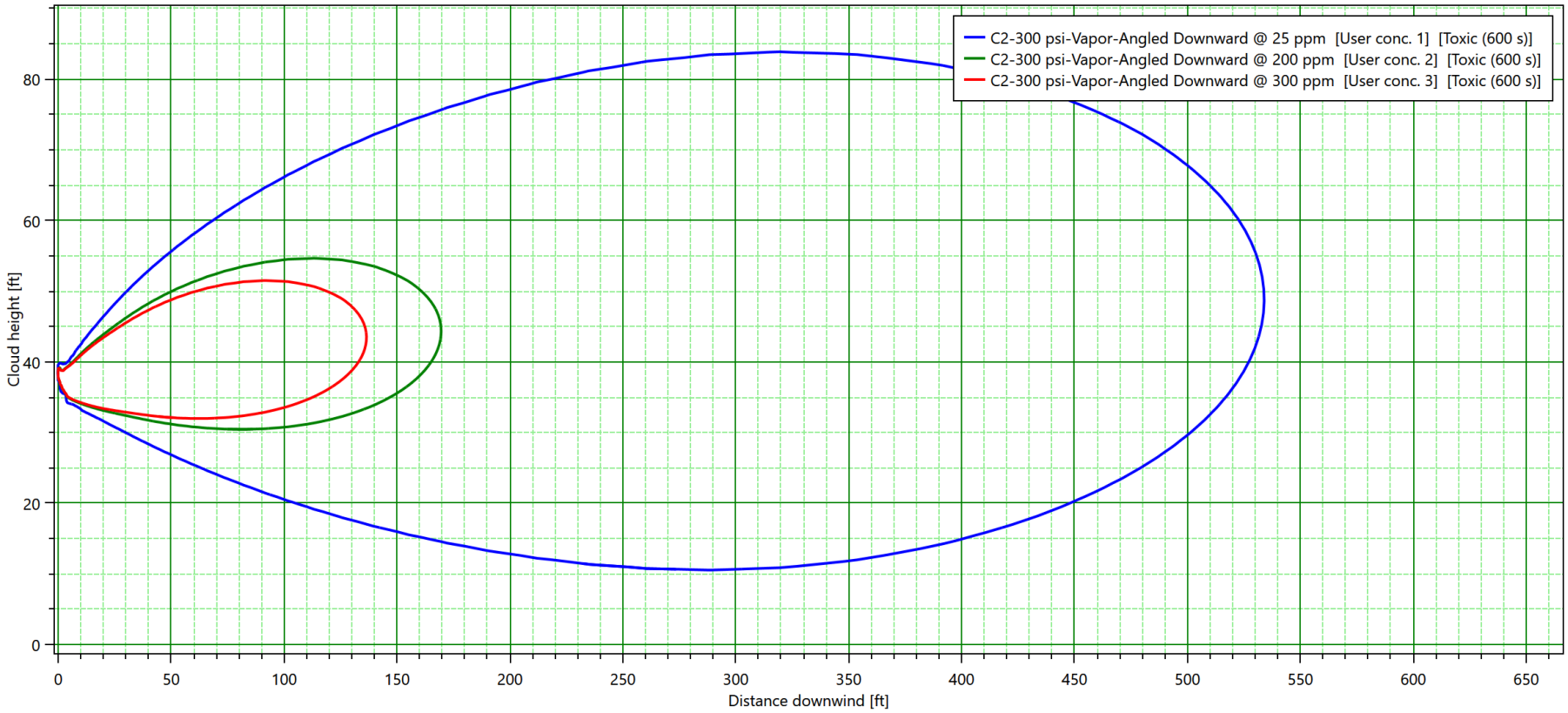
Side view

IAD-Wind-2407312024



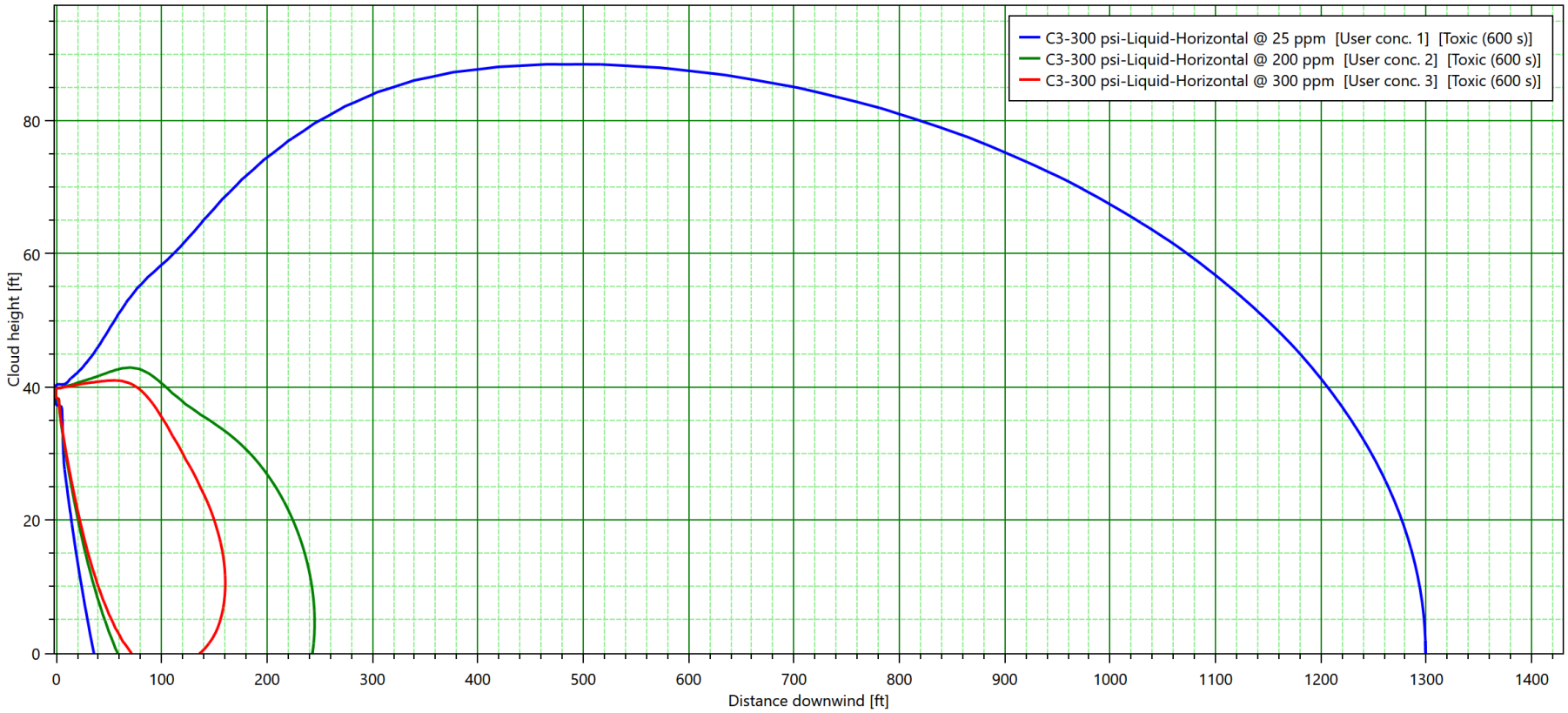
Side view

IAD-Wind-2407312024



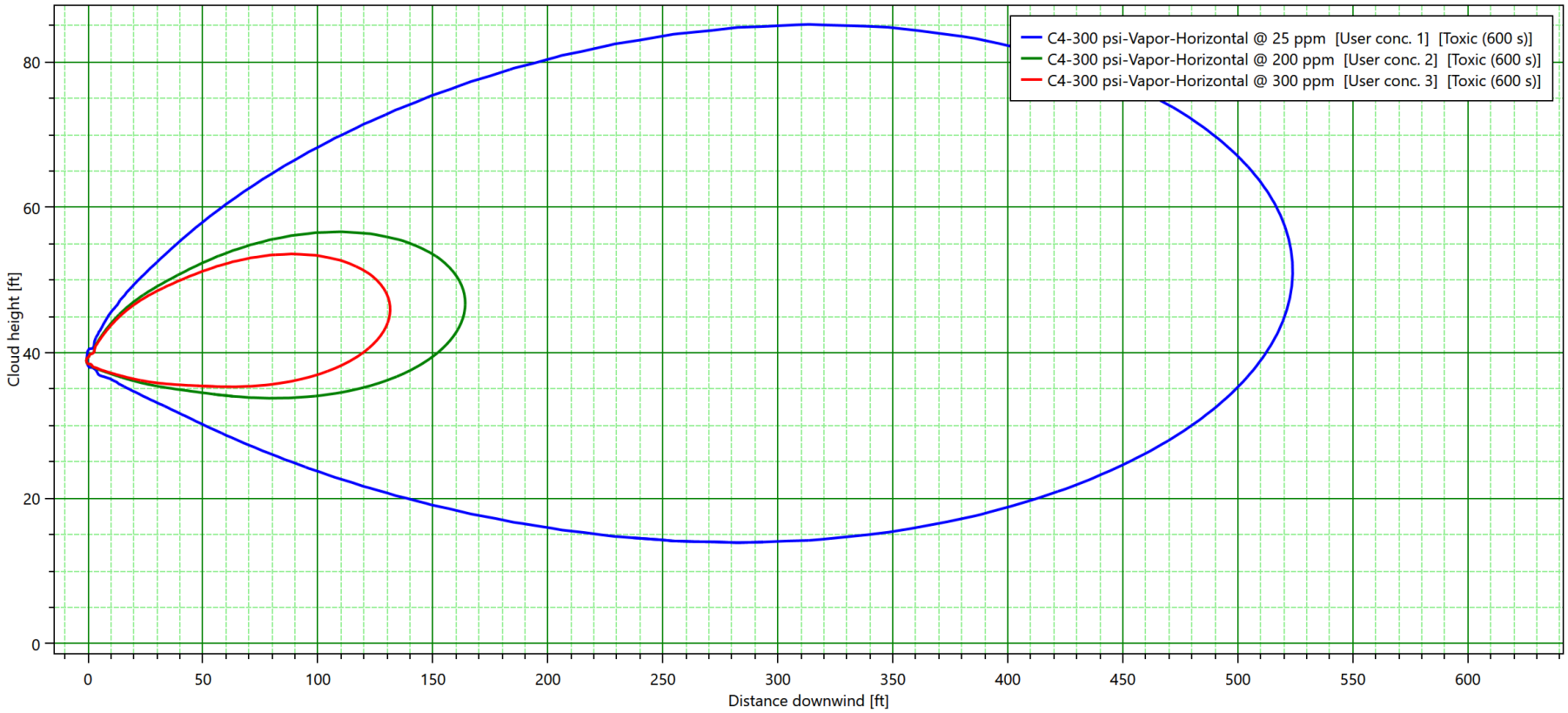
Side view

IAD-Wind-2407312024



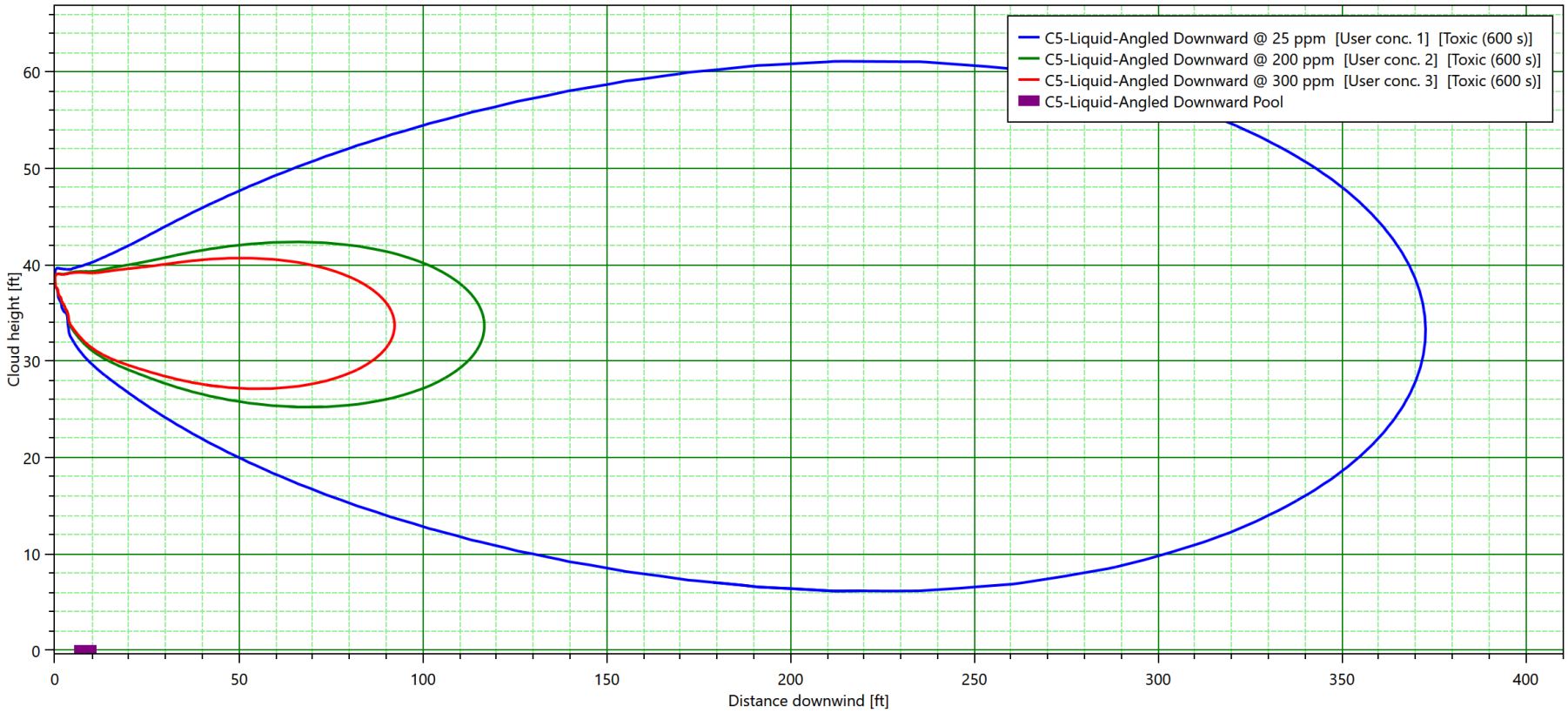
Side view

IAD-Wind-2407312024



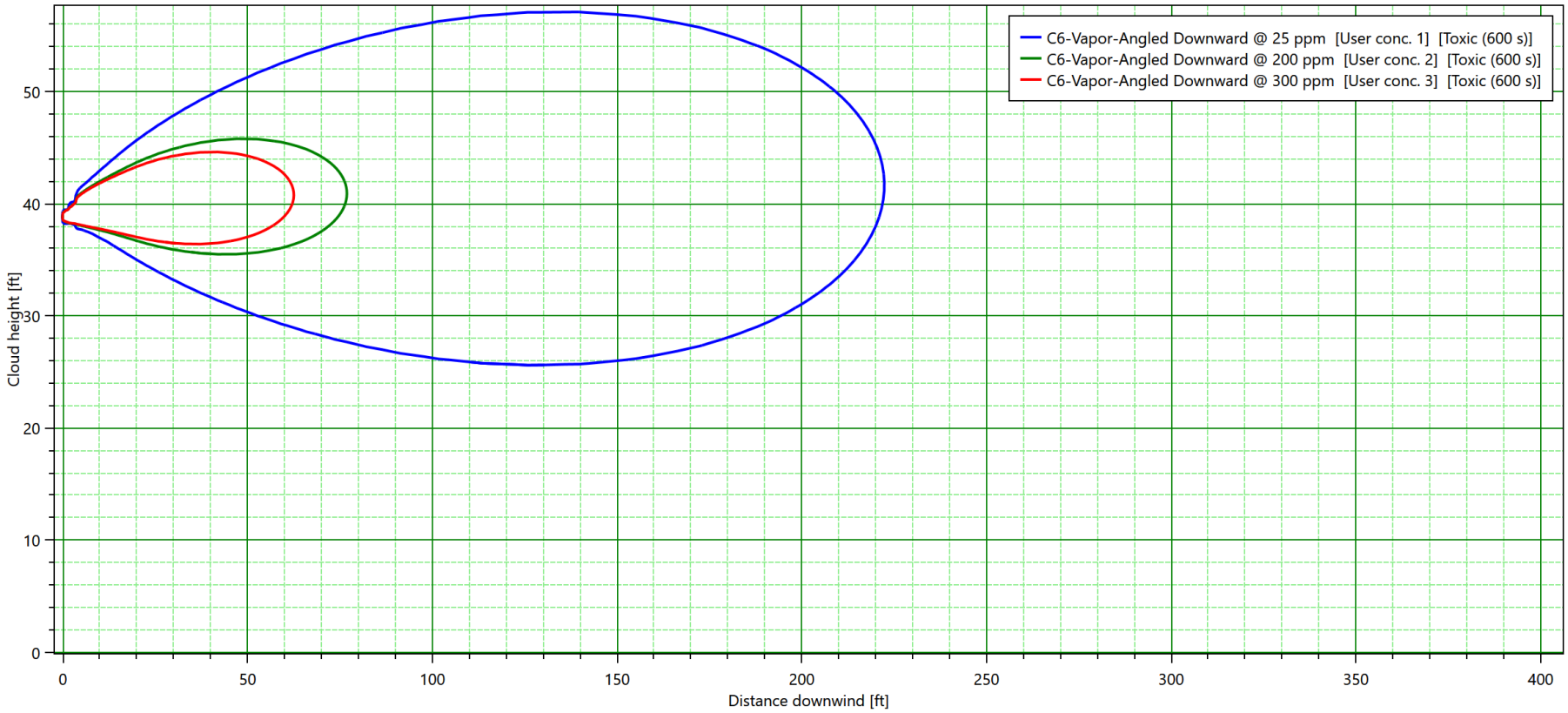
Side view

IAD-Wind-2407312024



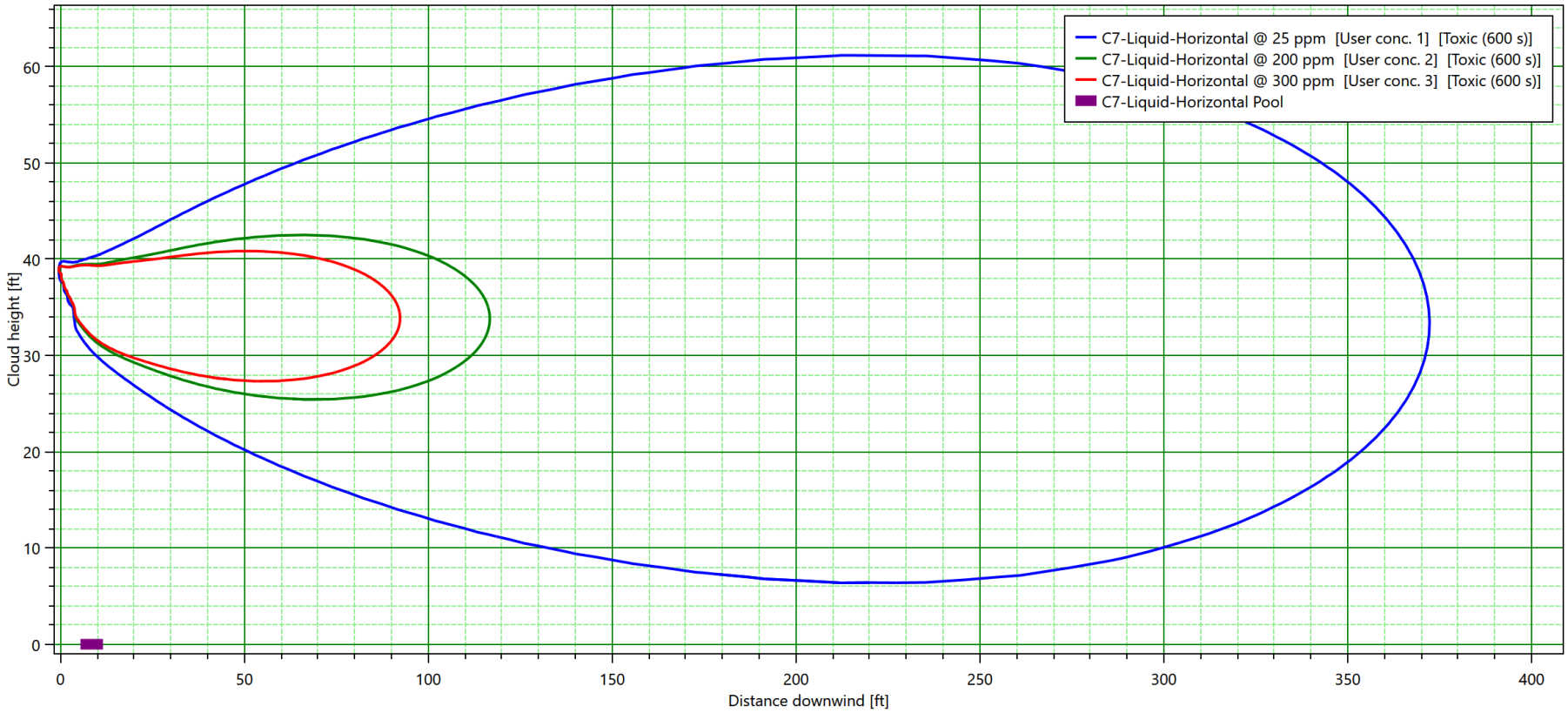
Side view

IAD-Wind-2407312024



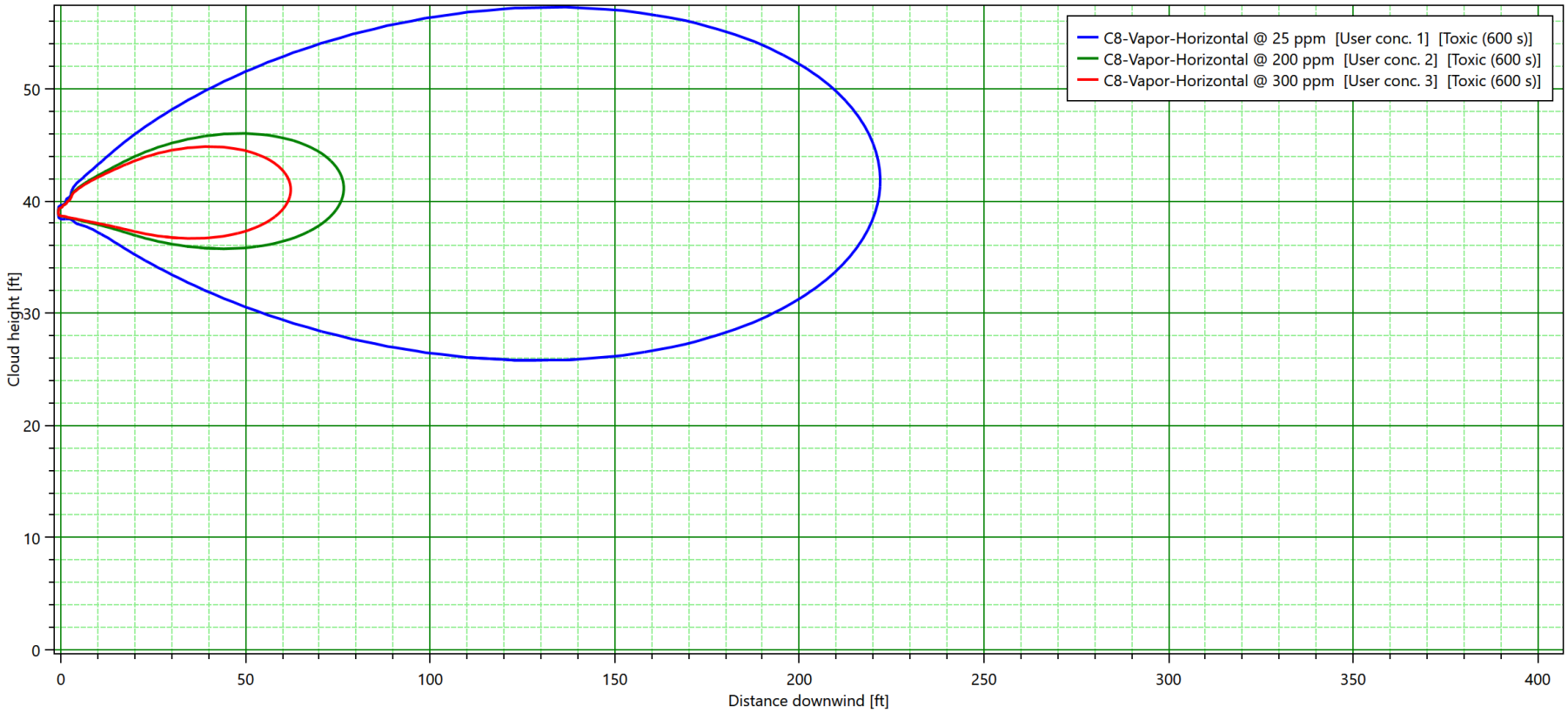
Side view

IAD-Wind-2407312024



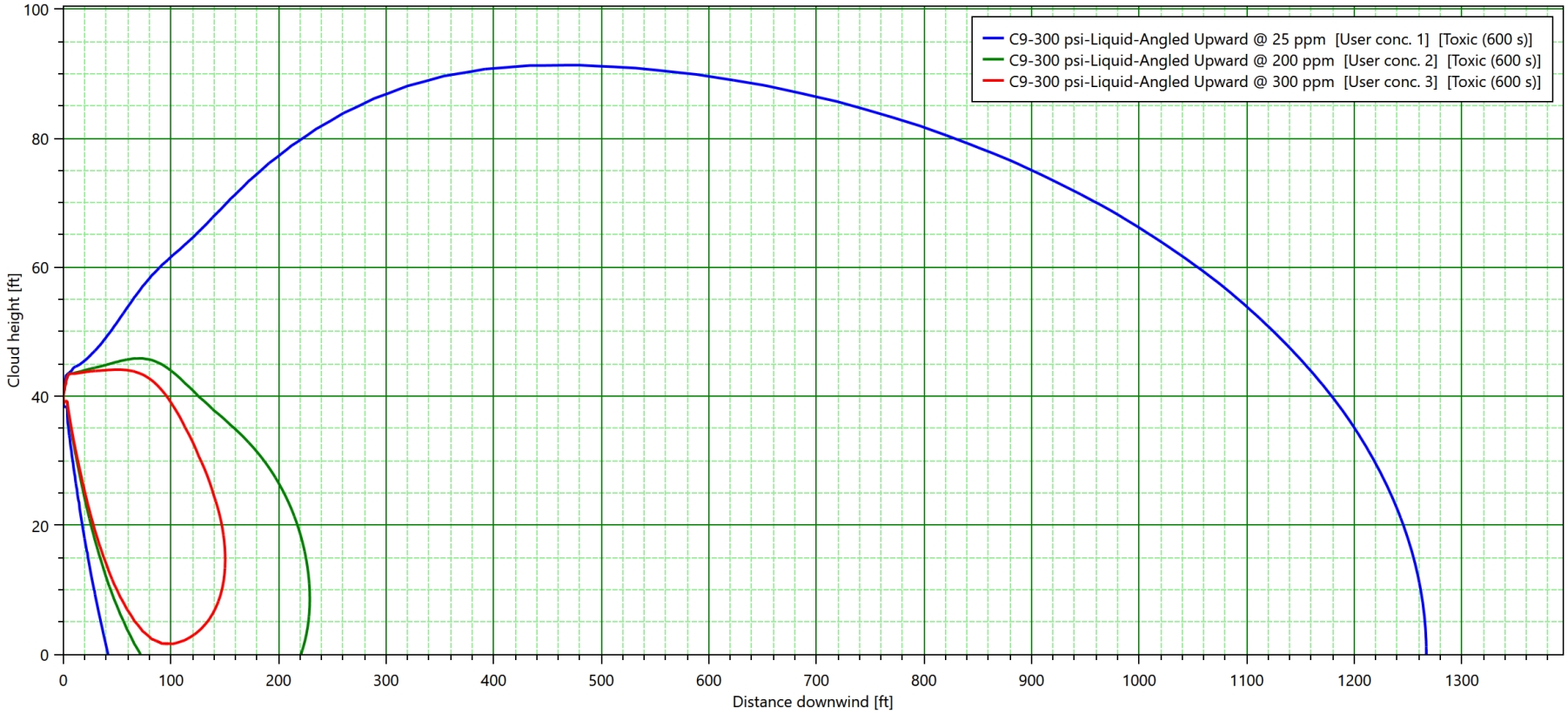
Side view

IAD-Wind-2407312024



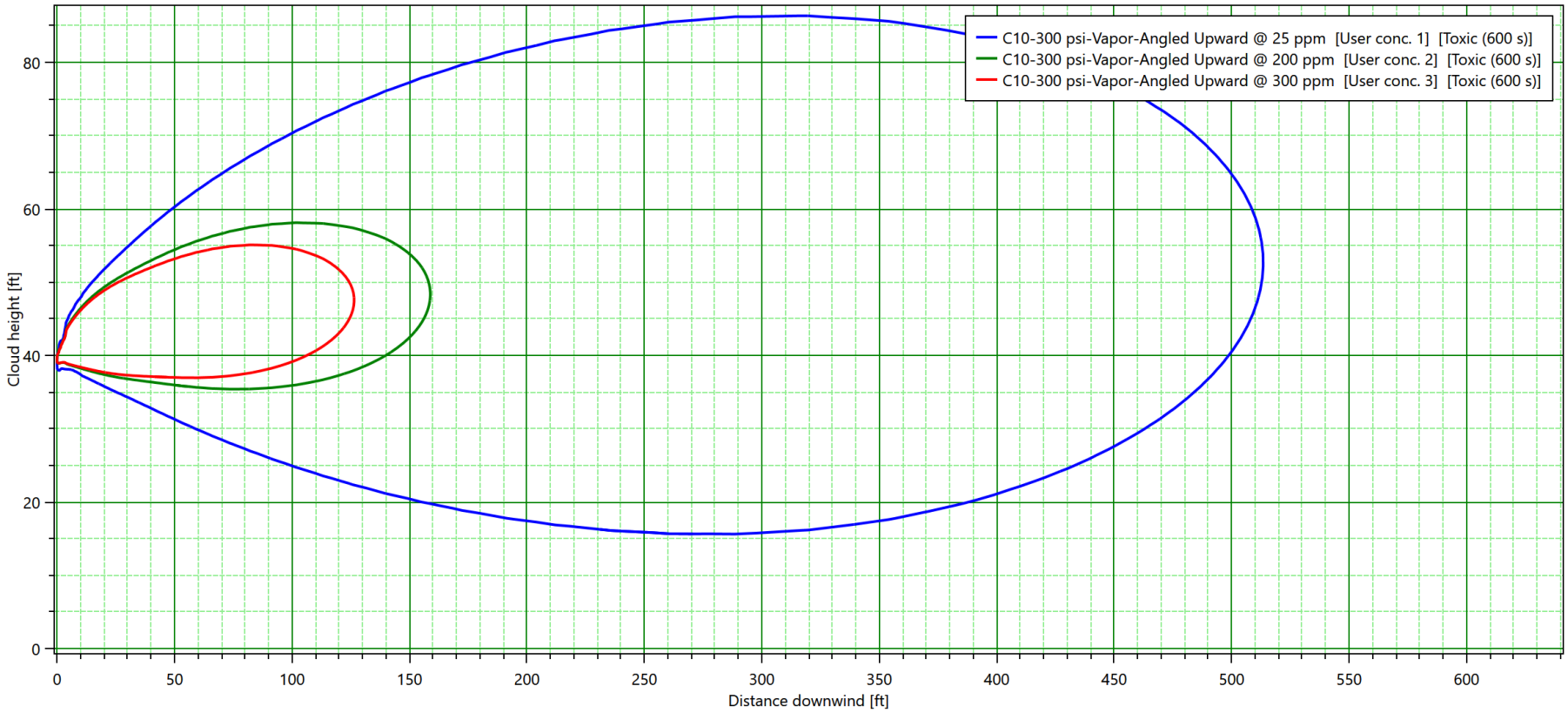
Side view

IAD-Wind-2407312024



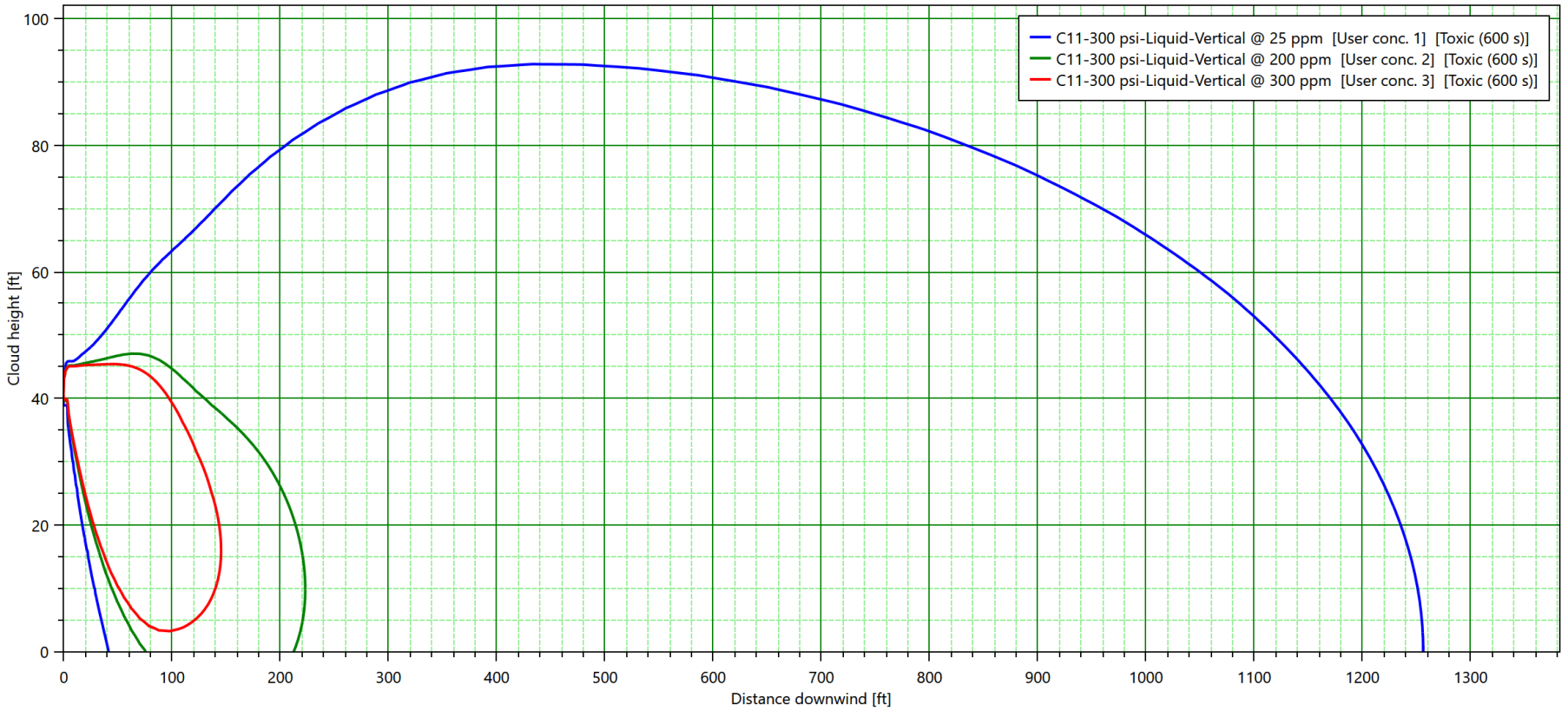
Side view

IAD-Wind-2407312024



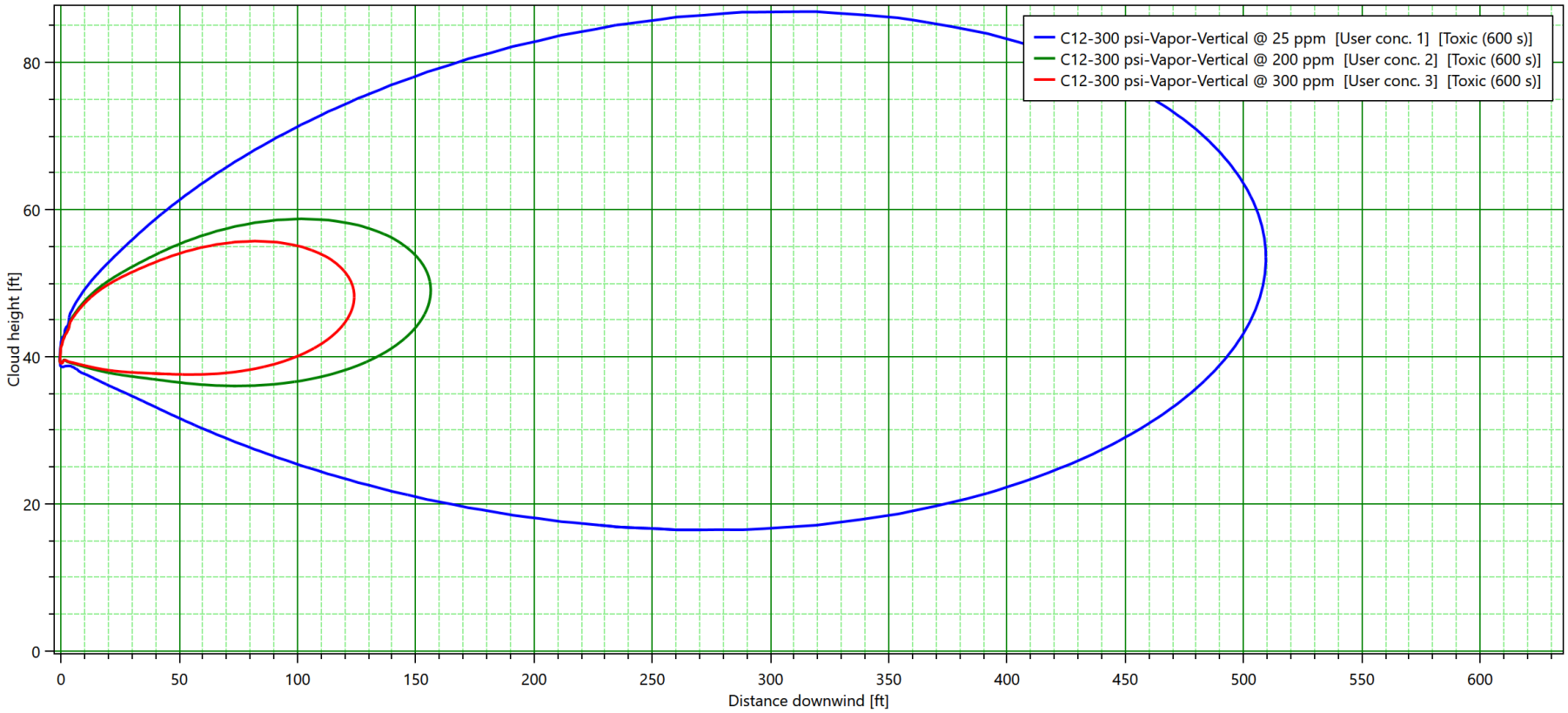
Side view

IAD-Wind-2407312024



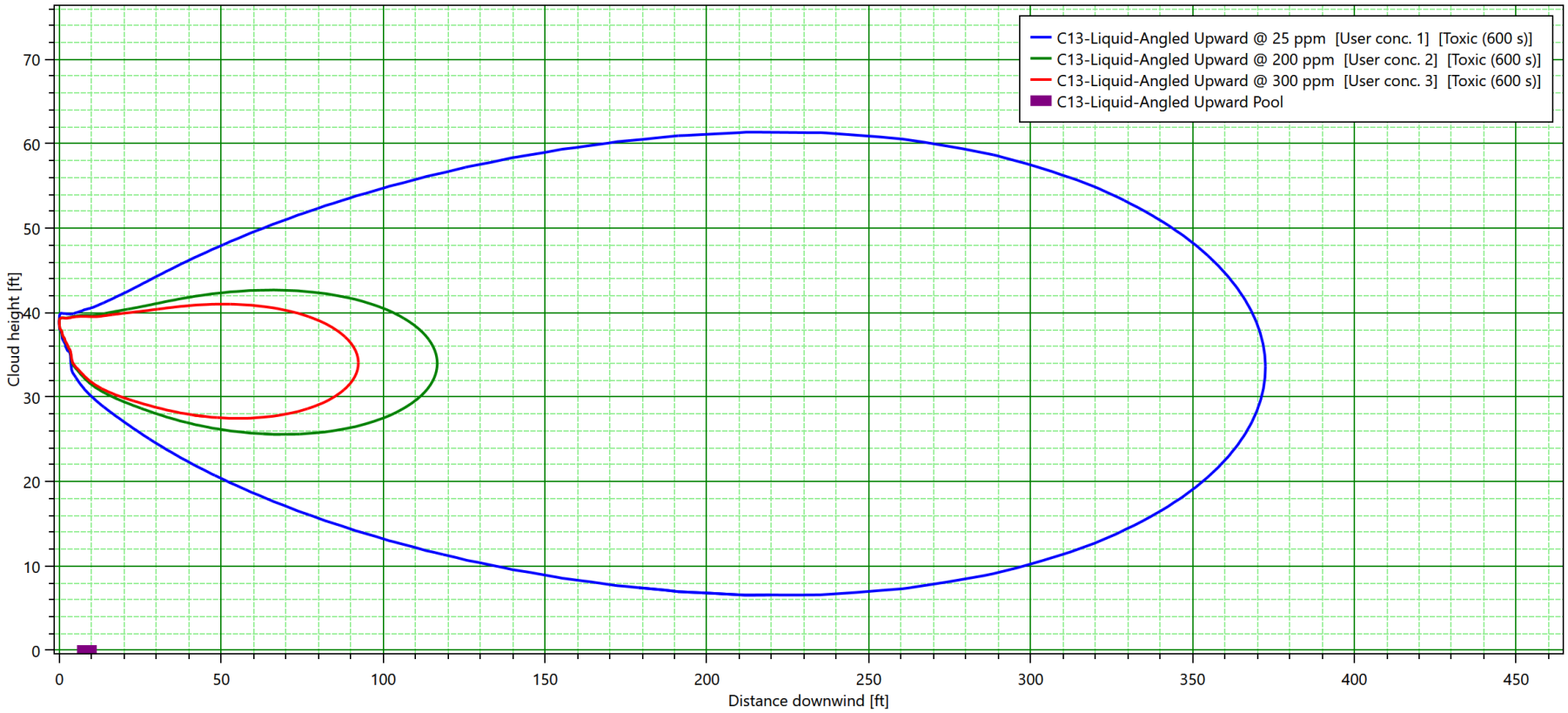
Side view

IAD-Wind-2407312024



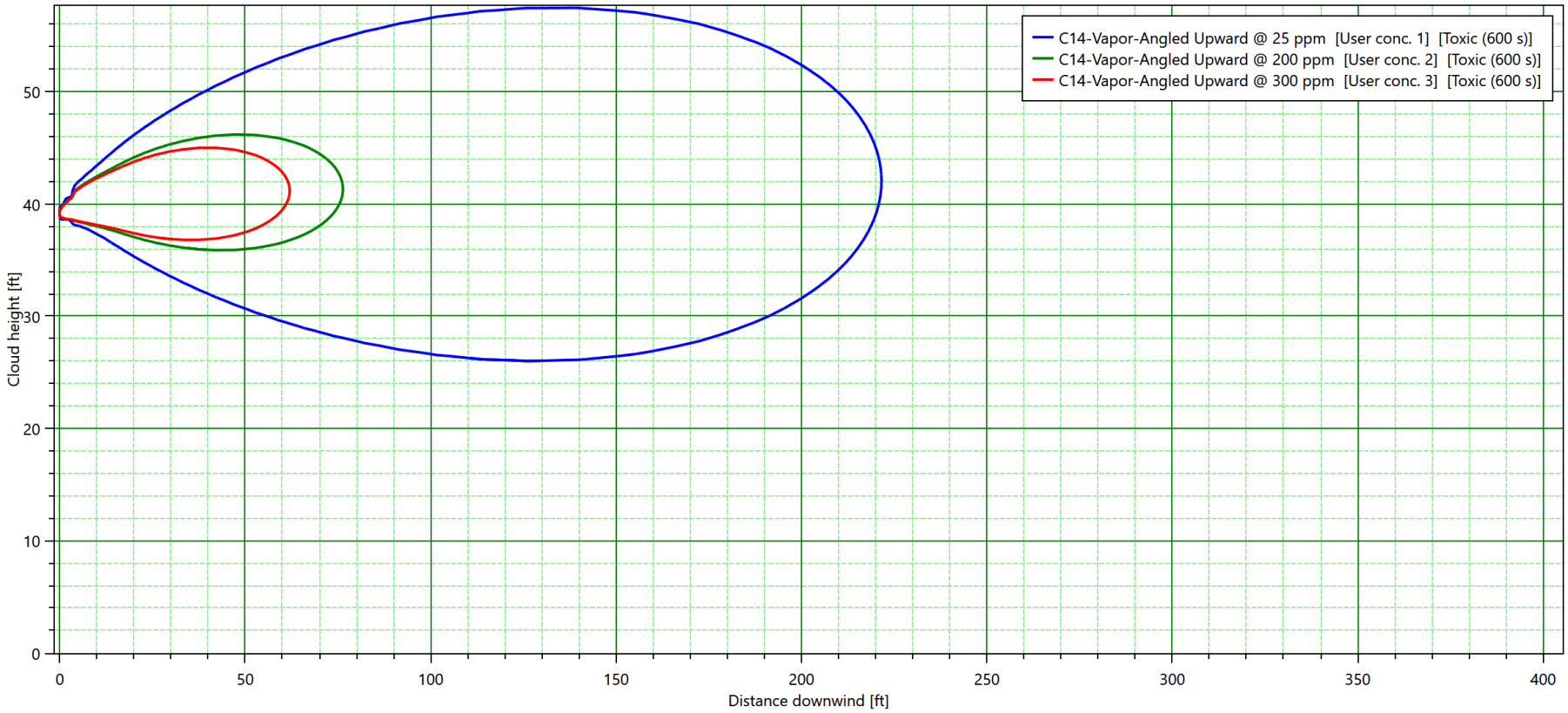
Side view

IAD-Wind-2407312024



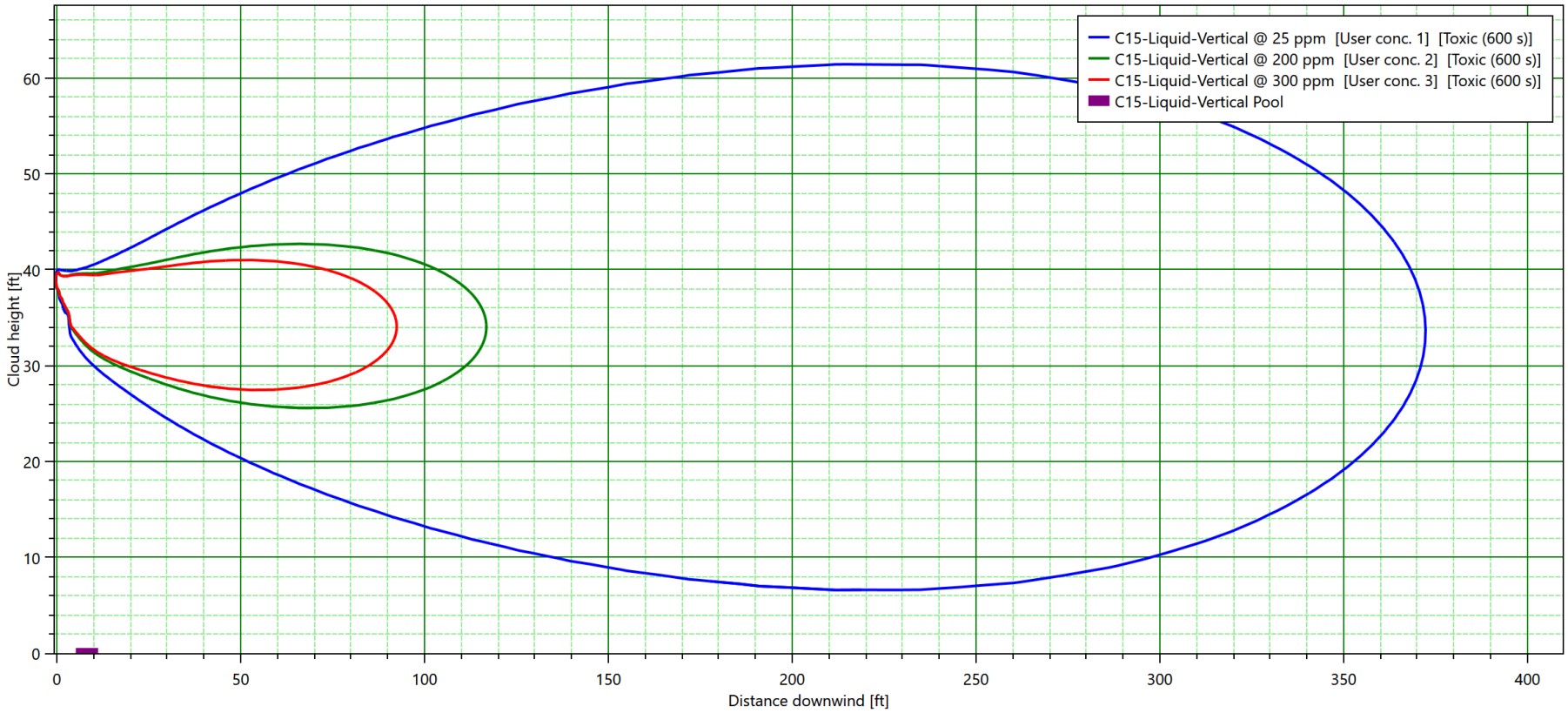
Side view

IAD-Wind-2407312024



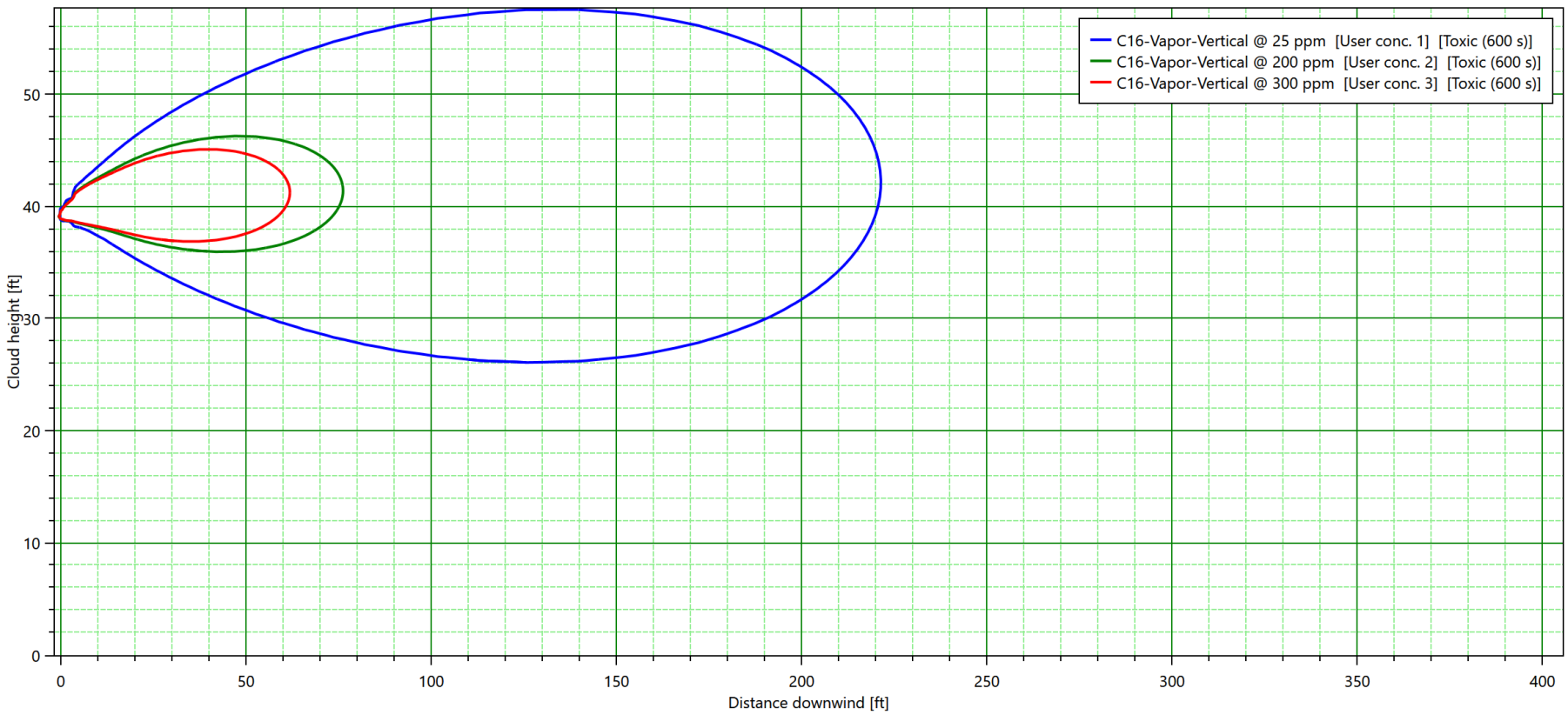
Side view

IAD-Wind-2407312024



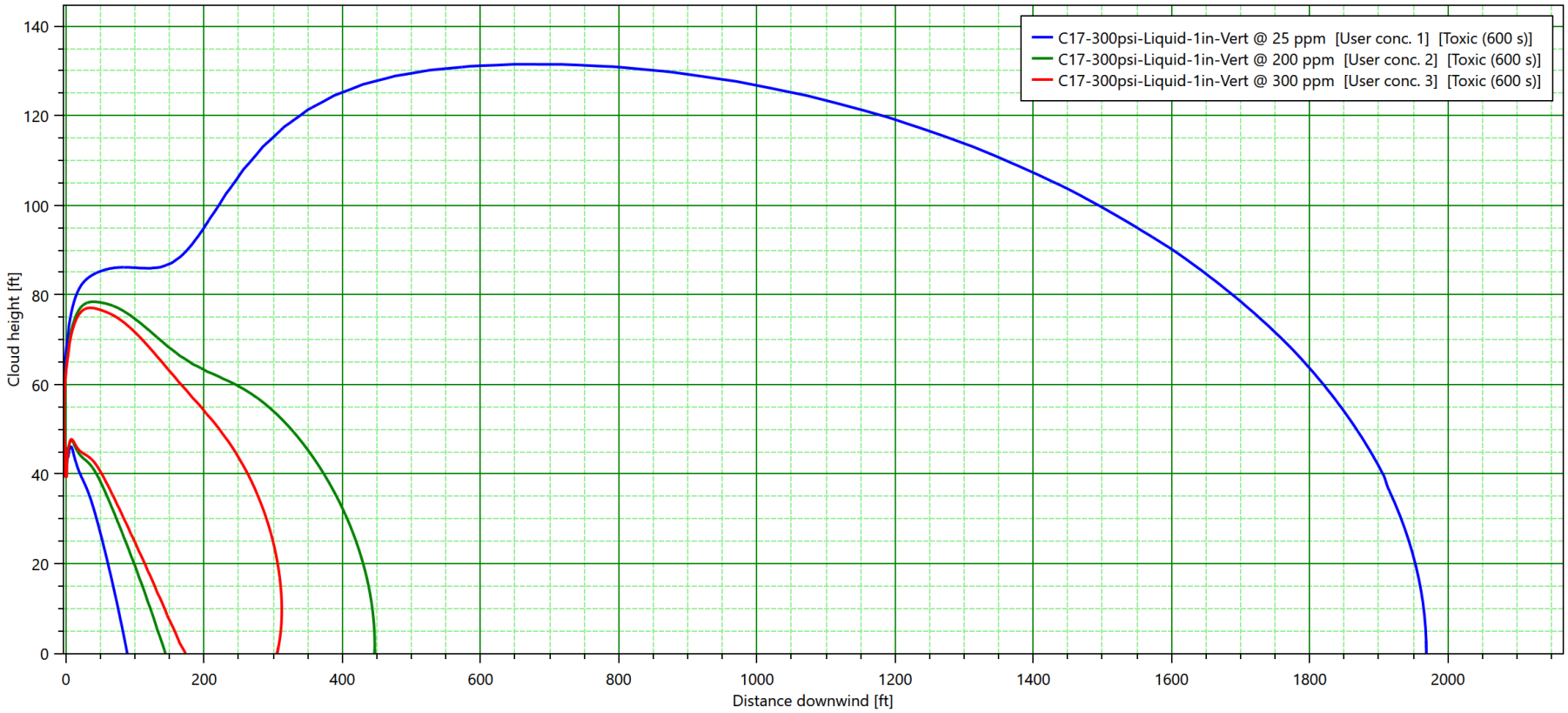
Side view

IAD-Wind-2407312024



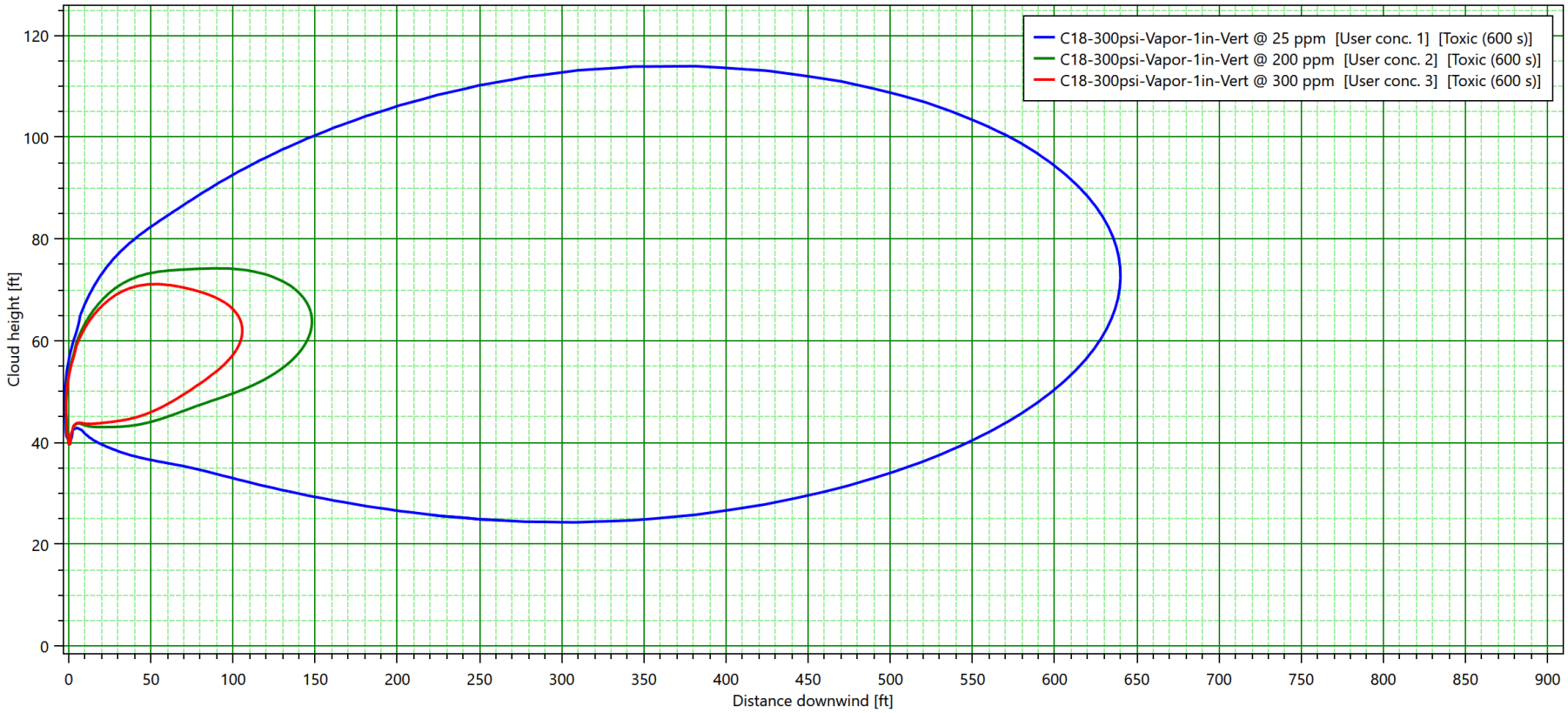
Side view

IAD-Wind-2407312024



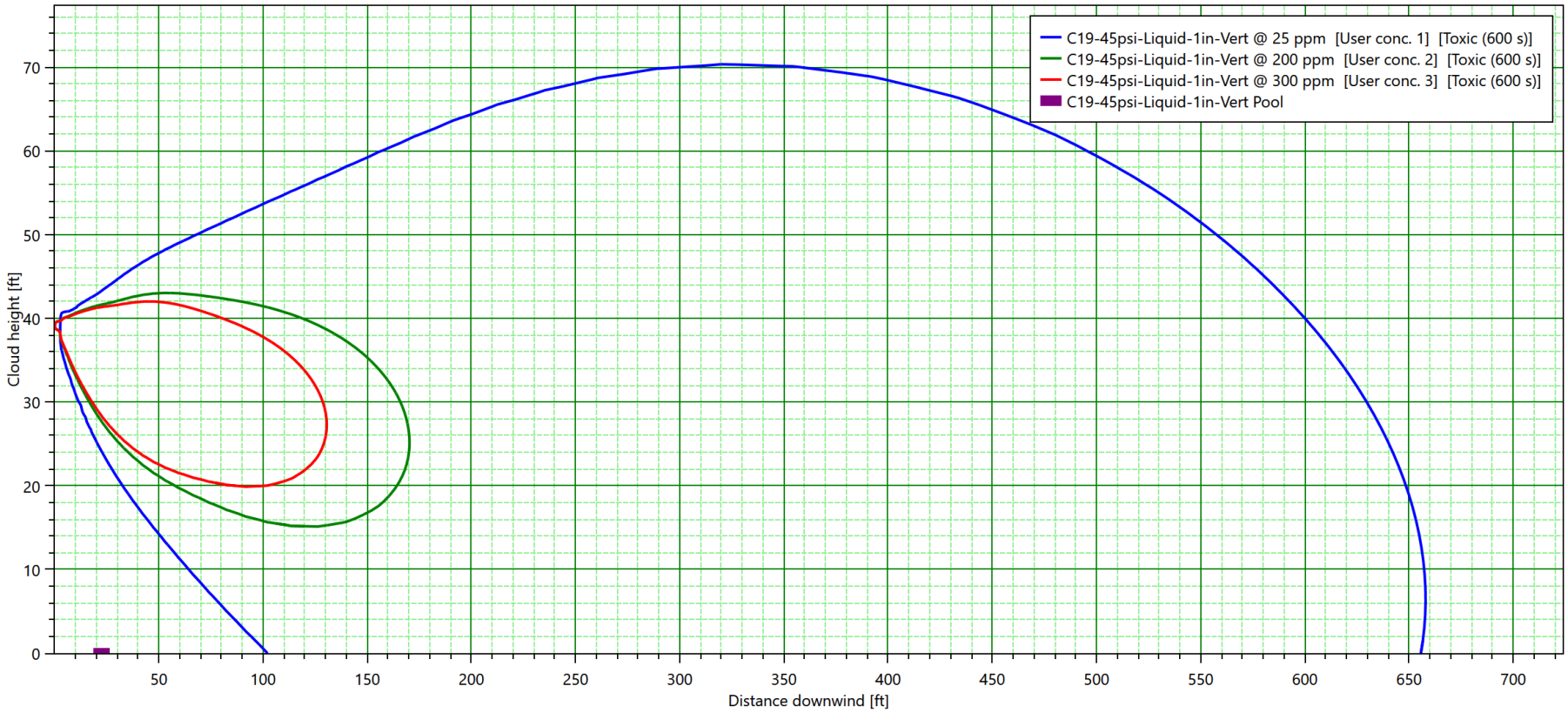
Side view

IAD-Wind-2407312024



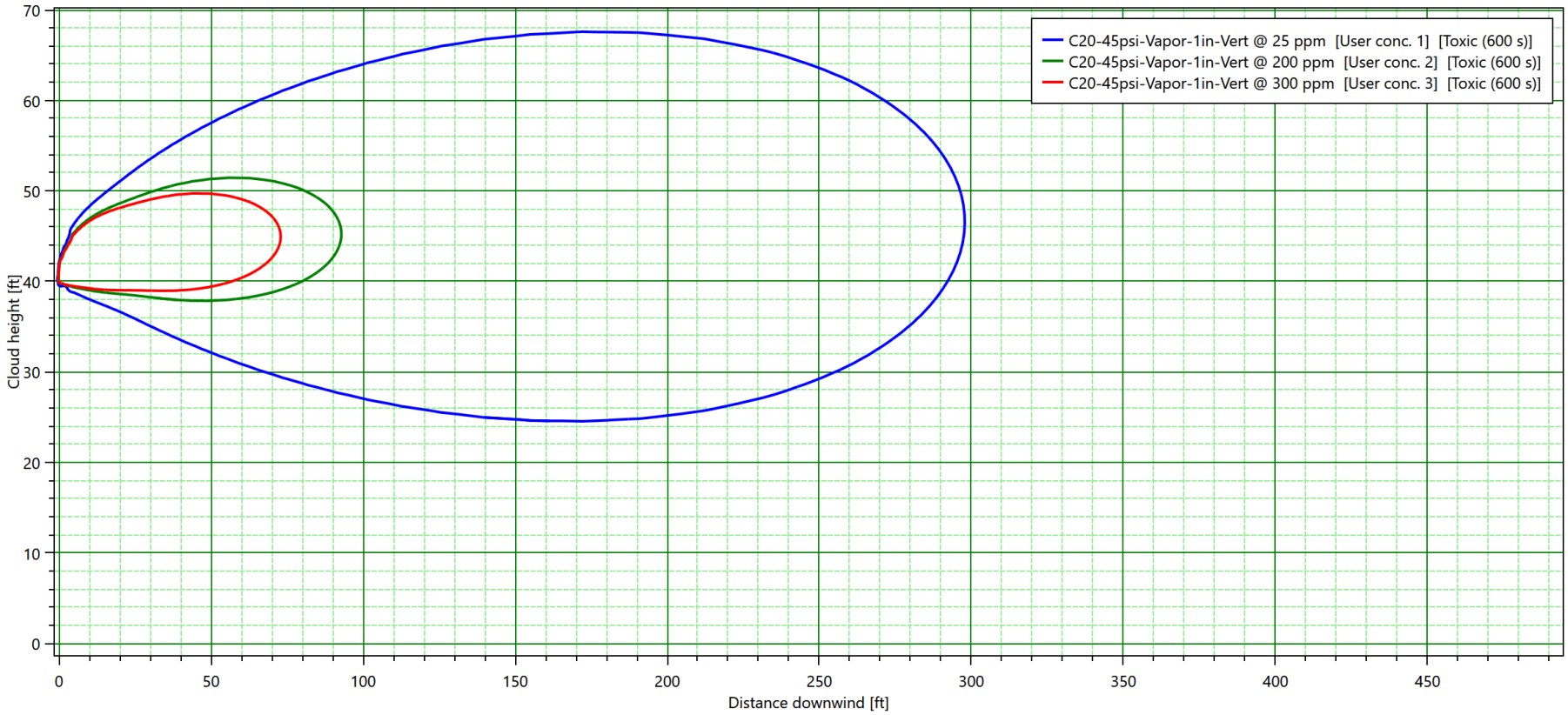
Side view

IAD-Wind-2407312024



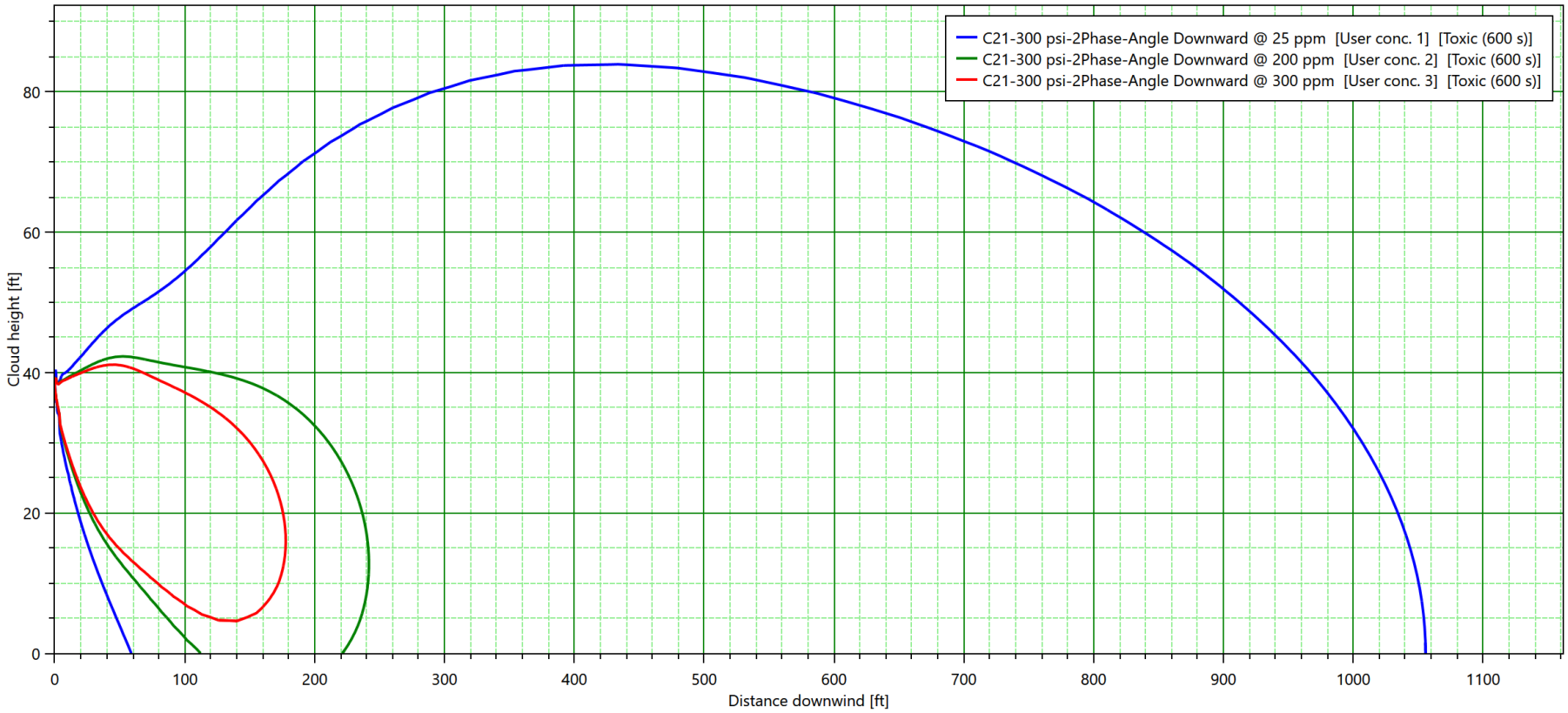
Side view

IAD-Wind-2407312024



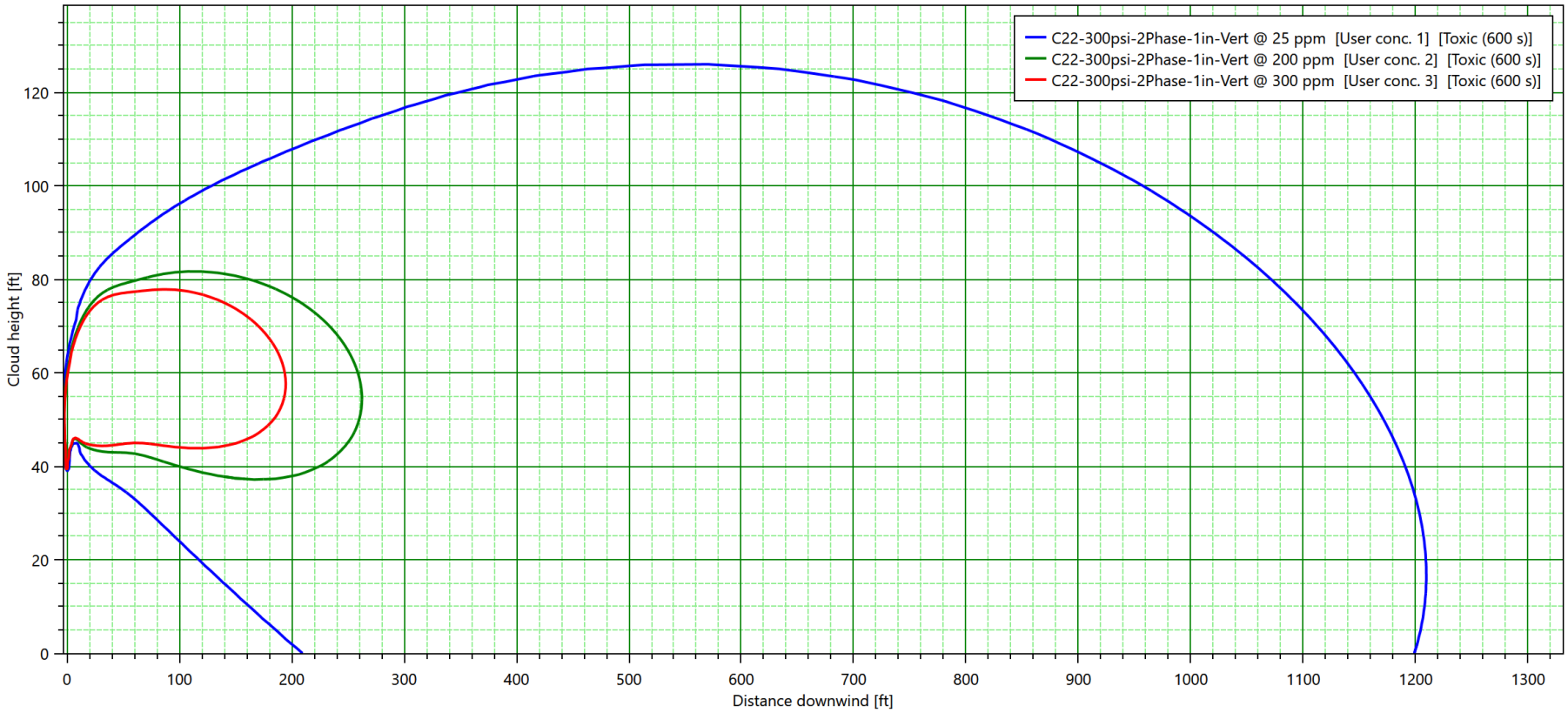
Side view

IAD-Wind-2407312024



Side view

IAD-Wind-2407312024



Side view

IAD-Wind-2407312024

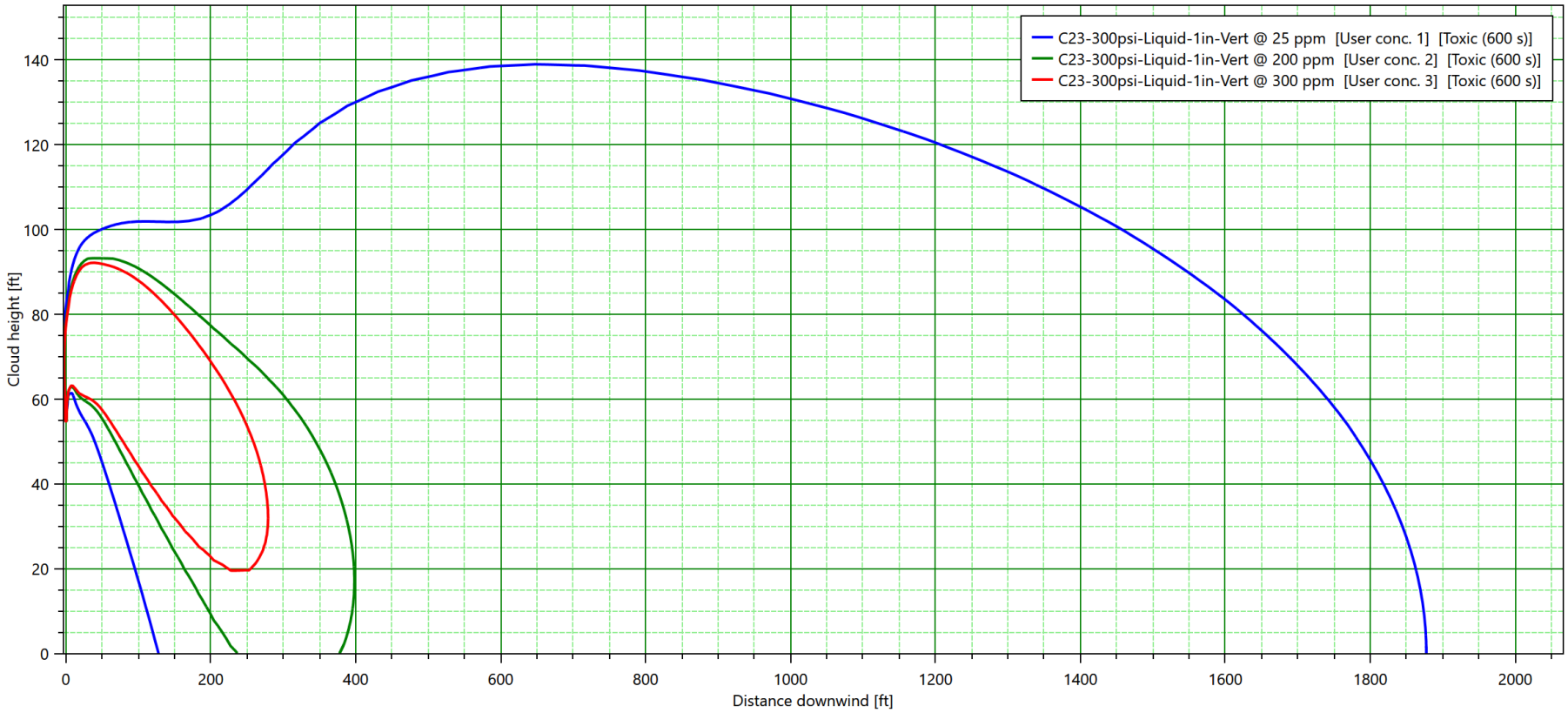


Table 3 - Distance to Concentration Endpoints at Ground Level

Scenario	Concentration Endpoints					
	25 ppm		200 ppm		300 ppm	
	Max distance to concentration (ft)	Min distance to concentration (ft)	Max distance to concentration (ft)	Min distance to concentration (ft)	Max distance to concentration (ft)	Min distance to concentration (ft)
C1-300 psi-Liquid-Angle Downward	1317.22	27.5528	257.058	44.4303	161.161	52.4654
C2-300 psi-Vapor-Angled Downward						
C3-300 psi-Liquid-Horizontal	1297.74	35.5971	243.185	58.023	136.313	71.3884
C4-300 psi-Vapor-Horizontal						
C9-300 psi-Liquid-Angled Upward	1265.75	41.5323	221.112	71.4876		
C10-300 psi-Vapor-Angled Upward						
C11-300 psi-Liquid-Vertical	1254.86	41.3204	212.595	75.1694		
C12-300 psi-Vapor-Vertical						
C17-300psi-Liquid-1in-Vert	1974.76	88.7149	447.008	143.595	305.943	171.757
C18-300psi-Vapor-1in-Vert						
C21-300 psi-2Phase-Angle Downward	1054.62	58.7079	221.717	112.045		
C22-300psi-2Phase-1in-Vert	1197.23	209.098				
C23-300psi-Liquid-1in-Vert	1879.93	127.789	378.359	234.93		
C5-Liquid-Angled Downward						
C6-Vapor-Angled Downward						
C7-Liquid-Horizontal						
C8-Vapor-Horizontal						
C13-Liquid-Angled Upward						
C14-Vapor-Angled Upward						
C15-Liquid-Vertical						
C16-Vapor-Vertical						
C19-45psi-Liquid-1in-Vert	673.405	101.971				
C20-45psi-Vapor-1in-Vert						

*Note these values represent the dispersion of a single plume from the tee-diffuser, with the discharge and wind oriented the same direction and therefore is not intended to represent the far-field dispersion of event which occurred at Cuisine Solutions. These values are provided for reference accordingly. Blank cells indicate that the concentration was not reached at ground level.

Appendix D: Model Input Report

Input Report

Workspace: Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0

Study

Study
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0

Tab	Group	Field	Value
Context of calculations	Selection of context	Weathers to use for this study	Weather folder
		Parameters to use for this study	Parameter set
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land
		Type of pool substrate and bunds	Concrete, no bund
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected
		Building type (downwind building type)	Buildings\Building type

300 psi Sat

Pressure vessel
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study

Tab	Group	Field	Value	Units
Material	Material	Material	AMMONIA	
		Specify volume inventory?	No	
		Mass inventory	21000	lb
		Volume inventory	603.431	ft3
		Material to track	AMMONIA	
	Phase	Specified condition	Pressure/bubble point	
		Temperature	126.752	degF
		Pressure (gauge)	300	psi
		Fluid state	Liquid	
		Liquid mole fraction	1	fraction
Scenario	Pipe dimensions	Pipe length		ft
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
		Droplet break-up mechanism - continuous	Do not force correlation	
Short pipe	Pipe characteristics	Pipe roughness	0.00177165	in
	Frequencies	Frequency of bends in pipe	0	/ft
		Frequency of couplings in pipe	0	/ft
		Frequency of junctions in pipe	0	/ft
	Frequencies of valves	Frequency of excess flow valves	0	/ft
		Frequency of non-return valves	0	/ft
		Frequency of shut-off valves	0	/ft
	Velocity head losses	Excess flow valve velocity head losses	0	
		Non-return valve velocity head losses	0	
		Shut-off valve velocity head losses	0	
Time varying releases	Modelling of time-varying leaks and line ruptures	Vacuum relief valve	Operating	
		Vacuum relief valve set point	0	psi
	Inventory data for time-varying releases	Tank volume	603.431	ft3
		Tank vapour volume	0	ft3
		Tank liquid volume	603.431	ft3
		Tank liquid level	0	ft

		Maximum vapour release height		ft
		Minimum mass inventory	0.220462	lb
		Maximum mass inventory	2.20462E+09	lb
	Safety system modelling for time-varying releases	Safety system modelling (isolation and blowdown)	No	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
	Building definition	Release building		
		In-building release?	Outdoor	
		Building wake effect	Roof/lee	
		Wind or release angle from North	0	deg
		Handling of droplets	Trapped	
		Indoor mass modification factor	3	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	
		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction
Geometry	Geometry	East	945886	ft
		North	1.41699E+07	ft

C1-300 psi-Liquid-Angle Downward

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat
'User defined source (1)' created from scenario 'two-phase' using results from weather 'Category 1.5/F'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Two-phase, Two-phase	
		Mass flow	823.59, 823.59	lb/hr
		Final temperature	-28.1722, -28.1722	degF
		Final velocity	26.4229, 26.4229	ft/s
		Liquid fraction	0.691282, 0.691282	fraction
		Droplet diameter	0.00328366, 0.00328366	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Angled from horizontal	
		Outdoor release angle	-60	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	300	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C2-300 psi-Vapor-Angled Downward

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat
'User defined source' created from scenario 'Vapor' using results from weather 'Category 1.5/F'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Vapour, Vapour	
		Mass flow	242.54, 242.54	lb/hr
		Final temperature	66.195, 66.195	degF
		Final velocity	30.8201, 30.8201	ft/s
		Liquid fraction	0, 0	fraction
		Droplet diameter	0, 0	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Angled from horizontal	
		Outdoor release angle	-60	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	300	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C3-300 psi-Liquid-Horizontal

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat
'User defined source (1)' created from scenario 'two-phase' using results from weather 'Category 1.5/F'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Two-phase, Two-phase	
		Mass flow	823.59, 823.59	lb/hr
		Final temperature	-28.1722, -28.1722	degF
		Final velocity	26.4229, 26.4229	ft/s
		Liquid fraction	0.691282, 0.691282	fraction
		Droplet diameter	0.00328366, 0.00328366	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	300	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C4-300 psi-Vapor-Horizontal

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat
'User defined source' created from scenario 'Vapor' using results from weather 'Category 1.5/F'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Vapour, Vapour	
		Mass flow	242.54, 242.54	lb/hr
		Final temperature	66.195, 66.195	degF
		Final velocity	30.8201, 30.8201	ft/s
		Liquid fraction	0, 0	fraction
		Droplet diameter	0, 0	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	300	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C9-300 psi-Liquid-Angled Upward

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat
'User defined source (1)' created from scenario 'two-phase' using results from weather 'Category 1.5/F'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Two-phase, Two-phase	
		Mass flow	823.59, 823.59	lb/hr
		Final temperature	-28.1722, -28.1722	degF
		Final velocity	26.4229, 26.4229	ft/s
		Liquid fraction	0.691282, 0.691282	fraction
		Droplet diameter	0.00328366, 0.00328366	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Angled from horizontal	
		Outdoor release angle	45	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	300	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C10-300 psi-Vapor-Angled Upward

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat
'User defined source' created from scenario 'Vapor' using results from weather 'Category 1.5/F'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Vapour, Vapour	
		Mass flow	242.54, 242.54	lb/hr
		Final temperature	66.195, 66.195	degF
		Final velocity	30.8201, 30.8201	ft/s
		Liquid fraction	0, 0	fraction
		Droplet diameter	0, 0	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Angled from horizontal	
		Outdoor release angle	45	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	300	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C11-300 psi-Liquid-Vertical

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat
'User defined source (1)' created from scenario 'two-phase' using results from weather 'Category 1.5/F'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Two-phase, Two-phase	
		Mass flow	823.59, 823.59	lb/hr
		Final temperature	-28.1722, -28.1722	degF
		Final velocity	26.4229, 26.4229	ft/s
		Liquid fraction	0.691282, 0.691282	fraction
		Droplet diameter	0.00328366, 0.00328366	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Vertical	
		Outdoor release angle	90	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	300	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C12-300 psi-Vapor-Vertical

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat
'User defined source' created from scenario 'Vapor' using results from weather 'Category 1.5/F'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Vapour, Vapour	
		Mass flow	242.54, 242.54	lb/hr
		Final temperature	66.195, 66.195	degF
		Final velocity	30.8201, 30.8201	ft/s
		Liquid fraction	0, 0	fraction
		Droplet diameter	0, 0	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Vertical	
		Outdoor release angle	90	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	300	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C17-300psi-Liquid-1in-Vert

Short pipe
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat

Tab	Group	Field	Value	Units
Scenario	Scenario	Scenario type	Relief valve	
	Pipe dimensions	Pipe internal diameter	1	in
		Pipe length	35	ft
	Hole	Orifice diameter	0.175	in
	Release location	Elevation	39	ft
		Tank head	0	ft
	Flow control and isolation	Flow controller	None	
		Input option	Not applicable	
		Fixed flow rate		lb/hr
		Pump head		ft
		Active isolation valve		
		Valve closing time		s
	Direction	Outdoor release direction	Vertical	
		Outdoor release angle	90	deg
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
	Phase	Phase to be released	Two-phase	
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
		Droplet break-up mechanism - continuous	Do not force correlation	
Short pipe	Pipe characteristics	Pipe roughness	0.00181102	in
	Frequencies	Frequency of bends in pipe	0	/ft
		Frequency of couplings in pipe	0	/ft
		Frequency of junctions in pipe	0	/ft
	Frequencies of valves	Frequency of excess flow valves	0	/ft
		Frequency of non-return valves	0	/ft
		Frequency of shut-off valves	0	/ft
	Velocity head losses	Excess flow valve velocity head losses	0	
		Non-return valve velocity head losses	0	
		Shut-off valve velocity head losses	0	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	

		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	
		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C18-300psi-Vapor-1in-Vert

Short pipe
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat

Tab	Group	Field	Value	Units
Scenario	Scenario	Scenario type	Relief valve	
	Pipe dimensions	Pipe internal diameter	1	in
		Pipe length	35	ft
	Hole	Orifice diameter	0.175	in
	Release location	Elevation	39	ft
		Tank head	0	ft
	Flow control and isolation	Flow controller	None	
		Input option	Not applicable	
		Fixed flow rate		lb/hr
		Pump head		ft
		Active isolation valve		
		Valve closing time		s
	Direction	Outdoor release direction	Vertical	
		Outdoor release angle	90	deg
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
	Phase	Phase to be released	Vapour	
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
		Droplet break-up mechanism - continuous	Do not force correlation	
Short pipe	Pipe characteristics	Pipe roughness	0.00181102	in
	Frequencies	Frequency of bends in pipe	0	/ft
		Frequency of couplings in pipe	0	/ft
		Frequency of junctions in pipe	0	/ft
	Frequencies of valves	Frequency of excess flow valves	0	/ft
		Frequency of non-return valves	0	/ft
		Frequency of shut-off valves	0	/ft
	Velocity head losses	Excess flow valve velocity head losses	0	
		Non-return valve velocity head losses	0	
		Shut-off valve velocity head losses	0	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	

		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	
		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C21-300 psi-2Phase-Angle Downward

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat
'User defined source (1)' created from scenario 'two-phase' using results from weather 'Category 1.5/F'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Two-phase, Two-phase	
		Mass flow	533.065, 533.065	lb/hr
		Final temperature	-28.1722, -28.1722	degF
		Final velocity	28.6215, 28.6215	ft/s
		Liquid fraction	0.34, 0.34	fraction
		Droplet diameter	0.00328366, 0.00328366	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Angled from horizontal	
		Outdoor release angle	-60	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	300	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C22-300psi-2Phase-1in-Vert

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat
'User defined source' created from scenario 'C17-300psi-Liquid-1in-Vert' using results from weather 'IAD-Wind-2407312024'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Two-phase, Two-phase	
		Mass flow	1066.1, 1066.1	lb/hr
		Final temperature	-28.1722, -28.1722	degF
		Final velocity	503.6, 503.6	ft/s
		Liquid fraction	0.34, 0.34	fraction
		Droplet diameter	0.00072382, 0.00072382	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Vertical	
		Outdoor release angle	90	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	300	psi
	Jet fire Miller model hole size	Orifice diameter	1	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C23-300psi-Liquid-1in-Vert

Short pipe
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\300 psi Sat

Tab	Group	Field	Value	Units
Scenario	Scenario	Scenario type	Relief valve	
	Pipe dimensions	Pipe internal diameter	1	in
		Pipe length	35	ft
	Hole	Orifice diameter	0.175	in
	Release location	Elevation	55	ft
		Tank head	0	ft
	Flow control and isolation	Flow controller	None	
		Input option	Not applicable	
		Fixed flow rate		lb/hr
		Pump head		ft
		Active isolation valve		
		Valve closing time		s
	Direction	Outdoor release direction	Vertical	
		Outdoor release angle	90	deg
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
	Phase	Phase to be released	Two-phase	
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
		Droplet break-up mechanism - continuous	Do not force correlation	
Short pipe	Pipe characteristics	Pipe roughness	0.00181102	in
	Frequencies	Frequency of bends in pipe	0	/ft
		Frequency of couplings in pipe	0	/ft
		Frequency of junctions in pipe	0	/ft
	Frequencies of valves	Frequency of excess flow valves	0	/ft
		Frequency of non-return valves	0	/ft
		Frequency of shut-off valves	0	/ft
	Velocity head losses	Excess flow valve velocity head losses	0	
		Non-return valve velocity head losses	0	
		Shut-off valve velocity head losses	0	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	

		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	
		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

45 psi Sat Liq

Pressure vessel
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study

Tab	Group	Field	Value	Units
Material	Material	Material	AMMONIA	
		Specify volume inventory?	No	
		Mass inventory	21000	lb
		Volume inventory	526.117	ft3
		Material to track	AMMONIA	
	Phase	Specified condition	Pressure/bubble point	
		Temperature	30.0531	degF
		Pressure (gauge)	45	psi
		Fluid state	Liquid	
		Liquid mole fraction	1	fraction
Scenario	Pipe dimensions	Pipe length		ft
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
		Phase change upstream of orifice?	Disallow liquid phase change only (metastable liquid)	
	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
		Droplet break-up mechanism - continuous	Do not force correlation	
Short pipe	Pipe characteristics	Pipe roughness	0.00177165	in
	Frequencies	Frequency of bends in pipe	0	/ft
		Frequency of couplings in pipe	0	/ft
		Frequency of junctions in pipe	0	/ft
	Frequencies of valves	Frequency of excess flow valves	0	/ft
		Frequency of non-return valves	0	/ft
		Frequency of shut-off valves	0	/ft
	Velocity head losses	Excess flow valve velocity head losses	0	
		Non-return valve velocity head losses	0	
		Shut-off valve velocity head losses	0	
Time varying releases	Modelling of time-varying leaks and line ruptures	Vacuum relief valve	Operating	
		Vacuum relief valve set point	0	psi
	Inventory data for time-varying releases	Tank volume	526.117	ft3
		Tank vapour volume	0	ft3
		Tank liquid volume	526.117	ft3
		Tank liquid level	0	ft

		Maximum vapour release height		ft
		Minimum mass inventory	0.220462	lb
		Maximum mass inventory	2.20462E+09	lb
	Safety system modelling for time-varying releases	Safety system modelling (isolation and blowdown)	No	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
	Building definition	Release building		
		In-building release?	Outdoor	
		Building wake effect	Roof/lee	
		Wind or release angle from North	0	deg
		Handling of droplets	Trapped	
		Indoor mass modification factor	3	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	
		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction
Geometry	Geometry	East	945886	ft
		North	1.41699E+07	ft

C5-Liquid-Angled Downward

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\45 psi Sat Liq
'User defined source (1)' created from scenario 'two-phase' using results from weather 'IAD-Wind-2407312024'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Two-phase, Two-phase	
		Mass flow	239.566, 239.566	lb/hr
		Final temperature	-28.1722, -28.1722	degF
		Final velocity	2.73213, 2.73213	ft/s
		Liquid fraction	0.890622, 0.890622	fraction
		Droplet diameter	0.327591, 0.327591	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Angled from horizontal	
		Outdoor release angle	-60	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	45	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C6-Vapor-Angled Downward

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\45 psi Sat Liq
'User defined source' created from scenario 'Vapor' using results from weather 'IAD-Wind-2407312024'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Vapour, Vapour	
		Mass flow	46.1864, 46.1864	lb/hr
		Final temperature	19.2878, 19.2878	degF
		Final velocity	5.3091, 5.3091	ft/s
		Liquid fraction	0, 0	fraction
		Droplet diameter	0, 0	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Angled from horizontal	
		Outdoor release angle	-60	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	45	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C7-Liquid-Horizontal

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\45 psi Sat Liq
'User defined source (1)' created from scenario 'two-phase' using results from weather 'IAD-Wind-2407312024'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Two-phase, Two-phase	
		Mass flow	239.566, 239.566	lb/hr
		Final temperature	-28.1722, -28.1722	degF
		Final velocity	2.73213, 2.73213	ft/s
		Liquid fraction	0.890622, 0.890622	fraction
		Droplet diameter	0.327591, 0.327591	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	45	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C8-Vapor-Horizontal

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\45 psi Sat Liq
'User defined source' created from scenario 'Vapor' using results from weather 'IAD-Wind-2407312024'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Vapour, Vapour	
		Mass flow	46.1864, 46.1864	lb/hr
		Final temperature	19.2878, 19.2878	degF
		Final velocity	5.3091, 5.3091	ft/s
		Liquid fraction	0, 0	fraction
		Droplet diameter	0, 0	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	45	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C13-Liquid-Angled Upward

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\45 psi Sat Liq
'User defined source (1)' created from scenario 'two-phase' using results from weather 'IAD-Wind-2407312024'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Two-phase, Two-phase	
		Mass flow	239.566, 239.566	lb/hr
		Final temperature	-28.1722, -28.1722	degF
		Final velocity	2.73213, 2.73213	ft/s
		Liquid fraction	0.890622, 0.890622	fraction
		Droplet diameter	0.327591, 0.327591	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Angled from horizontal	
		Outdoor release angle	45	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	45	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C14-Vapor-Angled Upward

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\45 psi Sat Liq
'User defined source' created from scenario 'Vapor' using results from weather 'IAD-Wind-2407312024'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Vapour, Vapour	
		Mass flow	46.1864, 46.1864	lb/hr
		Final temperature	19.2878, 19.2878	degF
		Final velocity	5.3091, 5.3091	ft/s
		Liquid fraction	0, 0	fraction
		Droplet diameter	0, 0	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Angled from horizontal	
		Outdoor release angle	45	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	45	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C15-Liquid-Vertical

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\45 psi Sat Liq
'User defined source (1)' created from scenario 'two-phase' using results from weather 'IAD-Wind-2407312024'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Two-phase, Two-phase	
		Mass flow	239.566, 239.566	lb/hr
		Final temperature	-28.1722, -28.1722	degF
		Final velocity	2.73213, 2.73213	ft/s
		Liquid fraction	0.890622, 0.890622	fraction
		Droplet diameter	0.327591, 0.327591	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Vertical	
		Outdoor release angle	90	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	45	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C16-Vapor-Vertical

User defined source
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\45 psi Sat Liq
'User defined source' created from scenario 'Vapor' using results from weather 'IAD-Wind-2407312024'.

Tab	Group	Field	Value	Units
Scenario	Release scenario	Release scenario	Leak	
		The number of release observers	2	
	Release observers	Release time	0, 540	s
		Release phase	Vapour, Vapour	
		Mass flow	46.1864, 46.1864	lb/hr
		Final temperature	19.2878, 19.2878	degF
		Final velocity	5.3091, 5.3091	ft/s
		Liquid fraction	0, 0	fraction
		Droplet diameter	0, 0	in
		Pool radius	0, 0	ft
		Pre-dilution air rate	0, 0	lb/hr
		Downstream calculation status	No errors detected	
	Release location	Elevation	39	ft
		Tank head	0	ft
	Direction	Outdoor release direction	Vertical	
		Outdoor release angle	90	deg
	Fireball emissive power	Use vessel burst pressure	No	
		Vessel burst pressure - gauge	45	psi
	Jet fire Miller model hole size	Orifice diameter	1.5	in
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	
		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	

		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C19-45psi-Liquid-1in-Vert

Short pipe
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\45 psi Sat Liq

Tab	Group	Field	Value	Units
Scenario	Scenario	Scenario type	Relief valve	
	Pipe dimensions	Pipe internal diameter	1	in
		Pipe length	35	ft
	Hole	Orifice diameter	0.175	in
	Release location	Elevation	39	ft
		Tank head	0	ft
	Flow control and isolation	Flow controller	None	
		Input option	Not applicable	
		Fixed flow rate		lb/hr
		Pump head		ft
		Active isolation valve		
		Valve closing time		s
	Direction	Outdoor release direction	Horizontal	
		Outdoor release angle	0	deg
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
	Phase	Phase to be released	Two-phase	
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
		Droplet break-up mechanism - continuous	Do not force correlation	
Short pipe	Pipe characteristics	Pipe roughness	0.00181102	in
	Frequencies	Frequency of bends in pipe	0	/ft
		Frequency of couplings in pipe	0	/ft
		Frequency of junctions in pipe	0	/ft
	Frequencies of valves	Frequency of excess flow valves	0	/ft
		Frequency of non-return valves	0	/ft
		Frequency of shut-off valves	0	/ft
	Velocity head losses	Excess flow valve velocity head losses	0	
		Non-return valve velocity head losses	0	
		Shut-off valve velocity head losses	0	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	

		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	
		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

C20-45psi-Vapor-1in-Vert

Short pipe
Cuisine Solutions Investigation_Near Field-Low Concentrations_25-05-21_Phast 9.0\Study\45 psi Sat Liq

Tab	Group	Field	Value	Units
Scenario	Scenario	Scenario type	Relief valve	
	Pipe dimensions	Pipe internal diameter	1	in
		Pipe length	35	ft
	Hole	Orifice diameter	0.175	in
	Release location	Elevation	39	ft
		Tank head	0	ft
	Flow control and isolation	Flow controller	None	
		Input option	Not applicable	
		Fixed flow rate		lb/hr
		Pump head		ft
		Active isolation valve		
		Valve closing time		s
	Direction	Outdoor release direction	Vertical	
		Outdoor release angle	90	deg
Material	Material	Material characteristics	Toxic only	
		Material to track	AMMONIA	
	Phase	Phase to be released	Vapour	
Discharge parameters	Model settings	Atmospheric expansion method	DNV recommended	
	Droplet break-up mechanism	Droplet break-up mechanism - instantaneous	Use flashing correlation	
		Droplet break-up mechanism - continuous	Do not force correlation	
Short pipe	Pipe characteristics	Pipe roughness	0.00181102	in
	Frequencies	Frequency of bends in pipe	0	/ft
		Frequency of couplings in pipe	0	/ft
		Frequency of junctions in pipe	0	/ft
	Frequencies of valves	Frequency of excess flow valves	0	/ft
		Frequency of non-return valves	0	/ft
		Frequency of shut-off valves	0	/ft
	Velocity head losses	Excess flow valve velocity head losses	0	
		Non-return valve velocity head losses	0	
		Shut-off valve velocity head losses	0	
Dispersion	User-defined dispersion scope (N.B Based on the material to track)	Concentrations of interest	25, 200, 300	ppm
		Distances of interest		ft
		Averaging time for concentrations and distances of interest	Toxic	
		Specify user-defined averaging time	No	

		User defined averaging time		s
	Standardised toxic threshold concentrations and averaging times	ERPG [1 hr]	No	
		IDLH [30 mins]	No	
		STEL [15 mins]	No	
Bund, building and terrain	Terrain and bund definition	Type of terrain for dispersion	Land	
		Type of pool substrate and bunds	Concrete, no bund	
Toxic parameters	Indoor toxic calculations	Specify the downwind building type	Unselected	
		Building type (downwind building type)	Buildings\Building type	
	Exposure time data	Set averaging time equal to exposure time	Use a fixed averaging time	
		Cut-off fraction of toxic load for exposure time calculation	0.05	fraction
		Cut-off concentration for exposure time calculations	0	fraction
	Toxic contours	Number of toxic levels	4	
		Dose levels [ppm^n.min]	130000, 1.3E+06, 1.3E+07, 1.3E+08	
		Probit levels	2, 3, 4, 10	
		Lethality levels	0.001, 0.01, 0.1, 0.99	fraction

Addendum: Case 2 Building Wake Model

As an additional assessment following the initial dispersion analysis, Case 2 from the dispersion analysis, a 300 psig vapor relief scenario, was assessed using the building wake model to consider the potential for far-field dispersion of ammonia vapors. This additional assessment is intended to consider the potential for downwind dispersion of ammonia vapors across the building, and through the building wake zone from a vapor relief scenario.

The far-field dispersion is assessed considering the actual weather conditions at the time of the incident, as well as a stable nighttime weather condition (1.5 m/s, F stability) which represents a worst-credible condition.

The results are illustrated as dispersion footprint contours, illustrating the extent of the dispersion at a height of 5 feet above ground level. The 300 ppm IDLH concentration was not exceeded at this height at any location; 25 ppm concentration contours are plotted. The highest concentration predicted in the building wake was 64 ppm and 31 ppm for the stable nighttime and actual weather conditions respectively.

Dispersion Footprint Contours for Building Wake and Far Field Dispersion – Case 2 – Stable Nighttime Weather (1.5/F)



Dispersion Footprint Contours for Building Wake and Far Field Dispersion – Case 2 – Actual Weather During Incident

