

Appendix C

Risk of Upset

Supporting Information

Appendix C – Risk of Upset Supporting Information

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Pipeline Risk Assessment: 260 psig

Avg Frequency 2.90E-04 per miles-year
 Age Factor 1.78 applied to all pipeline segments except the new
 Effective Frequency 5.16E-04 Incidents per mile year
 Rupture fraction 0.15

Scenario Description	Segment #	Scenario ID	Segment Diameter (in)	Release Size (in)	Release Type (Rupture, Leak)	Segment Length (ft)	Population Density, ppsm	Exposure												Frequency							
								Jet 12.0 kbtu/hr-ft2 Distance (ft)	Jet 8.0 kbtu/hr-ft2 Distance (ft)	Jet 5.0 kbtu/hr-ft2 Distance (ft)	Jet 12.0 kbtu/hr-ft2 Area (ft2)	Jet 8.0 kbtu/hr-ft2 Area (ft2)	Jet 5.0 kbtu/hr-ft2 Area (ft2)	Max Persons Exposed	Injury Probability 12 kbtu/hr-ft2	Injury Probability 8 kbtu/hr-ft2	Injury Probability 5 kbtu/hr-ft2	Fatality Probability 12 kbtu/hr-ft2	Fatality Probability 8 kbtu/hr-ft2	Fatality Probability 5 kbtu/hr-ft2	Injuries (# people)	Fatalities (# people)	Pipeline Event Frequency, per year	Valve Event Frequency, per year	Ignition Probability	Fraction Persons Exposed	Fire Frequency, per year
Segment 1 Rupture	1	S1-R-1	6	8	R	2876	100	51.2	53.7	57.3	1235	1812	2579	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.01	2.37E-05	0.00E+00	1.00	0.079	1.87E-06
Segment 2 Rupture	2	S2-R-1	6-8	8	R	9410	100	51.2	53.7	57.3	1235	1812	2579	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.01	1.38E-04	0.00E+00	1.00	0.079	1.09E-05
Segment 2 Rupture	3	S2-R-2	6-8	8	R	5195	7112	51.2	53.7	57.3	1235	1812	2579	0.7	1.00	1.00	0.50	1.00	0.75	0.25	0.09	0.47	7.62E-05	8.76E-06	1.00	0.079	6.71E-06
Segment 2 Rupture	4	S2-R-3	6-8	8	R	2813	5448	51.2	53.7	57.3	1235	1812	2579	0.5	1.00	1.00	0.50	1.00	0.75	0.25	0.07	0.36	4.13E-05	0.00E+00	1.00	0.079	3.26E-06
Segment 2 Rupture	5	S2-R-4	6-8	8	R	4276	813	51.2	53.7	57.3	1235	1812	2579	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.05	6.27E-05	0.00E+00	1.00	0.079	4.95E-06
Segment 2 Rupture	6	S2-R-5	6-8	8	R	3869	11090	51.2	53.7	57.3	1235	1812	2579	1.0	1.00	1.00	0.50	1.00	0.75	0.25	0.13	0.74	5.67E-05	0.00E+00	1.00	0.125	7.09E-06
Segment 2 Rupture	7	S2-R-6	6-8	8	R	1234	23887	51.2	53.7	57.3	1235	1812	2579	2.2	1.00	1.00	0.50	1.00	0.75	0.25	0.29	1.59	1.81E-05	0.00E+00	1.00	0.079	1.43E-06
Segment 2 Rupture	8	S2-R-7	6-8	8	R	3266	22081	51.2	53.7	57.3	1235	1812	2579	2.0	1.00	1.00	0.50	1.00	0.75	0.25	0.27	1.47	4.79E-05	0.00E+00	1.00	0.079	3.78E-06
Segment 2 Rupture	9	S2-R-8	6-8	8	R	3006	20070	51.2	53.7	57.3	1235	1812	2579	1.9	1.00	1.00	0.50	1.00	0.75	0.25	0.24	1.34	4.41E-05	0.00E+00	1.00	0.125	5.51E-06
Segment 2 Rupture	10	S2-R-9	6-8	8	R	2874	15786	51.2	53.7	57.3	1235	1812	2579	1.5	1.00	1.00	0.50	1.00	0.75	0.25	0.19	1.05	4.21E-05	0.00E+00	1.00	0.079	3.33E-06
Segment 2 Rupture	11	S2-R-10	6-8	8	R	5038	15628	51.2	53.7	57.3	1235	1812	2579	1.4	1.00	1.00	0.50	1.00	0.75	0.25	0.19	1.04	7.39E-05	0.00E+00	1.00	0.079	5.84E-06
Segment 2 Rupture	12	S2-R-11	6-8	8	R	895	8574	51.2	53.7	57.3	1235	1812	2579	0.8	1.00	1.00	0.50	1.00	0.75	0.25	0.10	0.57	1.31E-05	0.00E+00	1.00	0.079	1.04E-06
Segment 3 Rupture	13	S3-R-1	12	12	R	895	8574	88.3	94.2	99.6	3674	5575	7791	2.4	1.00	1.00	0.50	1.00	0.75	0.25	0.32	1.74	1.31E-05	0.00E+00	1.00	0.079	1.04E-06
Segment 3 Rupture	14	S1-R-2	12	12	R	5825	6345	88.3	94.2	99.6	3674	5575	7791	1.8	1.00	1.00	0.50	1.00	0.75	0.25	0.23	1.29	8.54E-05	8.76E-06	1.00	0.125	1.18E-05
Segment 3 Rupture	15	S1-R-3	12	12	R	2907	19510	88.3	94.2	99.6	3674	5575	7791	5.5	1.00	1.00	0.50	1.00	0.75	0.25	0.72	3.96	4.26E-05	0.00E+00	1.00	0.079	3.37E-06
Segment 3 Rupture	16	S1-R-4	12	12	R	1046	13640	88.3	94.2	99.6	3674	5575	7791	3.8	1.00	1.00	0.50	1.00	0.75	0.25	0.50	2.77	1.53E-05	0.00E+00	1.00	0.079	1.21E-06
Segment 3 Rupture	17	S1-R-5	12	12	R	795	14233	88.3	94.2	99.6	3674	5575	7791	4.0	1.00	1.00	0.50	1.00	0.75	0.25	0.53	2.89	1.17E-05	0.00E+00	1.00	0.125	1.46E-06
Segment 3 Rupture	18	S1-R-6	12	12	R	2616	16682	88.3	94.2	99.6	3674	5575	7791	4.7	1.00	1.00	0.50	1.00	0.75	0.25	0.62	3.38	3.84E-05	0.00E+00	1.00	0.125	4.80E-06
Segment 3 Rupture	19	S1-R-7	12	12	R	2644	13977	88.3	94.2	99.6	3674	5575	7791	3.9	1.00	1.00	0.50	1.00	0.75	0.25	0.52	2.83	3.88E-05	0.00E+00	1.00	0.125	4.85E-06
Segment 3 Rupture	20	S1-R-8	12	12	R	2830	18222	88.3	94.2	99.6	3674	5575	7791	5.1	1.00	1.00	0.50	1.00	0.75	0.25	0.67	3.70	4.15E-05	0.00E+00	1.00	0.079	3.28E-06
Segment 1 Leak	1	S1-L-1	6	1	L	2876	100	36.2	36.8	37.2	515	532	543	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	1.34E-04	0.00E+00	1.00	0.079	1.06E-05
Segment 2 Leak	2	S2-L-1	6-8	1	L	9410	100	36.2	36.8	37.2	515	532	543	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	7.82E-04	0.00E+00	1.00	0.079	6.18E-05
Segment 2 Leak	3	S2-L-2	6-8	1	L	5195	7112	36.2	36.8	37.2	515	532	543	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.14	4.32E-04	7.88E-05	1.00	0.079	4.03E-05
Segment 2 Leak	4	S2-L-3	6-8	1	L	2813	5448	36.2	36.8	37.2	515	532	543	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.10	2.34E-04	0.00E+00	1.00	0.079	1.85E-05
Segment 2 Leak	5	S2-L-4	6-8	1	L	4276	813	36.2	36.8	37.2	515	532	543	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.02	3.55E-04	0.00E+00	1.00	0.079	2.81E-05
Segment 2 Leak	6	S2-L-5	6-8	1	L	3869	11090	36.2	36.8	37.2	515	532	543	0.2	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.21	3.22E-04	0.00E+00	1.00	0.125	4.02E-05
Segment 2 Leak	7	S2-L-6	6-8	1	L	1234	23887	36.2	36.8	37.2	515	532	543	0.5	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.45	1.03E-04	0.00E+00	1.00	0.079	8.10E-06
Segment 2 Leak	8	S2-L-7	6-8	1	L	3266	22081	36.2	36.8	37.2	515	532	543	0.4	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.42	2.71E-04	0.00E+00	1.00	0.079	2.14E-05
Segment 2 Leak	9	S2-L-8	6-8	1	L	3006	20070	36.2	36.8	37.2	515	532	543	0.4	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.38	2.50E-04	0.00E+00	1.00	0.125	3.13E-05
Segment 2 Leak	10	S2-L-9	6-8	1	L	2874	15786	36.2	36.8	37.2	515	532	543	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.30	2.39E-04	0.00E+00	1.00	0.079	1.89E-05
Segment 2 Leak	11	S2-L-10	6-8	1	L	5038	15628	36.2	36.8	37.2	515	532	543	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.30	4.19E-04	0.00E+00	1.00	0.079	3.31E-05
Segment 2 Leak	12	S2-L-11	6-8	1	L	895	8574	36.2	36.8	37.2	515	532	543	0.2	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.16	7.44E-05	0.00E+00	1.00	0.079	5.88E-06
Segment 3 Leak	13	S3-L-1	12	1	L	895	8574	36.5	37	37.5	523	538	552	0.2	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.17	7.44E-05	0.00E+00	1.00	0.079	5.88E-06
Segment 3 Leak	14	S1-L-2	12	1	L	5825	6345	36.5	37	37.5	523	538	552	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.12	4.84E-04	7.88E-05	1.00	0.125	7.04E-05
Segment 3 Leak	15	S1-L-3	12	1	L	2907	19510	36.5	37	37.5	523	538	552	0.4	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.38	2.42E-04	0.00E+00	1.00	0.079	1.91E-05
Segment 3 Leak	16	S1-L-4	12	1	L	1046	13640	36.5	37	37.5	523	538	552	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.26	8.69E-05	0.00E+00	1.00	0.079	6.87E-06
Segment 3 Leak	17	S1-L-5	12	1	L	795	14233	36.5	37	37.5	523	538	552	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.27	6.61E-05	0.00E+00	1.00	0.125	8.26E-06
Segment 3 Leak	18	S1-L-6	12	1	L	2616	16682	36.5	37	37.5	523	538	552	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.32	2.17E-04	0.00E+00	1.00	0.125	2.72E-05
Segment 3 Leak	19	S1-L-7	12	1	L	2644	13977	36.5	37	37.5	523	538	552	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.27	2.20E-04	0.00E+00	1.00	0.125	2.75E-05
Segment 3 Leak	20	S1-L-8	12	1	L	2830	18222	36.5	37	37.5	523	538	552	0.4	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.35	2.35E-04	0.00E+00	1.00	0.079	1.86E-05

Notes
 Fraction outside = 7.9% in general, and 3 hours per day (12.5%) for segments in front of schools as per CDE Risk protocol
 Weight population density, ppsm avg 10,149

Population density based on Census 2010 Tracts
 Area of impact based on modeling ellipses (ruptures: 0.60 length/width ratio for 12 kbtu, 0.80 ratio for 8kbtu and 1.0 ratio for 5 kbtu, leaks: 0.5 for all)
 Segments along schools have school population added in to the census tract population

Pipeline Risk Assessment: 160 psig

Avg Frequency 2.90E-04 per miles-year
 Age Factor 1.78 applied to all pipeline segments except the new
 Effective Frequency 5.16E-04 Incidents per mile year
 Rupture fraction 0.15

Scenario Description	Segment #	Scenario ID	Segment Diameter (in)	Release Size (in)	Release Type (Rupture, Leak)	Segment Length (ft)	Exposure														Frequency						
							Population Density, ppsm	Jet 12.0 kbtu/hr-ft2 Distance (ft)	Jet 8.0 kbtu/hr-ft2 Distance (ft)	Jet 5.0 kbtu/hr-ft2 Distance (ft)	Jet 12.0 kbtu/hr-ft2 Area (ft2)	Jet 8.0 kbtu/hr-ft2 Area (ft2)	Jet 5.0 kbtu/hr-ft2 Area (ft2)	Max Persons Exposed	Injury Probability 12 kbtu/hr-ft2	Injury Probability 8 kbtu/hr-ft2	Injury Probability 5 kbtu/hr-ft2	Fatality Probability 12 kbtu/hr-ft2	Fatality Probability 8 kbtu/hr-ft2	Fatality Probability 5 kbtu/hr-ft2	Injuries (# people)	Fatalities (# people)	Event Frequency, per year	Valve Event Frequency, per year	Ignition Probability	Fraction Persons Exposed	Fire Frequency, per year
Segment 1 Rupture	1	S1-R-1	6	8	R	2876	100	41.6	41.8	43.6	816	1098	1493	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	2.37E-05	0.00E+00	1.00	0.079	1.87E-06
Segment 2 Rupture	2	S2-R-1	6-8	8	R	9410	100	41.6	41.8	43.6	816	1098	1493	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	1.38E-04	0.00E+00	1.00	0.079	1.09E-05
Segment 2 Rupture	3	S2-R-2	6-8	8	R	5195	7112	41.6	41.8	43.6	816	1098	1493	0.4	1.00	1.00	0.50	1.00	0.75	0.25	0.04	0.29	7.62E-05	8.76E-06	1.00	0.079	6.02E-06
Segment 2 Rupture	4	S2-R-3	6-8	8	R	2813	5448	41.6	41.8	43.6	816	1098	1493	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.03	0.22	4.13E-05	0.00E+00	1.00	0.079	3.26E-06
Segment 2 Rupture	5	S2-R-4	6-8	8	R	4276	813	41.6	41.8	43.6	816	1098	1493	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.03	6.27E-05	0.00E+00	1.00	0.079	4.95E-06
Segment 2 Rupture	6	S2-R-5	6-8	8	R	3869	11090	41.6	41.8	43.6	816	1098	1493	0.6	1.00	1.00	0.50	1.00	0.75	0.25	0.07	0.45	5.67E-05	0.00E+00	1.00	0.083	4.73E-06
Segment 2 Rupture	7	S2-R-6	6-8	8	R	1234	23887	41.6	41.8	43.6	816	1098	1493	1.3	1.00	1.00	0.50	1.00	0.75	0.25	0.15	0.96	1.81E-05	0.00E+00	1.00	0.079	1.43E-06
Segment 2 Rupture	8	S2-R-7	6-8	8	R	3266	22081	41.6	41.8	43.6	816	1098	1493	1.2	1.00	1.00	0.50	1.00	0.75	0.25	0.13	0.89	4.79E-05	0.00E+00	1.00	0.079	3.78E-06
Segment 2 Rupture	9	S2-R-8	6-8	8	R	3006	20070	41.6	41.8	43.6	816	1098	1493	1.1	1.00	1.00	0.50	1.00	0.75	0.25	0.12	0.81	4.41E-05	0.00E+00	1.00	0.125	5.51E-06
Segment 2 Rupture	10	S2-R-9	6-8	8	R	2874	15786	41.6	41.8	43.6	816	1098	1493	0.8	1.00	1.00	0.50	1.00	0.75	0.25	0.10	0.64	4.21E-05	0.00E+00	1.00	0.079	3.33E-06
Segment 2 Rupture	11	S2-R-10	6-8	8	R	5038	15628	41.6	41.8	43.6	816	1098	1493	0.8	1.00	1.00	0.50	1.00	0.75	0.25	0.09	0.63	7.39E-05	0.00E+00	1.00	0.079	5.84E-06
Segment 2 Rupture	12	S2-R-11	6-8	8	R	895	8574	41.6	41.8	43.6	816	1098	1493	0.5	1.00	1.00	0.50	1.00	0.75	0.25	0.05	0.35	1.31E-05	0.00E+00	1.00	0.079	1.04E-06
Segment 3 Rupture	13	S3-R-1	12	12	R	895	8574	67.7	71.1	75.2	2160	3176	4441	1.4	1.00	1.00	0.50	1.00	0.75	0.25	0.18	1.00	1.31E-05	0.00E+00	1.00	0.079	1.04E-06
Segment 3 Rupture	14	S1-R-2	12	12	R	5825	6345	67.7	71.1	75.2	2160	3176	4441	1.0	1.00	1.00	0.50	1.00	0.75	0.25	0.13	0.74	8.54E-05	8.76E-06	1.00	0.125	1.07E-05
Segment 3 Rupture	15	S1-R-3	12	12	R	2907	19510	67.7	71.1	75.2	2160	3176	4441	3.1	1.00	1.00	0.50	1.00	0.75	0.25	0.40	2.27	4.26E-05	0.00E+00	1.00	0.079	3.37E-06
Segment 3 Rupture	16	S1-R-4	12	12	R	1046	13640	67.7	71.1	75.2	2160	3176	4441	2.2	1.00	1.00	0.50	1.00	0.75	0.25	0.28	1.58	1.53E-05	0.00E+00	1.00	0.079	1.21E-06
Segment 3 Rupture	17	S1-R-5	12	12	R	795	14233	67.7	71.1	75.2	2160	3176	4441	2.3	1.00	1.00	0.50	1.00	0.75	0.25	0.29	1.65	1.17E-05	0.00E+00	1.00	0.125	1.46E-06
Segment 3 Rupture	18	S1-R-6	12	12	R	2616	16682	67.7	71.1	75.2	2160	3176	4441	2.7	1.00	1.00	0.50	1.00	0.75	0.25	0.34	1.94	3.84E-05	0.00E+00	1.00	0.125	4.80E-06
Segment 3 Rupture	19	S1-R-7	12	12	R	2644	13977	67.7	71.1	75.2	2160	3176	4441	2.2	1.00	1.00	0.50	1.00	0.75	0.25	0.29	1.62	3.88E-05	0.00E+00	1.00	0.125	4.85E-06
Segment 3 Rupture	20	S1-R-8	12	12	R	2830	18222	67.7	71.1	75.2	2160	3176	4441	2.9	1.00	1.00	0.50	1.00	0.75	0.25	0.37	2.12	4.15E-05	0.00E+00	1.00	0.079	3.28E-06
Segment 1 Leak	1	S1-L-1	6	1	L	2876	100	32.8	33.5	34	422	441	454	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	1.34E-04	0.00E+00	1.00	0.079	1.06E-05
Segment 2 Leak	2	S2-L-1	6-8	1	L	9410	100	32.8	33.5	34	422	441	454	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	7.82E-04	0.00E+00	1.00	0.079	6.18E-05
Segment 2 Leak	3	S2-L-2	6-8	1	L	5195	7112	32.8	33.5	34	422	441	454	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.11	4.32E-04	7.88E-05	1.00	0.079	3.41E-05
Segment 2 Leak	4	S2-L-3	6-8	1	L	2813	5448	32.8	33.5	34	422	441	454	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.09	2.34E-04	0.00E+00	1.00	0.079	1.85E-05
Segment 2 Leak	5	S2-L-4	6-8	1	L	4276	813	32.8	33.5	34	422	441	454	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.01	3.55E-04	0.00E+00	1.00	0.079	2.81E-05
Segment 2 Leak	6	S2-L-5	6-8	1	L	3869	11090	32.8	33.5	34	422	441	454	0.2	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.17	3.22E-04	0.00E+00	1.00	0.083	2.68E-05
Segment 2 Leak	7	S2-L-6	6-8	1	L	1234	23887	32.8	33.5	34	422	441	454	0.4	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.38	1.03E-04	0.00E+00	1.00	0.079	8.10E-06
Segment 2 Leak	8	S2-L-7	6-8	1	L	3266	22081	32.8	33.5	34	422	441	454	0.4	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.35	2.71E-04	0.00E+00	1.00	0.079	2.14E-05
Segment 2 Leak	9	S2-L-8	6-8	1	L	3006	20070	32.8	33.5	34	422	441	454	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.32	2.50E-04	0.00E+00	1.00	0.125	3.12E-05
Segment 2 Leak	10	S2-L-9	6-8	1	L	2874	15786	32.8	33.5	34	422	441	454	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.25	2.39E-04	0.00E+00	1.00	0.079	1.89E-05
Segment 2 Leak	11	S2-L-10	6-8	1	L	5038	15628	32.8	33.5	34	422	441	454	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.25	4.19E-04	0.00E+00	1.00	0.079	3.31E-05
Segment 2 Leak	12	S2-L-11	6-8	1	L	895	8574	32.8	33.5	34	422	441	454	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.14	7.44E-05	0.00E+00	1.00	0.079	5.88E-06
Segment 3 Leak	13	S3-L-1	12	1	L	895	8574	32.9	33.6	34.1	425	443	457	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.14	7.44E-05	0.00E+00	1.00	0.079	5.88E-06
Segment 3 Leak	14	S1-L-2	12	1	L	5825	6345	32.9	33.6	34.1	425	443	457	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.10	4.84E-04	7.88E-05	1.00	0.125	6.05E-05
Segment 3 Leak	15	S1-L-3	12	1	L	2907	19510	32.9	33.6	34.1	425	443	457	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.31	2.42E-04	0.00E+00	1.00	0.079	1.91E-05
Segment 3 Leak	16	S1-L-4	12	1	L	1046	13640	32.9	33.6	34.1	425	443	457	0.2	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.22	8.69E-05	0.00E+00	1.00	0.079	6.87E-06
Segment 3 Leak	17	S1-L-5	12	1	L	795	14233	32.9	33.6	34.1	425	443	457	0.2	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.23	6.61E-05	0.00E+00	1.00	0.125	8.26E-06
Segment 3 Leak	18	S1-L-6	12	1	L	2616	16682	32.9	33.6	34.1	425	443	457	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.26	2.17E-04	0.00E+00	1.00	0.125	2.72E-05
Segment 3 Leak	19	S1-L-7	12	1	L	2644	13977	32.9	33.6	34.1	425	443	457	0.2	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.22	2.20E-04	0.00E+00	1.00	0.125	2.75E-05
Segment 3 Leak	20	S1-L-8	12	1	L	2830	18222	32.9	33.6	34.1	425	443	457	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.29	2.35E-04	0.00E+00	1.00	0.079	1.86E-05

Notes
 Fraction outside = 7.9% in general, and 3 hours per day (12.5%) for segments in front of schools as per CDE Risk protocol
 Weight population density, ppsm avg 10,149
 Population density based on Census 2010 Tracts
 Area of impact based on modeling ellipses (ruptures: 0.60 length/width ratio for 12 kbtu, 0.80 ratio for 8kbtu and 1.0 ratio for 5 kbtu, leaks: 0.5 for all)
 Segments along schools have school population added in to the census tract population

Pipeline Segment Lengths and Modeling

Segment Lengths

Segment	Description	Length, ft	Dia, inches	MRS Modeled Length	Notes
1	New line	2,929	8	15,745	
2	Sepulveda to Terminal	1,039	6		from center point of segment to ASV
2	Terminal - ASV	13,241	8		
2	ASV - N Paramount Blvd	26,551	8	26,069	From center point to refinery.
3	N Paramount Blvs - South Street Vault	980	12		Midpoint of 12" segment plus distance back to ASV ratioed by size
3	South Street Vault - Refinery	11,813	12	18,197	

Notes: does not include leg to Tesoro.

For segment 2, not any difference in modeling results once you exceed 5k feet, so used results from segment 1 instead

From INGAA Table 2 & 4

incidents whose PL age is known

Number of incidents

Incident Cause/Issue	Age-related Incidents ¹	Total incidents ²	Total incidents ³	Older PL Expected (12%) ⁴	Older PL Actual ⁵
External Corrosion	25	83	83	9.96	25
Internal Corrosion			46	5.52	5.52
Earth Movement			13	1.56	1.56
Lightning			8	0.96	0.96
Rains/Floods	4	15	15	1.8	4
Temperature			3	0.36	0.36
High Winds			5	0.6	0.6
Op.Exc. Damage			17	2.04	2.04
Third Party	20	101	101	12.12	20
Fire/Explosion			9	1.08	1.08
Vehicle			39	4.68	4.68
Rupture of rpreviously damaged PL			6	0.72	0.72
Vandalism			3	0.36	0.36
Bodyofpipe	15	21	21	2.52	15
Component	4	18	18	2.16	4
Joint			12	1.44	1.44
Butt Weld	5	25	25	3	5
Fillet			6	0.72	0.72
Seam	11	16	16	1.92	11
MCRE			35	4.2	4.2
TSBPC			14	1.68	1.68
LSP			9	1.08	1.08
Incorrect Operations			15	1.8	1.8
Miscellaneous			48	5.76	5.76
Unknown			20	2.4	2.4
Stress Corrosion Cracking	7	11	11	1.32	7
	91	290	598	71.76	127.96
Ratio of older to average -->					1.78

Notes

- 1) Incidents for older pipelines that were identified as age related (INGGA report Table 4)
- 2) Total incidents in age related category for all pipelines (INGGA Table 4)
- 3) Total incidents for all pipeline (where age of pipeline was known)
- 4) Expected number of incidents if evenly distributed by age for older pipelines
- 5) Total actual incidents for older pipelines

Truck Accidents Risk Analysis: Gaseous Hydrogen Tube Trailers

Accident Rate, per million miles 0.32
 Probability of a release 0.054
 Large release 0.266
 Fraction Explosions 0.5
 Probability of ignition 1
 Loaded miles per trip 11.7
 Trips per year 12775
 assumes 35 trucks per day at 480 kg H2/truck

Segment Description	Segment #	Scenario ID	Release Size (in)	Release Type (R, RExp, L)	Segment Length (ft)	Population Density, ppsm	Exposure										Frequency								
							Jet 12.0 kbtu/hr-ft2 or OverPressure 5psi Distance (ft)	Jet 8.0 kbtu/hr-ft2 or OverPressure 3psi Distance (ft)	Jet 5.0 kbtu/hr-ft2 or OverPressure 1psi Distance (ft)	Jet 12.0 kbtu/hr-ft2 or OverPressure 5psi Area (ft2)	Jet 8.0 kbtu/hr-ft2 or OverPressure 3psi Area (ft2)	Jet 5.0 kbtu/hr-ft2 or OverPressure 1psi Area (ft2)	Max Persons Exposed	Injury Probability 12 kbtu/hr-ft2 or OverPressure 5psi	Injury Probability 8 kbtu/hr-ft2 or OverPressure 3psi	Injury Probability 5 kbtu/hr-ft2 or OverPressure 1psi	Fatality Probability 12 kbtu/hr-ft2 or OverPressure 5psi	Fatality Probability 8 kbtu/hr-ft2 or OverPressure 3psi	Fatality Probability 5 kbtu/hr-ft2 or OverPressure 1psi	Injuries (# people)	Fatalities (# people)	Accident Frequency, per year	Thermal Frequency, per year	Fraction Persons Exposed*	Fire Frequency, per year
ApCarson-Hwy onramp	1	T1RJF	6	RJ	5808	100	127	129	130	8867	13070	13273	0.05	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.04	4.50E-03	3.23E-05	0.079	2.55E-06
Hwy Onramp	2	T2RJF	6	RJ	580	5827	127	129	130	8867	13070	13273	2.77	1.00	1.00	0.50	1.00	0.75	0.25	0.23	2.52	4.49E-04	3.23E-06	0.079	2.55E-07
Highways (405/710/105)	3	T3RJF	6	RJ	49632	0	127	129	130	8867	13070	13273	0.00	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	3.84E-02	2.76E-04	0.1428	3.94E-05
Lakewood1	4	T4RJF	6	RJ	1210	13068	127	129	130	8867	13070	13273	6.22	1.00	1.00	0.50	1.00	0.75	0.25	0.52	5.66	9.37E-04	6.73E-06	0.079	5.32E-07
Lakewood2	5	T5RJF	6	RJ	2960	13634	127	129	130	8867	13070	13273	6.49	1.00	1.00	0.50	1.00	0.75	0.25	0.54	5.90	2.29E-03	1.65E-05	0.079	1.30E-06
Lakewood3	6	T6RJF	6	RJ	1580	10439	127	129	130	8867	13070	13273	4.97	1.00	1.00	0.50	1.00	0.75	0.25	0.41	4.52	1.22E-03	8.79E-06	0.079	6.94E-07
ApCarson-Hwy onramp	1	T1REx	6	RExp	5808	100	68	126	383	14527	49876	460837	1.65	1.00	0.50	0.10	1.00	0.10	0.01	0.18	0.08	4.50E-03	3.23E-05	1.00	3.23E-05
Hwy Onramp	2	T2REx	6	RExp	580	5827	68	126	383	14527	49876	460837	96	1.00	0.50	0.10	1.00	0.10	0.01	10.69	4.63	4.49E-04	3.23E-06	1.00	3.23E-06
Highways (405/710/105)	3	T3REx	6	RExp	49632	0	68	126	383	14527	49876	460837	0	1.00	0.50	0.10	1.00	0.10	0.01	0.00	0.00	3.84E-02	2.76E-04	0.1428	3.94E-05
Lakewood1	4	T4REx	6	RExp	1210	13068	68	126	383	14527	49876	460837	216	1.00	0.50	0.10	1.00	0.10	0.01	23.97	10.39	9.37E-04	6.73E-06	1.00	6.73E-06
Lakewood2	5	T5REx	6	RExp	2960	13634	68	126	383	14527	49876	460837	225	1.00	0.50	0.10	1.00	0.10	0.01	25.00	10.84	2.29E-03	1.65E-05	1.00	1.65E-05
Lakewood3	6	T6REx	6	RExp	1580	10439	68	126	383	14527	49876	460837	173	1.00	0.50	0.10	1.00	0.10	0.01	19.14	8.30	1.22E-03	8.79E-06	1.00	8.79E-06
ApCarson-Hwy onramp	1	T1L	1	L	5808	100	60	61	62	1414	1461	1510	0.01	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.01	4.50E-03	1.78E-04	0.079	1.41E-05
Hwy Onramp	2	T2L	1	L	580	5827	60	61	62	1414	1461	1510	0.32	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.31	4.49E-04	1.78E-05	0.079	1.41E-06
Highways (405/710/105)	3	T3L	1	L	49632	0	60	61	62	1414	1461	1510	0.00	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	3.84E-02	1.52E-03	0.01428	2.17E-05
Lakewood1	4	T4L	1	L	1210	13068	60	61	62	1414	1461	1510	0.71	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.69	9.37E-04	3.71E-05	0.079	2.93E-06
Lakewood2	5	T5L	1	L	2960	13634	60	61	62	1414	1461	1510	0.74	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.71	2.29E-03	9.08E-05	0.079	7.18E-06
Lakewood3	6	T6L	1	L	1580	10439	60	61	62	1414	1461	1510	0.57	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.55	1.22E-03	4.85E-05	0.079	3.83E-06

* For highway impacts, this fraction is the fraction of releases and subsequent fires that produce one or more fatalities. The number of injuries and fatalities are based on a distribution curve. Injury frequency assumed to occur at 1.5x the fatality frequency, as per DOT 2001. Injury probability assumed to be 10% of fatality probability on the highways

Truck Accidents Risk Analysis: Liquid Hydrogen Tank Trailers

Accident Rate, per million miles 0.32
 Probability of a release 0.054
 Large release 0.37
 Probability of ignition 1.0
 Loaded miles per trip 45
 Trips per year 2190

Segment Description	Segment #	Scenario ID	Release Size (in)	Release Type (R, L)	Segment Length (ft)	Population Density, ppsm	Exposure												Frequency						
							Jet 12.0 kbtu/hr-ft2 Distance (ft)	Jet 8.0 kbtu/hr-ft2 Distance (ft)	Jet 5.0 kbtu/hr-ft2 Distance (ft)	Jet 12.0 kbtu/hr-ft2 Area (ft2)	Jet 8.0 kbtu/hr-ft2 Area (ft2)	Jet 5.0 kbtu/hr-ft2 Area (ft2)	Max Persons Exposed	Injury Probability 12 kbtu/hr-ft2	Injury Probability 8 kbtu/hr-ft2	Injury Probability 5 kbtu/hr-ft2	Fatality Probability 12 kbtu/hr-ft2	Fatality Probability 8 kbtu/hr-ft2	Fatality Probability 5 kbtu/hr-ft2	Injuries (# people)	Fatalities (# people)	Accident Frequency, per year	Thermal Frequency, per year	Fraction Persons Exposed*	Fire Frequency, per year
Praxair-Hwy	1	T1R	6	R	4733	391	81.6	82.1	86.7	3661	5294	5904	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.07	6.28E-04	1.27E-05	0.079	1.00E-06
Hwy-Lakewood Exit	2	T2R	6	R	227117	0	81.6	82.1	86.7	3661	5294	5904	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	3.01E-02	6.07E-04	0.1224	7.43E-05
Lakewood1	3	T1R	6	R	1210	13068	81.6	82.1	86.7	3661	5294	5904	2.8	1.00	1.00	0.50	1.00	0.75	0.25	0.26	2.36	1.61E-04	3.23E-06	0.079	2.56E-07
Lakewood2	4	T1R	6	R	2960	13634	81.6	82.1	86.7	3661	5294	5904	2.9	1.00	1.00	0.50	1.00	0.75	0.25	0.27	2.46	3.93E-04	7.91E-06	0.079	6.25E-07
Lakewood3	5	T1R	6	R	1580	10439	81.6	82.1	86.7	3661	5294	5904	2.2	1.00	1.00	0.50	1.00	0.75	0.25	0.21	1.89	2.10E-04	4.22E-06	0.079	3.34E-07
Praxair-Hwy	1	T1L	1	L	4733	391	26.5	27	27.3	276	286	293	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	6.28E-04	2.13E-05	0.079	1.68E-06
Hwy-Lakewood Exit	2	T2L	1	L	227117	0	26.5	27	27.3	276	286	293	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	3.01E-02	1.02E-03	0.01224	1.25E-05
Lakewood1	3	T1L	1	L	1210	13068	26.5	27	27.3	276	286	293	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.13	1.61E-04	5.44E-06	0.079	4.30E-07
Lakewood2	4	T1L	1	L	2960	13634	26.5	27	27.3	276	286	293	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.14	3.93E-04	1.33E-05	0.079	1.05E-06
Lakewood3	5	T1L	1	L	1580	10439	26.5	27	27.3	276	286	293	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.11	2.10E-04	7.10E-06	0.079	5.61E-07

* For highway impacts, this fraction is the fraction of releases and subsequent fires that produce one or more fatalities. The number of injuries and fatalities are based on a distribution curve.

As the one or more fatalities is nationwide, fatality fraction increased by average AADT increase on LA freeways (x2.55)

Injury frequency assumed to occur at 1.9x the fatality frequency, as per DOT 2001

Avg pop den non-hwy segments 7,108

Area of impact based on modeling ellipses (ruptures: 0.70 length/width ratio for 12 kbtu, 1.0 ratio for 8kbtu and 5 kbtu, leaks: 0.5 for all) as per Canary output

Pipeline Risk Assessment: Alternative New Pipeline at 160 psig

Avg Frequency 2.90E-04 per miles-year
 Age Factor 1.78 applied to all pipeline segments except the new
 Effective Frequency 5.16E-04 Incidents per mile year
 Rupture fraction 0.15

Scenario Description	Segment #	Scenario ID	Segment Diameter (in)	Release Size (in)	Release Type (Rupture, Leak)	Segment Length (ft)	Exposure														Frequency						
							Population Density, ppsm	Jet 12.0 kbtu/hr-ft2 Distance (ft)	Jet 8.0 kbtu/hr-ft2 Distance (ft)	Jet 5.0 kbtu/hr-ft2 Distance (ft)	Jet 12.0 kbtu/hr-ft2 Area (ft2)	Jet 8.0 kbtu/hr-ft2 Area (ft2)	Jet 5.0 kbtu/hr-ft2 Area (ft2)	Max Persons Exposed	Injury Probability 12 kbtu/hr-ft2	Injury Probability 8 kbtu/hr-ft2	Injury Probability 5 kbtu/hr-ft2	Fatality Probability 12 kbtu/hr-ft2	Fatality Probability 8 kbtu/hr-ft2	Fatality Probability 5 kbtu/hr-ft2	Injuries (# people)	Fatalities (# people)	Event Frequency, per year	Valve Event Frequency, per year	Ignition Probability	Fraction Persons Exposed	Fire Frequency, per year
Segment 1 Rupture	1	New-R-1	6	8	R	2876	100	41.6	41.8	43.6	816	1098	1493	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	2.37E-05	0.00E+00	1.00	0.079	1.87E-06
Segment 2 Rupture	2	S2-R-1	6-8	8	R	9410	100	41.6	41.8	43.6	816	1098	1493	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	1.38E-04	0.00E+00	1.00	0.079	1.09E-05
Segment 2 Rupture	3	S2-R-2	6-8	8	R	5195	7112	41.6	41.8	43.6	816	1098	1493	0.4	1.00	1.00	0.50	1.00	0.75	0.25	0.04	0.29	7.62E-05	8.76E-06	1.00	0.079	6.02E-06
Segment 2 Rupture	4	S2-R-3	6-8	8	R	2813	5448	41.6	41.8	43.6	816	1098	1493	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.03	0.22	4.13E-05	0.00E+00	1.00	0.079	3.26E-06
Segment 2 Rupture	5	S2-R-4	6-8	8	R	4276	813	41.6	41.8	43.6	816	1098	1493	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.03	6.27E-05	0.00E+00	1.00	0.079	4.95E-06
Segment 2 Rupture	6	New-R-2	12	12	R	11616	5927	67.7	71.1	75.2	2160	3176	4441	0.9	1.00	1.00	0.50	1.00	0.75	0.25	0.12	0.69	9.57E-05	0.00E+00	1.00	0.083	7.98E-06
Segment 2 Rupture	7	New-R-3	12	12	R	4858	13021	67.7	71.1	75.2	2160	3176	4441	2.1	1.00	1.00	0.50	1.00	0.75	0.25	0.27	1.51	4.00E-05	0.00E+00	1.00	0.079	3.16E-06
Segment 2 Rupture	8	New-R-4	12	12	R	2640	16725	67.7	71.1	75.2	2160	3176	4441	2.7	1.00	1.00	0.50	1.00	0.75	0.25	0.34	1.94	2.18E-05	0.00E+00	1.00	0.079	1.72E-06
Segment 2 Rupture	9	New-R-5	12	12	R	2761	14794	67.7	71.1	75.2	2160	3176	4441	2.4	1.00	1.00	0.50	1.00	0.75	0.25	0.30	1.72	2.28E-05	0.00E+00	1.00	0.125	2.84E-06
Segment 2 Rupture	10	New-R-6	12	12	R	4726	9950	67.7	71.1	75.2	2160	3176	4441	1.6	1.00	1.00	0.50	1.00	0.75	0.25	0.20	1.16	3.89E-05	0.00E+00	1.00	0.079	3.08E-06
Segment 2 Rupture	11	New-R-7	12	12	R	4921	6033	67.7	71.1	75.2	2160	3176	4441	1.0	1.00	1.00	0.50	1.00	0.75	0.25	0.12	0.70	4.05E-05	0.00E+00	1.00	0.079	3.20E-06
Segment 2 Rupture	12	New-R-8	12	12	R	4345	19863	67.7	71.1	75.2	2160	3176	4441	3.2	1.00	1.00	0.50	1.00	0.75	0.25	0.41	2.31	3.58E-05	0.00E+00	1.00	0.079	2.83E-06
Segment 1 Leak	1	New-L-1	6	1	L	2876	100	32.8	33.5	34.0	422	441	454	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	1.34E-04	0.00E+00	1.00	0.079	1.06E-05
Segment 2 Leak	2	S2-L-1	6-8	1	L	9410	100	32.8	33.5	34.0	422	441	454	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.00	7.82E-04	0.00E+00	1.00	0.079	6.18E-05
Segment 2 Leak	3	S2-L-2	6-8	1	L	5195	7112	32.8	33.5	34.0	422	441	454	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.11	4.32E-04	7.88E-05	1.00	0.079	3.41E-05
Segment 2 Leak	4	S2-L-3	6-8	1	L	2813	5448	32.8	33.5	34.0	422	441	454	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.09	2.34E-04	0.00E+00	1.00	0.079	1.85E-05
Segment 2 Leak	5	S2-L-4	6-8	1	L	4276	813	32.8	33.5	34.0	422	441	454	0.0	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.01	3.55E-04	0.00E+00	1.00	0.079	2.81E-05
Segment 2 Leak	6	New-L-2	12	1	L	11616	5927	32.9	33.6	34.1	425	443	457	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.09	5.42E-04	0.00E+00	1.00	0.083	4.52E-05
Segment 2 Leak	7	New-L-3	12	1	L	4858	13021	32.9	33.6	34.1	425	443	457	0.2	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.21	2.27E-04	0.00E+00	1.00	0.079	1.79E-05
Segment 2 Leak	8	New-L-4	12	1	L	2640	16725	32.9	33.6	34.1	425	443	457	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.27	1.23E-04	0.00E+00	1.00	0.079	9.74E-06
Segment 2 Leak	9	New-L-5	12	1	L	2761	14794	32.9	33.6	34.1	425	443	457	0.2	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.23	1.29E-04	0.00E+00	1.00	0.125	1.61E-05
Segment 2 Leak	10	New-L-6	12	1	L	4726	9950	32.9	33.6	34.1	425	443	457	0.2	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.16	2.21E-04	0.00E+00	1.00	0.079	1.74E-05
Segment 2 Leak	11	New-L-7	12	1	L	4921	6033	32.9	33.6	34.1	425	443	457	0.1	1.00	1.00	0.50	1.00	0.75	0.25	0.00	0.10	2.30E-04	0.00E+00	1.00	0.079	1.81E-05
Segment 2 Leak	12	New-L-8	12	1	L	4345	19863	32.9	33.6	34.1	425	443	457	0.3	1.00	1.00	0.50	1.00	0.75	0.25	0.01	0.31	2.03E-04	0.00E+00	1.00	0.079	1.60E-05

Notes
 Fraction outside = 7.9% in general, and 2 hours per day (8.3%) for segments in front of schools as per CDE Risk protocol
 Weight population density, ppsm avg 7,232
 Population density based on Census 2010 Tracts
 Segments along schools have school population added in to the census tract population

**CDE 2007 Guidance for Protocol for School Site Risk Analysis
TIR CALCULATIONS - BEGIN ZONE 1 - FRONT PROPERTY LINE**

Green cells (B19, B21, B47-53, D4-7, D10-15, H19, and H20) indicate data entry cells.

Input Data		
Product	hydrogen	
Diameter	12	inches
Pressure	260	psig
R0	0	ft

XSEG	RX(1%)	Units
XSEG(LJF)	76	ft
XSEG(RJF)	200	ft
XSEG(LFF)	0	ft
XSEG(RFF)	0	ft
XSEG(LEX)	0	ft
XSEG(REX)	0	ft

1. These instruction boxes apply to Worksheets TIR1, 2, 3, and 4.
2. Enter the Input Data indicated for the case under analysis.
3. Enter the XSEG values from Worksheet "XSEG Calculations".
4. In the table below enter the F0 data for the appropriate type of pipeline from the failure frequency data in the Protocol, Chapter 4.
5. Enter a value for the other green cell variables as explained in Chapter 4.

Base and Conditional Probability Calculations							
	Base		Leak		Rupture		Exposure
F0	2.9E-04	PC(L)	0.8	PC(R)	0.2	PC(OCC)	0.24
P0	2.9E-04	PC(LIG)	1	PC(RIG)	1	PC(OUT)	0.25
PAF	1.780	PC(FIG)	1	PC(FIG)	1		
PA	5.2E-04	PC(JF)	1	PC(JF)	1		
		PC(FF)	0	PC(FF)	0		
		PC(EIG)	0	PC(EIG)	0		
Calculated Values:							
PA(LJF)	7.4E-06	PCI(LJF)	0.800	PCI(RJF)	0.200		
PA(RJF)	2.0E-05	PCI(LFF)	0.000	PCI(RFF)	0.000		
PA(LFF)	0.0E+00	PCI(LEX)	0.000	PCI(REX)	0.000	PC(EXPO)	0.06
PA(RFF)	0.0E+00						
PA(LEX)	0.0E+00						
PA(REX)	0.0E+00						

Impact Probability Calculations							
Probability Term				Values			
PC(LJF) =	PA(LJF) x	PCI(LJF) x	PC(EXPO) =	7.4E-06	0.80	0.059	3.5E-07
PC(RJF) =	PA(RJF) x	PCI(RJF) x	PC(EXPO) =	2.0E-05	0.20	0.059	2.3E-07
PC(LFF) =	PA(LFF) x	PCI(LFF) x	PC(EXPO) =	0.0E+00	0.000	0.059	0.0E+00
PC(RFF) =	PA(RFF) x	PCI(RFF) x	PC(EXPO) =	0.0E+00	0.000	0.059	0.0E+00
PC(LEX) =	PA(LEX) x	PCI(LEX) x	PC(EXPO) =	0.0E+00	0.000	0.059	0.0E+00
PC(REX) =	PA(REX) x	PCI(REX) x	PC(EXPO) =	0.0E+00	0.000	0.059	0.0E+00

Based on data from impact distance figures in Section 4.6 and mortality figures in Section 4.5, enter the maximum impact probability at receptor location for each hazard in MAX PF(X) column.

IR Calculation				
	MAX PF(X)		PC(X)	IR(X)
IR(LJF) =	0.25		3.5E-07	8.8E-08
IR(RJF) =	0.25		2.3E-07	5.80E-08
IR(LFF) =	0.00		0.0E+00	0.00E+00
IR(RFF) =	0.00		0.0E+00	0.00E+00
IR(LEX) =	0.00		0.0E+00	0.00E+00
IR(REX) =	0.00		0.0E+00	0.00E+00
TOTAL INDIVIDUAL RISK, TIR				1.5E-07
CDE INDIVIDUAL RISK CRITERION, IRC				1.0E-06
TIR/IRC RATIO				0.15
PROTOCOL TIR INDICATOR RATIO				0.25

6. Enter the maximum fatality probability that corresponds to the maximum impact for each hazard type according to the Protocol, Chapter 4.

Notes:
 assumes year-round schooling, 52 wks/yr, 5 days per week
 assumes increase failure rate due to age of 1.78
 assumes pipeline is in very close proximity to the school grounds

```

+-----+
|               CANARY by Quest - Version 4.6.3               |
|               CANARY Case Input                             |
|               Case Name - 8L1                               |
|               Tue Jul 7 12:45:43 2020                       |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: 8in Leak Segment 1

```

Case Type       : Vapor Dispersion
Case Name      : 8L1
User ID       :
Project Number :
Type of Units  : English Units

```

NOTES:

MATERIAL MENU

Materials Released	: Number	Formula	Name	Fraction
Component 1	: 51	= H2	Hydrogen(equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

```

Temperature      : 70.00 °F
Pressure         : 260.00 psia
The material is Indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           80.3 °F
Spill surface temperature 80.3 °F

```

```

Substrate name           Soil
Substrate thermal conductivity 1.0000 Btu/hr-ft-F
Substrate density        100 lb/cu.ft
Substrate heat Capacity  0.24 Btu/lb-F
Substrate delay time     60 sec
Surrounding terrain      Long grass or crops > 15 cm (6 in)

```

NOTES:

Case continued on page 2.

-----+-----
CANARY by Quest - Version 4.6.3
CANARY Case Input
Case Name - 8L1
Tue Jul 7 12:45:43 2020
-----+-----

Page 2 Title: 8in Leak Segment 1

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 120 min
Normal flow rate 0.42 lb/sec
Duration of normal flow 5 min
Volume of vessel 0.00 cu.ft
Pipe inner diameter 7.98 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 15744.0 feet
Height of release point 0.0 feet
Angle of release from horizontal 10.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%

Dispersion coefficient averaging time 1 min

NOTES:

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                General Release Model UPSTREAM                  |
|                Case Name - 8L1                                |
|                Tue Jul 7 12:45:43 2020                        |
|                Quest Consultants Inc., Norman, Oklahoma, USA   |
|                www.questconsult.com    canary@questconsult.com |
|                telephone (405) 329-7475    fax (405) 329-7734 |
+-----+

```

TITLE: 8in Leak Segment 1

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.9270608	0.000000	0.000000	.9270608
0.100000	.9268216	0.000000	0.000000	.9268216
0.300000	.9263290	0.000000	0.000000	.9263290
0.500000	.9258362	0.000000	0.000000	.9258362
0.700000	.9253431	0.000000	0.000000	.9253431
1.000000	.9246101	0.000000	0.000000	.9246101
3.000000	.9197632	0.000000	0.000000	.9197632
5.000000	.9136833	0.000000	0.000000	.9136833
7.000000	.9119075	0.000000	0.000000	.9119075
10.00000	.9092419	0.000000	0.000000	.9092419
20.00000	.9004880	0.000000	0.000000	.9004880
30.00000	.8918915	0.000000	0.000000	.8918915
40.00000	.8834386	0.000000	0.000000	.8834386
50.00000	.8751440	0.000000	0.000000	.8751440
60.00000	.8669760	0.000000	0.000000	.8669760
70.00000	.8587666	0.000000	0.000000	.8587666
85.00000	.8467481	0.000000	0.000000	.8467481
100.0000	.8350623	0.000000	0.000000	.8350623
200.0000	.7649319	0.000000	0.000000	.7649319
300.0000	.7062528	0.000000	0.000000	.7062528
400.0000	.5905499	0.000000	0.000000	.5905499
500.0000	.4929617	0.000000	0.000000	.4929617
600.0000	.4114204	0.000000	0.000000	.4114204
700.0000	.3432801	0.000000	0.000000	.3432801
850.0000	.2615082	0.000000	0.000000	.2615082
1000.000	.1991017	0.000000	0.000000	.1991017
1923.682	0.000000	0.000000	0.000000	0.000000
Totals (lb)	601.6136	0.000000	0.000000	601.6136
Flowrate for Torch Fire [immediate ignition]	= 0.8924896			lb/sec.
Torch Fire [delayed ignition]	= 0.7985653			lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|           CANARY by Quest - Version 4.6.3           |
|           Jet Fire Radiation Model                   |
|           Case Name - 8L1JF                         |
|           Tue Jul 7 12:56:29 2020                  |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: 8in Leak Segment 1 Jet Fire

```

Length of Flame           : 33.3 feet
Flame Tilt from Horizontal: 11.1 degrees
Release Angle            : 10.0 degrees
Release Point Elevation  : 0.0 feet
Target Elevation         : 6.0 feet
Wind Speed               : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
9.8	18063
10.6	16463
11.3	1093
12.2	1255
13.1	1450
14.0	1603
15.1	***
16.2	***
17.4	***
18.6	***
20.0	***
21.5	***
23.1	***
24.8	***
26.6	***
28.5	***
30.6	***
32.9	***
35.3	***
37.9	1542
40.7	1091
43.7	771
46.9	553
50.4	405
54.1	303

*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
36.2	12000
36.8	8000
37.2	5000

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                              |
|                Case Name - 8R1                                |
|                Tue Jul  7 13:02:53 2020                       |
|                Quest Consultants Inc., Norman, Oklahoma, USA   |
|                www.questconsult.com    canary@questconsult.com |
|                telephone (405) 329-7475    fax (405) 329-7734 |
+-----+

```

Title: 8in Rupture Segment 1

```

Case Type           : Vapor Dispersion
Case Name           : 8R1
User ID             :
Project Number      :
Type of Units       : English Units

```

NOTES:

MATERIAL MENU

Materials Released	: Number	Formula	Name	Fraction
Component 1	: 51	= H2	Hydrogen(equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

```

Temperature       : 70.00 °F
Pressure           : 260.00 psia
The material is Indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           70.0 °F
Spill surface temperature 70.0 °F

```

```

Substrate name           Soil
Substrate thermal conductivity 1.0000 Btu/hr-ft-F
Substrate density         100 lb/cu.ft
Substrate heat Capacity   0.24 Btu/lb-F
Substrate delay time      60 sec
Surrounding terrain       Long grass or crops > 15 cm (6 in)

```

NOTES:

Case continued on page 2.

CANARY by Quest - Version 4.6.3
CANARY Case Input
Case Name - 8R1
Tue Jul 7 13:02:53 2020

Page 2 Title: 8in Rupture Segment 1

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 120 min
Normal flow rate 0.42 lb/sec
Duration of normal flow 5 min
Volume of vessel 0.00 cu.ft
Pipe inner diameter 7.98 inches
Equivalent release diameter 8.00 inches
Pipe length upstream of break 15744.0 feet
Pipe length downstream of break 0.0 feet
Height of release point 0.0 feet
Angle of release from horizontal 10.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%

Dispersion coefficient averaging time 1 min

NOTES:

```

+-----+
|               CANARY by Quest - Version 4.6.3               |
|               General Release Model UPSTREAM                 |
|               Case Name - 8R1                               |
|               Tue Jul  7 13:02:53 2020                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: 8in Rupture Segment 1

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	59.04032	0.000000	0.000000	59.04032
0.100000	31.48175	0.000000	0.000000	31.48175
0.300000	20.32211	0.000000	0.000000	20.32211
0.500000	16.15912	0.000000	0.000000	16.15912
0.700000	13.81665	0.000000	0.000000	13.81665
1.000000	11.65992	0.000000	0.000000	11.65992
3.000000	6.810619	0.000000	0.000000	6.810619
5.000000	5.587047	0.000000	0.000000	5.587047
7.000000	5.461331	0.000000	0.000000	5.461331
10.00000	5.278769	0.000000	0.000000	5.278769
20.00000	4.714764	0.000000	0.000000	4.714764
30.00000	4.215472	0.000000	0.000000	4.215472
40.00000	3.773885	0.000000	0.000000	3.773885
50.00000	3.383619	0.000000	0.000000	3.383619
60.00000	3.036966	0.000000	0.000000	3.036966
70.00000	2.725165	0.000000	0.000000	2.725165
85.00000	2.325039	0.000000	0.000000	2.325039
100.0000	1.993958	0.000000	0.000000	1.993958
200.0000	.8545774	0.000000	0.000000	.8545774
300.0000	.5284997	0.000000	0.000000	.5284997
402.6038	0.000000	0.000000	0.000000	0.000000
Totals (lb)	600.0881	0.000000	0.000000	600.0881

Flowrate for Torch Fire [immediate ignition] = 4.630519 lb/sec.
Torch Fire [delayed ignition] = 1.271781 lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|          CANARY by Quest - Version 4.6.3          |
|          Jet Fire Radiation Model                 |
|          Case Name - 8R1JF                       |
|          Tue Jul 7 13:06:31 2020                 |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
|          www.questconsult.com                     |
|          canary@questconsult.com                  |
|          telephone (405) 329-7475                 |
|          fax (405) 329-7734                       |
+-----+

```

Title: 8in Rupture Segment 1

```

Length of Flame      : 48.7 feet
Flame Tilt from Horizontal: 16.5 degrees
Release Angle       : 10.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
9.8	***
10.9	***
12.1	***
13.4	***
14.8	***
16.4	***
18.1	***
20.1	***
22.2	***
24.6	***
27.2	***
30.1	***
33.4	***
36.9	***
40.9	***
45.2	***
50.1	13724
55.5	5941
61.4	3178
68.0	1916
75.2	1238
83.3	838
92.2	586
102.1	420
113.0	306

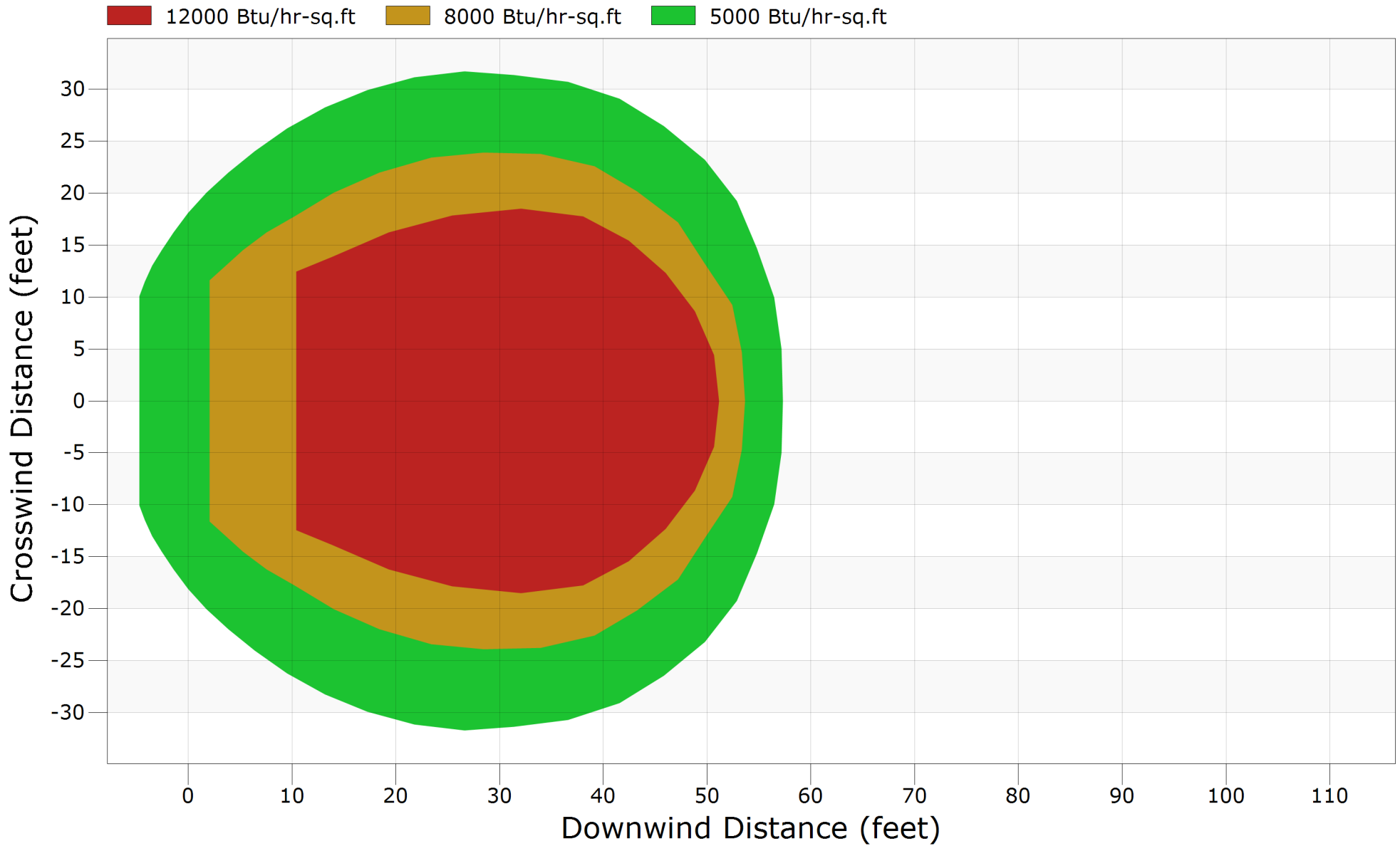
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
51.2	12000
53.7	8000
57.3	5000

Jet Fire Radiant Heat Contours - Overhead View

8in Rupture Segment 1 [8R1JF]



Note: Results presented for 6 feet above the release point during 20 mph winds.


```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                            |
|                Case Name - 12L3                             |
|                Tue Jul  7 13:35:16 2020                     |
|                Quest Consultants Inc., Norman, Oklahoma, USA  |
|                www.questconsult.com   canary@questconsult.com |
|                telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: 12in Leak Segment 3

```

Case Type           : Vapor Dispersion
Case Name           : 12L3
User ID             :
Project Number      :
Type of Units       : English Units

```

NOTES:

MATERIAL MENU

Materials Released	: Number	Formula	Name	Fraction
Component 1	:	51 = H2	Hydrogen(equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

```

Temperature         :          70.00 °F
Pressure            :          260.00 psia
The material is Indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           70.0 °F
Spill surface temperature 70.0 °F

```

```

Substrate name           Soil
Substrate thermal conductivity 1.0000 Btu/hr-ft-F
Substrate density        100 lb/cu.ft
Substrate heat Capacity  0.24 Btu/lb-F
Substrate delay time     60 sec
Surrounding terrain     Long grass or crops > 15 cm (6 in)

```

NOTES:

Case continued on page 2.

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 120 min
Normal flow rate 0.42 lb/sec
Duration of normal flow 5 min
Volume of vessel 0.00 cu.ft
Pipe inner diameter 12.00 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 18196.0 feet
Height of release point 0.0 feet
Angle of release from horizontal 10.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%
Dispersion coefficient averaging time 1 min

NOTES:

```

+-----+
|          CANARY by Quest - Version 4.6.3          |
|          General Release Model UPSTREAM           |
|          Case Name - 12L3                        |
|          Tue Jul 7 13:35:16 2020                |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
|          www.questconsult.com   canary@questconsult.com |
|          telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: 12in Leak Segment 3

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.9293086	0.000000	0.000000	.9293086
0.100000	.9292780	0.000000	0.000000	.9292780
0.300000	.9292169	0.000000	0.000000	.9292169
0.500000	.9291558	0.000000	0.000000	.9291558
0.700000	.9290839	0.000000	0.000000	.9290839
1.000000	.9289906	0.000000	0.000000	.9289906
3.000000	.9283405	0.000000	0.000000	.9283405
5.000000	.9261857	0.000000	0.000000	.9261857
7.000000	.9254804	0.000000	0.000000	.9254804
10.00000	.9244242	0.000000	0.000000	.9244242
20.00000	.9209192	0.000000	0.000000	.9209192
30.00000	.9174245	0.000000	0.000000	.9174245
40.00000	.9139676	0.000000	0.000000	.9139676
50.00000	.9105344	0.000000	0.000000	.9105344
60.00000	.9071194	0.000000	0.000000	.9071194
70.00000	.9036492	0.000000	0.000000	.9036492
85.00000	.8984922	0.000000	0.000000	.8984922
100.0000	.8933901	0.000000	0.000000	.8933901
200.0000	.8607306	0.000000	0.000000	.8607306
300.0000	.8299190	0.000000	0.000000	.8299190
400.0000	.7743998	0.000000	0.000000	.7743998
500.0000	.7222326	0.000000	0.000000	.7222326
600.0000	.6735584	0.000000	0.000000	.6735584
700.0000	.6281517	0.000000	0.000000	.6281517
850.0000	.5656812	0.000000	0.000000	.5656812
1000.000	.5093912	0.000000	0.000000	.5093912
2000.000	.2526954	0.000000	0.000000	.2526954
3000.000	.1247500	0.000000	0.000000	.1247500
4000.000	.4362841E-01	0.000000	0.000000	.4362841E-01
4648.102	0.000000	0.000000	0.000000	0.000000
Totals (lb)	1369.914	0.000000	0.000000	1369.914
Flowrate for Torch Fire [immediate ignition]	= 0.9175672			lb/sec.
Torch Fire [delayed ignition]	= 0.8767974			lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|           CANARY by Quest - Version 4.6.3           |
|           Jet Fire Radiation Model                   |
|           Case Name - 12L3JF                       |
|           Tue Jul 7 13:38:26 2020                  |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: 12in Leak Segment 3

```

Length of Flame           : 33.6 feet
Flame Tilt from Horizontal: 11.1 degrees
Release Angle            : 10.0 degrees
Release Point Elevation  : 0.0 feet
Target Elevation         : 6.0 feet
Wind Speed                : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
9.8	18216
10.6	18049
11.4	1035
12.2	1174
13.1	1328
14.1	1409
15.1	***
16.2	***
17.4	***
18.7	***
20.1	***
21.6	***
23.2	***
24.9	***
26.7	***
28.7	***
30.8	***
33.1	***
35.5	***
38.2	1576
41.0	1114
44.0	785
47.3	561
50.8	410
54.5	306

*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
36.5	12000
37.0	8000
37.5	5000

```

+-----+
|               CANARY by Quest - Version 4.6.3               |
|               CANARY Case Input                             |
|               Case Name - 12R3                              |
|               Tue Jul  7 13:40:04 2020                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: 12in Rupture Segment 3

```

Case Type       : Vapor Dispersion
Case Name      : 12R3
User ID       :
Project Number :
Type of Units  : English Units

```

NOTES:

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	:	51 = H2	Hydrogen(equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is Indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           70.0 °F
Spill surface temperature 70.0 °F

```

```

Substrate name           Soil
Substrate thermal conductivity 1.0000 Btu/hr-ft-F
Substrate density        100 lb/cu.ft
Substrate heat Capacity  0.24 Btu/lb-F
Substrate delay time     60 sec
Surrounding terrain     Long grass or crops > 15 cm (6 in)

```

NOTES:

Case continued on page 2.

-----+-----
CANARY by Quest - Version 4.6.3
CANARY Case Input
Case Name - 12R3
Tue Jul 7 13:40:04 2020
-----+-----

Page 2 Title: 12in Rupture Segment 3

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 120 min
Normal flow rate 0.42 lb/sec
Duration of normal flow 5 min
Volume of vessel 0.00 cu.ft
Pipe inner diameter 12.00 inches
Equivalent release diameter 12.00 inches
Pipe length upstream of break 18196.0 feet
Pipe length downstream of break 0.0 feet
Height of release point 0.0 feet
Angle of release from horizontal 10.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

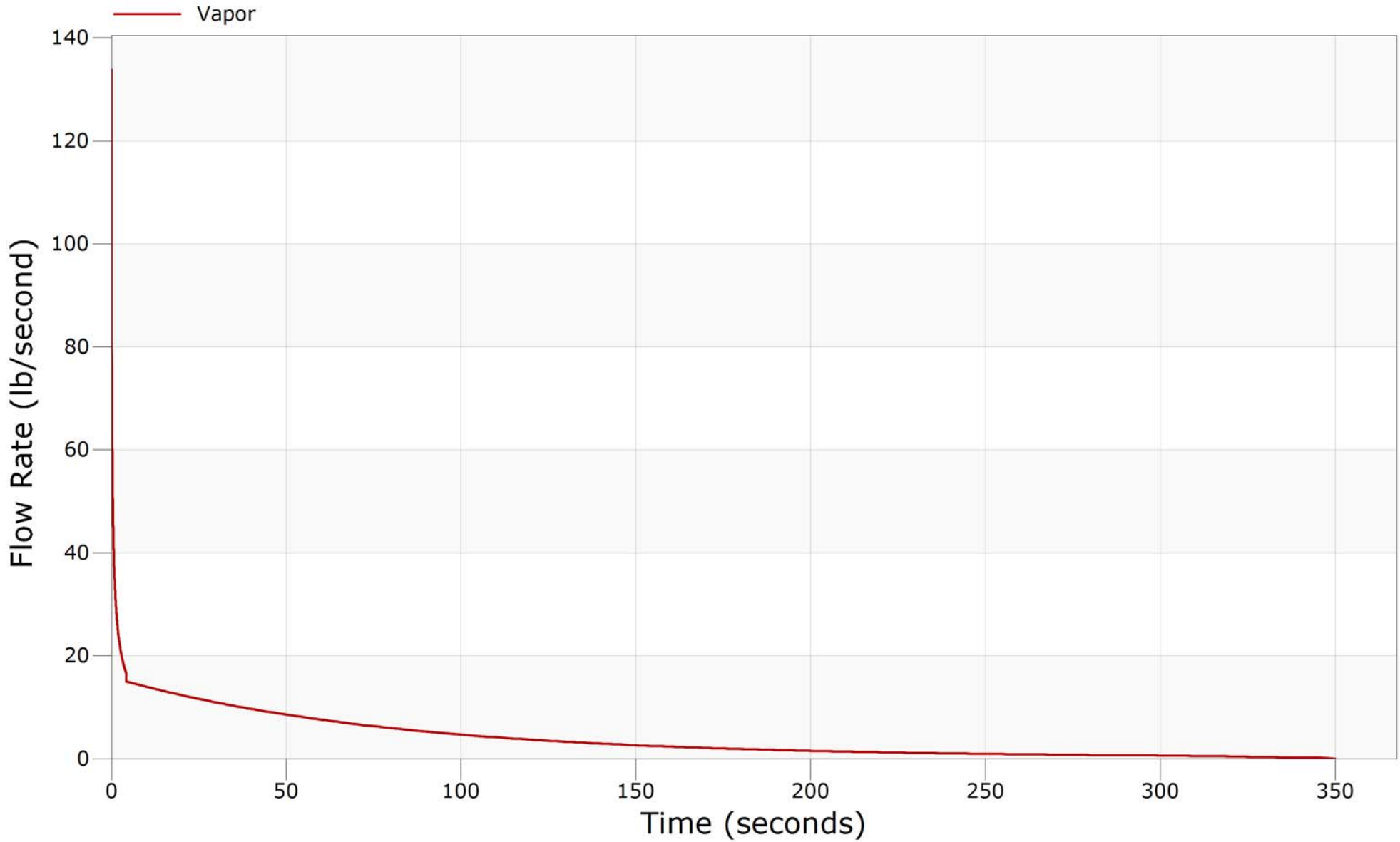
Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%

Dispersion coefficient averaging time 1 min

NOTES:

Mass Release Rate

12in Rupture Segment 3 [12R3]



```

+-----+
|          CANARY by Quest - Version 4.6.3          |
|          General Release Model UPSTREAM           |
|          Case Name - 12R3                        |
|          Tue Jul  7 13:40:04 2020                |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
|          www.questconsult.com   canary@questconsult.com |
|          telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: 12in Rupture Segment 3

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	133.8204	0.000000	0.000000	133.8204
0.100000	84.14796	0.000000	0.000000	84.14796
0.300000	56.86786	0.000000	0.000000	56.86786
0.500000	45.80060	0.000000	0.000000	45.80060
0.700000	39.39700	0.000000	0.000000	39.39700
1.000000	33.40885	0.000000	0.000000	33.40885
3.000000	19.66659	0.000000	0.000000	19.66659
5.000000	14.85388	0.000000	0.000000	14.85388
7.000000	14.49355	0.000000	0.000000	14.49355
10.00000	13.97038	0.000000	0.000000	13.97038
20.00000	12.36446	0.000000	0.000000	12.36446
30.00000	10.94196	0.000000	0.000000	10.94196
40.00000	9.685497	0.000000	0.000000	9.685497
50.00000	8.577910	0.000000	0.000000	8.577910
60.00000	7.600559	0.000000	0.000000	7.600559
70.00000	6.721172	0.000000	0.000000	6.721172
85.00000	5.598277	0.000000	0.000000	5.598277
100.0000	4.673763	0.000000	0.000000	4.673763
200.0000	1.514408	0.000000	0.000000	1.514408
300.0000	.6140651	0.000000	0.000000	.6140651
350.0236	0.000000	0.000000	0.000000	0.000000
Totals (lb)	1364.549	0.000000	0.000000	1364.549

Flowrate for Torch Fire [immediate ignition] = 12.19214 lb/sec.
Torch Fire [delayed ignition] = 2.668878 lb/sec.

Reason for Ending: Pressure Near Atmospheric


```

+-----+
|           CANARY by Quest - Version 4.6.3           |
|           Jet Fire Radiation Model                   |
|           Case Name - 12R3JF                       |
|           Fri Jul 17 21:37:54 2020                 |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: 12in Rupture Segment 3

```

Length of Flame      : 89.7 feet
Flame Tilt from Horizontal: 15.5 degrees
Release Angle       : 10.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
16.4	***
18.1	***
20.0	***
22.1	***
24.4	***
27.0	***
29.8	***
33.0	***
36.4	***
40.2	***
44.5	***
49.1	***
54.3	***
60.0	***
66.2	***
73.2	31216
80.9	23137
89.3	11621
98.7	5261
109.0	2705
120.5	1568
133.1	985
147.0	652
162.5	448
179.5	316

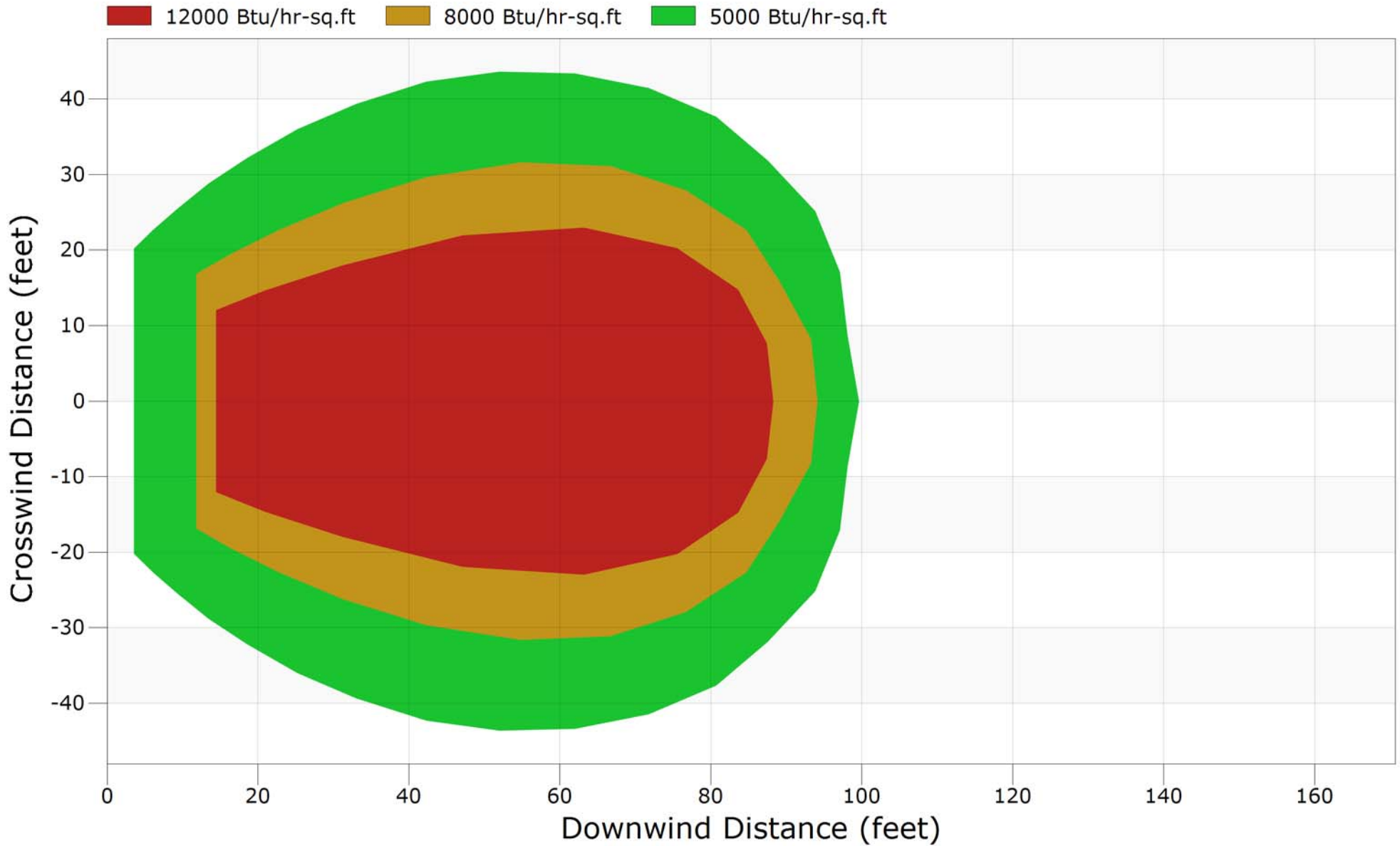
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
88.3	12000
94.2	8000
99.6	5000

Jet Fire Radiant Heat Contours - Overhead View

12in Rupture Segment 3 [12R3JF]



Note: Results presented for 6 feet above the release point during 20 mph winds.

```

+-----+
|               CANARY by Quest - Version 4.6.3               |
|               CANARY Case Input                             |
|               Case Name - 8L1-160                           |
|               Tue Jul  7 13:56:24 2020                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: 8in Leak Segment 1-160psi

```

Case Type           : Vapor Dispersion
Case Name           : 8L1-160
User ID             :
Project Number      :
Type of Units       : English Units

```

NOTES:

MATERIAL MENU

Materials Released	: Number	Formula	Name	Fraction
Component 1	: 51	= H2	Hydrogen(equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

```

Temperature       : 70.00 °F
Pressure          : 160.00 psia
The material is GAS

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           70.0 °F
Spill surface temperature 70.0 °F

```

```

Substrate name           Soil
Substrate thermal conductivity 1.0000 Btu/hr-ft-F
Substrate density         100 lb/cu.ft
Substrate heat Capacity   0.24 Btu/lb-F
Substrate delay time      60 sec
Surrounding terrain       Long grass or crops > 15 cm (6 in)

```

NOTES:

Case continued on page 2.

-----+
CANARY by Quest - Version 4.6.3
CANARY Case Input
Case Name - 8L1-160
Tue Jul 7 13:56:24 2020
-----+

Page 2 Title: 8in Leak Segment 1-160psi

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 120 min
Normal flow rate 0.42 lb/sec
Duration of normal flow 5 min
Volume of vessel 0.00 cu.ft
Pipe inner diameter 7.98 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 15744.0 feet
Height of release point 0.0 feet
Angle of release from horizontal 10.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%

Dispersion coefficient averaging time 1 min

NOTES:

AERMOD/MAP Receptor Listing

```

+-----+
|           CANARY by Quest - Version 4.6.3           |
|           Jet Fire Radiation Model                   |
|           Case Name - 8L1-160JF                     |
|           Tue Jul 7 14:14:39 2020                   |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: 8in Leak Segment 1-160psi

```

Length of Flame      : 28.8 feet
Flame Tilt from Horizontal: 11.5 degrees
Release Angle       : 10.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	6134
7.1	7442
7.7	8850
8.3	9613
9.0	8641
9.8	6022
10.6	2235
11.5	3288
12.4	5796
13.4	15282
14.5	15484
15.7	***
17.0	***
18.5	***
20.0	***
21.6	***
23.4	***
25.4	***
27.5	***
29.7	***
32.2	***
34.9	941
37.8	641
40.9	445
44.3	316

*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
32.8	12000
33.5	8000
34.0	5000

```

+-----+
|               CANARY by Quest - Version 4.6.3               |
|               CANARY Case Input                             |
|               Case Name - 8R1-160                           |
|               Tue Jul 7 13:57:09 2020                       |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: 8in Rupture Segment 1 - 160 psi

```

Case Type           : Vapor Dispersion
Case Name           : 8R1-160
User ID             :
Project Number      :
Type of Units       : English Units

```

NOTES:

MATERIAL MENU

```

Materials Released : Number Formula Name Fraction
Component 1       : 51 = H2 Hydrogen(equilibrium) 1.000000
Component 2       :
Component 3       :
Component 4       :
Component 5       :
Component 6       :
Component 7       :
Component 8       :
Component 9       :
Component 10      :

```

```

Temperature        : 70.00 °F
Pressure           : 160.00 psia
The material is GAS

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           70.0 °F
Spill surface temperature 70.0 °F

```

```

Substrate name           Soil
Substrate thermal conductivity 1.0000 Btu/hr-ft-F
Substrate density         100 lb/cu.ft
Substrate heat Capacity   0.24 Btu/lb-F
Substrate delay time      60 sec
Surrounding terrain       Long grass or crops > 15 cm (6 in)

```

NOTES:

Case continued on page 2.

-----+
CANARY by Quest - Version 4.6.3
CANARY Case Input
Case Name - 8R1-160
Tue Jul 7 13:57:09 2020
-----+

Page 2 Title: 8in Rupture Segment 1 - 160 psi

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 120 min
Normal flow rate 0.42 lb/sec
Duration of normal flow 5 min
Volume of vessel 0.00 cu.ft
Pipe inner diameter 7.98 inches
Equivalent release diameter 8.00 inches
Pipe length upstream of break 15744.0 feet
Pipe length downstream of break 0.0 feet
Height of release point 0.0 feet
Angle of release from horizontal 10.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%

Dispersion coefficient averaging time 1 min

NOTES:


```

+-----+
|          CANARY by Quest - Version 4.6.3          |
|          General Release Model UPSTREAM          |
|          Case Name - 8R1-160                    |
|          Tue Jul  7 13:57:09 2020              |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
|          www.questconsult.com   canary@questconsult.com |
|          telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: 8in Rupture Segment 1 - 160 psi

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	36.23317	0.000000	0.000000	36.23317
0.100000	19.27471	0.000000	0.000000	19.27471
0.300000	12.42684	0.000000	0.000000	12.42684
0.500000	9.874615	0.000000	0.000000	9.874615
0.700000	8.439948	0.000000	0.000000	8.439948
1.000000	7.119665	0.000000	0.000000	7.119665
3.000000	4.148919	0.000000	0.000000	4.148919
5.000000	3.412339	0.000000	0.000000	3.412339
7.000000	3.339576	0.000000	0.000000	3.339576
10.00000	3.233861	0.000000	0.000000	3.233861
20.00000	2.908093	0.000000	0.000000	2.908093
30.00000	2.619244	0.000000	0.000000	2.619244
40.00000	2.364107	0.000000	0.000000	2.364107
50.00000	2.137999	0.000000	0.000000	2.137999
60.00000	1.936961	0.000000	0.000000	1.936961
70.00000	1.755325	0.000000	0.000000	1.755325
85.00000	1.523161	0.000000	0.000000	1.523161
100.0000	1.329910	0.000000	0.000000	1.329910
200.0000	.6652644	0.000000	0.000000	.6652644
300.0000	.4794460	0.000000	0.000000	.4794460
402.6038	0.000000	0.000000	0.000000	0.000000
Totals (lb)	408.2468	0.000000	0.000000	408.2468

Flowrate for Torch Fire [immediate ignition] = 2.870226 lb/sec.
Torch Fire [delayed ignition] = 0.9084230 lb/sec.

Reason for Ending: Pressure Near Atmospheric

AERMOD/MAP Receptor Listing

```

+-----+
|           CANARY by Quest - Version 4.6.3           |
|           Jet Fire Radiation Model                 |
|           Case Name - 8R1-160JF                   |
|           Tue Jul 7 14:14:16 2020                 |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com                     |
|           telephone (405) 329-7475                 |
|           fax (405) 329-7734                       |
+-----+

```

Title: 8in Rupture Segment 1 - 160 psi

```

Length of Flame      : 36.6 feet
Flame Tilt from Horizontal: 16.6 degrees
Release Angle       : 10.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
9.8	***
10.8	***
11.8	***
12.9	***
14.2	***
15.5	***
17.0	***
18.6	***
20.4	***
22.3	***
24.5	***
26.8	***
29.4	***
32.2	***
35.2	***
38.6	***
42.3	5853
46.3	3389
50.7	2155
55.6	1458
60.9	1024
66.7	741
73.0	548
80.0	411
87.6	314

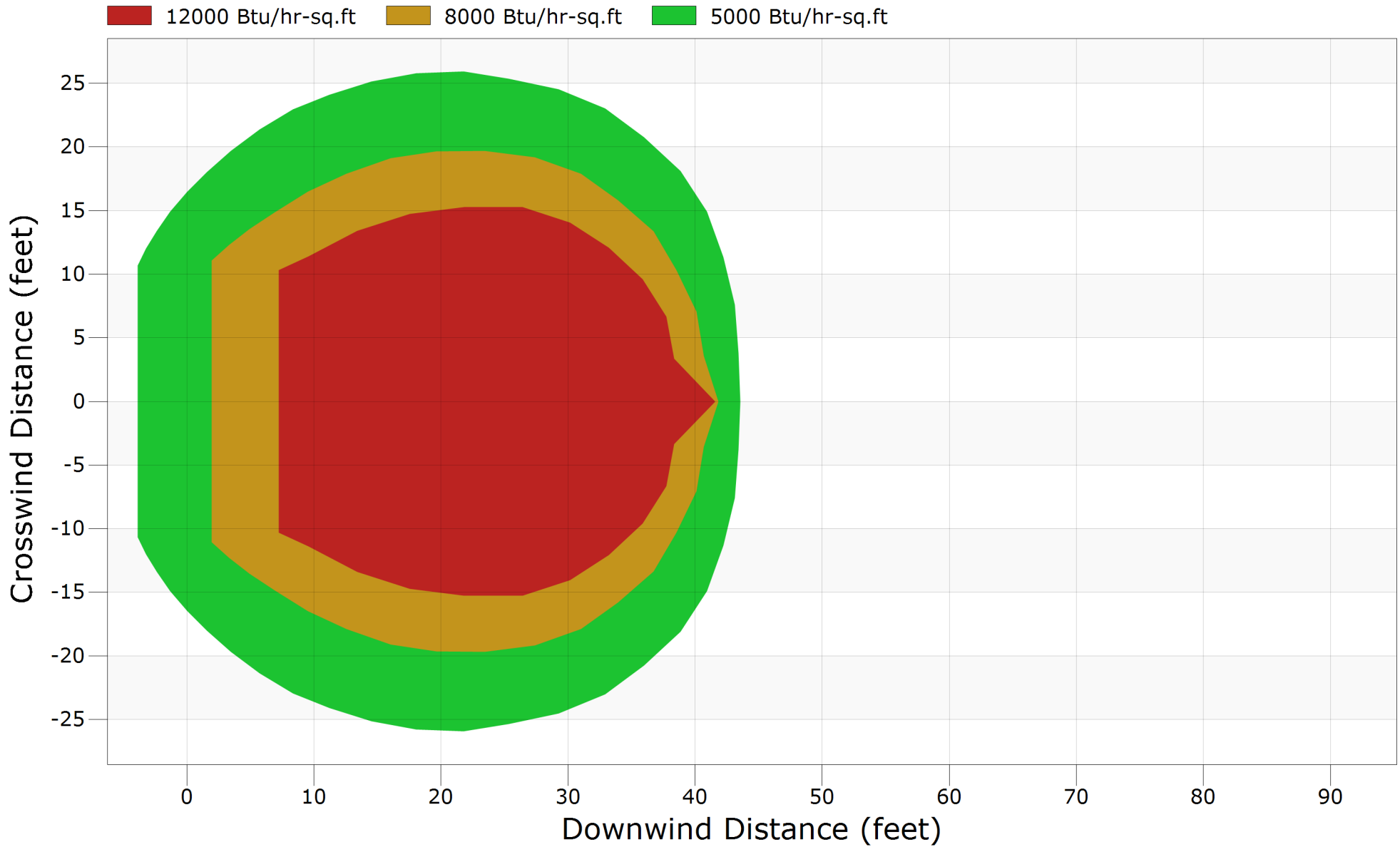
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
41.6	12000
41.8	8000
43.6	5000

Jet Fire Radiant Heat Contours - Overhead View

8in Rupture Segment 1 - 160 psi [8R1-160JF]



Note: Results presented for 6 feet above the release point during 20 mph winds.

```

+-----+
|               CANARY by Quest - Version 4.6.3               |
|               CANARY Case Input                             |
|               Case Name - 12L3-160                         |
|               Tue Jul 7 13:57:37 2020                      |
|               Quest Consultants Inc., Norman, Oklahoma, USA |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: 12in Leak Segment 3 - 160 psi

```

Case Type       : Vapor Dispersion
Case Name      : 12L3-160
User ID       :
Project Number :
Type of Units  : English Units

```

NOTES:

MATERIAL MENU

```

Materials Released : Number Formula Name Fraction
Component 1       : 51 = H2 Hydrogen(equilibrium) 1.000000
Component 2       :
Component 3       :
Component 4       :
Component 5       :
Component 6       :
Component 7       :
Component 8       :
Component 9       :
Component 10      :

```

```

Temperature      : 70.00 °F
Pressure         : 160.00 psia
The material is GAS

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           70.0 °F
Spill surface temperature 70.0 °F

```

```

Substrate name           Soil
Substrate thermal conductivity 1.0000 Btu/hr-ft-F
Substrate density        100 lb/cu.ft
Substrate heat Capacity  0.24 Btu/lb-F
Substrate delay time     60 sec
Surrounding terrain      Long grass or crops > 15 cm (6 in)

```

NOTES:

Case continued on page 2.

-----+-----
CANARY by Quest - Version 4.6.3
CANARY Case Input
Case Name - 12L3-160
Tue Jul 7 13:57:37 2020
-----+-----

Page 2 Title: 12in Leak Segment 3 - 160 psi

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 120 min
Normal flow rate 0.42 lb/sec
Duration of normal flow 5 min
Volume of vessel 0.00 cu.ft
Pipe inner diameter 12.00 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 18196.0 feet
Height of release point 0.0 feet
Angle of release from horizontal 10.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%

Dispersion coefficient averaging time 1 min

NOTES:

```

+-----+
|               CANARY by Quest - Version 4.6.3               |
|               General Release Model UPSTREAM                 |
|               Case Name - 12L3-160                          |
|               Tue Jul 7 13:57:37 2020                       |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: 12in Leak Segment 3 - 160 psi

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.5726018	0.000000	0.000000	.5726018
0.100000	.5725936	0.000000	0.000000	.5725936
0.300000	.5725688	0.000000	0.000000	.5725688
0.500000	.5725441	0.000000	0.000000	.5725441
0.700000	.5725194	0.000000	0.000000	.5725194
1.000000	.5724813	0.000000	0.000000	.5724813
3.000000	.5722398	0.000000	0.000000	.5722398
5.000000	.5715631	0.000000	0.000000	.5715631
7.000000	.5713528	0.000000	0.000000	.5713528
10.00000	.5710379	0.000000	0.000000	.5710379
20.00000	.5699928	0.000000	0.000000	.5699928
30.00000	.5689549	0.000000	0.000000	.5689549
40.00000	.5679241	0.000000	0.000000	.5679241
50.00000	.5669003	0.000000	0.000000	.5669003
60.00000	.5658819	0.000000	0.000000	.5658819
70.00000	.5648470	0.000000	0.000000	.5648470
85.00000	.5633083	0.000000	0.000000	.5633083
100.0000	.5617860	0.000000	0.000000	.5617860
200.0000	.5520324	0.000000	0.000000	.5520324
300.0000	.5428271	0.000000	0.000000	.5428271
400.0000	.5067715	0.000000	0.000000	.5067715
500.0000	.4727250	0.000000	0.000000	.4727250
600.0000	.4409514	0.000000	0.000000	.4409514
700.0000	.4112979	0.000000	0.000000	.4112979
850.0000	.3704862	0.000000	0.000000	.3704862
1000.000	.3336935	0.000000	0.000000	.3336935
2000.000	.1657333	0.000000	0.000000	.1657333
3000.000	.8053453E-01	0.000000	0.000000	.8053453E-01
4041.299	0.000000	0.000000	0.000000	0.000000

Totals (lb) 866.3778 0.000000 0.000000 866.3778

Flowrate for Torch Fire [immediate ignition] = 0.5689993 lb/sec.
Torch Fire [delayed ignition] = 0.5568301 lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                Jet Fire Radiation Model                        |
|                Case Name - 12L3-160JF                        |
|                Tue Jul 7 14:15:19 2020                       |
|                Quest Consultants Inc., Norman, Oklahoma, USA  |
|                www.questconsult.com    canary@questconsult.com |
|                telephone (405) 329-7475    fax (405) 329-7734 |
+-----+

```

Title: 12in Leak Segment 3 - 160 psi

```

Length of Flame      : 28.9 feet
Flame Tilt from Horizontal: 11.5 degrees
Release Angle       : 10.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	6129
7.1	7469
7.7	8953
8.3	9845
9.0	8968
9.8	6297
10.6	2171
11.5	3165
12.4	5497
13.4	14075
14.6	15581
15.8	***
17.1	***
18.5	***
20.0	***
21.7	***
23.5	***
25.5	***
27.6	***
29.9	***
32.3	***
35.0	953
37.9	648
41.1	449
44.5	319

*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
32.9	12000
33.6	8000
34.1	5000

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                              |
|                Case Name - 12R3-160                          |
|                Tue Jul 7 13:58:03 2020                       |
|                Quest Consultants Inc., Norman, Oklahoma, USA  |
|                www.questconsult.com    canary@questconsult.com |
|                telephone (405) 329-7475    fax (405) 329-7734 |
+-----+

```

Title: 12in Rupture Segment 3 - 160 psi

```

Case Type           : Vapor Dispersion
Case Name           : 12R3-160
User ID             :
Project Number      :
Type of Units       : English Units

```

NOTES:

MATERIAL MENU

Materials Released	: Number	Formula	Name	Fraction
Component 1	: 51	= H2	Hydrogen(equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

```

Temperature         : 70.00 °F
Pressure             : 160.00 psia
The material is GAS

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity     70 %
Air temperature       70.0 °F
Spill surface temperature 70.0 °F

```

```

Substrate name       Soil
Substrate thermal conductivity 1.0000 Btu/hr-ft-F
Substrate density    100 lb/cu.ft
Substrate heat Capacity 0.24 Btu/lb-F
Substrate delay time 60 sec
Surrounding terrain Long grass or crops > 15 cm (6 in)

```

NOTES:

Case continued on page 2.

-----+-----
CANARY by Quest - Version 4.6.3
CANARY Case Input
Case Name - 12R3-160
Tue Jul 7 13:58:03 2020
-----+-----

Page 2 Title: 12in Rupture Segment 3 - 160 psi

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 120 min
Normal flow rate 0.42 lb/sec
Duration of normal flow 5 min
Volume of vessel 0.00 cu.ft
Pipe inner diameter 12.00 inches
Equivalent release diameter 12.00 inches
Pipe length upstream of break 18196.0 feet
Pipe length downstream of break 0.0 feet
Height of release point 0.0 feet
Angle of release from horizontal 10.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%

Dispersion coefficient averaging time 1 min

NOTES:

```

+-----+
|          CANARY by Quest - Version 4.6.3          |
|          General Release Model UPSTREAM           |
|          Case Name - 12R3-160                   |
|          Tue Jul  7 13:58:03 2020               |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
|          www.questconsult.com   canary@questconsult.com |
|          telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: 12in Rupture Segment 3 - 160 psi

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	82.45465	0.000000	0.000000	82.45465
0.100000	51.75030	0.000000	0.000000	51.75030
0.300000	34.92923	0.000000	0.000000	34.92923
0.500000	28.11176	0.000000	0.000000	28.11176
0.700000	24.16772	0.000000	0.000000	24.16772
1.000000	20.48212	0.000000	0.000000	20.48212
3.000000	12.02891	0.000000	0.000000	12.02891
5.000000	9.072051	0.000000	0.000000	9.072051
7.000000	8.855784	0.000000	0.000000	8.855784
10.00000	8.541356	0.000000	0.000000	8.541356
20.00000	7.575262	0.000000	0.000000	7.575262
30.00000	6.723752	0.000000	0.000000	6.723752
40.00000	5.971670	0.000000	0.000000	5.971670
50.00000	5.307571	0.000000	0.000000	5.307571
60.00000	4.720435	0.000000	0.000000	4.720435
70.00000	4.191238	0.000000	0.000000	4.191238
85.00000	3.514002	0.000000	0.000000	3.514002
100.0000	2.954683	0.000000	0.000000	2.954683
200.0000	1.022378	0.000000	0.000000	1.022378
300.0000	.5081763	0.000000	0.000000	.5081763
344.7943	0.000000	0.000000	0.000000	0.000000
Totals (lb)	862.8361	0.000000	0.000000	862.8361

Flowrate for Torch Fire [immediate ignition] = 7.489854 lb/sec.
Torch Fire [delayed ignition] = 1.732843 lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|          CANARY by Quest - Version 4.6.3          |
|          Jet Fire Radiation Model                 |
|          Case Name - 12R3-160JF                 |
|          Tue Jul 7 14:15:53 2020                |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
|          www.questconsult.com                    |
|          canary@questconsult.com                 |
|          telephone (405) 329-7475                |
|          fax (405) 329-7734                      |
+-----+

```

Title: 12in Rupture Segment 3 - 160 psi

```

Length of Flame      : 65.9 feet
Flame Tilt from Horizontal: 16.2 degrees
Release Angle       : 10.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
16.4	***
18.0	***
19.7	***
21.5	***
23.6	***
25.8	***
28.2	***
30.9	***
33.8	***
37.0	***
40.5	***
44.4	***
48.6	***
53.2	***
58.2	***
63.7	19829
69.8	8977
76.4	4580
83.6	2660
91.5	1683
100.2	1126
109.7	785
120.1	562
131.5	412
143.9	307

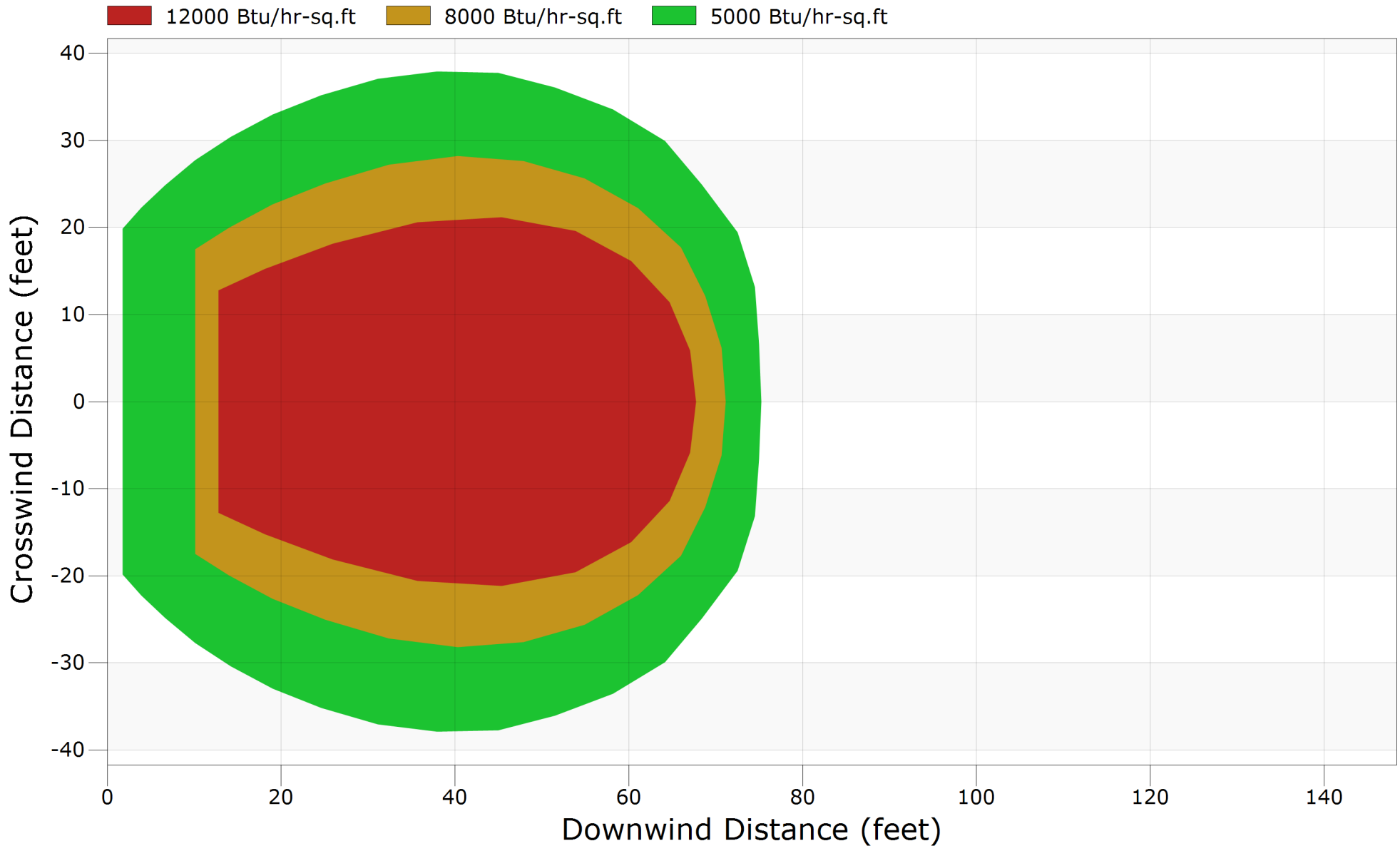
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
67.7	12000
71.1	8000
75.2	5000

Jet Fire Radiant Heat Contours - Overhead View

12in Rupture Segment 3 - 160 psi [12R3-160JF]



Note: Results presented for 6 feet above the release point during 20 mph winds.

AERMOD/MAP Receptor Listing

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                              |
|                Case Name - TruckGas-L                         |
|                Fri Jul 17 12:13:31 2020                      |
|                Quest Consultants Inc., Norman, Oklahoma, USA  |
|                www.questconsult.com   canary@questconsult.com |
|                telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: TruckGasH2Leak

Case Type : Vapor Dispersion
Case Name : TruckGas-L
User ID :
Project Number :
Type of Units : English Units

NOTES:

MATERIAL MENU

Materials Released	: Number	Formula	Name	Fraction
Component 1	: 51 =	H2	Hydrogen (equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

Temperature : 70.00 °F
Pressure : 7500.00 psia
The material is Indeterminate

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	70.0 °F
Spill surface temperature	70.0 °F
Substrate name	High density concrete
Substrate thermal conductivity	2.1999 Btu/hr-ft-F
Substrate density	150 lb/cu.ft
Substrate heat Capacity	0.16 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Long grass or crops > 15 cm (6 in)

NOTES:

Case continued on page 2.

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                              |
|                Case Name - TruckGas-L                         |
|                Fri Jul 17 12:13:31 2020                      |
+-----+

```

Page 2 Title: TruckGasH2Leak

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 60 min
Normal flow rate 0.00 lb/sec
Duration of normal flow 0 min
Volume of vessel 100.00 cu.ft
Percent of vessel filled with liquid 0 %
Liquid head above release point 0 feet
Pipe inner diameter 1.05 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 0.0 feet
Height of release point 3.0 feet
Angle of release from horizontal 0.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

CalPortland AB2588

AERMOD/MAP Receptor Listing

NOTES:

VDVE MENU

Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%
Dispersion coefficient averaging time 1 min

NOTES:

AERMOD/MAP Receptor Listing

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                General Release Model UPSTREAM                  |
|                Case Name - TruckGas-L                         |
|                Fri Jul 17 12:13:31 2020                       |
|                Quest Consultants Inc., Norman, Oklahoma, USA   |
|                www.questconsult.com   canary@questconsult.com |
|                telephone (405) 329-7475   fax (405) 329-7734  |
+-----+

```

TITLE: TruckGasH2Leak

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	23.37000	0.000000	0.000000	23.37000
0.100000	23.37000	0.000000	0.000000	23.37000
0.300000	23.37000	0.000000	0.000000	23.37000
0.500000	23.37000	0.000000	0.000000	23.37000
0.700000	23.37000	0.000000	0.000000	23.37000
1.000000	23.37000	0.000000	0.000000	23.37000
3.000000	23.37000	0.000000	0.000000	23.37000
5.000000	23.37000	0.000000	0.000000	23.37000
7.000000	7.334921	0.000000	0.000000	7.334921
10.00000	5.284562	0.000000	0.000000	5.284562
20.00000	1.812992	0.000000	0.000000	1.812992
30.00000	.6266470	0.000000	0.000000	.6266470
40.00000	.2153831	0.000000	0.000000	.2153831
50.00000	.6554239E-01	0.000000	0.000000	.6554239E-01
55.21591	0.000000	0.000000	0.000000	0.000000
Totals (lb)	201.4908	0.000000	0.000000	201.4908

Flowrate for Torch Fire [immediate ignition] = 3.358180 lb/sec.
 Torch Fire [delayed ignition] = 0.000000 lb/sec.

Reason for Ending: Pressure Near Atmospheric

AERMOD/MAP Receptor Listing

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                Jet Fire Radiation Model                       |
|                Case Name - TruckGas-LJF                      |
|                Fri Jul 17 12:14:30 2020                      |
|                Quest Consultants Inc., Norman, Oklahoma, USA  |
|                www.questconsult.com    canary@questconsult.com |
|                telephone (405) 329-7475    fax (405) 329-7734 |
+-----+

```

Title: TruckGasH2JetFireLeak

```

Length of Flame      : 53.9 feet
Flame Tilt from Horizontal: 0.7 degrees
Release Angle       : 0.0 degrees
Release Point Elevation : 3.0 feet
Target Elevation    : 0.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
13.1	***
14.2	***
15.5	***
16.8	***
18.2	***
19.8	***
21.5	***
23.3	***
25.3	***
27.5	***
29.9	***
32.4	***
35.2	***
38.3	***
41.5	***
45.1	***
49.0	***
53.2	***
57.7	***
62.7	2075
68.1	1326
73.9	884
80.2	609
87.1	431
94.6	312

*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
60.3	12000
61.1	8000
61.7	5000

AERMOD/MAP Receptor Listing

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                              |
|                Case Name - TruckGas-R                        |
|                Fri Jul 17 12:25:33 2020                     |
|                Quest Consultants Inc., Norman, Oklahoma, USA  |
|                www.questconsult.com    canary@questconsult.com |
|                telephone (405) 329-7475    fax (405) 329-7734 |
+-----+

```

Title: TruckGasH2

Case Type : Vapor Dispersion
Case Name : TruckGas-R
User ID :
Project Number :
Type of Units : English Units

NOTES:

MATERIAL MENU

Materials Released	: Number	Formula	Name	Fraction
Component 1	: 51 =	H2	Hydrogen (equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

Temperature : 70.00 °F
Pressure : 7500.00 psia
The material is Indeterminate

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	70.0 °F
Spill surface temperature	70.0 °F
Substrate name	High density concrete
Substrate thermal conductivity	2.1999 Btu/hr-ft-F
Substrate density	150 lb/cu.ft
Substrate heat Capacity	0.16 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Long grass or crops > 15 cm (6 in)

NOTES:

Case continued on page 2.

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                              |
|                Case Name - TruckGas-R                        |
|                Fri Jul 17 12:25:33 2020                     |
+-----+

```

Page 2 Title: TruckGasH2

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 60 min
Normal flow rate 0.00 lb/sec
Duration of normal flow 0 min
Volume of vessel 100.00 cu.ft
Percent of vessel filled with liquid 0 %
Liquid head above release point 0 feet
Pipe inner diameter 3.07 inches
Equivalent release diameter 3.00 inches
Pipe length upstream of break 0.0 feet
Height of release point 3.0 feet
Angle of release from horizontal 0.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

CalPortland AB2588

AERMOD/MAP Receptor Listing

NOTES:

VDVE MENU

Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%
Dispersion coefficient averaging time 1 min

NOTES:

AERMOD/MAP Receptor Listing

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                General Release Model UPSTREAM                  |
|                Case Name - TruckGas-R                          |
|                Fri Jul 17 12:25:33 2020                       |
|                Quest Consultants Inc., Norman, Oklahoma, USA   |
|                www.questconsult.com    canary@questconsult.com |
|                telephone (405) 329-7475    fax (405) 329-7734 |
+-----+
  
```

TITLE: TruckGasH2

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	210.3300	0.000000	0.000000	210.3300
5.080000	0.000000	0.000000	0.000000	0.000000
Totals (lb)	1060.063	0.000000	0.000000	1060.063
Flowrate for Torch Fire [immediate ignition] =				17.66772 lb/sec.
Torch Fire [delayed ignition] =				0.000000 lb/sec.

Reason for Ending: Pressure Near Atmospheric

AERMOD/MAP Receptor Listing

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                              |
|                Case Name - TruckGas-RExp1                    |
|                Fri Jul 17 12:34:22 2020                      |
|                Quest Consultants Inc., Norman, Oklahoma, USA  |
|                www.questconsult.com    canary@questconsult.com |
|                telephone (405) 329-7475    fax (405) 329-7734 |
+-----+

```

Title: TruckGasH2

```

Case Type      : Explosion
Case Name     : TruckGas-RExp1
User ID      :
Project Number :
Type of Units : English Units

```

NOTES:

MATERIAL MENU

Materials Released	: Number	Formula	Name	Fraction
Component 1	:	51 = H2	Hydrogen (equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

```

Temperature : 70.00 °F
Pressure     : 14.70 psia
The material is GAS

```

NOTES:

EXPLOSION TYPE MENU

```

Baker-Strehlow-Tang
  Total Mass Released          266.0 lb

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity           High
Obstacle density         Low
Flame expansion          2.5-D

```

Overpressure values

```

Overpressure endpoint 1    5.00 psi
Overpressure endpoint 2    3.00 psi
Overpressure endpoint 3    1.00 psi

```

NOTES:

AERMOD/MAP Receptor Listing

```

+-----+
|           CANARY by Quest - Version 4.6.3           |
| Baker-Strehlow-Tang Vapor Cloud Explosion          |
| Case Name - TruckGas-RExp1                        |
| Fri Jul 17 12:34:22 2020                          |
| Quest Consultants Inc., Norman, Oklahoma, USA      |
| www.questconsult.com   canary@questconsult.com    |
| telephone (405) 329-7475   fax (405) 329-7734     |
+-----+

```

Title: TruckGasH2

Fuel Reactivity: High Obstacle Density: Low
 Flame Expansion: 2.5-D Flame Speed: 0.47

Mass of released material involved in explosion: 266.001 lbs.

Distance from Center of Congested Volume (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	5.30	0.4385
17.1	5.30	0.4385
19.6	5.30	0.4385
22.4	5.30	0.4385
25.7	5.30	0.3978
29.4	5.30	0.3487
33.6	5.30	0.3056
38.4	5.30	0.2678
44.0	5.30	0.2347
50.3	5.30	0.2057
57.5	5.30	0.1803
65.8	5.11	0.1580
75.3	4.57	0.1385
86.2	4.09	0.1214
98.6	3.66	0.1064
112.8	3.27	0.0932
129.1	2.92	0.0817
147.7	2.62	0.0716
168.9	2.34	0.0628
193.3	2.03	0.0550
221.1	1.76	0.0482
253.0	1.53	0.0423
289.4	1.32	0.0370
331.1	1.14	0.0325
433.4	0.86	0.0249

The downwind distance to 5.00 psi is 67.7 feet
 The downwind distance to 3.00 psi is 125.5 feet
 The downwind distance to 1.00 psi is 382.6 feet

```

+-----+
|              CANARY by Quest - Version 4.6.3              |
|              CANARY Case Input                            |
|              Case Name - TruckGas-RJF                    |
|              Fri Jul 31 11:38:24 2020                    |
|              Quest Consultants Inc., Norman, Oklahoma, USA |
|              www.questconsult.com   canary@questconsult.com |
|              telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: TruckGasH2JetFire

```

Case Type           : Fire Radiation
Case Name           : TruckGas-RJF
User ID             :
Project Number      :
Type of Units       : English Units

```

NOTES:

MATERIAL MENU

Materials Released	: Number	Formula	Name	Fraction
Component 1	:	51 = H2	Hydrogen (equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

```

Temperature         :      70.00 °F
Pressure             :      7500.00 psia
The material is Indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      70.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      3.0 feet
Elevation of target (from grade)          0.0 feet
Diameter of jet fire tip                   0.2500 feet
Flow rate                                  17.66 lb/sec
Angle of release from horizontal           0.0 degrees

```

Fire radiation flux values

```

Radiation endpoint 1      12000 Btu/hr-sq.ft
Radiation endpoint 2      8000 Btu/hr-sq.ft
Radiation endpoint 3      5000 Btu/hr-sq.ft

```

NOTES:

AERMOD/MAP Receptor Listing

```

+-----+
|           CANARY by Quest - Version 4.6.3           |
|           Jet Fire Radiation Model                 |
|           Case Name - TruckGas-RJF                |
|           Fri Jul 31 11:38:24 2020                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com                     |
|           telephone (405) 329-7475                 |
|           fax (405) 329-7734                       |
+-----+

```

Title: TruckGasH2JetFire

```

Length of Flame      : 108.8 feet
Flame Tilt from Horizontal: 1.2 degrees
Release Angle       : 0.0 degrees
Release Point Elevation : 3.0 feet
Target Elevation    : 0.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
16.4	***
18.2	***
20.2	***
22.4	***
24.9	***
27.7	***
30.7	***
34.1	***
37.8	***
42.0	***
46.6	***
51.7	***
57.4	***
63.8	***
70.8	***
78.6	***
87.2	***
96.8	***
107.5	***
119.3	***
132.4	1942
147.0	1154
163.2	720
181.1	466
201.1	313

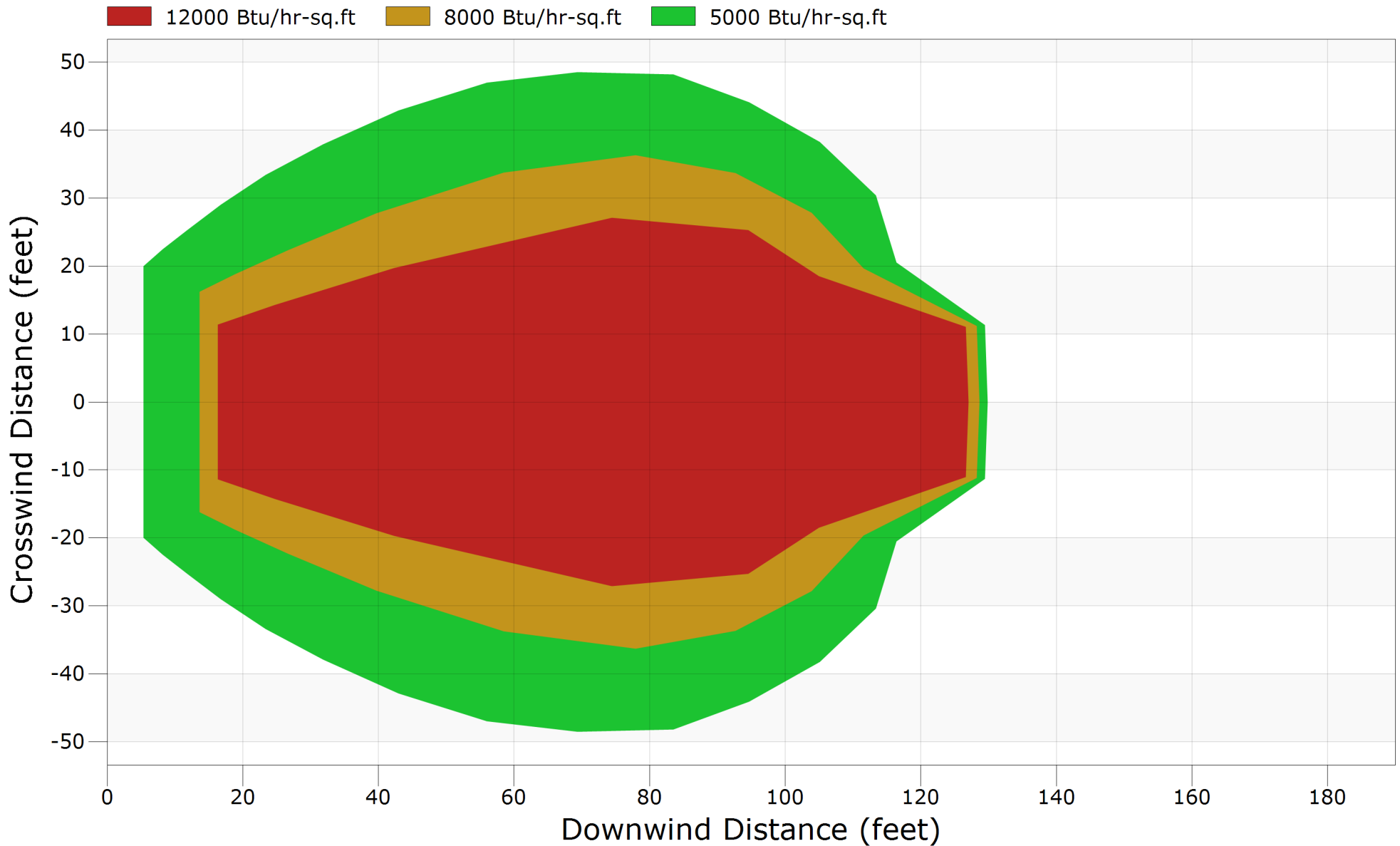
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
127.0	12000
128.7	8000
129.9	5000

Jet Fire Radiant Heat Contours - Overhead View

TruckGasH2JetFire [TruckGas-RJF]



Note: Results presented for 3 feet below the release point during 20 mph winds.

AERMOD/MAP Receptor Listing

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                              |
|                Case Name - Truck-L                            |
|                Wed Jul  8 18:44:44 2020                       |
|                Quest Consultants Inc., Norman, Oklahoma, USA   |
|                www.questconsult.com   canary@questconsult.com  |
|                telephone (405) 329-7475   fax (405) 329-7734  |
+-----+

```

Title: Truck Releases Leak

Case Type : Vapor Dispersion
Case Name : Truck-L
User ID :
Project Number :
Type of Units : English Units

NOTES:

MATERIAL MENU

Materials Released	: Number	Formula	Name	Fraction
Component 1	: 51 =	H2	Hydrogen (equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

Temperature : -424.00 °F
Pressure : 30.00 psia
The material is LIQUID

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	70.0 °F
Spill surface temperature	70.0 °F
Substrate name	High density concrete
Substrate thermal conductivity	2.1999 Btu/hr-ft-F
Substrate density	150 lb/cu.ft
Substrate heat Capacity	0.16 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Long grass or crops > 15 cm (6 in)

NOTES:

Case continued on page 2.

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                              |
|                Case Name - Truck-L                            |
|                Wed Jul  8 18:44:44 2020                       |
+-----+

```

Page 2 Title: Truck Releases Leak

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 60 min
Normal flow rate 0.00 lb/sec
Duration of normal flow 10 min
Volume of vessel 1370.00 cu.ft
Percent of vessel filled with liquid 100 %
Liquid head above release point 6 feet
Pipe inner diameter 1.05 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 0.0 feet
Height of release point 3.0 feet
Angle of release from horizontal 0.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

CalPortland AB2588

AERMOD/MAP Receptor Listing

NOTES:

VDVE MENU

Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%
Dispersion coefficient averaging time 1 min

NOTES:

AERMOD/MAP Receptor Listing

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                General Release Model UPSTREAM                 |
|                Case Name - Truck-L                          |
|                Wed Jul  8 18:44:44 2020                     |
|                Quest Consultants Inc., Norman, Oklahoma, USA |
|                www.questconsult.com   canary@questconsult.com |
|                telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: Truck Releases Leak

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	0.000000	2.751698	0.000000	2.751698
0.100000	0.000000	2.751334	0.000000	2.751334
0.300000	0.000000	2.750605	0.000000	2.750605
0.500000	0.000000	2.749877	0.000000	2.749877
0.700000	0.000000	2.749148	0.000000	2.749148
1.000000	0.000000	2.748055	0.000000	2.748055
3.000000	0.000000	2.740770	0.000000	2.740770
5.000000	0.000000	2.733485	0.000000	2.733485
7.000000	.4348865E-01	.9111618	.1672449	1.121895
10.000000	.6523048E-01	0.000000	.2508550	.3160855
20.000000	.6521801E-01	0.000000	.2507933	.3160113
30.000000	.6520554E-01	0.000000	.2507316	.3159371
40.000000	.6519306E-01	0.000000	.2506698	.3158629
50.000000	.6518059E-01	0.000000	.2506081	.3157887
60.000000	.6516812E-01	0.000000	.2505463	.3157144
70.000000	.6515565E-01	0.000000	.2504846	.3156402
85.000000	.6513695E-01	0.000000	.2503920	.3155289
100.000000	.6511825E-01	0.000000	.2502993	.3154176
200.000000	.6499362E-01	0.000000	.2496818	.3146754
300.000000	.6486905E-01	0.000000	.2490642	.3139333
400.000000	.6474456E-01	0.000000	.2484466	.3131912
500.000000	.6462012E-01	0.000000	.2478289	.3124490
600.000000	.6449327E-01	0.000000	.2471988	.3116920
700.000000	.6437182E-01	0.000000	.2465951	.3109669
850.000000	.6419003E-01	0.000000	.2456907	.3098808
1000.000000	.6400837E-01	0.000000	.2447862	.3087946
2000.000000	.6280062E-01	0.000000	.2387516	.3015523
3000.000000	.6159837E-01	0.000000	.2327093	.2943077
3600.000000	.6087087E-01	0.000000	.2290372	.2899080
Totals (lb)	226.5437	17.81319	862.2408	1106.598

Flowrate for Torch Fire [immediate ignition] = 0.3550244 lb/sec.
 Torch Fire [delayed ignition] = 0.6505593E-01 lb/sec.

Reason for Ending: Reached Stop Time

AERMOD/MAP Receptor Listing

```

+-----+
|           CANARY by Quest - Version 4.6.3           |
|           Jet Fire Radiation Model                 |
|           Case Name - Truck-LJF                   |
|           Fri Jul 17 22:20:22 2020                 |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: Truck Leak

```

Length of Flame      : 23.8 feet
Flame Tilt from Horizontal: 9.5 degrees
Release Angle       : 0.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 3.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	17721
7.1	17721
7.6	190
8.2	118
8.8	***
9.4	***
10.2	***
10.9	***
11.8	***
12.7	***
13.6	***
14.6	***
15.7	***
16.9	***
18.2	***
19.6	***
21.1	***
22.7	***
24.4	***
26.2	***
28.2	1246
30.4	837
32.7	579
35.1	413
37.8	302

*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
26.9	12000
27.3	8000
27.7	5000

AERMOD/MAP Receptor Listing

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                              |
|                Case Name - Truck-R                            |
|                Wed Jul  8 18:46:02 2020                       |
|                Quest Consultants Inc., Norman, Oklahoma, USA   |
|                www.questconsult.com   canary@questconsult.com |
|                telephone (405) 329-7475   fax (405) 329-7734  |
+-----+

```

Title: Truck

Case Type : Vapor Dispersion
Case Name : Truck-R
User ID :
Project Number :
Type of Units : English Units

NOTES:

MATERIAL MENU

Materials Released	: Number	Formula	Name	Fraction
Component 1	: 51 =	H2	Hydrogen (equilibrium)	1.000000
Component 2	:			
Component 3	:			
Component 4	:			
Component 5	:			
Component 6	:			
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

Temperature : -424.00 °F
Pressure : 30.00 psia
The material is LIQUID

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	70.0 °F
Spill surface temperature	70.0 °F
Substrate name	High density concrete
Substrate thermal conductivity	2.1999 Btu/hr-ft-F
Substrate density	150 lb/cu.ft
Substrate heat Capacity	0.16 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Long grass or crops > 15 cm (6 in)

NOTES:

Case continued on page 2.

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                CANARY Case Input                              |
|                Case Name - Truck-R                            |
|                Wed Jul  8 18:46:02 2020                       |
+-----+

```

Page 2 Title: Truck

RELEASE MENU

Type of release: Unregulated, Continuous release
Release duration 60 min
Normal flow rate 0.00 lb/sec
Duration of normal flow 10 min
Volume of vessel 1370.00 cu.ft
Percent of vessel filled with liquid 100 %
Liquid head above release point 6 feet
Pipe inner diameter 6.07 inches
Equivalent release diameter 6.00 inches
Pipe length upstream of break 0.0 feet
Height of release point 3.0 feet
Angle of release from horizontal 0.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

CalPortland AB2588

AERMOD/MAP Receptor Listing

NOTES:

VDVE MENU

Vapor generation and dispersion - Flammable calculation
Concentration endpoint 1 LFL mol%
Concentration endpoint 2 LFL mol%
Concentration endpoint 3 LFL mol%
Dispersion coefficient averaging time 1 min

NOTES:

AERMOD/MAP Receptor Listing

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                General Release Model UPSTREAM                |
|                Case Name - Truck-R                          |
|                Wed Jul  8 18:46:02 2020                     |
|                Quest Consultants Inc., Norman, Oklahoma, USA |
|                www.questconsult.com   canary@questconsult.com |
|                telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: Truck

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.2240456E-03	99.05997	.9370019E-03	99.06113
0.100000	.2247476E-03	99.04685	.9399375E-03	99.04801
0.300000	.2261514E-03	99.02062	.9458087E-03	99.02179
0.500000	.2275553E-03	98.99438	.9516799E-03	98.99556
0.700000	.2289591E-03	98.96815	.9575510E-03	98.96933
1.000000	.2310649E-03	98.92880	.9663578E-03	98.93000
3.000000	.2451035E-03	98.66646	.1025070E-02	98.66773
5.000000	.2591420E-03	98.40413	.1083782E-02	98.40547
7.000000	1.568352	32.80138	5.744003	40.11373
10.00000	2.349245	0.000000	8.599356	10.94860
20.00000	2.333470	0.000000	8.518825	10.85229
30.00000	2.317691	0.000000	8.438297	10.75599
40.00000	2.301904	0.000000	8.357775	10.65968
50.00000	2.286107	0.000000	8.277263	10.56337
60.00000	2.270294	0.000000	8.196765	10.46706
70.00000	2.254463	0.000000	8.116284	10.37075
85.00000	2.230679	0.000000	7.995598	10.22628
100.0000	2.206832	0.000000	7.874972	10.08180
200.0000	2.045305	0.000000	7.073265	9.118570
300.0000	1.876263	0.000000	6.278910	8.155173
400.0000	1.695985	0.000000	5.495589	7.191574
500.0000	1.502205	0.000000	4.725507	6.227712
600.0000	1.290276	0.000000	3.953935	5.244211
700.0000	1.074661	0.000000	3.225935	4.300596
850.0000	.7254165	0.000000	2.153874	2.879290
1000.000	.3616432	0.000000	1.073775	1.435418
1080.355	0.000000	0.000000	0.000000	0.000000
Totals (lb)	1456.020	641.2664	4783.896	6881.183
Flowrate for Torch Fire [immediate ignition]	=	12.74978		lb/sec.
Torch Fire [delayed ignition]	=	2.126659		lb/sec.

Reason for Ending: Pressure Near Atmospheric

AERMOD/MAP Receptor Listing

```

+-----+
|                CANARY by Quest - Version 4.6.3                |
|                Jet Fire Radiation Model                        |
|                Case Name - Truck-RJF                         |
|                Wed Jul  8 18:56:48 2020                       |
|                Quest Consultants Inc., Norman, Oklahoma, USA  |
|                www.questconsult.com   canary@questconsult.com |
|                telephone (405) 329-7475   fax (405) 329-7734  |
+-----+

```

Title: Truck

```

Length of Flame      : 73.4 feet
Flame Tilt from Horizontal: 10.7 degrees
Release Angle       : 0.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
16.4	***
18.0	***
19.9	***
21.8	***
24.0	***
26.4	***
29.1	***
32.0	***
35.2	***
38.7	***
42.6	***
46.8	***
51.5	***
56.7	***
62.3	***
68.6	***
75.4	***
83.0	6490
91.3	3445
100.4	2057
110.4	1312
121.5	876
133.6	605
147.0	429
161.7	311

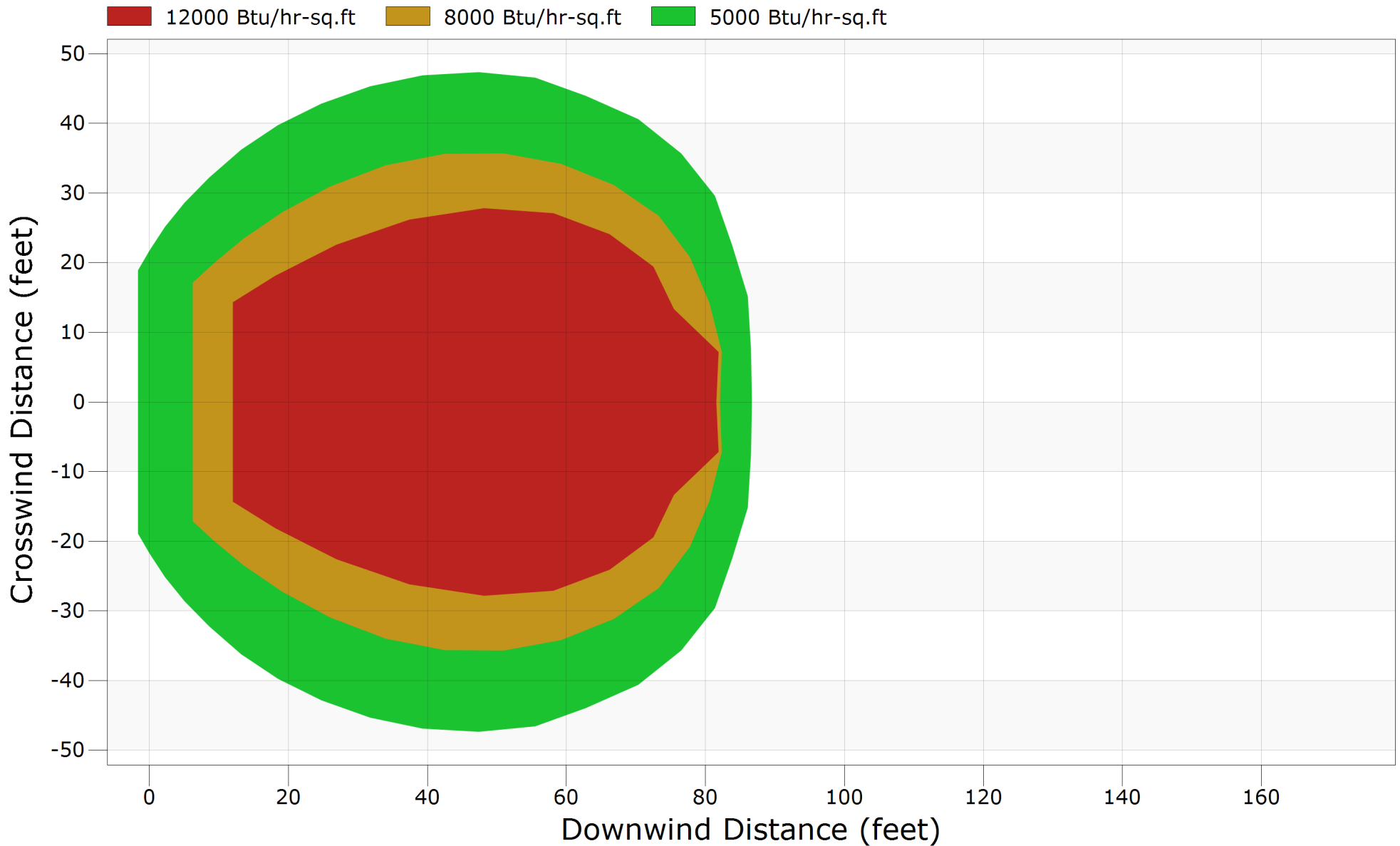
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
81.6	12000
82.1	8000
86.7	5000

Jet Fire Radiant Heat Contours - Overhead View

Truck [Truck-RJF]



Note: Results presented for 6 feet above the release point during 20 mph winds.

Air Products

**Carson to Paramount Hydrogen Pipeline
Project**

Pipeline Safety Technical Report

**Prepared for
Padre Associates, Inc.**

EDM Services, Inc.

4100 Guardian Street, Suite 250
Simi Valley, California 93063
Web Site Address: edmsvc.com
Phone: (805) 527-3300
FAX: (805) 583-1607
EDM Services Job Number 17-161-2134



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PIPELINE SAFETY AND RISK OF UPSET

Introduction, General Approach and Findings

The purpose of this report is to present the results of a risk assessment that has been performed to estimate the risks posed to the public from the proposed Air Products, Carson to Paramount Hydrogen Pipeline Project. A complete risk assessment has been performed at an operating pressure of 260 psig; the risk results are below the acceptable thresholds adopted by the California Department of Education and Santa Barbara County. Further, Air Products plans to operate the pipeline at 160 psig; this will further reduce the project individual and societal risks. (The societal risk results for the reduced operating pressure of 160 psig are included in the summary table on page 8 and Appendix D.6.)

The general approach used to conduct this risk assessment is summarized below:

1. Environmental and Regulatory Setting - Information was gathered regarding the existing and proposed pipe segments that will comprise the completed pipeline.
2. Baseline Data - Historical unintentional release data was obtained from the United States Department of Transportation (USDOT) for gas transmission pipelines. This included the USDOT database of all reported gas transmission and gathering line incidents that have occurred since January 1, 2010. This data is presented in Section 5.0, Baseline Data, of this report. This data was analyzed to develop the following estimates:
 - Frequency of reportable unintentional releases,
 - Frequency of public injuries and fatalities,
 - Causes of the unintentional releases, and the
 - Likelihood of fires or explosions following an unintentional release.
3. Qualitative Aggregate Risk Assessment - Using the above historical unintentional release data, high level estimates of the likelihood of various size releases, fires, and public fatalities resulting from unintentional releases from the proposed hydrogen pipeline were developed. This analysis is included in Section 6.0, Qualitative Aggregate Risk Assessment, of this Report. It should be noted however that the majority of the pipelines included in the USDOT database transport natural gas, not hydrogen. This data should be used for reference only, as the characteristics of hydrogen are much different than natural gas (e.g., methane).
4. Release Modeling - Using a pipeline operating parameter of 260 psig¹, release modeling was performed to evaluate the range of potential impacts to the public from fires, explosions and flash fires. The results of this release modeling are presented in Section 7.0, Release Modeling Results, of this Report.

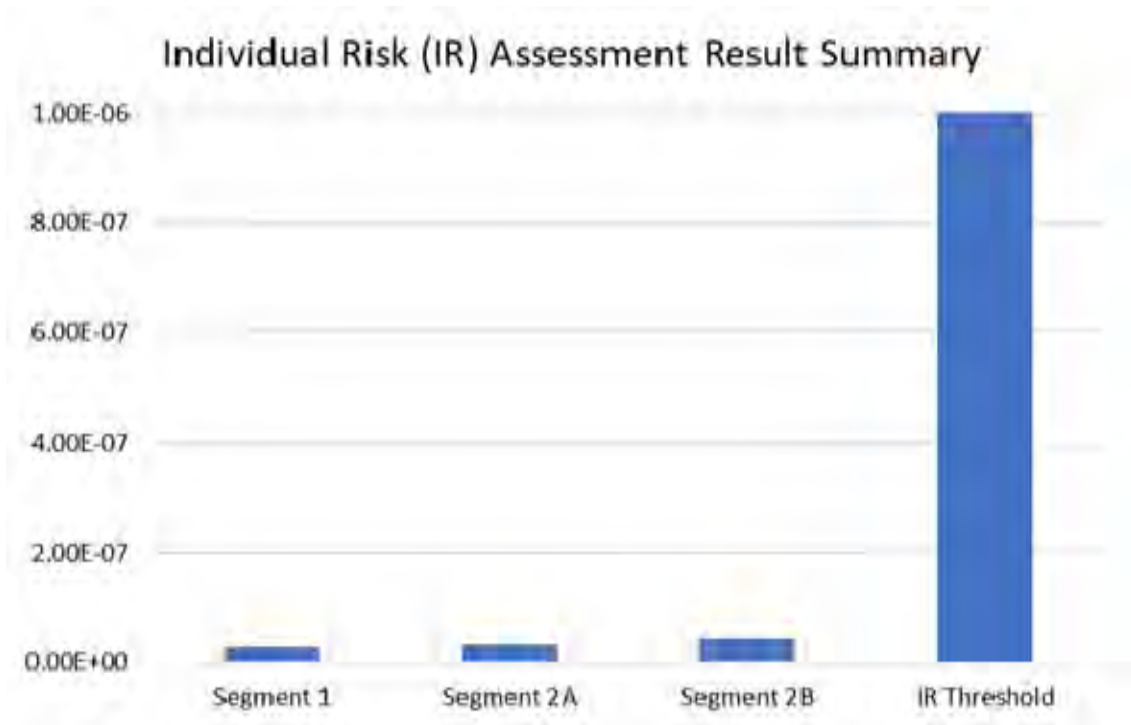
¹ The release modeling performed for this report, including appendices A, B, and C (pipeline risks near existing schools) assumed a pipeline operating pressure of 260 psig. In appendix D, a societal risk assessment is presented; societal risk results are presented for two operating pressures – 260 psig and 160 psig.



5. Conditional Probabilities - Using the above data, the conditional probabilities for each of the following items were estimated. The development of these estimates is presented in Section 8.0, Conditional Probabilities, of this Report.
- Percentage of the time that the proposed pipeline(s) would be operational;
 - Probability of various size unintentional releases;
 - Probability of various release angles;
 - Probability of wind direction;
 - Probability of fires or explosions following an unintentional release;
 - Probability of fatal injuries following a fire or explosion.
6. Individual Risk Assessment - An individual risk assessment was conducted for three separate pipeline segments using an operating pressure of 260 psig. This assessment estimates the likelihood of a public fatality to an individual. The likelihood of fatality versus the distance from the pipeline is presented. The results of this analysis are summarized below. As indicated, the maximum individual risk occurs on Segment 2B, which has the largest pipe diameter; the individual risk for this segment is 4.3% of the individual risk threshold adopted by the California Department of Education and Santa Barbara County.

Individual Risk Results Summary

Pipeline Segment	Individual Risk Probability of Fatality	Ratio of Individual Risk To Risk Threshold
Segment 1 Carson Plant to Dominguez Pump Station ASV	2.86×10^{-8} 1 in 35.0 million	0.029 2.9%
Segment 2A Dominguez Pump Station ASV to South Street Block Valve	3.37×10^{-8} 1 in 19.7 million	0.034 3.4%
Segment 2B South Street Block Valve to Paramount Refinery	4.29×10^{-8} 1 in 23.3 million	0.043 4.3%
Individual Risk Threshold	1.00×10^{-6} 1 in 1.0 million	N/A



- Pipeline Risks Near Schools - Sixteen (16) schools are within one-quarter mile of the proposed pipeline alignment. Individual risk assessments have been performed for the schools nearest the pipeline along two of the pipeline segments using an operating pressure of 260 psig. These results are summarized below. Both segments are within the acceptable risk threshold adopted by the California Department of Education and Santa Barbara County.

School Site Individual Risk Results Summary

School	Individual Risk Probability of Fatality	Ratio of Individual Risk To Risk Threshold
Dooley Elementary	1.23x10 ⁻⁸ 1 in 81.1 million	0.012 1.2%
Alondra Middle School	1.27x10 ⁻⁸ 1 in 78.5 million	0.013 1.3%
Individual Risk Threshold	1.00x10 ⁻⁶ 1 in 1.0 million	N/A

- Societal Risk Assessment - Societal risk is the probability that a specified number of people will be affected by a given event.

Since the individual risk posed by the proposed project is below the acceptable risk threshold, a societal risk assessment would not be required by either Santa Barbara County or the California



Department of Education. However, as requested by the Agency’s consultant, a societal risk assessment has been conducted.

Two separate societal risk analyses were performed. The first was performed using a 260 psig maximum operating pressure; this is the same pressure used for the individual risk assessments presented in this report. A second societal risk assessment was conducted at a 160 psig maximum operation pressure. The results for both the 260 psig and the 160 psig scenarios indicate that the societal risks are below the de minimis societal risk threshold established by Santa Barbara County.

The results of the societal risk assessments are summarized in the table below for the entire pipeline.

Societal Risk Results Summary

Operating Pressure	Societal Risk Probability of Single Fatality	Ratio of Societal Risk To Risk Threshold
260 psig	6.36x10 ⁻⁶ 1 in 157,000	0.636 (63.6%)
160 psig	6.98x10 ⁻⁶ 1 in 143,000	0.698 (69.8%)
Societal Risk Threshold for Single Fatality	1.00x10 ⁻⁵ 1 in 100,000	N/A

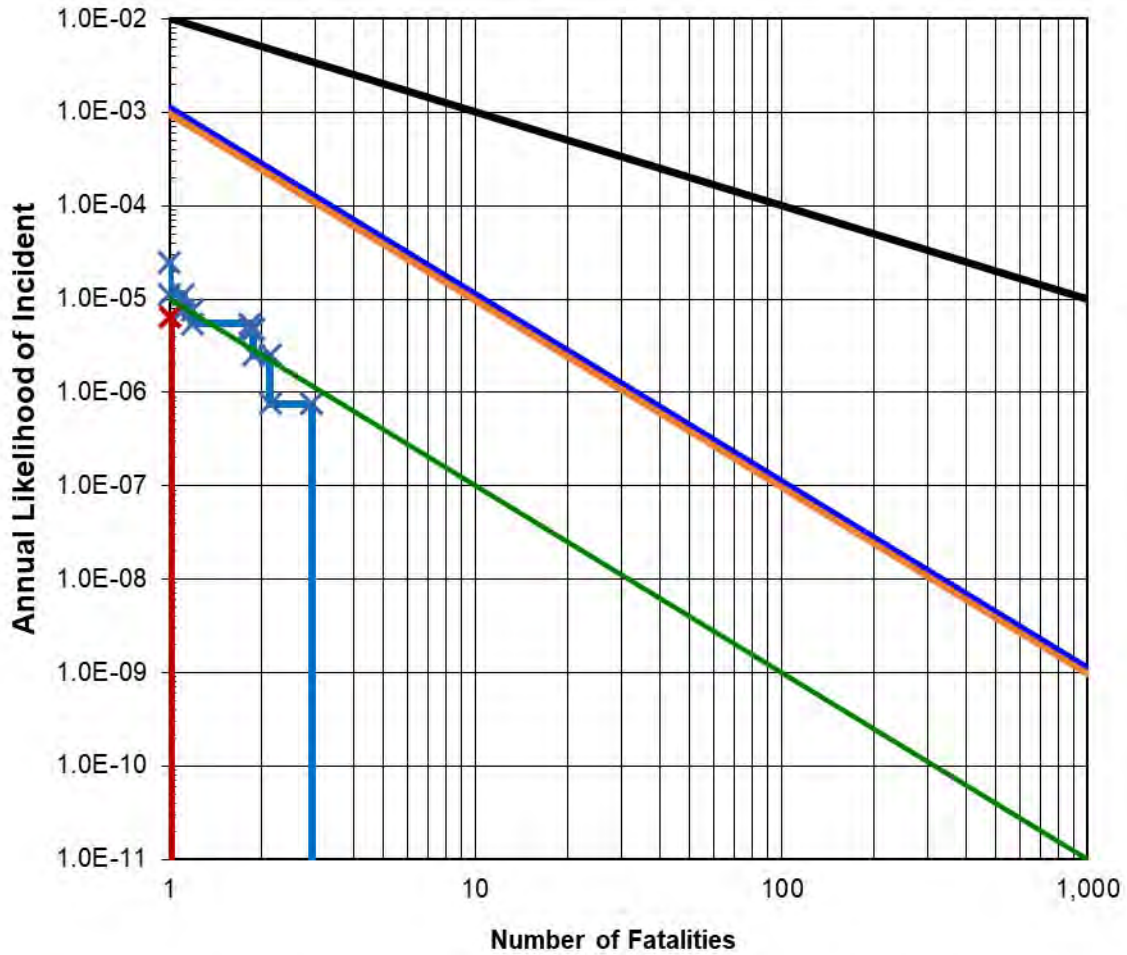
The societal risks for both 260 psig and 160 psig operating pressures are below the Santa Barbara County negligible risk threshold.

As an additional mitigation, Air Products plans to operate the pipeline at a maximum operating pressure of 160 psig. This pressure reduction reduces the societal risk if human reaction is not considered as shown in the following two figures. (The societal risk analyses assumed an 80% human response factor²).

² The “Green Book” (Mannan) indicates that 95% of the population is capable of a reaction, or which 80% is capable of a response within 15 seconds.



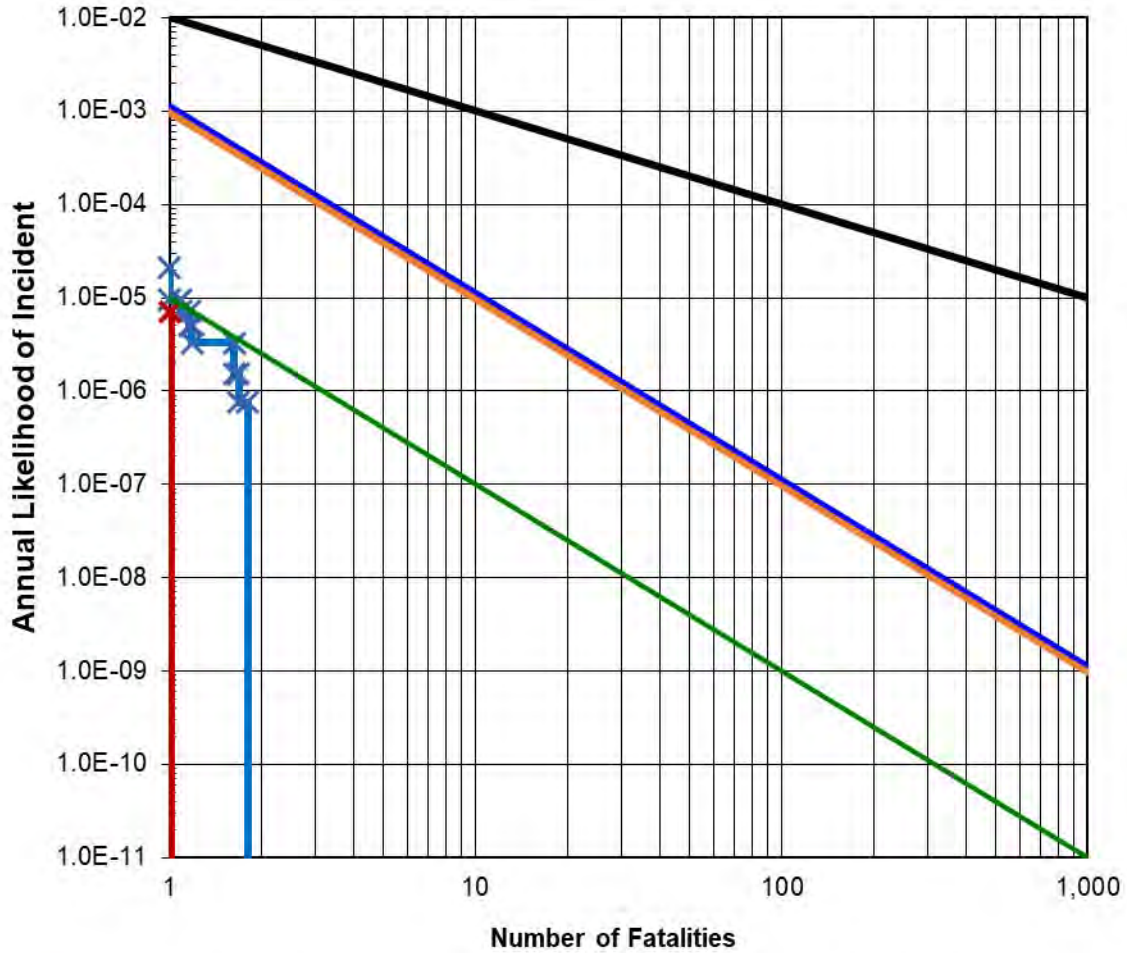
Project Societal Risk Results - 260 psig



- x— Project Societal Risk Results - No Human Reaction
- x— Project Societal Risk - 80% Human Reaction
- CDE and SBCO Negligible
- CDE and SBCO Intolerable
- UK R2P2, 2001
- Netherlands



Project Societal Risk Results - 160 psig



- x— Project Societal Risk Results - No Human Reaction
- x— Project Societal Risk - 80% Human Reaction
- CDE and SBCO Negligible
- CDE and SBCO Intolerable
- UK R2P2, 2001
- Netherlands



1.0 Environmental Setting

1.1 Project Summary

The Carson to Paramount Hydrogen Pipeline Project (Project) will extend from Air Products’ existing hydrogen facility in the City of Carson, to its new customer in the City of Paramount, California. Approximately 11.5-miles of existing hazardous liquid pipeline used for the transportation of crude oil and petroleum products will be converted to gas service as part of this Project. The hydrogen gas that will be transported by this pipeline project will replace liquid hydrogen that is currently being transported by truck. In addition, approximately 0.5 miles of new pipeline would be constructed as part of the Project within the City of Carson. Air Products would also remove existing manual valves and add automatic shut-off valves (ASVs) at each end and at one location along the pipeline route. The pipeline segments and alignment are depicted on the figures on the following pages.

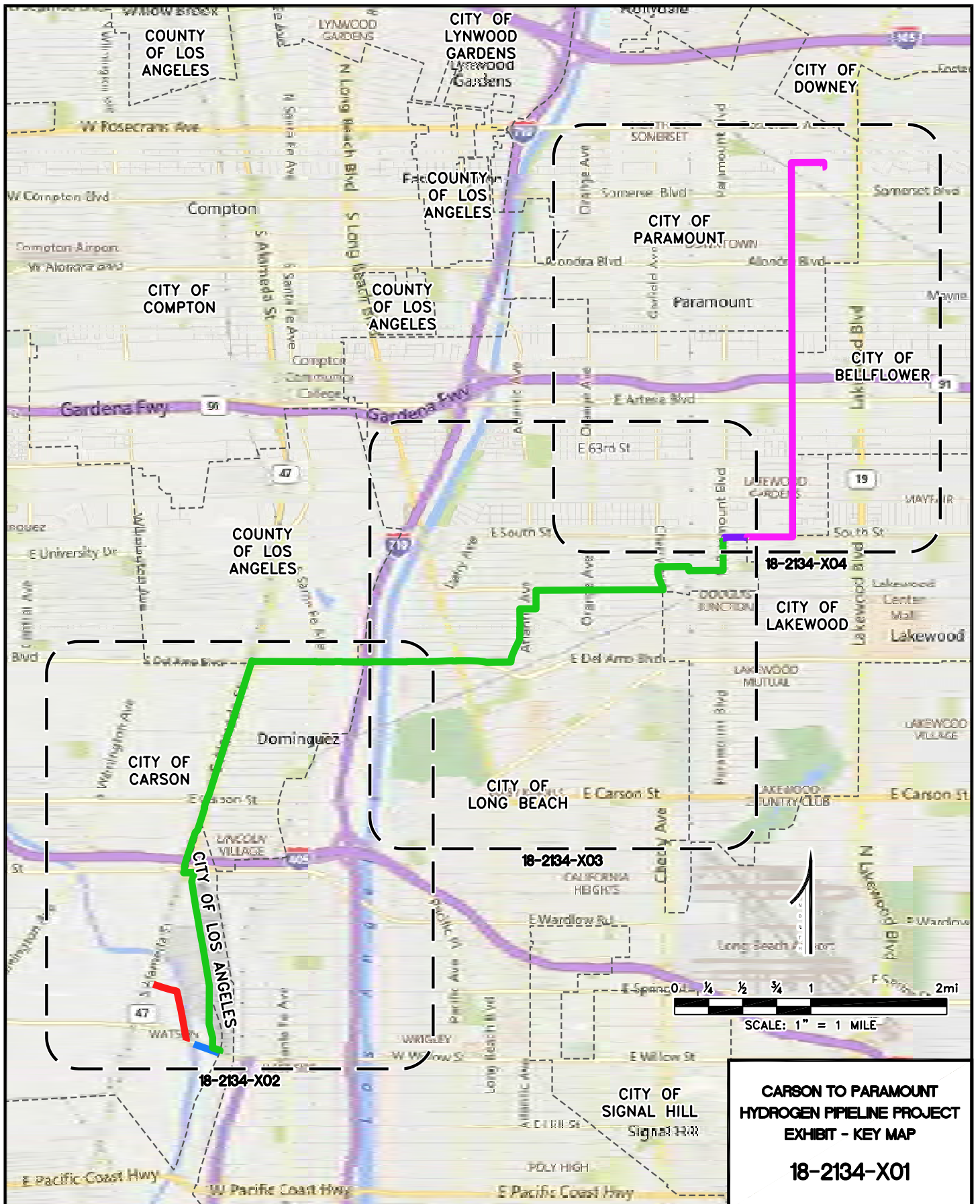
1.1.1 Pipe Segment Descriptions

The various segments of the proposed 12-mile pipeline are summarized in the table below.

Table 1.1.1-1 – Pipe Segment Summaries

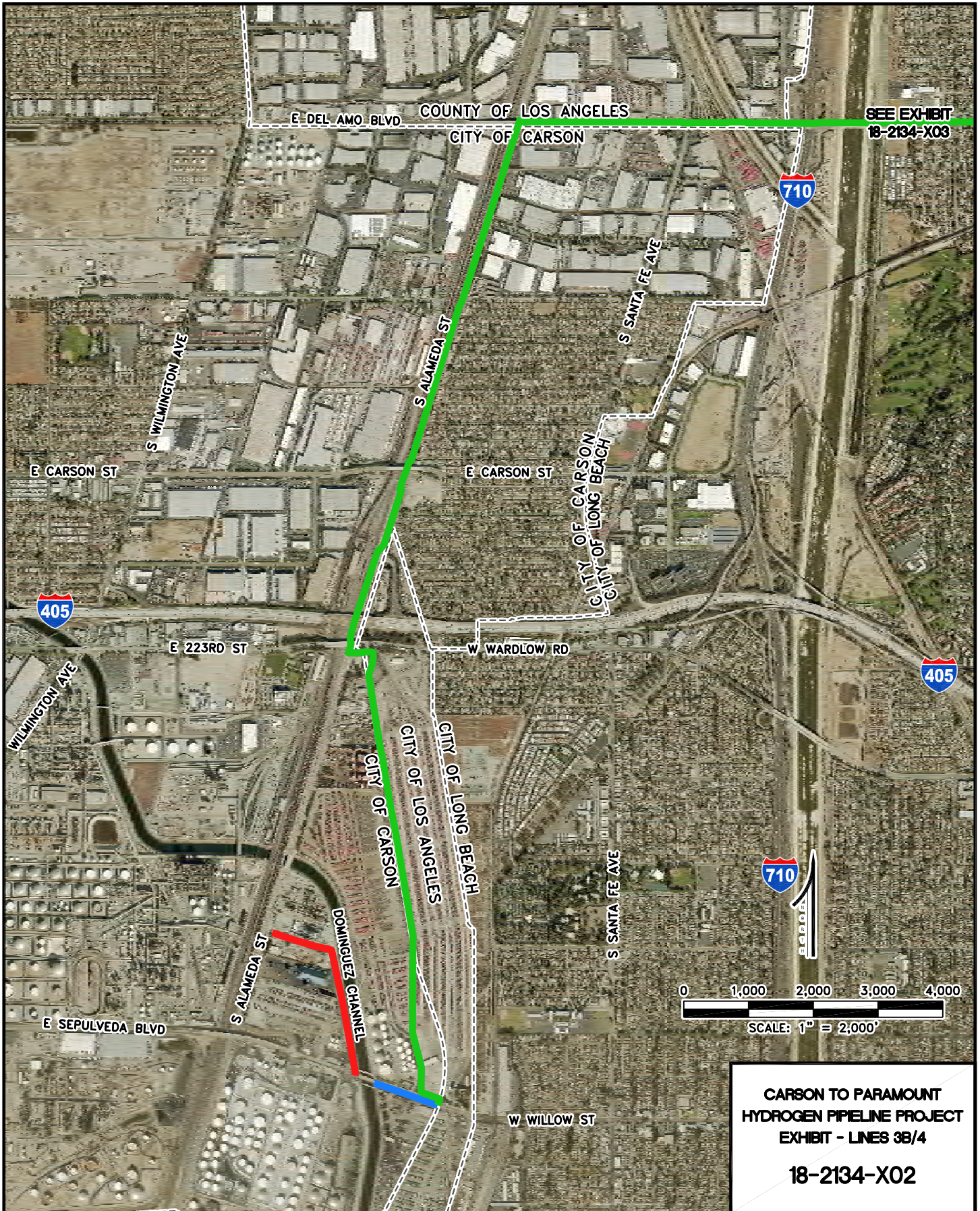
Segment Description	Pipe Outside Diameter	Pipe Wall Thickness	Pipe Grade	Segment Length
New Air Products Carson Plant Site to Sepulveda Boulevard	8.625"	0.322"	API 5L X52	2,929
Existing Line 3B from Sepulveda Boulevard to Intermodal Terminal	6.625"	0.280"	API 5L Grade B	1,039
Existing Line 4 from Intermodal Terminal to North Paramount Boulevard/South Street	6.625" and 8.625"	0.280" (6") 0.322" (8")	API 5L Grade B	39,792
Existing Line 1150 from North Paramount Boulevard to South Street Vault	12.750"	0.33"	API 5L Grade B	980
Existing Line 244 from South Street Vault to World Energy (Paramount) Refinery	12.750"	0.33"	API 5L Grade B	11,813

The existing pipelines are bonded together and are cathodically protected by an impressed current system. This system utilizes four (4) impressed current rectifiers and ground beds. There are 32 test stations along the pipeline route.



LEGEND

- █ SEGMENT 1 - PROPOSED PIPELINE, 8.625" O.D., 0.322" W.T., API 5L X52 (2,929 L.F.)
- █ SEGMENT 2A - LINE 3B, 6.625" O.D. AND 8.625" O.D., 0.250" W.T., VARIOUS GRADES (1,039 L.F.)
- █ SEGMENT 2A - LINE 4, 6.625" O.D., 0.188" TO 0.250" W.T., AND 8.625" O.D., 0.250" W.T., VARIOUS GRADES (39,793 L.F.)
- █ SEGMENT 2B - LINE 1150, 12.750" O.D., 0.330 W.T., VARIOUS GRADES (980 L.F.)
- █ SEGMENT 2B - LINE 244, 12.750" O.D., 0.330 W.T., VARIOUS GRADES (17,814 L.F.)

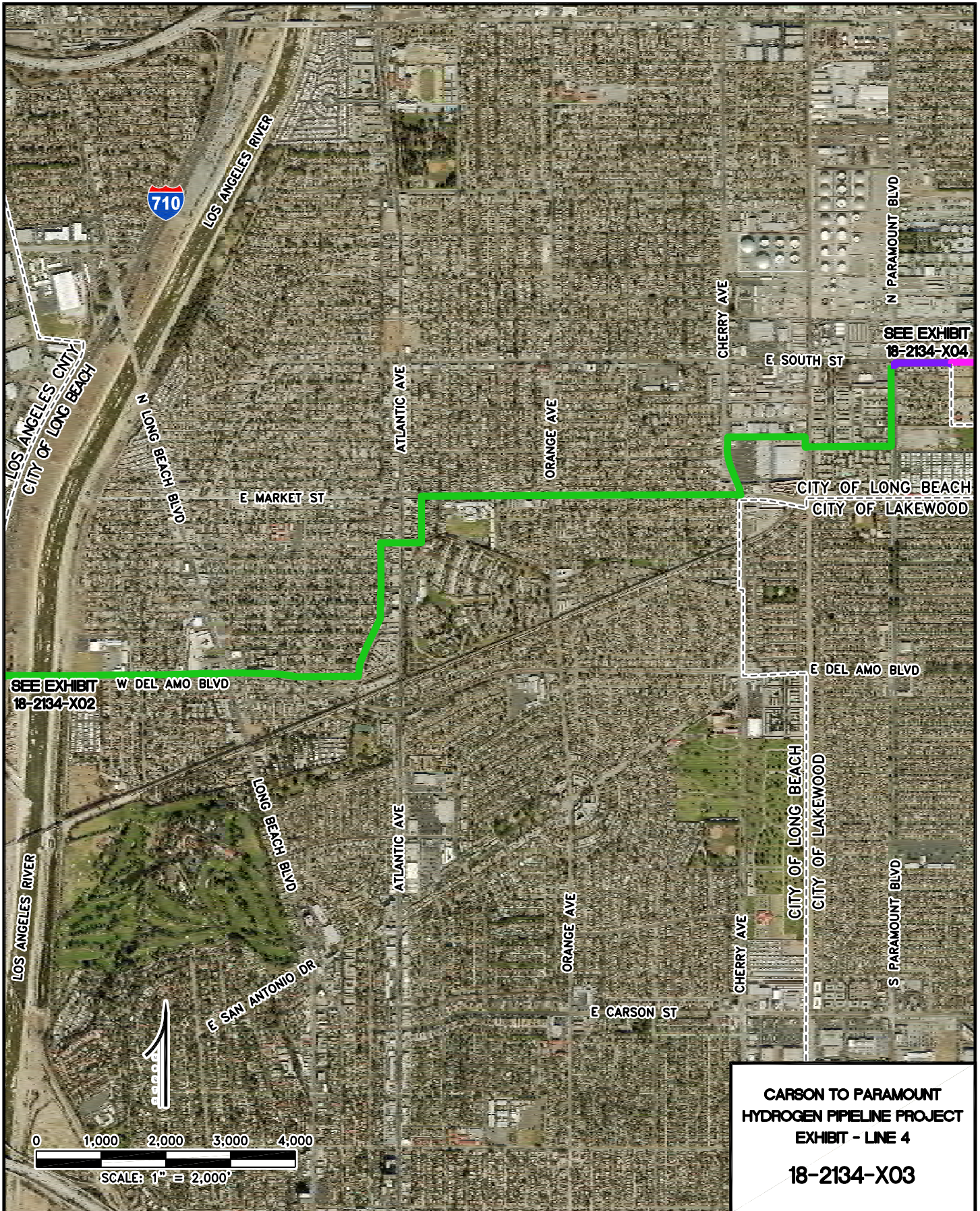


SEE EXHIBIT
18-2134-X03

**CARSON TO PARAMOUNT
HYDROGEN PIPELINE PROJECT
EXHIBIT - LINES 3B/4
18-2134-X02**

LEGEND

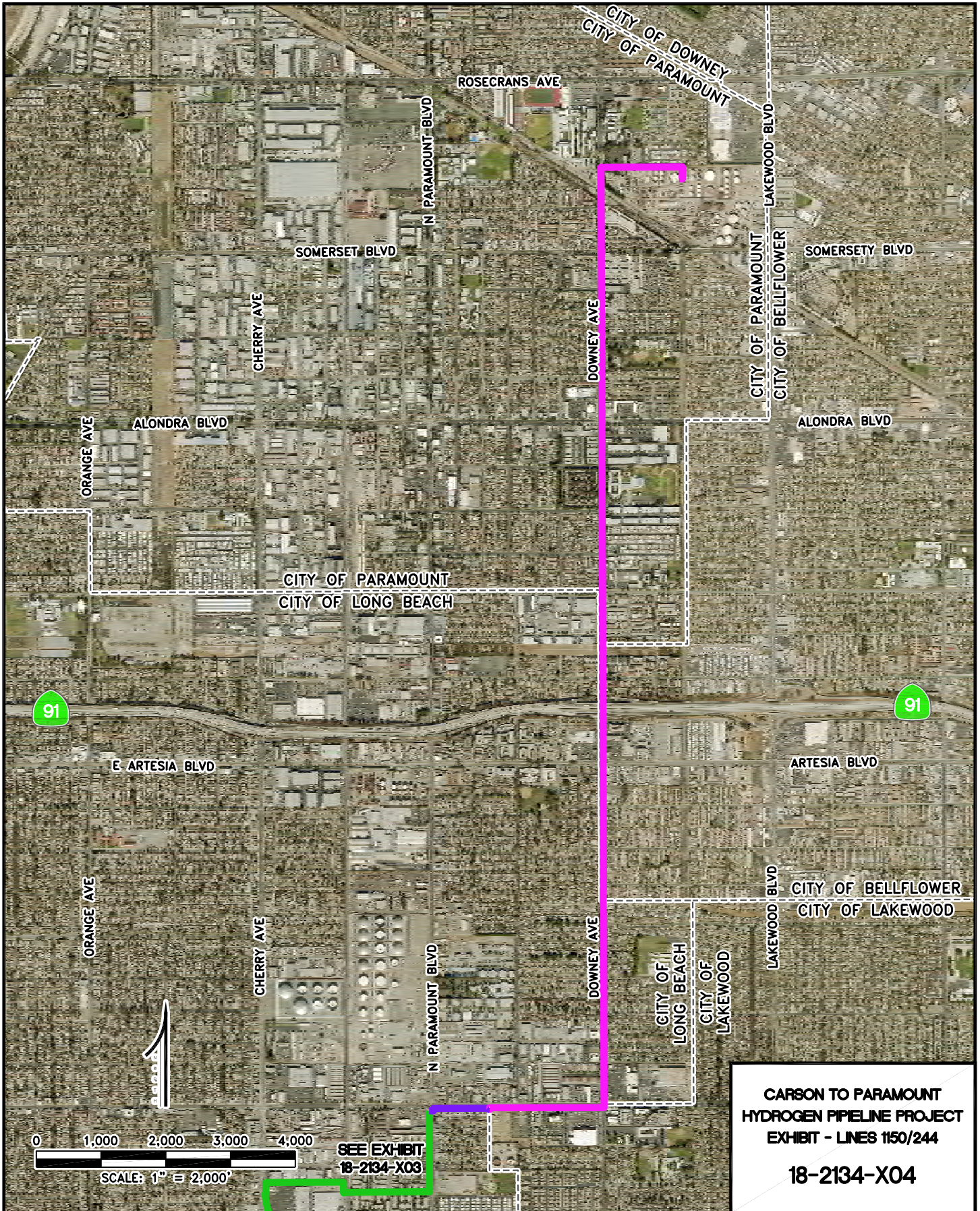
- █ SEGMENT 1 - PROPOSED PIPELINE, 8.625" O.D., 0.322" W.T., API 5L X52 (2,929 L.F.)
- █ SEGMENT 2A - LINE 3B, 6.625" O.D. AND 8.625" O.D., 0.250" W.T., VARIOUS GRADES (1,039 L.F.)
- █ SEGMENT 2A - LINE 4, 6.625" O.D., 0.188" TO 0.250" W.T., AND 8.625" O.D., 0.250" W.T., VARIOUS GRADES (39,793 L.F.)
- █ SEGMENT 2B - LINE 1150, 12.750" O.D., 0.330 W.T., VARIOUS GRADES (980 L.F.)
- █ SEGMENT 2B - LINE 244, 12.750" O.D., 0.330 W.T., VARIOUS GRADES (17,814 L.F.)



**CARSON TO PARAMOUNT
HYDROGEN PIPELINE PROJECT
EXHIBIT - LINE 4
18-2134-X03**

LEGEND

- █ SEGMENT 1 - PROPOSED PIPELINE, 8.625" O.D., 0.322" W.T., API 5L X52 (2,929 L.F.)
- █ SEGMENT 2A - LINE 3B, 6.625" O.D. AND 8.625" O.D., 0.250" W.T., VARIOUS GRADES (1,039 L.F.)
- █ SEGMENT 2A - LINE 4, 6.625" O.D., 0.188" TO 0.250" W.T., AND 8.625" O.D., 0.250" W.T., VARIOUS GRADES (39,793 L.F.)
- █ SEGMENT 2B - LINE 1150, 12.750" O.D., 0.330 W.T., VARIOUS GRADES (980 L.F.)
- █ SEGMENT 2B - LINE 244, 12.750" O.D., 0.330 W.T., VARIOUS GRADES (17,814 L.F.)



**CARSON TO PARAMOUNT
HYDROGEN PIPELINE PROJECT
EXHIBIT - LINES 1150/244
18-2134-X04**

LEGEND

- █ SEGMENT 1 - PROPOSED PIPELINE, 8.625" O.D., 0.322" W.T., API 5L X52 (2,929 L.F.)
- █ SEGMENT 2A - LINE 3B, 6.625" O.D. AND 8.625" O.D., 0.250" W.T., VARIOUS GRADES (1,039 L.F.)
- █ SEGMENT 2A - LINE 4, 6.625" O.D., 0.188" TO 0.250" W.T., AND 8.625" O.D., 0.250" W.T., VARIOUS GRADES (39,793 L.F.)
- █ SEGMENT 2B - LINE 1150, 12.750" O.D., 0.330 W.T., VARIOUS GRADES (980 L.F.)
- █ SEGMENT 2B - LINE 244, 12.750" O.D., 0.330 W.T., VARIOUS GRADES (17,814 L.F.)



Automated shut-off valves (ASVs) will be installed at the following locations:

- At each end of the pipeline – one at Air Products Carson Plant and one at the World Energy (Paramount) Refinery, and
- One at the Dominguez Pumping Station.

These valves can be actuated automatically by the leak detection system, by the local Carson Plant operators, Wilmington Plant Operators, or by the Air Products Customer Service Center in Texas.

A manually operated block valve will be installed at the South Street Block Valve.

1.1.2 Pipeline Operating Parameters

Once commissioned, it is envisioned that the pipeline will be operational 100% of the time, except for outages due to maintenance, periodic testing, etc. The operating pressure will be less than 160 psig at the Air Products Carson Plant Site and will drop somewhat along the line due to frictional pressure losses. The anticipated pipeline flow rate will be approximately Seven (7) million standard cubic feet per day (7 MMSCFD). The various components of the pipe contents are summarized in Table 1.3-1 below:

Table 1.1.2-1 – Components of Pipe Contents

Component	Percentage of Flow Stream
Hydrogen	99.99%
Carbon Monoxide (CO ₂)	10 ppmv ³ maximum
Carbon Dioxide (CO)	10 ppmv maximum
CH ₄ + N ₂	10 ppmv maximum
Water (H ₂ O)	20 ppmv maximum
Oxygen (O ₂)	5 ppmv maximum

1.1.3 Pipeline Design

The pipeline will be designed in accordance with Title 49, Code of Federal Regulations, Part 192 (49 CFR 192) – Transportation of Natural and Other Gas by Pipeline, Minimum Federal Safety Standards. For the various pipe segments, the maximum design pressures are shown in the following table. These values are for the following conditions:

- Pipe Grade - Where the grade of a given pipe segments is unknown, the specified minimum yield strength (SMYS) of these segments will be assumed to be 24,000 psi in accordance with 49 CFR 192.107.

³ Parts per million by volume (ppmv)



- Class Location – The class location was assumed to be class 3 with a design factor of 0.50. (See Section 2.2.3 which follows for a complete description of class locations.)
- Seam Factor – A seam factor of 0.60 has been used where the seam type is unknown.

Table 1.1.3-1 – Pipe Segment Summaries

Segment Description	Pipe Outside Diameter	Pipe Wall Thickness	Pipe Grade	Maximum Design Pressure
Proposed New Pipe Segment - Air Products Carson Plant Site to Sepulveda Boulevard	8.625"	0.322"	API 5L X52	1,941 psig
Line 3B from Sepulveda Boulevard to Intermodal Terminal	6.625"	0.280"	API 5L Grade B	887 psig
Line 4 from Intermodal Terminal to North Paramount Boulevard/South Street	6.625" and 8.625"	0.280" (6") 0.322" (8")	API 5L Grade B	887 psig and 784 psig
Line 1150 from North Paramount Boulevard to South Street Vault	12.750"	0.33"	API 5L Grade B	543 psig
Line 244 from South Street Vault to World Energy (Paramount) Refinery	12.750"	0.33"	API 5L Grade B	543 psig

1.1.4 Conversion of Service Hydrostatic Testing

Since the existing pipe segments were previously in hazardous liquid service, compliance with 49 CFR 192.14 is required; as a result, prior to operation, the pipeline will be hydrostatically tested to a pressure of 1.5 times the maximum allowable operating pressure (1.5 x 300 psig = 450 psig). See also Section 2.2 of this report for additional conversion of service requirements.

For reference, the existing pipe segments to be used for this pipeline were hydrostatically tested to the following pressures in 2014 and 2015. It is worth noting that these pipe segments have been tested to more than two times the pressure required for the conversion of service and are shown in the table below.



Table 1.1.4-1 – Prior Hydrostatic Test Pressures

Segment Description	Pipe Outside Diameter	Pipe Wall Thickness	Test Date	Test Pressure
Line 3B from Sepulveda Boulevard to Intermodal Terminal	6.625" and 8.625"	0.250"	9/04/2014	940 psig
Line 4 from Intermodal Terminal to North Paramount Boulevard/South Street	6.625" and 8.625"	0.188" (6") 0.250" (8")	9/04/2014	940 psig
Line 1150 from North Paramount Boulevard to South Street Vault	12.750"	0.33"	8/20/2015	942 psig
Line 244 from South Street Vault to World Energy (Paramount) Refinery	12.750"	0.33"	8/20/2015	942 psig

1.1.5 Supervisory Control and Data Acquisition (SCADA) System

Air Products has a supervisory control and data acquisition (SCADA) system which gathers pipeline operational data for transmission to their Customer Control Center (CSC), located in Pasadena, Texas. The Air Products Southern California SCADA system consists of the following components:

- Local controller sites consisting of field instrumentation powered and monitored by an Emerson Control Wave Micro remote terminal unit (RTU).
- A 4G cellular modem that provides continuous and reliable communications between the Emerson RTU and the Emerson “Open Enterprise” SCADA server over a private cellular/internet network.
- The Emerson Open Enterprise server collects data from the Control wave RTUs and compiles a real time database.
- The remote sites are monitored and controlled by way of the Open Enterprise human machine interface (HMI) from the control room in Pasadena, Texas.
- The database also provides data to the following systems:
 - VMS automated billing system
 - Aspen IP21 data historian
 - Leak detection system

The various SCADA system components have uninterruptable power supplies (UPS). They can operate on permanent power supplied by the local utility or back-up UPS power. In the event of a loss of communications, the pipeline will continue to operate using local independent RTU’s.

1.1.6 Leak Detection System

A leak detection system will be installed on the pipeline system and will be monitored 100% of the time. Automatic safety valves (ASVs) will be installed and a valve to flare will be controlled by the leak detection system. The isolation and de-pressurization components will be programmed to actuate automatically, without operator intervention, in the event of a detected leak. A sustained (at least a few minutes) leak flowrate in excess of 0.5 MMSCFD will trigger an automatic



pipeline shutdown and depressurization to the flare. If a leak is identified, the nearest isolation valves will be automatically be closed and initiation of pipeline depressurization will begin. Operator intervention is intended as a back-up system; there are operators at three separate locations – Carson, California; Wilmington, California; and Pasadena, Texas.

1.1.7 Emergency Response

In the event of an unintentional release, the pipeline will be designed such that it would be automatically isolated and depressurized. An alarm would also be sent the control room operator in Carson and the CSC. The Air Products controllers will immediately begin system isolation procedures and dispatch local technicians. Their response time will be dependent on several factors and will range from 15 minutes to 2 hours, depending on the time of day and traffic. In many instances, local emergency responders (e.g., polices, fire, etc.) would arrive at the scene before the Air Products personnel.

In an emergency, local officials will already be on scene and have an incident command center established when Air Products personnel arrive. When arriving at the scene, Air Products personnel would report first to the command post. Air Product's personnel would discuss appropriate response actions with the on-scene Incident Commander and Coordinate with incident command before taking any action. Air Products will provide MSDS sheets and other data to the Incident Commander.

If possible, Air Products personal will identify the location and size of the leak. SCADA Data, from the CSC Controller, and flammable gas detectors can be used to determine the size and specific location of the leak. Isolation of piping and equipment will be made to stop or reduce the leak volume.

In the unlikely event that an evacuation should become necessary, Air Products personnel will coordinate evacuation efforts with local emergency responders.

Air Products will also have a dedicated pipeline technician who will patrol the pipeline and respond to underground service alert (USA) calls.

1.1.8 Public Awareness Program

Title 49, Code of Federal Regulations, Part 192, Section 192.616 provides the minimum federal requirements for a pipeline operator. This regulation requires, among other things:

- Each pipeline operator must develop and implement a written continuing public education program that follows the guidance provided in the American Petroleum Institute's (API) Recommended Practice (RP) 1162.
- The operator's program must specifically include provisions to educate the public, appropriate government organizations, and persons engaged in excavation related activities on:



- (1) Use of a one-call notification system prior to excavation and other damage prevention activities;
 - (2) Possible hazards associated with unintended releases from a gas pipeline facility;
 - (3) Physical indications that such a release may have occurred;
 - (4) Steps that should be taken for public safety in the event of a gas pipeline release; and
 - (5) Procedures for reporting such an event.
- The program must include activities to advise affected municipalities, school districts, businesses, and residents of pipeline facility locations.
 - The program and the media used must be as comprehensive as necessary to reach all areas in which the operator transports gas.
 - The program must be conducted in English and in other languages commonly understood by a significant number and concentration of the non-English speaking population in the operator's area.

The majority of this pipeline system lies within paved street areas. Air Products plans to install high visibility pavement markers at fifty (50) foot intervals within streets and curbs. These markers include the following information.

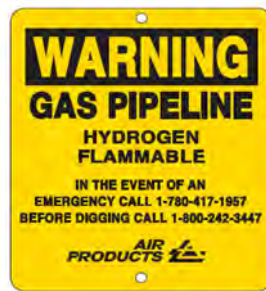


Figure 1.1.8-1 – Air Products Typical Pipeline Marker

Pipeline markers will be mounted on single, round polyethylene posts in more open areas.

1.1.9 Study Segments

For the purposes of this report, the pipeline has been divided into the following segments for analysis:

- Segment 1 - Carson Plant to Dominguez Pump Station ASV, 2,929 lineal feet of 8” nominal diameter pipe



- Segment 2A - Dominguez Pump Station ASV to South Street Block Valve, 40,832 lineal feet of 6" and 8" nominal diameter pipe
- Segment 2B – South Street Block Valve to Paramount Refinery, 18,794 lineal feet of 12" nominal diameter pipe

1.2 Potential Public Risks

Unintentional releases of hydrogen from the proposed pipeline could pose risks to human health and safety. If an ignition source was present, a fire and/or explosion could occur, resulting in possible injuries and/or deaths. (These potential hazards are presented in section 4.0 of this report.)

1.3 Hydrogen Characteristics

Hydrogen Gas is a diatomic gas with the molecular formula of H₂. It has a molecular weight of 2 and rises rapidly when released into the atmosphere. It is colorless, odorless, and flammable.

Hydrogen has a low ignition energy, meaning that it can be ignited very easily, and often is ignited by static discharge. The Minimum Ignition Energy (MIE) is defined as the minimum energy that can ignite a mixture of a flammable material with air or oxygen. For hydrogen, this value is – 0.019 millijoules (mJ).

Hydrogen forms combustible mixtures with air, with a lower flammability limit (LFL) of 4% and an upper flammability limit (UFL) of 75%.

The impacts of ignition are generally very localized for an unconfined release.



2.0 Regulatory Setting

The design, construction, and inspection of gas transmission pipeline facilities must comply with several federal, state, and local laws, regulations, ordinances and standards (LORS). This section summarizes the primary LORS for a typical gas transmission pipeline.

2.1 Regulatory Framework

The United States Department of Transportation (DOT) provides oversight for the nation's gas transmission pipeline transportation system. Its responsibilities are promulgated under Title 49, United States Code (USC) Chapter 601. The Pipeline and Hazardous Materials Safety Administration (PHMSA), Office of Pipeline Safety (OPS), administers the national regulatory program to ensure the safe transportation of gas and other hazardous materials by pipeline. PHMSA was originally the Research and Special Programs Administration (RSPA) within DOT.

In California, General Order No. 112-F, "State of California Rules Governing Design, Construction, Testing, Operation, and Maintenance of Gas Gathering, Transmission, and Distribution Piping Systems," provides additional requirements for gas pipelines.

2.2 Federal Pipeline Regulations

Two statutes provide the framework for the Federal pipeline safety program. The Natural Gas Pipeline Safety Act of 1968 as amended (NGPSA) authorizes the United States Department of Transportation (DOT) to regulate pipeline transportation of natural (flammable, toxic, or corrosive) gas and other gases as well as the transportation and storage of liquefied natural gas (LNG). Similarly, the Hazardous Liquid Pipeline Safety Act of 1979 as amended (HLPSA) authorized the DOT to regulate pipeline transportation of hazardous liquids (crude oil, petroleum products, anhydrous ammonia, and carbon dioxide). Both Acts have been re-codified as 49 USC Chapter 601.

Gas pipelines must conform with the design, construction, testing, operation and maintenance regulations contained in Title 49 Code of Federal Regulations (CFR) Part 192, "Transportation of Natural Gas and Other Gas by Pipeline: Minimum Safety Standards,". Many of these pipeline regulations are written as performance standards. However, the DOT does not issue a construction permit or conduct a plan check for all pipeline projects.

49 CFR Part 192 is administered under 49 CFR Part 190 – Pipeline Safety Enforcement and Regulatory. "This part prescribes procedures used by the Pipeline and Hazardous Materials Safety Administration in carrying out duties regarding pipeline safety under 49 U.S.C. 60101 et seq. (the pipeline safety laws) and 33 U.S.C. 1321 (the water pollution control laws)."

The Federal Office of Pipeline Safety (OPS) shares portions of the regulatory authority with state agency partners and others at the Federal, state, and local level. The State of California is certified under 49 USC Subtitle VIII, Chapter 601, §60105 as a regulatory partner. The State has the



authority to regulate intrastate natural and other gas pipeline facilities. The California Public Utilities Commission (CPUC) is the agency authorized to oversee intrastate gas pipeline facilities, including those proposed by the Applicant. (The California State Fire Marshal has jurisdiction for hazardous liquid pipelines.) The CPUC has adopted 49 CFR Part 192 as their model code as referenced to as CPUC General Order 112-F.

2.2.1 49 CFR Part 190 Overview

This part prescribes procedures that are used by the DOT relative to DOT's duties regarding gas and hazardous liquid pipeline safety. This part prescribes procedures that are used by Federal Regulators for:

- Enforcement,
- Compliance Orders,
- Civil Penalties,
- Specific Relief,
- Criminal Penalties,
- Procedures for Adoption of Rules, and
- Cost Recovery for Design Review.

2.2.2 49 CFR Part 191 Overview

This part prescribes the various pipeline operator reporting responsibilities to the DOT. This includes annual reporting of the physical makeup of an operator's pipeline system by diameter, age, length, material specification, etc. This part prescribes the required reporting of:

- incidents and accidents,
- safety related conditions discovered as a result of a periodic or unscheduled inspection, and
- procedures to be followed regarding the reduction of operating pressure should a safety related condition be discovered.

The pipeline operator is required to file a written report with the DOT within five working days of the time in which the operator first determined that any of the following conditions exist.

- General corrosion which has reduced the wall thickness to less than that required for the maximum operating pressure or localized corrosion which could result in a leak;
- Unintended movement or abnormal loading of a pipeline by environmental causes (e.g., earthquake, landslide, flood) that impairs its serviceability;
- Any material defect or physical damage that impairs the serviceability of a pipeline;
- Any malfunction or operating error that causes the pressure of a pipeline to rise above 110 percent of the maximum operating pressure;
- A leak in a pipeline that constitutes an emergency; or
- Any safety related condition that could lead to an imminent hazard and causes (either directly or indirectly by remedial action of the operator) a 20 percent or more reduction in operating pressure or shutdown of pipeline operation.



The following safety related conditions are excluded from reporting:

- A safety related condition that is more than 220 yards from a human occupancy or outdoor assembly place. (Please note that reports are required for safety related conditions within railroad rights-of-way, paved roadways, or where an incident could reasonably be expected to pollute any stream, river, lake, reservoir, or other body of water.)
- Any safety related condition that is corrected by repair or replacement in accordance with applicable safety standards before the report deadline. (Please note that reports are required for general corrosion on all lines and localized corrosion on unprotected lines.)

2.2.3 49 CFR Part 192 Overview

Section 192.1 – What is the Scope of this Part

This section defines what gas pipelines are covered by the regulation and the intent of the regulation.

Section 192.3 - Definitions

This section provides a description and definition of the terms used within the regulation.

Section 192.5 – Class Location

The regulation is structured to relate exposure risk to humans to the level of design, operation, and maintenance requirements imposed by the regulations. This is accomplished within the regulations using Class Locations. This section defines and describes the Class Location categories for gas pipelines. These categories impact testing and operating pressure requirements.

In general, the requirements of the Federal regulations become more stringent as the human population density increases. To this end, 49 CFR 192 defines area classifications, based on population density in the vicinity of a pipeline and specifies more rigorous safety requirements for more heavily populated areas. The class location is an area that extends 220 yards on either side of the centerline of any continuous 1-mile length of pipeline. The four area classifications are defined as follows:

- Class 1 - Location with 10 or fewer buildings intended for human occupancy.
- Class 2 - Location with more than 10 but less than 46 buildings intended for human occupancy.
- Class 3 - Location with 46 or more buildings intended for human occupancy or where the pipeline lies within 100 yards of a building, or small well-defined outside area pipeline any occupied by 20 or more people on at least 5 days a week for 10 weeks in any 12-month.
- Class 4 - Location where buildings with four or more stories aboveground are prevalent.

Pipeline facilities located within class locations representing more populated areas are required to have a more conservative design. For example, pipelines constructed on land in Class 1 locations



must be installed with a minimum depth of cover of 30 inches in normal soil and 18 inches in consolidated rock. Class 2, 3, and 4 locations, as well as drainage ditches of public roads and railroad crossings, require a minimum cover of 36 inches in normal soil and 24 inches in consolidated rock. All pipelines installed in navigable rivers, streams, and harbors must have a minimum cover of 48 inches in soil or 24 inches in consolidated rock.

Class locations also specify the maximum distance to a sectionalizing block valve (e.g., 10.0 miles in Class 1, 7.5 miles in Class 2, 4.0 miles in Class 3, and 2.5 miles in Class 4 locations). Pipe wall thickness and pipeline design pressures, hydrostatic test pressures, maximum allowable operating pressure, inspection and testing of welds and frequency of pipeline patrols and leak surveys must also conform to higher standards in more populated areas.

Section 192.7 – What Documents are Incorporated by Reference

This section incorporates many of the applicable national safety standards, including⁴:

- American Petroleum Institute (API)
- American Gas Association (AGA) – Part of Pipeline Research Council International (PRCI)
- American Society of Mechanical Engineers (ASME)
- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- Gas Technology Institute (GTI)
- Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)
- Plastic Pipe Institute (PPI)

Sections 192.8 to 192.13 - Definition and Description of Regulated Pipelines

These sections provide more in-depth descriptions of jurisdictional gas pipeline systems, general requirements and overall regulatory requirements.

⁴ A more detailed cross reference of the specific national standards is provided later in this document.



Sections 192.14 – Conversion of Service into Gas Service

This section deals specifically with the conversion of service of a pipeline, previously not in gas service or jurisdictional to this regulation, into gas service that is jurisdictional to the regulations⁵.

This section requires an operator to:

- Review the design, construction, operation and maintenance records of the subject pipeline to determine the suitability for the intended gas service,
- Where sufficient records do not exist, appropriate testing must be performed to determine the suitability for the intended gas service,
- Visual inspection of the pipeline and right-of-way for defects and condition that might affect the serviceability of the pipeline,
- Correction of defects found,
- Testing necessary to establish the maximum operating pressure of the pipeline,
- Record keeping, and
- Notification of regulator of conversion of service prior to operation.

Sections 192.15 – Rules of Regulator Construction

This section defines the intent of various terms used in the regulations.

Sections 192.16 – Customer Notification

This section defines the requirements of gas pipeline operators to communicate to customers to clearly define where the demarcation point exists for operations and maintenance of the customer owned gas piping systems.

Subpart B – Materials (Sections 192.51 to 192.65)

This subpart provides the requirements for the selection and qualification of pipe and other pipeline components. Generally, it covers the manufacture, marking, and transportation of steel, plastic, and copper pipe used in gas pipelines and distribution systems.

Subpart C – Pipe Design (Sections 192.101 to 192.125)

These sections include pipeline design requirements for new pipelines, relocated pipeline segments, pipe replacements, and other changes to existing systems that use steel, plastic, and copper pipe. These requirements include consideration for operating temperature, internal pressure, pipe seam joint type, specified minimum pipe yield strength, and other factors.

⁵ The proposed pipeline system will be required to comply with these conversion of service requirements.



Subpart D – Design of Pipeline Components (Sections 192.141 to 192.203)

This subpart provides the minimum requirements for the design and qualification of various components (e.g. valves, flanges, fittings, passage of internal inspection devices, taps, fabricated components, branch connections, extruded outlets, supports and anchors, compressor stations, vaults, overpressure protection, pressure regulators and relief devices, instrumentation and controls, etc.)

The federal regulations require the following for compressor buildings:

- The compressor building must be located to minimize the impact of fire on structures on adjacent property not under the control of the operator - 49 CFR Part 192.163(a).
- Space around the compressor building must be adequate to allow the free movement of firefighting equipment - 49 CFR Part 192.163(a).
- Compressor buildings must be constructed of noncombustible materials (where piping is greater than 2-inches in nominal diameter) - 49 CFR Part 192.163(b).
- Any main compressor building must have at least two unobstructed exits (per floor) with panic hardware on the doors that open outwardly - 49 CFR Part 192.163(c).
- All escape routes from the buildings must be unobstructed - 49 CFR Part 192.163(c).
- All fenced areas around compressor buildings must have two exits providing escape to a place of safety - 49 CFR Part 192.163(d).
- All fenced areas less than 200 feet from the compressor building must have gates that open outwardly, and when occupied, must be capable of being opened without a key - 49 CFR Part 192.163(d).
- All electrical equipment and wiring must conform to National Electric Code NFPA 70 - 49 CFR Part 192.163(e).
- The station must be equipped with an emergency shutdown system that: isolates the station piping from the incoming and outgoing pipeline, shuts down any gas fired equipment, blows down the station piping to a safe location, and allows operation from at least two sites outside the gas area of the station near emergency egress gates and not more than 500 feet from the limits of the compressor station. This ESD must not shut down emergency operating power for safety systems and emergency egress lighting - 49 CFR Part 192.167(a).
- The station piping must be protected by a pressure relief system or other suitable protective devices of sufficient capacity and sensitivity to ensure that the maximum operating pressure is not exceeded by more than 10%. Each vent line that exhausts gas from a pressure relief valve of a compressor station must extend to a location where the gas may be discharged without hazard - 49 CFR Part 192.169(a) and (b).
- Each compressor station must have adequate fire protection facilities. If fire pumps are part of these facilities, their operation must not be affected by the emergency shut-down system - 49 CFR Part 192.171(a).
- Each compressor station prime mover other than an electric motor, must have automatic shut-downs to protect against exceeding the maximum safe speed of the prime mover or compressor - 49 CFR Part 192.171(b).



- Each compressor unit within a compressor station must have a shut-down, or alarm device, that operates in the event of inadequate cooling or lubrication of the unit - 49 CFR Part 192.171(c).
- Each natural gas-powered prime mover (engine) that operates with pressure injection must be equipped so that stoppage of the engine automatically shuts off the fuel and vents the engine distribution manifold. The muffler of a gas engine must have vent slots, or holes, in the baffles of each compartment to prevent gas from being trapped in the muffler - 49 CFR Part 192.171(d) and (e).
- Each compressor station building must be ventilated to ensure that employees are not endangered by the accumulation of gas in rooms, sumps, attics, pits, or other enclosed places - 49 CFR Part 192.173.
- Natural gas compressor station buildings must be equipped with fixed gas detection and alarm systems – 49 CFR Part 192.736.

Subpart E – Welding of Steel in Pipelines (Sections 192.221 to 192.245)

This subpart provides the minimum requirements for welding procedures, welder qualification, inspection and repair/replacement of welds in steel pipeline systems. This subpart outlines the acceptable industry codes to follow in the development of these procedures and qualifications.

Subpart F – Joining of Materials Other Than by Welding (Sections 192.271 to 192.287)

These sections describe the low-pressure pipe construction methods for cast iron, ductile iron, copper, and plastic pipe.

Subpart G – General Construction Requirements for Transmission Lines and Mains (Sections 195.301 to 195.328)

This subpart provides the minimum construction requirements, including, but not limited to: inspection of materials, pipe repairs, bends and elbows, protection from hazards, installation in the ditch, installation in casings, underground clearances from other substructures, and minimum depth of cover.

Subpart H - Customer Meters, Service Regulators, and Service Lines (Sections 192.351 to 192.385)

This subpart prescribes the requirements for customer service meters and service lateral installations. This includes valve requirements, placement of valves, excess flow valves, and piping materials installation connection requirements other than steel.

Subpart I – Requirements for Corrosion Control (Sections 192.451 to 192.491)

This subpart provides the minimum requirements for cathodic protection systems, required inspections and monitoring, remedial measures, and records maintenance. This applies to



corrosion control for above and below grade piping systems. These sections outline the requirements for:

- Examination of buried pipelines when exposed,
- Protective coatings,
- Cathodic protection systems,
- Monitoring of corrosion control systems,
- Electrical isolation from other structures,
- Test stations,
- Test leads,
- Interference current testing,
- Internal corrosion control design and monitoring,
- Atmospheric corrosion control and monitoring,
- Remedial measures for transmission lines,
- Remedial measures for distribution systems other than cast or ductile iron,
- Remedial measures for distribution systems with cast or ductile iron piping,
- Direct assessment guidance for corrosion control relative to integrity management programs, and
- Record keeping.

Subpart J – Test Requirements (Sections 192.501 to 192.517)

This subpart prescribes the minimum requirements for hydrostatic testing, compliance dates, test pressures and duration, test medium, and records. The subpart defines the hydrostatic testing requirements by anticipated operating pressures and the subsequent pipe stress relative to the pipe's specified minimum yield strength (SMYS). This subpart requires new pipeline segments to be tested at 125% of the maximum allowable operating pressure (MAOP) for 8 hours.

Subpart K – Uprating (Section 192.551 to 192.557)

This subpart prescribes the requirements to increase the operating pressure of an existing pipe segment to a higher maximum operating pressure.

Subpart L - Operations (Sections 192.601 to 192.631)

This subpart specifies the following minimum requirements for operating natural gas pipeline systems:

- Procedural manual for operations, maintenance, and emergencies,
- Class location studies and changing class locations,
- Maximum operating pressure,
- Continued surveillance,
- Damage prevention,
- Public awareness,
- Investigating failures,



- Odorization of gas,
- Purging pipelines of gas,
- Tapping gas pipelines under pressure, and
- Control room management.

Subpart M – Maintenance (Sections 192.701 to 192.755)

This subpart defines the day-to-day maintenance tasks that must be performed on a natural gas pipeline system:

- Patrolling of the pipeline right-of-way.
- Leakage surveys,
- Maintenance record keeping,
- Repair procedures and testing,
- Abandonment of pipelines,
- Pressure safety device testing,
- Valve maintenance, and
- Protection of weak joint pipelines.

Subpart N - Qualification of Pipeline Personnel (Sections 192.801 to 192.809)

These sections prescribe the minimum requirements for natural gas pipeline operations and maintenance personnel. This includes documentation of the training and qualifications programs to perform certain pipeline duties.

Subpart O – Gas Transmission Pipeline Integrity Management (Sections 192.901 to 192.951)

This subpart prescribes the requirements of natural gas transmission pipeline operators to develop and manage a pipeline integrity program. This includes determining where high consequence areas exist, developing a base line assessment of the existing pipelines, and the development of a program to monitor and measure integrity on an ongoing basis. These sections describe acceptable methods to assess the condition of a pipeline and when an operator may deviate from these methods. Consistent with other regulatory requirements, these sections define the record keeping and reporting requirements for an integrity management program.

Pipeline Integrity Management grew out of a series of pipeline incidents with severe consequences. This subpart requires operators of gas pipeline systems in High Consequence Areas (HCA's) to significantly increase their minimum required maintenance and inspection efforts. For example, all lines located within HCA's must be analyzed by conducting a baseline risk assessment. In general, the integrity of the lines must also be evaluated using an internal inspection device or a direct assessment, as prescribed in the regulation. Two incidents raised public concern regarding pipeline safety and necessitated these relatively new requirements.



Bellingham, Washington, June 10, 1999

According to the National Transportation Safety Board (NTSB) accident report, “about 3:28 p.m., Pacific daylight time, on June 10, 1999, a 16-inch diameter steel pipeline owned by Olympic Pipe Line Company ruptured and released about 237,000 gallons of gasoline into a creek that flowed through Whatcom Falls Park in Bellingham, Washington. About one- and one-half hours after the rupture, the gasoline ignited and burned approximately one-half miles along the creek. Two 10-year-old boys and an 18-year-old young man died as a result of the accident. Eight additional injuries were documented. A single-family residence and the City of Bellingham’s water treatment plant were severely damaged. As of January 2002, Olympic estimated that total property damages were at least \$45 million.

The major safety issues identified during this investigation were excavations performed by IMCO General Construction, Inc., in the vicinity of Olympic’s pipeline during a major construction project and the adequacy of Olympic Pipe Line Company’s inspections thereof; the adequacy of Olympic Pipe Line Company’s interpretation of the results of in-line inspections of its pipeline and its evaluation of all pipeline data available to it to effectively manage system integrity; the adequacy of Olympic Pipe Line Company’s management of the construction and commissioning of the Bayview products terminal; the performance and security of Olympic Pipe Line Company’s supervisory control and data acquisition system; and the adequacy of Federal regulations regarding the testing of relief valves used in the protection of pipeline systems.” (NTSB 2002)

Carlsbad, New Mexico, August 19, 2000

Per the NTSB accident report, “At 5:26 a.m., mountain daylight time, on Saturday, August 19, 2000, a 30-inch diameter natural gas transmission pipeline operated by El Paso Natural Gas Company ruptured adjacent to the Pecos River near Carlsbad, New Mexico. The released gas ignited and burned for 55 minutes. 12 persons who were camping under a concrete-decked steel bridge that supported the pipeline across the river were killed and their three vehicles destroyed. Two nearby steel suspension bridges for gas pipelines crossing the river were extensively damaged. According to El Paso Natural Gas Company, property and other damages or losses totaled \$998,296.

The major safety issues identified in this investigation were the design and construction of the pipeline, the adequacy of El Paso Natural Gas Company’s internal corrosion control program, the adequacy of Federal safety regulations for natural gas pipelines, and the adequacy of Federal oversight of the pipeline operator.” (NTSB 2003)

As noted earlier, 49 CFR 192, Subpart O, Pipeline Integrity Management, is relatively new and was developed in response to the two major pipeline incidents discussed above. In 2002, Congress passed an Act to strengthen the pipeline safety laws. The Pipeline Safety Improvement Act of 2002 (HR 3609) was passed by Congress on November 15, 2002 and was signed into law by the President in December 2002. As of December 17, 2004, gas transmission operators of pipelines in high consequence areas (HCA’s) were required to develop and follow a written integrity



management program that contained all of the elements prescribed in 49 CFR 192.911 and addressed the risks on each covered transmission pipeline segment.

The DOT (68 Federal Register 69778, 69 Federal Register 18228, and 69 Federal Register 29903) defines HCA's as they relate to the different class zones, potential impact circles, or areas containing an identified site as defined in 49 CFR 192.903. The OPS published a series of rules from August 6, 2002 to May 26, 2004 (69 Federal Register 69817 and 29904) that define HCA's where a gas pipeline accident could do considerable harm to people and their property. This definition satisfies, in part, the Congressional mandate in 49 USC 60109 for the OPS to prescribe standards that establish criteria for identifying each gas pipeline facility in a high-density population area.

Subpart P - Gas Distribution Pipeline Integrity Management (Sections 192.1001 to 192.1015)

These sections prescribe the requirements of gas distribution pipeline operators to develop and manage a pipeline integrity program. This program is similar but not as complex as the integrity management plan requirements for transmission pipelines.

2.2.4 49 CFR Part 199 Overview

Operators of interstate gas gathering and transmission pipeline systems are required to comply with the drug testing requirements of this regulation. The regulation requires operators to maintain an anti-drug plan, provide pre-employment employee testing, conduct post-accident drug testing, and perform random testing such that half of the employee pool is tested each twelve-month period. All employees that perform operating, maintenance, or emergency response functions are subject to these requirements. Employees who fail or refuse a drug test may not be used in these functions unless they completed a rehabilitation program and have met other requirements.

2.3 State Pipeline Regulations

As noted previously, the California Public Utilities Commission (CPUC), General Order No. 112-F "State of California Rules Governing Design, Construction, Testing, Operation, and Maintenance of Gas Gathering, Transmission, and Distribution Piping Systems" was written to provide further regulatory guidance for the natural gas pipelines within California. As stated earlier in this document, the OPS shares portions of this responsibility with state agency partners and others at the Federal, state, and local level. The State of California is certified under 49 USC Subtitle VIII, Chapter 601, §60105 to as an OPS agency partner.

2.3.1 Subpart A – General (Sections 101 – 105)

This subpart states that these regulations are intended to enhance the requirements of 49 CFR Part 190, 191, 192, 193, and 199 and are not intended to supersede the Federal pipeline safety regulations. This subpart includes the definition of terms specific to General Order No. 112-F. Of



significance in the subpart is the CPUC's acceptable method for the determination of a High Consequence Area (HCA). 49 CFR Part 192 allows for the utility to use one of two methods to determine an HCA. The CPUC allows only the more conservative of the two analyses.

2.3.2 Subpart B – Reports (Sections 121 – 126)

This subpart establishes concurrent reporting of all DOT required periodic and incident reports to the CPUC. The subpart provides operator guidance regarding the timing and method of reporting. This subpart also includes reporting requirements for incidents beyond the 49 CFR Part 191 requirements.

This subpart requires the reporting of proposed pipeline construction in addition to that of 49 CFR Part 191.22.

This subpart also outlines the requirements for reporting any change in the maximum allowable operating pressure of a pipeline.

2.3.3 Subpart C – Construction & Safety Standards (Sections 141 – 145)

This subpart defines the State's construction and pressure testing requirements of gas pipelines, including plastic pipe, as well as the periodic leakage surveys required and the maintenance of valves. This subpart defines various grades of leaks and the timing priorities required for repairs.

This subpart also defines the requirements for the development of emergency response plans that utilize the Incident Command System (ICS) and defines the State's specific maintenance recordkeeping required for gas pipelines and the retention time of these records.

2.3.4 Subpart D – LNG (Sections 161 – 162)

This subpart establishes the State's requirements for pipelines in liquified natural gas service and requires these pipelines comply with NFPA Standard 59A.

2.3.5 Subpart E – Gas Holders (Sections 181 – 183)

The state defines "Holders" to mean "any structure used to store gas, which has a displacement of 500 or more cubic feet, or will contain 10,000 or more standard cubic feet of gas at its maximum design pressure, except that a pipeline which is used primarily for transmission or distribution of gas, but which also serves a storage function, is not a holder for purposes of this General Order". This subpart defines how holders are designed, constructed, inspected, and tested. It includes property offset requirements as well for the siting of holders.

2.3.6 Subpart F – Petroleum Gas Vessel Station (Sections 201 - 202)

The state defines a "Vessel" to mean "any structure with a capacity of 200 gallons or more used for the storage of petroleum gas but shall not refer to those vessels used for transporting purposes". This subpart defines how vessel stations are inspected and tested per Appendix A of



the General Order. This subpart also defines personal training and work practices and the liaison with local fire departments for emergency response.

2.3.7 Subpart G – Whistleblower Protections (Sections 301 - 302)

This subpart establishes specific protections from retaliation by an employer, for utility employees, that report unsafe conditions within facilities owned by that utility. This subpart also requires the utilities to prominently display this protection provided to the employees by the state and how to report unsafe conditions.

2.3.8 Appendix A – Petroleum Gas Vessel Station: Operation, Maintenance and Inspection

This appendix provides further details, as referenced in Subpart F, regarding the operation, maintenance and inspection of vessel stations.

2.3.9 Appendix B – California Public Utilities Commission Report of Gas Leak or Interruption

This appendix provides the correct reporting form to use to submit gas leak or service interruption to the CPUC.



3.0 Significance Criteria

3.1 Aggregate Risk

Aggregate risk or probable loss of life (PLL) is the total anticipated frequency of a particular consequence, normally public fatalities, that could be anticipated over a given time period, for all project components being analyzed. Aggregate risk is a type of risk integral; it is the summation of risk, as expressed by the product of the anticipated consequences and their respective likelihood. The integral is summed over all of the potential events that might occur for all of the project components, over the entire project length. For example, if one were evaluating a ten-mile pipeline system, which included a storage tank and pump station, the aggregate risk would be the risk posed by all components – ten miles of pipeline, pumps, station piping, storage tank, etc. There are no known codified *bright line thresholds*⁶ for acceptable levels of PLL or aggregate risk. (This risk is presented in Section 6.0, Qualitative Aggregate Risk Assessment of this Report.)

3.2 Individual Risk

Individual risk (IR) is defined as the frequency that an individual may be expected to sustain a given level of harm from the realization of specific hazards, at a specific location, within a specified time interval. Individual risk is typically measured as the probability of a fatality per year.

The United States federal and California state governments have not adopted individual risk thresholds; the acceptable level of risk is left to local decision makers and project proponents. Figure 3.2-1 presents the individual risk thresholds for a number of jurisdictions, where such thresholds have been adopted.

⁶ A bright-line rule (or bright-line test) is a clearly defined rule or standard, composed of objective factors, which leaves little or no room for varying interpretation. The purpose of a bright-line rule is to produce predictable and consistent results in its application. Bright-line rules are standards established by courts in legal precedent or by legislatures in statutory provisions.

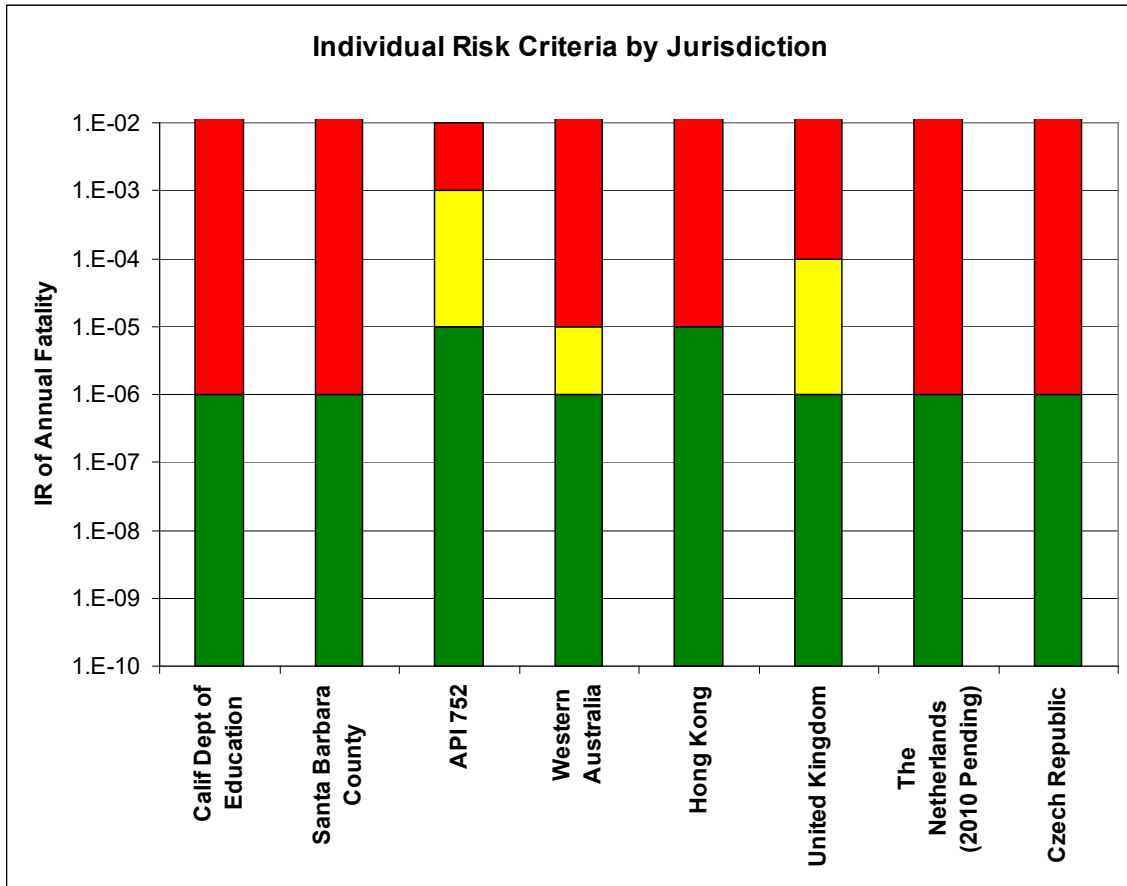


Figure – 3.2-1 Individual Risk Criteria by Jurisdiction⁷

The upper end of the green areas depict the de minimus⁸ risk values for each jurisdiction; IR risk levels within the green range are considered acceptable and are considered so low that no further consideration is warranted. In addition, risks within the green band are generally considered so low that it is unlikely that any risk reduction would be cost effective, since extraordinary measures would normally be required to further reduce the risk. As a result, a benefit – cost analysis of risk reduction is typically not undertaken.

The lower end of the red areas depict the de manifestus⁹ risk values; IR risk levels within the red range are considered unacceptable and the risks are not normally justified on any grounds.

⁷ Sources: (CDE 2007, SBCO 2008, API 752, Marszal 2001, Hong Kong

⁸ Latin term for "of minimum importance" or "trifling." Essentially it refers to something or a difference that is so little, small, minuscule, or tiny that the law does not refer to it and will not consider it.

⁹ ALARP (as low as reasonably practical) principle states that there is a level of risk that is intolerable, sometimes called the de manifestus risk level. Above this level risks cannot be justified.



For example, the California Department of Education (CDE) and Santa Barbara County use 1.0×10^{-6} as a trigger for further analysis; this is equivalent to a one in one million (1 : 1,000,000) likelihood that an individual at a specific location, would be fatally injured over a one year period¹⁰.

The exposure of an individual within the population is normally considered in this analysis. For example, CDE protocol adjusts for the period of time that students are outside, during school hours. The Santa Barbara County Environmental Thresholds and Guidelines Manual states, “Staff adjusts the Individual Risk to reflect conditional probabilities, called the Individual Specific Risk. Such probabilities address factors such as number of hours in the day in which someone is present in the hazard zone. A measurement of one in a million (1×10^{-6}) on an annual basis indicates sufficient evidence to trigger the risk thresholds and a comprehensive risk analysis.”

Some jurisdictions have adopted a “grey area”, where the risk levels may be negotiated or otherwise considered. This approach is depicted by the yellow areas in Figure 3.2-1. Generally, risks within the yellow area in Figure 3.2-1 may be tolerable only if risk reduction is impractical or if its cost is grossly disproportionate to the risk improvement gained. The underlying concept is to maximize the expected utility of an investment, but not expose anyone to an excessive increase in risk.

The United States government has opposed setting tolerable risk guidelines. The 1997 final report of the Presidential/Congressional Commission on Risk Assessment and Risk Management (Commission), entitled Framework for Environmental Health Risk Management, included the following finding, “There is much controversy about bright lines, “cut points,” or decision criteria used in setting and evaluating compliance with standards, tolerances, cleanup levels, or other regulatory actions. Risk managers sometimes rely on clearly demarcated bright lines, defining boundaries between unacceptable and negligible upper limits on cancer risk, to guide their decisions. Congress has occasionally sought to include specified bright lines in legislation. A strict “bright line” approach to decision making is vulnerable to misapplications since it cannot explicitly reflect uncertainty about risks, population within, variation in susceptibility, community preferences and values, or economic considerations – all of which are legitimate components of any credible risk management process.” The report states further, “Furthermore, use of risk estimates with bright lines, such as one-in-a-million, and single point estimates in general, provide a misleading implication of knowledge and certainty. As a result, reliance on command-and-control regulatory programs and use of strict bright lines in risk estimates to distinguish between safe and unsafe are inconsistent with the Commission’s Risk Management Framework and with the inclusion of cost, stakeholder values, and other considerations in decision-making.” (Commission 1997)

The United States is not alone in its opposition to establishing fixed risk thresholds. The vast majority of nations do not have government established risk tolerance criteria. In these cases, risk tolerance is left to individual owners and other decision makers.

¹⁰ For reference, National Geographic Magazine estimates that the odds of becoming a victim of a lightning strike in the United States is 1 in 700,000 (1 : 700,000).



4.0 Potential Hazards

The proposed project could pose additional risks to the public. For example, hydrogen gas could be released from a leak or rupture. If the hydrogen reached a combustible mixture and sufficient energy was present to ignite the mixture, a fire and/or explosion could occur, resulting in possible injuries and/or deaths.

This Report presents the life safety risks posed to the public. It does not analyze other potential damages.

4.1 Fire Hazards to Humans

The physiological effect of fire to humans depends on the rate at which heat is transferred from the fire to the person, and the amount of time the person is exposed to the fire. Skin that is in contact with flames can be seriously injured, even if the duration of the exposure is just a few seconds. Thus, a person wearing normal clothing is likely to receive serious burns to unprotected areas of the skin when directly exposed to the flames from a flash fire (vapor cloud fire).

Humans in the vicinity of a fire, but not in contact with the flames, would receive heat from the fire in the form of thermal radiation. Radiant heat flux decreases with increasing distance from a fire. Therefore, those close to the fire would receive thermal radiation at a higher rate than those farther away. The ability of a fire to cause skin burns due to radiant heating depends on the radiant heat flux to which the skin is exposed and the duration of the exposure. As a result, short-term exposure to high radiant heat flux levels can be injurious. However, if an individual is far enough from the fire, the radiant heat flux would be lower, likely incapable of causing injury, regardless of the duration of the exposure.

Various publications and authors cite various radiant heat flux levels and durations for specific levels of human impacts. The radiant heat flux endpoints used in the analyses presented herein are presented below. These are the same endpoints that are used by the California Department of Education (CDE), Guidance Protocol for School Site Pipeline Risk Analysis, which is used by the CDE to evaluate and select safe school sites¹¹.

- 12,000 Btu/ft²-hr (37.7 kW/m²) – 100% mortality after 30 second exposure (CDE 2007).
- 8,000 Btu/ft²-hr (25.1 kW/m²) – 50% mortality after 30 second exposure (CDE 2007).
- 5,000 Btu/ft²-hr (15.7 kW/m²) – 1% mortality after 30 second exposure (CDE 2007).

4.2 Explosion Hazards to Humans

An unintentional hydrogen release has the potential to ignite very quickly, due to the low minimum ignition energy required. As a result, it is rare that a significant hydrogen vapor cloud

¹¹ These radiant head flux values are lower than those that result from the Eisenberg equation. Specifically, the Eisenberg equation predicts that a 20,400 Btu/ft²-hr heat flux level is required for 100% mortality after a 30 second exposure; this is nearly two times the value used in the analyses presented herein.



can accumulate prior to ignition. However, hydrogen vapors can produce relatively high over-pressure levels, especially if they are confined within a specific range of mixtures with air and are ignited.

In the event of an explosion, the physiological effects depend on the peak overpressure that reaches a person. People located outside the flammable cloud when a combustible mixture ignites would be exposed to lower overpressure levels than those inside the flammable cloud. If a person were far enough from the source of overpressure, the explosion overpressure level would be incapable of causing injuries. The consequences of various levels of overpressure are outlined in the table below. Of significance to this project are the over-pressure levels and mortality rates for outdoor explosions. For example, there is a zero percent (0%) mortality rate for persons located outdoors with an over-pressure level of 2.3 psig.

Table 4.2-1 Explosion Over-Pressure Damage Thresholds¹²

Side-On Over-Pressure	Damage Description
0.02 psig	Annoying Noise
0.03 psig	Occasional Breaking of Large Window Panes Under Strain
0.04 psig	Loud Noise; Sonic Boom Glass Failure
0.10 psig	Breakage of Small Windows Under Strain
0.20 psig	Glass Breakage - No Injury to Building Occupants
0.30 psig	Some Damage to House Ceilings, 10% Window Glass Broken
0.50 to 1.00 psig	Large and Small Windows Usually Shattered, Occasional Damage to Window Frames
0.70 psig	Minor Damage to House Structures, Injury, but Very Unlikely to Be Serious
1.00 psig	1% Probability of a Serious Injury or Fatality for Occupants in a Reinforced Concrete or Reinforced Masonry Building from Flying Glass and Debris 10% Probability of a Serious Injury or Fatality for Occupants in a Simple Frame, Unreinforced Building
2.30 psig	0% Mortality to Persons Inside Buildings or Persons Outdoors (CDE 2007)
3.10 psig	10% Mortality to Persons Inside Buildings (CDE 2007)
3.20 psig	<10% Mortality to Persons Outdoors (CDE 2007)
14.5 psig	1% Mortality to Those Persons Outdoors (LEES)

¹² Sources: LEES, CDE 2007, Quest 2003



5.0 Baseline Data

In the following paragraphs, the anticipated frequency of unintentional releases and impacts to humans will be estimated using data from the following sources:

- United States Gas Transmission Pipelines (USDOT)

5.1 U.S. Onshore Gas Transmission Pipeline Releases

49 CFR 191.3 requires that the following incidents be reported to the DOT. These incidents are included in the DOT's raw incident data files.

“(1) An event that involves a release of gas from a pipeline, gas from an underground natural gas storage facility, liquefied natural gas, liquefied petroleum gas, refrigerant gas, or gas from an LNG facility, and that results in one or more of the following consequences:

(i) A death, or personal injury necessitating in-patient hospitalization;

(ii) Estimated property damage of \$50,000 or more, including loss to the operator and others, or both, but excluding cost of gas lost; or

(iii) Unintentional estimated gas loss of three million cubic feet or more.

(2) An event that results in an emergency shutdown of an LNG facility or an underground natural gas storage facility. Activation of an emergency shutdown system for reasons other than an actual emergency does not constitute an incident.

(3) An event that is significant in the judgment of the operator, even though it did not meet the criteria of paragraph (1) or (2) of this definition.”

On January 10, 2019, the raw incident data file for gas transmission pipeline releases occurring since January 1, 2010 was downloaded¹³. The raw data file included 1,087 incidents. The raw data file was manipulated as follows:

- Incidents which occurred after December 31, 2018 were deleted, since the data set is incomplete for the 2019 calendar year. (There were no 2019 incidents to delete.)
- 162 Incidents which occurred offshore were deleted.
- 93 incidents which occurred on gathering lines, portions of distribution systems, or in storage fields were deleted.
- 52 incidents which were either intentional releases (e.g., venting) or were reported for reasons other than the release of gas were deleted.

¹³ Downloaded from the PHMSA web site at <https://www.phmsa.dot.gov/data-and-statistics/pipeline/distribution-transmission-gathering-ling-and-liquid-accident-and-incident-data>.



This left 780 reported onshore gas transmission pipeline incidents which occurred during the nine (9) year period between January 1, 2010 and December 31, 2018. These incidents are summarized in the following table.

Of the above 780 reported incidents, only one was a result of a hydrogen release. This event occurred in 2015 on a pipeline operated by Markwest Javelina Pipeline Company, LLC. The release was ignited. However, no injuries or fatalities were reported. All of the other releases involved natural gas.

Table 5.1-1 – Reported U.S. Onshore Gas Transmission Pipeline Incidents and Fatalities, January 2010 through December 2018¹⁴

Calendar Year	Onshore Gas Transmission Pipeline Mileage ¹⁵	Number of Reported Incidents	Total Fatalities ¹⁶	General Public Fatalities
2018	298,000 ¹⁷	82	1	0
2017	297,552	91	3	0
2016	297,080	73	2	0
2015	297,333	116	2	0
2014	297,899	102	0	0
2013	298,388	80	0	0
2012	298,622	77	0	0
2011	299,734	90	0	0
2010	299,356	69	10	8
Totals	2,683,964	780	18	8

Using the above data, the following incident rates have been developed:

- Frequency of Reported Incidents – 0.2906 incidents per 1,000-mile years¹⁸
- Frequency of Fatalities¹⁹ – 0.0067 fatalities per 1,000-mile years

¹⁴ These data are for onshore gas transmission pipelines only; releases from gas distribution and other systems are not included.

¹⁵ As reported on the PHMSA web site at <https://www.phmsa.dot.gov/data-and-statistics/pipeline/annual-report-mileage-natural-gas-transmission-gathering-systems>.

¹⁶ The total number of fatalities includes fatalities of the pipeline operator’s personnel, the pipeline operator’s contractor’s personnel, and the general public.

¹⁷ Not reported. This value was estimated.

¹⁸ This unit provides a means of predicting the number of incidents for a given length of line, over a given time period. For example, if one considered an incident rate of 1.0 incidents per 1,000 miles years, one would expect one incident per year on a 1,000-mile pipeline. Using this unit, frequencies of occurrence can be calculated for any combination of pipeline length and time interval.

¹⁹ The total number of fatalities includes fatalities of the pipeline operator’s personnel, the pipeline operator’s contractor’s personnel, and the general public.



- Frequency of General Public Fatalities – 0.0030 fatalities per 1,000-mile years
- Frequency of General Public Injuries – 0.0224 injuries per 1,000-mile years²⁰

Of the 780 reportable releases, 117 (15%) were reported as ruptures. The remaining 663 releases (85%) were identified as leaks, other or mechanical puncture. The leaks were identified as pinholes, cracks, valve seal or packing, or cracks.

It should be noted that all eight (8) public fatalities were a result of the San Bruno, California natural gas pipeline rupture that occurred on September 9, 2010.

The causes of reportable incidents are summarized below.

Table 5.1-2 – Reported U.S. Onshore Gas Transmission Pipeline Incidents by Cause, January 2010 through December 2018²¹

Cause	Number of Reported Incidents	Percentage	Frequency (incidents per 1,000 mile years)
Equipment Failure ²²	278	35.6%	0.1036
Incorrect Operation ²³	45	5.8%	0.0168
External Corrosion	54	6.9%	0.0201
Outside Force/Excavation	154	19.7%	0.0574
Material Failure	108	13.8%	0.0402
Internal Corrosion	35	4.5%	0.0130
Natural Force ²⁴	66	8.5%	0.0246
Other	40	5.1%	0.0149

The public safety impacts associated with an unintentional pipeline release and subsequent fire or explosion depend largely on population density. A fire or explosion in a densely populated area is more like to impact human life than a similar incident in a rural area, all other things being equal. This is recognized in the minimum federal safety standards for gas transmission pipelines (49 CFR 192). For example, as noted previously in section 2.2.3 of this report, the lengths along a given gas transmission pipeline are designated a specific “class location”. These range from a rural

²⁰ As reported in the U.S. Onshore Gas Transmission Pipeline Incident reports.

²¹ These data are for onshore gas transmission pipelines only; releases from gas distribution and other systems are not included.

²² Includes items such as: defective or loose tubing, malfunction of control or relief equipment, non-threaded equipment failure, pump, threaded connection, or coupling failure.

²³ Includes items such as: incorrectly installed equipment, over-pressure, valve left in wrong position, wrong equipment installed, etc.

²⁴ Includes items such as: earth movement, floods, lightning, temperature, etc.



class location of 1, to a densely populated area as class location 4, where buildings of four or more stories are prevalent. The regulations require a higher factor of safety in more densely populated areas.

For example, class locations specify the maximum distance to a sectionalizing block valve (e.g., 10.0 miles in Class 1, 7.5 miles in Class 2, 4.0 miles in Class 3, and 2.5 miles in Class 4 locations). Pipe wall thickness and pipeline design pressures, hydrostatic test pressures, maximum allowable operating pressure, inspection and testing of welds and frequency of pipeline patrols and leak surveys must also conform to higher standards in more populated areas. For example, the design factor in a class 4 location is 0.40 while it is 0.72 in a class 1 location; as a result, all other things being equal, steel gas transmission pipe in a class 4 location must be 1.8 times thicker than in a class 1 location.

The PHMSA database, including the data presented in Tables 5.1-1 and 5.1-2, includes both rural and urban pipelines. However, data is not available to facilitate the development of separate incident rates for pipelines located in various class locations. The following data would be required to develop separate incident rates for various class locations:

- An inventory of the pipeline mileage within each class location and
- An identification of the class location for each reported release.

Pipeline age, operating temperature, and other factors also can affect the frequency of unintentional pipeline releases. However, as with class location, the PHMSA database does not include the data required to facilitate the development of separate incident rates for each parameter. And further, even if these data were available, it may not be possible to identify the specific variable that affects the resulting incident rate. For example, the pipe within densely populated is of various age, has different operating pressures and temperatures, varying external coatings, etc. Multiple regression analyses would be required to determine the degree to which the individual variables affect pipeline safety.

5.2 Air Products Pipeline Leak History

The PHMSA incident data file for onshore gas transmission lines was reviewed to identify the frequency of releases from any of Air Products' pipelines. Between January 1, 2010 and December 31, 2018, there were no releases from pipelines operated by Air Products.



6.0 Qualitative Aggregate Risk Assessment

In this section, the likelihood of fatalities will be estimated using these historical baseline data presented in the preceding Section 5.1 of this report. Although these data are based primarily on natural gas transmission pipelines, the results provide a means of framing the risk posed by the proposed pipeline. The qualitative aggregate risk estimates are based on the following criteria:

- 11.85 total miles of hydrogen pipeline
- Baseline incident rate for releases from onshore gas transmission pipelines – 0.2906 reported incidents per 1,000-mile years
- Baseline rate of general public injury for onshore gas transmission pipelines – 0.0030 fatalities per 1,000-mile years
- Baseline rate of general public fatality for onshore gas transmission pipelines - 0.0224 injuries per 1,000-mile years

For the proposed 11.85-mile pipeline system, the results are presented in the following table.

Table 6.0-1 Qualitative Aggregate Risk Assessment Results – 11.85 Miles of Hydrogen Pipeline

Unintentional Release Resulting In	Anticipated Frequency ²⁵ Incidents per 1,000-mile years	Anticipated Number of Incidents per Year	Annual Likelihood of Occurrence
Unintentional Release	0.2906	2.4×10^{-3}	1 in 290
General Public Fatality	0.0030	3.6×10^{-5}	1 in 28,000
General Public Injury	0.0224	2.6×10^{-4}	1 in 3,800

It should be noted that these historical data do not differentiate between various population densities. Further, all the general public fatalities used to determine the probability of public fatalities resulted from the 2010 San Bruno, CA natural gas release; there have not been any general public fatalities on the nations onshore gas transmission pipelines since this event.

In Section 9.0 (Individual Risk Assessment) of this Report, the actual environment will be considered; these analyses will consider pipe contents, pipe diameter, actual operating conditions, etc.

²⁵ These frequencies are from the USDOT database. See Section 5.1 of this report for details. This database includes primarily natural gas pipelines. Hydrogen pipeline release data is not available.



7.0 Release Modeling Results

In this section, various pipeline release scenarios are presented. The releases were modeled using CANARY, by Quest, version 4.6.2 software. For vapor cloud explosion modeling, this software uses the Baker-Strehlow model to determine peak side-on over-pressures as a function of distance from a release. The following assumptions and data inputs were used.

Table 7.0-1 Release Modeling Input

Parameter	Model Input
Nominal Pipe Diameter	8-inches and 12-inches
Normal Operating Pressure	260 psig
Average Flow Rate	7 MMSCFD
Pipe Contents Temperature	70 degrees F
Release Angle	45 degrees above the horizon upwind 45 degrees above the horizon downwind
Wind Speed ²⁶	9 meters per second (20 miles per hour) - Jet Fires 2 meters per second (4.5 miles per hour) - Flash Fires and Explosions
Stability Class	D - Pasquill-Gifford atmospheric stability is classified by the letters A through F. Stability can be determined by three main factors: wind speed, solar insolation, and general cloudiness. In general, the most unstable (turbulent) atmosphere is characterized by stability class A. Stability A occurs during strong solar radiation and moderate winds. This combination allows for rapid fluctuations in the air and thus greater mixing of the released gas with time. Stability D is characterized by fully overcast or partial cloud cover during daytime or nighttime and covers all wind speeds. The atmospheric turbulence is not as great during D conditions, so the gas will not mix as quickly with the surrounding atmosphere. Stability F generally occurs during the early morning hours before sunrise (no solar radiation) and under low winds. This combination allows for an atmosphere which appears calm or still and thus restricts the ability to actively mix with the released gas. A stability classification of "D" is generally considered to represent average conditions.
Relative Humidity	70%
Air and Surface Temperature	70 degrees F
Spill Surface	Soil
Fuel Reactivity	High - High reactivity fluids include hydrogen, acetylene, ethylene oxide, and propylene oxide.

²⁶ These wind conditions normally give the highest impact distances.



Parameter	Model Input
Obstacle Density	Low This parameter describes the general level of obstruction in the area including and surrounding the confined (or semi-confined) volume. Low obstacle density is appropriate due to the low building density and open space within the pipeline corridor. Normally, the vapor cloud would be located at ground level, near the release; these surroundings are relatively open along the entire pipeline alignment (low obstacle density).
Flame Expansion	3 D - This parameter defines the number of dimensions available for flame expansion. Open areas are 3-D and produce the smallest levels of overpressure.
Reflection Factor	2 - This factor is used to include the effects of ground reflection when an explosion is located near grade. A value of 2 is recommended for ground level explosions.

7.1 Jet Fires

As noted previously, automated shut-off valves (ASVs) will be installed at each end of the pipeline – one at the Air Products Carson Plant and one at the Paramount Refinery. In addition, one ASVs will be installed along the pipeline – at the Dominguez Pumping Station; a manually operated block valve will be installed in an underground vault on South Street, near Orizaba Avenue. The ASV valves can be actuated automatically by the leak detection system, by the local Carson Plant operators, or by the Air Products Customer Service Center in Texas. For the purposes of this study, the pipeline was broken into the two pipeline segments; each segment comprised that portion of the pipeline located between these ASVs.

7.1.1 Segment 2 Jet Fire Modeling

The Quest CANARY software used for the release analysis is limited to a single pipe diameter for each release. For segment 2 of the pipeline, which is comprised of 6”, 8” and 12” nominal diameter pipe, this posed a barrier to precise release modeling. To facilitate the limitations of the software, the following adjustments we made.

- Segment 2 was divided into 2 sub-segments:
 - Segment 2A - Dominguez Pump Station ASV to South Street Block Valve, 40,832 lineal feet of 6” and 8” nominal pipe
 - Segment 2B – South Street Block Valve to Paramount Refinery, 18,794 lineal feet of 12” nominal pipe
- Location of Release – Both the 1-inch and full-bore rupture releases were assumed to occur in the mid-points of Segments 2A and 2B.
- South Street Block Valve – The South Street manually operated block valve which separates Segments 2A and 2B was conservatively assumed to remain “open” during the entire release.



- 1-inch Releases - The initial release flow rates (maximums) for the 1-inch diameter releases were modeled from both Segments 2A and 2B using a 10" nominal diameter pipe for the combined segment length of 59,626 lineal feet (40,832 + 18,794). (Using a 10" nominal diameter pipe for the entire segment 2 length has almost the same internal volume as the actual pipe segments.)
- Segment 2A Rupture - The initial flow rate (maximums) for the Segment 2A full bore rupture 8-inch diameter release was modeled using a 10" nominal diameter pipe for the combined segment length of 59,626 lineal feet (40,832 + 18,794). (Using a 10" nominal diameter pipe for the entire segment 2 length has almost the same internal volume as the actual pipe segments.)
- Segment 2B Rupture - The initial flow rate for the Segment 2B full bore rupture 12-inch diameter release was modeled using a 12" nominal diameter pipe for the combined segment length of 59,626 lineal feet (40,832 + 18,794). This approach is conservative as the modeled pipe volume is about 60% greater than the actual pipe volume.

7.1.2 Jet Fire Duration

The impacts associated with a hydrogen jet fire are dependent on the pressure of the pipeline, the size of the release, and to a lesser degree the location of the release. As the pressure and flow rate decline, so do the impact distances to various potentially harmful endpoints.

In order to evaluate the duration of jet fires, Segment 2B was modeled using Synergi Pipeline Simulator software (SPS). This software enables dynamic analysis of pipeline hydraulics and multiple pipe diameters.

Segment 2A was modeled as 8-inch nominal diameter pipe and segment 2B was modeled as 12-inch nominal diameter pipe. A 12-inch diameter was then analyzed to determine the rate of pressure and flow rate decay after the initiation of the release; the release was located at the mid-point of segment 2B.

As demonstrated below, the flow rates and pressures decline very rapidly for a full-bore rupture.



Table 7.1.2-1 Jet Fire Decay, Segment 2B, Full Bore 12-inch diameter Rupture

Internal Pipeline Pressure	Leak Flow Rate (MMSCFD)	Time (minutes)
260 psig	1,594	0.0
10 psig	230	0.3
1 psig	57	1
0.1 psig	10	8
0.01 psig	1	14

7.1.3 Jet Fire Results

The jet fire results for each pipe segment, for a variety of releases are shown in the following table.



Table 7.1-1 Jet Fire Modeling Results²⁷

Segment	Size of Release	Release Relative to Wind	Release Duration ²⁸ (minutes)	Horizontal Distance from Unintentional Release to Endpoint Measured Perpendicular to Pipeline (feet) ²⁹		
				Distance from Unintentional Release to Endpoint Measured Parallel to Pipeline (feet)		
				Approximate Area of Impact (feet ²) ³⁰		
				12,000 btu/hr-ft ² 100% Mortality	8,000 btu/hr-ft ² 50% Mortality	5,000 btu/hr-ft ² 1% Mortality
Segment 1 - Carson Plant to Dominguez Pump Station ASV	Rupture	Downwind	5.3	25.3	25.4	27.2
				10.0	12.5	17.0
				342	190	334
Segment 1 - Carson Plant to Dominguez Pump Station ASV	Rupture	Upwind	5.3	23.4	25.1	27.4
				10.0	13.0	17.0
				331	202	350
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	Rupture	Downwind	7.4	46.7	55.4	63.7
				14.0	22.0	32.0
				930	925	1,654
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	Rupture	Upwind	7.4	*	18.4	29.1
				*	15.0	24.0
				*	408	1,385
Segment 2B - South Street Block Valve to Paramount Refinery	Rupture	Downwind	8.0 ³¹	60.6	67.7	76.1
				24.0	32.0	43.0
				2,099	1,435	2,424
Segment 2B - South Street Block Valve to Paramount Refinery	Rupture	Upwind	8.0	30.1	42.2	56.2
				16.0	25.0	38.0
				757	1,358	2,423

²⁷ All releases were modeled with an operating pipeline pressure of 260-psig and a 45-degree release angle above the horizon, at a flow rate of 7 MMSCFD.

²⁸ The release durations are the maximum that could occur. They do not consider depressurization of the pipeline by routing hydrogen to the flare. For the longer releases, the actual durations would likely be reduced dramatically.

²⁹ Radiant heat flux values shown are measured at 6-feet above ground surface.

* Indicates that this level of radiant heat flux is not present for the indicated release.

³⁰ The impact areas were determined by digitizing the Quest Canary software jet fire radiation isopleths. For the 50% mortality area value, this is the area between the 50% and 100% mortality endpoints; the mortality within this area is 75%. For the 1% mortality area value, this is the area between the 1% and 50% mortality endpoints; the mortality within this area is 25%.

³¹ Full bore release durations from Segment 2B were analyzed using Synergi Pipeline Simulator software due to the single pipe diameter modeling restrictions of Quest CANARY software. The duration depicted corresponds to the time required to reach an internal pipeline pressure of 0.1 psig.



Segment	Size of Release	Release Relative to Wind	Release Duration ²⁸ (minutes)	Horizontal Distance from Unintentional Release to Endpoint Measured Perpendicular to Pipeline (feet) ²⁹		
				Distance from Unintentional Release to Endpoint Measured Parallel to Pipeline (feet)		
				Approximate Area of Impact (feet ²) ³⁰		
				12,000 btu/hr-ft ² 100% Mortality	8,000 btu/hr-ft ² 50% Mortality	5,000 btu/hr-ft ² 1% Mortality
Segment 1 - Carson Plant to Dominguez Pump Station ASV	1-inch	Downwind	6.9	13.8	18.8	21.5
				4.5	6.6	9.5
				54	81	158
Segment 1 - Carson Plant to Dominguez Pump Station ASV	1-inch	Upwind	6.9	*	*	*
				*	*	*
				*	*	*
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	1-inch	Downwind	50	15.1	19.9	23.4
				5.0	7.0	10.5
				76	92	211
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	1-inch	Upwind	50	*	*	*
				*	*	*
				*	*	*
Segment 2B - South Street Block Valve to Paramount Refinery	1-inch	Downwind	120	15.2	19.9	23.4
				5.0	7.0	10.5
				76	93	211
Segment 2B - South Street Block Valve to Paramount Refinery	1-inch	Upwind	120	*	*	*
				*	*	*
				*	*	*

As noted in Table 7.0-1, jet fires were modeled considering a wind speed of 20 miles per hour. As noted in the results above, this wind speed blows the flame toward the downwind side of the pipeline. This results in the highest likelihood of individual risk, since the impacts for both upwind and downwind releases are both on the downwind side of the pipeline.

Figures 7.1-1 and 7.1-2 depict the jet fire results for a full-bore, downwind release from Segment 3. It should be noted that Figure 7.1-1 depicts the impacts in plan view (looking from above); Figure 7.1-2 depicts the impacts in elevation (looking horizontally, along the pipeline).

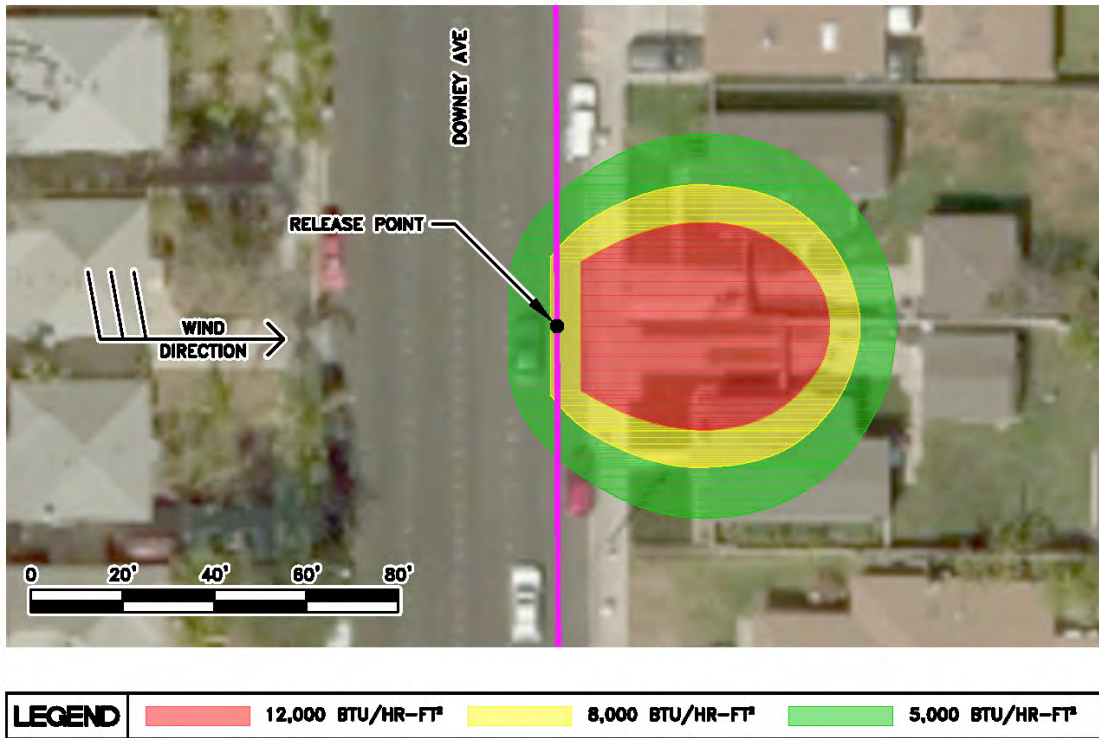


Figure 7.1-1 Typical Jet Fire Radiant Heat Flux, Plan View

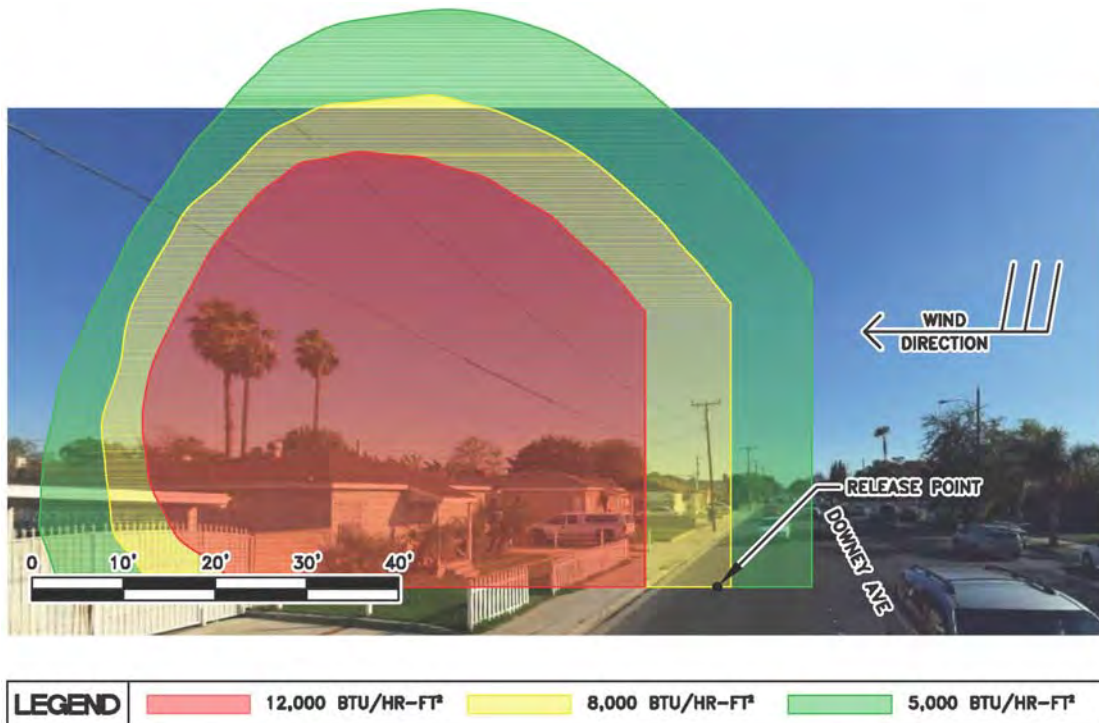


Figure 7.1-2 Typical Jet Fire Radiant Heat Flux, Elevation



7.2 Explosions

The potential impacts to humans as a result of explosions was presented earlier in Section 4.2 of this Report. Unconfined hydrogen generally does not explode; since it is so easily ignited, significant unignited vapor clouds normally do not result from a release. Rather, the gas is usually ignited during release by static discharge or other means.

The potential hydrogen releases were modeled using CANARY software. The resulting peak overpressure level was 3.36 psig, due to the relatively open environment. This overpressure level is high enough to pose a potentially fatal risk to the public, as it exceeds 2.4 psig³². For reference, the explosion modeling endpoints used in this report are presented in the following table.

Table 7.2-1– Explosion Modeling Endpoints (CDE 2007)

Mortality Rate	Outdoor Exposure (psi)
99% Mortality	72
50% Mortality	13
1% Mortality	2.4

Explosion modeling has been performed for releases from the proposed project using the following assumptions:

- Unconfined Vapor Cloud,
- Urban Terrain,
- Time Required to Shut-In Pipeline – Five (5) minutes
- Duration of Release – Up to Two (2) Hours
- Location of Release – Mid-Point of Each Pipe Segment

The explosion modeling results are summarized in the table below for 2.40 psig and 1.0 psig overpressure levels.

Table 7.2-2– Unconfined Vapor Cloud Explosion Modeling Results

Segment	Size of Release	Release Relative to Wind	1.00 psig Overpressure Level from Center of Flammable Vapor Cloud	2.40 psig Overpressure Level from Center of Flammable Vapor Cloud
Segment 1 - Carson Plant to Dominguez Pump Station ASV	Rupture	Downwind	30 feet	12 feet
Segment 1 - Carson Plant to Dominguez Pump Station ASV	Rupture	Upwind	29 feet	12 feet

³² The 2.4 psig endpoint is used by the California Department of Education and others for 1% mortality. The mortality rate for a 3.36 psig overpressure would be slightly greater than 1%.



Segment	Size of Release	Release Relative to Wind	1.00 psig Overpressure Level from Center of Flammable Vapor Cloud	2.40 psig Overpressure Level from Center of Flammable Vapor Cloud
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	Rupture	Downwind	42 feet	18 feet
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	Rupture	Upwind	42 feet	17 feet
Segment 2B - South Street Block Valve to Paramount Refinery	Rupture	Downwind	57 feet	23 feet
Segment 2B - South Street Block Valve to Paramount Refinery	Rupture	Upwind	57 feet	23 feet
Segment 1 - Carson Plant to Dominguez Pump Station ASV	1-inch	Downwind	13 feet	5 feet
Segment 1 - Carson Plant to Dominguez Pump Station ASV	1-inch	Upwind	13 feet	5 feet
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	1-inch	Downwind	15 feet	6 feet
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	1-inch	Upwind	15 feet	6 feet
Segment 2B - South Street Block Valve to Paramount Refinery	1-inch	Downwind	15 feet	6 feet
Segment 2B - South Street Block Valve to Paramount Refinery	1-inch	Upwind	15 feet	6 feet

For the individual risk analyses presented herein, we have conservatively assumed that 100% of the releases are jet fires, not explosions. The conservatism can be demonstrated by comparing the jet fire and explosion results for a complete full-bore rupture from Segment 1 (downwind):

- Jet Fire – 100% mortality (12,000 btu/hr-ft² isopleth) within an area of approximately 342 feet². Assuming a population density of 10,000 persons per square mile, this would yield a 1 in 8.2 likelihood of fatality (1.23 x 10⁻¹) for a jet fire.
- Explosion – Approximately 1% mortality within a radius of 30-feet from the center of the vapor cloud with a conservative area of $\pi * 30\text{-feet}^2 = 2,827 \text{ feet}^2$ (conservatively, as the shape of the vapor cloud is not actually a circle and a large portion would be located overhead). Assuming the same population density of 10,000 persons per square mile, this would yield a 1 in 99 likelihood of fatality (1.01x 10⁻²) for an explosion.



As a result, for a given population density, a jet fire resulting from a complete full-bore rupture from Segment 1 (downwind) is more than 10 times more likely to result in a fatality than a hydrogen vapor cloud explosion.

7.3 Flash Fires

Flash fires can occur when a vapor cloud is formed, with some portion of the vapor cloud within the combustible range, and the ignition is delayed. In a flash fire, the portion of the vapor cloud within the combustible range burns very quickly, reducing the potential impacts to humans.

Like explosions, for the purposes of this analysis for an unintentional hydrogen pipeline release, we have assumed that all releases would be jet fires, not flash fires, for the following reasons:

- Hydrogen has a low ignition energy, meaning that it can be ignited very easily, and often is ignited by static discharge. As a result, delayed ignition, which is required for flash fires, is unlikely.
- Hydrogen has a low molecular weight. As a result, in an unconfined environment, much of the vapor cloud within the combustible range would be well above grade level. As a result, the impact area to humans would normally be smaller than that for jet fires. Thus, assuming all releases result in jet fires is conservative. (It should be noted that this is not the case for confined hydrogen gas and air mixtures.)
- As stated in the Handbook of Fire and Explosion Protection Engineering Principles, “If a combustible gas release is not ignited immediately, a vapor plume will form. This will drift and be dispersed by the ambient winds or natural ventilation. If the gas is ignited at this point, but does not explode, it will result in a flash fire, in which the entire gas cloud burns very rapidly. It is unlikely to cause any fatalities but will damage steel structures. If the gas release has not been isolated during this time, the flash fire will burn back to a jet fire at the source of the release. A flash fire is represented by its limiting envelope, since no damage is caused beyond it. This envelope is usually taken as the LFL of the gas cloud.”

The location of the vapor cloud would depend on the wind. This is depicted in the graphics below, which depict the flammable portion of the vapor cloud. The area within the blue line is the combustible portion of the vapor cloud. It should be noted that explosion and flash fire modeling was performed using a wind speed of 2 meters per second (4.5 miles per hour); this wind speed most often results in the greatest impacts.

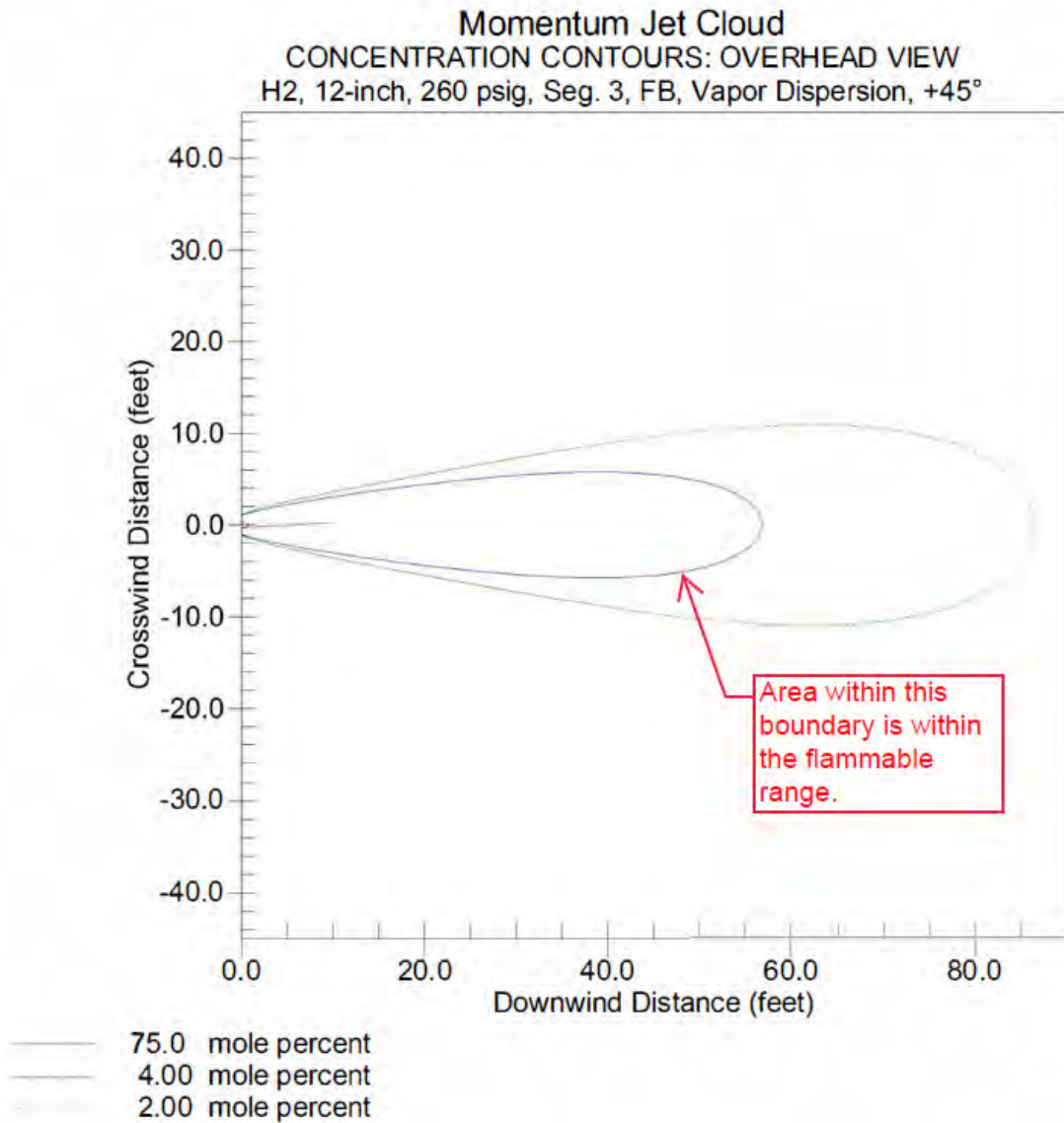


Figure 7.3-1 – Plan View of Flammable Hypothetical Vapor Cloud, Downwind Release at 45 Degrees Above Horizon

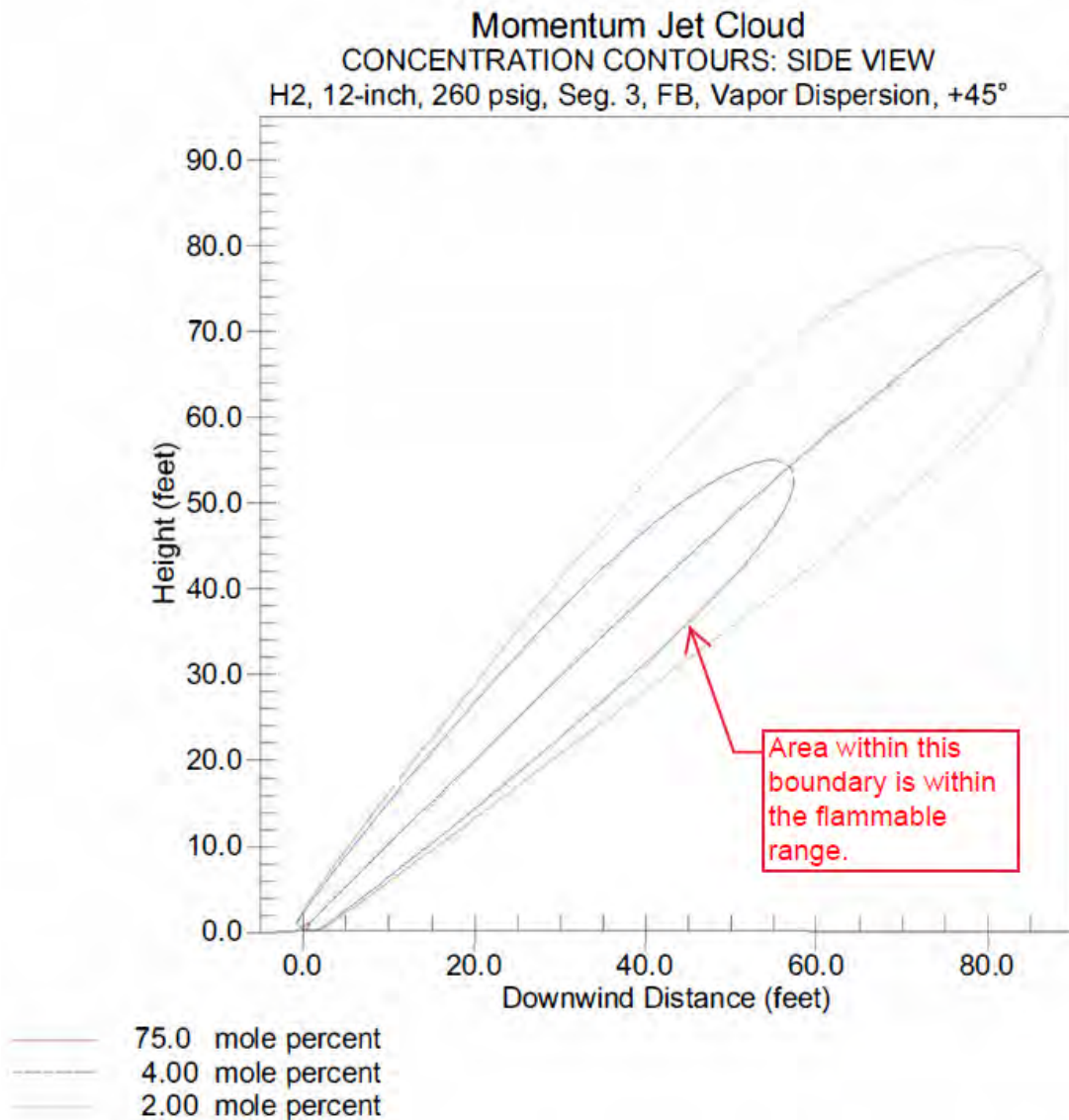


Figure 7.2-2 – Elevation View of Hypothetical Vapor Cloud, Downwind Release at 45 Degrees Above Horizon

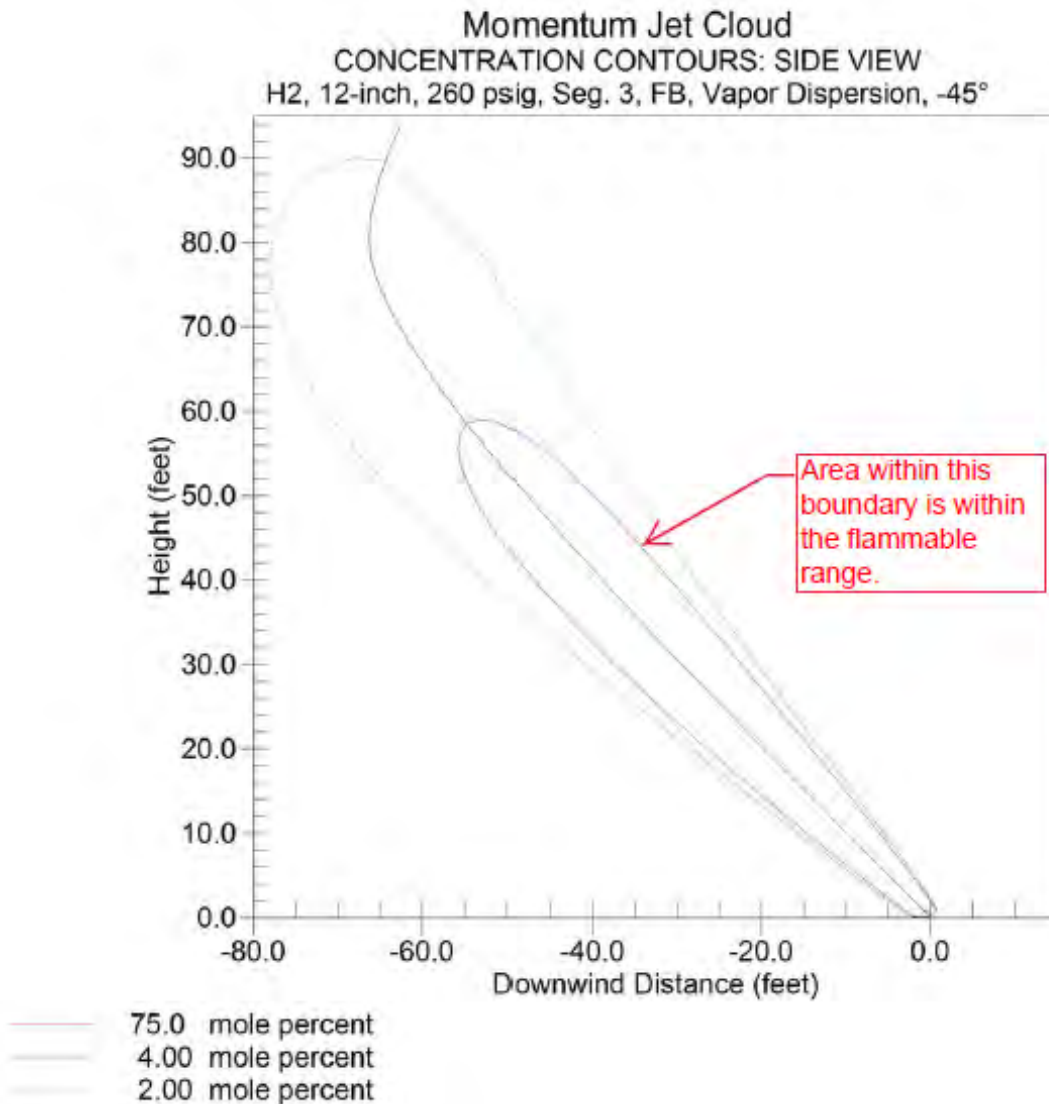


Figure 7.2-3 – Elevation View of Hypothetical Flammable Vapor Cloud, Upwind Release at 45 Degrees Above Horizon

For completeness, the flash fire vapor cloud parameters are presented below for a variety of releases.



Table 7.3-1– Flash Fire Modeling Results³³

Segment	Size of Release	Release Relative to Wind	Width of Combustible Vapor Cloud Measured Parallel to Pipeline	Length of Combustible Vapor Cloud Measured Perpendicular to Pipeline
Segment 1 - Carson Plant to Dominguez Pump Station ASV	Rupture	Downwind	7.4 feet	22 feet
Segment 1 - Carson Plant to Dominguez Pump Station ASV	Rupture	Upwind	1.4 feet	21 feet
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	Rupture	Downwind	7.8 feet	48 feet
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	Rupture	Upwind	1.4 feet	48 feet
Segment 2B - South Street Block Valve to Paramount Refinery	Rupture	Downwind	11.6 feet	58 feet
Segment 2B - South Street Block Valve to Paramount Refinery	Rupture	Upwind	2.0 feet	57 feet
Segment 1 - Carson Plant to Dominguez Pump Station ASV	1-inch	Downwind	2.4 feet	16 feet
Segment 1 - Carson Plant to Dominguez Pump Station ASV	1-inch	Upwind	0.4 feet	16 feet
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	1-inch	Downwind	2.6 feet	18 feet
Segment 2A - Dominguez Pump Station ASV to South Street Block Valve	1-inch	Upwind	0.4 feet	18 feet
Segment 2B - South Street Block Valve to Paramount Refinery	1-inch	Downwind	2.6 feet	18 feet
Segment 2B - South Street Block Valve to Paramount Refinery	1-inch	Upwind	0.4 feet	18feet

³³ The length and width dimensions are provided at a receptor height of 6-feet above grade. At lower elevations, the impact area is smaller.



8.0 Conditional Probabilities

8.1 Baseline Incident Rate

The individual risk analyses assumed that the baseline incident rate was 0.2906 reportable incidents per 1,000 mile-years. This is the frequency of onshore U.S. gas transmission lines from 2010 through 2018, as presented earlier, in Section 5.1.

8.2 Pipeline Operability

The analyses assumed that the Air Products hydrogen pipeline would be operational one-hundred percent (100%) of the time, at a pressure of 260 psig.

8.3 Release Size

The analyses assumed that fifteen percent (15%) of the releases were full bore ruptures, with a cross sectional area equal to the pipe diameter. We have assumed that the remaining eight-five percent (85%) were leaks. This is based on the U.S. onshore gas transmission pipeline data presented in Section 5.1. For the leaks, we have assumed a 1-inch diameter hole in the pipe wall.

8.4 Release Angle

The analyses assumed that all releases would occur at 45 degrees above the horizon³⁴. We believe that this is a reasonable assumption, for the following reasons:

- Releases at greater angles above the horizon (more vertical) would result in smaller impact areas.
- Releases at a smaller angle above the horizon (more horizontal) would result in greater impact areas if they were unimpeded. However, for these releases, the effects of the soils surrounding the pipe would tend to restrict the flow of hydrogen, redirecting it to a more vertical flow, reducing the impact areas.

8.5 Wind Direction

The modeling assumed that 50% of the releases were upwind and 50% were downwind. The wind was assumed to blow perpendicular to the pipeline.

The wind was assumed to blow in a single direction 100% of the time (prevailing wind). This results in the highest individual risk. To the extent that the wind blows in the other direction, the individual risk at a given distance from the pipeline would be reduced; however, the downwind

³⁴ It should be noted that all 45-degree releases were evaluated as unimpeded. The effects of the soils surrounding the pipe, roadway paving, etc. have not been considered. These parameters would tend to deflect the releasing hydrogen to a more vertical release, reducing the impact areas.



impacts would be mirrored to the other side (upwind side) of the pipe. (See individual risk transects presented in Section 9.0.)

8.6 Probability of Ignition

The analyses assumed that 100% of the releases would be ignited as hydrogen gas has a low ignition energy; it is easily ignited, often by static discharge.

8.7 Jet Fires, Explosions, and Flash Fires

The analyses assumed that 100% of the releases would result in jet fires for the reasons cited in Sections 7.2, 7.3 and 8.6.

8.8 Likelihood of Fatal Injuries

The following radiant heat flux exposure mortality end points have been used in the individual risk assessments:

- 12,000 Btu/ft²-hr (37.7 kW/m²) – 100% mortality
- 8,000 Btu/ft²-hr (25.1 kW/m²) – 50% mortality
- 5,000 Btu/ft²-hr (15.7 kW/m²) – 1% mortality

8.9 Likelihood of Exposure

Santa Barbara County and other agencies adjust the individual risk to consider the probability of exposure. As noted in the Santa Barbara County Environmental Thresholds and Guidelines Manual, “Staff adjusts the Individual Risk to reflect conditional probabilities, called the Individual Specific Risk. Such probabilities address factors such as number of hours in the day in which someone is present in the hazard zone. A measurement of one in a million (1 x 10⁻⁶) on an annual basis indicates sufficient evidence to trigger the risk thresholds and a comprehensive risk analysis.”

For those located outdoors, they would be unprotected from radiant heat from a fire. However, the likelihood of a fatality from the radiant heat flux would depend on whether or not persons were present.

The California Department of Education (CDE), Guidance Protocol for School Site Pipeline Risk Analysis, which is used to select safe school sites, uses the following probabilities of exposure:

- Likelihood of Occupancy - A probability of occupancy of 16% (180 days per year x 8 hours per day) is used.
- Likelihood of Outdoor Exposures - A probability of outdoor exposure of 25% (2 hours of 8 hours) is used.
- Likelihood of Outdoor Exposure - As a result, the combined likelihood of exposure is assumed to be 4% of the year (15% of 25% = 4%).



Lee's Loss Prevention in the Process Industries publishes various data to support the assessment of hazards. They publish the following data for the portion of the population exposed outdoors³⁵:

- Regular Population – 1 hour per day or 4.2% of the time
- Vulnerable Population (children, those infirmed, the elderly, etc.) – 0.5 hours per day or 2.1% of the time
- Total Population – 0.88 hours per day, 3.7% of the time

The National Human Activity Patter Survey (NHAPS): A Resource for Assessing Exposure to Environmental Pollutants, provides the following data regarding outdoor exposures based on a study of 9,196 participants. These results (7.6%) are reportedly consistent with U.S. and Canadian time budgets reported by various other authors which reported that respondents spent 6% of their time outdoors over a ten-year period.

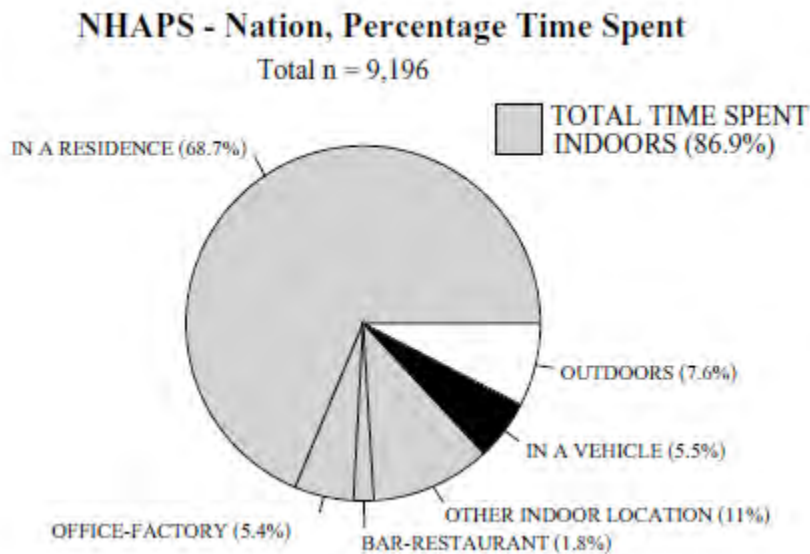


Figure 8.9-1 Percentage of Time Spent (NHAPS 2001)

It is interesting to note that throughout the participants, there was very little variation in the amount of time spent outdoors. The results are shown on the histogram below.

³⁵ These data were cross checked by the authors using wartime data for rocket bomb casualties.

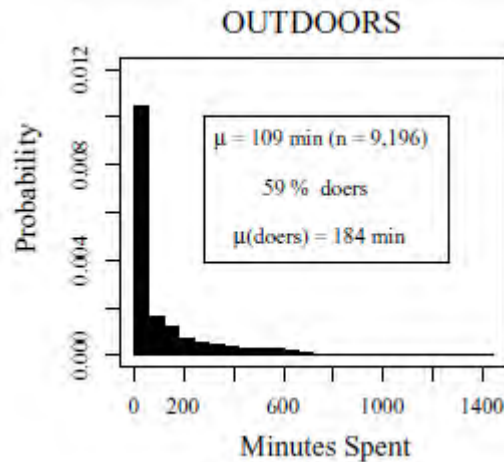


Figure 8.9-2 Histogram for NHAPS Participants Time Outdoors (minutes per day)

The Committee for the Prevention of Disasters Caused by Dangerous Substances, “Green Book”, Methods for the Determination of Possible Damage, provides the following references regarding the likelihood of outdoor exposure.

- Past TNO studies
 - Daytime – 80% indoors and 20% outdoors
 - Nighttime – 95% indoors and 5% outdoors
- COVO study and Technica program
 - 1% outdoors
 - 99% indoors
- Hardee and Lee
 - Vulnerable Population (25% of population) – one-half hour per day outdoors
 - Remainder of Population (75% of population) – one hour per day outdoors

The “Green Book” also cites some references regarding how individuals split their time.

- Home Indoors – 69% of the time
- Somewhere Else, Indoors – 24% of the time
- Outdoors (includes travel time) – 7% of the time

The above data sources cite a wide range of times when individuals are outside versus indoors. The percentages of time for outdoor exposures range from a low of 1% to a high of 12.5% (average of 20% day and 5% night). During travel time, individuals are protected in the automobiles or other means of transportation.

For the analyses presented herein, we have used an average outdoor exposure probability of 7.6%, based on the NHAPS publication. This is somewhat conservative as other sources report values between 1% and 7%.



In this analysis, we have not considered risks to those indoors for the following reasons:

- Separation Distance – The proposed pipeline is located within the City streets. It is tens of feet from nearby residences.
- Relatively Small Impact Distances – As noted in Section 7.1, the impact distances are relatively short.
- Unlikely Ignition of Structures – The “Green Book” cites references indicating that wood may be damaged at level 1 (catch fire) after a 30-minute exposure with a radiant heat intensity of 15 btu/hr-ft². For a “blocked in” pipe segment, without blowing down the pipeline to the flare, as presented in Section 7.1.3, the maximum release times are as follows:

Full Bore Rupture – The flow from the pipeline will cease after 5 to 8 minutes, depending on pipe segment.

1-inch Leak – These releases have very small impact distances. The flow from the pipeline will cease after 7 to 120 minutes, depending on pipe segment. However, the maximum extent of the 12,000 btu/hr-ft² isopleth only extends a maximum of 15 feet from the release and are unlikely to reach an existing structure.

- Ability to “Blow Down” – Air Products can automatically blow down the pipeline to the flare in the event of a release. This will significantly reduce the exposure times cited above.
- Evacuation – In the event of a pipeline release threatening nearby structures, emergency responders would likely implement evacuations within 30 minutes of release.

8.10 Likelihood of Human Response

The natural human response to a fire is to seek shelter. This may be done by seeking shelter, trying to distance oneself from the hazard, etc. However, the ability of a human to seek shelter depends on their reaction time. Research has shown that humans have various responses to unexpected situations. Specifically, as stated in the “Green Book”:

- 5% of the population are incapable of any reaction
- 95% of the population are capable of reaction, of whom 80% react within 15 seconds, 25% react within 10 seconds, and 10% can react within 7.5 seconds (Mannan)³⁶.

In the individual risk assessment presented, the likelihood of human response has not been considered. The analyses summarized herein assumed that 100% of the population was incapable of any reaction. Further, the endpoints used in the jet fire analyses are for a 30 second exposure. As noted above, 95% of the population would likely react in less than this much time resulting in less severe injuries than predicted herein.

³⁶ The data is correct and does not sum to 100% for unknown reasons.



9.0 Individual Risk Assessment

Individual risk (IR) is most commonly defined as the frequency that an individual may be expected to sustain a given level of harm from the realization of specific hazards, at a specific location, within a specified time interval. Individual risk is typically measured as the probability of a fatality per year. The risk level is typically determined for the maximally exposed individual; in other words, it assumes that a person is present continuously – 24 hours per day, 365 days per year. The likelihood is most often expressed numerically, using one of the values shown in Table 9.0-1 below. The values shown on each row may be used interchangeably.

Table 9.0-1 Individual Risk Numerical Values

Annual Likelihood of Fatality	Numerical Equivalent	Scientific Notation	Shorthand
1 in 100	1.0×10^{-2}	1.0 E-2	10^{-2}
1 in 1,000	1.0×10^{-3}	1.0 E-3	10^{-3}
1 in 10,000	1.0×10^{-4}	1.0 E-4	10^{-4}
1 in 100,000	1.0×10^{-5}	1.0 E-5	10^{-5}
1 in 1,000,000	1.0×10^{-6}	1.0 E-6	10^{-6}
1 in 10,000,000	1.0×10^{-7}	1.0 E-7	10^{-7}

The individual risks are most often presented graphically. These figures present risk transects, which show the annual risk of fatality resulting from a pipeline release as a function of the distance from the center of the unintentional release.

9.1 Segment 1 - Carson Plant to Dominguez Pump Station ASV

In this section, the individual risk posed by Segment 1 will be presented. For the purposes of this study, Segment 1 is that portion of the system between the Air Products Carson Plant and the Dominguez Pump Station ASV. The release modeling was conducted for an 8-inch nominal diameter pipe.

The individual risk maximum annual probability of fatality from Segment 1 was estimated at 2.86×10^{-8} (1 in 35.0 million). The estimated maximum downwind distance to potentially fatal impacts, measured from the release is 27 feet. The estimated maximum upwind distance to potentially fatal impacts, measured from the release is 4 feet. The maximum individual risk is presented in the figure below, as a function of the distance from the pipeline release.

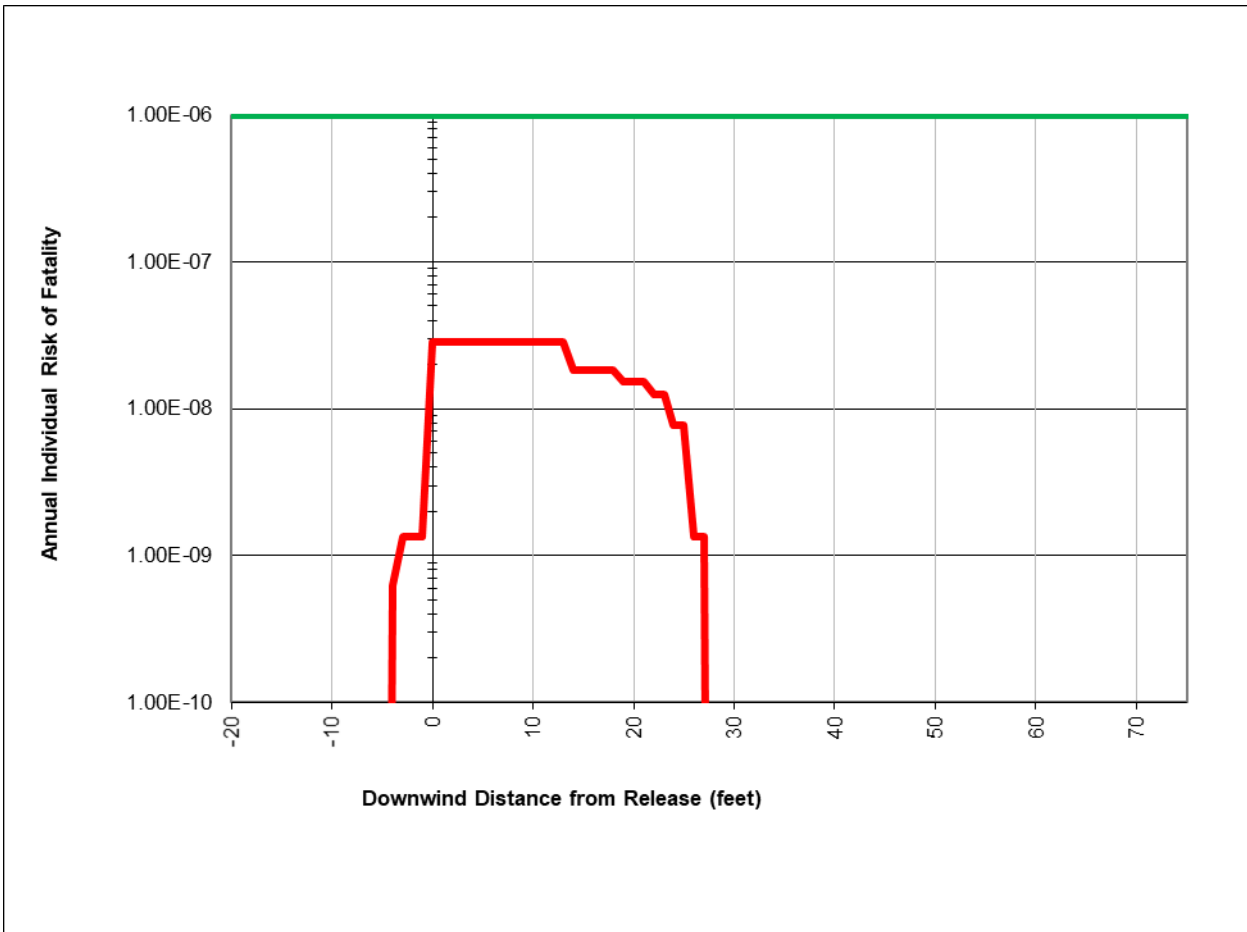


Figure 9.2-1 Individual Risk Transect, Segment 1 - Carson Plant to Dominguez Pump Station ASV

It should be noted that the individual risk results are below the threshold of 1.0×10^{-6} (1 in 1.0 million)³⁷. The ratio of the individual risk to this threshold is 0.029.

Based on these results, further analysis would not be required if this project were in Santa Barbara County.

9.2 Segment 2A - Dominguez Pump Station ASV to South Street Block Valve

In this section, the individual risk posed by Segment 2A will be presented. For the purposes of this study, Segment 2A is that portion of the system between the Dominguez Pump Station ASV and the South Street Block Valve.

The individual risk maximum annual probability of fatality from Segment 2 was estimated to be 3.37×10^{-8} (1 in 29.7 million). The estimated maximum downwind distance to potentially fatal impacts, measured from the release is 63 feet. The estimated maximum upwind distance to

³⁷ See Section 3.2 of this Report for a discussion of individual risk criteria.



potentially fatal impacts, measured from the release is 14 feet. The maximum individual risk is presented in the figure below, as a function of the distance from the pipeline release.

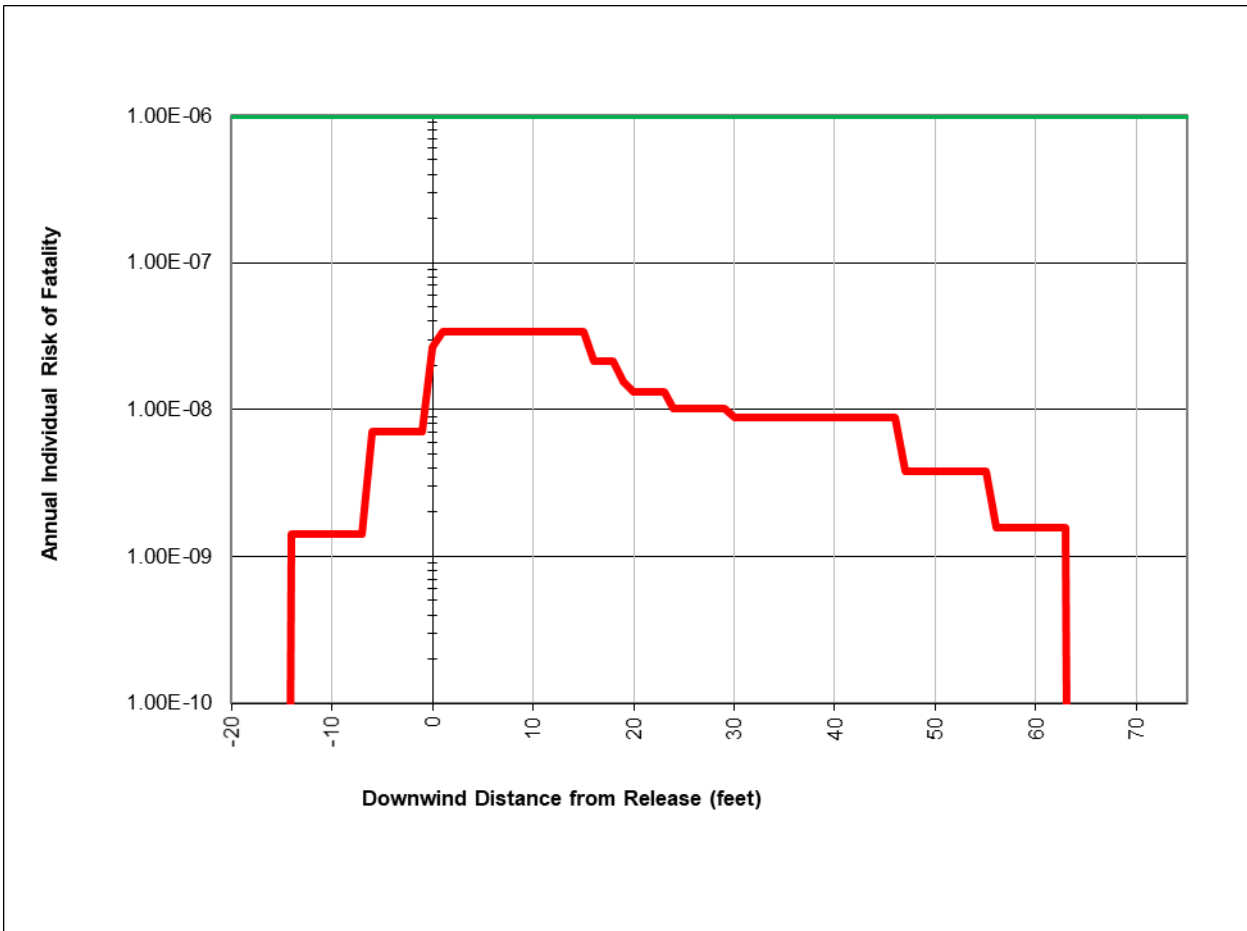


Figure 9.2-2 Individual Risk Transect, Segment 2A - Dominguez Pump Station ASV to South Street Block Valve

It should be noted that the individual risk results are below the threshold of 1.0×10^{-6} (1 in 1.0 million)³⁸. The ratio of the individual risk to this threshold is 0.034.

Based on these results, further analysis would not be required if this project were in Santa Barbara County.

9.3 Segment 2B - South Street Block Valve to Paramount Refinery

In this section, the individual risk posed by Segment 2B will be presented. For the purposes of this study, Segment 2B is that portion of the system between the South Street ASV and the Paramount Refinery.

³⁸ See Section 3.2 of this Report for a discussion of individual risk criteria.



The individual risk maximum annual probability of fatality from Segment 3 was estimated to be 4.29×10^{-8} (1 in 23.3 million). The estimated maximum downwind distance to potentially fatal impacts, measured from the release is 76 feet. The estimated maximum upwind distance to potentially fatal impacts, measured from the release is 19 feet. The maximum individual risk is presented in the figure below, as a function of the distance from the pipeline release.

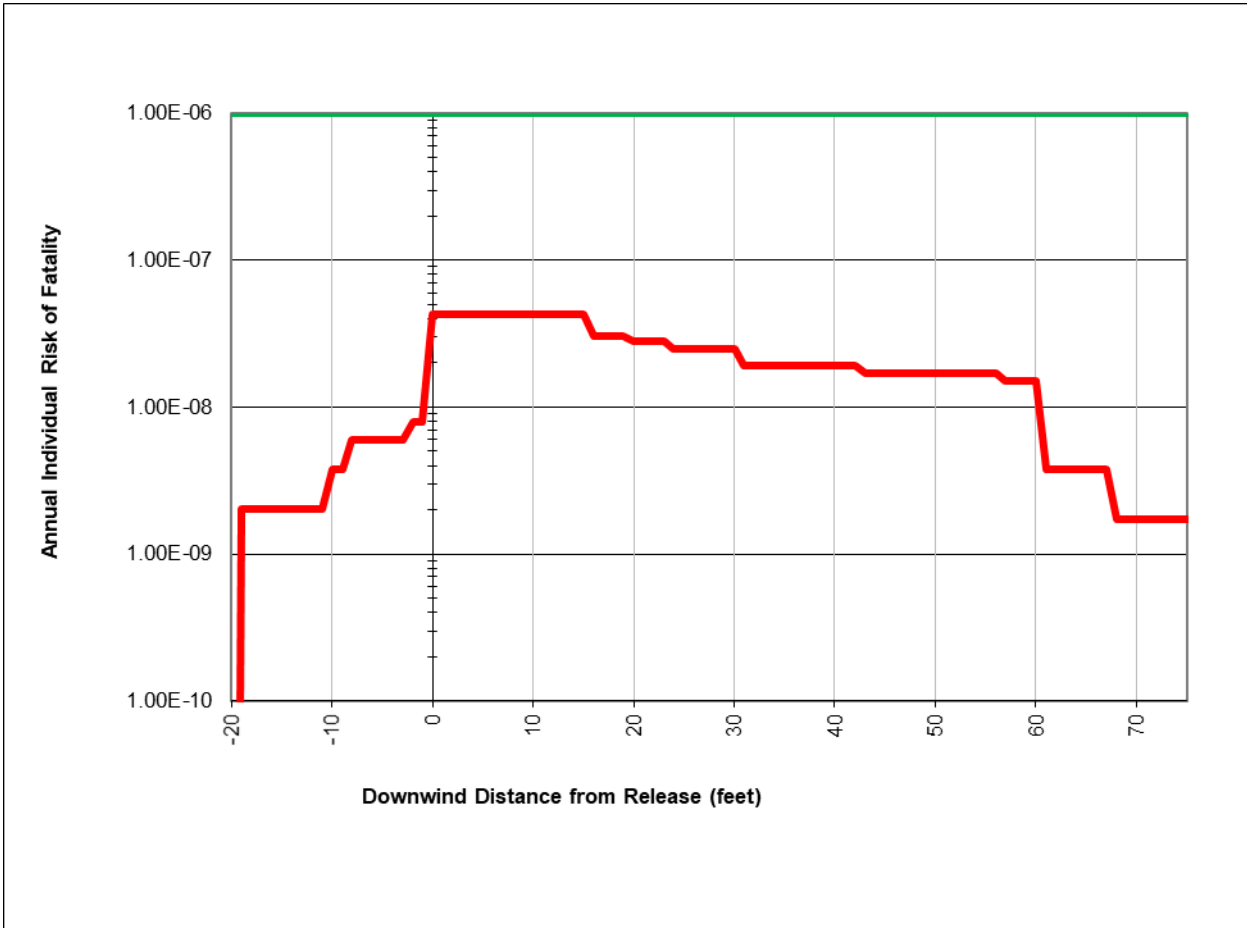


Figure 9.2-3 Individual Risk Transect, Segment 2B - South Street Block Valve to Paramount Refinery

It should be noted that the individual risk results are below the threshold of 1.0×10^{-6} (1 in 1.0 million)³⁹. The ratio of the individual risk to this threshold is 0.043.

Based on these results, further analysis would not be required if this project were in Santa Barbara County.

³⁹ See Section 3.2 of this Report for a discussion of individual risk criteria.



10.0 References

10.1 Acronyms

ALARP - As Low as Reasonably Practicable

ANSI - American National Standards Institute

API - American Petroleum Institute

API 5L X52 – Pipe manufactured in accordance with API Standard 5L, Specification for Line Pipe, with a specified minimum yield strength of 52,000 psi

ASME - American Society of Mechanical Engineers

ASV – Automated Shut-Off Valves

ASTM - American Society for Testing and Materials

CFR - Code of Federal Regulations

CPUC – California Public Utilities Commission

CSC – Control Support Center

CWA - Clean Water Act

EIS – Environmental Impact Statement

HLPSA - Hazardous Liquid Pipeline Safety Act

HMI – Human Machine Interface

IR – Individual Risk

LFL – Lower Flammability Limit

MIE – Minimum Ignition Energy

MMSCFD – Million Standard Cubic Feet per Day

MSS - Manufacturers Standardization Society of the Valve and Fittings Industry

NFPA – National Fire Protection Association

NTSB – National Transportation Safety Board



OPS – Office of Pipeline Safety

PHMSA - The Pipeline and Hazardous Materials Safety Administration

PLDS - Pipeline Leak Detection System

PLL - Probable Loss of Life

PPM – Parts per Million

PSI – Pounds per Square Inch

RSPA - Research and Special Programs Administration

RTU – Remote Terminal Unit

SCADA – Supervisory Control and Data Acquisition

SMYS – Specified Minimum Yield Strength

SPCC - Oil Spill Prevention Control & Countermeasures

UFL – Upper Flammability Limit

UPS – Uninterruptable Power Source

USA - Unusually Sensitive Areas

USC – United States Code

USDOT - United States Department of Transportation

10.2 Definitions

Aggregate Risk - Aggregate risk, or probable loss of life (PLL), is one risk measure used to evaluate projects. Aggregate risk is the total anticipated frequency of a consequence, normally fatalities, that could be anticipated over a given time period, for all project components being analyzed. Aggregate risk is a type of risk integral; it is the summation of risk, as expressed by the product of the anticipated consequences and their respective likelihood. The integral is summed over all the potential events that might occur for all of the project components, over the entire project length.

Bright Line Threshold - A bright-line rule (or bright-line test) is a clearly defined rule or standard, composed of objective factors, which leaves little or no room for varying interpretation. The purpose of a bright-line rule is to produce predictable and consistent results in its application. The term "bright-line" in this sense generally occurs in a legal context.



Bright-line rules are usually standards established by courts in legal precedent or by legislatures in statutory provisions.

De Manifestus - ALARP (as low as reasonably practical) principle states that there is a level of risk that is intolerable, sometimes called the de manifestus risk level. Above this level risks cannot be justified.

De Minimus - Latin term for "of minimum importance" or "trifling." Essentially it refers to something or a difference that is so little, small, minuscule, or tiny that the law does not refer to it and will not consider it. In a million-dollar deal, a \$10 mistake is de minimus.

Flammability Limit - Flammable liquid only burns in its gaseous state. If the ratio of fuel to air is greater than the upper flammability limit, the mixture is too rich to burn; if it is less than the lower flammability limit, the mixture is too lean to burn. (The mixture will only burn in gaseous state, between the upper and lower flammability limit.)

Flash Fire – A flash fire is a rapidly burning gas or vapor cloud of short duration. The duration lasts until all vapor and oxygen in the cloud is consumed. The duration of the flash fire at any point in the space depends on the concentration of the flammable vapor in air and the specific vapor substance involved. (CDE 2005)

Incidents per 1,000-mile years - This unit provides a means of predicting the number of incidents for a given length of line, over a given period. For example, if one considered an incident rate of 1.0 incidents per 1,000 miles years, one would expect one incident per year on a 1,000-mile pipeline. Using this unit, frequencies of occurrence can be calculated for any combination of pipeline length and time interval.

Jet Fire - A jet fire is a flame resulting from the combustion of a fuel being continuously released with significant momentum in a particular direction.

Individual Risk - Individual risk (IR) is most commonly defined as the frequency that an individual may be expected to sustain a given level of harm from the realization of specific hazards, at a specific location, within a specified time interval. Individual risk is typically measured as the probability of a fatality per year. The risk level is typically determined for the maximally exposed individual; in other words, it assumes that a person is present continuously – 24 hours per day, 365 days per year.

Isopleth – A line connecting points at which a given variable has a specified value. In this context, the line connects points of a specified heat flux value.

Pasquill-Gifford Atmospheric Stability – This is classified by the letters A through F. Stability can be determined by three main factors: wind speed, solar insolation, and general cloudiness. In general, the most unstable (turbulent) atmosphere is characterized by stability class A. Stability A occurs during strong solar radiation and moderate winds. This combination allows for rapid fluctuations in the air and thus greater mixing of the



released gas with time. Stability D is characterized by fully overcast or partial cloud cover during daytime or nighttime and covers all wind speeds. The atmospheric turbulence is not as great during D conditions, so the gas will not mix as quickly with the surrounding atmosphere. Stability F generally occurs during the early morning hours before sunrise (no solar radiation) and under low winds. This combination allows for an atmosphere which appears calm or still and thus restricts the ability to actively mix with the released gas. A stability classification of “D” is generally considered to represent average conditions.

10.3 Reference Documents

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Appendix A –Pipeline Risks Near Existing Schools

A.1 Introduction

Along the pipeline route, there are sixteen (16) schools within one-quarter mile of the pipeline alignment. These schools and the nearest distance to each are listed in the table below.

Table A.1-1 Schools within One-Quarter Mile of Pipeline

School Name	Address	Location Pipeline Segment	Distance to School Property Boundary (feet)	Distance to First Building/Playground (feet)
Dooley Elementary	5075 Long Beach Blvd. Long Beach	2A	5	10
Perry Lindsey Middle School	5075 Daisy Avenue, Long Beach	2A	12	29
Alondra Middle School	16200 Downey Avenue, Paramount	2B	17	85
Lindbergh Middle School	1022 E. Market Street, Long Beach	2A	55	89
Paramount High School	14429 Downey Avenue, Paramount	2B	70	70
St. Athanasius Elementary	5369 Linden Ave., Long Beach	2A	368	368
Maj. Lynn Mokler Elementary School	8571 Flower Street, Paramount	2B	385	385
Harry Wirtz Elementary	8535 Contreras St., Paramount	2B	386	386
Jefferson Elementary School	8600 Jefferson Street, Paramount	2B	473	500
Cpt. Raymond Collins Elementary School	6125 Coke Avenue, Long Beach	2B	475	475
St. Pancratius Parish School	3601 St. Pancratius Place, Lakewood	2B	564	595
Buena Vista High School	3717 Michelson Street, Lakewood	2B	788	788
Harte Elementary	1671 E. Phillips St., Long Beach	2A	968	1,041
Paramount Alternative Education Center	3701 Michelson St., Lakewood	2B	1,060	1,060
Addams Elementary School	256 E. Plymouth Street, Long Beach	2A	1,189	1,432



School Name	Address	Location Pipeline Segment	Distance to School Property Boundary (feet)	Distance to First Building/Playground (feet)
Creative Day Academy	8740 Ramona Street, Bellflower	2B	1,723	1,723

The California Department of Education (CDE), School Facilities Planning Division has established standards for use by Local Educational Agencies in the safe and educationally appropriate school sites. The CDE requires that when seeking approval for new construction or modernization plans on existing school sites, the Local Educational Agencies certify that the project will not create nor substantially exacerbate an existing safety hazard, including those related to pipelines.

Although this project does not involve the new construction or modernization plans on existing school sites, an analysis has been performed to document the potential risks at these facilities from the proposed hydrogen pipeline. These analyses have been performed in accordance with the CDE, Guidance Protocol for School Site Pipeline Risk Analysis (Protocol).

A.2 Methodology

As stated in Section 2.5 of the Protocol, “The fundamental risk calculations for the CDE risk evaluation process is the estimated Individual Risk (IR). IR is defined as the annual probability of fatality resulting from a pipeline failure and product release for an individual at the property line or boundary between the usable and occupied portion of a school sites for a defined level of occupancy (fraction of time at the school site) and outdoor exposure(fraction of time outdoors at the school site).

Since this proposed pipeline system will transport hydrogen, which is not covered by the Protocol, a Stage 3 analysis has been performed. However, the Stage 3 analysis incorporated the CDE recommended Stage 2 methodology.

The baseline incident rate of 0.2906 reportable incidents per 1,000 mile-years (2.9×10^{-4} mile-year). This is the frequency of onshore U.S. gas transmission pipeline incidents from 2010 through 2018, as presented earlier, in Section 5.1. This incident frequency is much higher than the 0.12 incidents per 1,000 mile-years (1.2×10^{-4} mile-year) used in the Protocol.

Each of the schools near the proposed pipeline lie along either pipeline Segment 2 or Segment 3. Releases were modeled from the pipeline for each of these two pipeline segments, at the location of the school nearest the pipeline. For pipeline segment 2, the Dooley Elementary school property boundary is 5-feet from the pipeline. For pipeline segment 3, the Alondra Middle School property boundary is 17-feet from the pipeline.



A.3 Conditional Probabilities

The school site analyses used the same conditional probabilities as those stated in Section 8.0 of this report, except as noted below.

A.3.1 Release Size

Consistent with the CDE Protocol, the school analyses assumed that twenty percent (20%) of the releases were full bore ruptures, with a cross sectional area equal to the pipe diameter. We have assumed that the remaining eight percent (80%) were leaks. (For the leaks, we have assumed a 1-inch diameter hole in the pipe wall.) This is slightly different than the conditional probabilities used in the report, which were based on the U.S. onshore gas transmission pipeline data presented in Section 5.1 (15% ruptures and 85% leaks).

A.3.2 Release Angle and Wind Direction

A vertical release has been modeled for these analyses. This is different than the release angles considered in the earlier which considered a 45-degree release above the horizon, with 50% occurring in the downwind direction and 50% in the upwind direction. (See Sections 8.4 and 8.5 of report.)

A.3.3 Probability of Ignition

The CDE protocol recommends a 30% probability of ignition for a leak and 45% probability of a rupture from a gas pipeline. However, these values are not appropriate for hydrogen. A 100% probability of ignition has been used in the school site analyses.

A.3.4 Probabilities of Explosion, Flash Fire, and Jet Fire

The CDE protocol recommends 1%, 1% and 98% probabilities of explosion, flash fire, and jet fire respectively for ignited release from gas pipelines. However, these values are not appropriate for hydrogen. The school site analyses assumed that 100% of ignited releases would result in jet fires. This is conservative for the reasons stated in Section 8.7 of this report.

A.3.5 Probability of Exposure

Based on the CDE protocol, the school site analyses assumed that the probability of occupancy is 16% and the probability of outdoor exposure is 25%. The resulting probability of exposure is 4% (16% x 25% = 4%).

A.4 Modeling Parameters

The school site release modeling was performed using CARNARY software, by Quest Consultants. The input parameters are shown in the table below; these parameters are consistent with those used in the CDE protocol follows:



Table A.4-1 Release Modeling Input

Parameter	Model Input
Nominal Pipe Diameter	8-inches and 12-inches
Normal Operating Pressure	260 psig
Average Flow Rate	7 MMSCFD
Pipe Contents Temperature	60 degrees F
Release Angle	Vertical
Wind Speed ⁴⁰	3.0 meters per second (6.7 miles per hour) Directed Toward School (worst case)
Stability Class	D - Pasquill-Gifford atmospheric stability is classified by the letters A through F. Stability can be determined by three main factors: wind speed, solar insolation, and general cloudiness. In general, the most unstable (turbulent) atmosphere is characterized by stability class A. Stability D is characterized by fully overcast or partial cloud cover during daytime or nighttime and covers all wind speeds. The atmospheric turbulence is not as great during D conditions, so the gas will not mix as quickly with the surrounding atmosphere. A stability classification of "D" is generally considered to represent average conditions.
Relative Humidity	50%
Air Temperature	77 degrees F
Surface Temperature	70 degrees F
Spill Surface	Medium Density Concrete
Segment Length	Actual
Fuel Reactivity	High - Most hydrocarbons have medium reactivity, as defined by the Baker-Strehlow method. High reactivity fluids include hydrogen, acetylene, ethylene oxide, and propylene oxide.
Obstacle Density	Low This parameter describes the general level of obstruction in the area including and surrounding the confined (or semi-confined) volume. Low density occurs in open areas or in areas containing widely spaced obstacles. Low obstacle density is appropriate due to the low building density and open space within the pipeline corridor. Normally, the vapor cloud would be located at ground level, near the release; these surroundings are relatively open along the entire pipeline alignment (low obstacle density).
Flame Expansion	3 D - This parameter defines the number of dimensions available for flame expansion. Open areas are 3-D and produce the smallest levels of overpressure. 2.5-D expansions are used to describe areas that quickly transition from 2-D to 3-D. Examples include compressor sheds and the volume under elevated fan-type heat exchangers.

⁴⁰ Sensitivity analyses have been performed for past projects. These wind conditions normally give the highest impact distances.



Parameter	Model Input
Reflection Factor	2 - This factor is used to include the effects of ground reflection when an explosion is located near grade. A value of 2 is recommended for ground level explosions.

A.5 Hazard Lengths

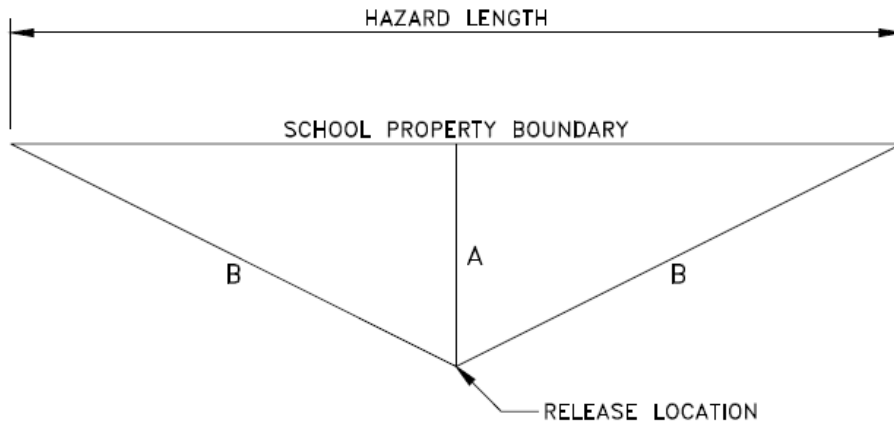
As defined by the Protocol, “the individual hazard segment length “S” segment length (XSEG) is the length of pipe within the segment of concern from which product release would result in a flash fire, jet or pool fire, or explosion, the impacts of which could reach the receptor with potential for fatality at a level of at least 1% mortality.” The hazard length may be calculated using the following equation:

$$XSEG = 2 \times (B^2 - A^2)^{0.5}$$

where:

A = Minimum Distance to School Boundary

B = Maximum Impact Distance



A = DISTANCE TO SCHOOL PROPERTY BOUNDARY
 B = MAXIMUM IMPACT DISTANCE FOR STATED HAZARD

Figure A.5-1 – Hazard Length Determination

In this analysis, endpoints have been determined at 1%, 50% and 100% mortality. This is depicted graphically below. The average mortality between the two endpoints has been used. For example, the area bounded by the 1% and 50% mortality endpoints has an average mortality of 25%; the area bounded by the 50% and 100% mortality endpoints has an average mortality of 75%. The depicted hazard length and corresponding average mortalities have been used.

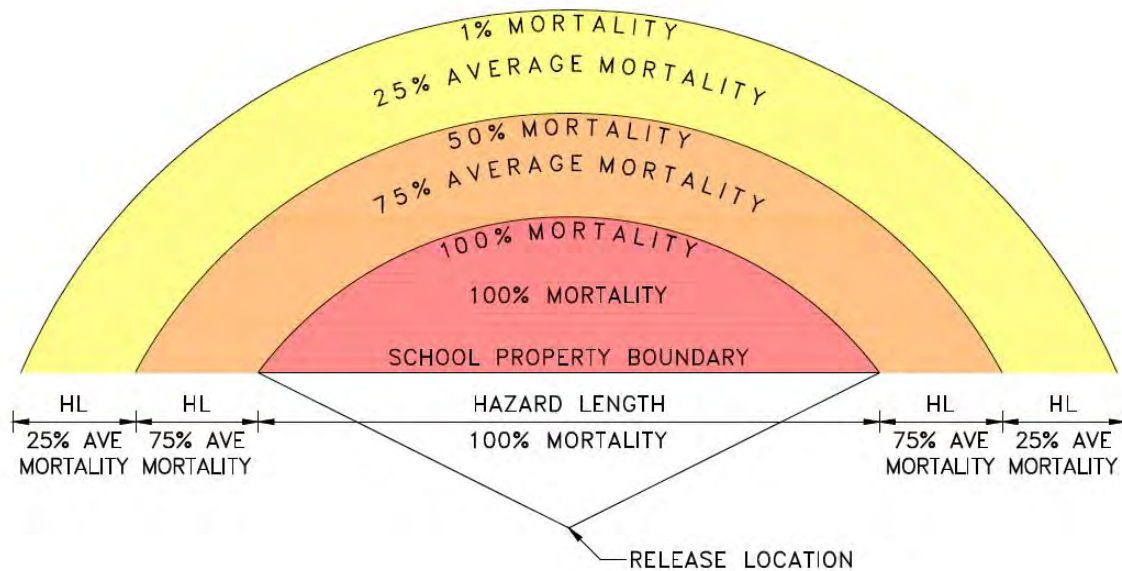


Figure A.5-2 Hazard Length Determination Used in Analyses

It should be noted that the above approach considers a circular hazard footprint. However, the hazard footprint is elliptical in shape, due to wind effects. As a result, the hazard lengths calculated using this approach are longer than their actual length; the results are somewhat conservative.



Appendix B - Dooley Elementary School Risk Assessment (Segment 2A)

B.1 Introduction

Dooley Elementary School is the nearest school to the proposed hydrogen pipeline; the property boundary is only approximately 5-feet from Segment 2A of the pipeline. The school site is located at 5075 Long Beach Boulevard, Long Beach, California. A Google Maps image of the facility is shown below. The pipeline runs along West Del Amo Boulevard.



Figure B.1-1 – Dooley Elementary School Site

B.2 Jet Fire Modeling Results

The jet fire modeling results from Segment 2A, with a release located at this school site are shown in the table below. For the 1-inch leak, the flame is located overhead. At the 6-foot receptor height, the maximum radiant heat flux is 4,810 btu/hr-ft², less than that required to result in fatalities.



Table B2-1 Jet Fire Modeling Results⁴¹

Segment	Size of Release	Horizontal Distance from Unintentional Release to Endpoint Measured Perpendicular to Pipeline (feet) ⁴²		
		Distance from Unintentional Release to Endpoint Measured Parallel to Pipeline (feet)		
		12,000 btu/hr-ft ² 100% Mortality	8,000 btu/hr-ft ² 50% Mortality	5,000 btu/hr-ft ² 1% Mortality
Segment 2A Dooley Elementary School	Rupture	*	21.8	35.1
		*	15.5	25.0
Segment 2A Dooley Elementary School	Leak (1-inch)	*	*	*
		*	*	*

The hazard lengths for each hazard are shown below. These hazard lengths were determined in accordance with the Protocol, as described previously in Section A.5.

Table B2-2 Hazard Lengths

Segment	Size of Release	Hazard Lengths (feet)		
		12,000+ btu/hr-ft ² 100% Mortality	8,000 – 11,999 btu/hr-ft ² 75% Mortality	5,000 – 7,999 btu/hr-ft ² 25% Mortality
Segment 2A Dooley Elementary School	Rupture	0	42.4	27.0
Segment 2A Dooley Elementary School	Leak (1-inch)	0	0	0

B.3 Probability of Fatality

Using the data presented herein, the probabilities of the various incidents have been determined. The results are presented in the table below.

⁴¹ All releases were modeled with an operating pipeline pressure of 260-psig, vertical release angle, at a flow rate of 7 MMSCFD.

⁴² Radiant heat flux values shown are measured at 6-feet above ground surface. The impact distances are less, closer to ground level.

* Indicates that this level of radiant heat flux is not present for the indicated release.



Table B.3-1 Total Annual Probability of Fatality

Release Size	Frequency of Occurrence ⁴³ (per foot per year)	Annual Probability of Fatality ⁴⁴	Annual Probability of Fatality	Annual Probability of Fatality	Total Annual Probability of Fatality
		12,000+ btu/hr-ft ² 100% Mortality	8,000 – 11,999 btu/hr-ft ² 75% Mortality	5,000 – 7,999 btu/hr-ft ² 25% Mortality	
Rupture	4.403E-10	0	1.401E-08	1.964E-09	1.232E-08
Leak (1-inch)	1.761E-9	0	0	0	0

By summing the total annual probabilities of fatality above, for both ruptures and leaks, the total individual risk (TIR) results for this school site are as follows. The total individual risk at this school site is much less than the CDE individual risk criterion.

Total Individual Risk (TIR)	1.232 x 10 ⁻⁸	1 in 81.1 million
CDE Individual Risk Criterion (IRC)	1.000 x 10 ⁻⁶	1 in 1.0 million
TIR / IRC Ratio	0.012	

⁴³ The frequency of occurrence was determined by multiplying the baseline incident rate of 2.9 x 10⁻⁴ incidents per mile-year times the conditional probabilities. For example, the frequency of rupture was determined as follows: 2.9 x 10⁻⁴ incidents per mile-year x 20% probability of rupture x 4% occupancy / 5,280 feet per mile = 4.4 x 10⁻¹⁰ incidents per foot of hazard length per year.

⁴⁴ The annual probabilities of fatality were determined by multiplying the hazard length for each situation times the frequency of occurrence times the probability of mortality. For example, for the pipeline rupture and 8,000 btu/hr-ft² case was determined as follows: 4.403 x 10⁻¹⁰ incidents per foot-year x 42.4-foot hazard length x 75% probability of mortality = 1.401 x 10⁻⁸.



Appendix C – Alondra Middle School Risk Assessment (Segment 2B)

C.1 Introduction

Alondra Middle School is the nearest school to Segment 2B of the proposed hydrogen pipeline; the property boundary is only approximately 17-feet from the pipeline. The school site is located at 16200 Downey Avenue, Paramount, California. A Google Maps image of the facility is shown below. The pipeline runs along North-South along Downey Avenue.

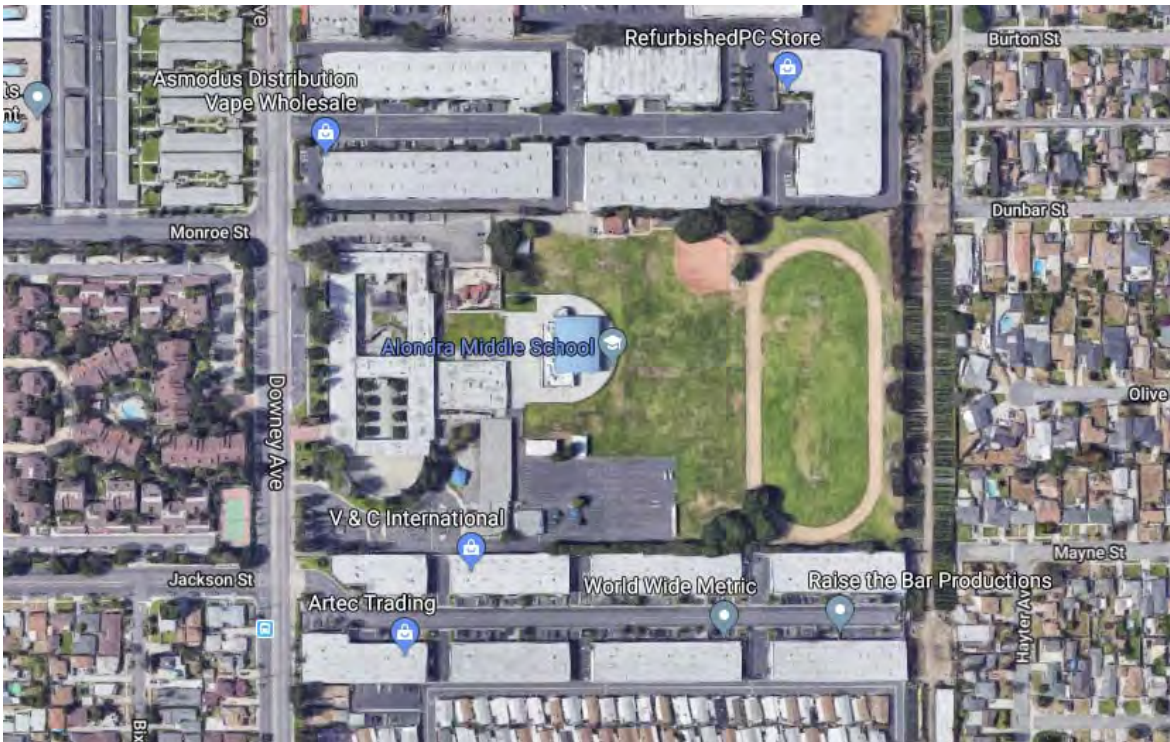


Figure C.1-1 – Alondra Middle School Site

C.2 Jet Fire Modeling Results

The jet fire modeling results from Segment 2B, with a release located at this school site are shown in the table below. For the 1-inch leak, the flame is located overhead. At the 6-foot receptor height, the maximum radiant heat flux is 4,823 btu/hr-ft², less than that required to result in fatalities.



Table C2-1 Jet Fire Modeling Results⁴⁵

Segment	Size of Release	Horizontal Distance from Unintentional Release to Endpoint Measured Perpendicular to Pipeline (feet) ⁴⁶		
		Distance from Unintentional Release to Endpoint Measured Parallel to Pipeline (feet)		
		12,000 btu/hr-ft ² 100% Mortality	8,000 btu/hr-ft ² 50% Mortality	5,000 btu/hr-ft ² 1% Mortality
Segment 2B Dooley Elementary School	Rupture	*	26.0	41.8
		*	18.0	30.0
Segment 2B Dooley Elementary School	Leak (1-inch)	*	*	*
		*	*	*

The hazard lengths for each hazard are shown below. These hazard lengths were determined in accordance with the Protocol, as described previously in Section A.5.

Table C2-2 Hazard Lengths

Segment	Size of Release	Hazard Lengths (feet)		
		12,000+ btu/hr-ft ² 100% Mortality	8,000 – 11,999 btu/hr-ft ² 75% Mortality	5,000 – 7,999 btu/hr-ft ² 25% Mortality
Segment 2B Dooley Elementary School	Rupture	0	39.3	37.0
Segment 2B Dooley Elementary School	Leak (1-inch)	0	0	0

C.3 Probability of Fatality

Using the data presented herein, the probabilities of the various incidents have been determined. The results are presented in the table below.

⁴⁵ All releases were modeled with an operating pipeline pressure of 260-psig, vertical release angle, at a flow rate of 7 MMSCFD.

⁴⁶ Radiant heat flux values shown are measured at 6-feet above ground surface. The impact distances are less, closer to ground level.

* Indicates that this level of radiant heat flux is not present for the indicated release.



Table C.3-1 Total Annual Probability of Fatality

Release Size	Frequency of Occurrence (per foot per year)	Annual Probability of Fatality	Annual Probability of Fatality	Annual Probability of Fatality	Total Annual Probability of Fatality
		12,000+ btu/hr-ft ² 100% Mortality	8,000 – 11,999 btu/hr-ft ² 75% Mortality	5,000 – 7,999 btu/hr-ft ² 25% Mortality	
Rupture	4.403E-10	0	1.299E-08	2.549E-09	1.274E-08
Leak (1-inch)	1.761E-9	0	0	0	0

By summing the total annual probabilities of fatality above, for both ruptures and leaks, the total individual risk (TIR) results for this school site are as follows. The total individual risk at this school site is much less than the CDE individual risk criterion.

Total Individual Risk (TIR)	1.274 x 10 ⁻⁸	1 in 78.5 million
CDE Individual Risk Criterion (IRC)	1.000 x 10 ⁻⁶	1 in 1.0 million
TIR / IRC Ratio	0.013	



Appendix D – Societal Risk Assessment

Societal risk is the probability that a specified number of people will be affected by a given event. As shown in Figure D-1, the acceptable values for societal risk vary greatly by different agencies and jurisdictions. Although Santa Barbara County has adopted societal risk guidelines, we are not aware of any prescribed societal risk guidelines for the United States, the State of California, nor the City of Carson. Further, since the individual risks presented in Section 9.0, Appendix A, Appendix B, and Appendix C of this report are less than the one in one-million threshold, a societal risk analysis would not be required for this project if it were located in Santa Barbara County.

D.1 Societal Risk Thresholds

When a societal risk assessment is required, the California Department of Education and the County of Santa Barbara, California have upper and lower bounds for unacceptable and acceptable societal risk levels respectively. The upper bound is represented by the red line in the following figure; risks above this line are deemed intolerable. The lower bound is represented by the green line in the following figure; risks below this line are deemed acceptable. Between these two bounds is a “gray area”.

Using the Netherlands, as one possible criteria, for a given number of fatalities, if the likelihood is greater than the value represented by the blue line (e.g., above the line), then the societal risk is deemed unacceptable; if the likelihood is less than the value represented by the line (e.g., below the line) then the societal risk that falls below the line is acceptable. For example, for one hundred (100) fatalities, as shown on the “x” axis, the bright line threshold for the Netherlands (blue line) is 1.00E-07 (or 1.0×10^{-7} , or 1 : 10,000,000), as shown on the “y” axis. In other words, if the likelihood of one hundred (100) fatalities is less than one in ten million (1 : 10,000,000), the risk is deemed acceptable; if not, it is unacceptable.



Societal Risk Criteria

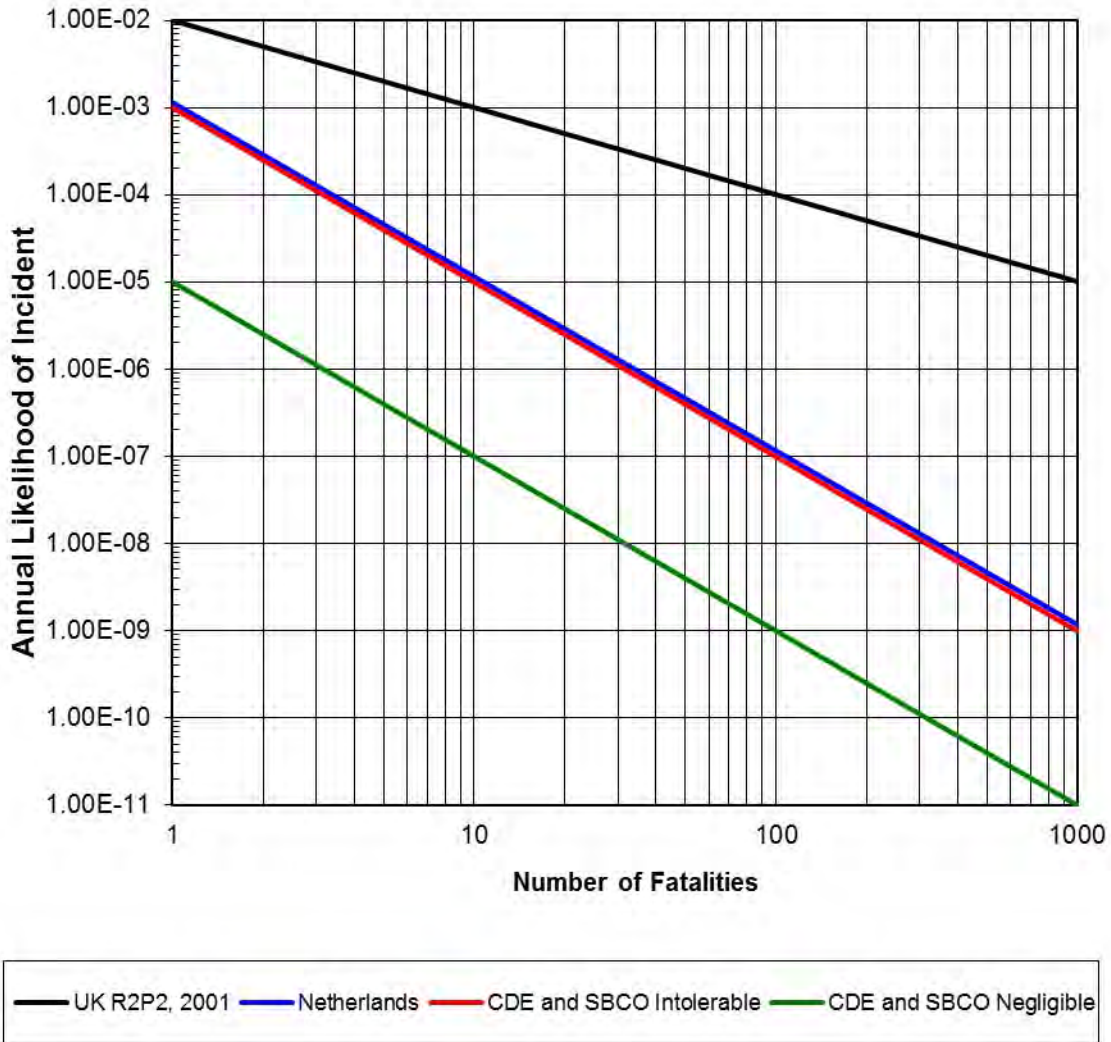


Figure D.1-1 – Various Societal Risk Criteria⁴⁷

In order to determine the number of persons exposed to the potential hazard, population density has been used. The individuals were assumed to be spread uniformly throughout the area.

⁴⁷ Sources – CDE 2005 and 2007, API 752, SBCO 2008, Marzal 2001, Hong Kong



D.2 Population Density

Societal risk is dependent on the number of exposed individuals. In the societal risk analysis presented, population densities were used to determine the number of exposed individuals. These data were obtained by analyzing census data; the following data were provided by Padre Associates. The individuals were assumed to be spread uniformly throughout the area. However, nearly all persons within these areas would be protected from the radiant heat flux from a torch fire by their vehicle or other structure. As a result, the actual risk posed by a pipeline release would be less than presented herein.

D.2.1 Segment 1 - Carson Plant to Dominguez Pump Station ASV

This segment of the pipeline alignment is uninhabited. The length of this segment is approximately 11,593 feet (2.20 miles).

D.2.2 Segment 2A - Dominguez Pump Station ASV to South Street Block Valve

The population densities along this segment of the pipeline alignment varies considerably. The length of this segment is approximately 31,028 feet (5.88 miles). The raw population density was sorted by population density and was placed into three groups:

- Low Mean Population Density – 1,000 to 9,999 persons per square mile,
- Medium Mean Population Density – 10,000 to 19,999 persons per square mile, and
- High Mean Population Density – 20,000 or more persons per square mile.

The weighted average population and the length of pipeline within each of the above were then determined. The results are provided in Table D.2.2-1 below.

Table D.2.2-1 – Population Densities, Segment 2A - Dominguez Pump Station ASV to South Street Block Valve

Population Density Category	Total Length (feet)	Weighted Average Population Density (persons per square mile)
High Mean Population Density 20,000 or more persons per square mile	5,593	29,101
Medium Mean Population Density 10,000 to 19,999 persons per square mile	11,274	15,200
Low Mean Population Density 1,000 to 9,999 persons per square mile	14,161	4,638



D.2.3 Segment 2B - South Street Block Valve to Paramount Refinery

Similar to Segment 2A, the population density along this segment of the pipeline alignment varies considerably. The length of this segment is approximately 13,932 feet (2.64 miles). As with Segment 2A, the raw population density was sorted by population density and was placed into three groups:

- Low Mean Population Density – 1,000 to 9,999 persons per square mile,
- Medium Mean Population Density – 10,000 to 19,999 persons per square mile, and
- High Mean Population Density – 20,000 or more persons per square mile.

The weighted average population and the length of pipeline within each of the above were then determined. The results area provided in Table D.2.3-1 below

Table D.2.3-1 – Population Densities, Segment 2B - South Street ASV to Paramount Refinery

Population Density Category	Total Length (feet)	Weighted Average Population Density (persons per square mile)
High Mean Population Density 20,000 or more persons per square mile	2,426	21,534
Medium Mean Population Density 10,000 to 19,999 persons per square mile	7,021	13,855
Low Mean Population Density 1,000 to 9,999 persons per square mile	4,485	6,536

D.3 Conditional Probabilities

The societal risk assessment used the same conditional probabilities as those presented in Section 8.0 which were used for the individual risk assessment. For societal risk, results are presented for

- 100% of the population was incapable of any reaction. These results conservatively assumed that none of the population was capable of any human reaction to distance themselves from the hazard.
- 80% of the population reacted to distance themselves from the hazard sufficiently to avoid fatal injuries. As discussed in section 8.10 previously, 80% of the population is expected to react within 15 seconds. This is conservative as the endpoints used in the jet fire analyses are for a 30 second exposure.

D.4 Jet Fire Modeling Results

Jet fire modeling results were presented in Section 7.1 for a pipeline pressure of 260 psig. Release modeling was also performed for a pipeline pressure of 160 psig. This provides a means to



evaluate the extent to which societal risks may be reduced by lowering the pipeline maximum operating pressure. The impact areas are presented in the following table for each segment.

Table D.4-1 Jet Fire Modeling Results⁴⁸

Segment	Size of Release	Release Relative to Wind	160 psig ^{49, 50}		
			260 psig		
			12,000 btu/hr-ft ² 100% Mortality	8,000 btu/hr-ft ² 50% Mortality	5,000 btu/hr-ft ² 1% Mortality
Segment 1	Rupture	Downwind	247	126	250
			342	190	334
		Upwind	217	157	257
			331	202	350
	1-inch	Downwind	21	46	136
			54	81	158
Upwind	*	*	*		
	*	*	*		
Segment 2A	Rupture	Downwind	919	749	1,126
			930	925	1,654
		Upwind	320	698	1,156
			*	408	1,385
	1-inch	Downwind	7	56	151
			76	92	211
Upwind	*	*	*		
	*	*	*		
Segment 2B	Rupture	Downwind	1,157	890	1,425
			2,099	1,435	2,424
		Upwind	1,173	1,001	1,636
			757	1,358	2,423
	1-inch	Downwind	7	56	167
			76	93	211
Upwind	*	*	*		
	*	*	*		

⁴⁸ All releases were modeled with an operating pipeline pressure of 260-psig or 150-psig and a 45-degree release angle above the horizon, at a flow rate of 7 MMSCFD.

⁴⁹ Radiant heat flux values shown are measured at 6-feet above ground surface.

* Indicates that this level of radiant heat flux is not present for the indicated release.

⁵⁰ The impact areas were determined by digitizing the Quest Canary software jet fire radiation isopleths. For the 50% mortality area value, this is the area between the 50% and 100% mortality endpoints; the mortality within this area is 75%. For the 1% mortality area value, this is the area between the 1% and 50% mortality endpoints; the mortality within this area is 25%.



D.5 Societal Risk Results for 260 psig

D.5.1 Segment 1 - Carson Plant to Dominguez Pump Station ASV

Since this area of the pipeline alignment is uninhabited, there is no societal risk posed by this segment.

D.5.2 Segment 2A - Dominguez Pump Station ASV to South Street Block Valve

The societal risks posed by this segment are presented in the table below for the three different population densities for two cases – no human response and 80% human response.

Table D.5.2-1 – Segment 2A Societal Risk Results for 260 psig

Population Density Category	Segment Length (miles)	No Human Response		80% Human Response	
		Downwind Rupture Upwind Rupture Downwind Leak		Downwind Rupture Upwind Rupture Downwind Leak	
		Fatalities	Probability	Fatalities	Probability
		High Mean Population Density 29,101 persons per square mile	1.06	2.127	1.75 x 10 ⁻⁶ (1 in 571,000)
0.681	1.75 x 10 ⁻⁶ (1 in 571,000)	0.136		1.75 x 10 ⁻⁶ (1 in 571,000)	
0.206	9.94 x 10 ⁻⁶ (1 in 101,000)	0.041		9.94 x 10 ⁻⁶ (1 in 101,000)	
Medium Mean Population Density 15,200 persons per square mile	2.14	1.111	3.54 x 10 ⁻⁶ (1 in 282,000)	0.222	3.54 x 10 ⁻⁶ (1 in 282,000)
		0.356	3.54 x 10 ⁻⁶ (1 in 282,000)	0.071	3.54 x 10 ⁻⁶ (1 in 282,000)
		0.108	2.00 x 10 ⁻⁵ (1 in 50,000)	0.022	2.00 x 10 ⁻⁵ (1 in 50,000)
Low Mean Population Density 4,638 persons per square mile	2.68	0.339	4.44 x 10 ⁻⁶ (1 in 225,000)	0.068	4.44 x 10 ⁻⁶ (1 in 225,000)
		0.109	4.44 x 10 ⁻⁶ (1 in 225,000)	0.022	4.44 x 10 ⁻⁶ (1 in 225,000)
		0.033	2.52 x 10 ⁻⁵ (1 in 40,000)	0.007	2.52 x 10 ⁻⁵ (1 in 40,000)



D.5.3 Segment 2B - South Street Block Valve to Paramount Refinery

The societal risks posed by this segment are presented in the table below for the three different population densities for two cases – no human response and 80% human response.

Table D.5.3-1 – Segment 2B Societal Risk Results for 260 psig

Population Density Category	Segment Length (miles)	No Human Response		80% Human Response	
		Downwind Rupture Upwind Rupture Downwind Leak		Downwind Rupture Upwind Rupture Downwind Leak	
		Fatalities	Probability	Fatalities	Probability
		High Mean Population Density 21,534 persons per square mile	0.46	2.921	7.61 x 10 ⁻⁷ (1 in 1,314,000)
1.839	7.61 x 10 ⁻⁷ (1 in 1,314,000)	0.368		7.61 x 10 ⁻⁷ (1 in 1,314,000)	
0.153	4.31 x 10 ⁻⁶ (1 in 232,000)	0.031		4.31 x 10 ⁻⁶ (1 in 232,000)	
Medium Mean Population Density 13,855 persons per square mile	1.33	1.879	2.20 x 10 ⁻⁶ (1 in 455,000)	0.376	2.20 x 10 ⁻⁶ (1 in 282,000)
1.183		2.20 x 10 ⁻⁶ (1 in 455,000)	0.237	2.20 x 10 ⁻⁶ (1 in 282,000)	
0.099		1.25 x 10 ⁻⁵ (1 in 80,000)	0.020	1.25 x 10 ⁻⁵ (1 in 50,000)	
Low Mean Population Density 6,536 persons per square mile	0.85	0.887	1.41 x 10 ⁻⁶ (1 in 709,000)	0.177	1.41 x 10 ⁻⁶ (1 in 709,000)
0.558		1.41 x 10 ⁻⁶ (1 in 709,000)	0.112	1.41 x 10 ⁻⁶ (1 in 709,000)	
0.047		7.97 x 10 ⁻⁶ (1 in 125,000)	0.009	7.97 x 10 ⁻⁶ (1 in 125,000)	

D.5.4 Overall Project Societal Risk

As noted above, most of the incident scenarios result in less than one fatality. Each of these scenarios has been converted to the likelihood of a single fatality. For example, if there was a 1 in 1,000,000 likelihood of 0.1 fatalities, this was converted to a 1 in 10,000,000 likelihood of 1.0 fatalities. The likelihood of each of these scenarios were then summed to determine the total likelihood of a single fatality.



The results presented above for Segments 1, 2A and 2B have been combined to determine the overall project societal risk. The results are presented below for two cases with a pipeline pressure of 260 psig:

- No Human Reaction (blue line)
- 80% Human Reaction (red line)

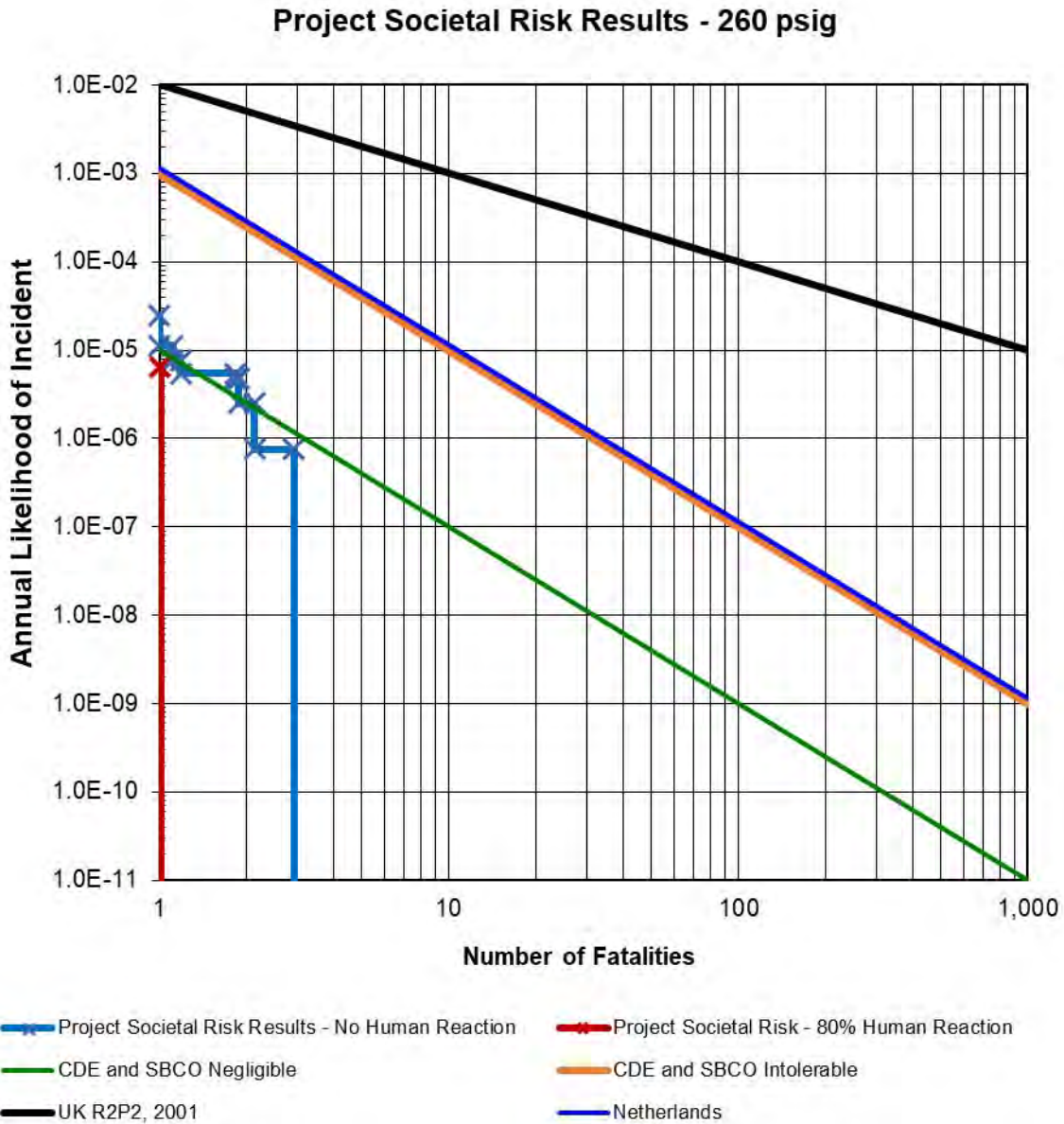


Figure D.5.4-1 Project Societal Risk Results for 260 psig



As noted in Section 8.10, 95% of the population are capable of reaction; 80% react within 15 seconds, 25% react within 10 seconds, and 10% can react within 7.5 seconds. (The endpoints used in the jet fire analyses are for a 30 second exposure.)

Conservatively assuming 80% human reaction within 30 seconds, the results are below the negligible threshold. Specifically, assuming 80% human reaction:

Assuming 80% human reaction, the results are below the negligible societal risk threshold. Specifically:

- The worst-case incident, a full-bore downwind rupture from Segment 2B in the high population density, results in only 0.584 fatalities.
- When all the incidents resulting in less than one fatality are summed, the total likelihood of a single fatality is 6.36×10^{-6} (1 in 157,000). This is less than the Santa Barbara County “green line” threshold of 1.0×10^{-5} (1 in 100,000). For Santa Barbara County, risks below this level (green line), are deemed to pose an insignificant impact to public safety and no mitigation is required for CEQA compliance. However, this project is not located in Santa Barbara County; we are not aware of any bright line societal risk thresholds for this project.

Also, these results are conservative. The population was assumed to be uniformly distributed, including areas within the streets, where most of this pipeline is installed. However, nearly all persons within these areas would be protected from the radiant heat flux from a torch fire by their vehicles. This would further significantly reduce the likelihood of fatal injuries.

The actual societal risk of fatality is less than presented herein. The societal risks are below the Santa Barbara County negligible risk threshold. Further, it should be noted that if this project were located in Santa Barbara County, a societal risk analysis would not be required since the maximum individual risk of fatality is less than the one in one million threshold; the maximum ratio of the individual risk to this threshold is 0.043 (4.3%) with a maximum operating pressure of 260 psig.



D.6 Societal Risk Results for 160 psig

D.6.1 Segment 1 - Carson Plant to Dominguez Pump Station ASV

Since this area of the pipeline alignment is uninhabited, there is no societal risk posed by this segment.

D.6.2 Segment 2A - Dominguez Pump Station ASV to South Street Block Valve

The societal risks posed by this segment are presented in the table below for the three different population densities for two cases – no human response and 80% human response.

Table D.6.2-1 – Segment 2A Societal Risk Results for 160 psig

Population Density Category	Segment Length (miles)	No Human Response		80% Human Response	
		Downwind Rupture Upwind Rupture Downwind Leak		Downwind Rupture Upwind Rupture Downwind Leak	
		Fatalities	Probability	Fatalities	Probability
		High Mean Population Density 29,101 persons per square mile	1.06	1.628	1.75 x 10 ⁻⁶ (1 in 571,000)
Medium Mean Population Density 15,200 persons per square mile	2.14	1.182	1.75 x 10 ⁻⁶ (1 in 571,000)	0.236	1.75 x 10 ⁻⁶ (1 in 571,000)
		0.091	9.94 x 10 ⁻⁶ (1 in 101,000)	0.018	9.94 x 10 ⁻⁶ (1 in 101,000)
		0.850	3.54 x 10 ⁻⁶ (1 in 282,000)	0.170	3.54 x 10 ⁻⁶ (1 in 282,000)
Low Mean Population Density 4,638 persons per square mile	2.68	0.617	3.54 x 10 ⁻⁶ (1 in 282,000)	0.123	3.54 x 10 ⁻⁶ (1 in 282,000)
		0.047	2.00 x 10 ⁻⁵ (1 in 50,000)	0.009	2.00 x 10 ⁻⁵ (1 in 50,000)
		0.259	4.44 x 10 ⁻⁶ (1 in 225,000)	0.052	4.44 x 10 ⁻⁶ (1 in 225,000)
Low Mean Population Density 4,638 persons per square mile	2.68	0.188	4.44 x 10 ⁻⁶ (1 in 225,000)	0.038	4.44 x 10 ⁻⁶ (1 in 225,000)
		0.014	2.52 x 10 ⁻⁵ (1 in 40,000)	0.003	2.52 x 10 ⁻⁵ (1 in 40,000)



D.6.3 Segment 2B - South Street Block Valve to Paramount Refinery

The societal risks posed by this segment are presented in the table below for the three different population densities for two cases – no human response and 80% human response.

Table D.6.3-1 – Segment 2B Societal Risk Results for 160 psig

Population Density Category	Segment Length (miles)	No Human Response		80% Human Response	
		Downwind Rupture Upwind Rupture Downwind Leak		Downwind Rupture Upwind Rupture Downwind Leak	
		Fatalities	Probability	Fatalities	Probability
		High Mean Population Density 21,534 persons per square mile	0.46	1.684	7.61 x 10 ⁻⁷ (1 in 1,314,000)
1.802	7.61 x 10 ⁻⁷ (1 in 1,314,000)	0.360		7.61 x 10 ⁻⁷ (1 in 1,314,000)	
0.070	4.31 x 10 ⁻⁶ (1 in 232,000)	0.014		4.31 x 10 ⁻⁶ (1 in 232,000)	
Medium Mean Population Density 13,855 persons per square mile	1.33	1.084	2.20 x 10 ⁻⁶ (1 in 455,000)	0.217	2.20 x 10 ⁻⁶ (1 in 282,000)
1.159		2.20 x 10 ⁻⁶ (1 in 455,000)	0.232	2.20 x 10 ⁻⁶ (1 in 282,000)	
0.045		1.25 x 10 ⁻⁵ (1 in 80,000)	0.009	1.25 x 10 ⁻⁵ (1 in 50,000)	
Low Mean Population Density 6,536 persons per square mile	0.85	0.511	1.41 x 10 ⁻⁶ (1 in 709,000)	0.102	1.41 x 10 ⁻⁶ (1 in 709,000)
0.547		1.41 x 10 ⁻⁶ (1 in 709,000)	0.109	1.41 x 10 ⁻⁶ (1 in 709,000)	
0.021		7.97 x 10 ⁻⁶ (1 in 125,000)	0.004	7.97 x 10 ⁻⁶ (1 in 125,000)	

D.6.4 Overall Project Societal Risk

As noted above, most of the incident scenarios result in less than one fatality. Each of these scenarios has been converted to the likelihood of a single fatality. For example, if there was a 1 in 1,000,000 likelihood of 0.1 fatalities, this was converted to a 1 in 10,000,000 likelihood of 1.0 fatalities. The likelihood of each of these scenarios were then summed to determine the total likelihood of a single fatality.



The results presented above for Segments 1, 2A and 2B have been combined to determine the overall project societal risk. The results are presented below for two cases, with a pipeline operating pressure of 160 psig:

- No Human Reaction (blue line)
- 80% Human Reaction (red line)

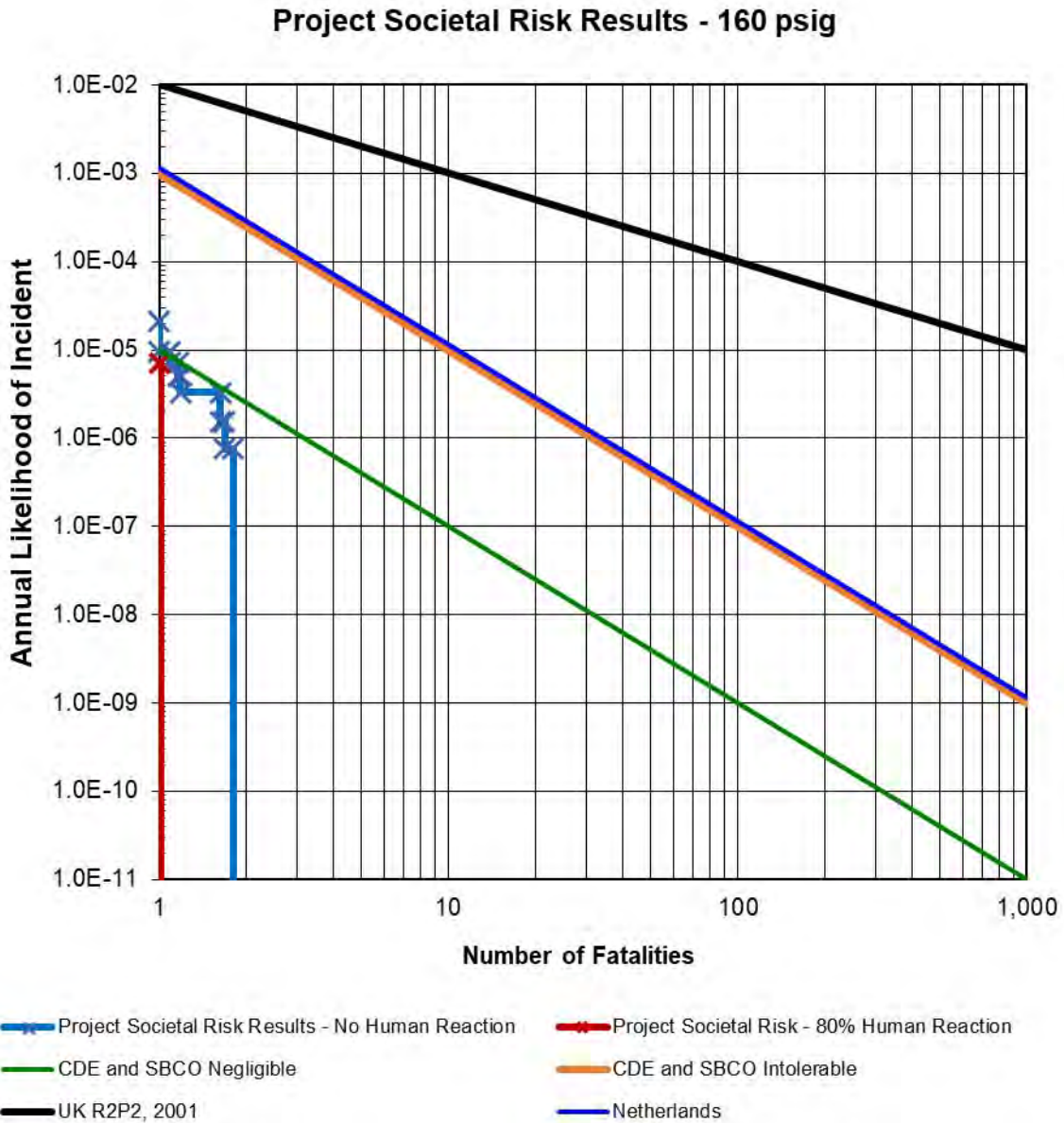


Figure D.6.4-1 Project Societal Risk Results for 160 psig



As noted in Section 8.10, 95% of the population are capable of reaction; 80% react within 15 seconds, 25% react within 10 seconds, and 10% can react within 7.5 seconds. (The endpoints used in the jet fire analyses are for a 30 second exposure.)

Conservatively assuming 80% human reaction within 30 seconds, the results are below the negligible threshold. Specifically, assuming 80% human reaction:

- The worst-case incident, a full-bore downwind rupture from Segment 2B in the high population density, results in 0.360 fatalities.
- When all the incidents resulting in less than one fatality are summed, the total likelihood of a single fatality is 6.98×10^{-6} (1 in 143,000). This is less than the Santa Barbara County “green line” threshold of 1.0×10^{-5} (1 in 100,000). For Santa Barbara County, risks below this level (green line), are deemed to pose an insignificant impact to public safety and no mitigation is required for CEQA compliance. However, this project is not located in Santa Barbara County; we are not aware of any bright line societal risk thresholds for this project.

As stated previously, the actual societal risk of fatality is less than presented herein. These risks are below the Santa Barbara County negligible risk threshold. Further, it should be noted that if this project were located in Santa Barbara County, a societal risk analysis would not be required since the maximum individual risk of fatality is less than the one in one million threshold; the maximum ratio of the individual risk to this threshold is only 0.043 (4.3%) for a pipeline pressure of 260 psig.



Appendix E – Release Modeling Results for 260 psig



Vapor Dispersion Modeling Results, Segment 1

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 8DFB260S1+45_7MMSCFD       |
|           Mon Jul 22 15:29:21 2019                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°

```

Case Type       : Vapor Dispersion
Case Name      : 8DFB260S1+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: 7MMSCFD

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	72.0 °F
Spill surface temperature	72.0 °F
Substrate name	Medium density concrete
Substrate thermal conductivity	0.2698 Btu/hr-ft-F
Substrate density	80 lb/cu.ft
Substrate heat Capacity	0.22 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Wooded area or urban area

NOTES:

Case continued on page 2.

```

+-----+
|                                     |
| CANARY by Quest - Version 4.6.2   |
| CANARY Case Input                 |
| Case Name - 8DFB260S1+45_7MMSCFD |
| Mon Jul 22 15:29:21 2019         |
|                                     |
+-----+

```

Page 2 Title: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°

RELEASE MENU

Type of release: Unregulated, Continuous release
 Release duration 120 min
 Normal flow rate 0.43 lb/sec
 Duration of normal flow 5 min
 Volume of vessel 0.00 cu.ft
 Pipe inner diameter 7.98 inches
 Equivalent release diameter 7.98 inches
 Pipe length upstream of break 1464.0 feet
 Pipe length downstream of break 1464.0 feet
 Height of release point 0.0 feet
 Angle of release from horizontal 45.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation, dispersion and cloud explosion - Flammable calculation
 Concentration endpoint 1 UFL mol%
 Concentration endpoint 2 LFL mol%
 Concentration endpoint 3 1/2 LFL mol%

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

Fuel reactivity High
 Obstacle density Low
 Flame expansion 3-D

Overpressure values

Overpressure endpoint 1 1.00 psi
 Overpressure endpoint 2 0.70 psi
 Overpressure endpoint 3 0.10 psi

NOTES:

```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 8DFB260S1+45_7MMSCFD
Mon Jul 22 15:29:21 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

TITLE: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	59.21172	0.000000	0.000000	59.21172
0.100000	32.05492	0.000000	0.000000	32.05492
0.300000	20.60204	0.000000	0.000000	20.60204
0.500000	14.34251	0.000000	0.000000	14.34251
0.700000	13.24315	0.000000	0.000000	13.24315
1.000000	11.75198	0.000000	0.000000	11.75198
3.000000	5.384513	0.000000	0.000000	5.384513
5.000000	2.458764	0.000000	0.000000	2.458764
7.000000	1.161266	0.000000	0.000000	1.161266
10.00000	.5036736	0.000000	0.000000	.5036736
20.00000	.4312341	0.000000	0.000000	.4312341
30.00000	.4312341	0.000000	0.000000	.4312341
40.00000	.4312341	0.000000	0.000000	.4312341
50.00000	.4312341	0.000000	0.000000	.4312341
60.00000	.4312341	0.000000	0.000000	.4312341
70.00000	.4312341	0.000000	0.000000	.4312341
85.00000	.4312341	0.000000	0.000000	.4312341
100.0000	.4312341	0.000000	0.000000	.4312341
200.0000	.4312341	0.000000	0.000000	.4312341
300.0000	.4312341	0.000000	0.000000	.4312341
315.3274	0.000000	0.000000	0.000000	0.000000
Totals (lb)	178.3227	0.000000	0.000000	178.3227

Flowrate for Torch Fire [immediate ignition] = 1.164827 lb/sec.
Torch Fire [delayed ignition] = 0.4312341 lb/sec.

Reason for Ending: No Mass Left in System

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|   General Release Model DOWNSTREAM  |
|   Case Name - 8DFB260S1+45_7MMSCFD |
|   Mon Jul 22 15:29:21 2019         |
|   Quest Consultants Inc., Norman, Oklahoma, USA |
|   www.questconsult.com      canary@questconsult.com |
|   telephone (405) 329-7475    fax (405) 329-7734 |
|               |
+-----+

```

TITLE: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	59.21172	0.000000	0.000000	59.21172
0.100000	32.04995	0.000000	0.000000	32.04995
0.300000	20.59215	0.000000	0.000000	20.59215
0.500000	14.25280	0.000000	0.000000	14.25280
0.700000	13.12423	0.000000	0.000000	13.12423
1.000000	11.59729	0.000000	0.000000	11.59729
3.000000	5.064280	0.000000	0.000000	5.064280
5.000000	2.051201	0.000000	0.000000	2.051201
7.000000	.6313257	0.000000	0.000000	.6313257
10.000000	0.000000	0.000000	0.000000	0.000000
20.000000	0.000000	0.000000	0.000000	0.000000
30.000000	0.000000	0.000000	0.000000	0.000000
40.000000	0.000000	0.000000	0.000000	0.000000
50.000000	0.000000	0.000000	0.000000	0.000000
60.000000	0.000000	0.000000	0.000000	0.000000
70.000000	0.000000	0.000000	0.000000	0.000000
85.000000	0.000000	0.000000	0.000000	0.000000
100.000000	0.000000	0.000000	0.000000	0.000000
200.000000	0.000000	0.000000	0.000000	0.000000
300.000000	0.000000	0.000000	0.000000	0.000000
400.000000	0.000000	0.000000	0.000000	0.000000
500.000000	0.000000	0.000000	0.000000	0.000000
600.000000	0.000000	0.000000	0.000000	0.000000
700.000000	0.000000	0.000000	0.000000	0.000000
850.000000	0.000000	0.000000	0.000000	0.000000
1000.000000	0.000000	0.000000	0.000000	0.000000
2000.000000	0.000000	0.000000	0.000000	0.000000
3000.000000	0.000000	0.000000	0.000000	0.000000
4000.000000	0.000000	0.000000	0.000000	0.000000
5000.000000	0.000000	0.000000	0.000000	0.000000
6000.000000	0.000000	0.000000	0.000000	0.000000
7000.000000	0.000000	0.000000	0.000000	0.000000
7200.000000	0.000000	0.000000	0.000000	0.000000

Totals (lb) 44.24023 0.000000 0.000000 44.24023

Flowrate for Torch Fire [immediate ignition] = 0.7373372 lb/sec.
Torch Fire [delayed ignition] = 0.000000 lb/sec.

Reason for Ending: Reached Stop Time


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions               |
|           Case Name - 8DFB260S1+45_7MMSCFD         |
|           Mon Jul 22 15:29:21 2019                 |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com           canary@questconsult.com |
|           telephone (405) 329-7475           fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°

Component Number	Component Name, Formula
------------------	-------------------------

51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
| Momentum Jet Vapor Dispersion Model |
| Case Name - 8DFB260S1+45_7MMSCFD  |
| Mon Jul 22 15:29:21 2019           |
| Quest Consultants Inc., Norman, Oklahoma, USA |
| www.questconsult.com   canary@questconsult.com |
| telephone (405) 329-7475   fax (405) 329-7734 |
|               |
+-----+

```

TITLE: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.7	0.7	0.2	0.1
0.5	0.728521	0.214573	1.0	0.9	0.0	0.6
1.0	0.595357	0.032710	1.2	1.0	0.0	1.1
1.5	0.507683	0.005303	1.3	1.2	0.0	1.6
2.0	0.443825	0.001016	1.5	1.3	0.0	2.1
2.5	0.394374	0.000236	1.6	1.4	0.0	2.6
3.0	0.354987	0.000066	1.8	1.5	0.0	3.1
3.5	0.322250	0.000022	1.9	1.7	0.0	3.6
4.0	0.294663	0.000009	2.1	1.8	0.0	4.1
4.5	0.270530	0.000004	2.2	1.9	0.0	4.5
5.0	0.249568	0.000002	2.3	2.0	0.0	5.0
5.5	0.230947	0.000001	2.5	2.1	0.0	5.5
6.0	0.214389	0.000001	2.6	2.2	0.0	6.0
6.5	0.199583	0.000001	2.8	2.3	0.0	6.5
7.0	0.186227	0.000001	2.9	2.4	0.0	7.0
7.5	0.174272	0.000000	3.1	2.5	0.0	7.5
8.0	0.163221	0.000000	3.2	2.6	0.0	8.0
8.5	0.153179	0.000000	3.4	2.8	0.0	8.5
9.0	0.144066	0.000000	3.5	2.9	0.0	8.9
9.5	0.135481	0.000001	3.7	2.9	0.0	9.4
10.0	0.127751	0.000001	3.8	3.0	0.0	9.9
10.5	0.120551	0.000001	4.0	3.1	0.0	10.4
11.0	0.113956	0.000001	4.2	3.2	0.0	10.8
11.5	0.107725	0.000001	4.3	3.3	0.0	11.3
12.0	0.102066	0.000001	4.5	3.4	0.0	11.8
12.5	0.096679	0.000001	4.6	3.4	0.0	12.2
13.0	0.091794	0.000002	4.8	3.5	0.0	12.7
13.5	0.087143	0.000002	4.9	3.6	0.0	13.1
14.0	0.082822	0.000003	5.0	3.6	0.0	13.6
14.5	0.078839	0.000003	5.2	3.6	0.0	14.0
15.0	0.075010	0.000004	5.3	3.7	0.0	14.5
15.5	0.071490	0.000005	5.5	3.7	0.0	14.9
16.0	0.068201	0.000007	5.6	3.7	0.0	15.3
16.5	0.065048	0.000008	5.7	3.7	0.0	15.8
17.0	0.062136	0.000010	5.8	3.6	0.0	16.2

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
17.5	0.059438	0.000013	6.0	3.6	0.0	16.6
18.0	0.056816	0.000016	6.1	3.5	0.0	17.0
18.5	0.054376	0.000019	6.2	3.4	0.0	17.4
19.0	0.052099	0.000023	6.3	3.3	0.0	17.8
19.5	0.049957	0.000028	6.4	3.1	0.0	18.2
20.0	0.047886	0.000033	6.4	2.9	0.0	18.6
20.5	0.045956	0.000039	6.5	2.7	0.0	18.9
21.0	0.044155	0.000047	6.6	2.3	0.0	19.3
21.5	0.042442	0.000054	6.6	1.9	0.0	19.7
22.0	0.040799	0.000063	6.7	1.1	0.0	20.0
22.5	0.039260	0.000073	6.7	0.0	0.0	20.4
23.0	0.037806	0.000084	6.7	0.0	0.0	20.8
23.5	0.036445	0.000096	6.7	0.0	0.0	21.1
24.0	0.035101	0.000109	6.7	0.0	0.0	21.4
24.5	0.033831	0.000123	6.7	0.0	0.0	21.8
25.0	0.032654	0.000139	6.6	0.0	0.0	22.1
25.5	0.031502	0.000155	6.6	0.0	0.0	22.4
26.0	0.030488	0.000173	6.5	0.0	0.0	22.8
26.5	0.029429	0.000191	6.4	0.0	0.0	23.1
27.0	0.028441	0.000211	6.3	0.0	0.0	23.4
27.5	0.027524	0.000231	6.1	0.0	0.0	23.7
28.0	0.026663	0.000253	6.0	0.0	0.0	24.0
28.5	0.025818	0.000276	5.8	0.0	0.0	24.3
29.0	0.025023	0.000300	5.5	0.0	0.0	24.6
29.5	0.024271	0.000325	5.3	0.0	0.0	24.9
30.0	0.023524	0.000350	4.9	0.0	0.0	25.1
30.5	0.022821	0.000376	4.6	0.0	0.0	25.4
31.0	0.022128	0.000402	4.1	0.0	0.0	25.7
31.5	0.021509	0.000429	3.5	0.0	0.0	26.0
32.0	0.020879	0.000456	2.8	0.0	0.0	26.2
32.5	0.020274	0.000485	1.5	0.0	0.0	26.5
33.0	0.019715	0.000512	0.0	0.0	0.0	26.7

The downwind distance to c3 is 0.44 ft after about 0 seconds
The downwind distance to c2 is 22.25 ft after about 0 seconds
The downwind distance to c1 is 32.74 ft after about 1 seconds

```

+-----+
|           CANARY by Quest - Version 4.6.2           |
| Momentum Jet Vapor Cloud Explosion                 |
| Case Name - 8DFB260S1+45_7MMSCFD                 |
| Mon Jul 22 15:29:21 2019                           |
| Quest Consultants Inc., Norman, Oklahoma, USA       |
| www.questconsult.com           canary@questconsult.com |
| telephone (405) 329-7475       fax (405) 329-7734   |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°

```

Fuel Reactivity: High           Obstacle Density: Low
Flame Expansion: 3-D           Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.500646 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0438
2.1	3.36	0.0438
2.6	3.36	0.0438
3.1	3.36	0.0438
3.8	3.36	0.0379
4.5	3.36	0.0315
5.5	3.36	0.0261
6.7	3.36	0.0216
8.1	3.36	0.0179
9.8	2.99	0.0148
11.9	2.48	0.0123
14.4	2.05	0.0102
17.4	1.70	0.0085
21.0	1.41	0.0070
25.5	1.16	0.0058
30.9	0.96	0.0048
37.4	0.79	0.0040
45.3	0.65	0.0033
54.8	0.54	0.0027
66.4	0.44	0.0023
80.4	0.37	0.0019
97.4	0.30	0.0016
117.9	0.25	0.0013
142.8	0.21	0.0011
291.7	0.10	0.0005

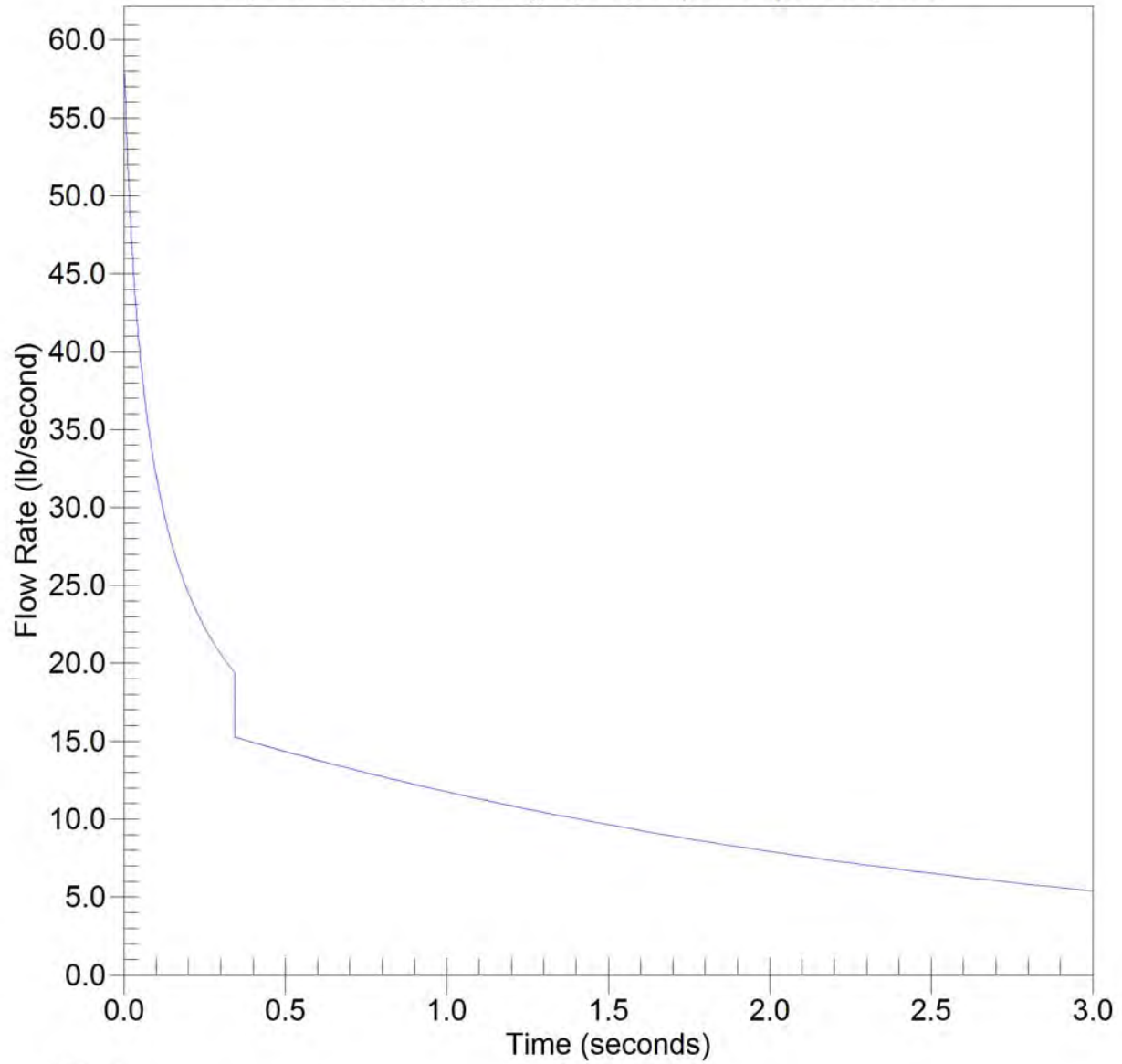
```

The downwind distance to dp3 is 29.7 feet
The downwind distance to dp2 is 42.5 feet
The downwind distance to dp1 is 291.7 feet

```

MASS RELEASE RATE

H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°



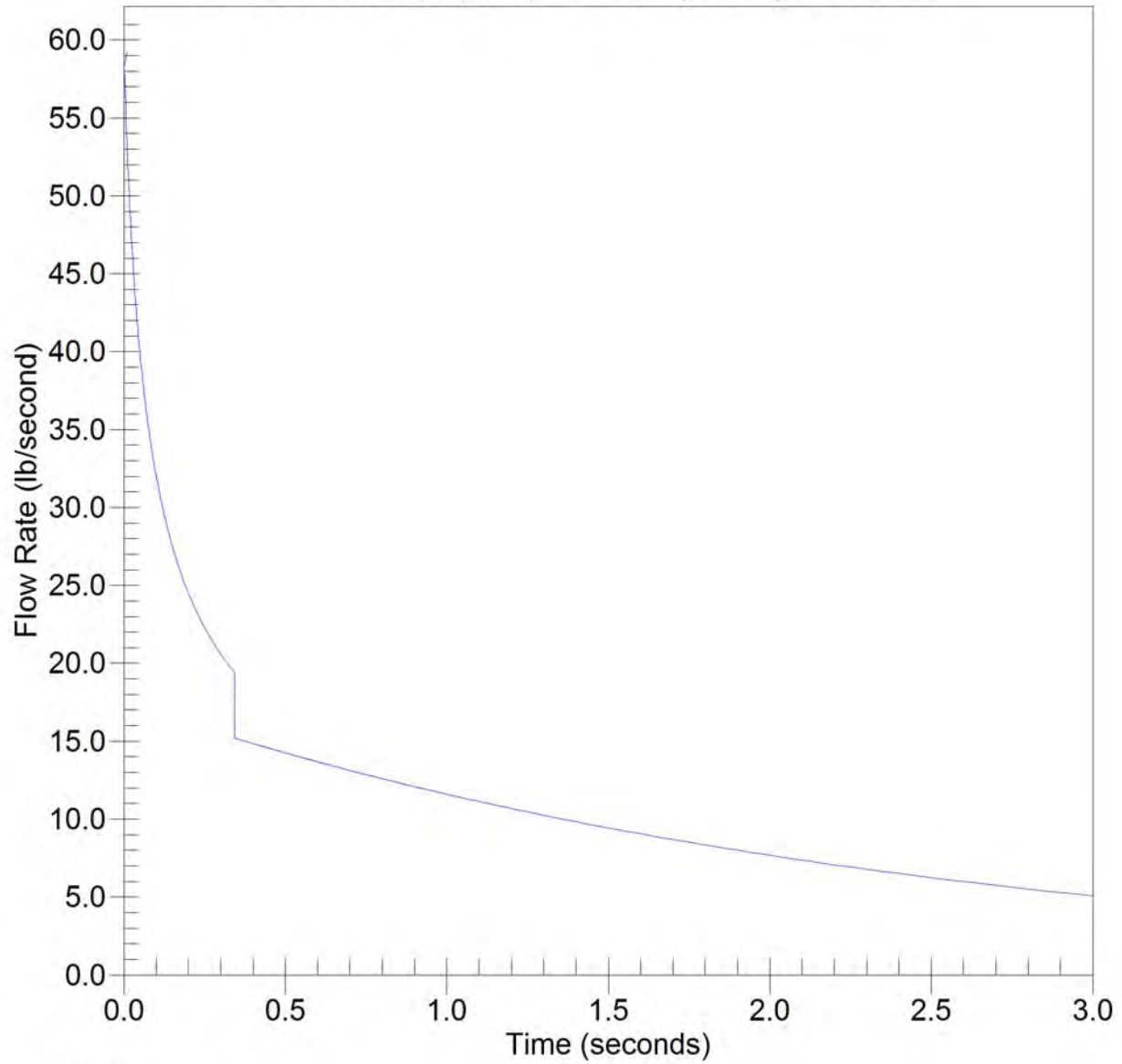
— Total
— Vapor

CANARY by Quest

casename=8DFB260S1+45_7MMSCFD
Mon Jul 22 15:29:21 2019

MASS RELEASE RATE - DOWNSTREAM PIPING

H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°

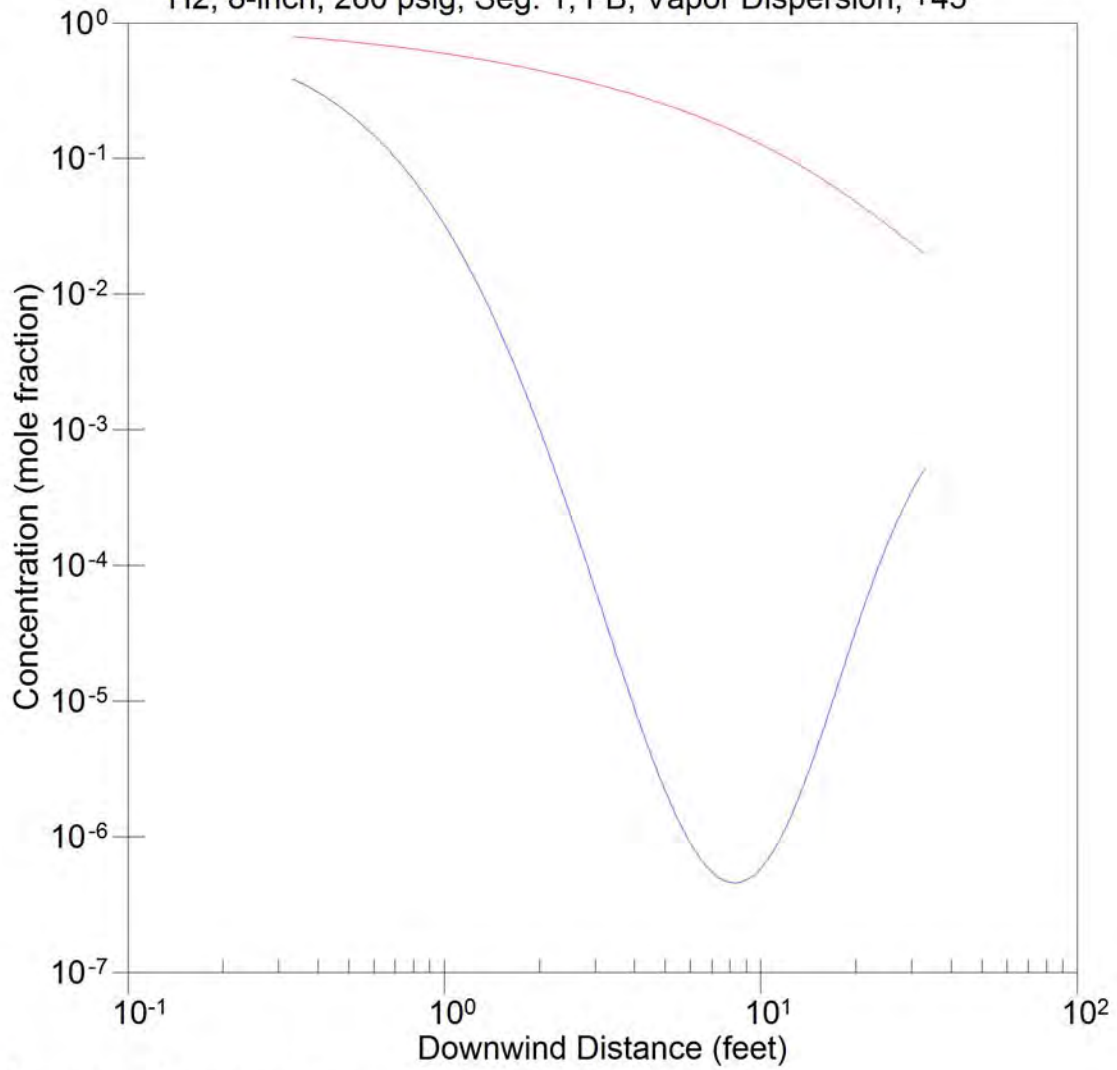


— Total
— Vapor

CANARY by Quest

casename=8DFB260S1+45_7MMSCFD
Mon Jul 22 15:29:21 2019

Momentum Jet Cloud
CONCENTRATION vs. DISTANCE
H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°



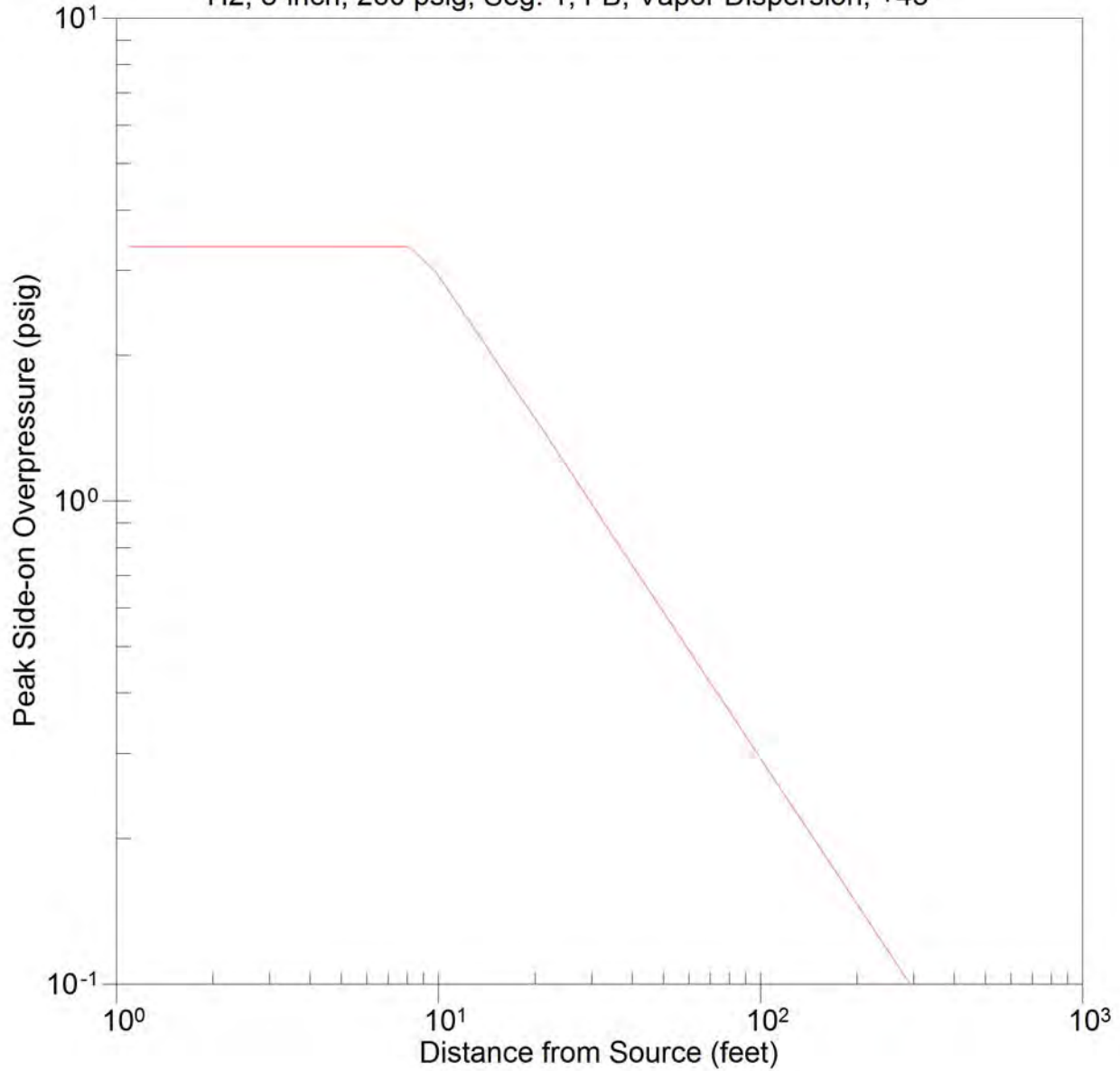
— Centerline Concentration
— Ground Level Concentration

casename=8DFB260S1+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Jul 22 15:29:21 2019

CANARY by Quest

Momentum Jet VCE

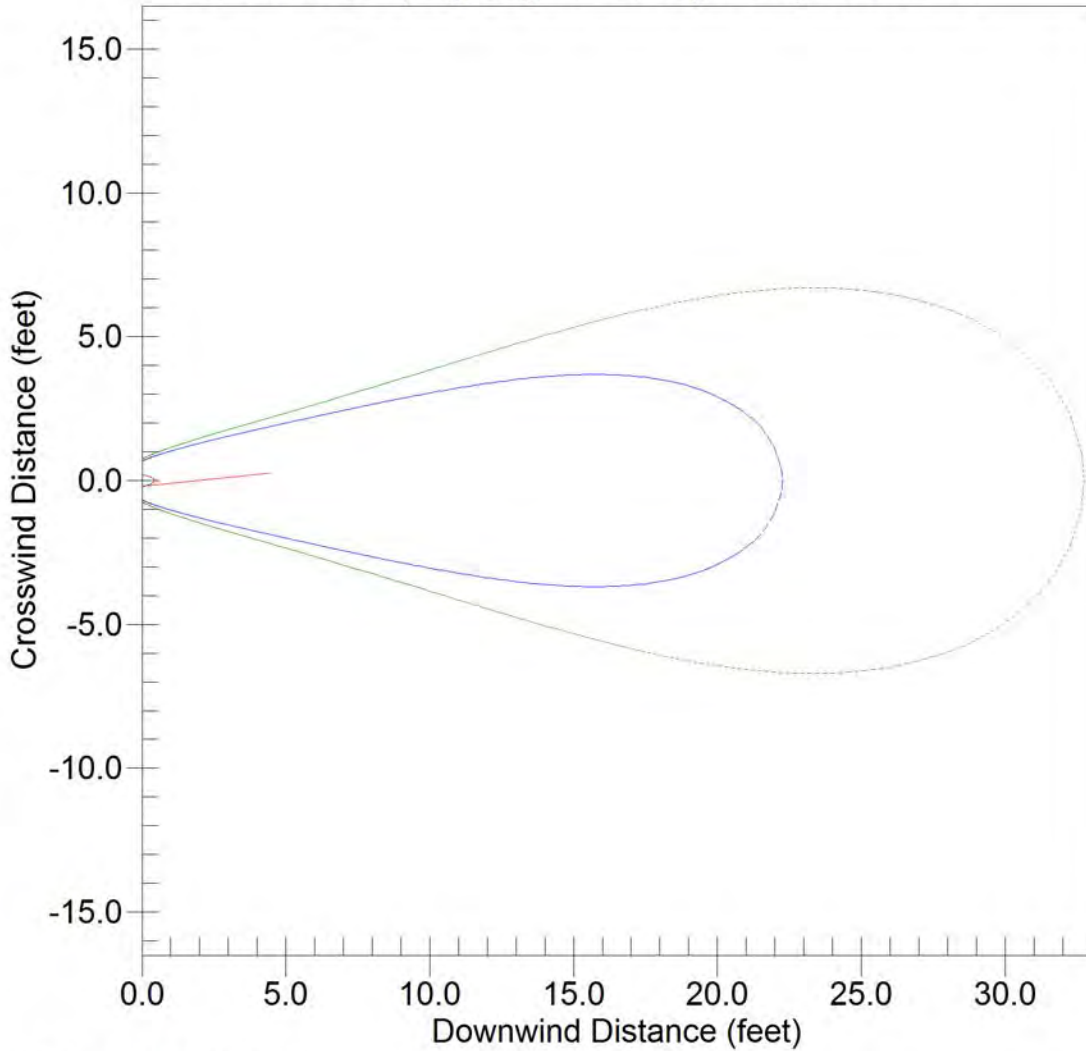
BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°



CANARY by Quest

casename=8DFB260S1+45_7MMSCFD
Mon Jul 22 15:29:21 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°

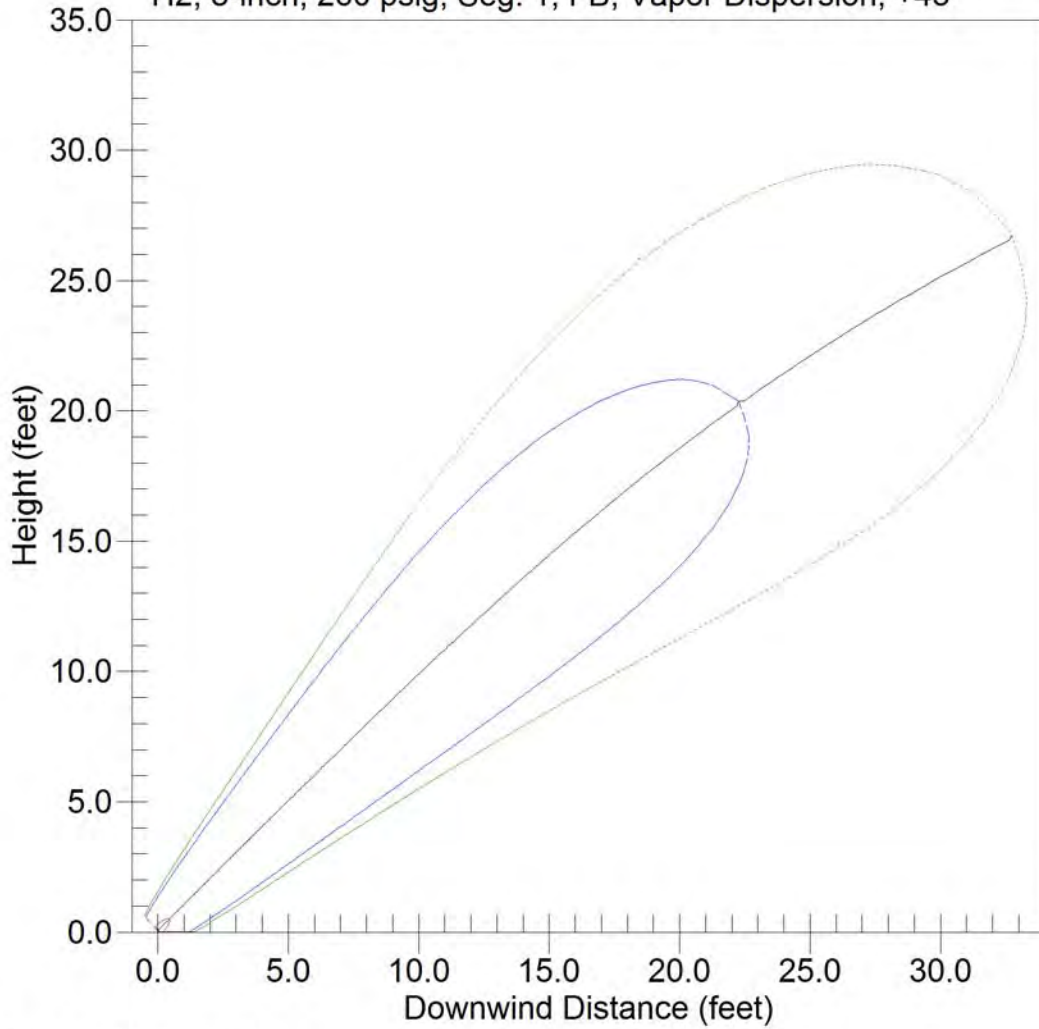


- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=8DFB260S1+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Jul 22 15:29:21 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, +45°



- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=8DFB260S1+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Jul 22 15:29:21 2019

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|               Case Name - 8DFB260S1-45_7MMSCFD             |
|               Mon Jul 22 15:30:19 2019                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, -45°

```

Case Type       : Vapor Dispersion
Case Name      : 8DFB260S1-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: 7MMSCFD

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
  Substrate thermal conductivity 0.2698 Btu/hr-ft-F
  Substrate density              80 lb/cu.ft
  Substrate heat Capacity        0.22 Btu/lb-F
  Substrate delay time           0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 8DFB260S1-45_7MMSCFD |
| Mon Jul 22 15:30:19 2019 |
|               |
+-----+

```

Page 2 Title: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, -45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration                120 min
Normal flow rate                0.43 lb/sec
Duration of normal flow        5 min
Volume of vessel                0.00 cu.ft
Pipe inner diameter             7.98 inches
Equivalent release diameter     7.98 inches
Pipe length upstream of break   1464.0 feet
Pipe length downstream of break 1464.0 feet
Height of release point         0.0 feet
Angle of release from horizontal 135.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1          UFL mol%
Concentration endpoint 2          LFL mol%
Concentration endpoint 3          1/2 LFL mol%

```

```

Dispersion coefficient averaging time          1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity                High
Obstacle density                Low
Flame expansion                  3-D

```

Overpressure values

```

Overpressure endpoint 1          1.00 psi
Overpressure endpoint 2          0.70 psi
Overpressure endpoint 3          0.10 psi

```

NOTES:

```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 8DFB260S1-45_7MMSCFD
Mon Jul 22 15:30:19 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

TITLE: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	59.21172	0.000000	0.000000	59.21172
0.100000	32.05492	0.000000	0.000000	32.05492
0.300000	20.60204	0.000000	0.000000	20.60204
0.500000	14.34251	0.000000	0.000000	14.34251
0.700000	13.24315	0.000000	0.000000	13.24315
1.000000	11.75198	0.000000	0.000000	11.75198
3.000000	5.384513	0.000000	0.000000	5.384513
5.000000	2.458764	0.000000	0.000000	2.458764
7.000000	1.161266	0.000000	0.000000	1.161266
10.00000	.5036736	0.000000	0.000000	.5036736
20.00000	.4312341	0.000000	0.000000	.4312341
30.00000	.4312341	0.000000	0.000000	.4312341
40.00000	.4312341	0.000000	0.000000	.4312341
50.00000	.4312341	0.000000	0.000000	.4312341
60.00000	.4312341	0.000000	0.000000	.4312341
70.00000	.4312341	0.000000	0.000000	.4312341
85.00000	.4312341	0.000000	0.000000	.4312341
100.0000	.4312341	0.000000	0.000000	.4312341
200.0000	.4312341	0.000000	0.000000	.4312341
300.0000	.4312341	0.000000	0.000000	.4312341
315.3274	0.000000	0.000000	0.000000	0.000000
Totals (lb)	178.3227	0.000000	0.000000	178.3227

Flowrate for Torch Fire [immediate ignition] = 1.164827 lb/sec.
Torch Fire [delayed ignition] = 0.4312341 lb/sec.

Reason for Ending: No Mass Left in System


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions             |
|           Case Name - 8DFB260S1-45_7MMSCFD       |
|           Mon Jul 22 15:30:19 2019               |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com           canary@questconsult.com |
|           telephone (405) 329-7475           fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, -45°

Component Number	Component Name, Formula
------------------	-------------------------

51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
| Momentum Jet Vapor Dispersion Model                         |
| Case Name - 8DFB260S1-45_7MMSCFD                          |
| Mon Jul 22 15:30:19 2019                                    |
| Quest Consultants Inc., Norman, Oklahoma, USA              |
| www.questconsult.com    canary@questconsult.com            |
| telephone (405) 329-7475    fax (405) 329-7734            |
+-----+

```

TITLE: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance	centerline conc.	ground conc.	y(c1) 1/2 width	y(c2) 1/2 width	y(c3) 1/2 width	centerline height
x(ft)	c(mole frac.)	c(mole frac.)	(ft)	(ft)	(ft)	(ft)
0	1.000000	0.000000	0.7	0.7	0.2	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is 0.00 ft after about 1 seconds
The downwind distance to c2 is 0.00 ft after about 1 seconds
The downwind distance to c1 is 0.00 ft after about 1 seconds

```



```

+-----+
|          CANARY by Quest - Version 4.6.2          |
| Momentum Jet Vapor Cloud Explosion                |
| Case Name - 8DFB260S1-45_7MMSCFD                |
| Mon Jul 22 15:30:19 2019                          |
| Quest Consultants Inc., Norman, Oklahoma, USA      |
| www.questconsult.com      canary@questconsult.com  |
| telephone (405) 329-7475      fax (405) 329-7734  |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, -45°

```

Fuel Reactivity: High           Obstacle Density: Low
Flame Expansion: 3-D           Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.460459 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0426
2.1	3.36	0.0426
2.5	3.36	0.0426
3.0	3.36	0.0426
3.6	3.36	0.0370
4.4	3.36	0.0307
5.3	3.36	0.0255
6.4	3.36	0.0212
7.8	3.36	0.0176
9.4	3.02	0.0146
11.4	2.50	0.0121
13.8	2.08	0.0100
16.7	1.72	0.0083
20.2	1.43	0.0069
24.4	1.18	0.0057
29.5	0.97	0.0048
35.7	0.80	0.0040
43.2	0.66	0.0033
52.2	0.55	0.0027
63.2	0.45	0.0023
76.4	0.37	0.0019
92.4	0.31	0.0016
111.8	0.26	0.0013
135.2	0.21	0.0011
283.6	0.10	0.0005

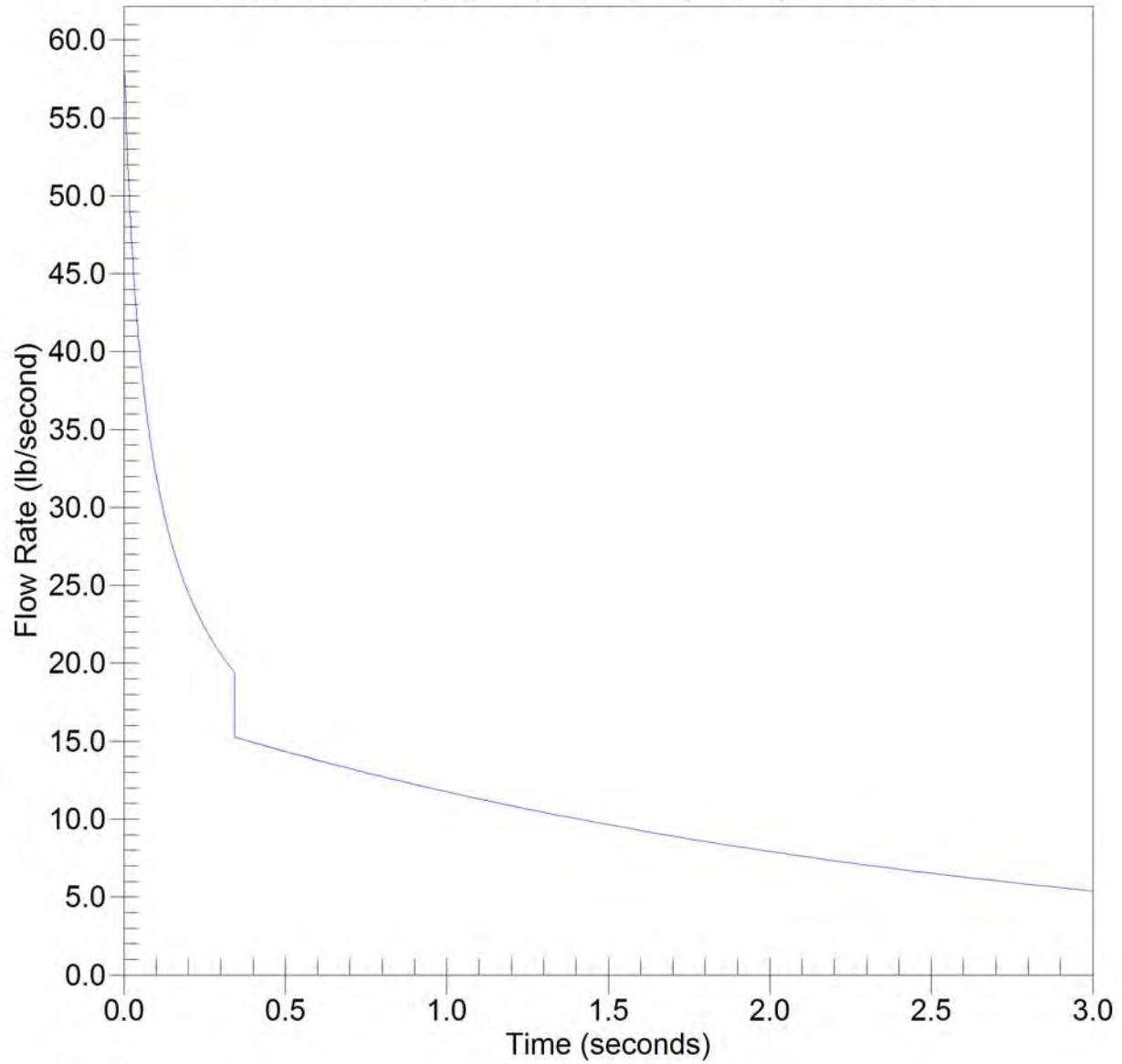
```

The downwind distance to dp3 is      28.9 feet
The downwind distance to dp2 is      41.3 feet
The downwind distance to dp1 is     283.6 feet

```

MASS RELEASE RATE

H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, -45°



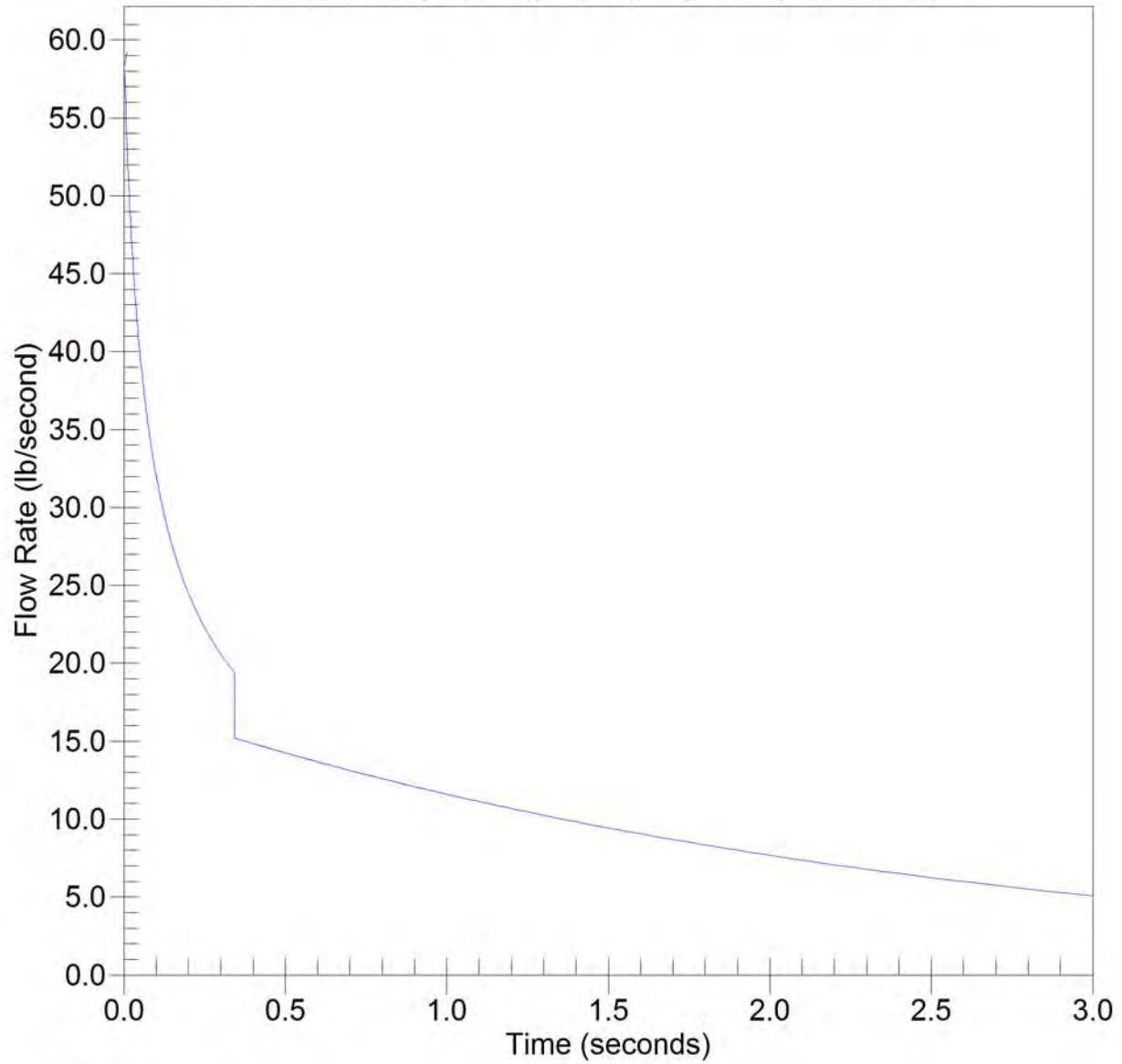
— Total
— Vapor

CANARY by Quest

casename=8DFB260S1-45_7MMSCFD
Mon Jul 22 15:30:19 2019

MASS RELEASE RATE - DOWNSTREAM PIPING

H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, -45°

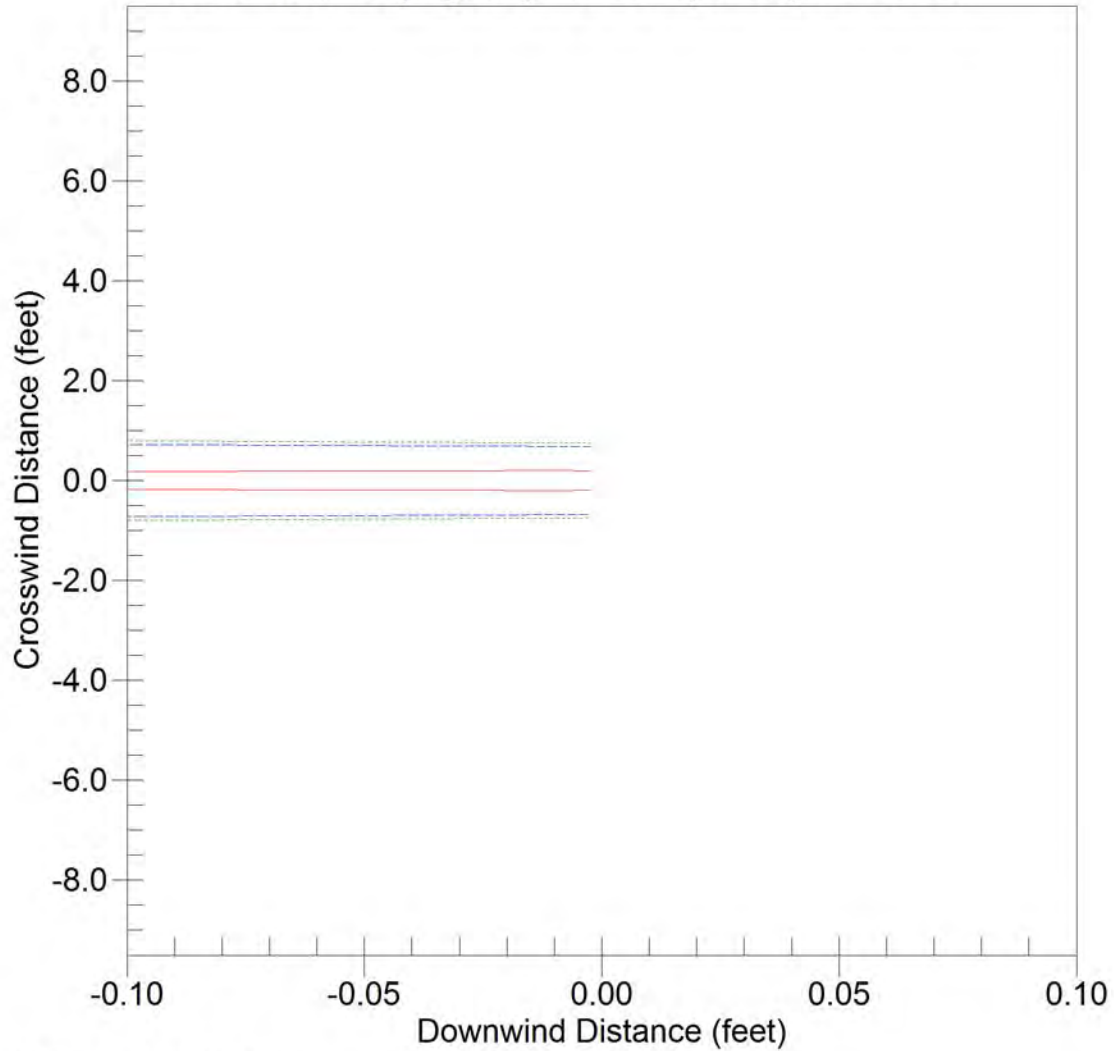


— Total
— Vapor

CANARY by Quest

casename=8DFB260S1-45_7MMSCFD
Mon Jul 22 15:30:19 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, -45°

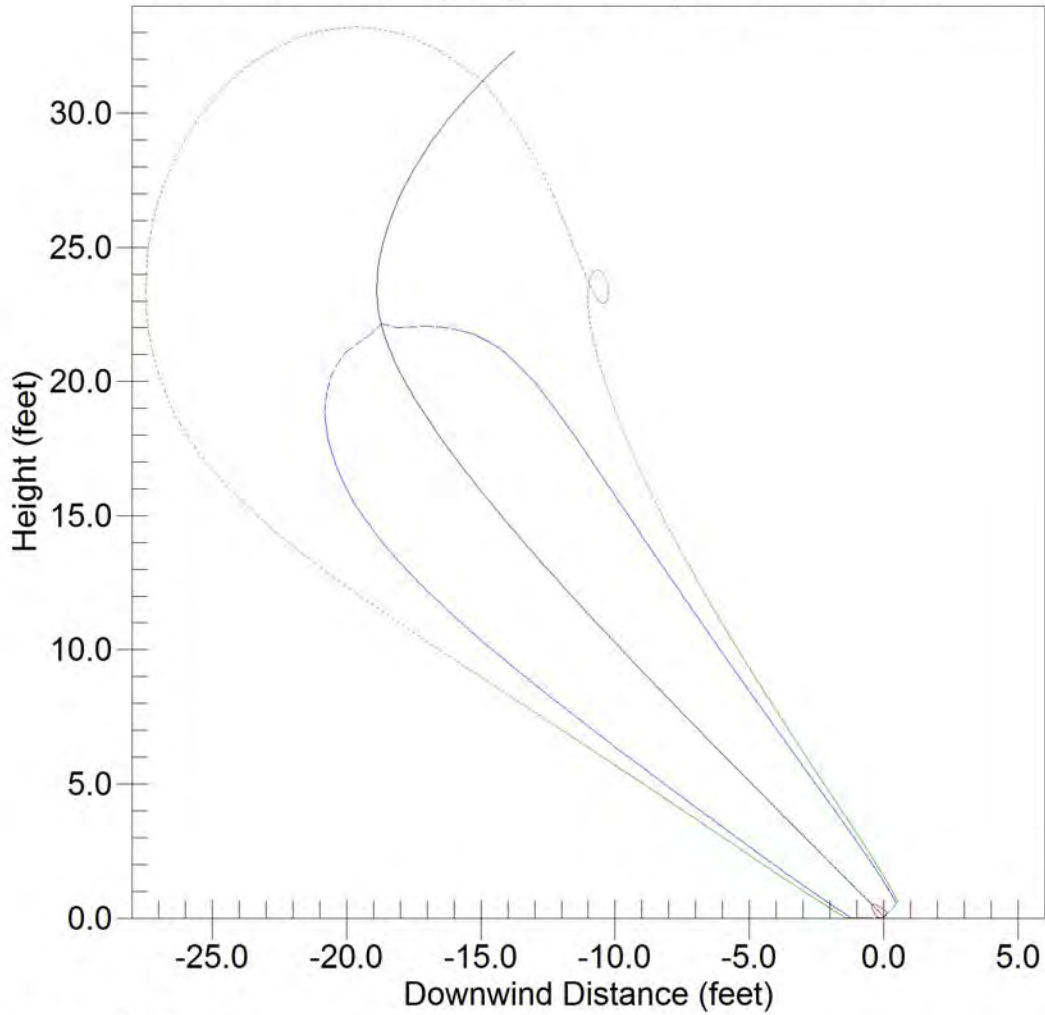


- 75.0 mole percent
- - - 4.00 mole percent
- 2.00 mole percent

casename=8DFB260S1-45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Jul 22 15:30:19 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, -45°

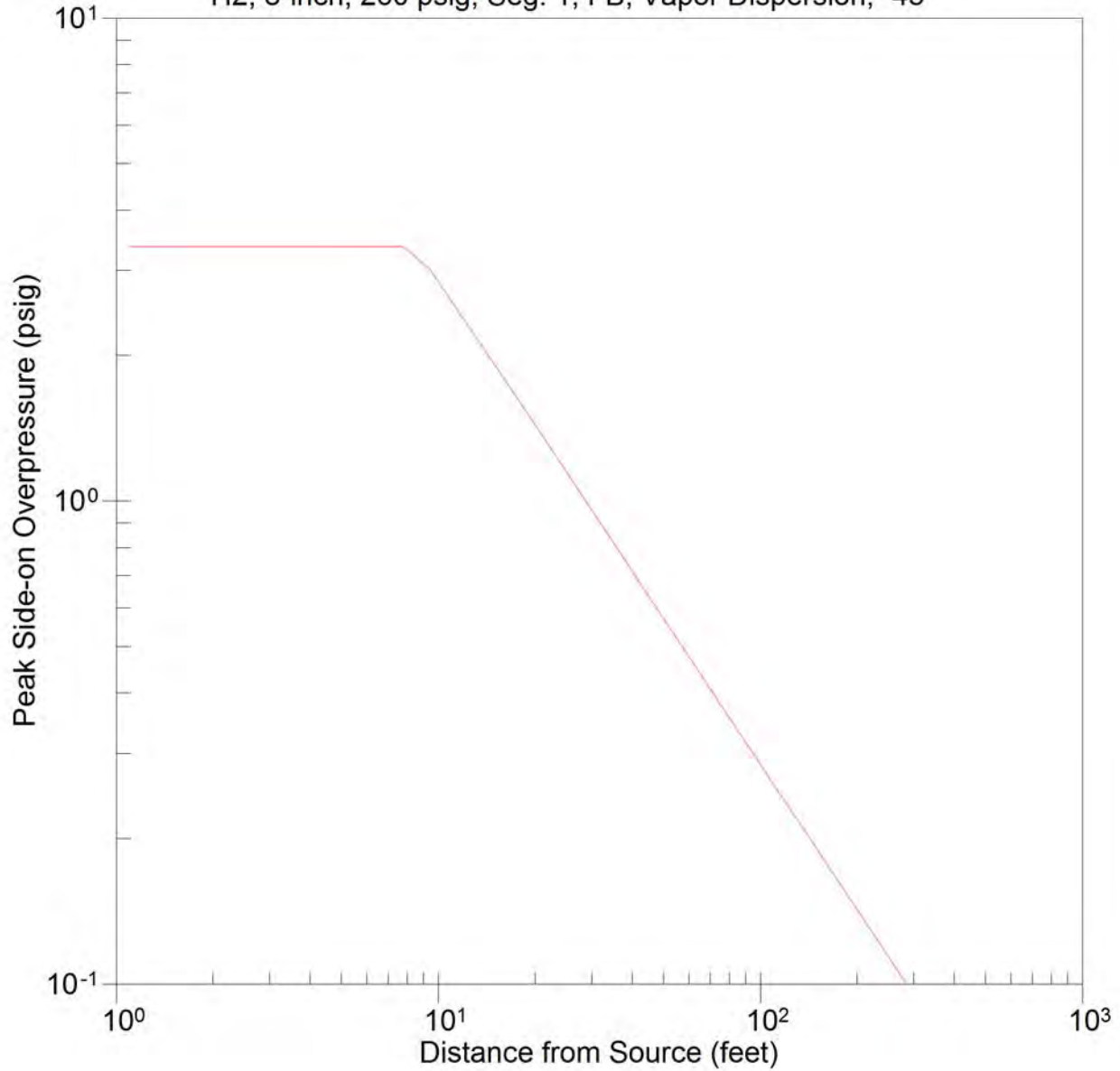


- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=8DFB260S1-45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Jul 22 15:30:19 2019

CANARY by Quest

Momentum Jet VCE
BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 8-inch, 260 psig, Seg. 1, FB, Vapor Dispersion, -45°



CANARY by Quest

casename=8DFB260S1-45_7MMSCFD
Mon Jul 22 15:30:19 2019

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 8D1IN260S1+45_7MMSCFD                 |
|           Mon Jul 22 15:38:51 2019                         |
|           Quest Consultants Inc., Norman, Oklahoma, USA      |
| www.questconsult.com           canary@questconsult.com      |
| telephone (405) 329-7475       fax (405) 329-7734          |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

```

Case Type           : Vapor Dispersion
Case Name           : 8D1IN260S1+45_7MMSCFD
User ID             : BLPayne
Project Number      : Job 2134
Type of Units       : English Units

```

NOTES: 7MMSCFD

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature         :          70.00 °F
Pressure             :          260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity     70 %
Air temperature       72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name           Medium density concrete
  Substrate thermal conductivity 0.2698 Btu/hr-ft-F
  Substrate density          80 lb/cu.ft
  Substrate heat Capacity    0.22 Btu/lb-F
  Substrate delay time       0 sec
Surrounding terrain     Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|         CANARY Case Input           |
| Case Name - 8D1IN260S1+45_7MMSCFD  |
|   Mon Jul 22 15:38:51 2019         |
|               |
+-----+

```

Page 2 Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration           120 min
Normal flow rate          0.43 lb/sec
Duration of normal flow   5 min
Volume of vessel          0.00 cu.ft
Pipe inner diameter       7.98 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 1464.0 feet
Height of release point   0.0 feet
Angle of release from horizontal 45.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1           UFL mol%
Concentration endpoint 2           LFL mol%
Concentration endpoint 3           1/2 LFL mol%

```

```

Dispersion coefficient averaging time           1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity           High
Obstacle density          Low
Flame expansion           3-D

```

Overpressure values

```

Overpressure endpoint 1           1.00 psi
Overpressure endpoint 2           0.70 psi
Overpressure endpoint 3           0.10 psi

```

NOTES:


```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 8D1IN260S1+45_7MMSCFD
Mon Jul 22 15:38:51 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

TITLE: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.9297522	0.000000	0.000000	.9297522
0.100000	.9294642	0.000000	0.000000	.9294642
0.300000	.9289317	0.000000	0.000000	.9289317
0.500000	.9238878	0.000000	0.000000	.9238878
0.700000	.9219604	0.000000	0.000000	.9219604
1.000000	.9190834	0.000000	0.000000	.9190834
3.000000	.9003251	0.000000	0.000000	.9003251
5.000000	.8822828	0.000000	0.000000	.8822828
7.000000	.8649297	0.000000	0.000000	.8649297
10.00000	.8401338	0.000000	0.000000	.8401338
20.00000	.7672035	0.000000	0.000000	.7672035
30.00000	.7071326	0.000000	0.000000	.7071326
40.00000	.6577690	0.000000	0.000000	.6577690
50.00000	.6171208	0.000000	0.000000	.6171208
60.00000	.5837354	0.000000	0.000000	.5837354
70.00000	.5563003	0.000000	0.000000	.5563003
85.00000	.5240016	0.000000	0.000000	.5240016
100.0000	.4999840	0.000000	0.000000	.4999840
200.0000	.4403176	0.000000	0.000000	.4403176
300.0000	.4323000	0.000000	0.000000	.4323000
400.0000	.3859192E-01	0.000000	0.000000	.3859192E-01
414.5990	0.000000	0.000000	0.000000	0.000000
Totals (lb)	175.3637	0.000000	0.000000	175.3637

Flowrate for Torch Fire [immediate ignition] = 0.7233396 lb/sec.
Torch Fire [delayed ignition] = 0.4579744 lb/sec.

Reason for Ending: Pressure Near Atmospheric

CANARY by Quest - Version 4.6.2
 Release Stream Compositions
 Case Name - 8D1IN260S1+45_7MMSCFD
 Mon Jul 22 15:38:51 2019
 Quest Consultants Inc., Norman, Oklahoma, USA
 www.questconsult.com canary@questconsult.com
 telephone (405) 329-7475 fax (405) 329-7734

Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
| Momentum Jet Vapor Dispersion Model |
| Case Name - 8D1IN260S1+45_7MMSCFD  |
| Mon Jul 22 15:38:51 2019            |
| Quest Consultants Inc., Norman, Oklahoma, USA |
| www.questconsult.com   canary@questconsult.com |
| telephone (405) 329-7475   fax (405) 329-7734 |
|               |
+-----+

```

TITLE: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.2	0.2	0.1	0.1
0.5	0.533794	0.000462	0.4	0.3	0.0	0.6
1.0	0.390028	0.000001	0.5	0.4	0.0	1.1
1.5	0.311365	0.000000	0.6	0.5	0.0	1.6
2.0	0.260270	0.000000	0.7	0.6	0.0	2.1
2.5	0.223910	0.000000	0.8	0.7	0.0	2.6
3.0	0.196728	0.000000	0.9	0.7	0.0	3.1
3.5	0.175274	0.000000	0.9	0.8	0.0	3.6
4.0	0.158011	0.000000	1.0	0.8	0.0	4.1
4.5	0.143607	0.000000	1.1	0.9	0.0	4.6
5.0	0.131449	0.000000	1.2	0.9	0.0	5.1
5.5	0.121051	0.000000	1.2	1.0	0.0	5.6
6.0	0.112039	0.000000	1.3	1.0	0.0	6.1
6.5	0.104162	0.000000	1.4	1.1	0.0	6.6
7.0	0.097181	0.000000	1.5	1.1	0.0	7.1
7.5	0.090932	0.000000	1.5	1.1	0.0	7.6
8.0	0.085350	0.000000	1.6	1.1	0.0	8.0
8.5	0.080327	0.000000	1.6	1.2	0.0	8.5
9.0	0.075787	0.000000	1.7	1.2	0.0	9.0
9.5	0.071608	0.000000	1.8	1.2	0.0	9.5
10.0	0.067804	0.000000	1.8	1.2	0.0	10.0
10.5	0.064330	0.000000	1.9	1.2	0.0	10.5
11.0	0.061091	0.000000	1.9	1.2	0.0	11.0
11.5	0.058141	0.000000	2.0	1.2	0.0	11.5
12.0	0.055360	0.000000	2.0	1.1	0.0	12.0
12.5	0.052801	0.000000	2.1	1.1	0.0	12.5
13.0	0.050412	0.000000	2.1	1.1	0.0	13.0
13.5	0.048200	0.000000	2.2	1.0	0.0	13.5
14.0	0.046086	0.000000	2.2	0.9	0.0	14.0
14.5	0.044145	0.000000	2.2	0.8	0.0	14.4
15.0	0.042290	0.000000	2.3	0.6	0.0	14.9
15.5	0.040562	0.000000	2.3	0.3	0.0	15.4
16.0	0.038928	0.000000	2.3	0.0	0.0	15.9
16.5	0.037390	0.000000	2.3	0.0	0.0	16.4
17.0	0.035947	0.000000	2.3	0.0	0.0	16.9

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
17.5	0.034560	0.000000	2.3	0.0	0.0	17.3
18.0	0.033251	0.000000	2.3	0.0	0.0	17.8
18.5	0.032031	0.000000	2.3	0.0	0.0	18.3
19.0	0.030847	0.000000	2.3	0.0	0.0	18.8
19.5	0.029730	0.000000	2.3	0.0	0.0	19.2
20.0	0.028682	0.000000	2.3	0.0	0.0	19.7
20.5	0.027661	0.000000	2.2	0.0	0.0	20.2
21.0	0.026698	0.000000	2.2	0.0	0.0	20.7
21.5	0.025782	0.000000	2.1	0.0	0.0	21.1
22.0	0.024918	0.000000	2.0	0.0	0.0	21.6
22.5	0.024070	0.000000	1.9	0.0	0.0	22.0
23.0	0.023270	0.000000	1.8	0.0	0.0	22.5
23.5	0.022510	0.000000	1.6	0.0	0.0	23.0
24.0	0.021795	0.000000	1.4	0.0	0.0	23.4
24.5	0.021081	0.000000	1.2	0.0	0.0	23.9
25.0	0.020423	0.000000	0.7	0.0	0.0	24.3
25.5	0.019778	0.000000	0.0	0.0	0.0	24.8

The downwind distance to c3 is 0.16 ft after about 0 seconds
The downwind distance to c2 is 15.67 ft after about 0 seconds
The downwind distance to c1 is 25.32 ft after about 0 seconds

```

+-----+
|           CANARY by Quest - Version 4.6.2           |
| Momentum Jet Vapor Cloud Explosion                 |
| Case Name - 8D1IN260S1+45_7MMSCFD                 |
| Mon Jul 22 15:38:51 2019                           |
| Quest Consultants Inc., Norman, Oklahoma, USA       |
| www.questconsult.com           canary@questconsult.com |
| telephone (405) 329-7475       fax (405) 329-7734   |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

```

Fuel Reactivity: High           Obstacle Density: Low
Flame Expansion: 3-D           Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.0439789 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0195
0.9	3.36	0.0195
1.1	3.36	0.0195
1.3	3.36	0.0195
1.5	3.36	0.0187
1.8	3.36	0.0160
2.1	3.36	0.0137
2.4	3.36	0.0118
2.8	3.36	0.0101
3.3	3.36	0.0087
3.9	3.36	0.0074
4.5	2.89	0.0064
5.3	2.47	0.0055
6.2	2.12	0.0047
7.2	1.82	0.0040
8.4	1.56	0.0034
9.9	1.33	0.0030
11.6	1.14	0.0025
13.5	0.97	0.0022
15.8	0.83	0.0019
18.5	0.71	0.0016
21.6	0.61	0.0014
25.3	0.52	0.0012
29.6	0.44	0.0010
129.7	0.10	0.0002

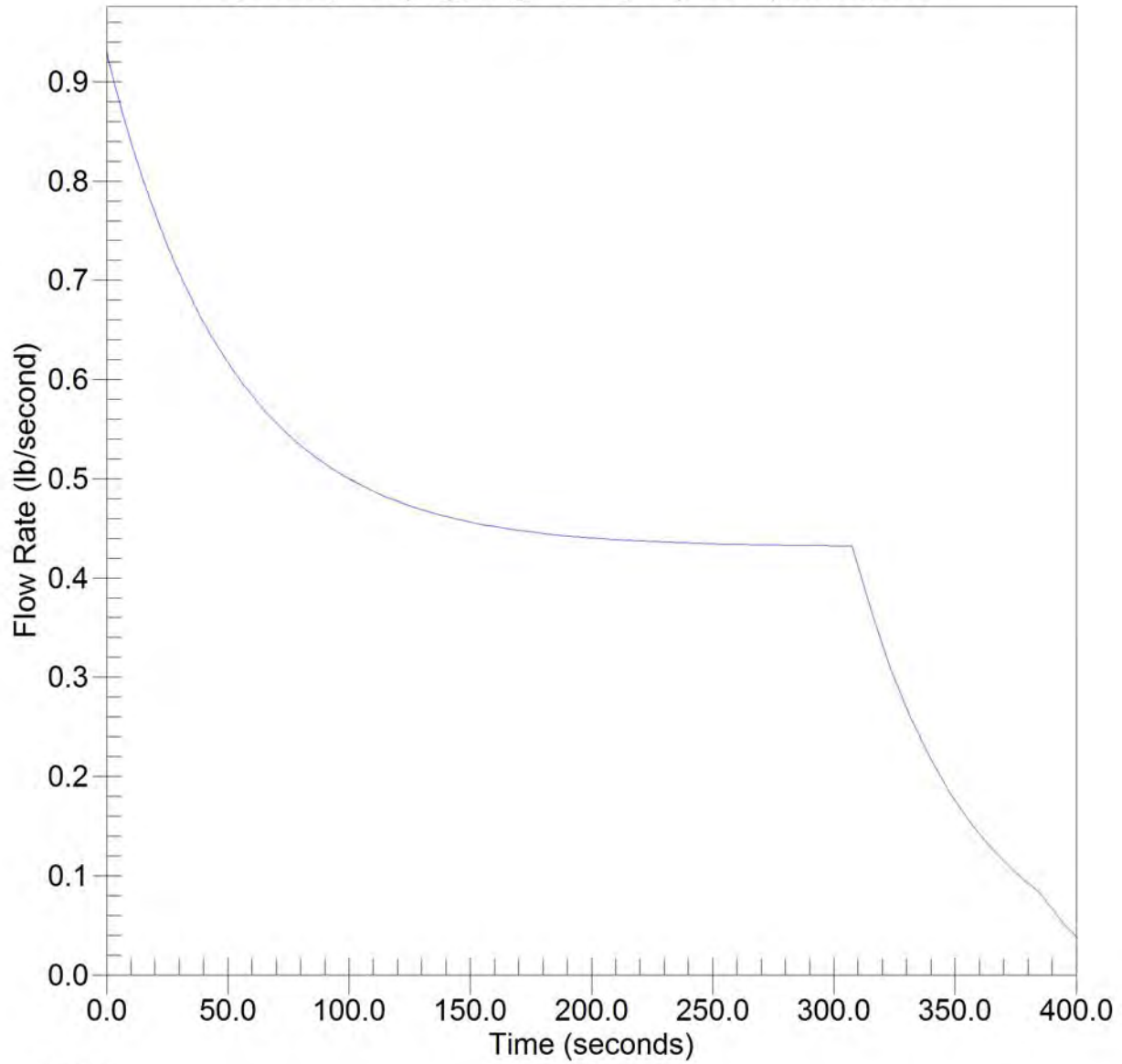
```

The downwind distance to dp3 is 13.2 feet
The downwind distance to dp2 is 18.8 feet
The downwind distance to dp1 is 129.7 feet

```

MASS RELEASE RATE

H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

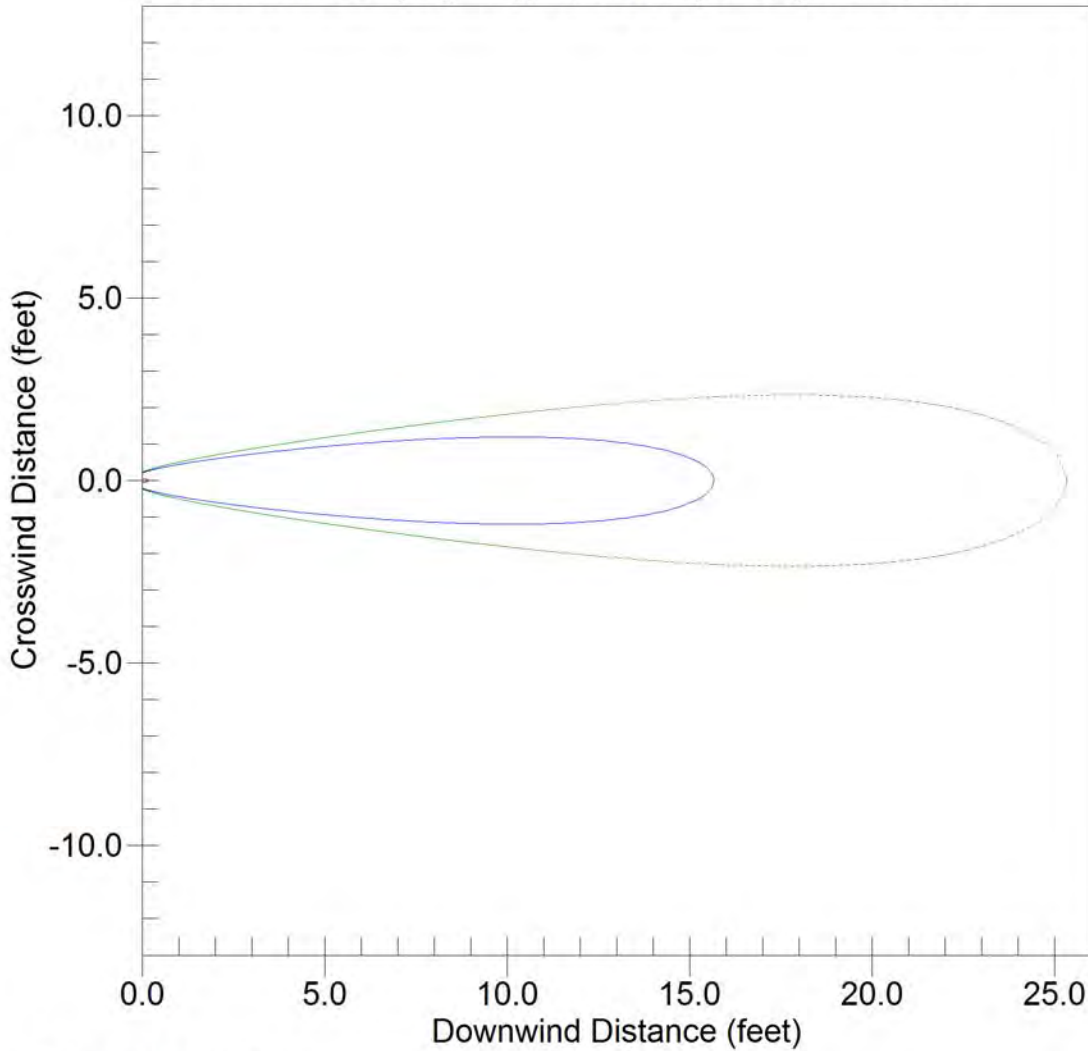


— Total
— Vapor

CANARY by Quest

casename=8D1IN260S1+45_7MMSCFD
Mon Jul 22 15:38:51 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

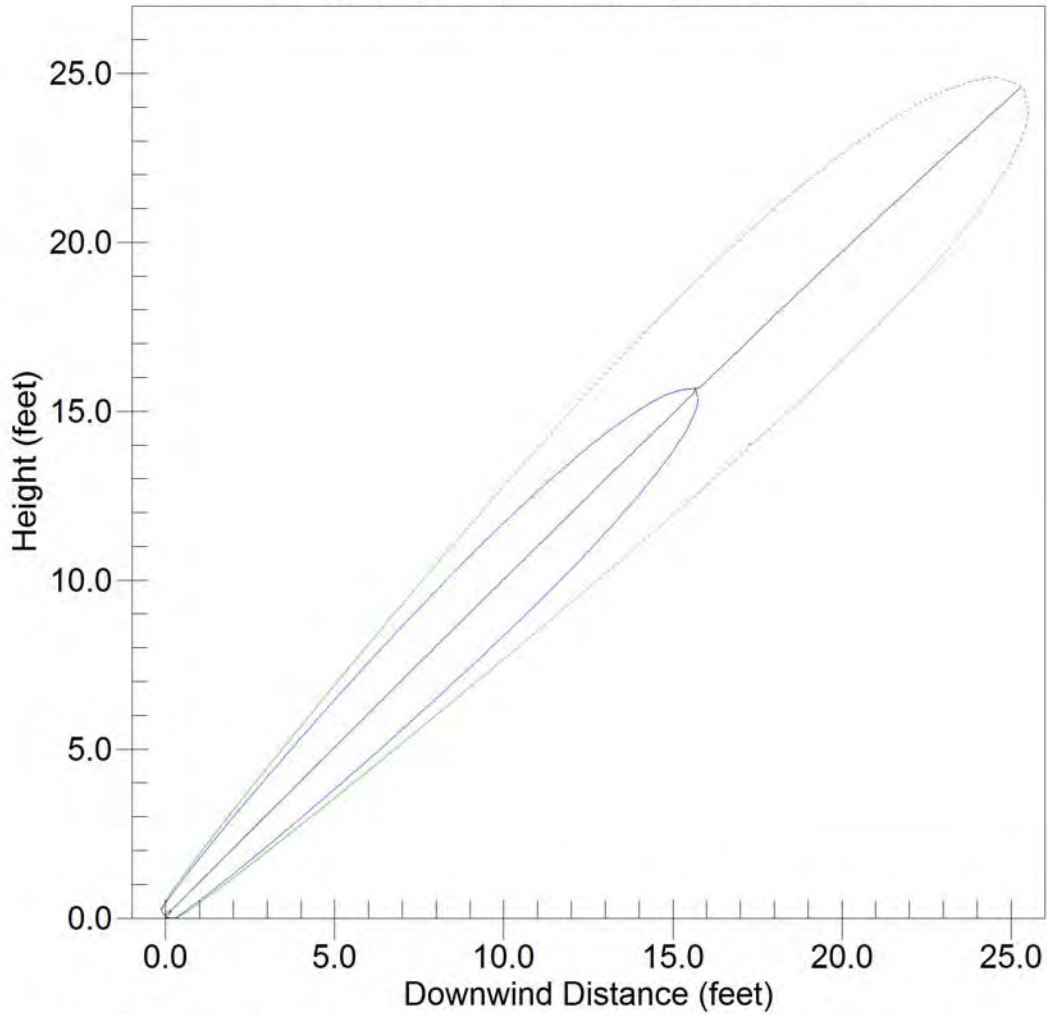


- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=8D1IN260S1+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Jul 22 15:38:51 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, +45°



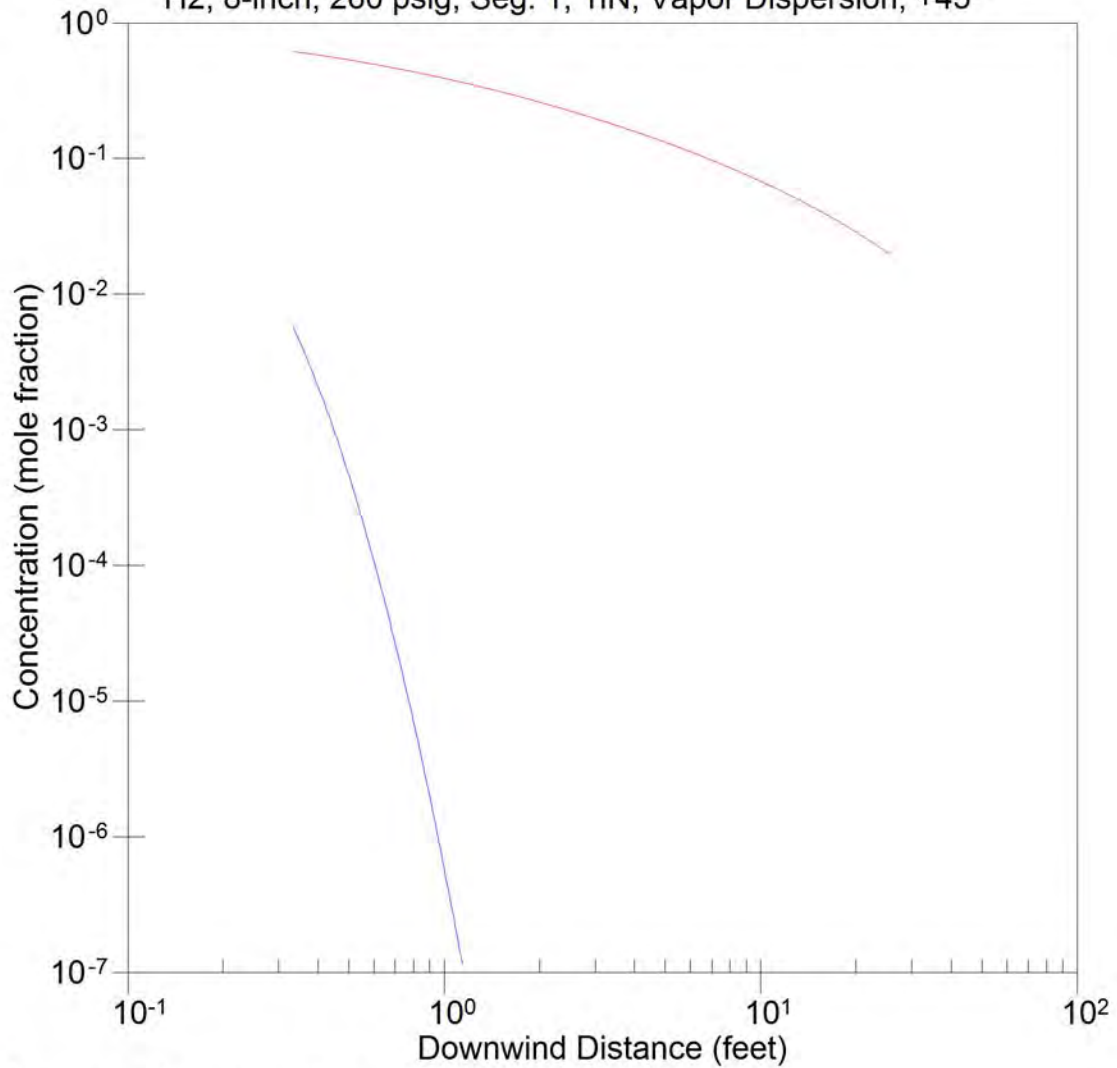
- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=8D1IN260S1+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Jul 22 15:38:51 2019

CANARY by Quest

Momentum Jet Cloud CONCENTRATION vs. DISTANCE

H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

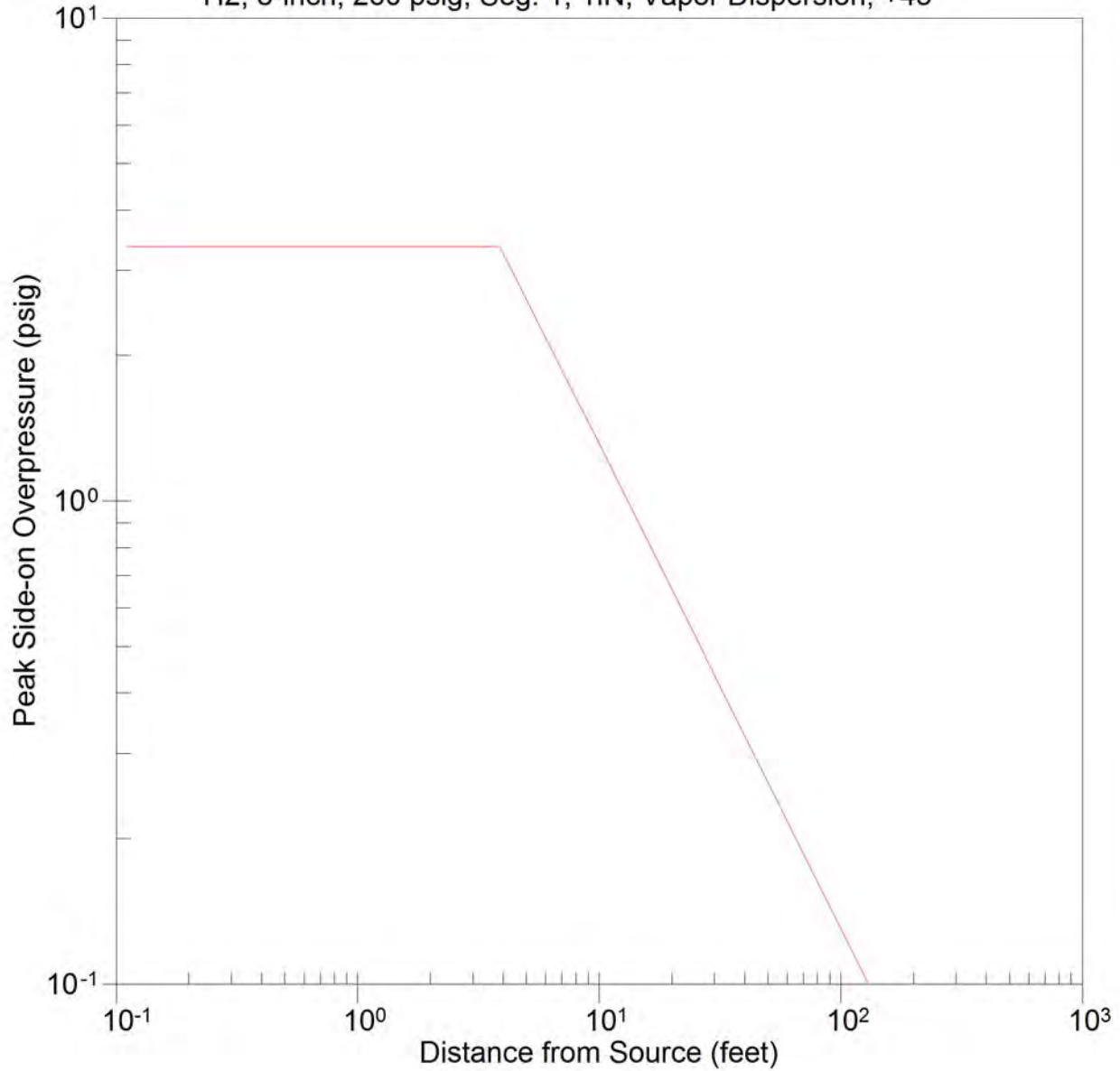


— Centerline Concentration
— Ground Level Concentration

casename=8D1IN260S1+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Jul 22 15:38:51 2019

CANARY by Quest

Momentum Jet VCE
BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, +45°



CANARY by Quest

casename=8D1IN260S1+45_7MMSCFD
Mon Jul 22 15:38:51 2019

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 8D1IN260S1-45_7MMSCFD                |
|           Mon Jul 22 15:39:54 2019                          |
|   Quest Consultants Inc., Norman, Oklahoma, USA             |
| www.questconsult.com           canary@questconsult.com      |
| telephone (405) 329-7475       fax (405) 329-7734          |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

```

Case Type           : Vapor Dispersion
Case Name           : 8D1IN260S1-45_7MMSCFD
User ID             : BLPayne
Project Number      : Job 2134
Type of Units       : English Units

```

NOTES: 7MMSCFD

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature         :          70.00 °F
Pressure             :          260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	72.0 °F
Spill surface temperature	72.0 °F
Substrate name	Medium density concrete
Substrate thermal conductivity	0.2698 Btu/hr-ft-F
Substrate density	80 lb/cu.ft
Substrate heat Capacity	0.22 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Wooded area or urban area

NOTES:

Case continued on page 2.

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|   CANARY Case Input                 |
| Case Name - 8D1IN260S1-45_7MMSCFD  |
|   Mon Jul 22 15:39:54 2019         |
|               |
+-----+

```

Page 2 Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration           120 min
Normal flow rate          0.43 lb/sec
Duration of normal flow   5 min
Volume of vessel          0.00 cu.ft
Pipe inner diameter       7.98 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 1464.0 feet
Height of release point   0.0 feet
Angle of release from horizontal 135.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1          UFL mol%
Concentration endpoint 2          LFL mol%
Concentration endpoint 3          1/2 LFL mol%

```

```

Dispersion coefficient averaging time          1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity          High
Obstacle density         Low
Flame expansion          3-D

```

Overpressure values

```

Overpressure endpoint 1          1.00 psi
Overpressure endpoint 2          0.70 psi
Overpressure endpoint 3          0.10 psi

```

NOTES:

```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 8D1IN260S1-45_7MMSCFD
Mon Jul 22 15:39:54 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

TITLE: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.9297522	0.000000	0.000000	.9297522
0.100000	.9294642	0.000000	0.000000	.9294642
0.300000	.9289317	0.000000	0.000000	.9289317
0.500000	.9238878	0.000000	0.000000	.9238878
0.700000	.9219604	0.000000	0.000000	.9219604
1.000000	.9190834	0.000000	0.000000	.9190834
3.000000	.9003252	0.000000	0.000000	.9003252
5.000000	.8822829	0.000000	0.000000	.8822829
7.000000	.8649299	0.000000	0.000000	.8649299
10.00000	.8401340	0.000000	0.000000	.8401340
20.00000	.7672038	0.000000	0.000000	.7672038
30.00000	.7071330	0.000000	0.000000	.7071330
40.00000	.6577694	0.000000	0.000000	.6577694
50.00000	.6171213	0.000000	0.000000	.6171213
60.00000	.5837360	0.000000	0.000000	.5837360
70.00000	.5563010	0.000000	0.000000	.5563010
85.00000	.5240023	0.000000	0.000000	.5240023
100.0000	.4999848	0.000000	0.000000	.4999848
200.0000	.4403185	0.000000	0.000000	.4403185
300.0000	.4323009	0.000000	0.000000	.4323009
400.0000	.3859213E-01	0.000000	0.000000	.3859213E-01
414.5990	0.000000	0.000000	0.000000	0.000000
Totals (lb)	175.3640	0.000000	0.000000	175.3640

Flowrate for Torch Fire [immediate ignition] = 0.7233400 lb/sec.
Torch Fire [delayed ignition] = 0.4579752 lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions               |
|           Case Name - 8D1IN260S1-45_7MMSCFD       |
|           Mon Jul 22 15:39:54 2019                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com           canary@questconsult.com |
|           telephone (405) 329-7475           fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 8D1IN260S1-45_7MMSCFD                     |
|      Mon Jul 22 15:39:54 2019                               |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

TITLE: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance	centerline conc.	ground conc.	y(c1) 1/2 width	y(c2) 1/2 width	y(c3) 1/2 width	centerline height
x(ft)	c(mole frac.)	c(mole frac.)	(ft)	(ft)	(ft)	(ft)
0	1.000000	0.000000	0.2	0.2	0.1	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is 0.00 ft after about 0 seconds
The downwind distance to c2 is 0.00 ft after about 0 seconds
The downwind distance to c1 is 0.00 ft after about 0 seconds

```

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
| Momentum Jet Vapor Cloud Explosion                          |
| Case Name - 8D1IN260S1-45_7MMSCFD                          |
| Mon Jul 22 15:39:54 2019                                    |
| Quest Consultants Inc., Norman, Oklahoma, USA                |
| www.questconsult.com          canary@questconsult.com        |
| telephone (405) 329-7475      fax (405) 329-7734            |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

Fuel Reactivity: High Obstacle Density: Low
 Flame Expansion: 3-D Flame Speed: 0.36

Overpressure levels:

```

-----
dp3 =        1.00 psi gauge
dp2 =        0.70 psi gauge
dp1 =        0.10 psi gauge

```

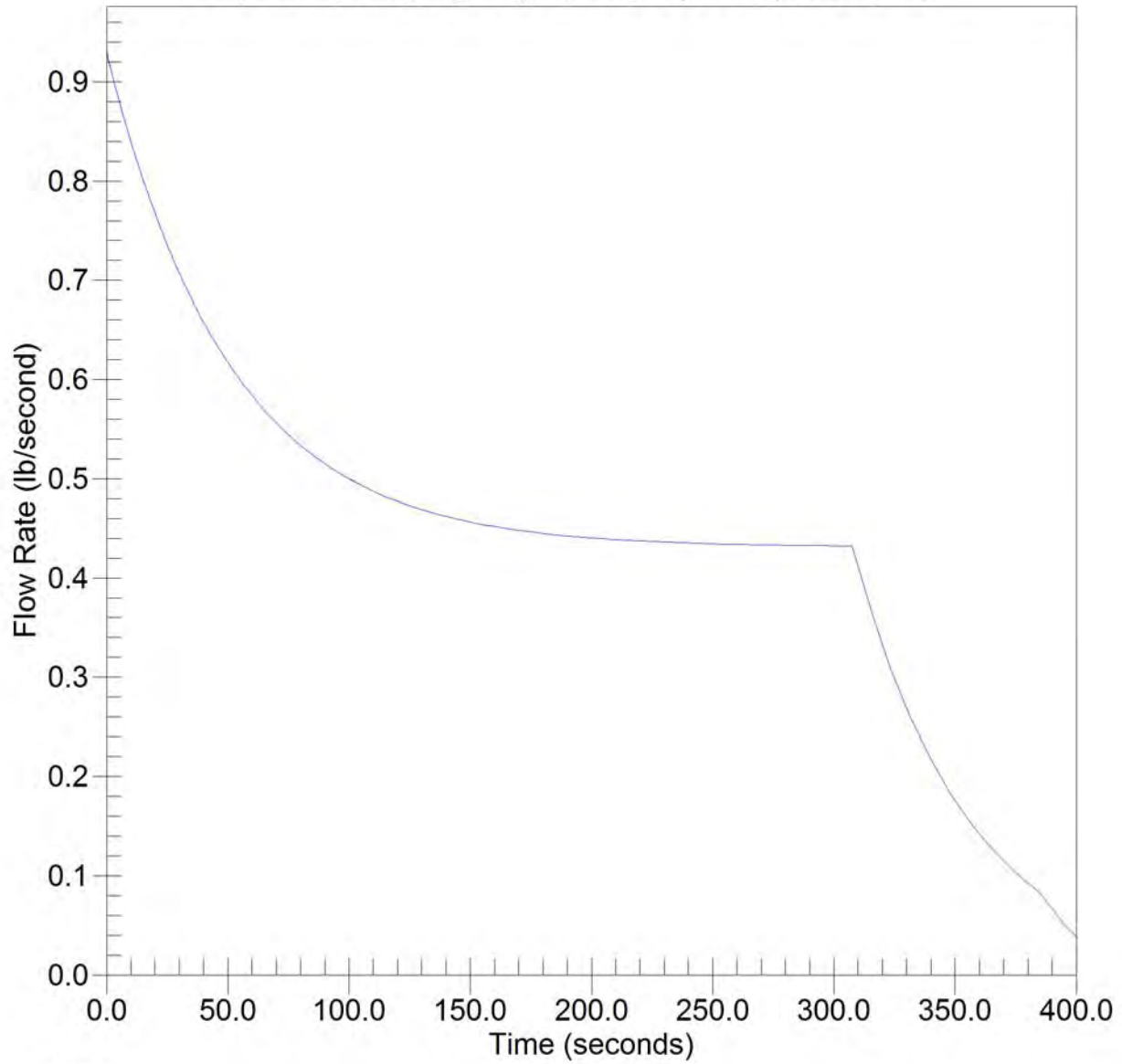
Mass of released material in explosive range: 0.0446371 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0196
0.9	3.36	0.0196
1.1	3.36	0.0196
1.3	3.36	0.0196
1.5	3.36	0.0188
1.8	3.36	0.0161
2.1	3.36	0.0138
2.4	3.36	0.0118
2.8	3.36	0.0101
3.3	3.36	0.0087
3.9	3.36	0.0075
4.5	2.88	0.0064
5.3	2.47	0.0055
6.2	2.11	0.0047
7.3	1.81	0.0040
8.5	1.55	0.0035
10.0	1.33	0.0030
11.7	1.13	0.0025
13.6	0.97	0.0022
16.0	0.83	0.0019
18.7	0.71	0.0016
21.8	0.60	0.0014
25.6	0.51	0.0012
29.9	0.44	0.0010
130.3	0.10	0.0002

The downwind distance to dp3 is 13.3 feet
 The downwind distance to dp2 is 18.8 feet
 The downwind distance to dp1 is 130.3 feet

MASS RELEASE RATE

H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

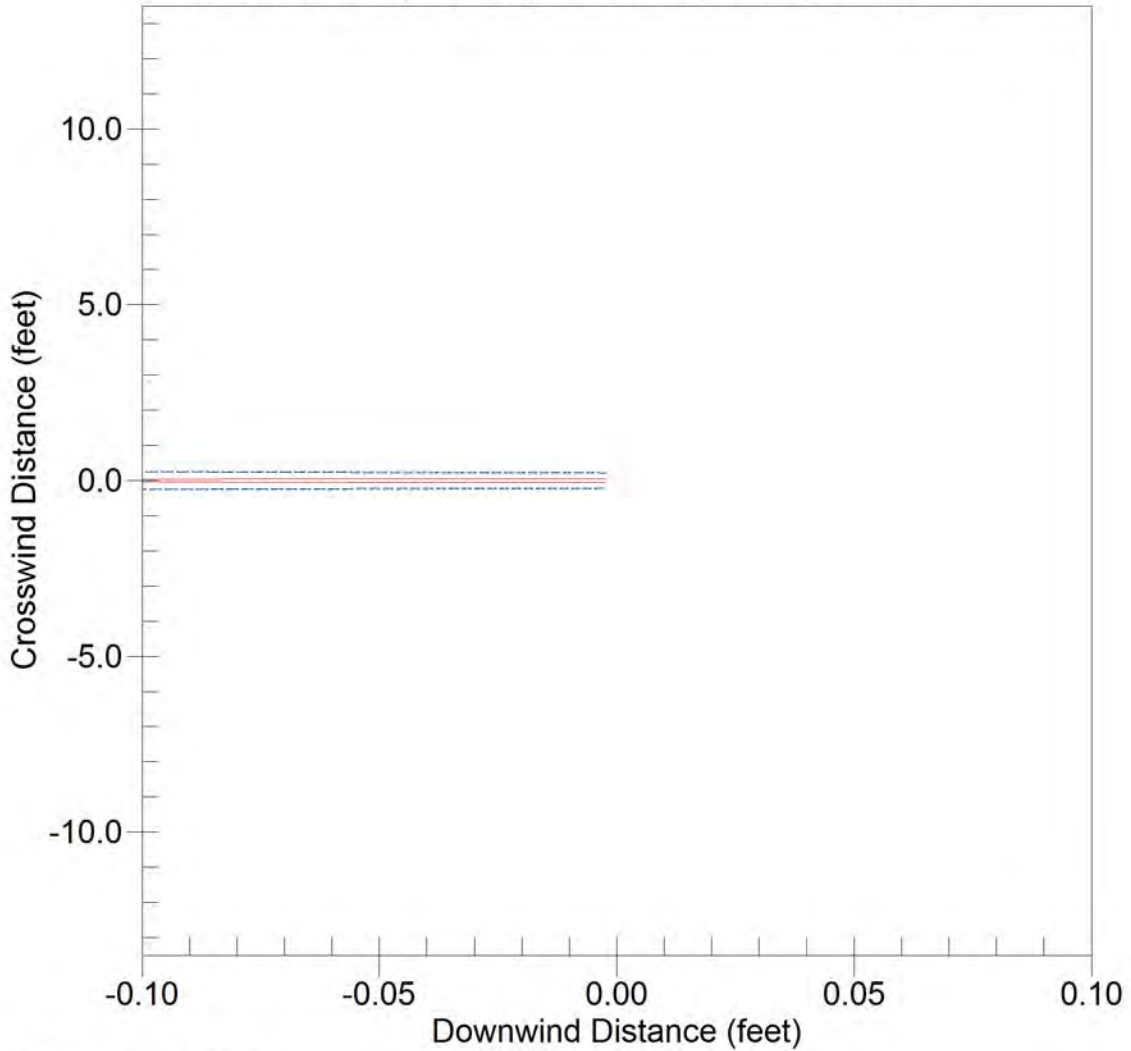


— Total
— Vapor

CANARY by Quest

casename=8D1IN260S1-45_7MMSCFD
Mon Jul 22 15:39:54 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

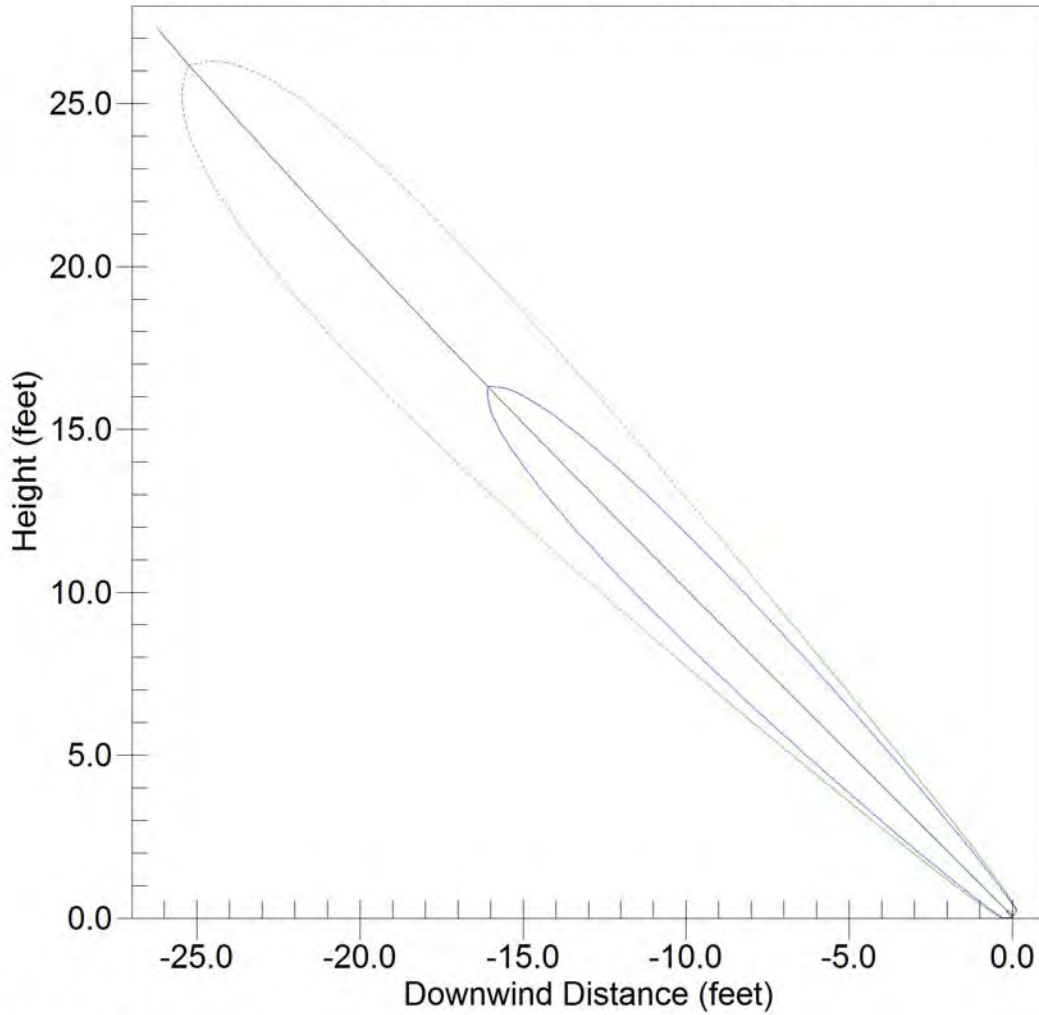


- 75.0 mole percent
- - - 4.00 mole percent
- 2.00 mole percent

casename=8D1IN260S1-45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Jul 22 15:39:54 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, -45°



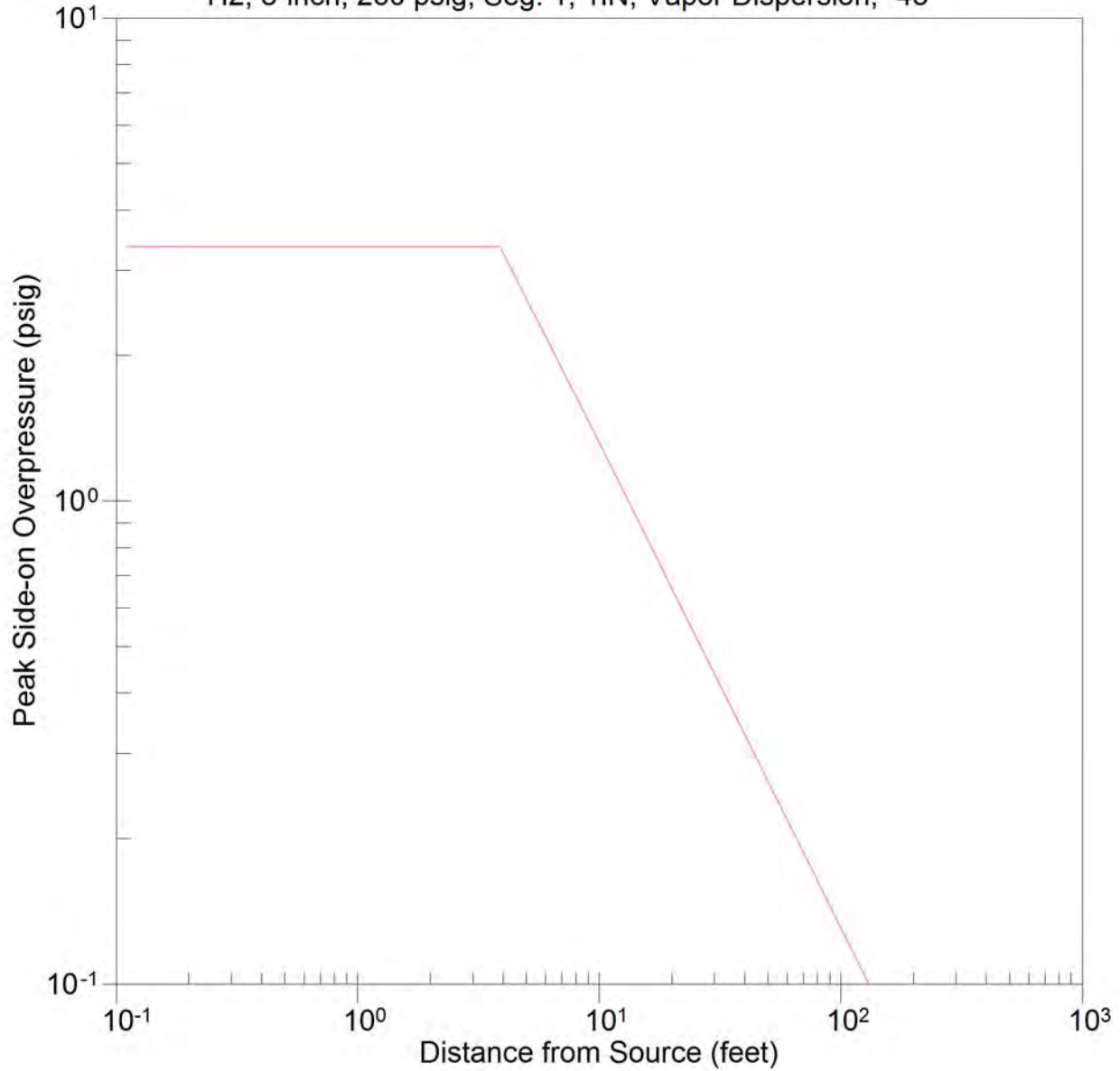
- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=8D1IN260S1-45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Jul 22 15:39:54 2019

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 8-inch, 260 psig, Seg. 1, 1IN, Vapor Dispersion, -45°



CANARY by Quest

casename=8D1IN260S1-45_7MMSCFD
Mon Jul 22 15:39:54 2019



Vapor Dispersion Modeling Results, Segment 2A

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 10D8IN260S2A+45_7MMSCFD     |
|           Sun Sep  8 17:27:04 2019                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com                     |
|           telephone (405) 329-7475                 |
|           canary@questconsult.com                  |
|           fax (405) 329-7734                       |
|                                     |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

```

Case Type       : Vapor Dispersion
Case Name      : 10D8IN260S2A+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A - 8-inch Hole

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Psuedo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity       0.22 Btu/lb-F
Substrate delay time          0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 10D8IN260S2A+45_7MMSCFD |
| Sun Sep 8 17:27:04 2019 |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

RELEASE MENU

Type of release: Unregulated, Continuous release
 Release duration 120 min
 Normal flow rate 0.43 lb/sec
 Duration of normal flow 5 min
 Volume of vessel 0.00 cu.ft
 Pipe inner diameter 10.02 inches
 Equivalent release diameter 8.00 inches
 Pipe length upstream of break 20416.0 feet
 Height of release point 0.0 feet
 Angle of release from horizontal 45.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation, dispersion and cloud explosion - Flammable calculation
 Concentration endpoint 1 UFL mol%
 Concentration endpoint 2 LFL mol%
 Concentration endpoint 3 1/2 LFL mol%

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

Fuel reactivity High
 Obstacle density Low
 Flame expansion 3-D

Overpressure values

Overpressure endpoint 1 1.00 psi
 Overpressure endpoint 2 0.70 psi
 Overpressure endpoint 3 0.10 psi

NOTES:

```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 10D8IN260S2A+45_7MMSCFD
Sun Sep 8 17:27:04 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com canary@questconsult.com
telephone (405) 329-7475 fax (405) 329-7734

```

TITLE: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	59.44477	0.000000	0.000000	59.44477
0.100000	44.77628	0.000000	0.000000	44.77628
0.300000	32.82373	0.000000	0.000000	32.82373
0.500000	27.14510	0.000000	0.000000	27.14510
0.700000	23.66186	0.000000	0.000000	23.66186
1.000000	20.28323	0.000000	0.000000	20.28323
3.000000	12.16274	0.000000	0.000000	12.16274
5.000000	8.931694	0.000000	0.000000	8.931694
7.000000	8.772329	0.000000	0.000000	8.772329
10.00000	8.538814	0.000000	0.000000	8.538814
20.00000	7.807017	0.000000	0.000000	7.807017
30.00000	7.141262	0.000000	0.000000	7.141262
40.00000	6.535929	0.000000	0.000000	6.535929
50.00000	5.984982	0.000000	0.000000	5.984982
60.00000	5.483925	0.000000	0.000000	5.483925
70.00000	5.024159	0.000000	0.000000	5.024159
85.00000	4.409205	0.000000	0.000000	4.409205
100.0000	3.875961	0.000000	0.000000	3.875961
200.0000	1.734734	0.000000	0.000000	1.734734
300.0000	.8735602	0.000000	0.000000	.8735602
400.0000	.2297237	0.000000	0.000000	.2297237
445.6723	0.000000	0.000000	0.000000	0.000000
Totals (lb)	1102.928	0.000000	0.000000	1102.928

Flowrate for Torch Fire [immediate ignition] = 7.835432 lb/sec.
Torch Fire [delayed ignition] = 2.586878 lb/sec.

Reason for Ending: Pressure Near Atmospheric


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions             |
|           Case Name - 10D8IN260S2A+45_7MMSCFD    |
|           Sun Sep  8 17:27:04 2019              |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com                   |
|           telephone (405) 329-7475               |
|           canary@questconsult.com                |
|           fax (405) 329-7734                    |
|                                     |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

Component Number Component Name, Formula

```

-----
51      Hydrogen(equilibrium), H2
43      Carbon Monoxide, CO
17      Carbon Dioxide, CO2
  1      Methane, CH4
299     pseudo Water, H2O
 28      Oxygen, O2

```

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
| Momentum Jet Vapor Dispersion Model |
| Case Name - 10D8IN260S2A+45_7MMSCFD |
|   Sun Sep  8 17:27:04 2019         |
| Quest Consultants Inc., Norman, Oklahoma, USA |
| www.questconsult.com   canary@questconsult.com |
| telephone (405) 329-7475   fax (405) 329-7734 |
|               |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.8	0.7	0.2	0.1
1	0.635511	0.024296	1.1	1.0	0.0	1.1
2	0.493742	0.000295	1.4	1.2	0.0	2.1
3	0.409507	0.000005	1.6	1.4	0.0	3.1
4	0.351904	0.000000	1.8	1.6	0.0	4.1
5	0.309212	0.000000	2.0	1.7	0.0	5.1
6	0.276099	0.000000	2.2	1.9	0.0	6.1
7	0.249443	0.000000	2.4	2.0	0.0	7.1
8	0.227495	0.000000	2.6	2.2	0.0	8.1
9	0.209057	0.000000	2.7	2.3	0.0	9.1
10	0.193221	0.000000	2.9	2.4	0.0	10.1
11	0.179537	0.000000	3.1	2.5	0.0	11.0
12	0.167478	0.000000	3.2	2.7	0.0	12.0
13	0.156907	0.000000	3.4	2.8	0.0	13.0
14	0.147522	0.000000	3.6	2.9	0.0	14.0
15	0.139098	0.000000	3.7	3.0	0.0	15.0
16	0.131387	0.000000	3.9	3.1	0.0	16.0
17	0.124438	0.000000	4.0	3.2	0.0	17.0
18	0.118092	0.000000	4.2	3.3	0.0	18.0
19	0.112297	0.000000	4.3	3.3	0.0	19.0
20	0.106985	0.000000	4.5	3.4	0.0	20.0
21	0.102080	0.000000	4.6	3.5	0.0	21.0
22	0.097533	0.000000	4.8	3.6	0.0	21.9
23	0.093314	0.000000	4.9	3.6	0.0	22.9
24	0.089331	0.000000	5.0	3.7	0.0	23.9
25	0.085721	0.000000	5.2	3.7	0.0	24.9
26	0.082226	0.000000	5.3	3.8	0.0	25.9
27	0.079001	0.000000	5.4	3.8	0.0	26.8
28	0.076009	0.000000	5.6	3.9	0.0	27.8
29	0.073138	0.000000	5.7	3.9	0.0	28.8
30	0.070436	0.000000	5.8	3.9	0.0	29.8
31	0.067935	0.000000	5.9	3.9	0.0	30.7
32	0.065515	0.000000	6.1	3.9	0.0	31.7
33	0.063256	0.000000	6.2	3.9	0.0	32.6
34	0.061102	0.000000	6.3	3.9	0.0	33.6

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
35	0.058936	0.000000	6.4	3.8	0.0	34.6
36	0.057014	0.000000	6.5	3.8	0.0	35.5
37	0.055193	0.000000	6.6	3.7	0.0	36.5
38	0.053456	0.000000	6.7	3.7	0.0	37.4
39	0.051741	0.000000	6.8	3.5	0.0	38.4
40	0.050097	0.000000	6.9	3.4	0.0	39.3
41	0.048603	0.000000	7.0	3.3	0.0	40.3
42	0.047133	0.000000	7.1	3.1	0.0	41.2
43	0.045696	0.000000	7.2	2.9	0.0	42.2
44	0.044345	0.000000	7.2	2.6	0.0	43.1
45	0.043073	0.000000	7.3	2.3	0.0	44.0
46	0.041837	0.000000	7.4	1.8	0.0	45.0
47	0.040635	0.000000	7.4	1.1	0.0	45.9
48	0.039476	0.000000	7.5	0.0	0.0	46.8
49	0.038371	0.000000	7.5	0.0	0.0	47.7
50	0.037326	0.000000	7.5	0.0	0.0	48.7
51	0.036337	0.000000	7.6	0.0	0.0	49.6
52	0.035319	0.000000	7.6	0.0	0.0	50.5
53	0.034379	0.000000	7.6	0.0	0.0	51.4
54	0.033462	0.000000	7.6	0.0	0.0	52.3
55	0.032596	0.000000	7.6	0.0	0.0	53.2
56	0.031758	0.000000	7.6	0.0	0.0	54.1
57	0.030947	0.000000	7.5	0.0	0.0	54.9
58	0.030148	0.000000	7.5	0.0	0.0	55.8
59	0.029384	0.000000	7.4	0.0	0.0	56.7
60	0.028644	0.000000	7.3	0.0	0.0	57.6
61	0.027942	0.000000	7.2	0.0	0.0	58.5
62	0.027261	0.000000	7.1	0.0	0.0	59.4
63	0.026607	0.000000	7.0	0.0	0.0	60.2
64	0.025957	0.000000	6.8	0.0	0.0	61.1
65	0.025324	0.000000	6.7	0.0	0.0	61.9
66	0.024723	0.000000	6.5	0.0	0.0	62.8
67	0.024140	0.000000	6.2	0.0	0.0	63.7
68	0.023600	0.000000	6.0	0.0	0.0	64.5
69	0.023065	0.000000	5.6	0.0	0.0	65.3
70	0.022531	0.000000	5.3	0.0	0.0	66.2
71	0.022006	0.000000	4.8	0.0	0.0	67.0
72	0.021505	0.000000	4.3	0.0	0.0	67.8
73	0.021027	0.000000	3.6	0.0	0.0	68.7
74	0.020551	0.000000	2.7	0.0	0.0	69.5
75	0.020101	0.000000	1.1	0.0	0.0	70.3

The downwind distance to c3 is 0.53 ft after about 0 seconds
The downwind distance to c2 is 47.53 ft after about 0 seconds
The downwind distance to c1 is 75.23 ft after about 0 seconds

```

+-----+
|           CANARY by Quest - Version 4.6.2           |
| Momentum Jet Vapor Cloud Explosion                 |
| Case Name - 10D8IN260S2A+45_7MMSCFD              |
| Sun Sep  8 17:27:04 2019                          |
| Quest Consultants Inc., Norman, Oklahoma, USA      |
| www.questconsult.com      canary@questconsult.com  |
| telephone (405) 329-7475    fax (405) 329-7734    |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

Fuel Reactivity: High Obstacle Density: Low
 Flame Expansion: 3-D Flame Speed: 0.36

Overpressure levels:

```

-----
dp3 =        1.00 psi gauge
dp2 =        0.70 psi gauge
dp1 =        0.10 psi gauge

```

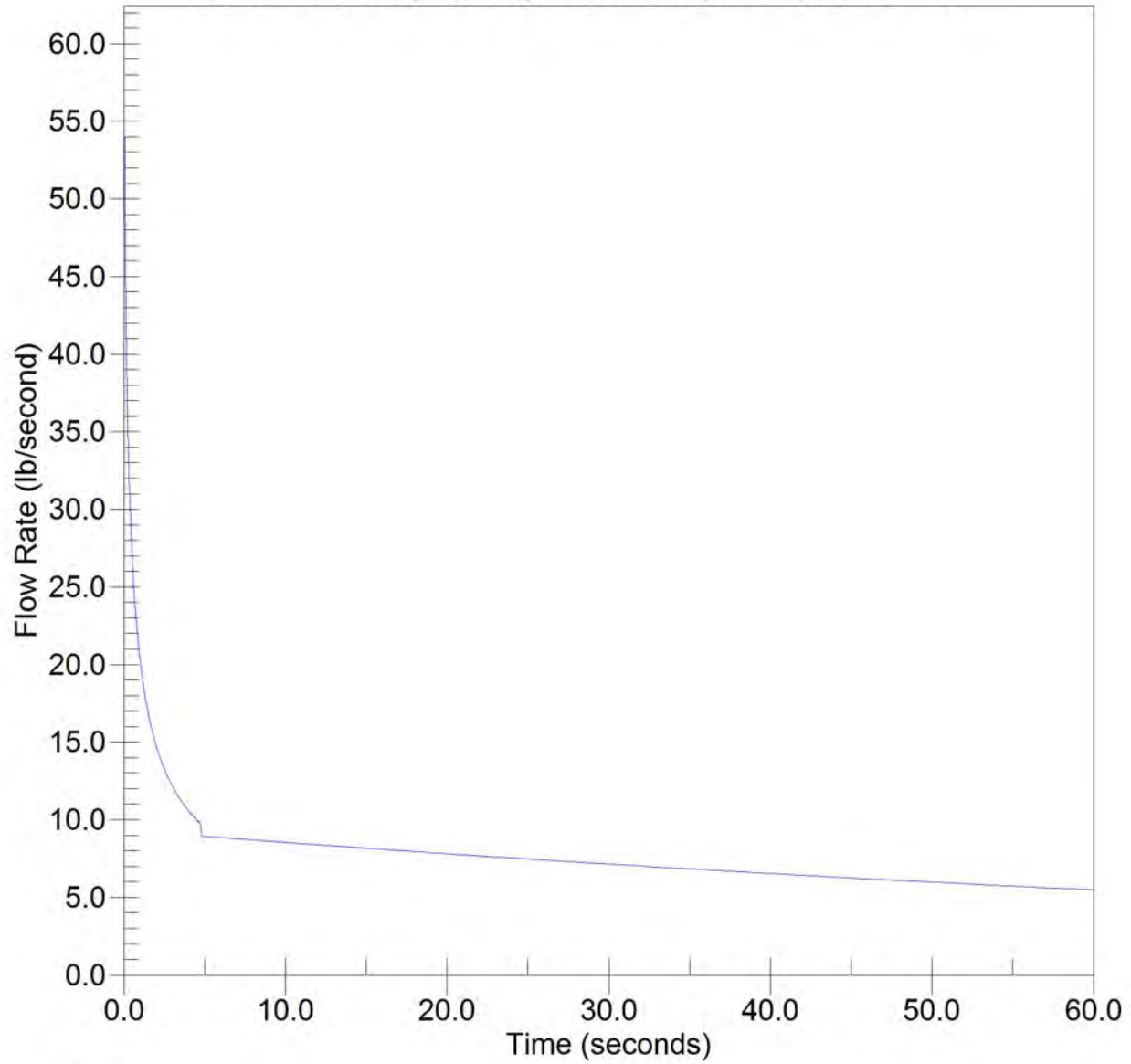
Mass of released material in explosive range: 1.38531 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0615
3.0	3.36	0.0615
3.6	3.36	0.0615
4.5	3.36	0.0615
5.5	3.36	0.0510
6.8	3.36	0.0417
8.3	3.36	0.0341
10.2	3.36	0.0278
12.6	3.27	0.0228
15.4	2.67	0.0186
19.0	2.18	0.0152
23.3	1.78	0.0124
28.7	1.45	0.0101
35.2	1.18	0.0083
43.3	0.96	0.0068
53.2	0.78	0.0055
65.3	0.63	0.0045
80.3	0.51	0.0037
98.7	0.42	0.0030
121.2	0.34	0.0025
149.0	0.28	0.0020
183.1	0.22	0.0016
224.9	0.18	0.0013
276.4	0.15	0.0011
409.5	0.10	0.0007

The downwind distance to dp3 is 41.8 feet
 The downwind distance to dp2 is 59.8 feet
 The downwind distance to dp1 is 409.5 feet

MASS RELEASE RATE

H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

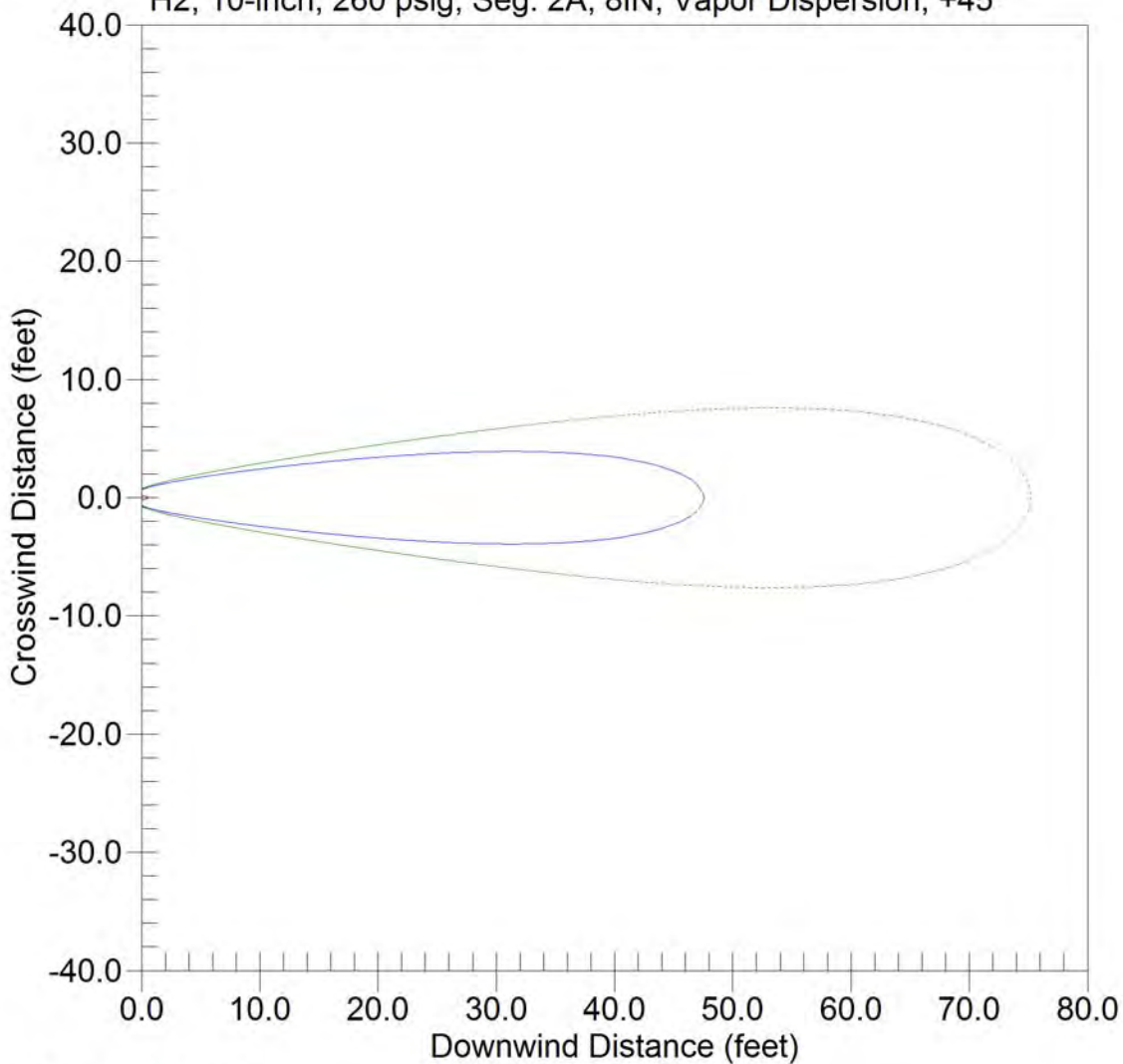


— Total
— Vapor

CANARY by Quest

casename=10D8IN260S2A+45_7MMSCFD
Sun Sep 8 17:27:04 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

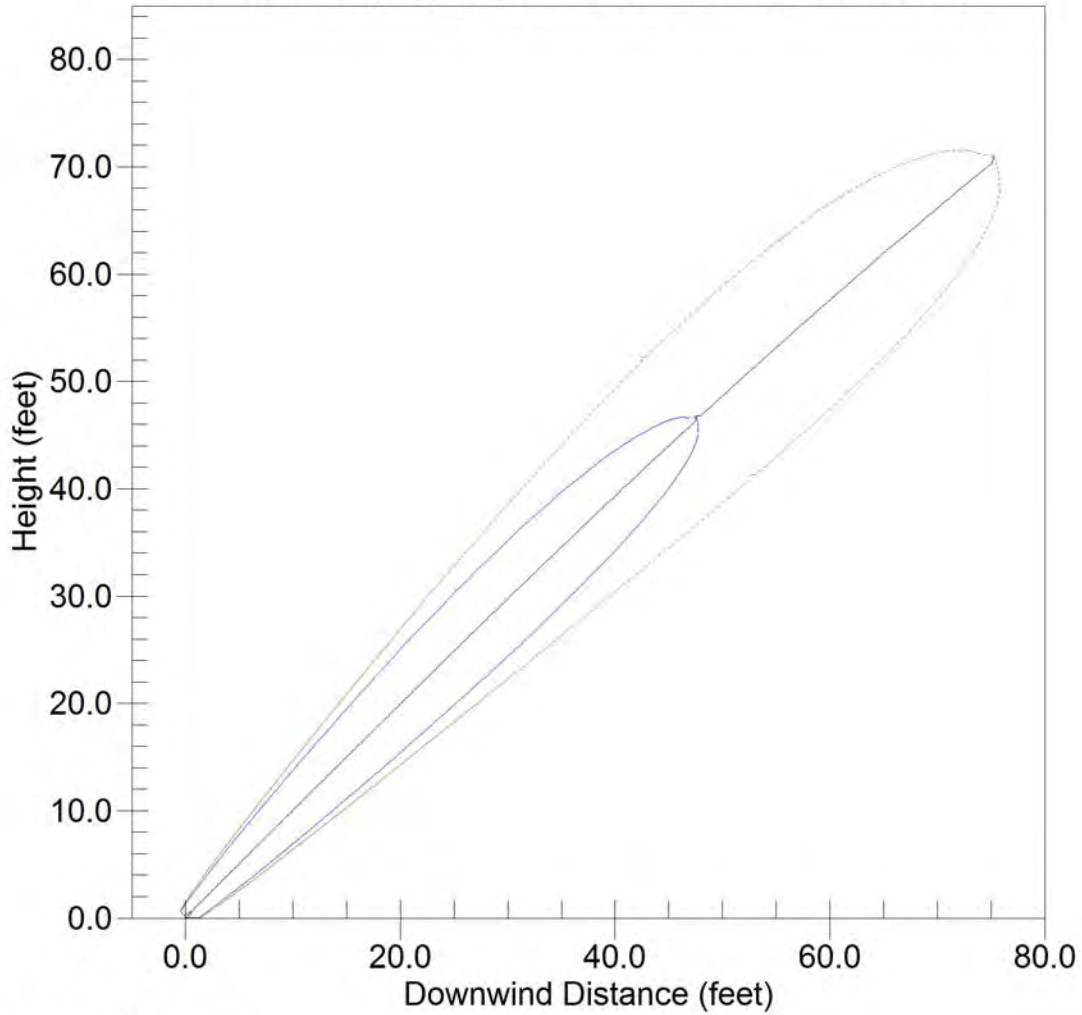


- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=10D8IN260S2A+45_7MMSCFD
windspeed = 4.5 mph
D stability
Sun Sep 8 17:27:04 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°



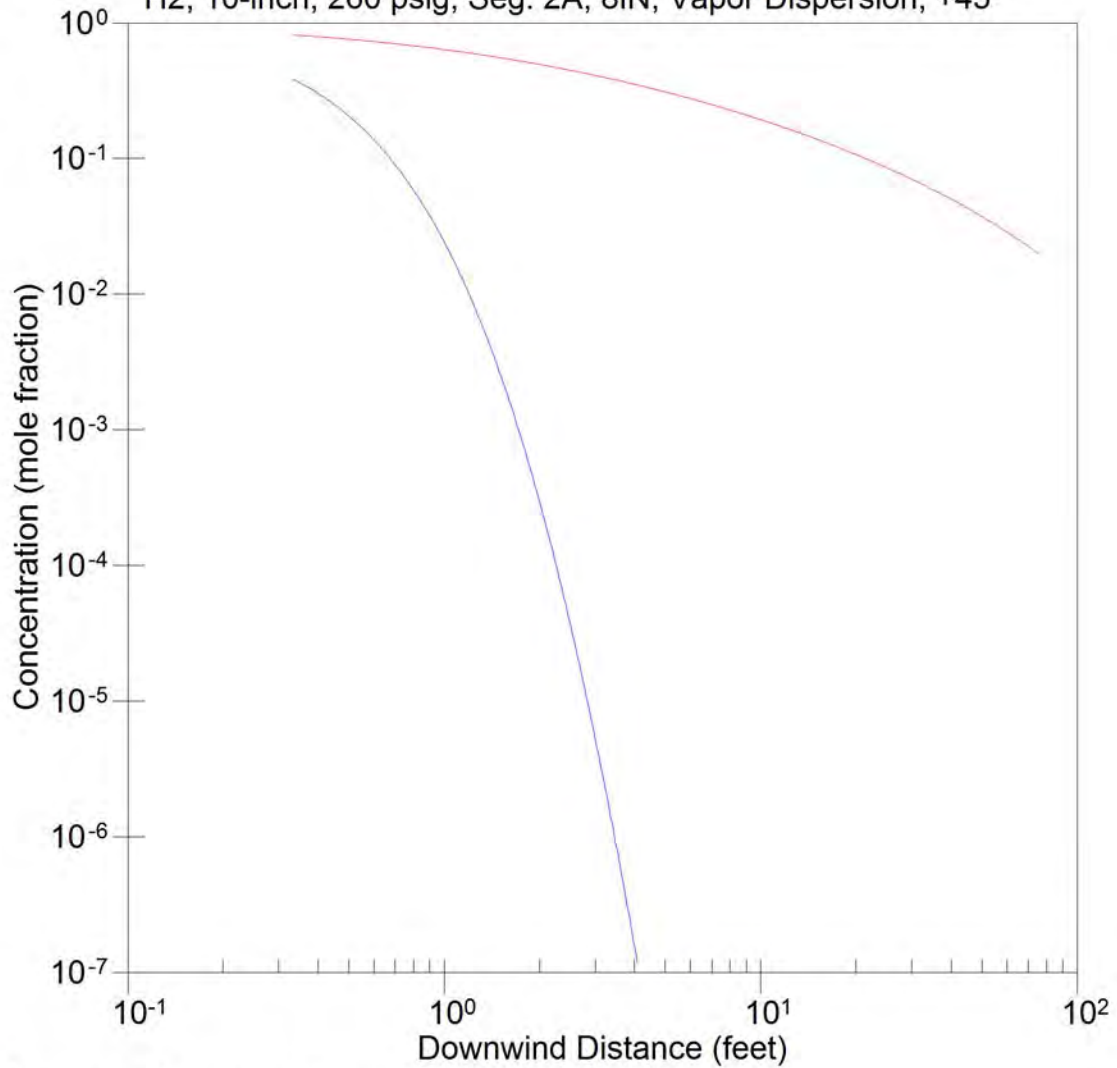
- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=10D8IN260S2A+45_7MMSCFD
windspeed = 4.5 mph
D stability
Sun Sep 8 17:27:04 2019

CANARY by Quest

Momentum Jet Cloud CONCENTRATION vs. DISTANCE

H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°



— Centerline Concentration
— Ground Level Concentration

casename=10D8IN260S2A+45_7MMSCFD

windspeed = 4.5 mph

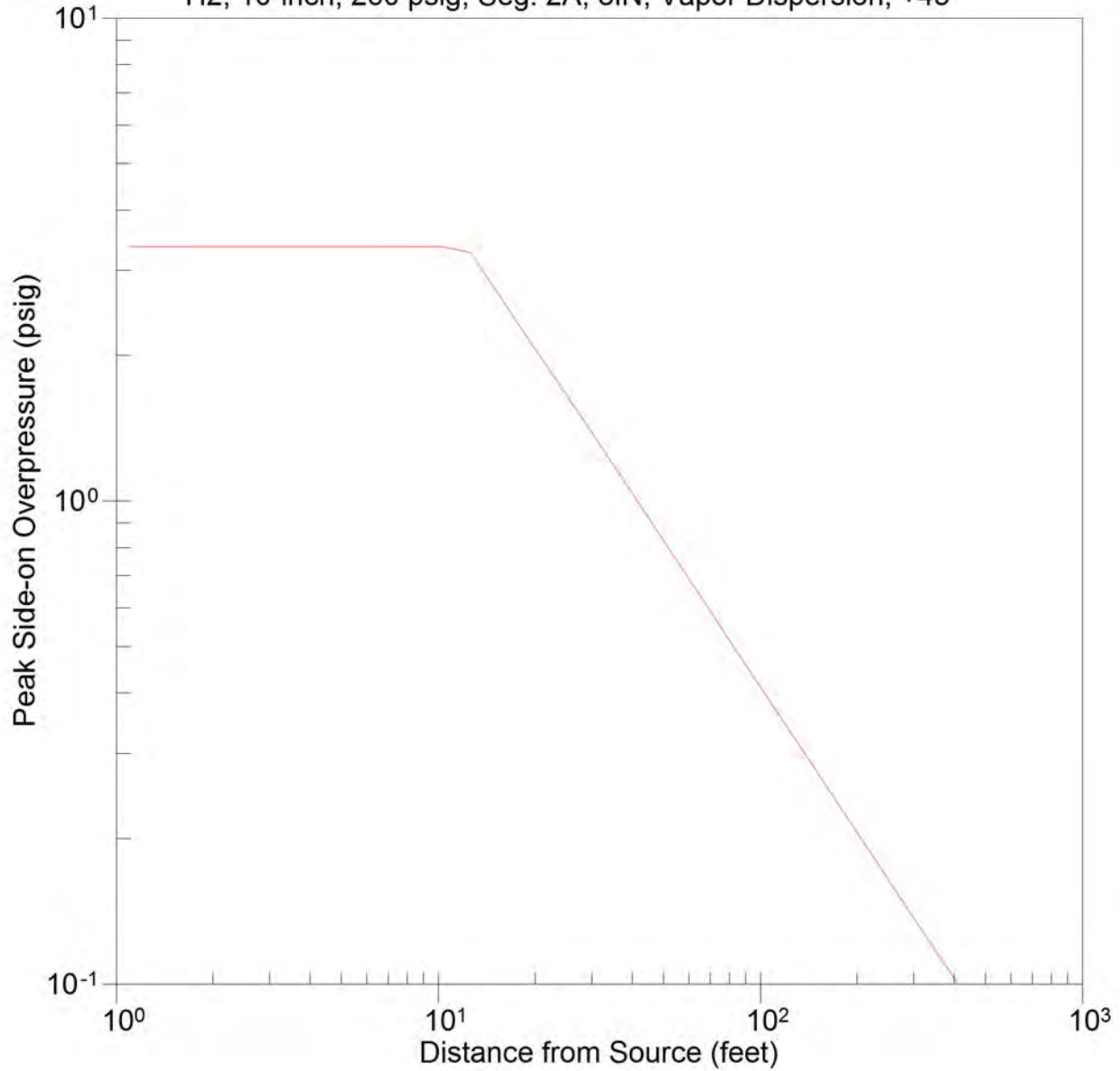
D stability

Sun Sep 8 17:27:04 2019

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°



CANARY by Quest

casename=10D8IN260S2A+45_7MMSCFD
Sun Sep 8 17:27:04 2019

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 10D8IN260S2A-45_7MMSCFD     |
|           Sun Sep  8 17:27:51 2019                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com                     |
|           telephone (405) 329-7475                 |
|           canary@questconsult.com                   |
|           fax (405) 329-7734                       |
|                                     |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

```

Case Type       : Vapor Dispersion
Case Name      : 10D8IN260S2A-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A - 8-inch Hole

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	72.0 °F
Spill surface temperature	72.0 °F
Substrate name	Medium density concrete
Substrate thermal conductivity	0.2698 Btu/hr-ft-F
Substrate density	80 lb/cu.ft
Substrate heat Capacity	0.22 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Wooded area or urban area

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 10D8IN260S2A-45_7MMSCFD |
| Sun Sep 8 17:27:51 2019 |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

RELEASE MENU

Type of release: Unregulated, Continuous release
 Release duration 120 min
 Normal flow rate 0.43 lb/sec
 Duration of normal flow 5 min
 Volume of vessel 0.00 cu.ft
 Pipe inner diameter 10.02 inches
 Equivalent release diameter 8.00 inches
 Pipe length upstream of break 20416.0 feet
 Height of release point 0.0 feet
 Angle of release from horizontal 135.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation, dispersion and cloud explosion - Flammable calculation
 Concentration endpoint 1 UFL mol%
 Concentration endpoint 2 LFL mol%
 Concentration endpoint 3 1/2 LFL mol%

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

Fuel reactivity High
 Obstacle density Low
 Flame expansion 3-D

Overpressure values

Overpressure endpoint 1 1.00 psi
 Overpressure endpoint 2 0.70 psi
 Overpressure endpoint 3 0.10 psi

NOTES:

```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 10D8IN260S2A-45_7MMSCFD
Sun Sep 8 17:27:51 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com canary@questconsult.com
telephone (405) 329-7475 fax (405) 329-7734

```

TITLE: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	59.44477	0.000000	0.000000	59.44477
0.100000	44.77628	0.000000	0.000000	44.77628
0.300000	32.82373	0.000000	0.000000	32.82373
0.500000	27.14510	0.000000	0.000000	27.14510
0.700000	23.66186	0.000000	0.000000	23.66186
1.000000	20.28323	0.000000	0.000000	20.28323
3.000000	12.16274	0.000000	0.000000	12.16274
5.000000	8.931694	0.000000	0.000000	8.931694
7.000000	8.772329	0.000000	0.000000	8.772329
10.00000	8.538814	0.000000	0.000000	8.538814
20.00000	7.807017	0.000000	0.000000	7.807017
30.00000	7.141262	0.000000	0.000000	7.141262
40.00000	6.535929	0.000000	0.000000	6.535929
50.00000	5.984982	0.000000	0.000000	5.984982
60.00000	5.483925	0.000000	0.000000	5.483925
70.00000	5.024159	0.000000	0.000000	5.024159
85.00000	4.409205	0.000000	0.000000	4.409205
100.0000	3.875961	0.000000	0.000000	3.875961
200.0000	1.734734	0.000000	0.000000	1.734734
300.0000	.8735602	0.000000	0.000000	.8735602
400.0000	.2297237	0.000000	0.000000	.2297237
445.6723	0.000000	0.000000	0.000000	0.000000
Totals (lb)	1102.928	0.000000	0.000000	1102.928

Flowrate for Torch Fire [immediate ignition] = 7.835432 lb/sec.
Torch Fire [delayed ignition] = 2.586878 lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions               |
|           Case Name - 10D8IN260S2A-45_7MMSCFD     |
|           Sun Sep  8 17:27:51 2019                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com           canary@questconsult.com |
|           telephone (405) 329-7475           fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
| Momentum Jet Vapor Dispersion Model                         |
| Case Name - 10D8IN260S2A-45_7MMSCFD                       |
| Sun Sep  8 17:27:51 2019                                    |
| Quest Consultants Inc., Norman, Oklahoma, USA              |
| www.questconsult.com    canary@questconsult.com            |
| telephone (405) 329-7475    fax (405) 329-7734            |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance	centerline conc.	ground conc.	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
x(ft)	c(mole frac.)	c(mole frac.)	(ft)	(ft)	(ft)	(ft)
0	1.000000	0.000000	0.8	0.7	0.2	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is 0.00 ft after about 1 seconds
The downwind distance to c2 is 0.00 ft after about 1 seconds
The downwind distance to c1 is 0.00 ft after about 1 seconds

```

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
| Momentum Jet Vapor Cloud Explosion              |
| Case Name - 10D8IN260S2A-45_7MMSCFD           |
| Sun Sep  8 17:27:51 2019                       |
| Quest Consultants Inc., Norman, Oklahoma, USA   |
| www.questconsult.com       canary@questconsult.com |
| telephone (405) 329-7475   fax (405) 329-7734   |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

Fuel Reactivity: High Obstacle Density: Low
 Flame Expansion: 3-D Flame Speed: 0.36

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

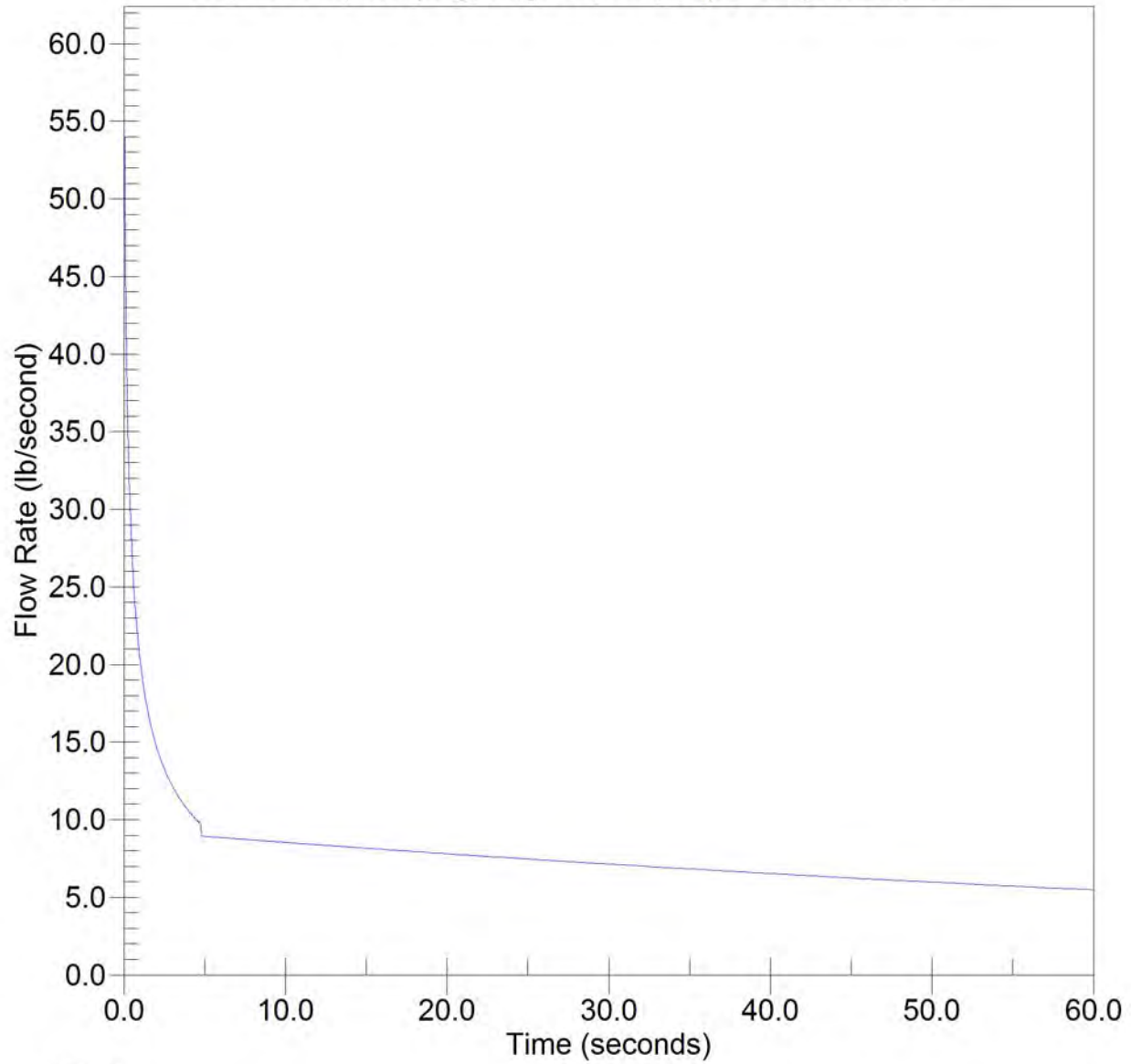
Mass of released material in explosive range: 1.42684 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0621
3.0	3.36	0.0621
3.7	3.36	0.0621
4.5	3.36	0.0621
5.6	3.36	0.0515
6.9	3.36	0.0420
8.4	3.36	0.0343
10.4	3.36	0.0280
12.7	3.26	0.0229
15.6	2.66	0.0187
19.2	2.17	0.0153
23.6	1.77	0.0125
29.1	1.44	0.0102
35.7	1.17	0.0083
43.9	0.95	0.0068
54.0	0.77	0.0056
66.4	0.63	0.0045
81.6	0.51	0.0037
100.4	0.42	0.0030
123.4	0.34	0.0025
151.7	0.27	0.0020
186.4	0.22	0.0017
229.2	0.18	0.0013
281.8	0.15	0.0011
413.5	0.10	0.0008

The downwind distance to dp3 is 42.2 feet
 The downwind distance to dp2 is 60.4 feet
 The downwind distance to dp1 is 413.5 feet

MASS RELEASE RATE

H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

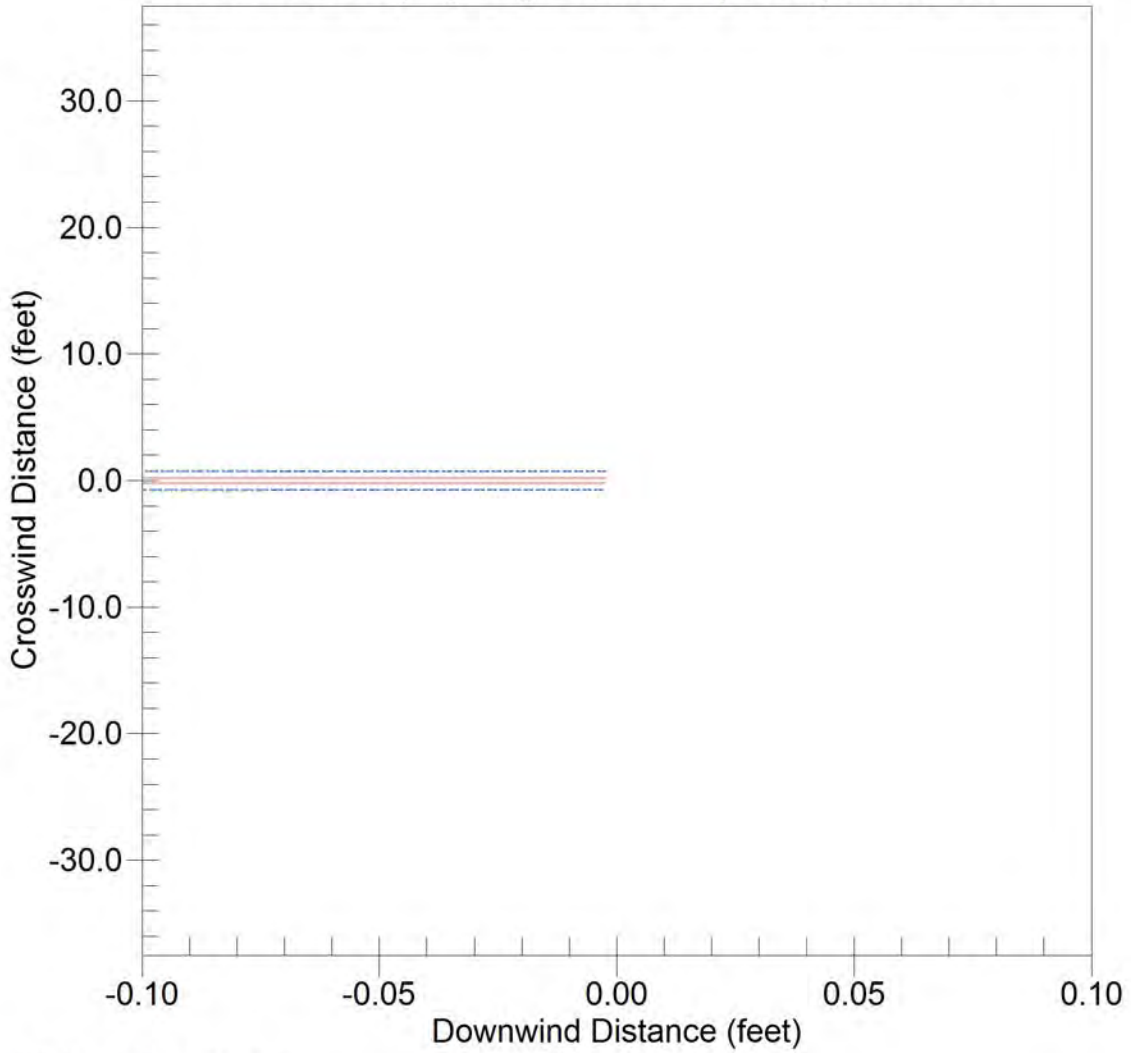


— Total
— Vapor

CANARY by Quest

casename=10D8IN260S2A-45_7MMSCFD
Sun Sep 8 17:27:51 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

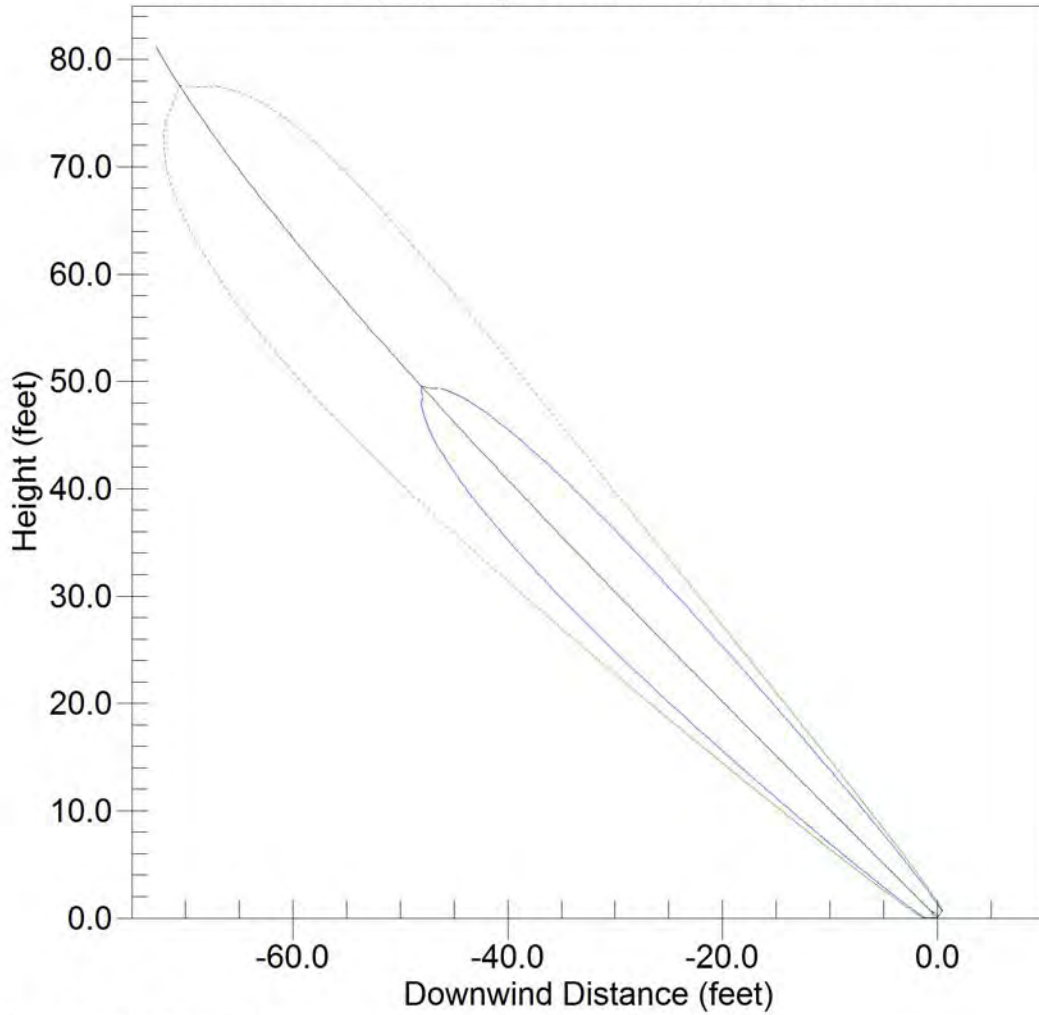


- 75.0 mole percent
- 4.00 mole percent
- 2.00 mole percent

casename=10D8IN260S2A-45_7MMSCFD
windspeed = 4.5 mph
D stability
Sun Sep 8 17:27:51 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°



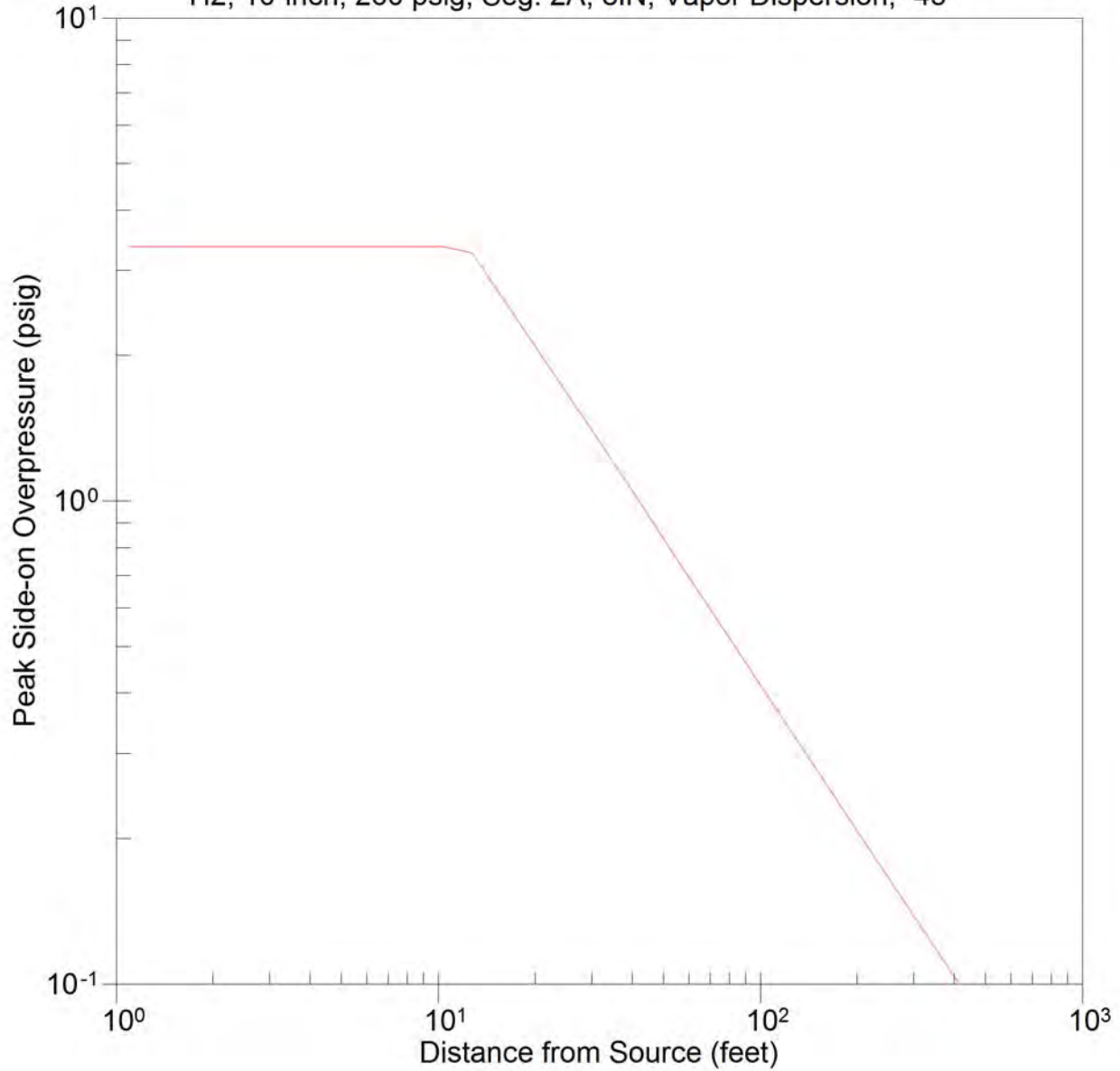
- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=10D8IN260S2A-45_7MMSCFD
windspeed = 4.5 mph
D stability
Sun Sep 8 17:27:51 2019

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 260 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°



CANARY by Quest

casename=10D8IN260S2A-45_7MMSCFD
Sun Sep 8 17:27:51 2019

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D1IN260S2A+45_7MMSCFD             |
|           Mon Sep  2 15:26:40 2019                       |
|           Quest Consultants Inc., Norman, Oklahoma, USA    |
| www.questconsult.com           canary@questconsult.com    |
| telephone (405) 329-7475       fax (405) 329-7734       |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

```

Case Type           : Vapor Dispersion
Case Name          : 10D1IN260S2A+45_7MMSCFD
User ID           : BLPayne
Project Number    : Job 2134
Type of Units     : English Units

```

NOTES: Segment 2A

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature       : 70.00 °F
Pressure          : 260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity       0.22 Btu/lb-F
Substrate delay time          0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|   CANARY Case Input                 |
| Case Name - 10D1IN260S2A+45_7MMSCFD |
|   Mon Sep  2 15:26:40 2019         |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration           120 min
Normal flow rate          0.43 lb/sec
Duration of normal flow   5 min
Volume of vessel          0.00 cu.ft
Pipe inner diameter       10.02 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 20416.0 feet
Height of release point   0.0 feet
Angle of release from horizontal 45.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1          UFL mol%
Concentration endpoint 2          LFL mol%
Concentration endpoint 3          1/2 LFL mol%

```

```

Dispersion coefficient averaging time          1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity          High
Obstacle density         Low
Flame expansion          3-D

```

Overpressure values

```

Overpressure endpoint 1          1.00 psi
Overpressure endpoint 2          0.70 psi
Overpressure endpoint 3          0.10 psi

```

NOTES:

```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 10D1IN260S2A+45_7MMSCFD
Mon Sep  2 15:26:40 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

TITLE: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.9288246	0.000000	0.000000	.9288246
0.100000	.9286860	0.000000	0.000000	.9286860
0.300000	.9285421	0.000000	0.000000	.9285421
0.500000	.9283802	0.000000	0.000000	.9283802
0.700000	.9282278	0.000000	0.000000	.9282278
1.000000	.9280103	0.000000	0.000000	.9280103
3.000000	.9264225	0.000000	0.000000	.9264225
5.000000	.9228070	0.000000	0.000000	.9228070
7.000000	.9219351	0.000000	0.000000	.9219351
10.00000	.9206301	0.000000	0.000000	.9206301
20.00000	.9163049	0.000000	0.000000	.9163049
30.00000	.9120174	0.000000	0.000000	.9120174
40.00000	.9077673	0.000000	0.000000	.9077673
50.00000	.9035534	0.000000	0.000000	.9035534
60.00000	.8993778	0.000000	0.000000	.8993778
70.00000	.8952391	0.000000	0.000000	.8952391
85.00000	.8890985	0.000000	0.000000	.8890985
100.0000	.8829717	0.000000	0.000000	.8829717
200.0000	.8445645	0.000000	0.000000	.8445645
300.0000	.8077704	0.000000	0.000000	.8077704
400.0000	.7429247	0.000000	0.000000	.7429247
500.0000	.6783869	0.000000	0.000000	.6783869
600.0000	.6204552	0.000000	0.000000	.6204552
700.0000	.5675117	0.000000	0.000000	.5675117
850.0000	.4963883	0.000000	0.000000	.4963883
1000.000	.4341867	0.000000	0.000000	.4341867
2000.000	.1770492	0.000000	0.000000	.1770492
3000.000	.5977657E-01	0.000000	0.000000	.5977657E-01
4000.000	0.000000	0.000000	0.000000	0.000000
5000.000	0.000000	0.000000	0.000000	0.000000
6000.000	0.000000	0.000000	0.000000	0.000000
7000.000	0.000000	0.000000	0.000000	0.000000
7200.000	0.000000	0.000000	0.000000	0.000000

Totals (lb) 1102.268 0.000000 0.000000 1102.268

Flowrate for Torch Fire [immediate ignition] = 0.9123141 lb/sec.
Torch Fire [delayed ignition] = 0.8633903 lb/sec.

Reason for Ending: Reached Stop Time

```

CANARY by Quest - Version 4.6.2
Release Stream Compositions
Case Name - 10D1IN260S2A+45_7MMSCFD
Mon Sep 2 15:26:40 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
| Momentum Jet Vapor Dispersion Model |
| Case Name - 10D1IN260S2A+45_7MMSCFD |
|   Mon Sep  2 15:26:40 2019          |
| Quest Consultants Inc., Norman, Oklahoma, USA |
| www.questconsult.com   canary@questconsult.com |
| telephone (405) 329-7475   fax (405) 329-7734 |
|               |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.3	0.2	0.1	0.1
0.5	0.557964	0.001245	0.4	0.4	0.0	0.6
1.0	0.413681	0.000003	0.5	0.5	0.0	1.1
1.5	0.333238	0.000000	0.6	0.6	0.0	1.6
2.0	0.280467	0.000000	0.7	0.6	0.0	2.1
2.5	0.242446	0.000000	0.8	0.7	0.0	2.6
3.0	0.213906	0.000000	0.9	0.8	0.0	3.1
3.5	0.191329	0.000000	1.0	0.8	0.0	3.6
4.0	0.172971	0.000000	1.1	0.9	0.0	4.1
4.5	0.157664	0.000000	1.2	0.9	0.0	4.6
5.0	0.144707	0.000000	1.2	1.0	0.0	5.1
5.5	0.133619	0.000000	1.3	1.0	0.0	5.6
6.0	0.123958	0.000000	1.4	1.1	0.0	6.1
6.5	0.115447	0.000000	1.4	1.1	0.0	6.6
7.0	0.107960	0.000000	1.5	1.2	0.0	7.1
7.5	0.101271	0.000000	1.6	1.2	0.0	7.6
8.0	0.095264	0.000000	1.7	1.2	0.0	8.0
8.5	0.089821	0.000000	1.7	1.3	0.0	8.5
9.0	0.084908	0.000000	1.8	1.3	0.0	9.0
9.5	0.080388	0.000000	1.8	1.3	0.0	9.5
10.0	0.076267	0.000000	1.9	1.3	0.0	10.0
10.5	0.072476	0.000000	2.0	1.3	0.0	10.5
11.0	0.068998	0.000000	2.0	1.3	0.0	11.0
11.5	0.065751	0.000000	2.1	1.3	0.0	11.5
12.0	0.062744	0.000000	2.1	1.3	0.0	12.0
12.5	0.059929	0.000000	2.2	1.3	0.0	12.5
13.0	0.057341	0.000000	2.2	1.3	0.0	13.0
13.5	0.054882	0.000000	2.3	1.3	0.0	13.5
14.0	0.052598	0.000000	2.3	1.2	0.0	14.0
14.5	0.050453	0.000000	2.4	1.2	0.0	14.5
15.0	0.048421	0.000000	2.4	1.1	0.0	15.0
15.5	0.046540	0.000000	2.5	1.0	0.0	15.4
16.0	0.044731	0.000000	2.5	0.9	0.0	15.9
16.5	0.043033	0.000000	2.5	0.8	0.0	16.4
17.0	0.041445	0.000000	2.5	0.6	0.0	16.9

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
17.5	0.039912	0.000000	2.6	0.0	0.0	17.4
18.0	0.038458	0.000000	2.6	0.0	0.0	17.9
18.5	0.037101	0.000000	2.6	0.0	0.0	18.3
19.0	0.035800	0.000000	2.6	0.0	0.0	18.8
19.5	0.034554	0.000000	2.6	0.0	0.0	19.3
20.0	0.033381	0.000000	2.6	0.0	0.0	19.8
20.5	0.032276	0.000000	2.6	0.0	0.0	20.2
21.0	0.031192	0.000000	2.6	0.0	0.0	20.7
21.5	0.030155	0.000000	2.6	0.0	0.0	21.2
22.0	0.029183	0.000000	2.6	0.0	0.0	21.7
22.5	0.028262	0.000000	2.5	0.0	0.0	22.1
23.0	0.027351	0.000000	2.5	0.0	0.0	22.6
23.5	0.026476	0.000000	2.4	0.0	0.0	23.1
24.0	0.025664	0.000000	2.4	0.0	0.0	23.5
24.5	0.024881	0.000000	2.3	0.0	0.0	24.0
25.0	0.024128	0.000000	2.2	0.0	0.0	24.4
25.5	0.023379	0.000000	2.0	0.0	0.0	24.9
26.0	0.022683	0.000000	1.9	0.0	0.0	25.3
26.5	0.022034	0.000000	1.7	0.0	0.0	25.8
27.0	0.021398	0.000000	1.5	0.0	0.0	26.2
27.5	0.020780	0.000000	1.1	0.0	0.0	26.7
28.0	0.020191	0.000000	0.6	0.0	0.0	27.1

The downwind distance to c3 is 0.18 ft after about 0 seconds
The downwind distance to c2 is 17.47 ft after about 0 seconds
The downwind distance to c1 is 28.16 ft after about 0 seconds

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
| Momentum Jet Vapor Cloud Explosion              |
| Case Name - 10D1IN260S2A+45_7MMSCFD           |
| Mon Sep  2 15:26:40 2019                       |
| Quest Consultants Inc., Norman, Oklahoma, USA   |
| www.questconsult.com       canary@questconsult.com |
| telephone (405) 329-7475   fax (405) 329-7734   |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

```

Fuel Reactivity: High           Obstacle Density: Low
Flame Expansion: 3-D           Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.0619372 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0218
1.1	3.36	0.0218
1.2	3.36	0.0218
1.5	3.36	0.0218
1.7	3.36	0.0206
2.0	3.36	0.0176
2.4	3.36	0.0150
2.8	3.36	0.0128
3.3	3.36	0.0110
3.8	3.36	0.0093
4.5	3.23	0.0080
5.3	2.75	0.0068
6.2	2.35	0.0058
7.3	2.00	0.0050
8.6	1.71	0.0042
10.1	1.46	0.0036
11.9	1.24	0.0031
14.0	1.05	0.0026
16.5	0.89	0.0022
19.3	0.76	0.0019
22.7	0.65	0.0016
26.7	0.55	0.0014
31.4	0.47	0.0012
36.9	0.40	0.0010
145.3	0.10	0.0003

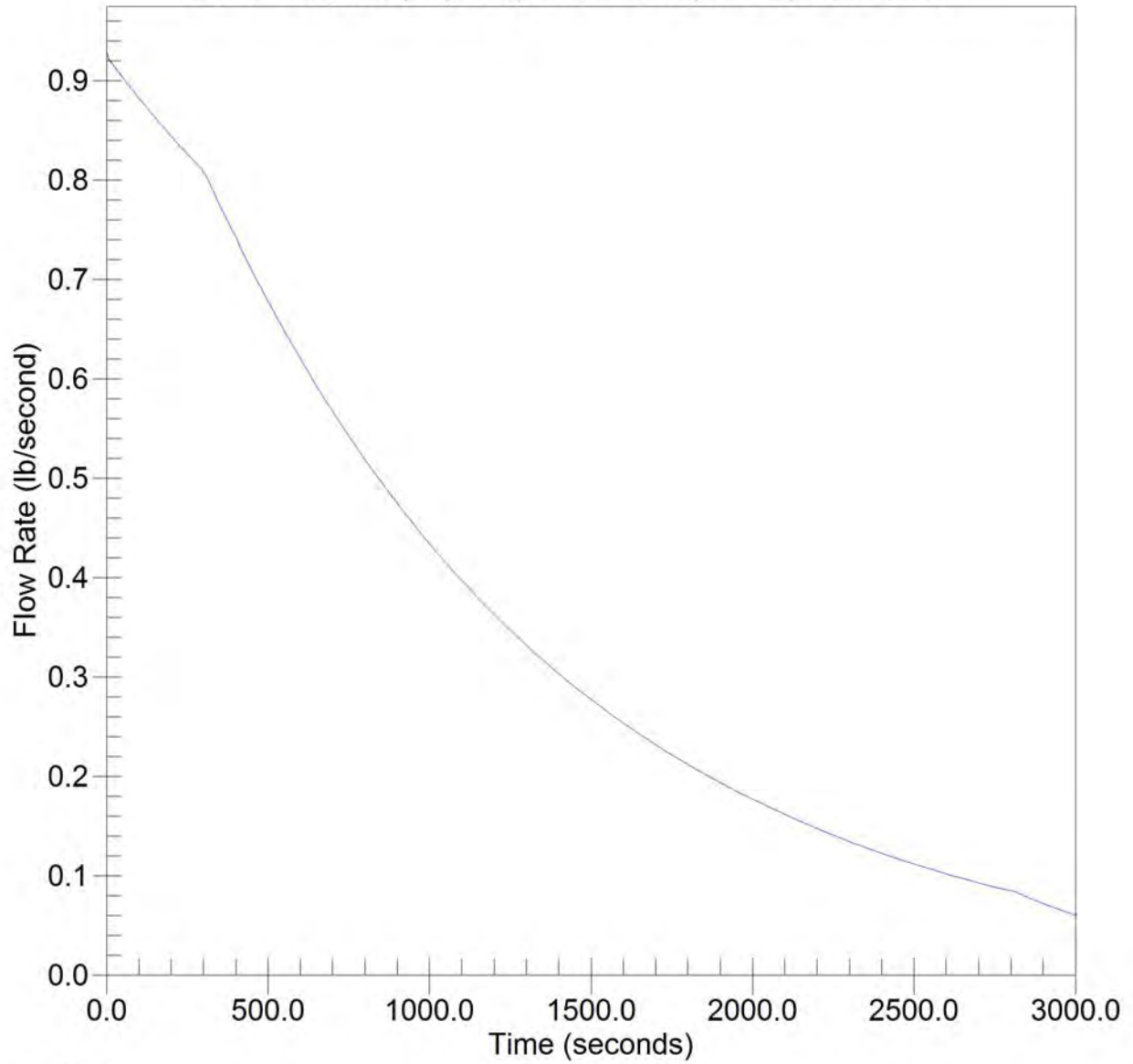
```

The downwind distance to dp3 is 14.8 feet
The downwind distance to dp2 is 21.1 feet
The downwind distance to dp1 is 145.3 feet

```

MASS RELEASE RATE

H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°



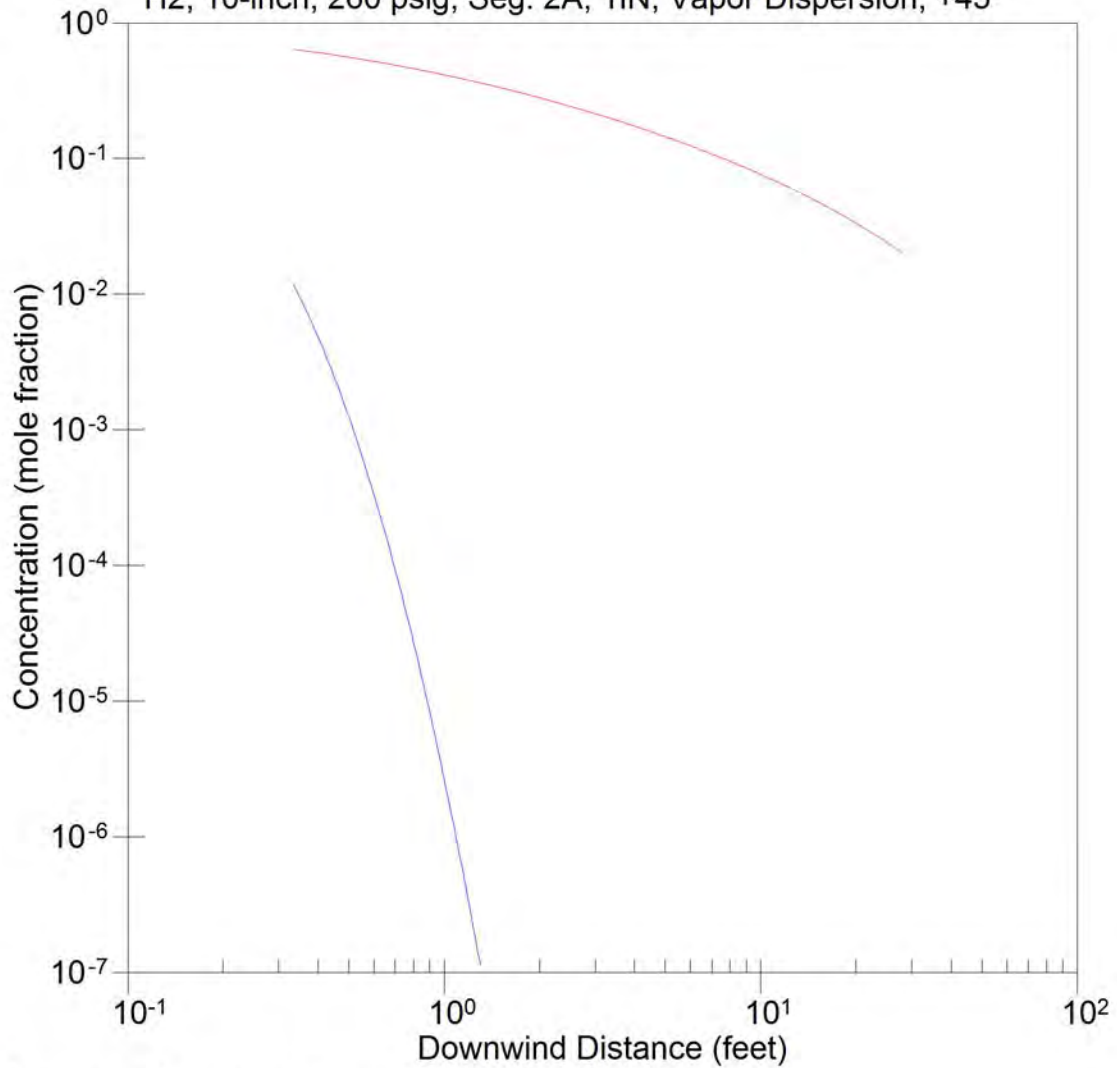
— Total
— Vapor

CANARY by Quest

casename=10D1IN260S2A+45_7MMSCFD
Mon Sep 2 15:26:40 2019

Momentum Jet Cloud CONCENTRATION vs. DISTANCE

H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°



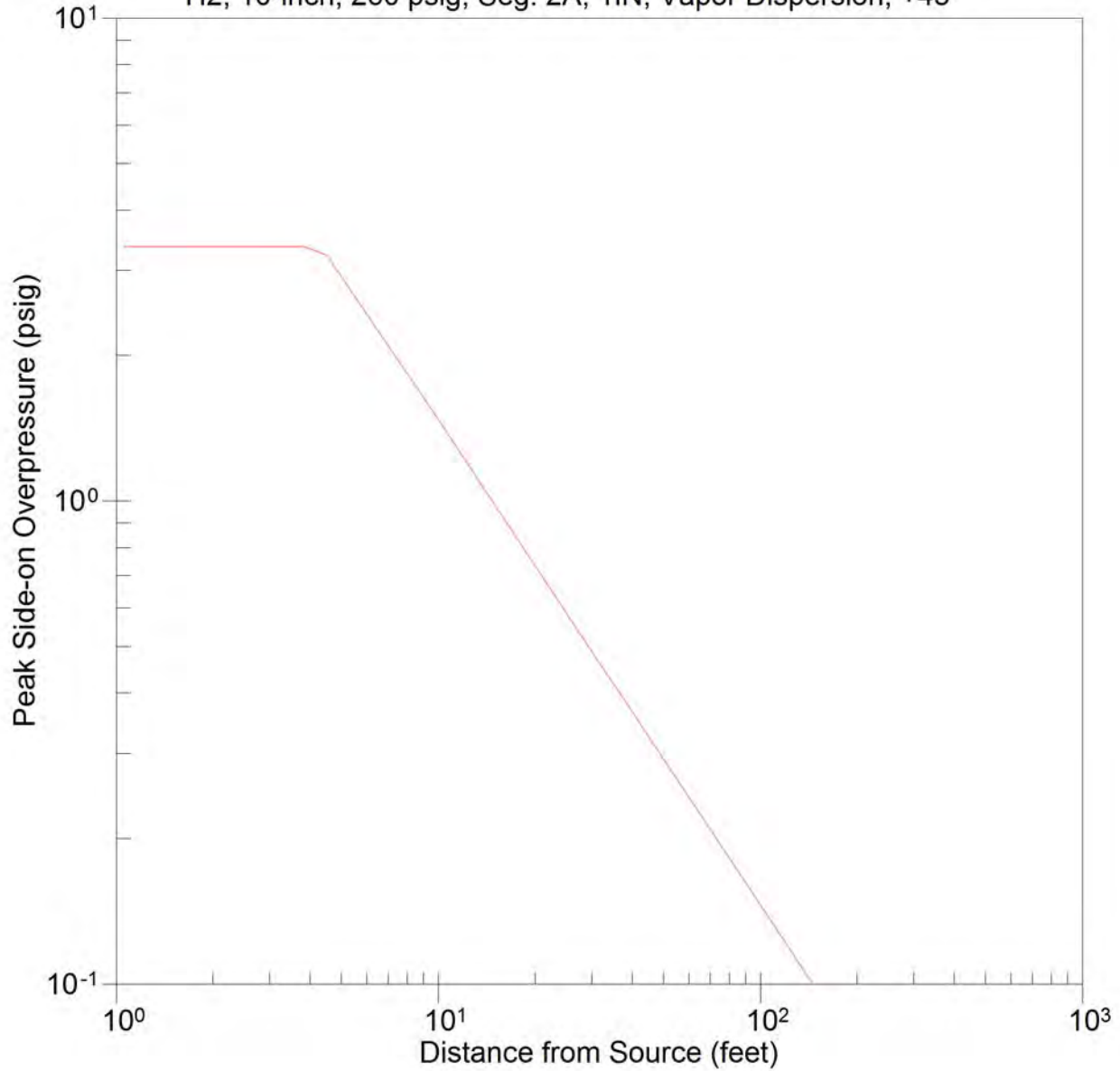
— Centerline Concentration
— Ground Level Concentration

casename=10D1IN260S2A+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:26:40 2019

CANARY by Quest

Momentum Jet VCE

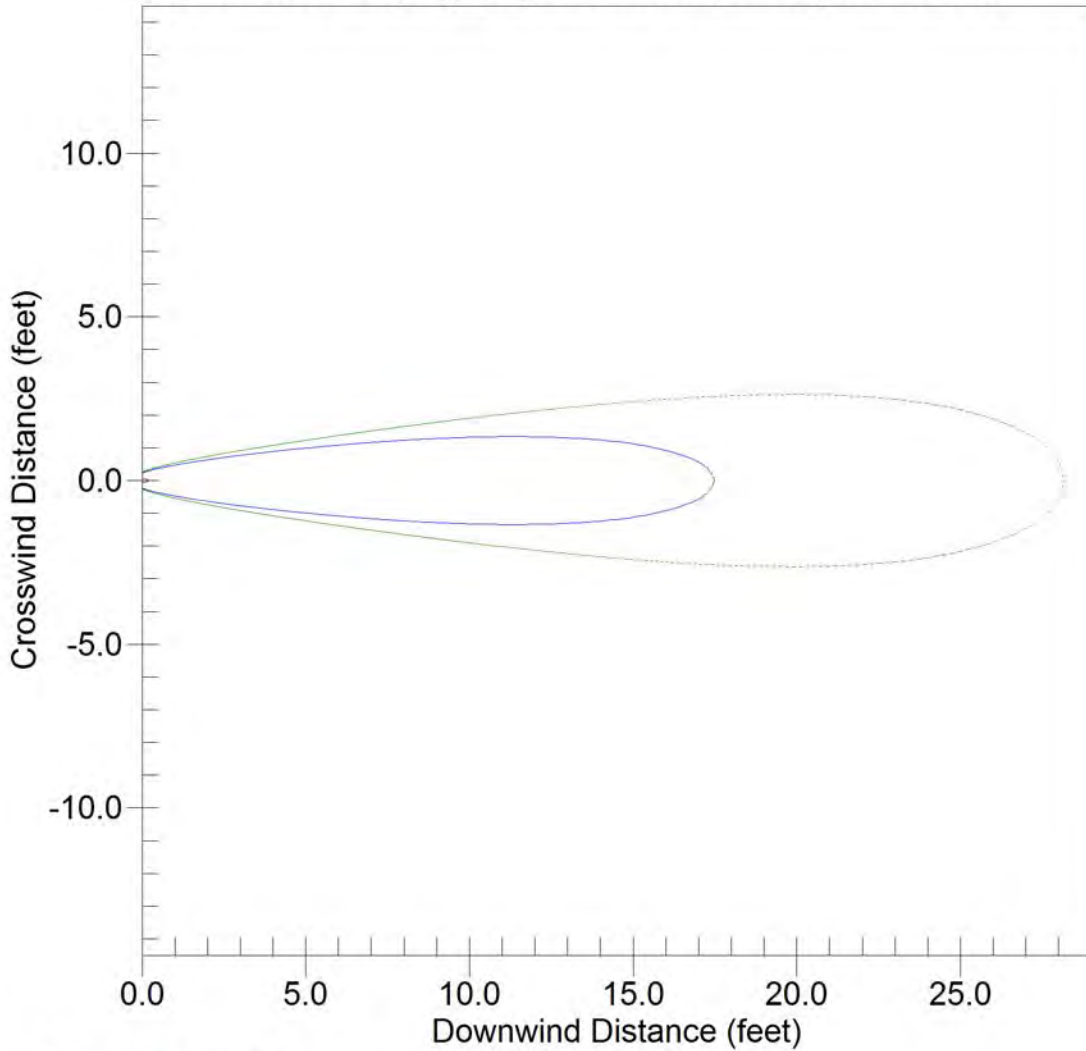
BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°



CANARY by Quest

casename=10D1IN260S2A+45_7MMSCFD
Mon Sep 2 15:26:40 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

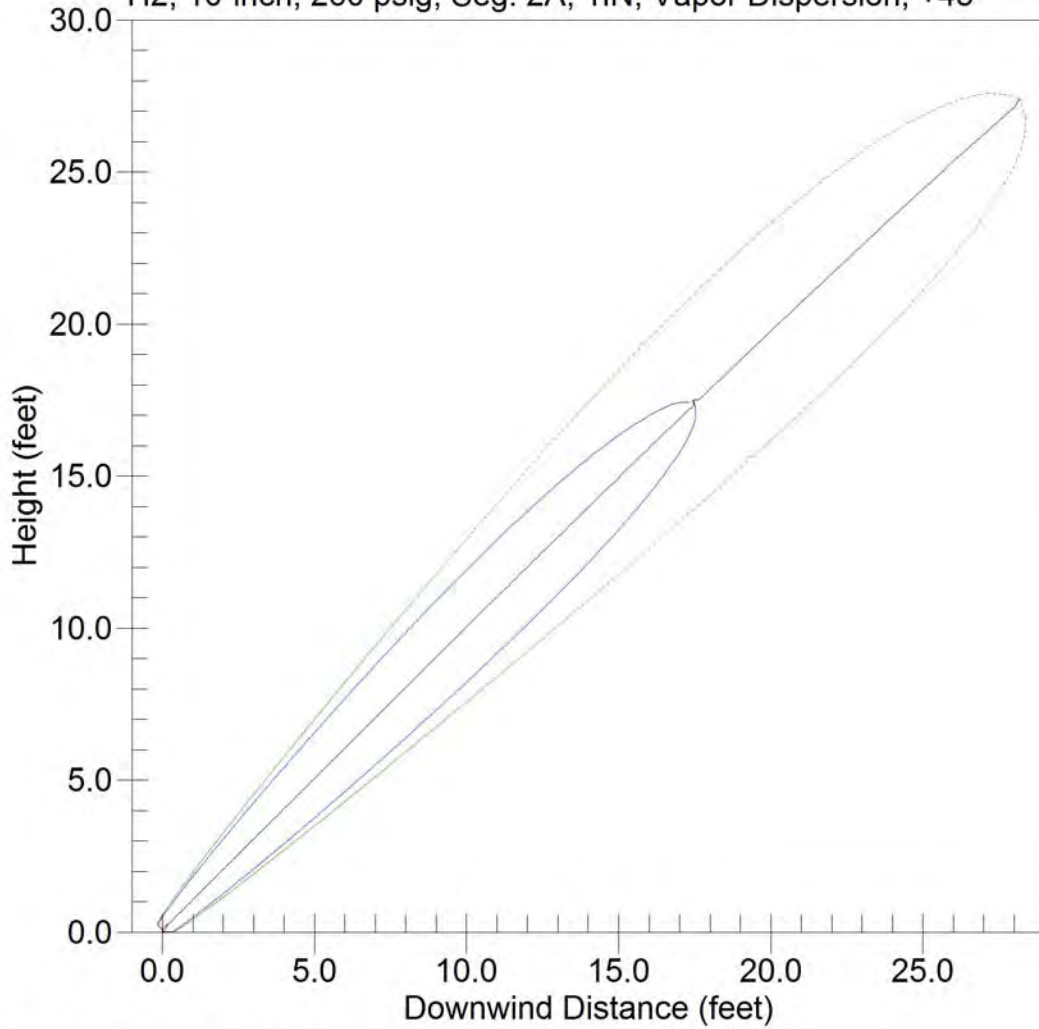


- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=10D1IN260S2A+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:26:40 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°



- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=10D1IN260S2A+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:26:40 2019

CANARY by Quest

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 10D1IN260S2A-45_7MMSCFD     |
|           Mon Sep  2 15:26:21 2019                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

```

Case Type       : Vapor Dispersion
Case Name      : 10D1IN260S2A-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity        0.22 Btu/lb-F
Substrate delay time           0 sec
Surrounding terrain            Wooded area or urban area

```

NOTES:

Case continued on page 2.


```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 10D1IN260S2A-45_7MMSCFD |
| Mon Sep  2 15:26:21 2019 |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

RELEASE MENU

Type of release: Unregulated, Continuous release
 Release duration 120 min
 Normal flow rate 0.43 lb/sec
 Duration of normal flow 5 min
 Volume of vessel 0.00 cu.ft
 Pipe inner diameter 10.02 inches
 Equivalent release diameter 1.00 inches
 Pipe length upstream of break 20416.0 feet
 Height of release point 0.0 feet
 Angle of release from horizontal 135.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation, dispersion and cloud explosion - Flammable calculation
 Concentration endpoint 1 UFL mol%
 Concentration endpoint 2 LFL mol%
 Concentration endpoint 3 1/2 LFL mol%

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

Fuel reactivity High
 Obstacle density Low
 Flame expansion 3-D

Overpressure values

Overpressure endpoint 1 1.00 psi
 Overpressure endpoint 2 0.70 psi
 Overpressure endpoint 3 0.10 psi

NOTES:

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               General Release Model UPSTREAM                 |
|               Case Name - 10D1IN260S2A-45_7MMSCFD          |
|               Mon Sep  2 15:26:21 2019                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.9288246	0.000000	0.000000	.9288246
0.100000	.9286860	0.000000	0.000000	.9286860
0.300000	.9285421	0.000000	0.000000	.9285421
0.500000	.9283802	0.000000	0.000000	.9283802
0.700000	.9282278	0.000000	0.000000	.9282278
1.000000	.9280103	0.000000	0.000000	.9280103
3.000000	.9264225	0.000000	0.000000	.9264225
5.000000	.9228070	0.000000	0.000000	.9228070
7.000000	.9219351	0.000000	0.000000	.9219351
10.00000	.9206301	0.000000	0.000000	.9206301
20.00000	.9163049	0.000000	0.000000	.9163049
30.00000	.9120174	0.000000	0.000000	.9120174
40.00000	.9077673	0.000000	0.000000	.9077673
50.00000	.9035534	0.000000	0.000000	.9035534
60.00000	.8993778	0.000000	0.000000	.8993778
70.00000	.8952391	0.000000	0.000000	.8952391
85.00000	.8890985	0.000000	0.000000	.8890985
100.0000	.8829717	0.000000	0.000000	.8829717
200.0000	.8445645	0.000000	0.000000	.8445645
300.0000	.8077704	0.000000	0.000000	.8077704
400.0000	.7429247	0.000000	0.000000	.7429247
500.0000	.6783869	0.000000	0.000000	.6783869
600.0000	.6204552	0.000000	0.000000	.6204552
700.0000	.5675117	0.000000	0.000000	.5675117
850.0000	.4963883	0.000000	0.000000	.4963883
1000.000	.4341867	0.000000	0.000000	.4341867
2000.000	.1770492	0.000000	0.000000	.1770492
3000.000	.5977657E-01	0.000000	0.000000	.5977657E-01
4000.000	0.000000	0.000000	0.000000	0.000000
5000.000	0.000000	0.000000	0.000000	0.000000
6000.000	0.000000	0.000000	0.000000	0.000000
7000.000	0.000000	0.000000	0.000000	0.000000
7200.000	0.000000	0.000000	0.000000	0.000000
Totals (lb)	1102.268	0.000000	0.000000	1102.268

Flowrate for Torch Fire [immediate ignition] = 0.9123141 lb/sec.
Torch Fire [delayed ignition] = 0.8633903 lb/sec.

Reason for Ending: Reached Stop Time

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
|          Release Stream Compositions              |
|          Case Name - 10D1IN260S2A-45_7MMSCFD     |
|          Mon Sep  2 15:26:21 2019                |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
|          www.questconsult.com      canary@questconsult.com |
|          telephone (405) 329-7475      fax (405) 329-7734 |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
| Momentum Jet Vapor Dispersion Model                        |
| Case Name - 10D1IN260S2A-45_7MMSCFD                      |
| Mon Sep  2 15:26:21 2019                                  |
| Quest Consultants Inc., Norman, Oklahoma, USA              |
| www.questconsult.com   canary@questconsult.com            |
| telephone (405) 329-7475   fax (405) 329-7734            |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance	centerline conc.	ground conc.	y(c1) 1/2 width	y(c2) 1/2 width	y(c3) 1/2 width	centerline height
x(ft)	c(mole frac.)	c(mole frac.)	(ft)	(ft)	(ft)	(ft)
0	1.000000	0.000000	0.3	0.2	0.1	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is 0.00 ft after about 0 seconds
The downwind distance to c2 is 0.00 ft after about 0 seconds
The downwind distance to c1 is 0.00 ft after about 0 seconds

```

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
| Momentum Jet Vapor Cloud Explosion                |
| Case Name - 10D1IN260S2A-45_7MMSCFD             |
| Mon Sep  2 15:26:21 2019                         |
| Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com      canary@questconsult.com |
| telephone (405) 329-7475    fax (405) 329-7734   |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

```

Fuel Reactivity: High          Obstacle Density: Low
Flame Expansion: 3-D          Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.0629134 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0219
1.1	3.36	0.0219
1.2	3.36	0.0219
1.5	3.36	0.0219
1.7	3.36	0.0207
2.0	3.36	0.0177
2.4	3.36	0.0151
2.8	3.36	0.0129
3.3	3.36	0.0110
3.9	3.36	0.0094
4.5	3.22	0.0080
5.3	2.75	0.0068
6.3	2.34	0.0058
7.4	2.00	0.0050
8.7	1.70	0.0042
10.2	1.45	0.0036
12.0	1.23	0.0031
14.1	1.05	0.0026
16.6	0.89	0.0022
19.5	0.76	0.0019
23.0	0.64	0.0016
27.0	0.55	0.0014
31.7	0.46	0.0012
37.3	0.39	0.0010
146.1	0.10	0.0003

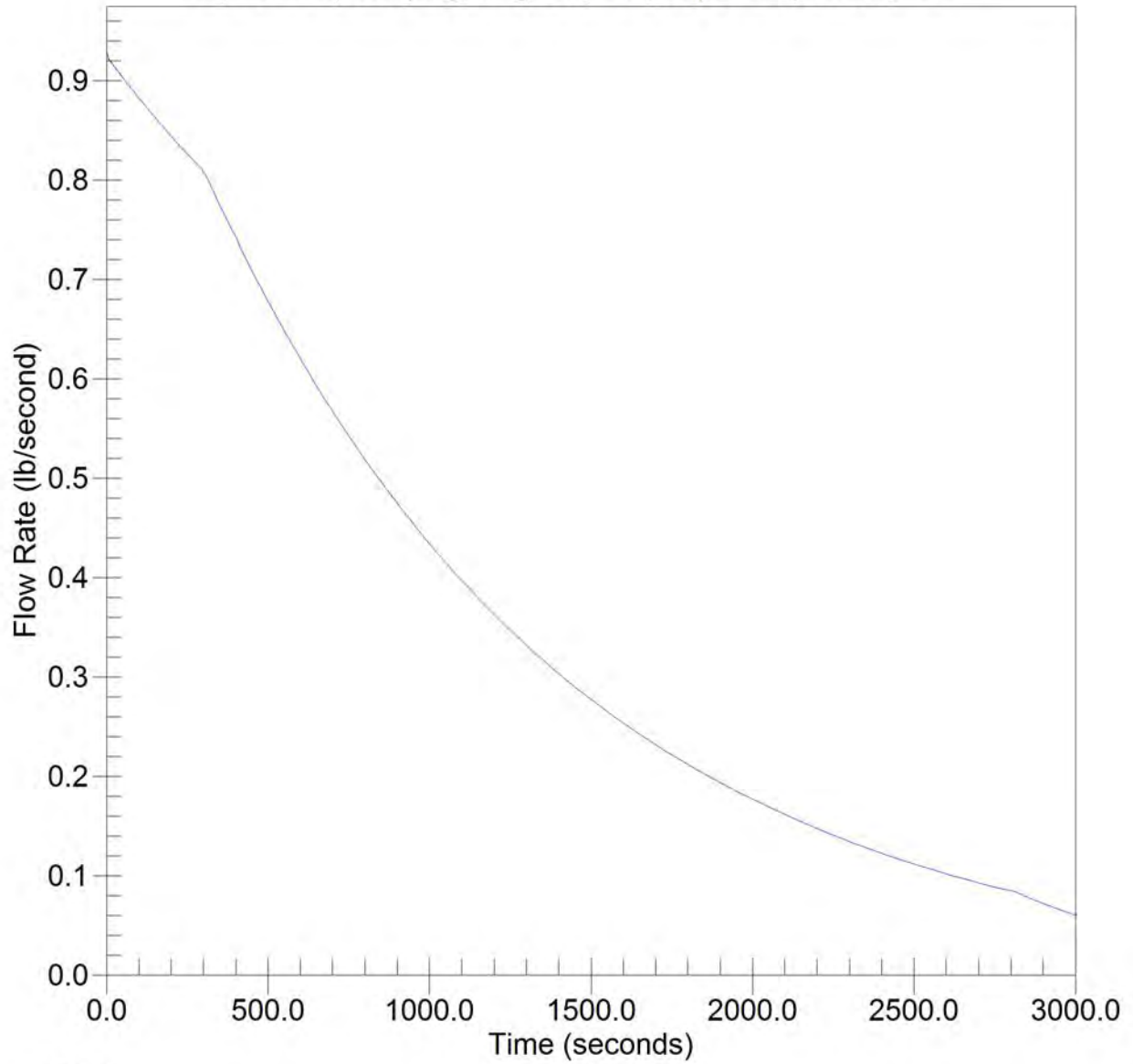
```

The downwind distance to dp3 is  14.9 feet
The downwind distance to dp2 is  21.2 feet
The downwind distance to dp1 is 146.1 feet

```

MASS RELEASE RATE

H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

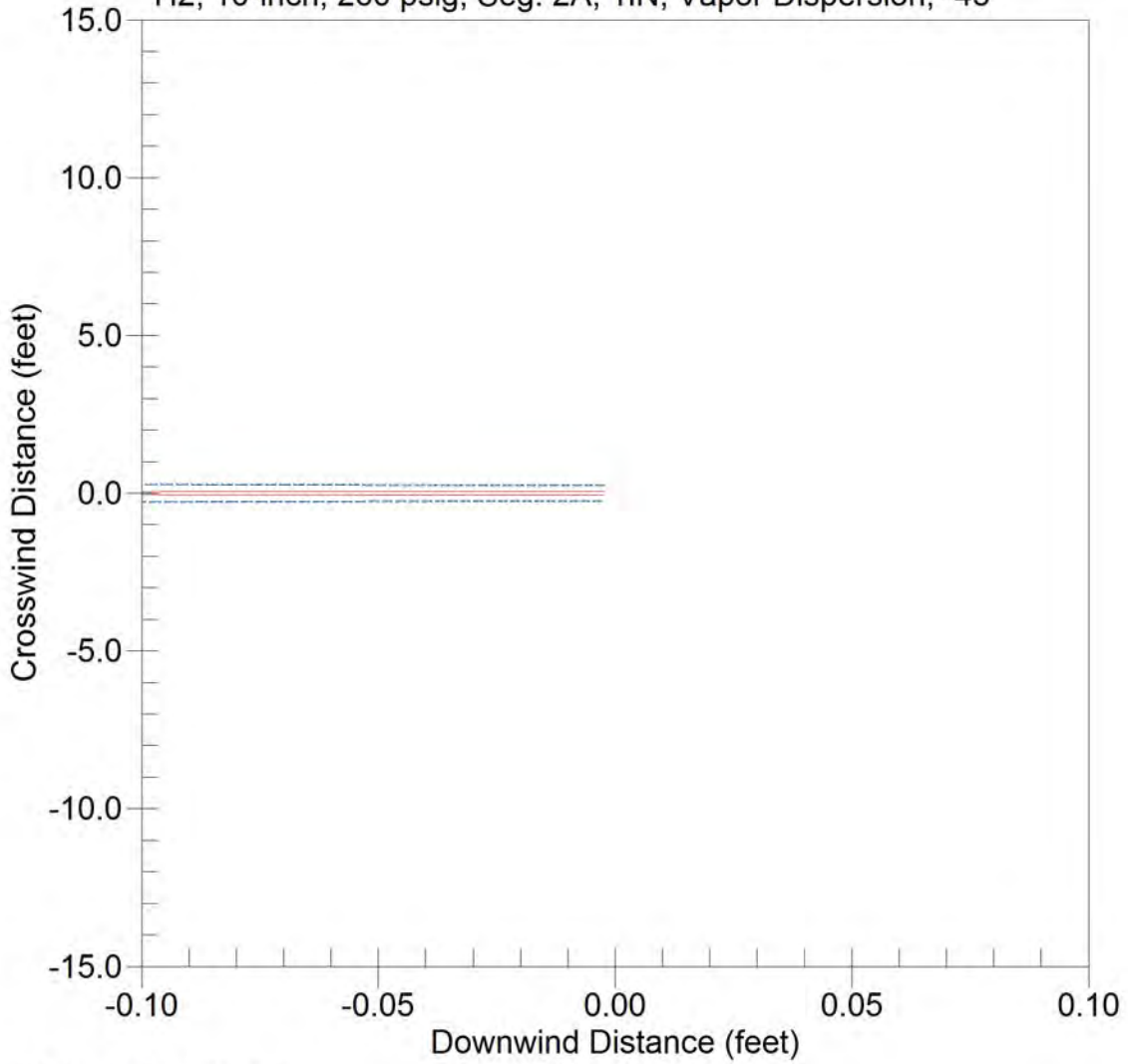


— Total
— Vapor

CANARY by Quest

casename=10D1IN260S2A-45_7MMSCFD
Mon Sep 2 15:26:21 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

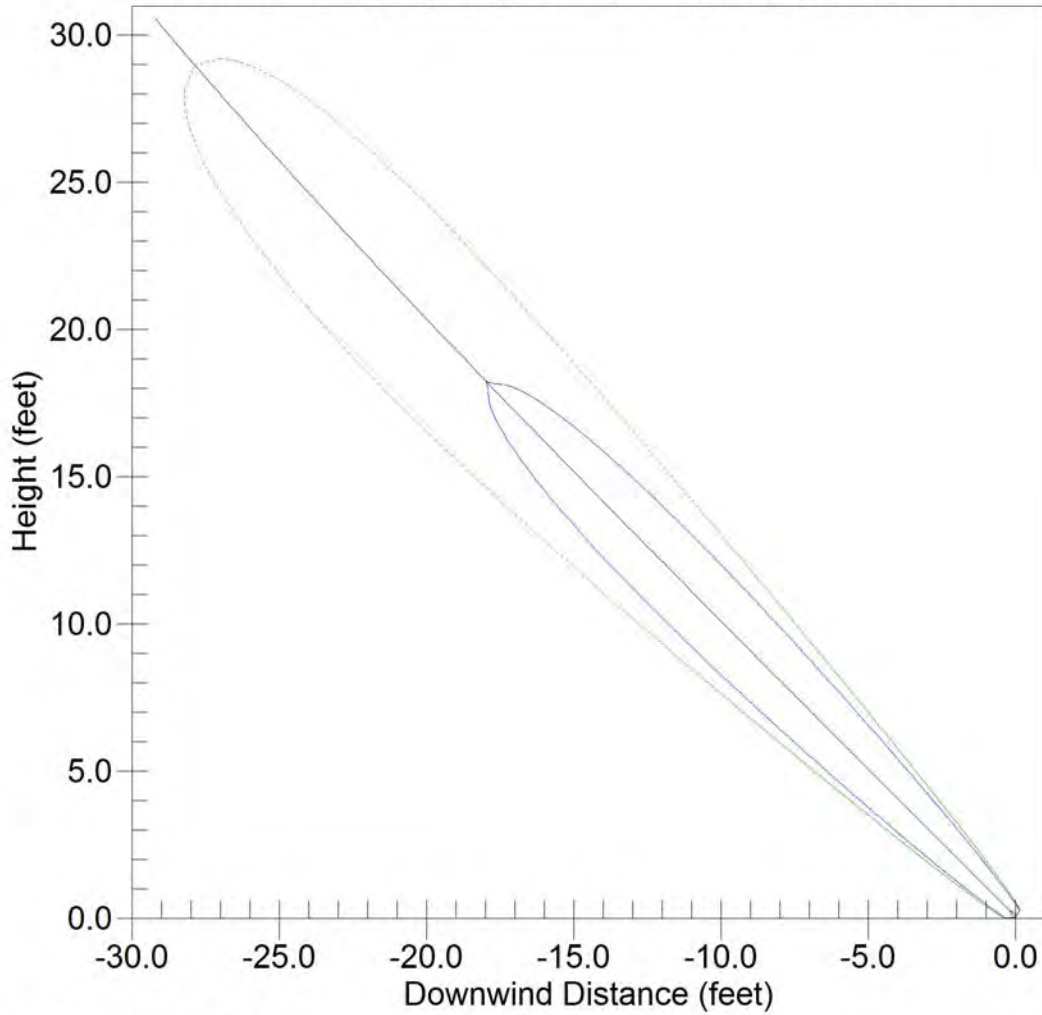


- 75.0 mole percent
- 4.00 mole percent
- 2.00 mole percent

casename=10D1IN260S2A-45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:26:21 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°



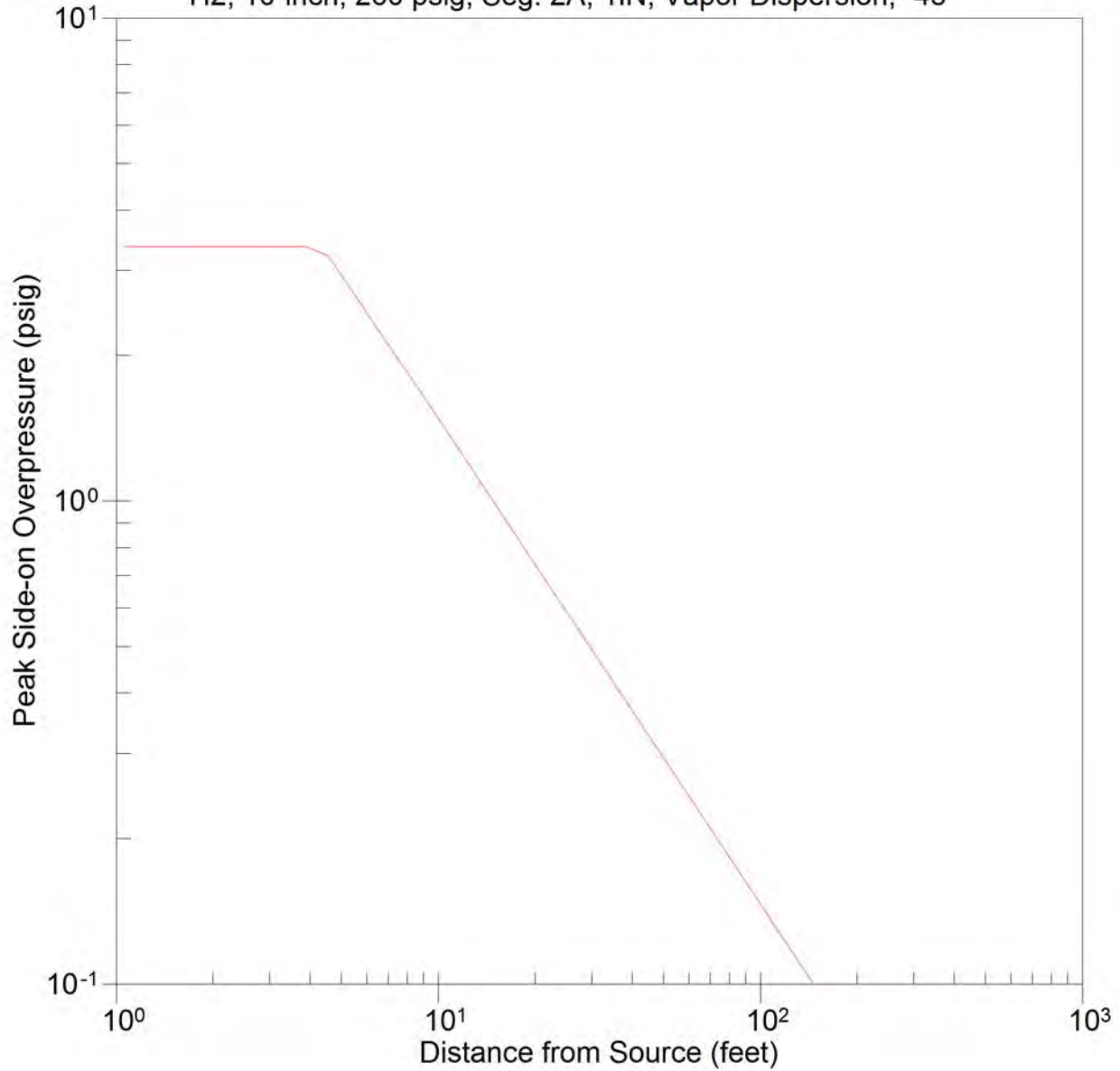
- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=10D1IN260S2A-45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:26:21 2019

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 260 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°



CANARY by Quest

casename=10D1IN260S2A-45_7MMSCFD
Mon Sep 2 15:26:21 2019



Vapor Dispersion Modeling Results, Segment 2B

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|               Case Name - 10DFB260S2B+45_7MMSCFD          |
|               Mon Sep  2 15:28:03 2019                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°

```

Case Type       : Vapor Dispersion
Case Name      : 10DFB260S2B+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity       0.22 Btu/lb-F
Substrate delay time          0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 10DFB260S2B+45_7MMSCFD |
| Mon Sep  2 15:28:03 2019 |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°

RELEASE MENU

Type of release: Unregulated, Continuous release
 Release duration 120 min
 Normal flow rate 0.43 lb/sec
 Duration of normal flow 5 min
 Volume of vessel 0.00 cu.ft
 Pipe inner diameter 10.02 inches
 Equivalent release diameter 10.02 inches
 Pipe length upstream of break 50225.0 feet
 Pipe length downstream of break 9397.0 feet
 Height of release point 0.0 feet
 Angle of release from horizontal 45.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation, dispersion and cloud explosion - Flammable calculation
 Concentration endpoint 1 UFL mol%
 Concentration endpoint 2 LFL mol%
 Concentration endpoint 3 1/2 LFL mol%

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

Fuel reactivity High
 Obstacle density Low
 Flame expansion 3-D

Overpressure values

Overpressure endpoint 1 1.00 psi
 Overpressure endpoint 2 0.70 psi
 Overpressure endpoint 3 0.10 psi

NOTES:

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               General Release Model UPSTREAM                 |
|               Case Name - 10DFB260S2B+45_7MMSCFD           |
|               Mon Sep  2 15:28:03 2019                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
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|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	93.07441	0.000000	0.000000	93.07441
0.100000	52.96829	0.000000	0.000000	52.96829
0.300000	35.30645	0.000000	0.000000	35.30645
0.500000	28.38994	0.000000	0.000000	28.38994
0.700000	24.41630	0.000000	0.000000	24.41630
1.000000	20.71885	0.000000	0.000000	20.71885
3.000000	12.22385	0.000000	0.000000	12.22385
5.000000	9.497117	0.000000	0.000000	9.497117
7.000000	8.029019	0.000000	0.000000	8.029019
10.00000	6.711814	0.000000	0.000000	6.711814
20.00000	5.752362	0.000000	0.000000	5.752362
30.00000	5.621967	0.000000	0.000000	5.621967
40.00000	5.494804	0.000000	0.000000	5.494804
50.00000	5.370830	0.000000	0.000000	5.370830
60.00000	5.249862	0.000000	0.000000	5.249862
70.00000	5.131925	0.000000	0.000000	5.131925
85.00000	4.960181	0.000000	0.000000	4.960181
100.0000	4.794872	0.000000	0.000000	4.794872
200.0000	3.836592	0.000000	0.000000	3.836592
300.0000	3.045668	0.000000	0.000000	3.045668
400.0000	2.381379	0.000000	0.000000	2.381379
500.0000	1.857074	0.000000	0.000000	1.857074
600.0000	1.445599	0.000000	0.000000	1.445599
700.0000	1.122339	0.000000	0.000000	1.122339
850.0000	.7627813	0.000000	0.000000	.7627813
1000.000	.5121486	0.000000	0.000000	.5121486
1480.062	0.000000	0.000000	0.000000	0.000000
Totals (lb)	2508.363	0.000000	0.000000	2508.363
Flowrate for Torch Fire [immediate ignition]	= 6.736325			lb/sec.
Torch Fire [delayed ignition]	= 4.289247			lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               General Release Model DOWNSTREAM              |
|               Case Name - 10DFB260S2B+45_7MMSCFD          |
|               Mon Sep  2 15:28:03 2019                    |
|               Quest Consultants Inc., Norman, Oklahoma, USA |
|               www.questconsult.com    canary@questconsult.com |
|               telephone (405) 329-7475    fax (405) 329-7734 |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	93.07441	0.000000	0.000000	93.07441
0.100000	54.95421	0.000000	0.000000	54.95421
0.300000	36.28660	0.000000	0.000000	36.28660
0.500000	29.00826	0.000000	0.000000	29.00826
0.700000	24.86028	0.000000	0.000000	24.86028
1.000000	21.01303	0.000000	0.000000	21.01303
3.000000	12.35260	0.000000	0.000000	12.35260
5.000000	11.62472	0.000000	0.000000	11.62472
7.000000	10.93976	0.000000	0.000000	10.93976
10.000000	9.987377	0.000000	0.000000	9.987377
20.000000	7.361129	0.000000	0.000000	7.361129
30.000000	5.410036	0.000000	0.000000	5.410036
40.000000	3.968129	0.000000	0.000000	3.968129
50.000000	2.900025	0.000000	0.000000	2.900025
60.000000	2.105893	0.000000	0.000000	2.105893
70.000000	1.510930	0.000000	0.000000	1.510930
85.000000	.8742072	0.000000	0.000000	.8742072
100.000000	.4363947	0.000000	0.000000	.4363947
200.000000	0.000000	0.000000	0.000000	0.000000
300.000000	0.000000	0.000000	0.000000	0.000000
400.000000	0.000000	0.000000	0.000000	0.000000
500.000000	0.000000	0.000000	0.000000	0.000000
600.000000	0.000000	0.000000	0.000000	0.000000
700.000000	0.000000	0.000000	0.000000	0.000000
850.000000	0.000000	0.000000	0.000000	0.000000
1000.000000	0.000000	0.000000	0.000000	0.000000
2000.000000	0.000000	0.000000	0.000000	0.000000
3000.000000	0.000000	0.000000	0.000000	0.000000
4000.000000	0.000000	0.000000	0.000000	0.000000
5000.000000	0.000000	0.000000	0.000000	0.000000
6000.000000	0.000000	0.000000	0.000000	0.000000
7000.000000	0.000000	0.000000	0.000000	0.000000
7200.000000	0.000000	0.000000	0.000000	0.000000
Totals (lb)	446.8515	0.000000	0.000000	446.8515

Flowrate for Torch Fire [immediate ignition] = 6.626809 lb/sec.
Torch Fire [delayed ignition] = 0.000000 lb/sec.

Reason for Ending: Reached Stop Time

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions             |
|           Case Name - 10DFB260S2B+45_7MMSCFD     |
|           Mon Sep  2 15:28:03 2019              |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com                   |
|           canary@questconsult.com               |
|           telephone (405) 329-7475             |
|           fax (405) 329-7734                   |
|                                     |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 10DFB260S2B+45_7MMSCFD                   |
|      Mon Sep  2 15:28:03 2019                               |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734     |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

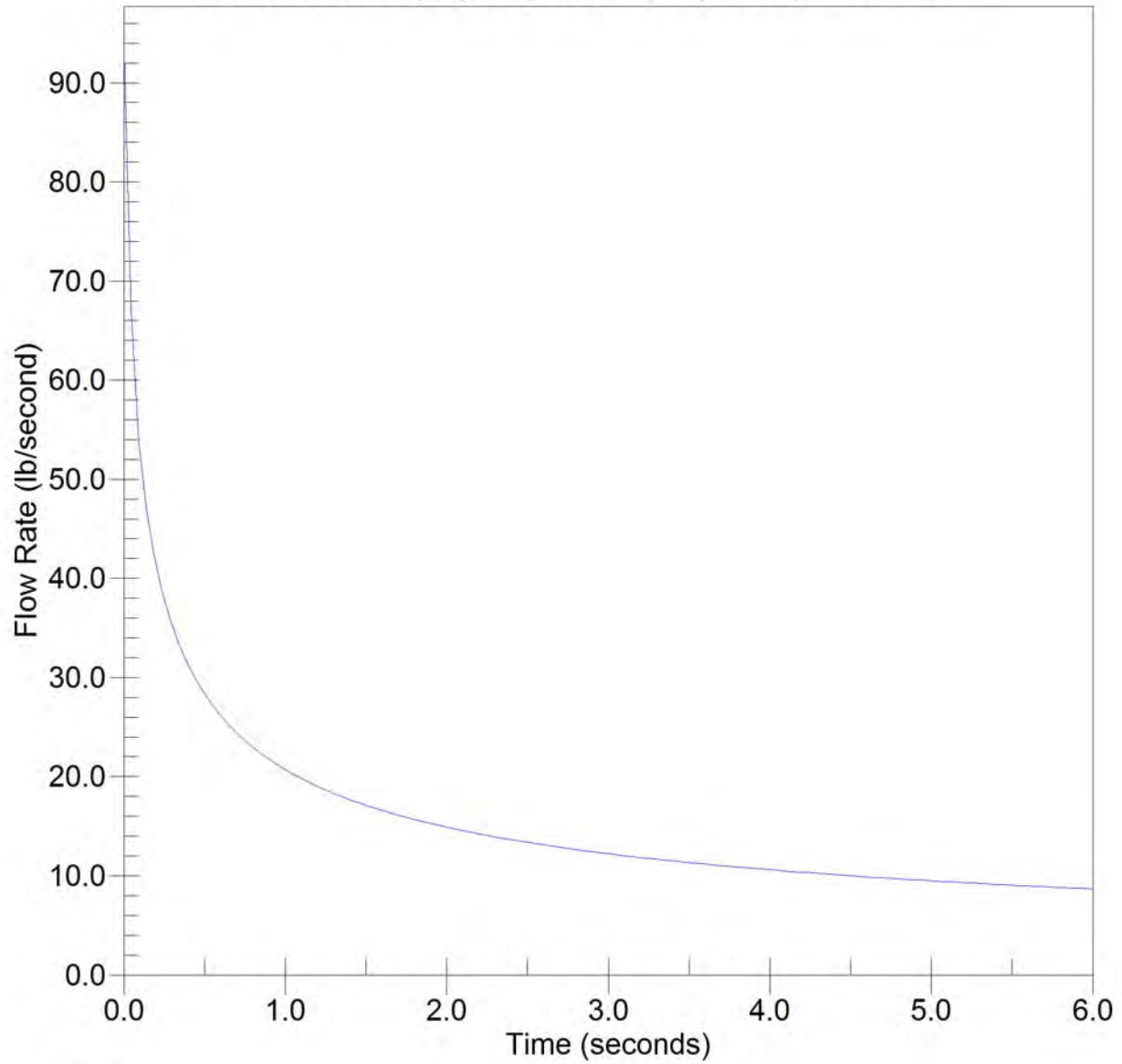
downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.9	0.9	0.2	0.1
1	0.672186	0.064482	1.3	1.2	0.0	1.1
2	0.533151	0.002061	1.6	1.4	0.0	2.1
3	0.447449	0.000080	1.8	1.6	0.0	3.1
4	0.387609	0.000004	2.1	1.8	0.0	4.1
5	0.342437	0.000000	2.3	2.0	0.0	5.1
6	0.306767	0.000000	2.5	2.2	0.0	6.1
7	0.277818	0.000000	2.7	2.3	0.0	7.1
8	0.253678	0.000000	2.9	2.5	0.0	8.0
9	0.233253	0.000000	3.1	2.6	0.0	9.0
10	0.215584	0.000000	3.3	2.8	0.0	10.0
11	0.200320	0.000000	3.5	2.9	0.0	11.0
12	0.186750	0.000000	3.7	3.1	0.0	12.0
13	0.174710	0.000000	3.9	3.2	0.0	13.0
14	0.163966	0.000000	4.1	3.3	0.0	14.0
15	0.154347	0.000000	4.3	3.5	0.0	15.0
16	0.145524	0.000000	4.5	3.6	0.0	16.0
17	0.137581	0.000000	4.7	3.7	0.0	17.0
18	0.130285	0.000000	4.8	3.8	0.0	17.9
19	0.123592	0.000000	5.0	3.9	0.0	18.9
20	0.117429	0.000000	5.2	4.1	0.0	19.9
21	0.111745	0.000000	5.4	4.2	0.0	20.9
22	0.106449	0.000000	5.6	4.3	0.0	21.9
23	0.101569	0.000000	5.7	4.3	0.0	22.8
24	0.096956	0.000000	5.9	4.4	0.0	23.8
25	0.092764	0.000000	6.1	4.5	0.0	24.8
26	0.088691	0.000000	6.3	4.6	0.0	25.7
27	0.084953	0.000000	6.4	4.6	0.0	26.7
28	0.081486	0.000000	6.6	4.7	0.0	27.6
29	0.078124	0.000000	6.8	4.7	0.0	28.6
30	0.075004	0.000000	6.9	4.8	0.0	29.5
31	0.072109	0.000000	7.1	4.8	0.0	30.5
32	0.069306	0.000000	7.3	4.8	0.0	31.4
33	0.066637	0.000000	7.4	4.8	0.0	32.4
34	0.064204	0.000000	7.6	4.8	0.0	33.3

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
35	0.061735	0.000000	7.7	4.8	0.0	34.2
36	0.059502	0.000000	7.8	4.7	0.0	35.1
37	0.057442	0.000000	8.0	4.7	0.0	36.0
38	0.055402	0.000000	8.1	4.6	0.0	37.0
39	0.053418	0.000000	8.2	4.5	0.0	37.9
40	0.051571	0.000000	8.4	4.3	0.0	38.8
41	0.049830	0.000000	8.5	4.2	0.0	39.7
42	0.048229	0.000000	8.6	4.0	0.0	40.6
43	0.046575	0.000000	8.7	3.7	0.0	41.5
44	0.045059	0.000000	8.8	3.4	0.0	42.3
45	0.043591	0.000000	8.9	2.9	0.0	43.2
46	0.042237	0.000000	9.0	2.4	0.0	44.1
47	0.040850	0.000000	9.0	1.5	0.0	45.0
48	0.039576	0.000000	9.1	0.0	0.0	45.8
49	0.038367	0.000000	9.1	0.0	0.0	46.7
50	0.037161	0.000000	9.2	0.0	0.0	47.6
51	0.036081	0.000000	9.2	0.0	0.0	48.4
52	0.034983	0.000000	9.2	0.0	0.0	49.2
53	0.033931	0.000000	9.2	0.0	0.0	50.1
54	0.032931	0.000000	9.2	0.0	0.0	50.9
55	0.031956	0.000000	9.1	0.0	0.0	51.7
56	0.031055	0.000000	9.1	0.0	0.0	52.6
57	0.030193	0.000000	9.0	0.0	0.0	53.4
58	0.029331	0.000000	8.9	0.0	0.0	54.2
59	0.028494	0.000000	8.8	0.0	0.0	55.0
60	0.027698	0.000000	8.7	0.0	0.0	55.8
61	0.026937	0.000000	8.5	0.0	0.0	56.5
62	0.026211	0.000000	8.3	0.0	0.0	57.3
63	0.025514	0.000000	8.1	0.0	0.0	58.1
64	0.024854	0.000000	7.8	0.0	0.0	58.9
65	0.024169	0.000000	7.4	0.0	0.0	59.6
66	0.023535	0.000000	7.1	0.0	0.0	60.4
67	0.022926	0.000000	6.6	0.0	0.0	61.1
68	0.022340	0.000000	6.1	0.0	0.0	61.9
69	0.021770	0.000000	5.5	0.0	0.0	62.6
70	0.021241	0.000000	4.7	0.0	0.0	63.3
71	0.020720	0.000000	3.7	0.0	0.0	64.1
72	0.020199	0.000001	1.9	0.0	0.0	64.8

The downwind distance to c3 is 0.64 ft after about 0 seconds
The downwind distance to c2 is 47.67 ft after about 0 seconds
The downwind distance to c1 is 72.40 ft after about 1 seconds

MASS RELEASE RATE

H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°



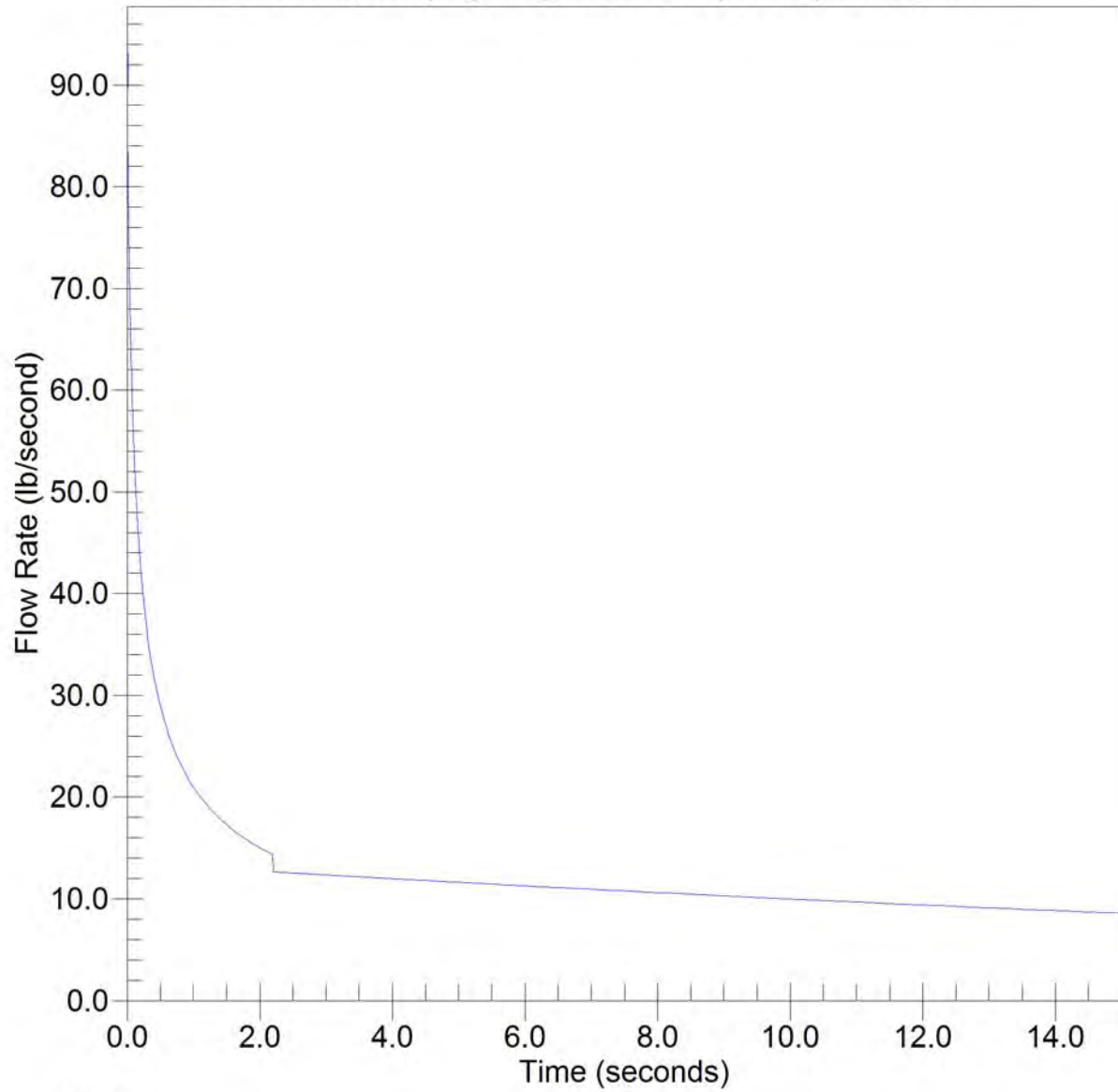
— Total
— Vapor

CANARY by Quest

casename=10DFB260S2B+45_7MMSCFD
Mon Sep 2 15:28:03 2019

MASS RELEASE RATE - DOWNSTREAM PIPING

H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°



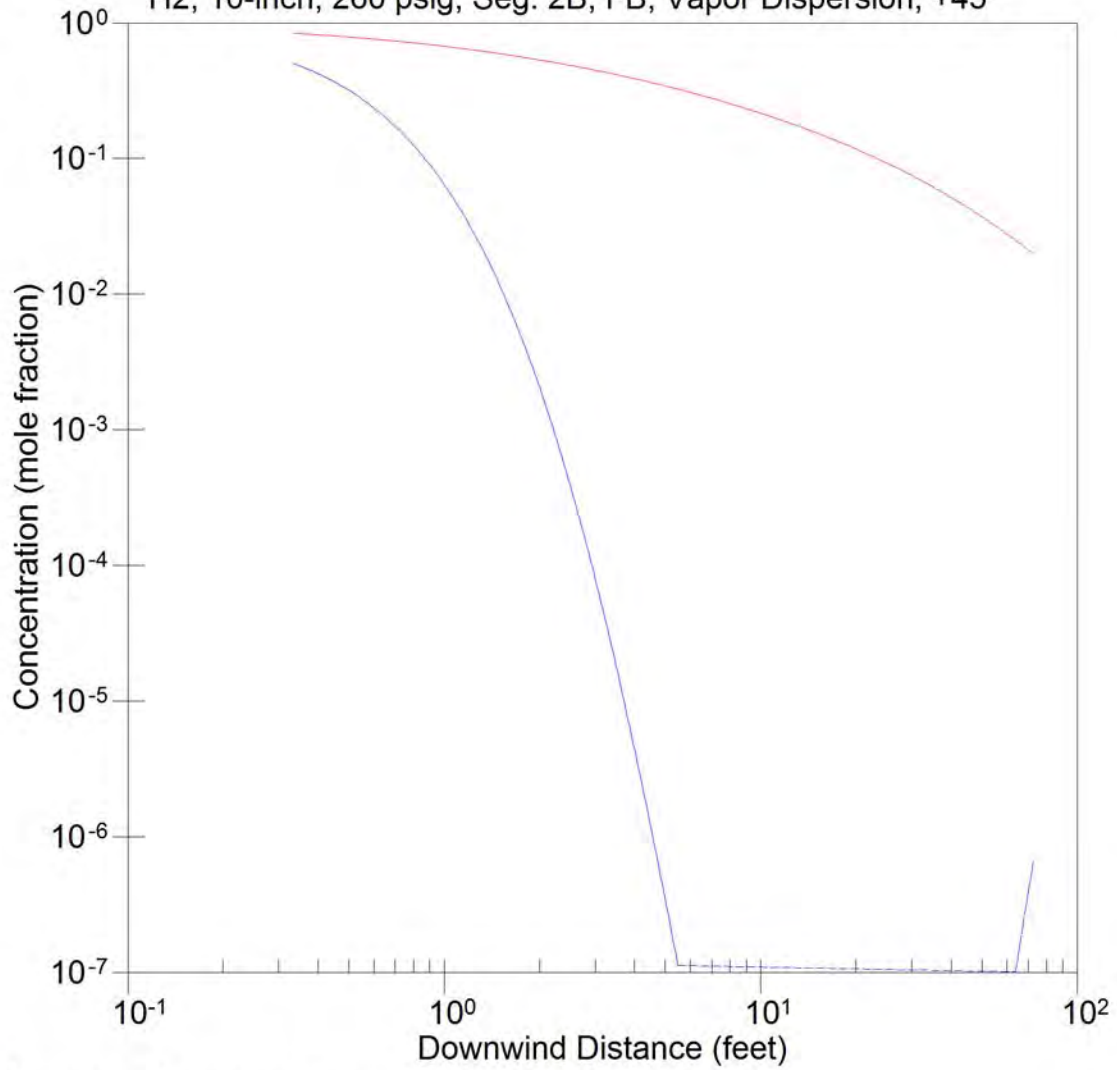
— Total
— Vapor

CANARY by Quest

casename=10DFB260S2B+45_7MMSCFD
Mon Sep 2 15:28:03 2019

Momentum Jet Cloud CONCENTRATION vs. DISTANCE

H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°



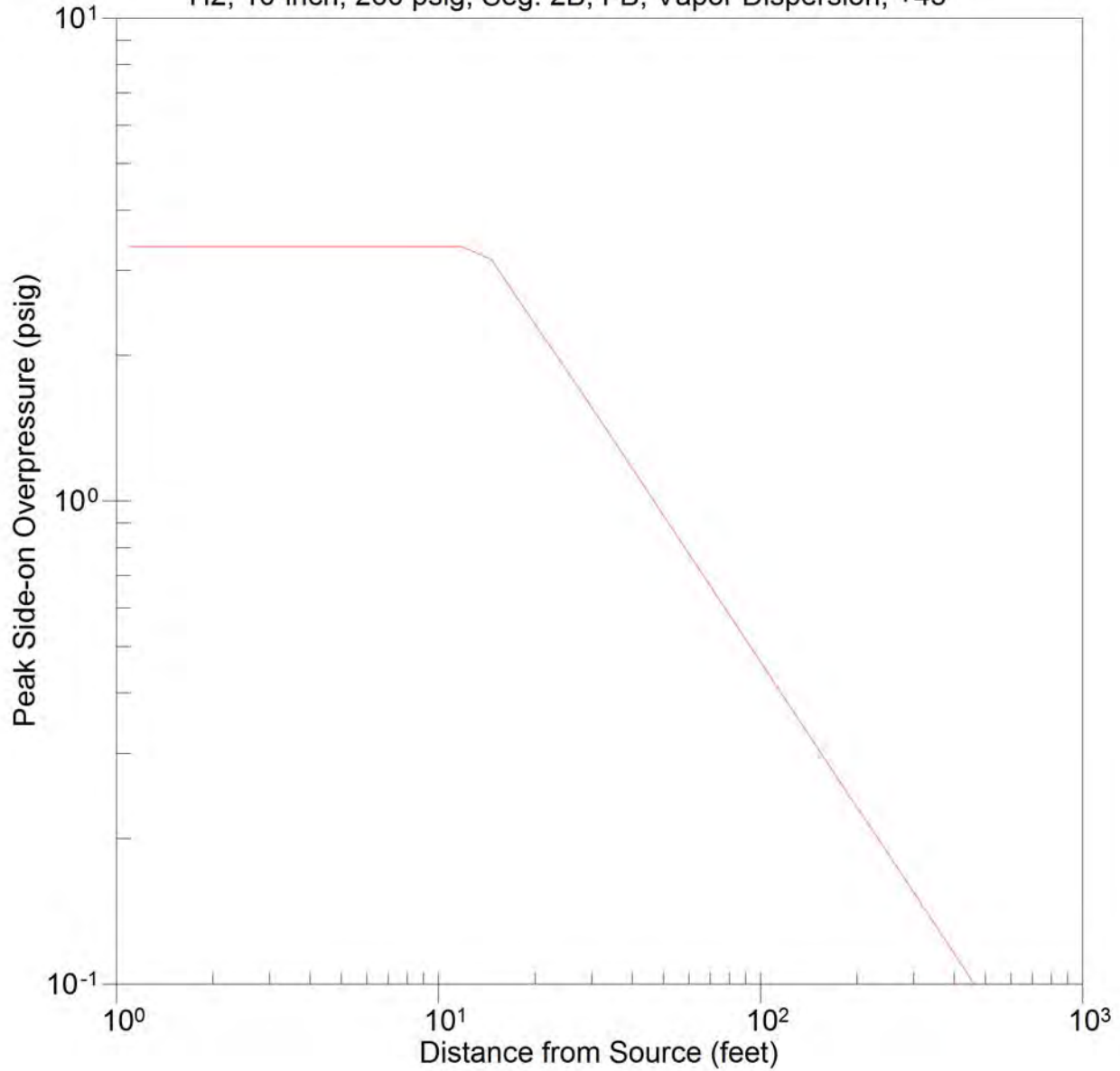
— Centerline Concentration
- - - Ground Level Concentration

casename=10DFB260S2B+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:28:03 2019

CANARY by Quest

Momentum Jet VCE

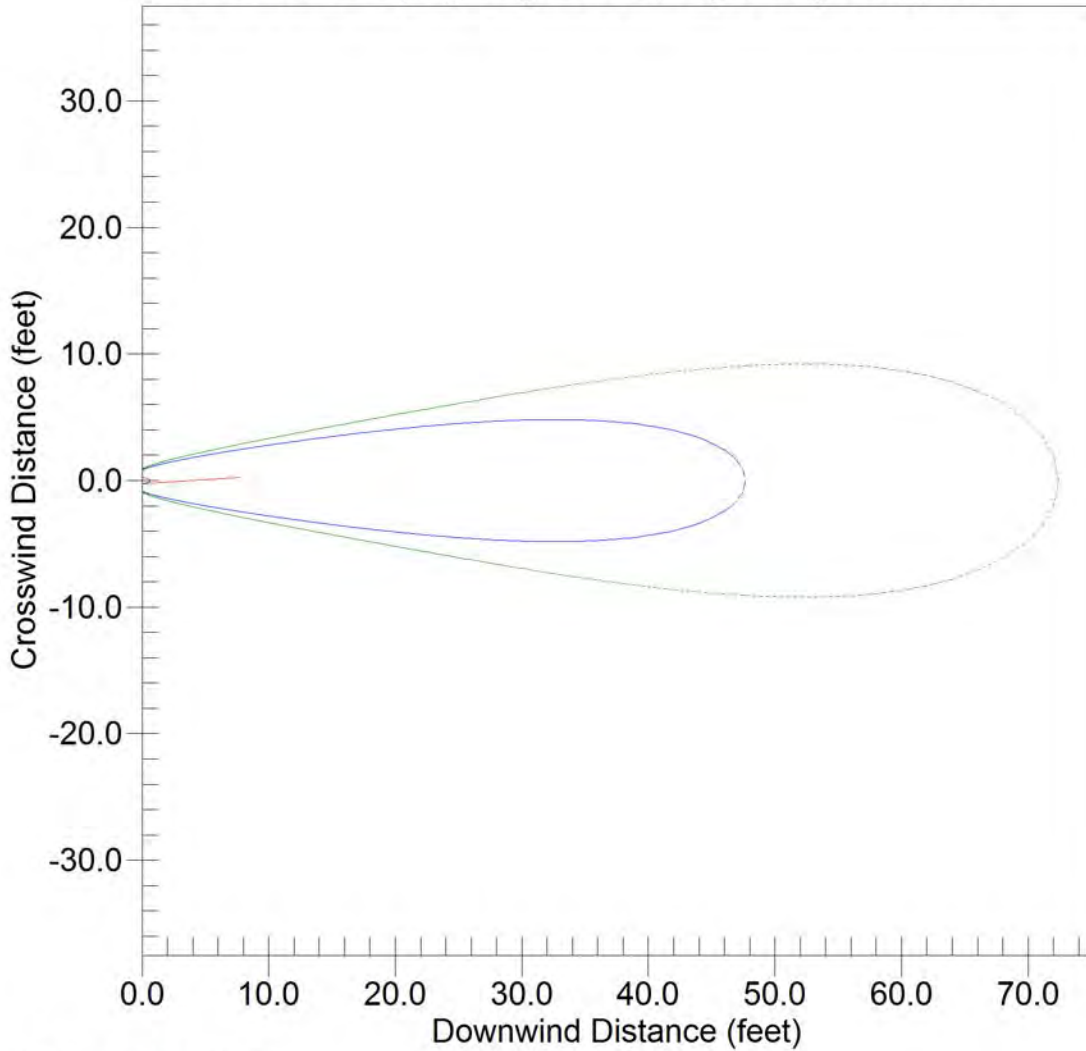
BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°



CANARY by Quest

casename=10DFB260S2B+45_7MMSCFD
Mon Sep 2 15:28:03 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°

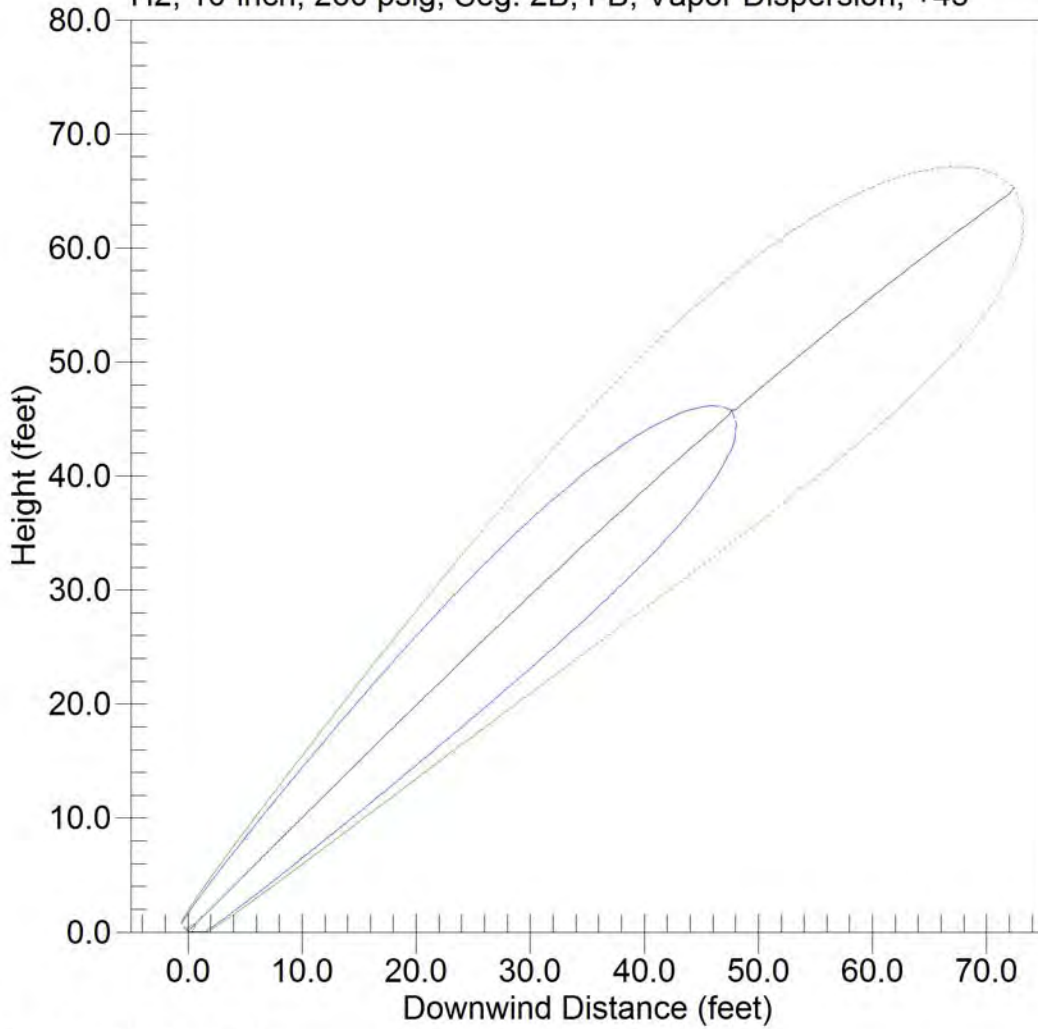


- 75.0 mole percent
- - - 4.00 mole percent
- · - · 2.00 mole percent

casename=10DFB260S2B+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:28:03 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, +45°



- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=10DFB260S2B+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:28:03 2019

CANARY by Quest


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 10DFB260S2B-45_7MMSCFD      |
|           Mon Sep  2 15:29:03 2019                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°

```

Case Type       : Vapor Dispersion
Case Name      : 10DFB260S2B-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity       0.22 Btu/lb-F
Substrate delay time          0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 10DFB260S2B-45_7MMSCFD |
| Mon Sep  2 15:29:03 2019 |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°

RELEASE MENU

Type of release: Unregulated, Continuous release
 Release duration 120 min
 Normal flow rate 0.43 lb/sec
 Duration of normal flow 5 min
 Volume of vessel 0.00 cu.ft
 Pipe inner diameter 10.02 inches
 Equivalent release diameter 10.02 inches
 Pipe length upstream of break 50225.0 feet
 Pipe length downstream of break 9397.0 feet
 Height of release point 0.0 feet
 Angle of release from horizontal 135.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation, dispersion and cloud explosion - Flammable calculation
 Concentration endpoint 1 UFL mol%
 Concentration endpoint 2 LFL mol%
 Concentration endpoint 3 1/2 LFL mol%

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

Fuel reactivity High
 Obstacle density Low
 Flame expansion 3-D

Overpressure values

Overpressure endpoint 1 1.00 psi
 Overpressure endpoint 2 0.70 psi
 Overpressure endpoint 3 0.10 psi

NOTES:

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               General Release Model UPSTREAM                 |
|               Case Name - 10DFB260S2B-45_7MMSCFD           |
|               Mon Sep  2 15:29:03 2019                      |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	93.07441	0.000000	0.000000	93.07441
0.100000	52.96829	0.000000	0.000000	52.96829
0.300000	35.30645	0.000000	0.000000	35.30645
0.500000	28.38994	0.000000	0.000000	28.38994
0.700000	24.41630	0.000000	0.000000	24.41630
1.000000	20.71885	0.000000	0.000000	20.71885
3.000000	12.22385	0.000000	0.000000	12.22385
5.000000	9.497117	0.000000	0.000000	9.497117
7.000000	8.029019	0.000000	0.000000	8.029019
10.00000	6.711814	0.000000	0.000000	6.711814
20.00000	5.752362	0.000000	0.000000	5.752362
30.00000	5.621967	0.000000	0.000000	5.621967
40.00000	5.494804	0.000000	0.000000	5.494804
50.00000	5.370830	0.000000	0.000000	5.370830
60.00000	5.249862	0.000000	0.000000	5.249862
70.00000	5.131925	0.000000	0.000000	5.131925
85.00000	4.960181	0.000000	0.000000	4.960181
100.0000	4.794872	0.000000	0.000000	4.794872
200.0000	3.836592	0.000000	0.000000	3.836592
300.0000	3.045668	0.000000	0.000000	3.045668
400.0000	2.381379	0.000000	0.000000	2.381379
500.0000	1.857074	0.000000	0.000000	1.857074
600.0000	1.445599	0.000000	0.000000	1.445599
700.0000	1.122339	0.000000	0.000000	1.122339
850.0000	.7627813	0.000000	0.000000	.7627813
1000.000	.5121486	0.000000	0.000000	.5121486
1480.062	0.000000	0.000000	0.000000	0.000000
Totals (lb)	2508.363	0.000000	0.000000	2508.363

Flowrate for Torch Fire [immediate ignition] = 6.736325 lb/sec.
Torch Fire [delayed ignition] = 4.289247 lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               General Release Model DOWNSTREAM              |
|               Case Name - 10DFB260S2B-45_7MMSCFD          |
|               Mon Sep  2 15:29:03 2019                    |
|               Quest Consultants Inc., Norman, Oklahoma, USA |
|               www.questconsult.com      canary@questconsult.com |
|               telephone (405) 329-7475    fax (405) 329-7734 |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	93.07441	0.000000	0.000000	93.07441
0.100000	54.95421	0.000000	0.000000	54.95421
0.300000	36.28660	0.000000	0.000000	36.28660
0.500000	29.00826	0.000000	0.000000	29.00826
0.700000	24.86028	0.000000	0.000000	24.86028
1.000000	21.01303	0.000000	0.000000	21.01303
3.000000	12.35260	0.000000	0.000000	12.35260
5.000000	11.62472	0.000000	0.000000	11.62472
7.000000	10.93976	0.000000	0.000000	10.93976
10.000000	9.987377	0.000000	0.000000	9.987377
20.000000	7.361129	0.000000	0.000000	7.361129
30.000000	5.410036	0.000000	0.000000	5.410036
40.000000	3.968129	0.000000	0.000000	3.968129
50.000000	2.900025	0.000000	0.000000	2.900025
60.000000	2.105893	0.000000	0.000000	2.105893
70.000000	1.510930	0.000000	0.000000	1.510930
85.000000	.8742072	0.000000	0.000000	.8742072
100.000000	.4363947	0.000000	0.000000	.4363947
200.000000	0.000000	0.000000	0.000000	0.000000
300.000000	0.000000	0.000000	0.000000	0.000000
400.000000	0.000000	0.000000	0.000000	0.000000
500.000000	0.000000	0.000000	0.000000	0.000000
600.000000	0.000000	0.000000	0.000000	0.000000
700.000000	0.000000	0.000000	0.000000	0.000000
850.000000	0.000000	0.000000	0.000000	0.000000
1000.000000	0.000000	0.000000	0.000000	0.000000
2000.000000	0.000000	0.000000	0.000000	0.000000
3000.000000	0.000000	0.000000	0.000000	0.000000
4000.000000	0.000000	0.000000	0.000000	0.000000
5000.000000	0.000000	0.000000	0.000000	0.000000
6000.000000	0.000000	0.000000	0.000000	0.000000
7000.000000	0.000000	0.000000	0.000000	0.000000
7200.000000	0.000000	0.000000	0.000000	0.000000
Totals (lb)	446.8515	0.000000	0.000000	446.8515

Flowrate for Torch Fire [immediate ignition] = 6.626809 lb/sec.
Torch Fire [delayed ignition] = 0.000000 lb/sec.

Reason for Ending: Reached Stop Time

```

CANARY by Quest - Version 4.6.2
Release Stream Compositions
Case Name - 10DFB260S2B-45_7MMSCFD
Mon Sep  2 15:29:03 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 10DFB260S2B-45_7MMSCFD                   |
|      Mon Sep  2 15:29:03 2019                               |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance	centerline conc.	ground conc.	y(c1) 1/2 width	y(c2) 1/2 width	y(c3) 1/2 width	centerline height
x(ft)	c(mole frac.)	c(mole frac.)	(ft)	(ft)	(ft)	(ft)
0	1.000000	0.000000	0.9	0.9	0.2	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is      0.00 ft after about      1 seconds
The downwind distance to c2 is      0.00 ft after about      1 seconds
The downwind distance to c1 is      0.00 ft after about      1 seconds

```

```

+-----+
|           CANARY by Quest - Version 4.6.2           |
| Momentum Jet Vapor Cloud Explosion                 |
| Case Name - 10DFB260S2B-45_7MMSCFD                |
|           Mon Sep  2 15:29:03 2019                 |
| Quest Consultants Inc., Norman, Oklahoma, USA      |
| www.questconsult.com           canary@questconsult.com |
| telephone (405) 329-7475       fax (405) 329-7734   |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°

```

Fuel Reactivity: High           Obstacle Density: Low
Flame Expansion: 3-D           Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 2.01009 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0696
3.4	3.36	0.0696
4.2	3.36	0.0696
5.1	3.36	0.0696
6.3	3.36	0.0569
7.8	3.36	0.0462
9.7	3.36	0.0376
12.0	3.36	0.0305
14.8	3.15	0.0248
18.2	2.56	0.0202
22.5	2.08	0.0164
27.8	1.69	0.0133
34.4	1.37	0.0108
42.5	1.11	0.0088
52.5	0.89	0.0072
64.9	0.72	0.0058
80.1	0.58	0.0047
99.0	0.47	0.0038
122.3	0.38	0.0031
151.1	0.31	0.0025
186.7	0.25	0.0021
230.7	0.20	0.0017
285.0	0.16	0.0014
352.1	0.13	0.0011
463.6	0.10	0.0008

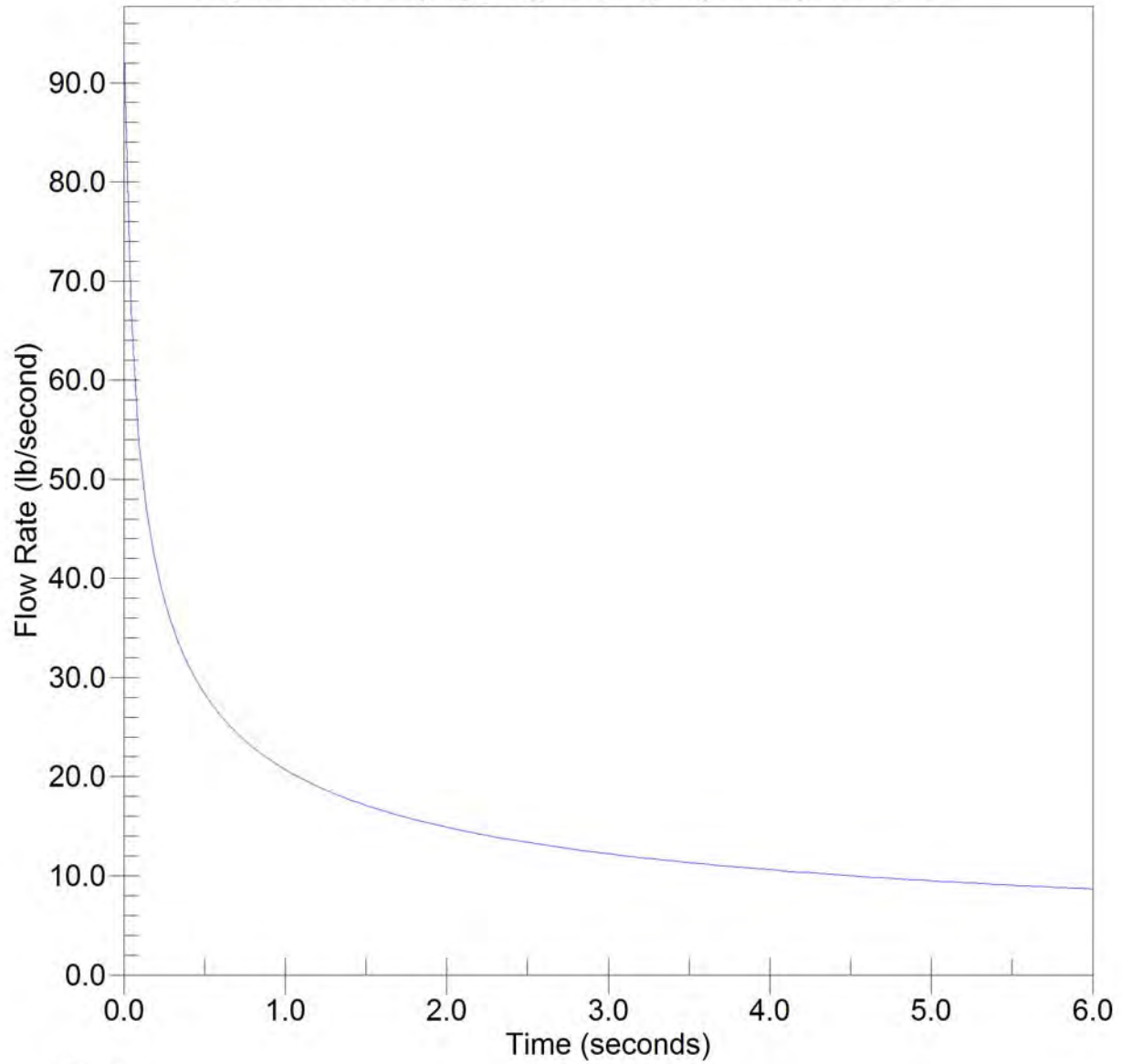
```

The downwind distance to dp3 is 47.5 feet
The downwind distance to dp2 is 67.4 feet
The downwind distance to dp1 is 463.6 feet

```

MASS RELEASE RATE

H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°



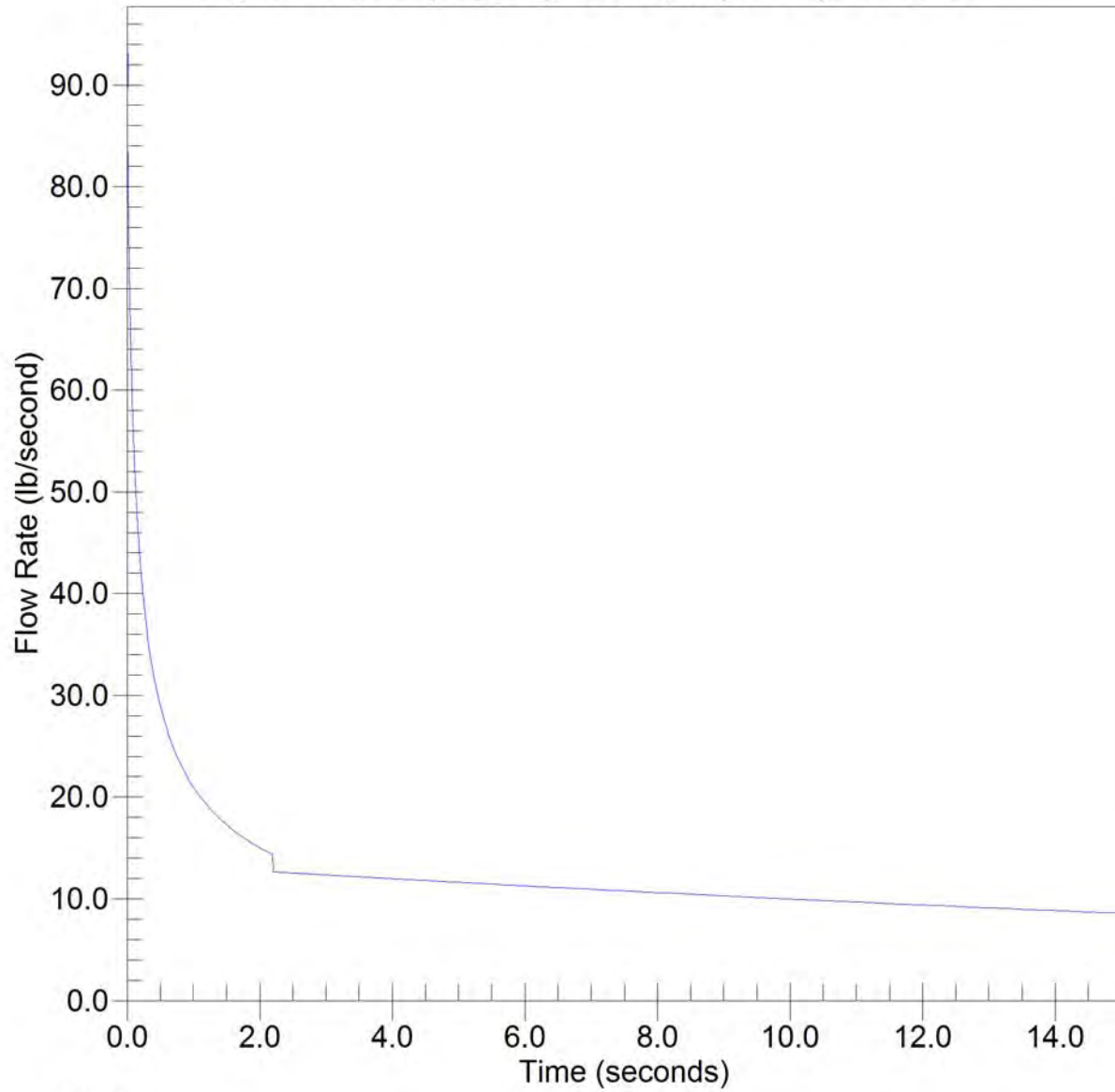
— Total
— Vapor

CANARY by Quest

casename=10DFB260S2B-45_7MMSCFD
Mon Sep 2 15:29:03 2019

MASS RELEASE RATE - DOWNSTREAM PIPING

H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°

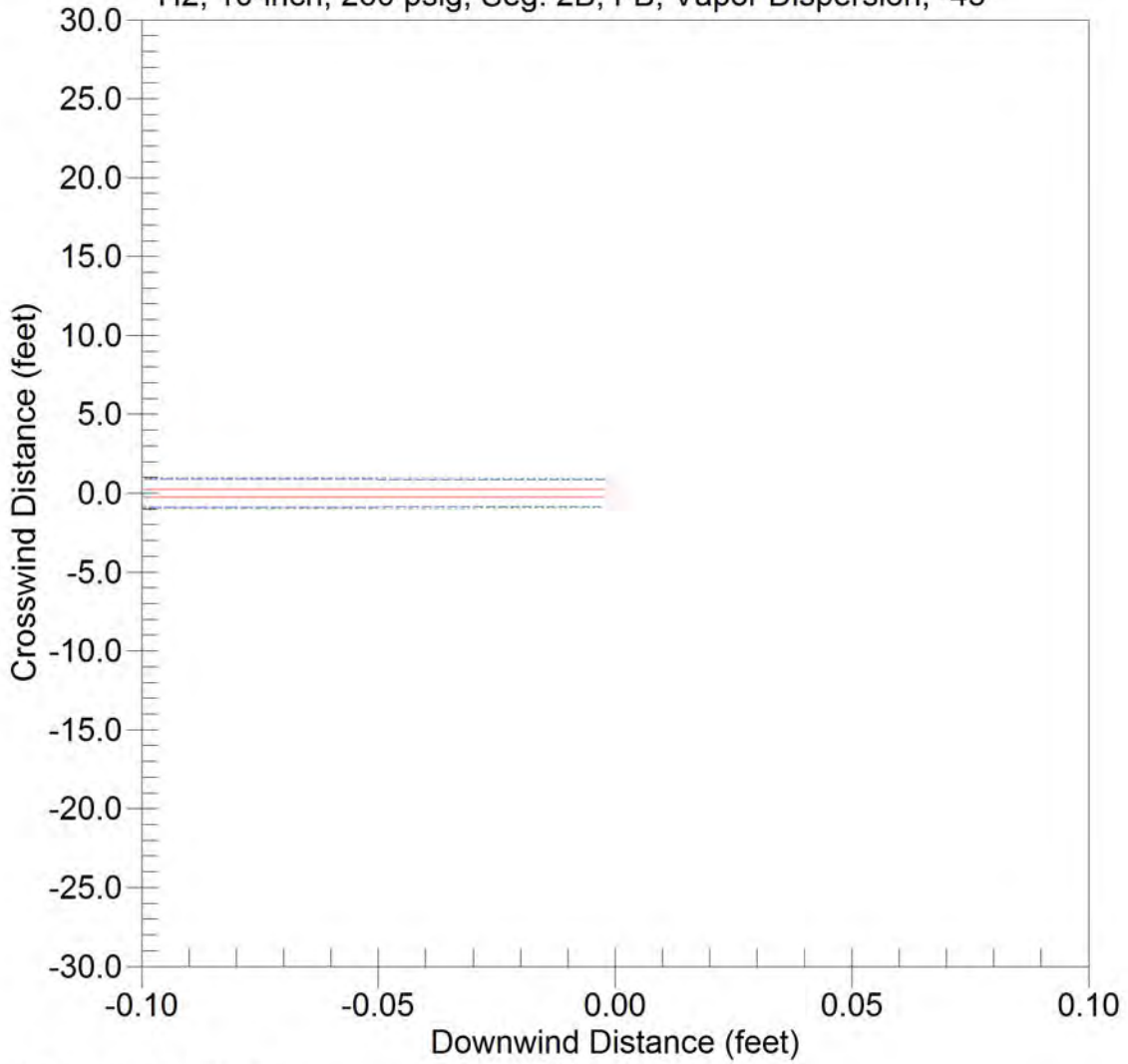


— Total
— Vapor

CANARY by Quest

casename=10DFB260S2B-45_7MMSCFD
Mon Sep 2 15:29:03 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°

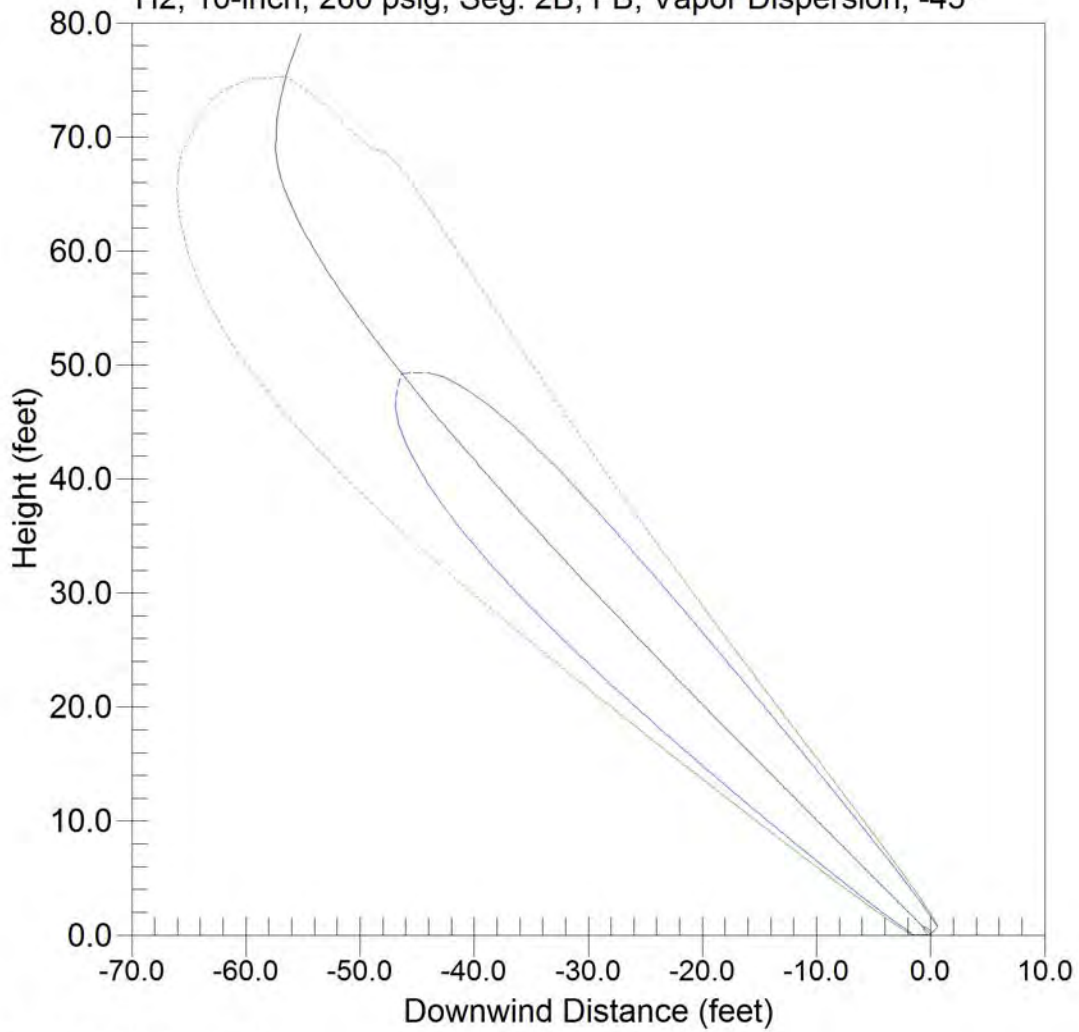


- 75.0 mole percent
- - 4.00 mole percent
- 2.00 mole percent

casename=10DFB260S2B-45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:29:03 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°

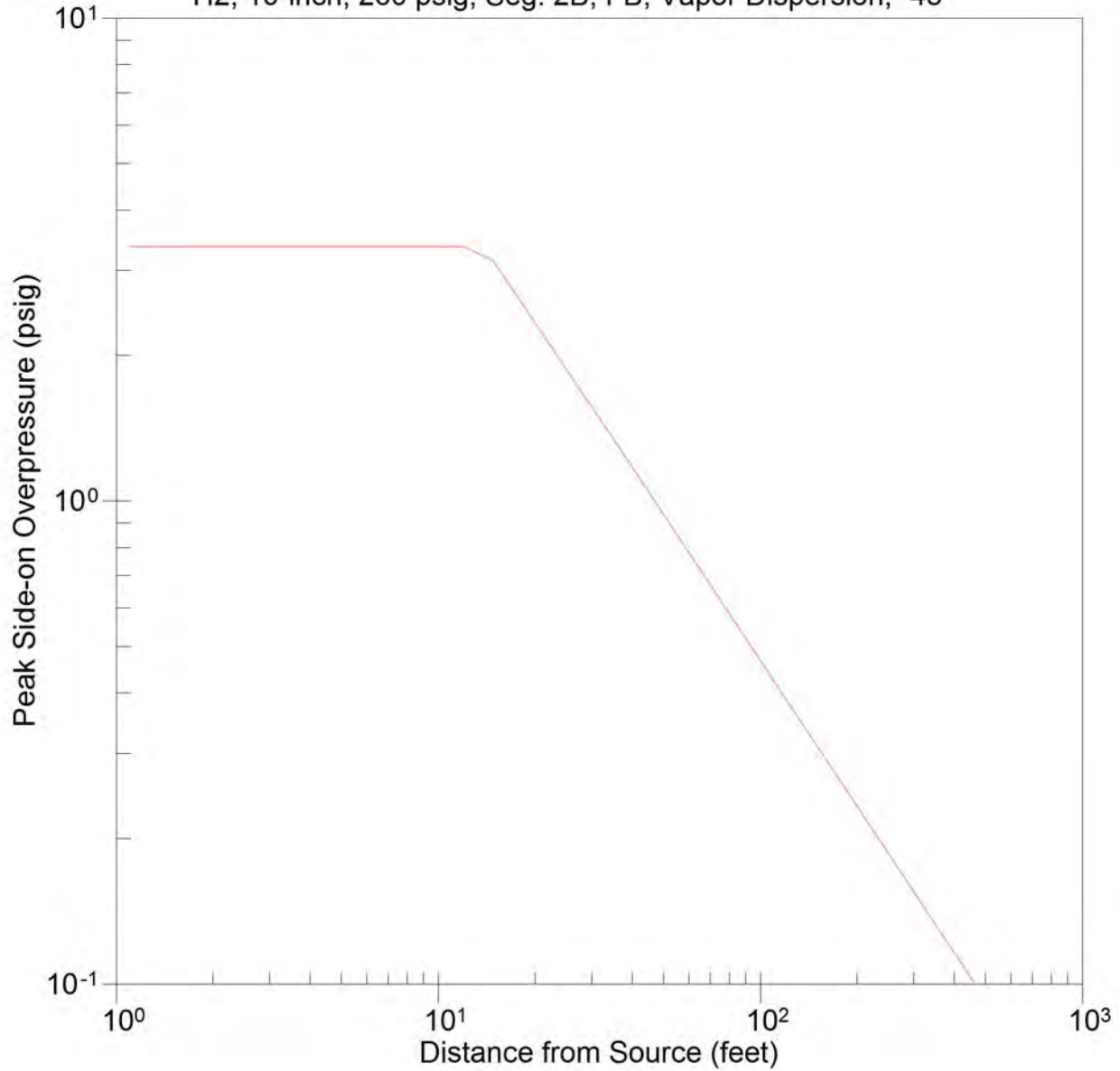


- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=10DFB260S2B-45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:29:03 2019

CANARY by Quest

Momentum Jet VCE
BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 260 psig, Seg. 2B, FB, Vapor Dispersion, -45°



CANARY by Quest

casename=10DFB260S2B-45_7MMSCFD
Mon Sep 2 15:29:03 2019

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 10D1IN260S2B+45_7MMSCFD     |
|           Mon Sep  2 15:29:53 2019                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

```

Case Type       : Vapor Dispersion
Case Name      : 10D1IN260S2B+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	72.0 °F
Spill surface temperature	72.0 °F
Substrate name	Medium density concrete
Substrate thermal conductivity	0.2698 Btu/hr-ft-F
Substrate density	80 lb/cu.ft
Substrate heat Capacity	0.22 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Wooded area or urban area

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 10D1IN260S2B+45_7MMSCFD |
| Mon Sep  2 15:29:53 2019 |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

RELEASE MENU

Type of release: Unregulated, Continuous release
 Release duration 120 min
 Normal flow rate 0.43 lb/sec
 Duration of normal flow 5 min
 Volume of vessel 0.00 cu.ft
 Pipe inner diameter 10.02 inches
 Equivalent release diameter 1.00 inches
 Pipe length upstream of break 50225.0 feet
 Height of release point 0.0 feet
 Angle of release from horizontal 45.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation, dispersion and cloud explosion - Flammable calculation
 Concentration endpoint 1 UFL mol%
 Concentration endpoint 2 LFL mol%
 Concentration endpoint 3 1/2 LFL mol%

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

Fuel reactivity High
 Obstacle density Low
 Flame expansion 3-D

Overpressure values

Overpressure endpoint 1 1.00 psi
 Overpressure endpoint 2 0.70 psi
 Overpressure endpoint 3 0.10 psi

NOTES:

```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 10D1IN260S2B+45_7MMSCFD
Mon Sep 2 15:29:53 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com canary@questconsult.com
telephone (405) 329-7475 fax (405) 329-7734

```

TITLE: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.9270879	0.000000	0.000000	.9270879
0.100000	.9269543	0.000000	0.000000	.9269543
0.300000	.9268099	0.000000	0.000000	.9268099
0.500000	.9266477	0.000000	0.000000	.9266477
0.700000	.9265017	0.000000	0.000000	.9265017
1.000000	.9262636	0.000000	0.000000	.9262636
3.000000	.9247061	0.000000	0.000000	.9247061
5.000000	.9231407	0.000000	0.000000	.9231407
7.000000	.9216298	0.000000	0.000000	.9216298
10.000000	.9193701	0.000000	0.000000	.9193701
20.000000	.9145233	0.000000	0.000000	.9145233
30.000000	.9127272	0.000000	0.000000	.9127272
40.000000	.9110069	0.000000	0.000000	.9110069
50.000000	.9092927	0.000000	0.000000	.9092927
60.000000	.9075845	0.000000	0.000000	.9075845
70.000000	.9058821	0.000000	0.000000	.9058821
85.000000	.9033396	0.000000	0.000000	.9033396
100.000000	.9008106	0.000000	0.000000	.9008106
200.000000	.8842270	0.000000	0.000000	.8842270
300.000000	.8672781	0.000000	0.000000	.8672781
400.000000	.8380946	0.000000	0.000000	.8380946
500.000000	.8082353	0.000000	0.000000	.8082353
600.000000	.7796765	0.000000	0.000000	.7796765
700.000000	.7521501	0.000000	0.000000	.7521501
850.000000	.7127176	0.000000	0.000000	.7127176
1000.000000	.6752641	0.000000	0.000000	.6752641
2000.000000	.4712316	0.000000	0.000000	.4712316
3000.000000	.3260070	0.000000	0.000000	.3260070
4000.000000	.2254789	0.000000	0.000000	.2254789
5000.000000	.1561165	0.000000	0.000000	.1561165
6000.000000	.1081254	0.000000	0.000000	.1081254
7000.000000	.6814837E-01	0.000000	0.000000	.6814837E-01
7200.000000	.5740807E-01	0.000000	0.000000	.5740807E-01

Totals (lb) 2461.309 0.000000 0.000000 2461.309

Flowrate for Torch Fire [immediate ignition] = 0.9138496 lb/sec.
Torch Fire [delayed ignition] = 0.8924799 lb/sec.

Reason for Ending: Reached Stop Time

```

CANARY by Quest - Version 4.6.2
Release Stream Compositions
Case Name - 10D1IN260S2B+45_7MMSCFD
Mon Sep 2 15:29:53 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

Component Number	Component Name, Formula
------------------	-------------------------

51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	


```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 10D1IN260S2B+45_7MMSCFD                  |
|              Mon Sep  2 15:29:53 2019                      |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.3	0.2	0.1	0.1
0.5	0.558141	0.001253	0.4	0.4	0.0	0.6
1.0	0.413882	0.000003	0.5	0.5	0.0	1.1
1.5	0.333401	0.000000	0.6	0.6	0.0	1.6
2.0	0.280567	0.000000	0.7	0.6	0.0	2.1
2.5	0.242600	0.000000	0.8	0.7	0.0	2.6
3.0	0.214006	0.000000	0.9	0.8	0.0	3.1
3.5	0.191429	0.000000	1.0	0.8	0.0	3.6
4.0	0.173071	0.000000	1.1	0.9	0.0	4.1
4.5	0.157822	0.000000	1.2	0.9	0.0	4.6
5.0	0.144838	0.000000	1.2	1.0	0.0	5.1
5.5	0.133719	0.000000	1.3	1.0	0.0	5.6
6.0	0.124058	0.000000	1.4	1.1	0.0	6.1
6.5	0.115547	0.000000	1.4	1.1	0.0	6.6
7.0	0.108060	0.000000	1.5	1.2	0.0	7.1
7.5	0.101370	0.000000	1.6	1.2	0.0	7.6
8.0	0.095341	0.000000	1.7	1.2	0.0	8.0
8.5	0.089891	0.000000	1.7	1.3	0.0	8.5
9.0	0.084978	0.000000	1.8	1.3	0.0	9.0
9.5	0.080452	0.000000	1.8	1.3	0.0	9.5
10.0	0.076327	0.000000	1.9	1.3	0.0	10.0
10.5	0.072536	0.000000	2.0	1.3	0.0	10.5
11.0	0.069056	0.000000	2.0	1.3	0.0	11.0
11.5	0.065804	0.000000	2.1	1.3	0.0	11.5
12.0	0.062794	0.000000	2.1	1.3	0.0	12.0
12.5	0.059979	0.000000	2.2	1.3	0.0	12.5
13.0	0.057391	0.000000	2.2	1.3	0.0	13.0
13.5	0.054932	0.000000	2.3	1.3	0.0	13.5
14.0	0.052648	0.000000	2.3	1.2	0.0	14.0
14.5	0.050501	0.000000	2.4	1.2	0.0	14.5
15.0	0.048465	0.000000	2.4	1.1	0.0	15.0
15.5	0.046581	0.000000	2.5	1.0	0.0	15.4
16.0	0.044771	0.000000	2.5	0.9	0.0	15.9
16.5	0.043073	0.000000	2.5	0.8	0.0	16.4
17.0	0.041485	0.000000	2.5	0.6	0.0	16.9

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
17.5	0.039952	0.000000	2.6	0.0	0.0	17.4
18.0	0.038498	0.000000	2.6	0.0	0.0	17.9
18.5	0.037138	0.000000	2.6	0.0	0.0	18.3
19.0	0.035839	0.000000	2.6	0.0	0.0	18.8
19.5	0.034590	0.000000	2.6	0.0	0.0	19.3
20.0	0.033414	0.000000	2.6	0.0	0.0	19.8
20.5	0.032306	0.000000	2.6	0.0	0.0	20.2
21.0	0.031222	0.000000	2.6	0.0	0.0	20.7
21.5	0.030185	0.000000	2.6	0.0	0.0	21.2
22.0	0.029213	0.000000	2.6	0.0	0.0	21.7
22.5	0.028287	0.000000	2.5	0.0	0.0	22.1
23.0	0.027379	0.000000	2.5	0.0	0.0	22.6
23.5	0.026501	0.000000	2.4	0.0	0.0	23.1
24.0	0.025687	0.000000	2.4	0.0	0.0	23.5
24.5	0.024902	0.000000	2.3	0.0	0.0	24.0
25.0	0.024150	0.000000	2.2	0.0	0.0	24.4
25.5	0.023403	0.000000	2.0	0.0	0.0	24.9
26.0	0.022709	0.000000	1.9	0.0	0.0	25.3
26.5	0.022062	0.000000	1.7	0.0	0.0	25.8
27.0	0.021428	0.000000	1.5	0.0	0.0	26.2
27.5	0.020806	0.000000	1.1	0.0	0.0	26.7
28.0	0.020221	0.000000	0.6	0.0	0.0	27.1

The downwind distance to c3 is 0.18 ft after about 0 seconds
The downwind distance to c2 is 17.48 ft after about 0 seconds
The downwind distance to c1 is 28.19 ft after about 0 seconds

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
|      Momentum Jet Vapor Cloud Explosion          |
|      Case Name - 10D1IN260S2B+45_7MMSCFD      |
|          Mon Sep  2 15:29:53 2019              |
|      Quest Consultants Inc., Norman, Oklahoma, USA |
|      www.questconsult.com      canary@questconsult.com |
|      telephone (405) 329-7475      fax (405) 329-7734 |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

```

Fuel Reactivity: High          Obstacle Density: Low
Flame Expansion: 3-D          Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.0619871 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0218
1.1	3.36	0.0218
1.2	3.36	0.0218
1.5	3.36	0.0218
1.7	3.36	0.0206
2.0	3.36	0.0176
2.4	3.36	0.0150
2.8	3.36	0.0128
3.3	3.36	0.0110
3.8	3.36	0.0093
4.5	3.23	0.0080
5.3	2.75	0.0068
6.2	2.35	0.0058
7.3	2.00	0.0050
8.6	1.71	0.0042
10.1	1.45	0.0036
11.9	1.24	0.0031
14.0	1.05	0.0026
16.5	0.89	0.0022
19.4	0.76	0.0019
22.7	0.65	0.0016
26.7	0.55	0.0014
31.4	0.47	0.0012
36.9	0.40	0.0010
145.4	0.10	0.0003

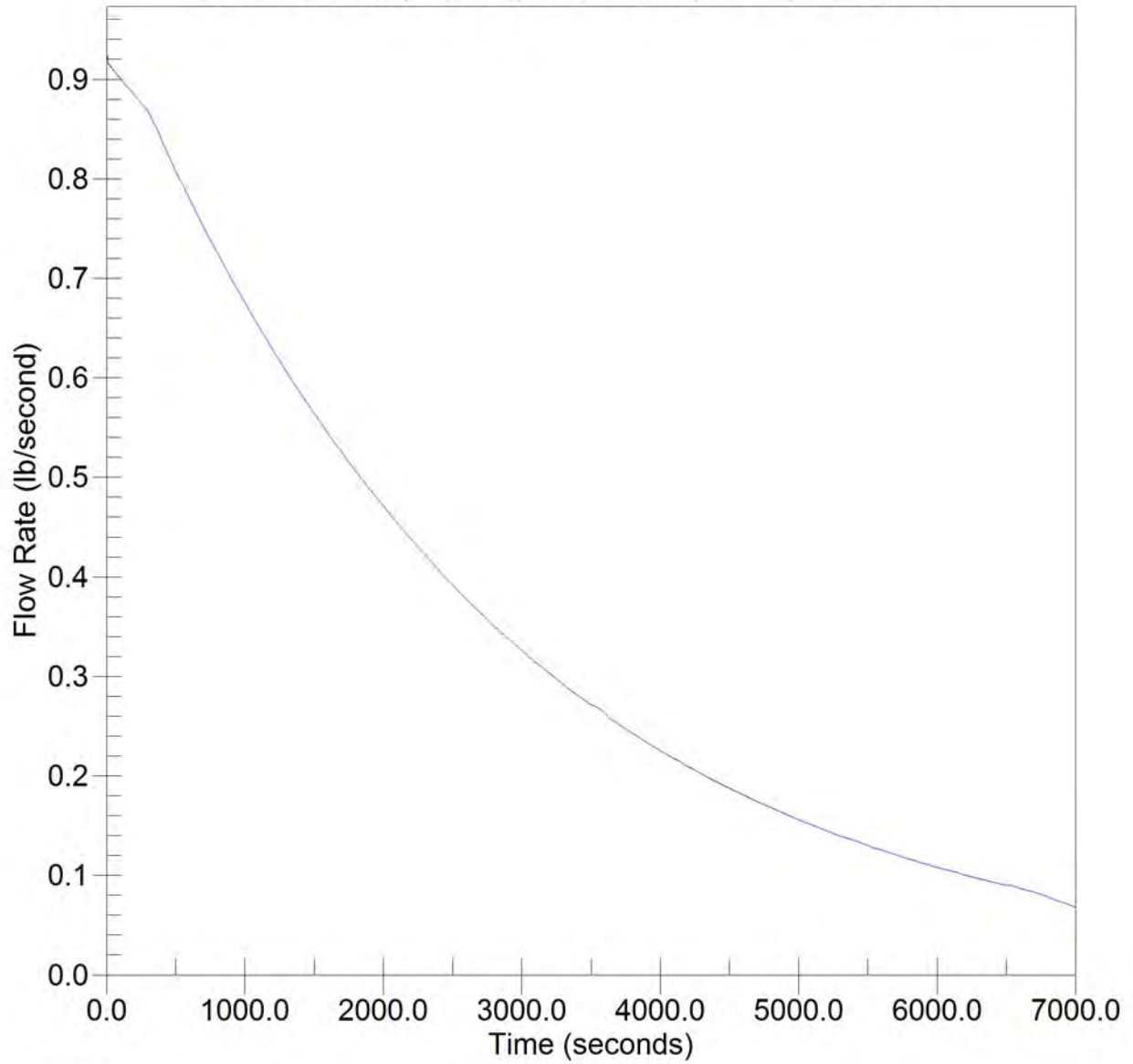
```

The downwind distance to dp3 is      14.8 feet
The downwind distance to dp2 is      21.1 feet
The downwind distance to dp1 is     145.4 feet

```

MASS RELEASE RATE

H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

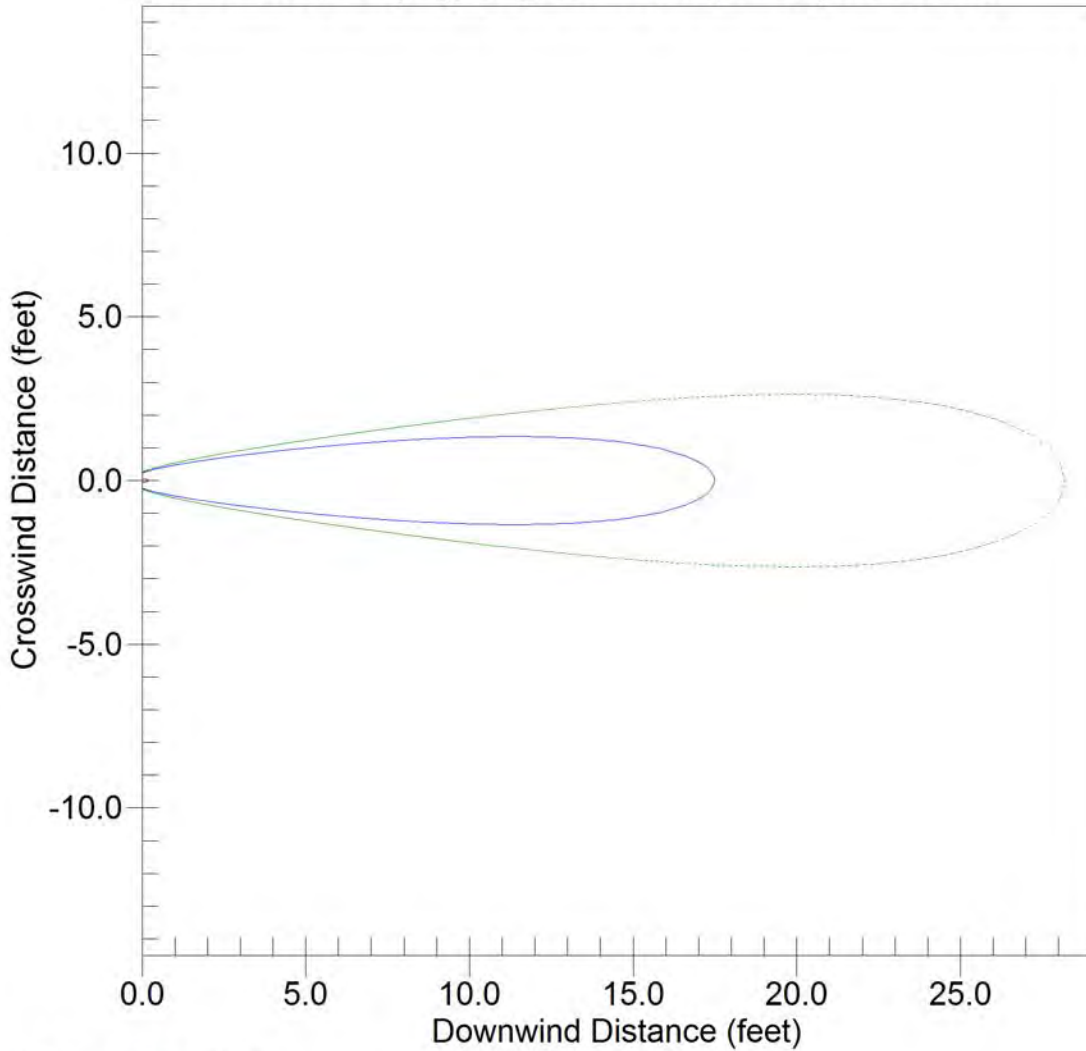


— Total
— Vapor

CANARY by Quest

casename=10D1IN260S2B+45_7MMSCFD
Mon Sep 2 15:29:53 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

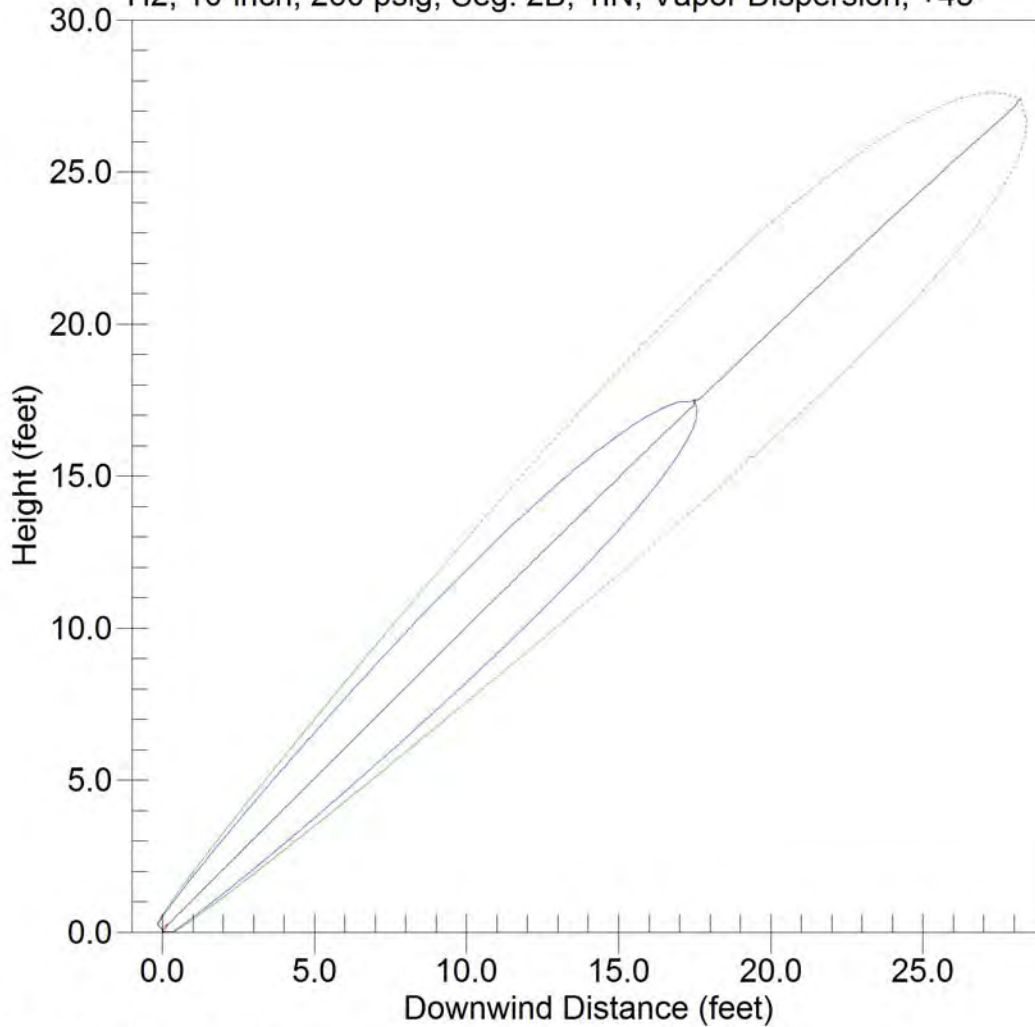


- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=10D1IN260S2B+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:29:53 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°



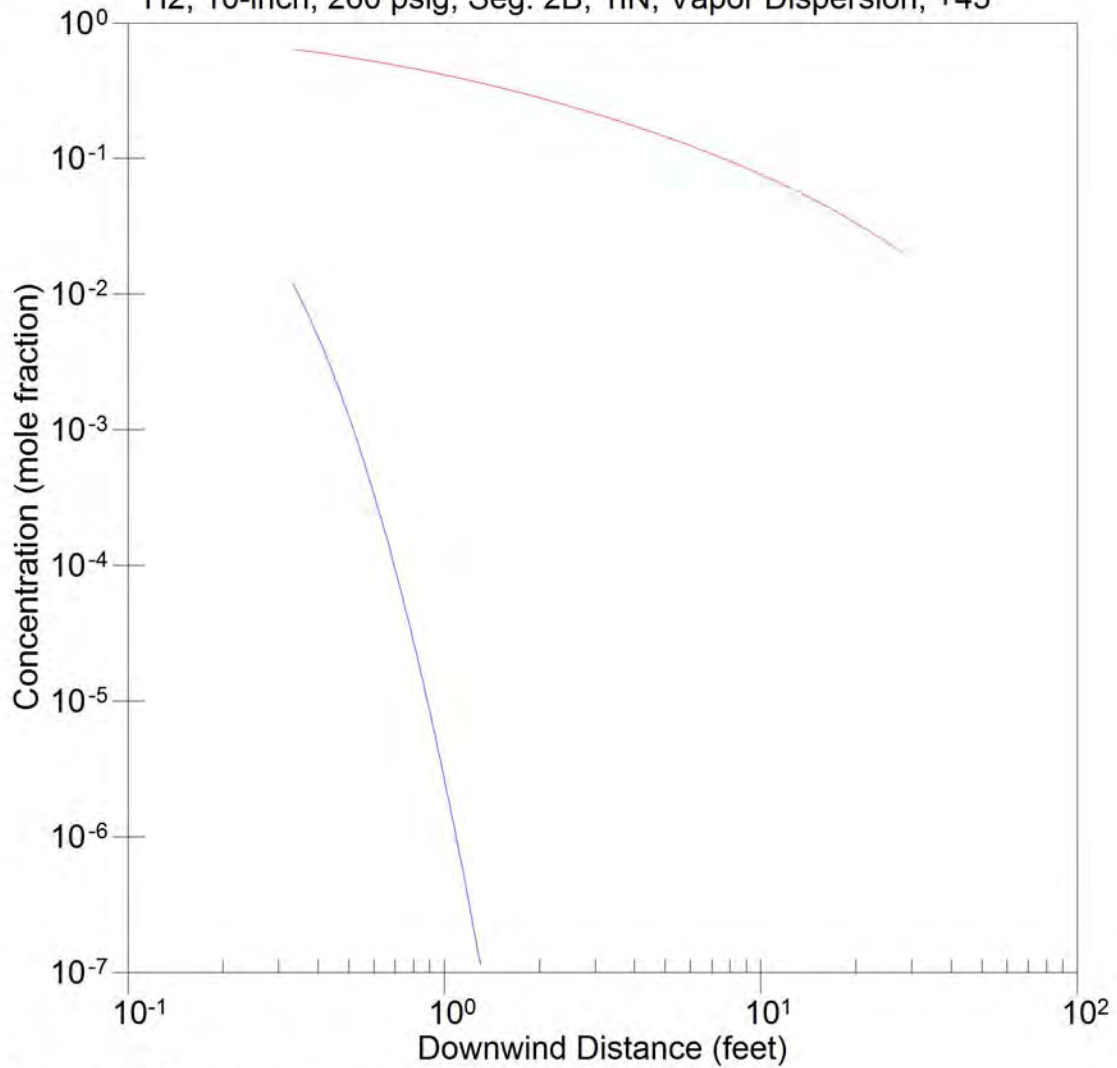
- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=10D1IN260S2B+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:29:53 2019

CANARY by Quest

Momentum Jet Cloud CONCENTRATION vs. DISTANCE

H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°



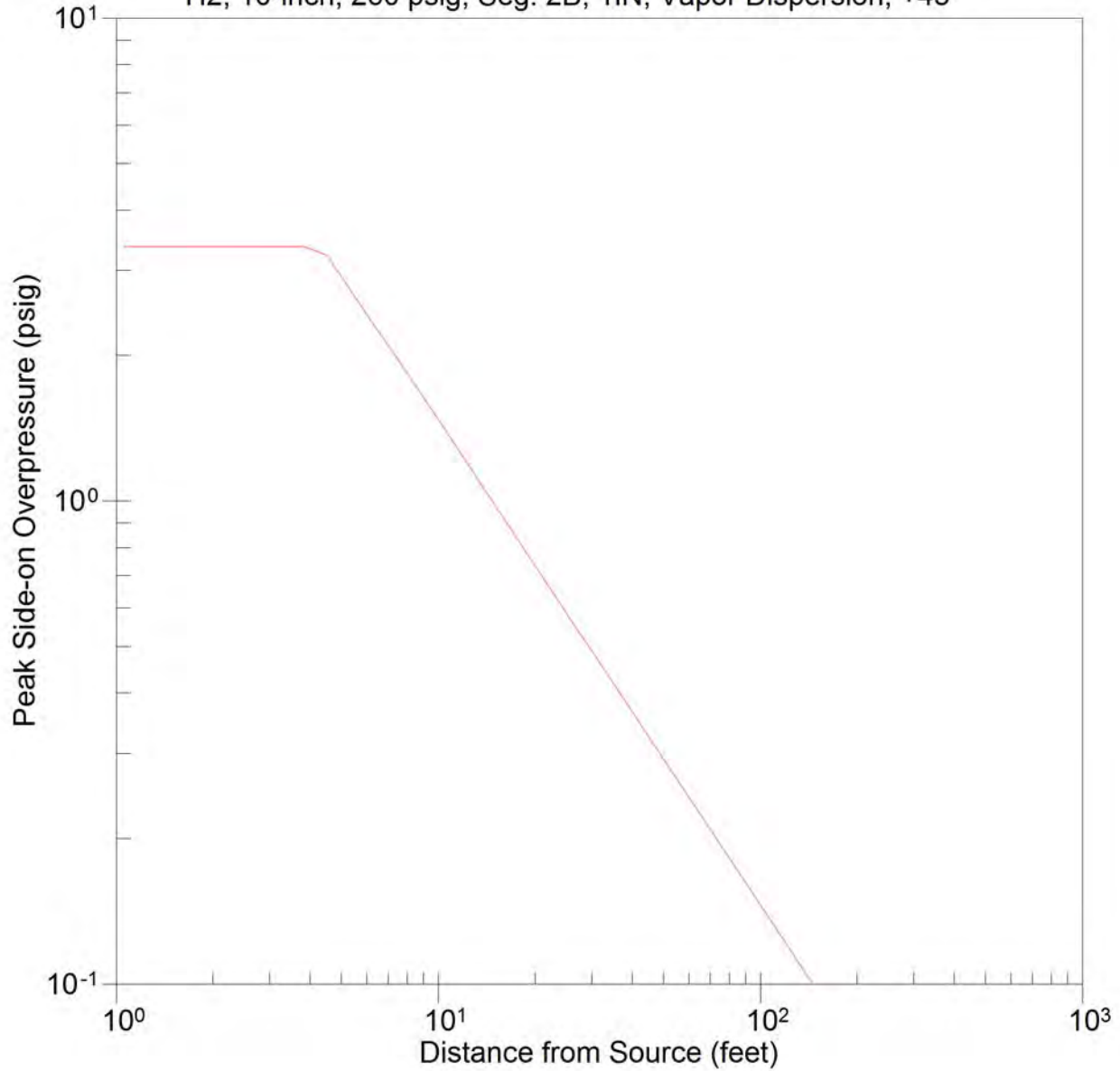
— Centerline Concentration
— Ground Level Concentration

casename=10D1IN260S2B+45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:29:53 2019

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°



CANARY by Quest

casename=10D1IN260S2B+45_7MMSCFD
Mon Sep 2 15:29:53 2019


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 10D1IN260S2B-45_7MMSCFD     |
|           Mon Sep  2 15:30:35 2019                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

```

Case Type       : Vapor Dispersion
Case Name      : 10D1IN260S2B-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity        0.22 Btu/lb-F
Substrate delay time           0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 10D1IN260S2B-45_7MMSCFD |
| Mon Sep  2 15:30:35 2019 |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration           120 min
Normal flow rate          0.43 lb/sec
Duration of normal flow   5 min
Volume of vessel          0.00 cu.ft
Pipe inner diameter       10.02 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 50225.0 feet
Height of release point   0.0 feet
Angle of release from horizontal 135.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1          UFL mol%
Concentration endpoint 2          LFL mol%
Concentration endpoint 3          1/2 LFL mol%

```

```

Dispersion coefficient averaging time          1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity          High
Obstacle density        Low
Flame expansion          3-D

```

Overpressure values

```

Overpressure endpoint 1          1.00 psi
Overpressure endpoint 2          0.70 psi
Overpressure endpoint 3          0.10 psi

```

NOTES:

```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 10D1IN260S2B-45_7MMSCFD
Mon Sep  2 15:30:35 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

TITLE: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.9270879	0.000000	0.000000	.9270879
0.100000	.9269543	0.000000	0.000000	.9269543
0.300000	.9268099	0.000000	0.000000	.9268099
0.500000	.9266477	0.000000	0.000000	.9266477
0.700000	.9265017	0.000000	0.000000	.9265017
1.000000	.9262636	0.000000	0.000000	.9262636
3.000000	.9247061	0.000000	0.000000	.9247061
5.000000	.9231407	0.000000	0.000000	.9231407
7.000000	.9216298	0.000000	0.000000	.9216298
10.00000	.9193701	0.000000	0.000000	.9193701
20.00000	.9145233	0.000000	0.000000	.9145233
30.00000	.9127272	0.000000	0.000000	.9127272
40.00000	.9110069	0.000000	0.000000	.9110069
50.00000	.9092927	0.000000	0.000000	.9092927
60.00000	.9075845	0.000000	0.000000	.9075845
70.00000	.9058821	0.000000	0.000000	.9058821
85.00000	.9033396	0.000000	0.000000	.9033396
100.0000	.9008106	0.000000	0.000000	.9008106
200.0000	.8842270	0.000000	0.000000	.8842270
300.0000	.8672781	0.000000	0.000000	.8672781
400.0000	.8380946	0.000000	0.000000	.8380946
500.0000	.8082353	0.000000	0.000000	.8082353
600.0000	.7796765	0.000000	0.000000	.7796765
700.0000	.7521501	0.000000	0.000000	.7521501
850.0000	.7127176	0.000000	0.000000	.7127176
1000.000	.6752641	0.000000	0.000000	.6752641
2000.000	.4712316	0.000000	0.000000	.4712316
3000.000	.3260070	0.000000	0.000000	.3260070
4000.000	.2254789	0.000000	0.000000	.2254789
5000.000	.1561165	0.000000	0.000000	.1561165
6000.000	.1081254	0.000000	0.000000	.1081254
7000.000	.6814837E-01	0.000000	0.000000	.6814837E-01
7200.000	.5740807E-01	0.000000	0.000000	.5740807E-01

Totals (lb) 2461.309 0.000000 0.000000 2461.309

Flowrate for Torch Fire [immediate ignition] = 0.9138496 lb/sec.
Torch Fire [delayed ignition] = 0.8924799 lb/sec.

Reason for Ending: Reached Stop Time

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
|          Release Stream Compositions             |
|          Case Name - 10D1IN260S2B-45_7MMSCFD    |
|          Mon Sep  2 15:30:35 2019              |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
|          www.questconsult.com                   |
|          canary@questconsult.com                |
|          telephone (405) 329-7475              |
|          fax (405) 329-7734                    |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

Component Number	Component Name, Formula
------------------	-------------------------

51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
| Momentum Jet Vapor Dispersion Model |
| Case Name - 10D1IN260S2B-45_7MMSCFD |
|   Mon Sep  2 15:30:35 2019         |
| Quest Consultants Inc., Norman, Oklahoma, USA |
| www.questconsult.com   canary@questconsult.com |
| telephone (405) 329-7475   fax (405) 329-7734 |
|               |
+-----+

```

TITLE: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance	centerline conc.	ground conc.	y(c1) 1/2 width	y(c2) 1/2 width	y(c3) 1/2 width	centerline height
x(ft)	c(mole frac.)	c(mole frac.)	(ft)	(ft)	(ft)	(ft)
0	1.000000	0.000000	0.3	0.2	0.1	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is 0.00 ft after about 0 seconds
The downwind distance to c2 is 0.00 ft after about 0 seconds
The downwind distance to c1 is 0.00 ft after about 0 seconds

```

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
| Momentum Jet Vapor Cloud Explosion              |
| Case Name - 10D1IN260S2B-45_7MMSCFD           |
| Mon Sep  2 15:30:35 2019                       |
| Quest Consultants Inc., Norman, Oklahoma, USA    |
| www.questconsult.com      canary@questconsult.com |
| telephone (405) 329-7475    fax (405) 329-7734  |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

```

Fuel Reactivity: High           Obstacle Density: Low
Flame Expansion: 3-D           Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.062965 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0220
1.1	3.36	0.0220
1.2	3.36	0.0220
1.5	3.36	0.0220
1.7	3.36	0.0207
2.0	3.36	0.0177
2.4	3.36	0.0151
2.8	3.36	0.0129
3.3	3.36	0.0110
3.9	3.36	0.0094
4.6	3.22	0.0080
5.3	2.75	0.0068
6.3	2.34	0.0058
7.4	2.00	0.0050
8.7	1.70	0.0042
10.2	1.45	0.0036
12.0	1.23	0.0031
14.1	1.05	0.0026
16.6	0.89	0.0022
19.5	0.76	0.0019
23.0	0.64	0.0016
27.0	0.55	0.0014
31.7	0.46	0.0012
37.3	0.39	0.0010
146.1	0.10	0.0003

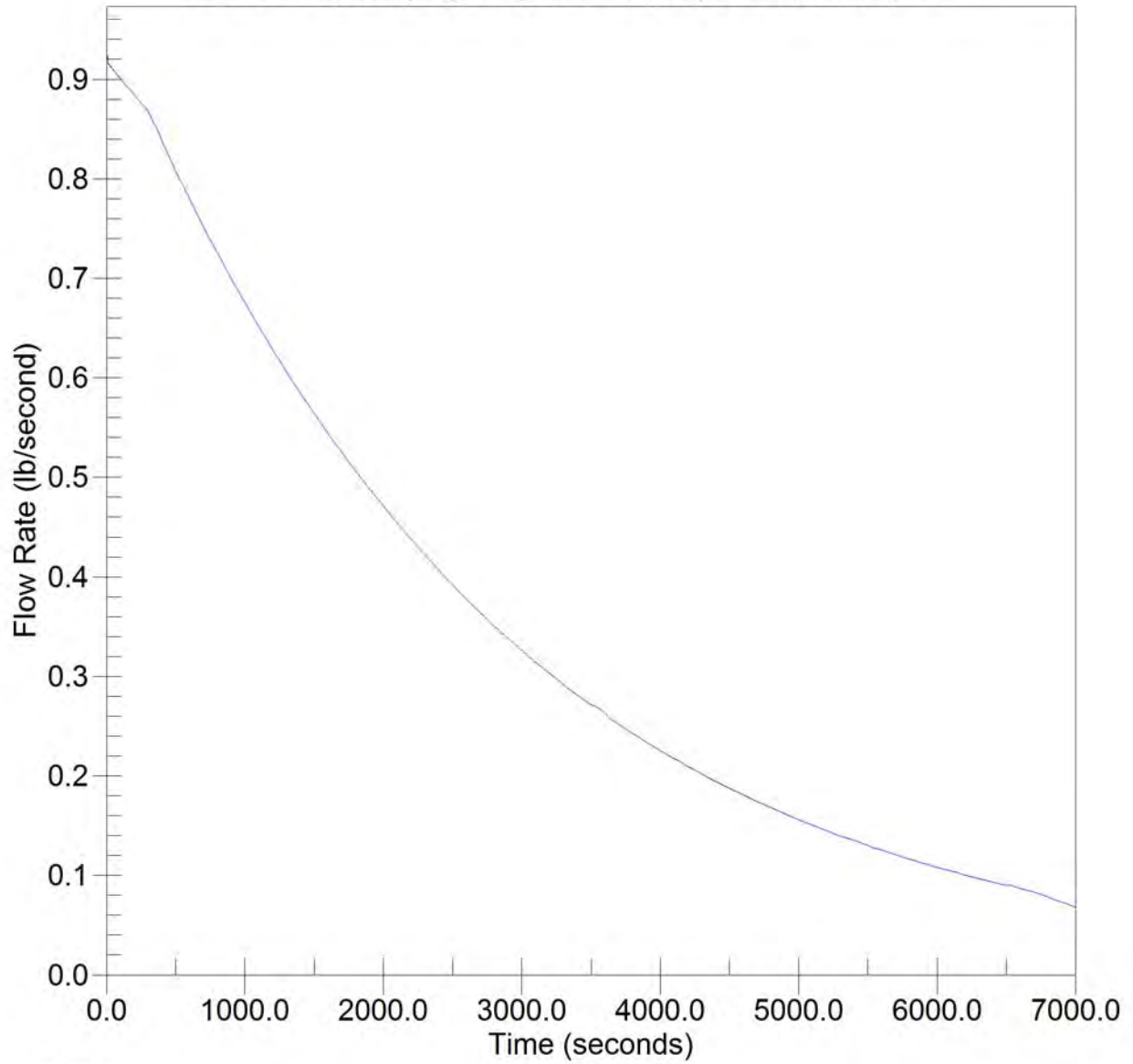
```

The downwind distance to dp3 is  14.9 feet
The downwind distance to dp2 is  21.2 feet
The downwind distance to dp1 is 146.1 feet

```

MASS RELEASE RATE

H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

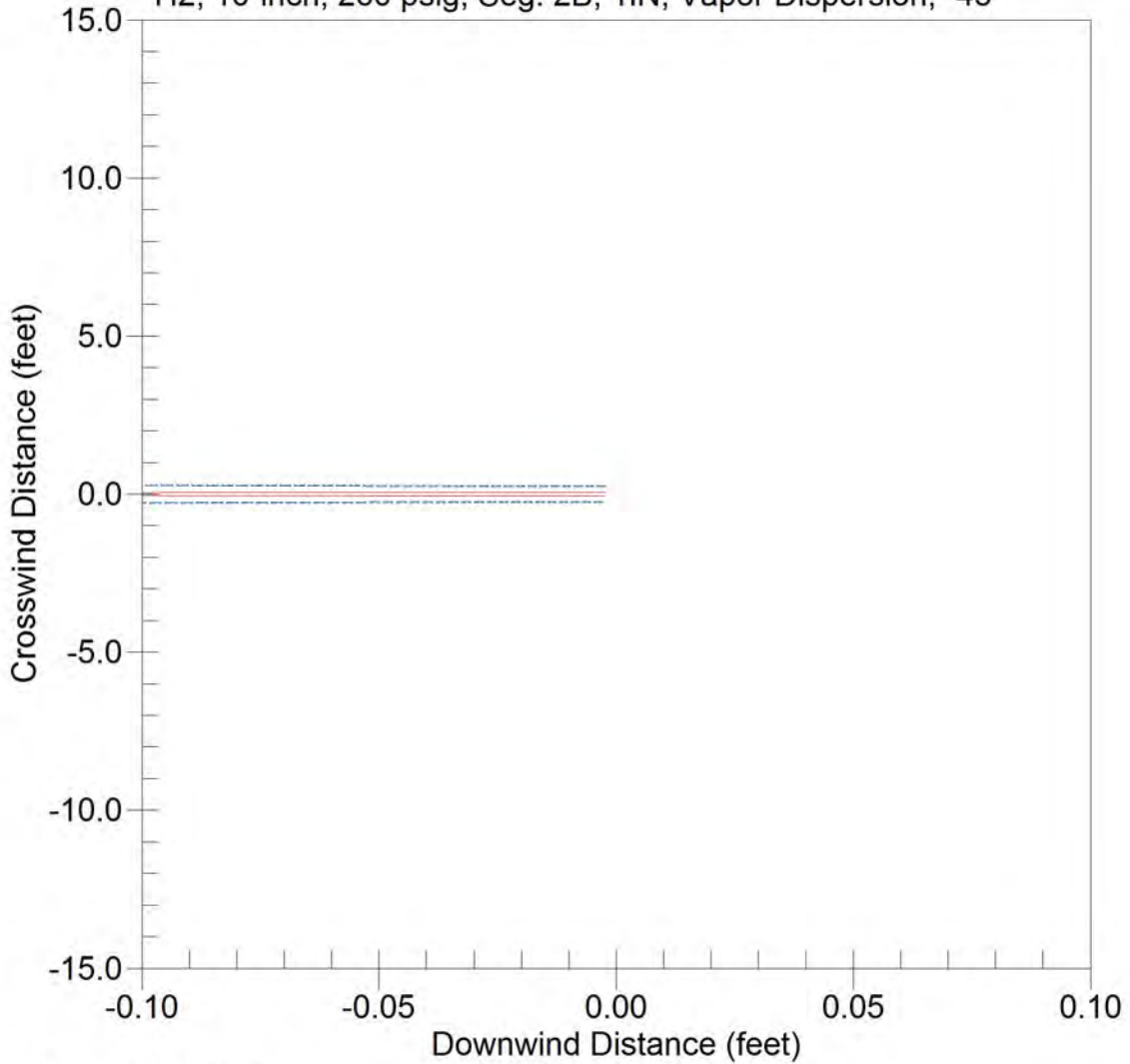


— Total
— Vapor

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casename=10D1IN260S2B-45_7MMSCFD
Mon Sep 2 15:30:35 2019

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

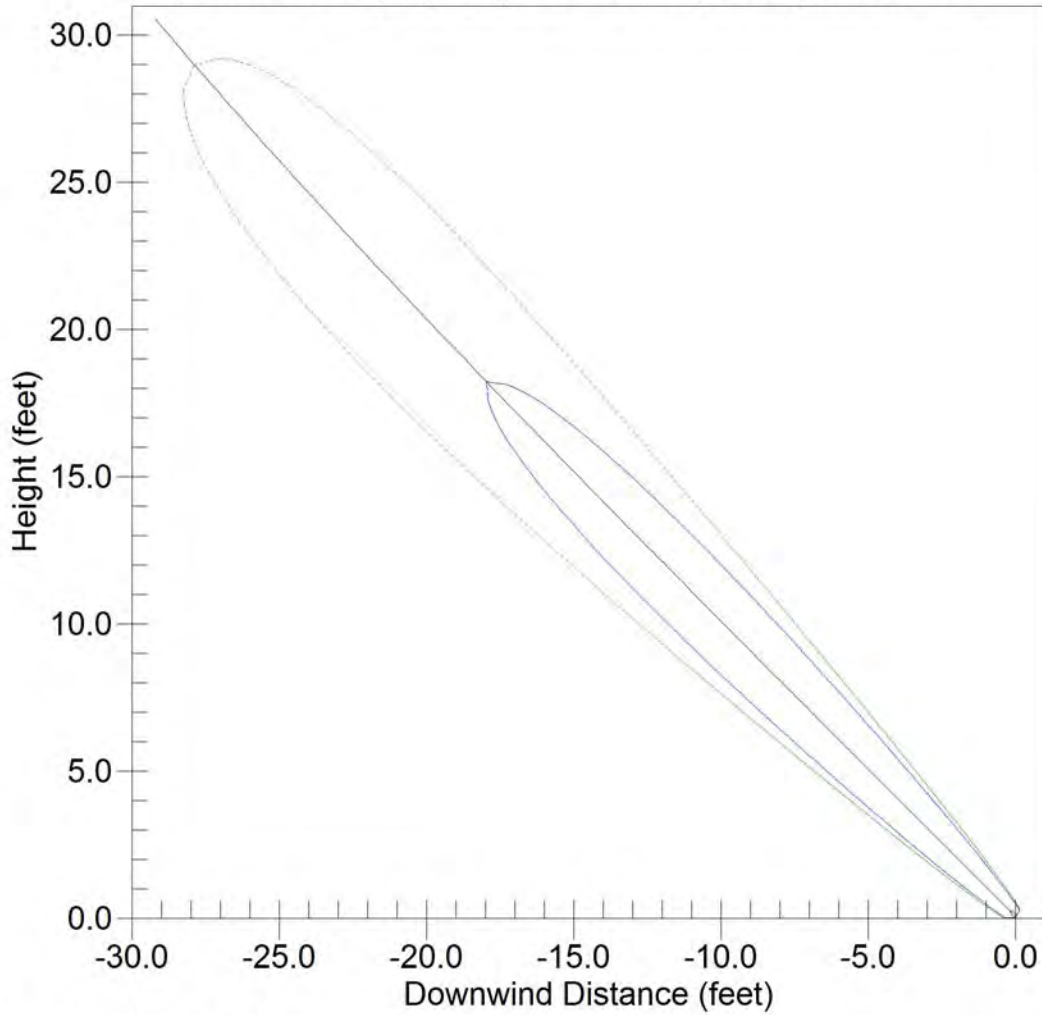


- 75.0 mole percent
- 4.00 mole percent
- 2.00 mole percent

casename=10D1IN260S2B-45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:30:35 2019

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°



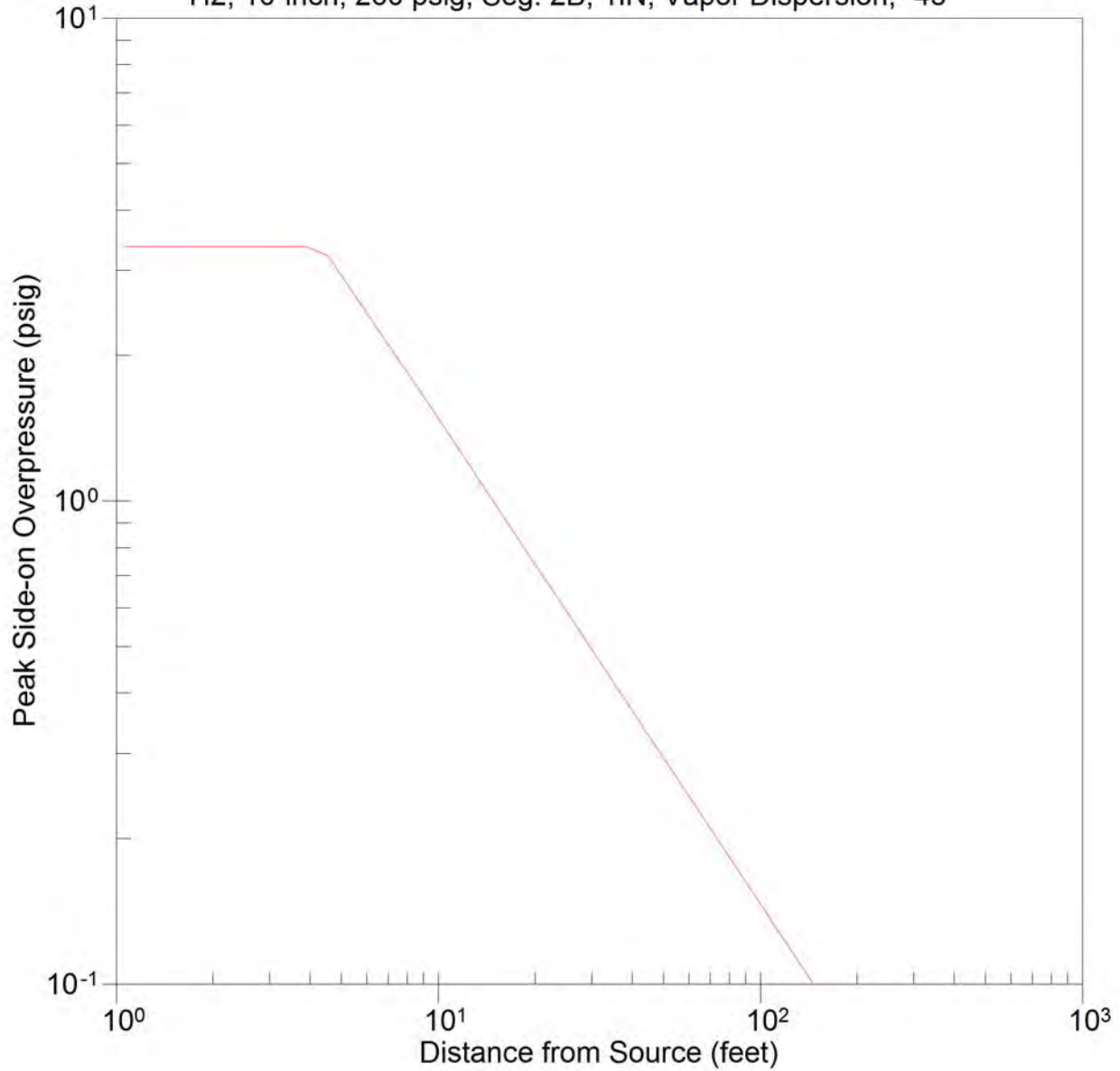
- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=10D1IN260S2B-45_7MMSCFD
windspeed = 4.5 mph
D stability
Mon Sep 2 15:30:35 2019

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 260 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°



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casename=10D1IN260S2B-45_7MMSCFD
Mon Sep 2 15:30:35 2019



Torch Fire Modeling Results, Segment 1

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|               Case Name - 8DTF260S1+45_7MMSCFD             |
|               Tue Jul 23 11:00:29 2019                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, Torch Fire, +45

```

Case Type       : Fire Radiation
Case Name      : 8DTF260S1+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES:

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Pseudo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) 0.0 feet
Elevation of target (from grade) 6.0 feet
Diameter of jet fire tip 0.6667 feet
Flow rate 1.16 lb/sec
Angle of release from horizontal 45.0 degrees

```

Fire radiation flux values

```

Radiation endpoint 1 12000 Btu/hr-sq.ft
Radiation endpoint 2 8000 Btu/hr-sq.ft
Radiation endpoint 3 5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 8DTF260S1+45_7MMSCFD
Tue Jul 23 11:00:29 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 8-inch, 260 psig, Seg. 1, Torch Fire, +45

```

Length of Flame      : 23.1 feet
Flame Tilt from Horizontal: 21.7 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	33843
7.2	5434
7.9	5310
8.6	3079
9.4	***
10.3	***
11.3	***
12.4	***
13.6	***
14.9	***
16.3	***
17.8	***
19.5	***
21.4	***
23.4	***
25.6	7242
28.1	4136
30.7	2644
33.7	1800
36.9	1277
40.4	932
44.2	694
48.4	526
53.0	404
58.1	313

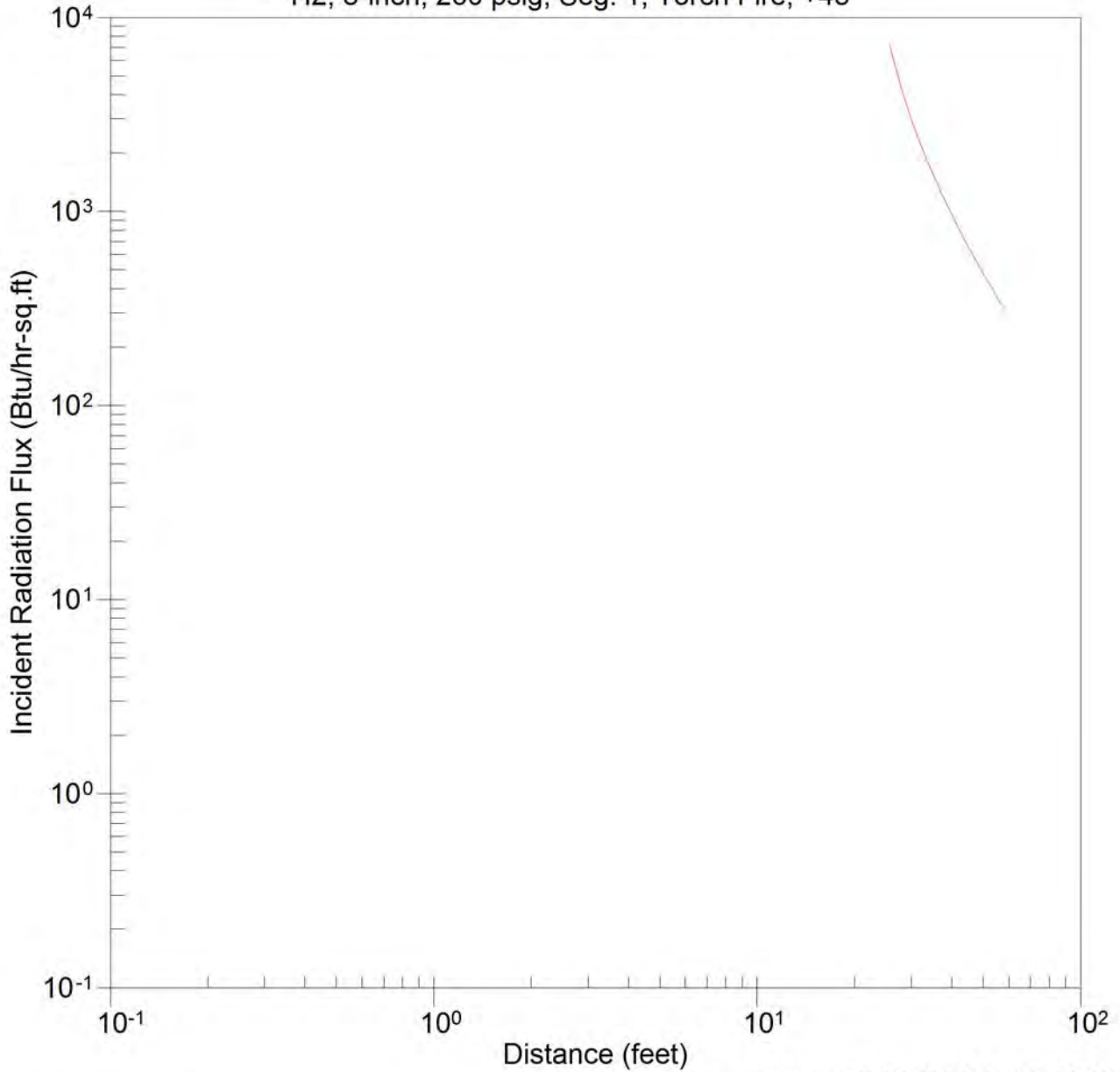
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
25.3	12000
25.4	8000
27.2	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 8-inch, 260 psig, Seg. 1, Torch Fire, +45



casename=8DTF260S1+45_7MMSCFD

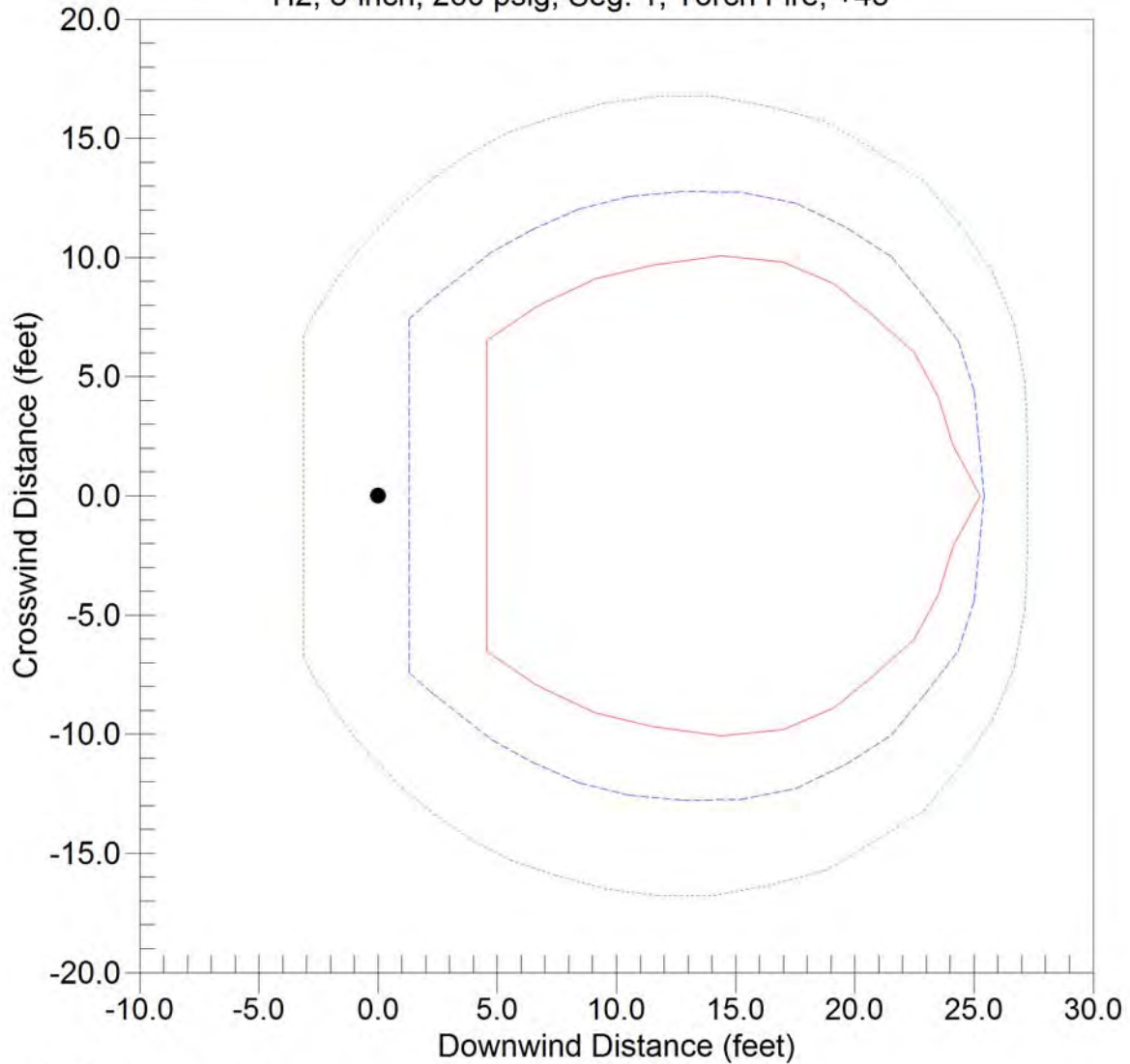
windspeed = 20.0 mph

Tue Jul 23 11:00:29 2019

CANARY by Quest

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 8-inch, 260 psig, Seg. 1, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=8DTF260S1+45_7MMSCFD

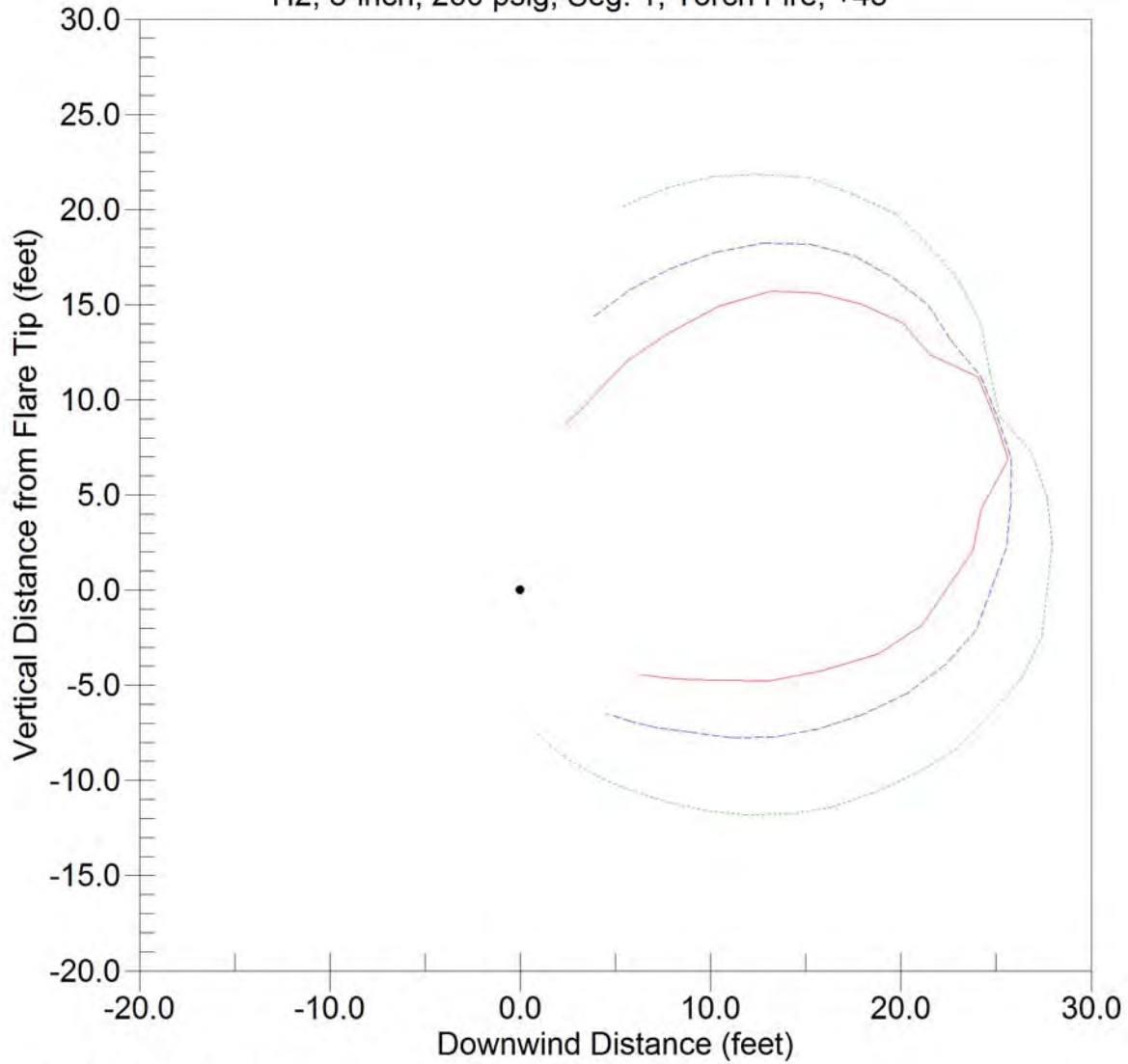
windspeed = 20.0 mph

Tue Jul 23 11:00:29 2019

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 8-inch, 260 psig, Seg. 1, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- ... 5000 Btu/hr-sq.ft

casename=8DTF260S1+45_7MMSCFD

windspeed = 20.0 mph

Tue Jul 23 11:00:29 2019

CANARY by Quest


```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|               Case Name - 8DTF260S1-45_7MMSCFD             |
|               Tue Jul 23 11:01:43 2019                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, Torch Fire, -45

```

Case Type       : Fire Radiation
Case Name      : 8DTF260S1-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES:

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)          6.0 feet
Diameter of jet fire tip                   0.6667 feet
Flow rate                                  1.16 lb/sec
Angle of release from horizontal           135.0 degrees

Fire radiation flux values
Radiation endpoint 1      12000 Btu/hr-sq.ft
Radiation endpoint 2      8000 Btu/hr-sq.ft
Radiation endpoint 3      5000 Btu/hr-sq.ft

```

NOTES:

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
|          Jet Fire Radiation Model                |
|          Case Name - 8DTF260S1-45_7MMSCFD       |
|          Tue Jul 23 11:01:43 2019               |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
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|          telephone (405) 329-7475                |
|          fax (405) 329-7734                      |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, Torch Fire, -45

```

Length of Flame      : 23.1 feet
Flame Tilt from Horizontal: 28.9 degrees
Release Angle       : 135.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	***
7.2	***
7.9	***
8.7	***
9.6	***
10.5	***
11.5	***
12.7	***
13.9	***
15.3	***
16.8	***
18.4	***
20.3	28316
22.3	16242
24.5	9065
26.9	5453
29.5	3517
32.4	2390
35.6	1684
39.1	1222
43.0	905
47.2	681
51.9	519
57.0	399
62.6	310

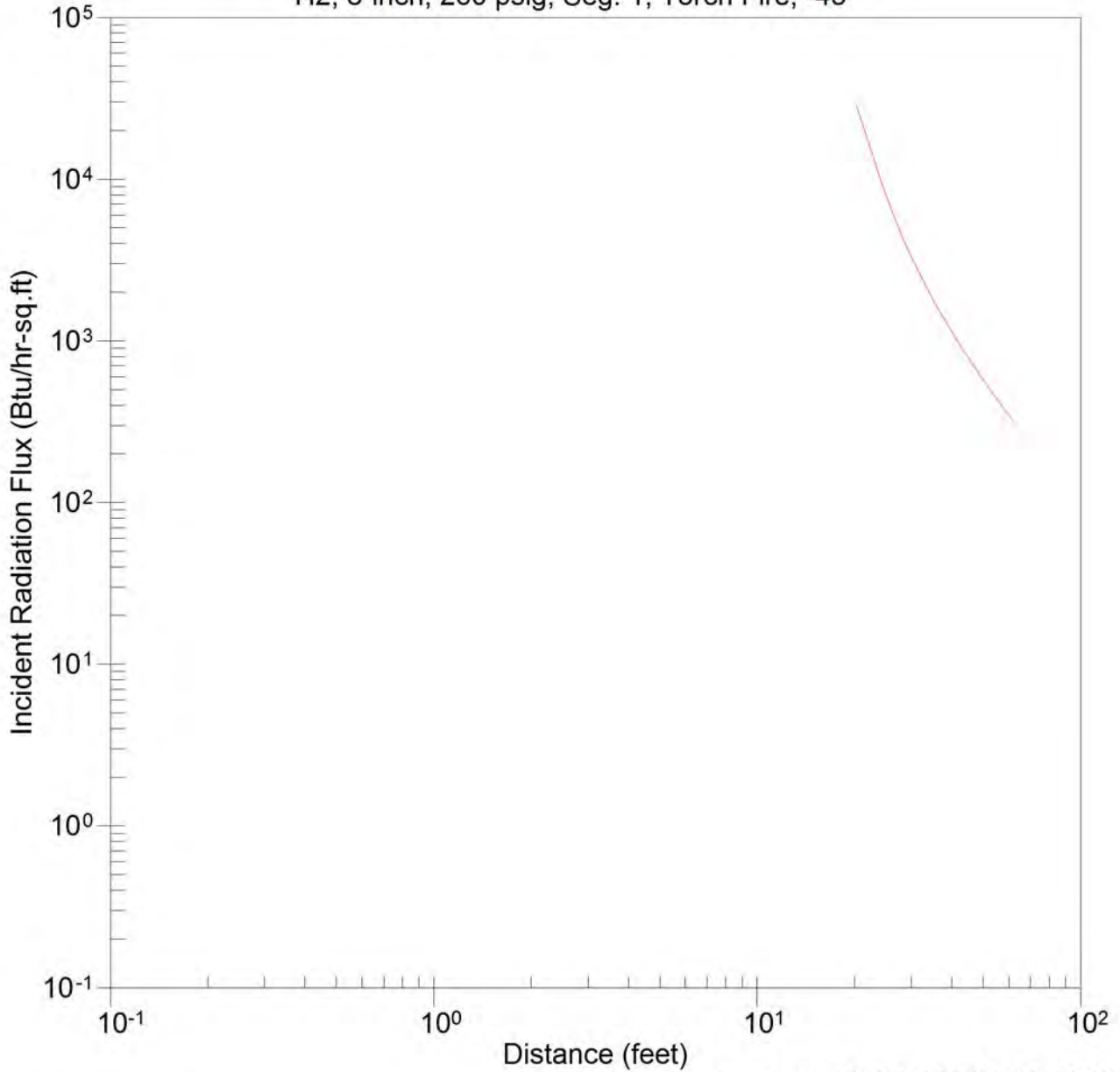
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
23.4	12000
25.1	8000
27.4	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 8-inch, 260 psig, Seg. 1, Torch Fire, -45



casename=8DTF260S1-45_7MMSCFD

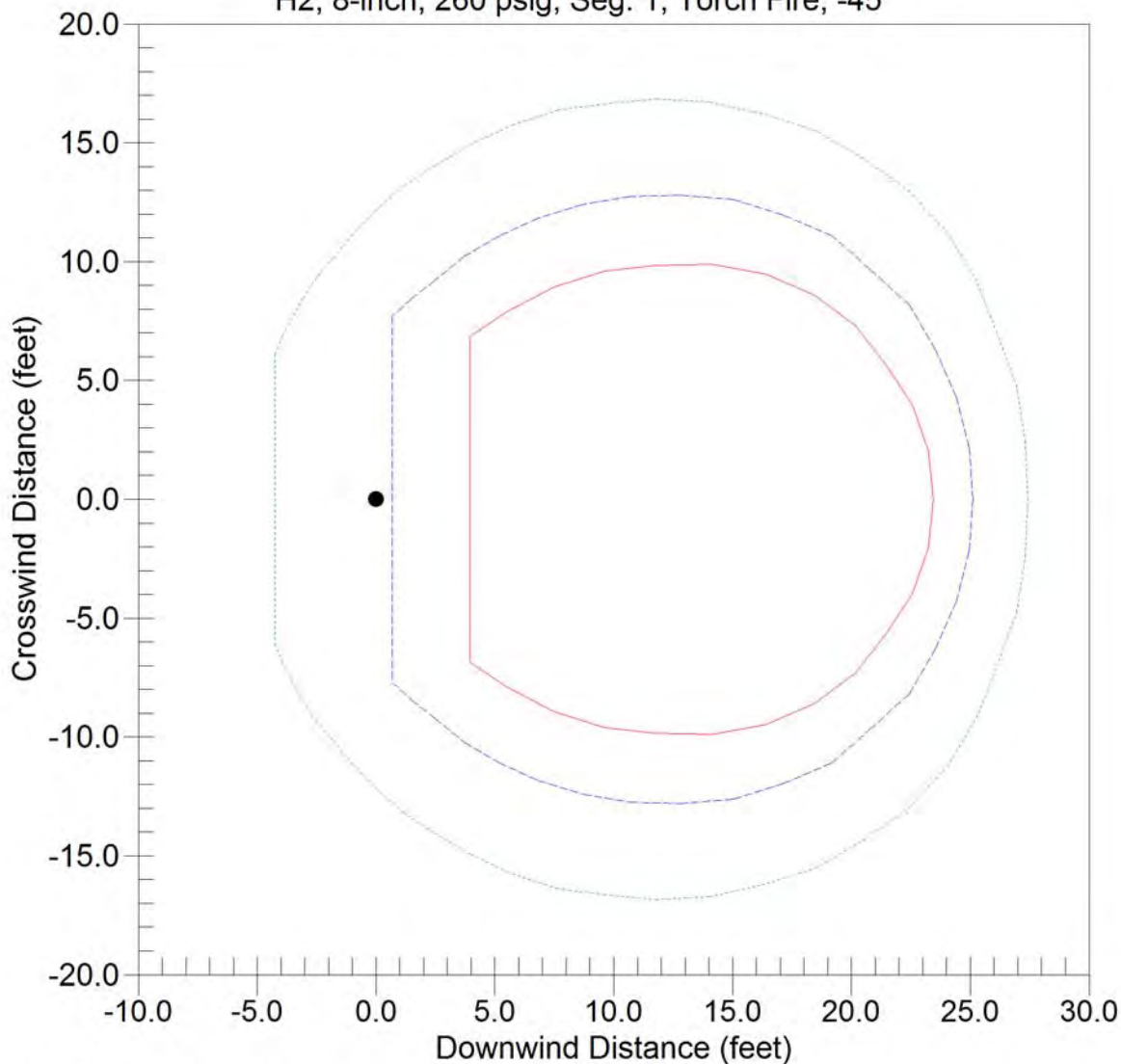
windspeed = 20.0 mph

Tue Jul 23 11:01:43 2019

CANARY by Quest

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 8-inch, 260 psig, Seg. 1, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=8DTF260S1-45_7MMSCFD

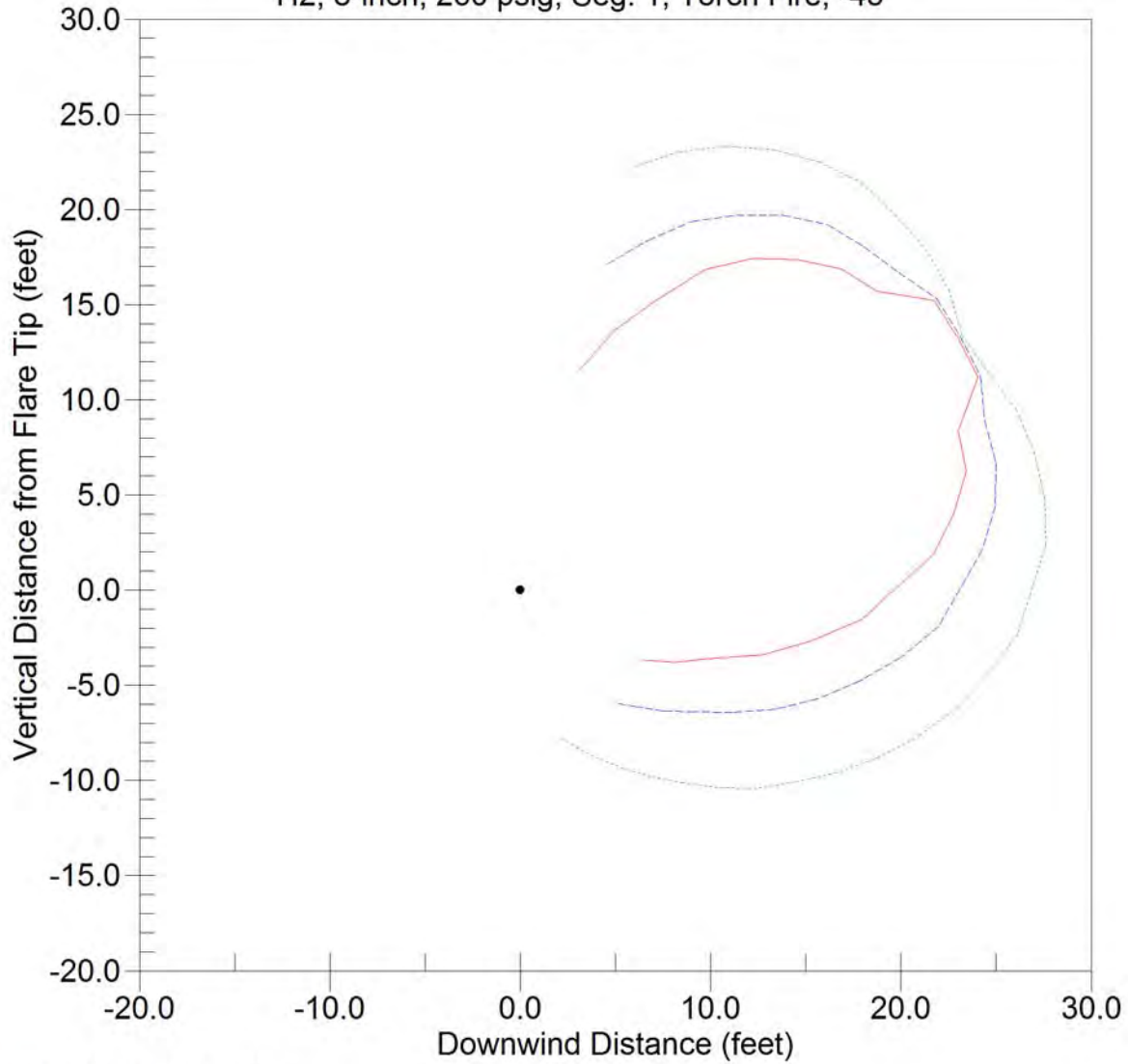
windspeed = 20.0 mph

Tue Jul 23 11:01:43 2019

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 8-inch, 260 psig, Seg. 1, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=8DTF260S1-45_7MMSCFD

windspeed = 20.0 mph

Tue Jul 23 11:01:43 2019

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 8D1INTF260S1+45_7MMSCFD             |
|           Tue Jul 23 10:52:50 2019                         |
|   Quest Consultants Inc., Norman, Oklahoma, USA           |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734        |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Torch Fire, +45

```

Case Type           : Fire Radiation
Case Name           : 8D1INTF260S1+45_7MMSCFD
User ID             : BLPayne
Project Number      : Job 2134
Type of Units       : English Units

```

NOTES:

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature       : 70.00 °F
Pressure          : 260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                20.00 mph
Relative humidity         70 %
Air temperature           72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)          6.0 feet
Diameter of jet fire tip                   0.0833 feet
Flow rate                                  0.72 lb/sec
Angle of release from horizontal           45.0 degrees

Fire radiation flux values
Radiation endpoint 1      12000 Btu/hr-sq.ft
Radiation endpoint 2      8000 Btu/hr-sq.ft
Radiation endpoint 3      5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 8D1INTF260S1+45_7MMSCFD
Tue Jul 23 10:52:50 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Torch Fire, +45

```

Length of Flame      : 24.3 feet
Flame Tilt from Horizontal: 41.5 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	***
7.1	***
7.8	***
8.5	***
9.2	***
10.1	***
10.9	26381
11.9	26381
13.0	19455
14.1	9684
15.4	9326
16.8	10177
18.3	8734
19.9	6638
21.7	4945
23.6	3680
25.7	2733
28.0	2030
30.5	1515
33.2	1139
36.1	866
39.4	664
42.9	514
46.7	401
50.9	315

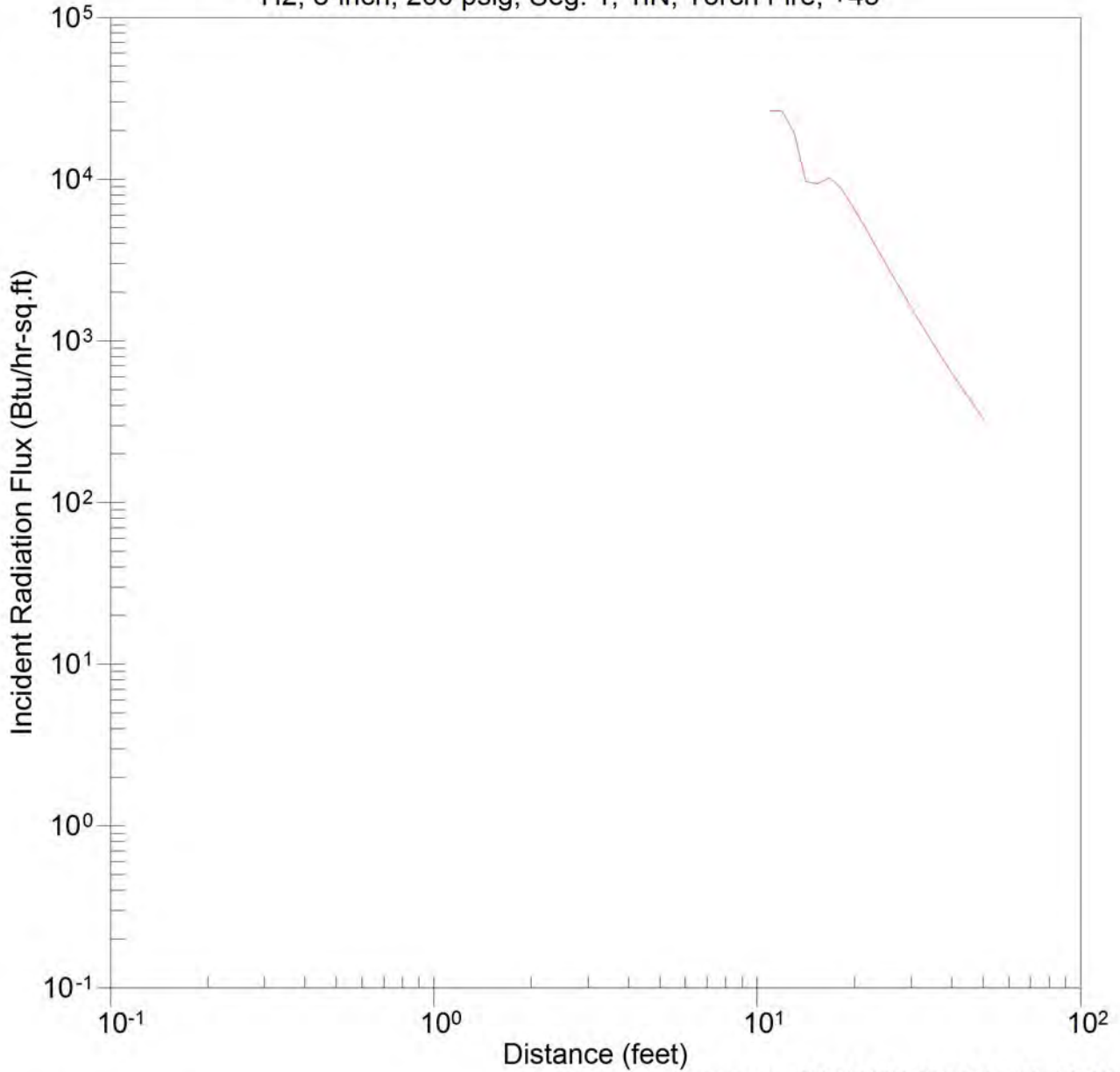
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
13.8	12000
18.8	8000
21.5	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 8-inch, 260 psig, Seg. 1, 1IN, Torch Fire, +45



CANARY by Quest

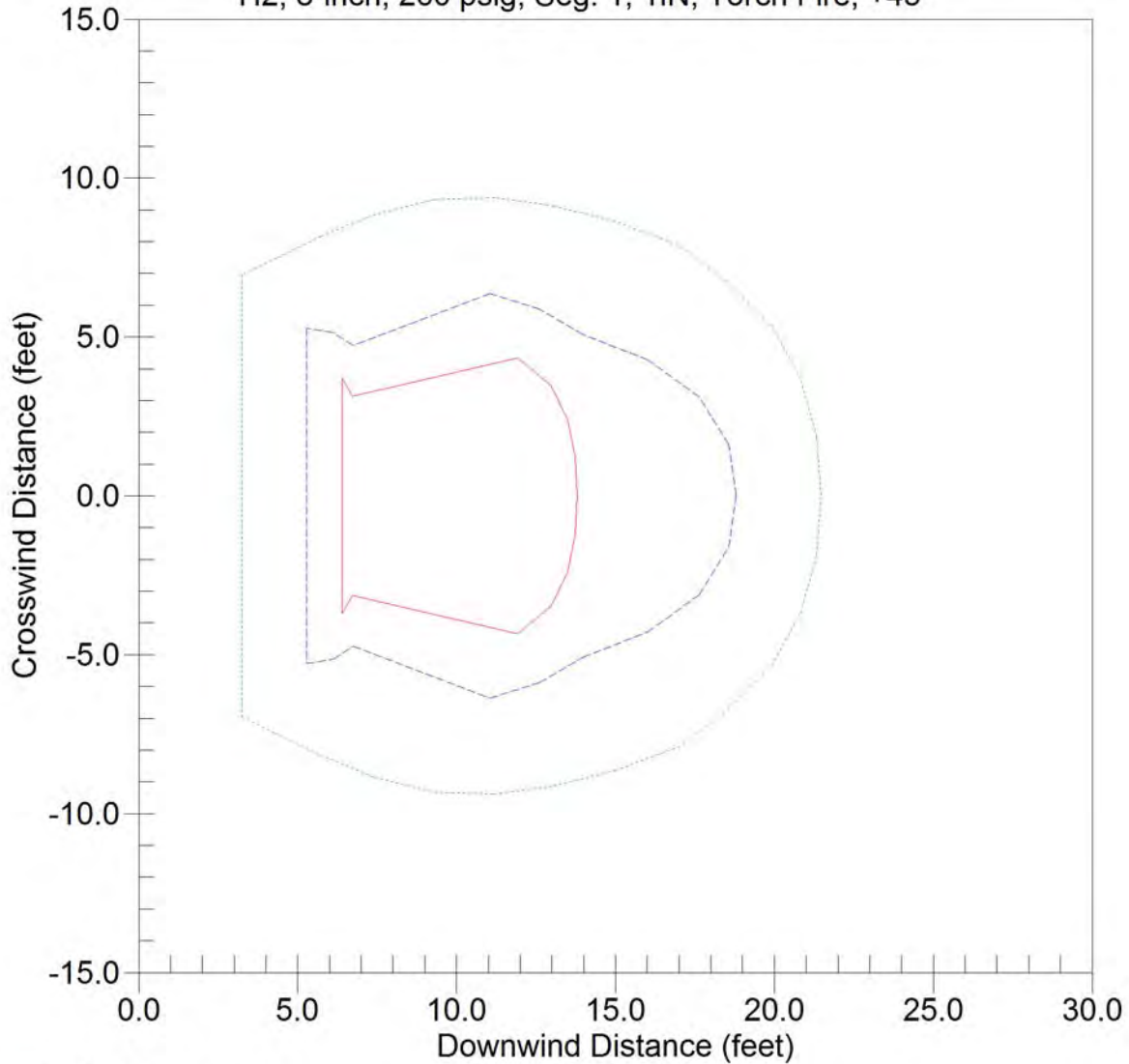
casename=8D1INTF260S1+45_7MMSCFD

windspeed = 20.0 mph

Tue Jul 23 10:52:50 2019

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 8-inch, 260 psig, Seg. 1, 1IN, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- ... 5000 Btu/hr-sq.ft

casename=8D1INTF260S1+45_7MMSCFD

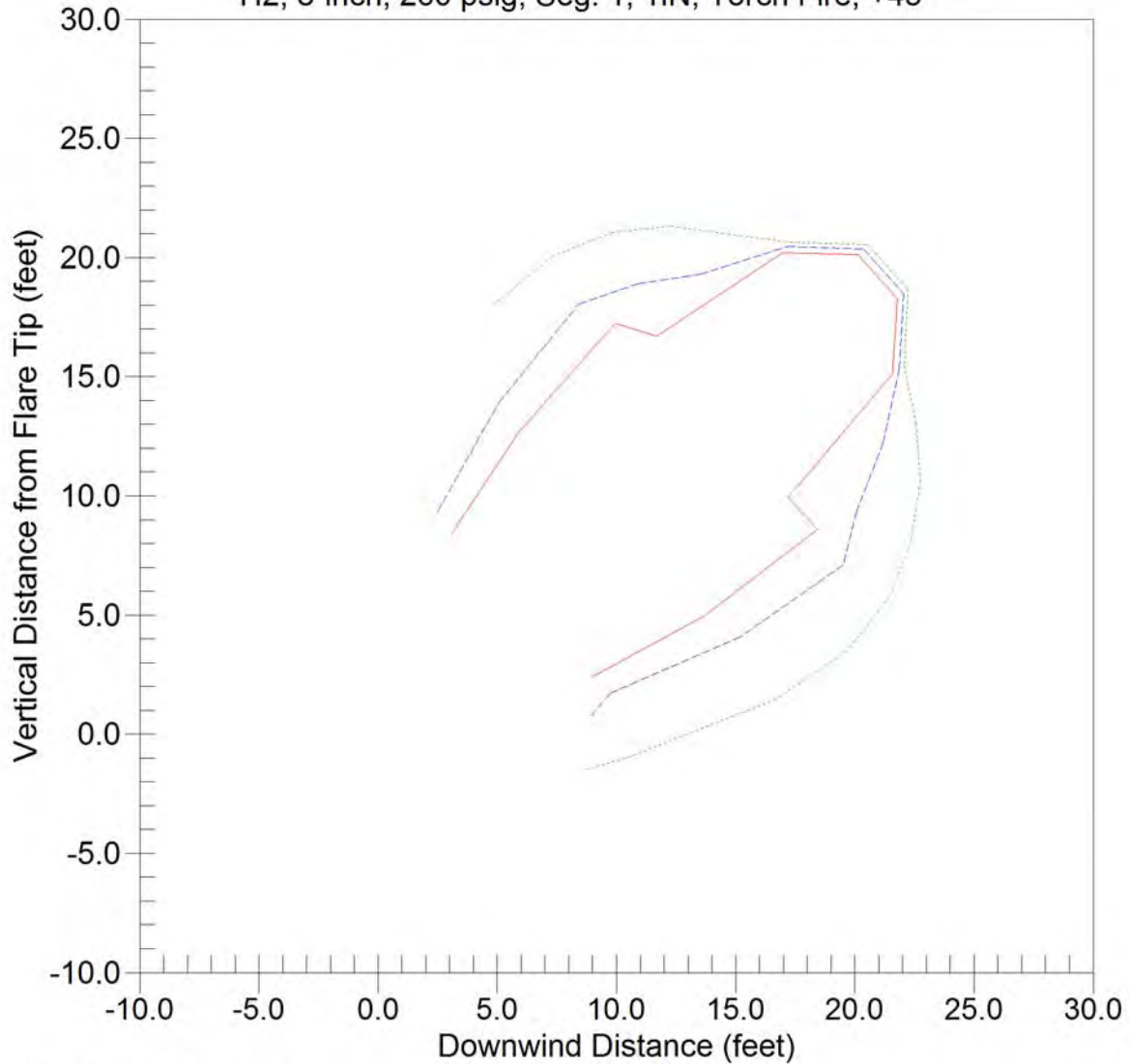
windspeed = 20.0 mph

Tue Jul 23 10:52:50 2019

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 8-inch, 260 psig, Seg. 1, 1IN, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=8D1INTF260S1+45_7MMSCFD

windspeed = 20.0 mph

Tue Jul 23 10:52:50 2019

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 8D1INTF260S1-45_7MMSCFD             |
|           Tue Jul 23 10:53:51 2019                         |
|           Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734         |
+-----+

```

Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Torch Fire, -45

```

Case Type           : Fire Radiation
Case Name           : 8D1INTF260S1-45_7MMSCFD
User ID             : BLPayne
Project Number      : Job 2134
Type of Units       : English Units

```

NOTES:

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Pseudo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature       : 70.00 °F
Pressure          : 260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                20.00 mph
Relative humidity         70 %
Air temperature           72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)          6.0 feet
Diameter of jet fire tip                   0.0833 feet
Flow rate                                  0.72 lb/sec
Angle of release from horizontal           135.0 degrees

Fire radiation flux values
Radiation endpoint 1      12000 Btu/hr-sq.ft
Radiation endpoint 2      8000 Btu/hr-sq.ft
Radiation endpoint 3      5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 8D1INTF260S1-45_7MMSCFD
Tue Jul 23 10:53:51 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 8-inch, 260 psig, Seg. 1, 1IN, Torch Fire, -45

```

Length of Flame      : 24.3 feet
Flame Tilt from Horizontal: 126.2 degrees
Release Angle       : 135.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	2544
7.0	2382
7.5	2226
8.1	2074
8.6	1931
9.2	1794
9.9	1664
10.6	1539
11.3	1422
12.1	1310
13.0	1206
13.9	1108
14.9	1017
15.9	931
17.0	851
18.2	776
19.5	707
20.9	642
22.4	582
24.0	527
25.7	476
27.5	429
29.4	386
31.5	347
33.7	311

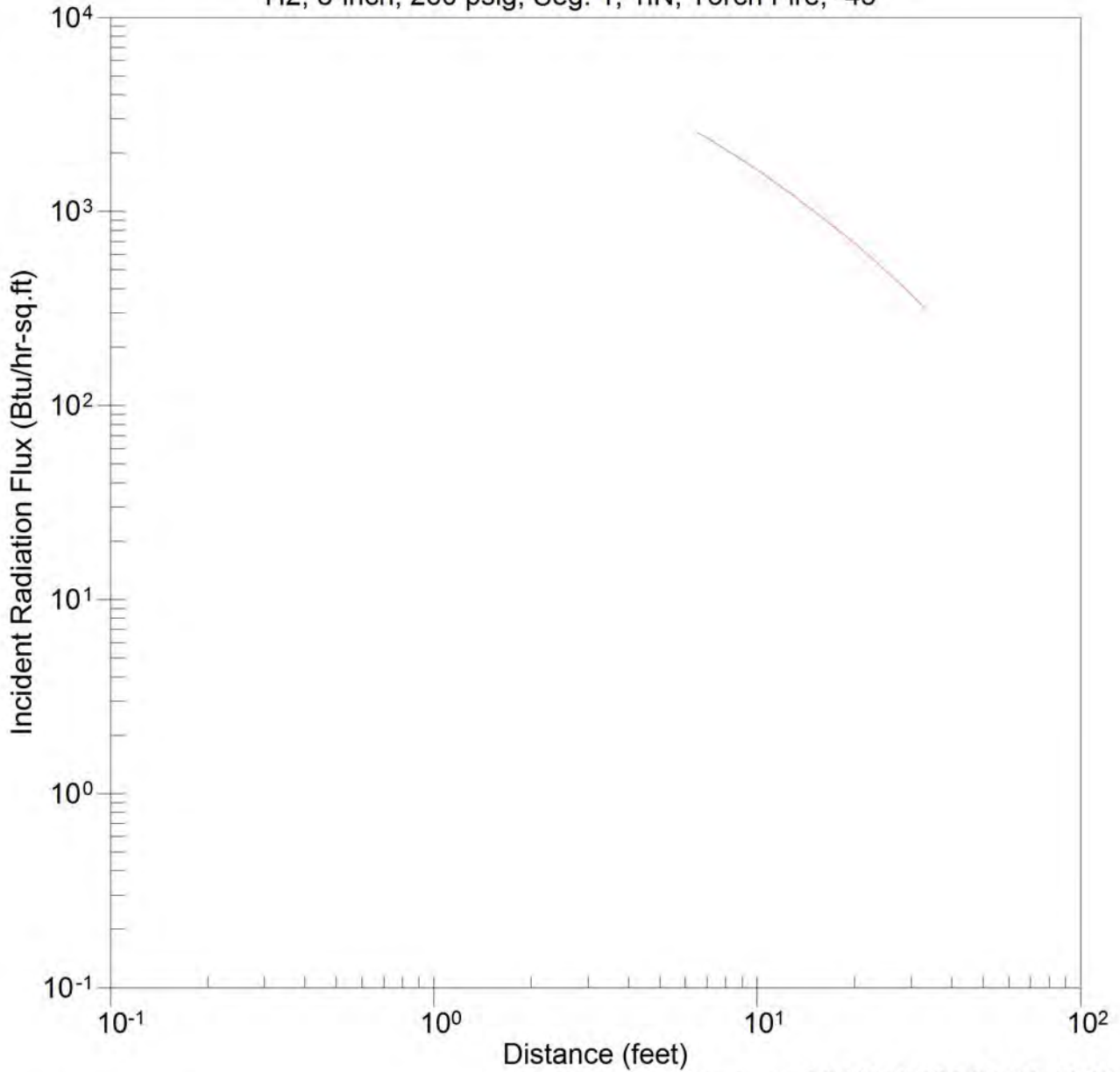
Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
**	12000
**	8000
**	5000

** Endpoint does not exist at this elevation

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 8-inch, 260 psig, Seg. 1, 1IN, Torch Fire, -45



CANARY by Quest

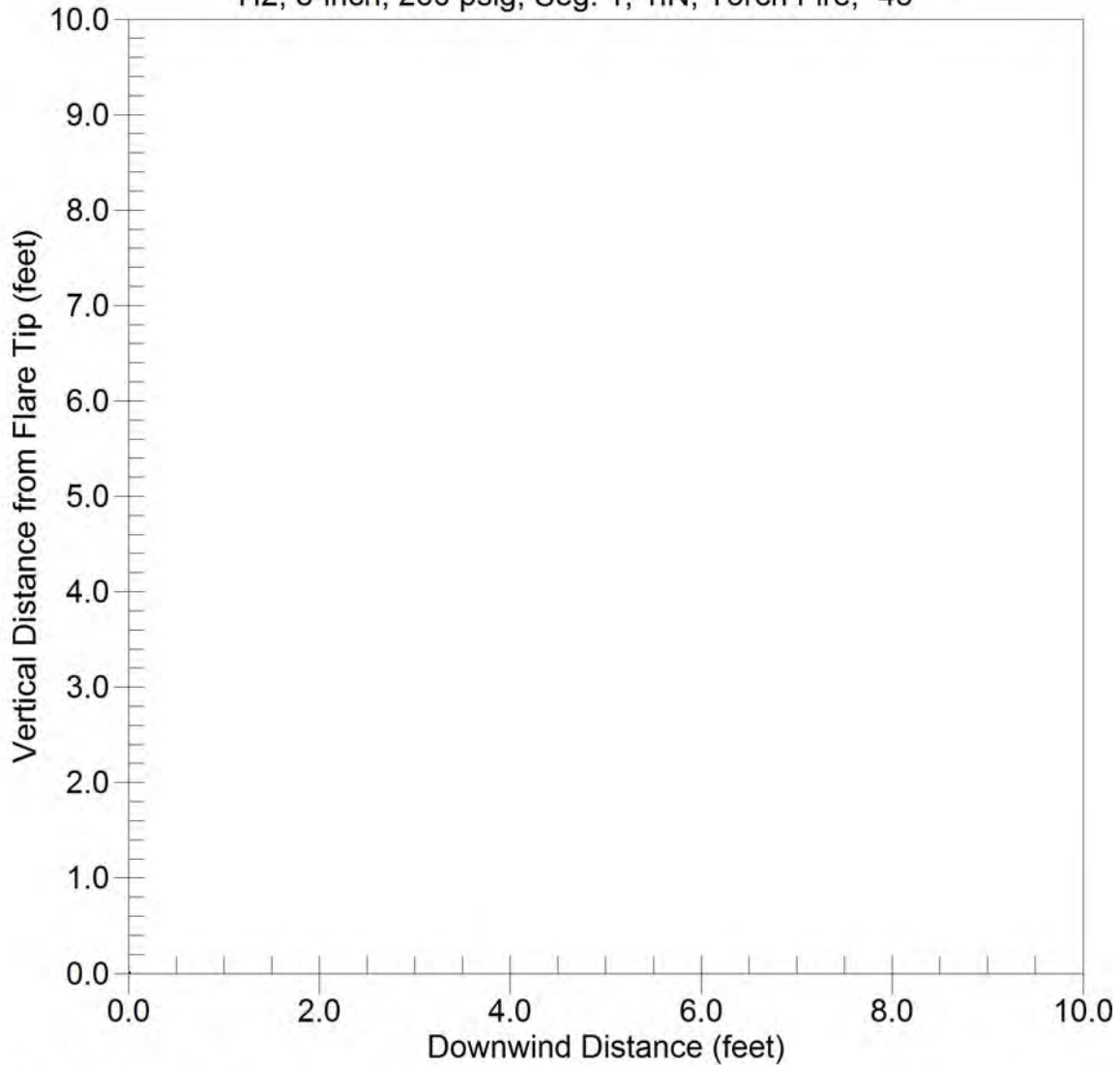
casename=8D1INTF260S1-45_7MMSCFD

windspeed = 20.0 mph

Tue Jul 23 10:53:51 2019

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 8-inch, 260 psig, Seg. 1, 1IN, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=8D1INTF260S1-45_7MMSCFD

windspeed = 20.0 mph

Tue Jul 23 10:53:51 2019

CANARY by Quest



Torch Fire Modeling Results, Segment 2A

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D8INTF260S2A+45_7MMSCFD           |
|           Sun Sep  8 17:58:50 2019                         |
|   Quest Consultants Inc., Norman, Oklahoma, USA            |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475      fax (405) 329-7734         |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Torch Fire, +45

```

Case Type       : Fire Radiation
Case Name      : 10D8INTF260S2A+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A - 8-inch Release

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                20.00 mph
Relative humidity         70 %
Air temperature           72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)          6.0 feet
Diameter of jet fire tip                   0.6667 feet
Flow rate                                  7.84 lb/sec
Angle of release from horizontal           45.0 degrees

Fire radiation flux values
Radiation endpoint 1      12000 Btu/hr-sq.ft
Radiation endpoint 2      8000 Btu/hr-sq.ft
Radiation endpoint 3      5000 Btu/hr-sq.ft

```

NOTES:


```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 10D8INTF260S2A+45_7MMSCFD
Sun Sep  8 17:58:50 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Torch Fire, +45

```

Length of Flame      : 59.5 feet
Flame Tilt from Horizontal: 32.5 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
13.1	***
14.5	***
16.1	***
17.8	***
19.6	35793
21.7	30531
24.0	26923
26.6	24048
29.4	21655
32.5	19628
36.0	17726
39.8	15806
44.0	13658
48.7	11226
53.9	8689
59.6	6351
65.9	4460
72.9	3079
80.7	2130
89.2	1491
98.7	1059
109.2	765
120.8	560
133.6	415
147.8	311

*** Target Location inside Flame

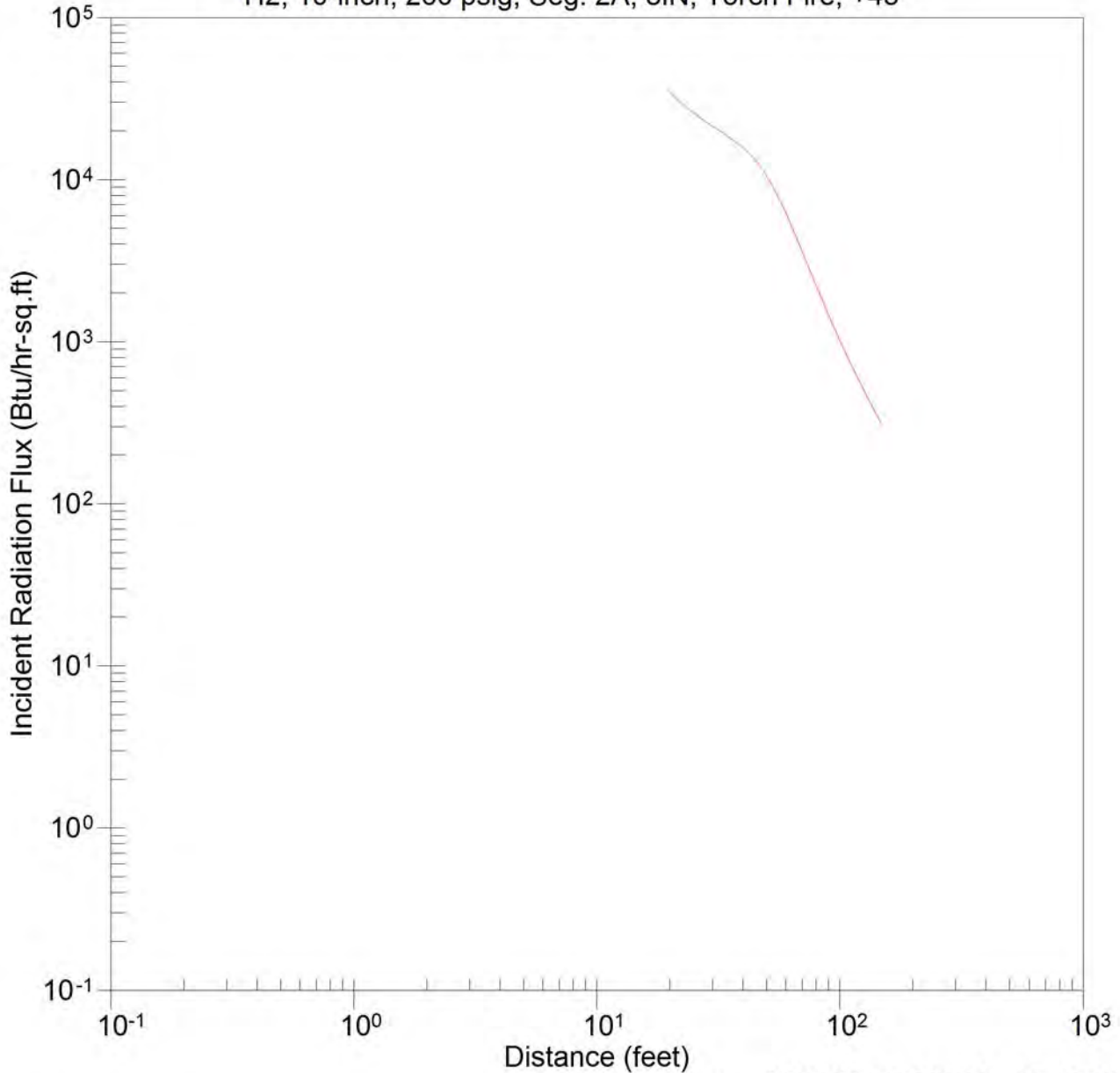
Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
46.9	12000
55.4	8000
63.7	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point

H2, 10-inch, 260 psig, Seg. 2A, 8IN, Torch Fire, +45



casename=10D8INTF260S2A+45_7MMSCFD

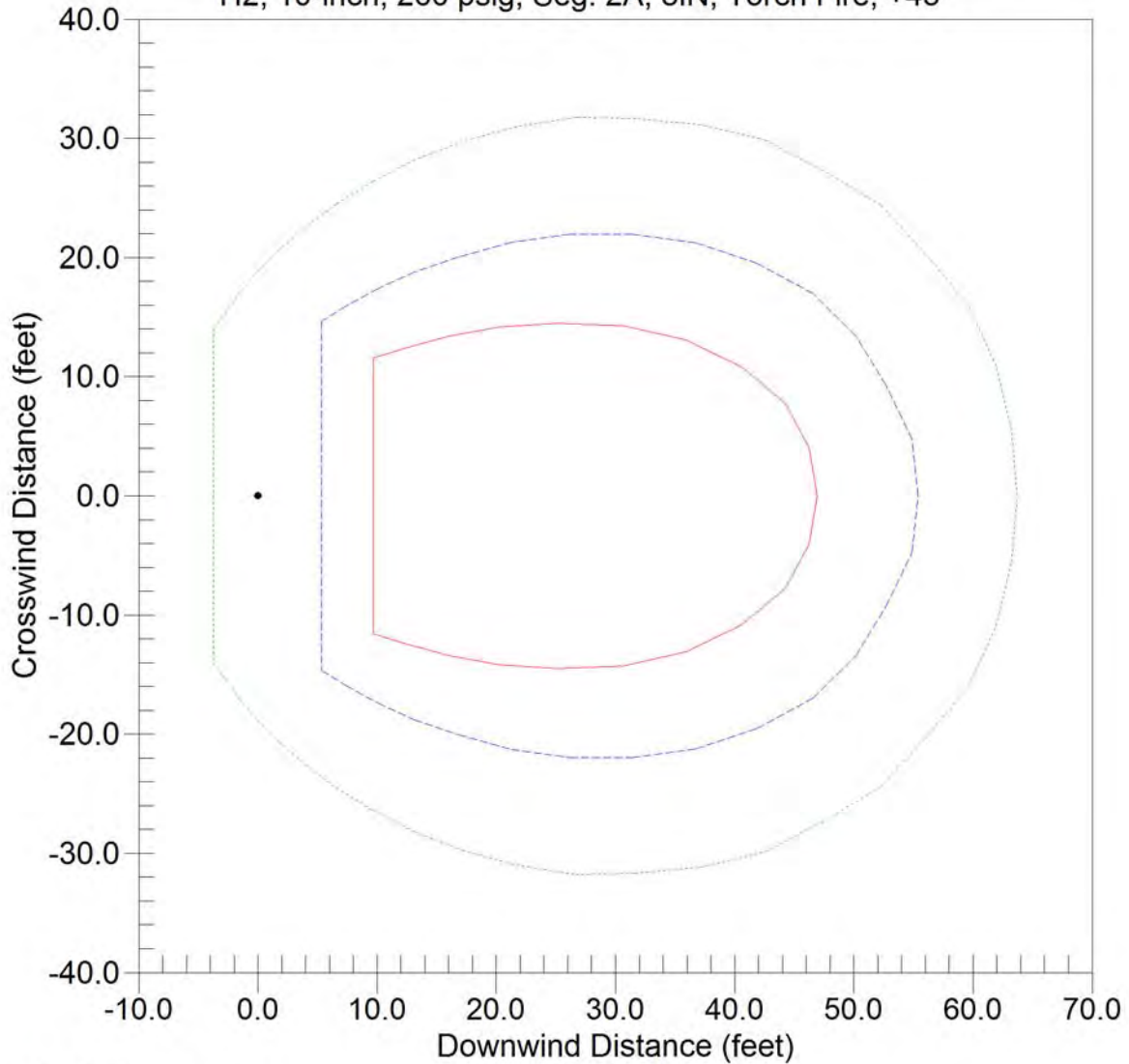
windspeed = 20.0 mph

Sun Sep 8 17:58:50 2019

CANARY by Quest

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 10-inch, 260 psig, Seg. 2A, 8IN, Torch Fire, +45



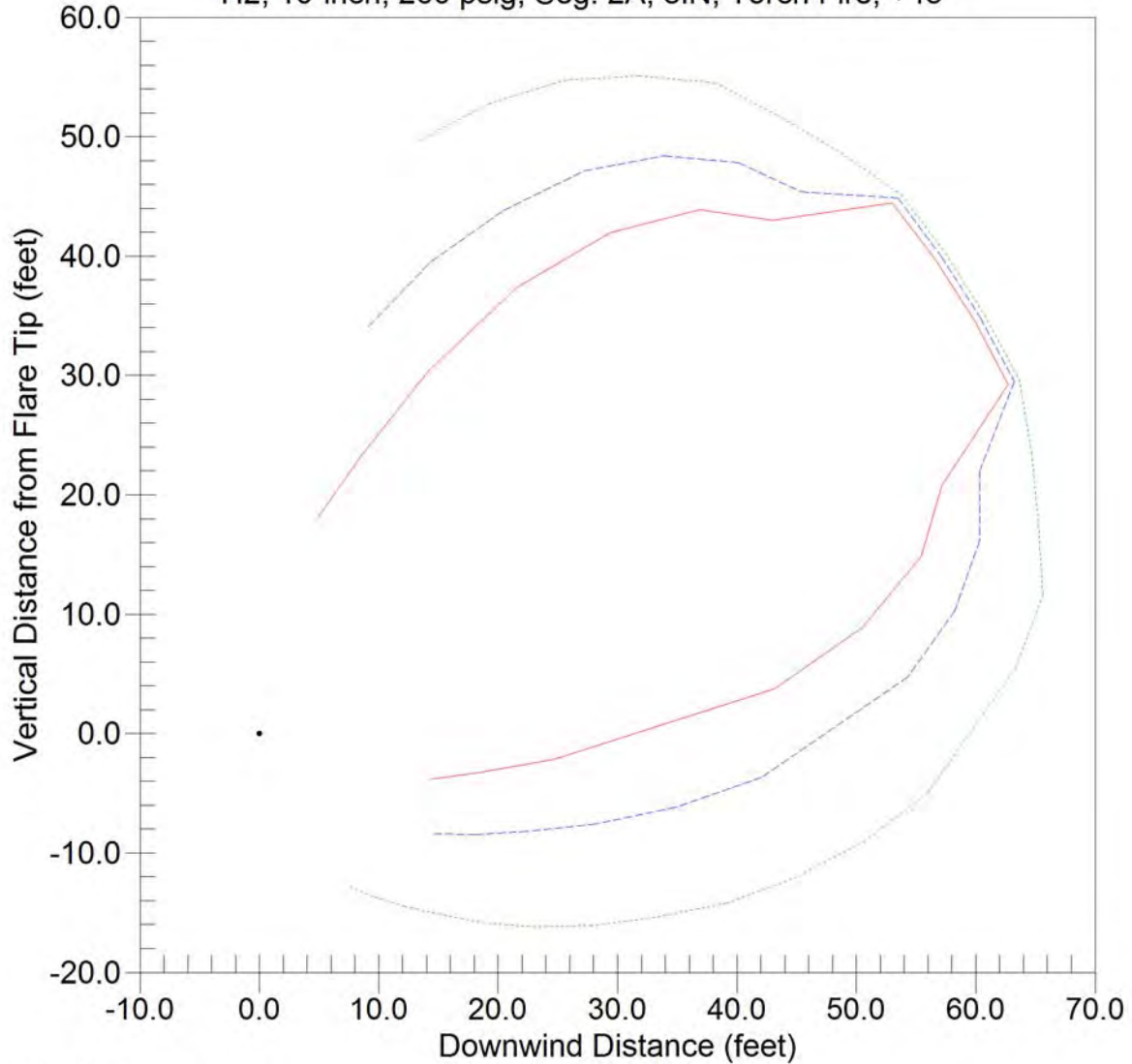
- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=10D8INTF260S2A+45_7MMSCFD
windspeed = 20.0 mph
Sun Sep 8 17:58:50 2019

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 260 psig, Seg. 2A, 8IN, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=10D8INTF260S2A+45_7MMSCFD
windspeed = 20.0 mph
Sun Sep 8 17:58:50 2019

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D8INTF260S2A-45_7MMSCFD           |
|           Sun Sep  8 17:59:24 2019                         |
|   Quest Consultants Inc., Norman, Oklahoma, USA            |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734        |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Torch Fire, -45

```

Case Type       : Fire Radiation
Case Name       : 10D8INTF260S2A-45_7MMSCFD
User ID        : BLPayne
Project Number  : Job 2134
Type of Units   : English Units

```

NOTES: Segment 2A - 8-inch Release

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed              20.00 mph
Relative humidity       70 %
Air temperature         72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)          6.0 feet
Diameter of jet fire tip                   0.6667 feet
Flow rate                                  7.84 lb/sec
Angle of release from horizontal           135.0 degrees

Fire radiation flux values
Radiation endpoint 1      12000 Btu/hr-sq.ft
Radiation endpoint 2      8000 Btu/hr-sq.ft
Radiation endpoint 3      5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 10D8INTF260S2A-45_7MMSCFD
Sun Sep  8 17:59:24 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 8IN, Torch Fire, -45

```

Length of Flame      : 59.5 feet
Flame Tilt from Horizontal: 79.0 degrees
Release Angle       : 135.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
13.1	11059
14.5	10033
16.1	9109
17.8	8271
19.7	7503
21.8	6798
24.1	6146
26.7	5536
29.5	4960
32.7	4416
36.1	3903
40.0	3421
44.3	2973
49.0	2561
54.2	2186
60.0	1849
66.4	1552
73.4	1293
81.3	1070
89.9	880
99.5	720
110.1	587
121.9	477
134.9	387
149.2	313

*** Target Location inside Flame

Downwind Distances to Endpoints

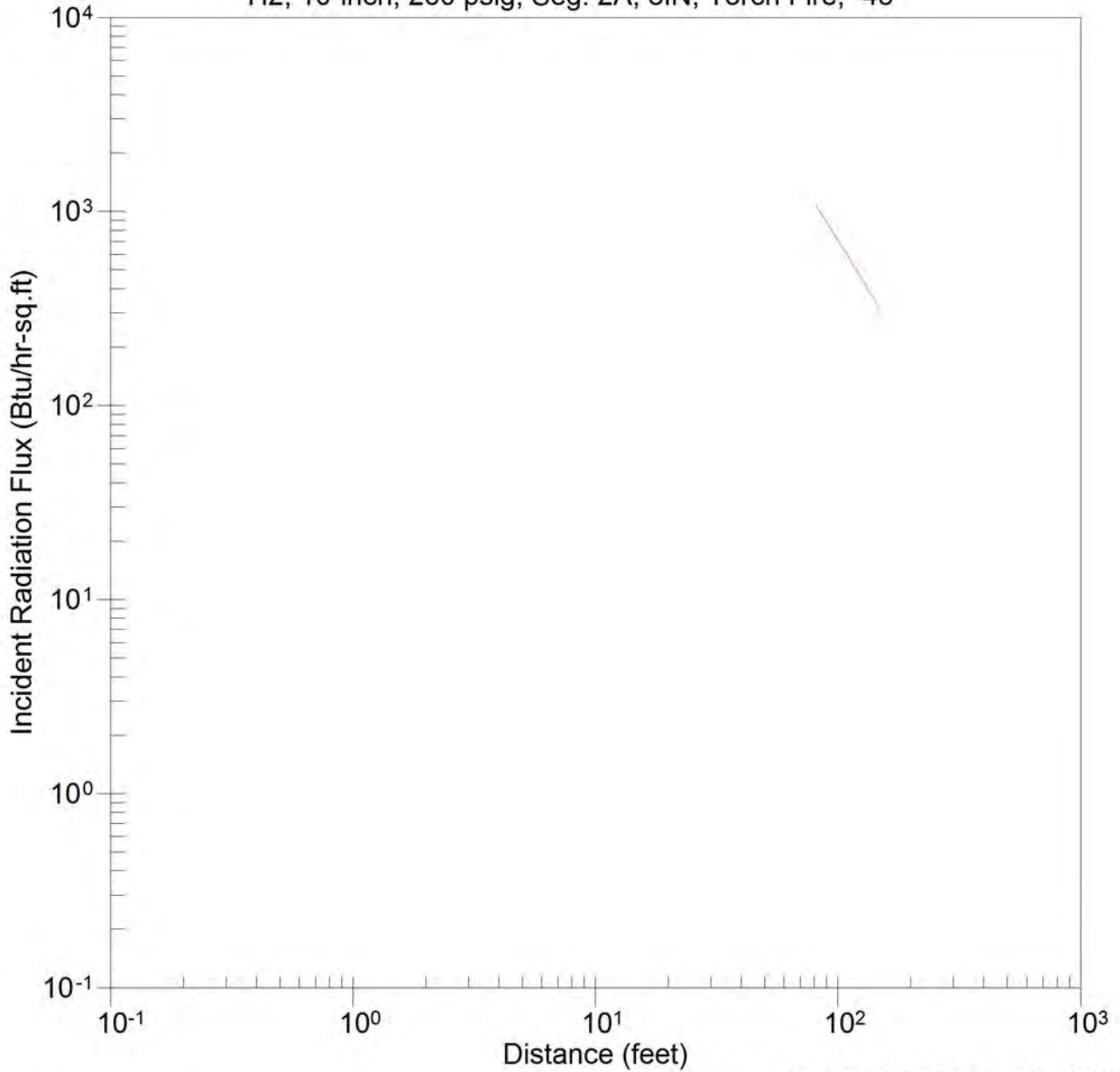
Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
**	12000
18.4	8000
29.1	5000

** Endpoint does not exist at this elevation

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point

H2, 10-inch, 260 psig, Seg. 2A, 8IN, Torch Fire, -45



CANARY by Quest

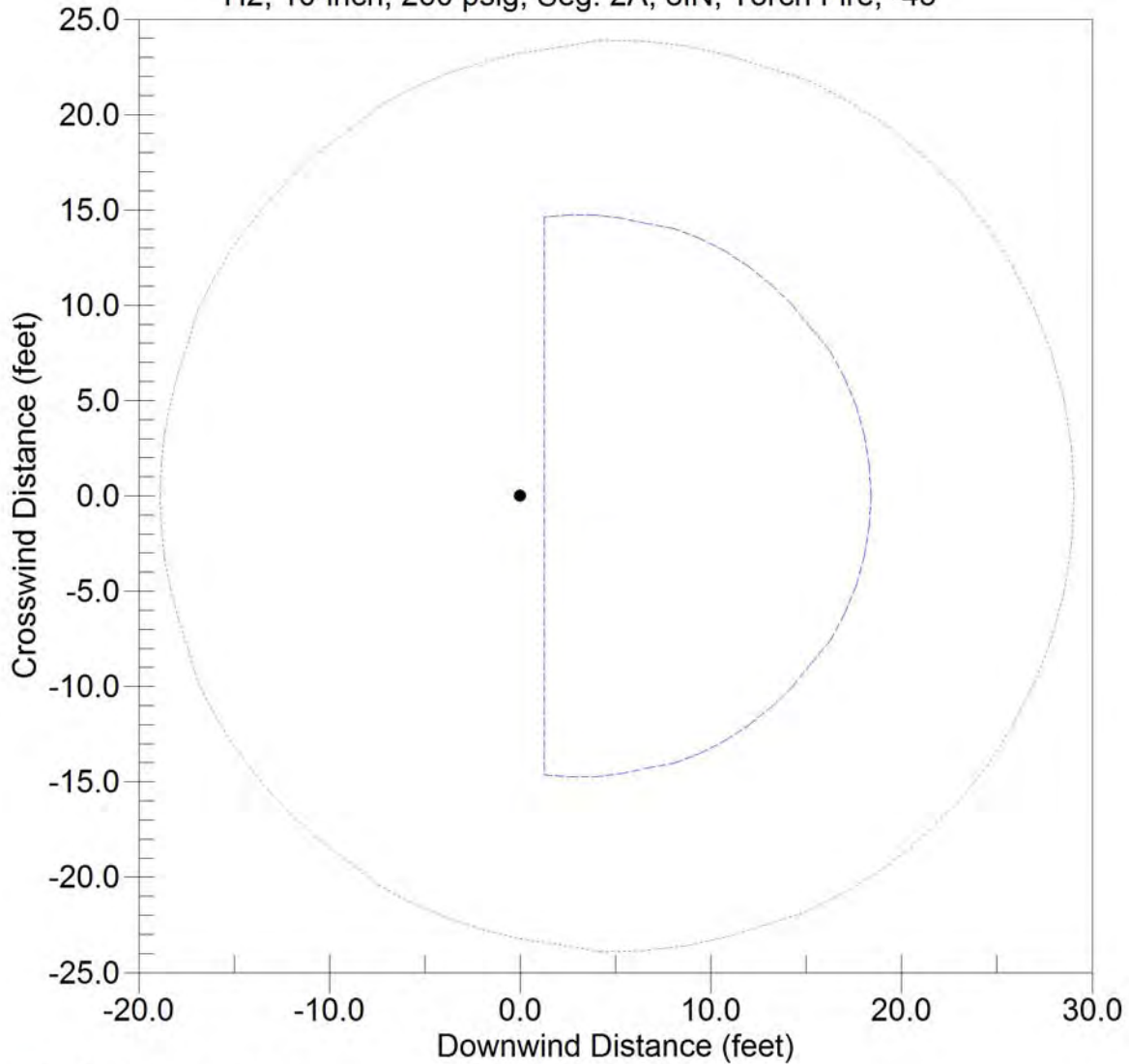
casename=10D8INTF260S2A-45_7MMSCFD

windspeed = 20.0 mph

Sun Sep 8 17:59:24 2019

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 10-inch, 260 psig, Seg. 2A, 8IN, Torch Fire, -45



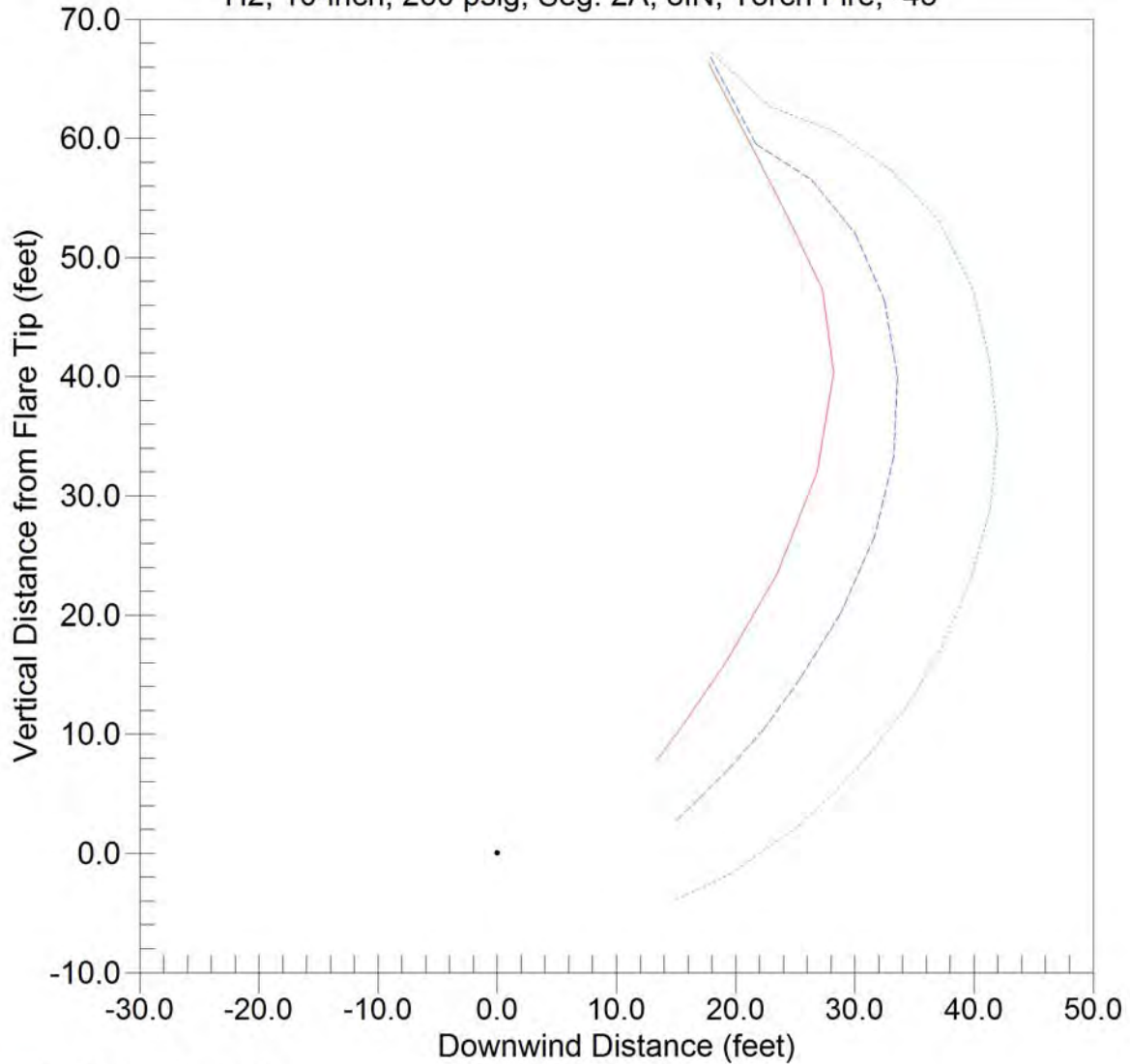
- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=10D8INTF260S2A-45_7MMSCFD
windspeed = 20.0 mph
Sun Sep 8 17:59:24 2019

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 260 psig, Seg. 2A, 8IN, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=10D8INTF260S2A-45_7MMSCFD
windspeed = 20.0 mph
Sun Sep 8 17:59:24 2019

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D1INTF260S2A+45_7MMSCFD           |
|           Mon Sep  2 16:23:58 2019                         |
|           Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734         |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Torch Fire, +45

```

Case Type       : Fire Radiation
Case Name      : 10D1INTF260S2A+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) 0.0 feet
Elevation of target (from grade) 6.0 feet
Diameter of jet fire tip 0.0833 feet
Flow rate 0.91 lb/sec
Angle of release from horizontal 45.0 degrees

Fire radiation flux values
Radiation endpoint 1 12000 Btu/hr-sq.ft
Radiation endpoint 2 8000 Btu/hr-sq.ft
Radiation endpoint 3 5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 10D1INTF260S2A+45_7MMSCFD
Mon Sep  2 16:23:58 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Torch Fire, +45

```

Length of Flame      : 26.2 feet
Flame Tilt from Horizontal: 42.2 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	***
7.2	***
7.9	***
8.6	***
9.4	***
10.3	1345
11.3	13615
12.3	28338
13.5	24297
14.8	13174
16.2	9160
17.7	9576
19.4	8604
21.2	6794
23.2	5124
25.4	3817
27.8	2827
30.4	2090
33.3	1550
36.4	1158
39.8	872
43.6	663
47.7	509
52.2	393
57.1	306

*** Target Location inside Flame

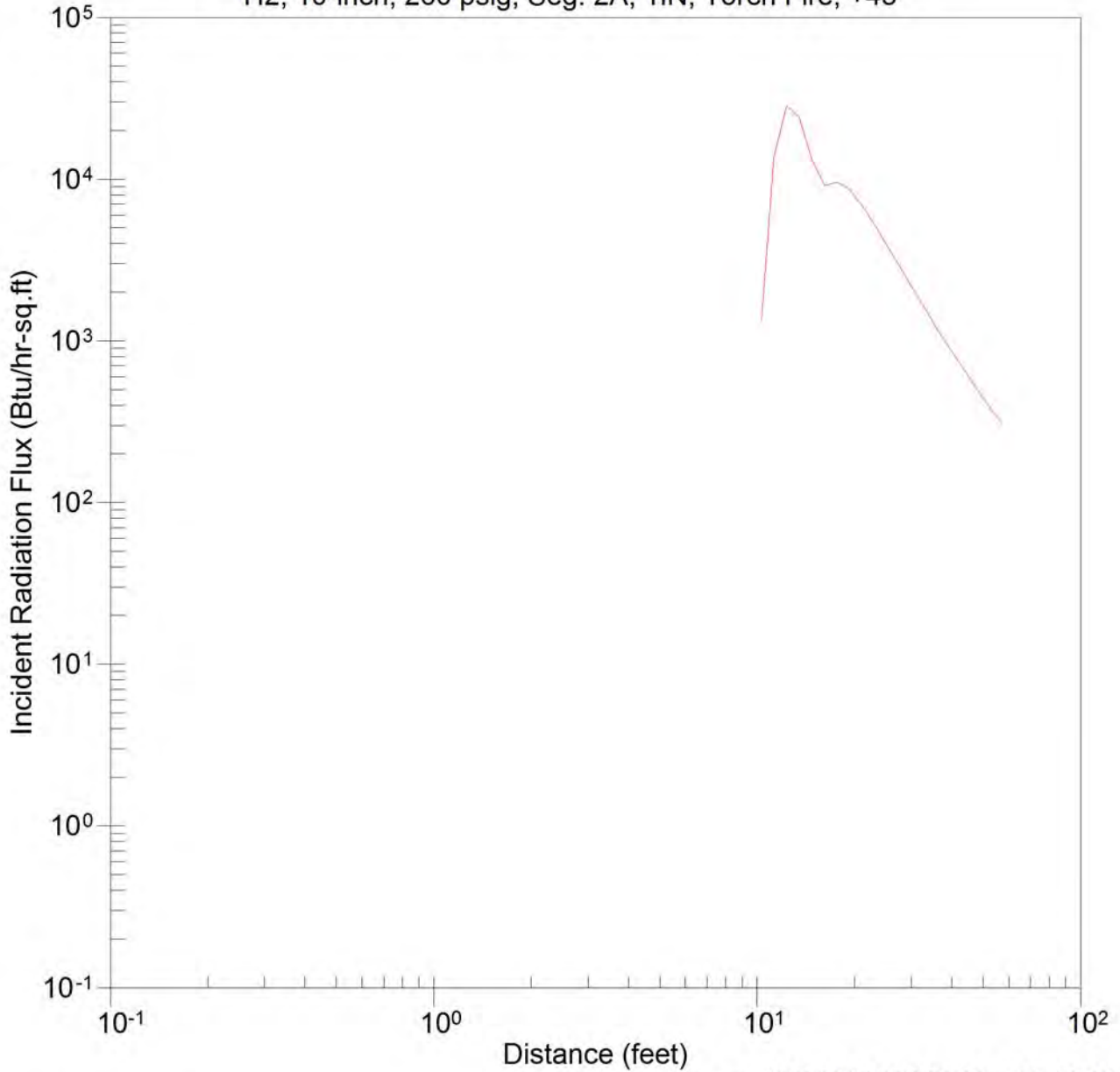
Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
15.1	12000
19.9	8000
23.4	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point

H2, 10-inch, 260 psig, Seg. 2A, 1IN, Torch Fire, +45



casename=10D1INTF260S2A+45_7MMSCFD

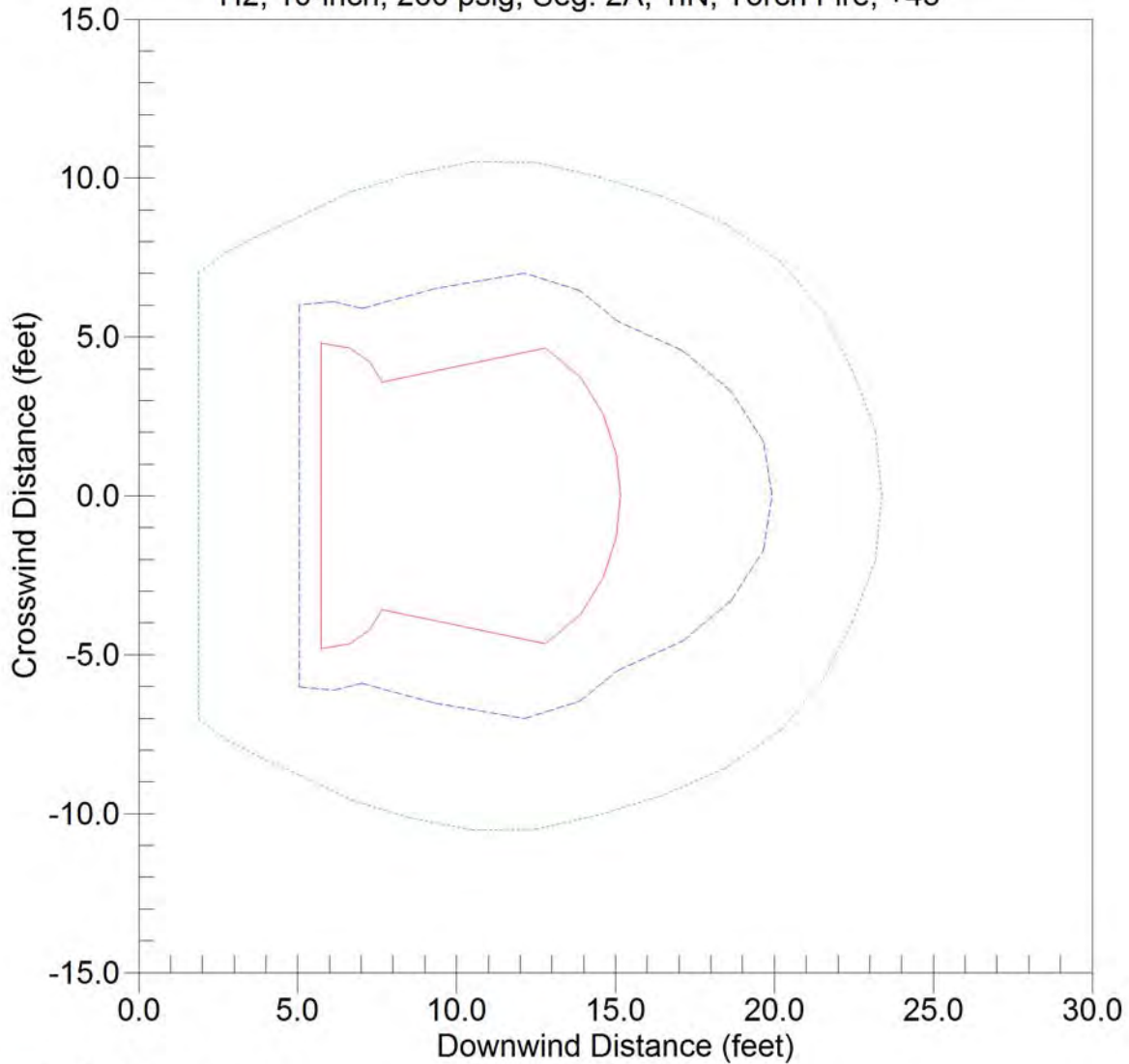
windspeed = 20.0 mph

Mon Sep 2 16:23:58 2019

CANARY by Quest

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 10-inch, 260 psig, Seg. 2A, 1IN, Torch Fire, +45



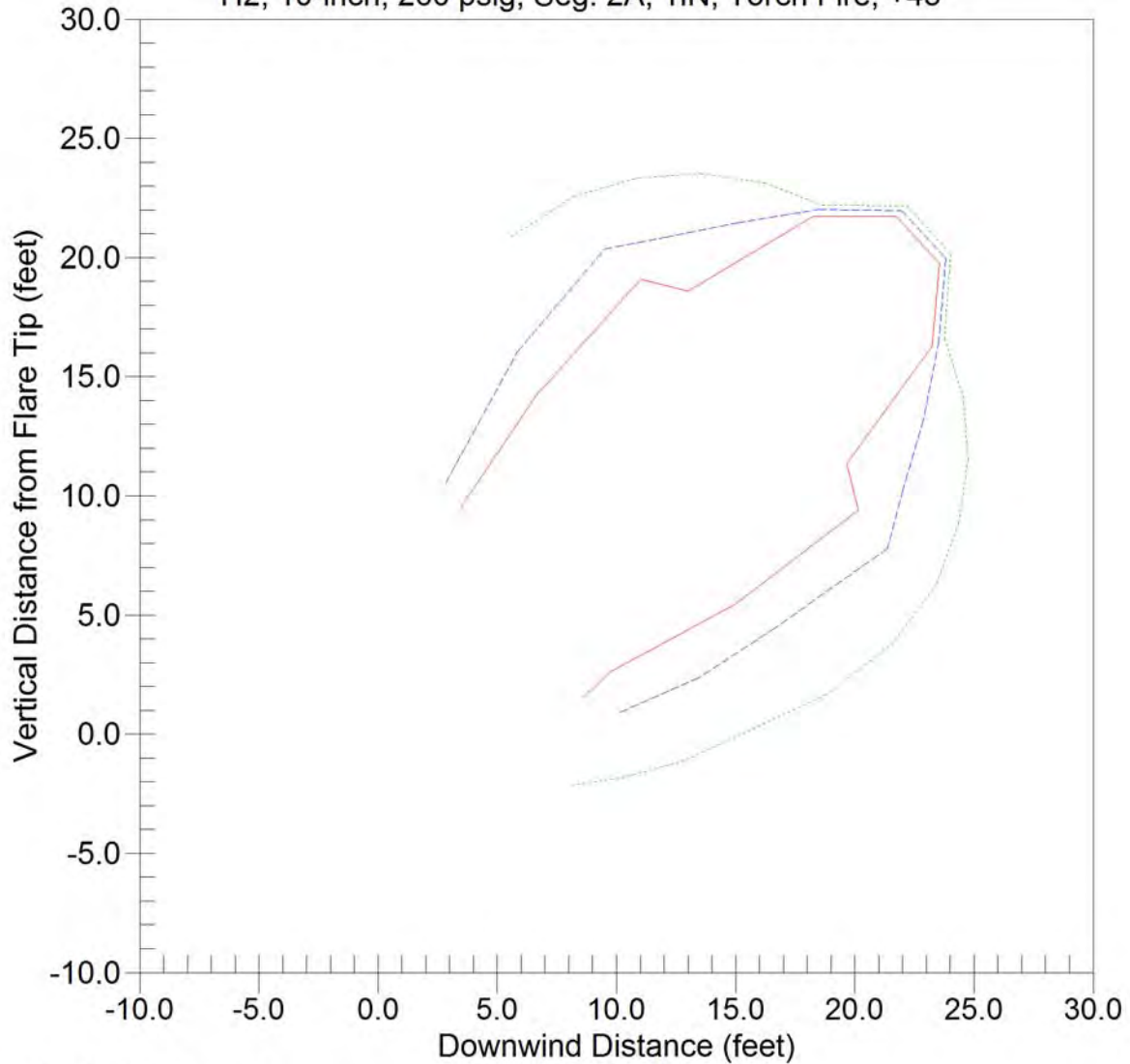
- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=10D1INTF260S2A+45_7MMSCFD
windspeed = 20.0 mph
Mon Sep 2 16:23:58 2019

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 260 psig, Seg. 2A, 1IN, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=10D1INTF260S2A+45_7MMSCFD

windspeed = 20.0 mph

Mon Sep 2 16:23:58 2019

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D1INTF260S2A-45_7MMSCFD           |
|           Mon Sep  2 16:24:45 2019                         |
|           Quest Consultants Inc., Norman, Oklahoma, USA    |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734        |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Torch Fire, -45

```

Case Type       : Fire Radiation
Case Name      : 10D1INTF260S2A-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

Wind speed	20.00 mph
Relative humidity	70 %
Air temperature	72.0 °F

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)          6.0 feet
Diameter of jet fire tip                   0.0833 feet
Flow rate                                  0.91 lb/sec
Angle of release from horizontal           135.0 degrees

```

Fire radiation flux values

Radiation endpoint 1	12000 Btu/hr-sq.ft
Radiation endpoint 2	8000 Btu/hr-sq.ft
Radiation endpoint 3	5000 Btu/hr-sq.ft

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 10D1INTF260S2A-45_7MMSCFD
Mon Sep 2 16:24:45 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com canary@questconsult.com
telephone (405) 329-7475 fax (405) 329-7734

```

Title: H2, 10-inch, 260 psig, Seg. 2A, 1IN, Torch Fire, -45

```

Length of Flame      : 26.2 feet
Flame Tilt from Horizontal: 128.0 degrees
Release Angle       : 135.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	2819
7.1	2632
7.6	2450
8.2	2277
8.8	2113
9.4	1957
10.1	1808
10.9	1666
11.7	1533
12.6	1407
13.5	1289
14.6	1179
15.7	1076
16.8	981
18.1	893
19.5	810
20.9	734
22.5	663
24.2	598
26.0	538
28.0	483
30.1	433
32.3	387
34.8	346
37.4	308

Downwind Distances to Endpoints

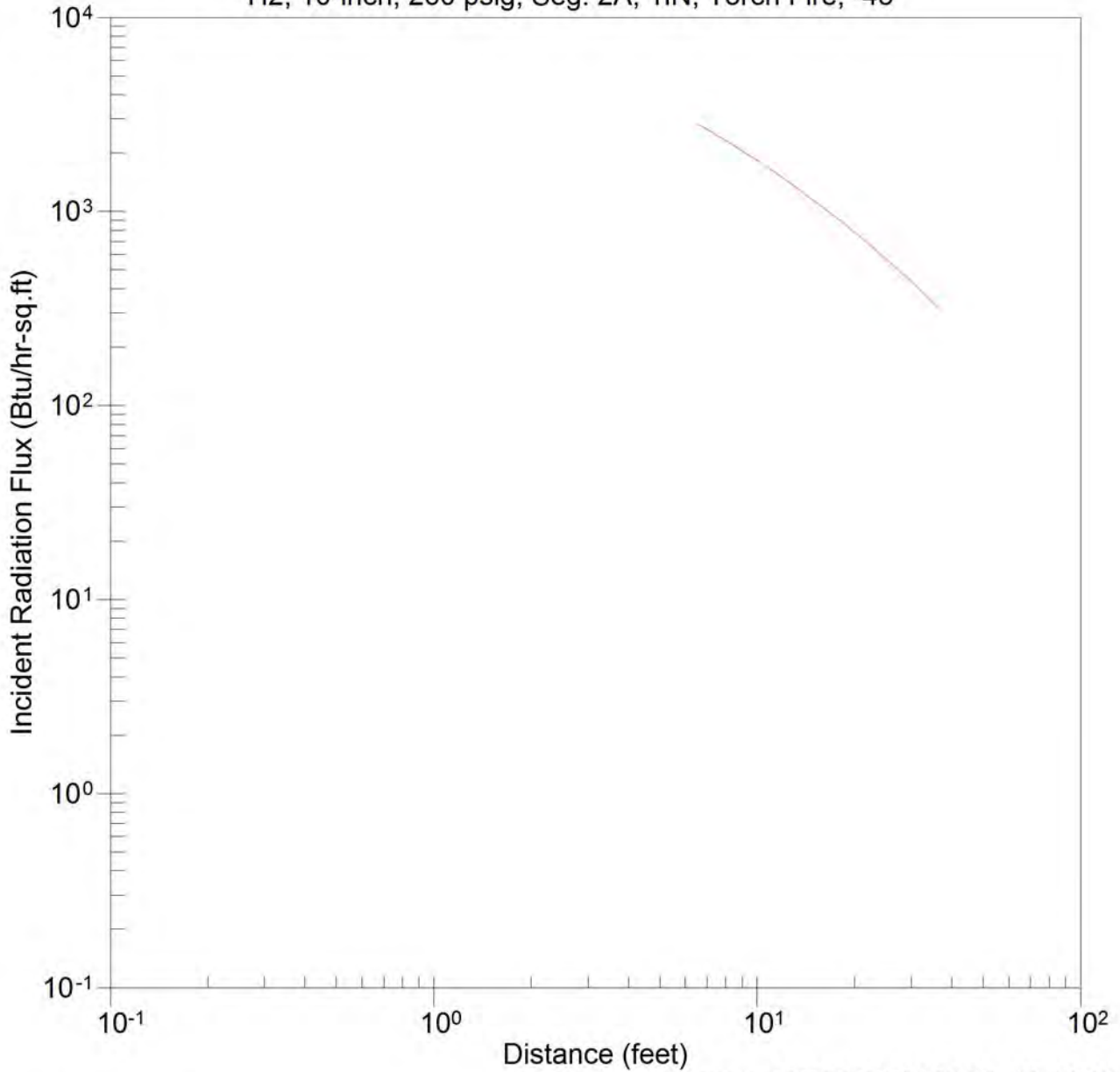
Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
**	12000
**	8000
**	5000

** Endpoint does not exist at this elevation

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point

H2, 10-inch, 260 psig, Seg. 2A, 1IN, Torch Fire, -45



casename=10D1INTF260S2A-45_7MMSCFD

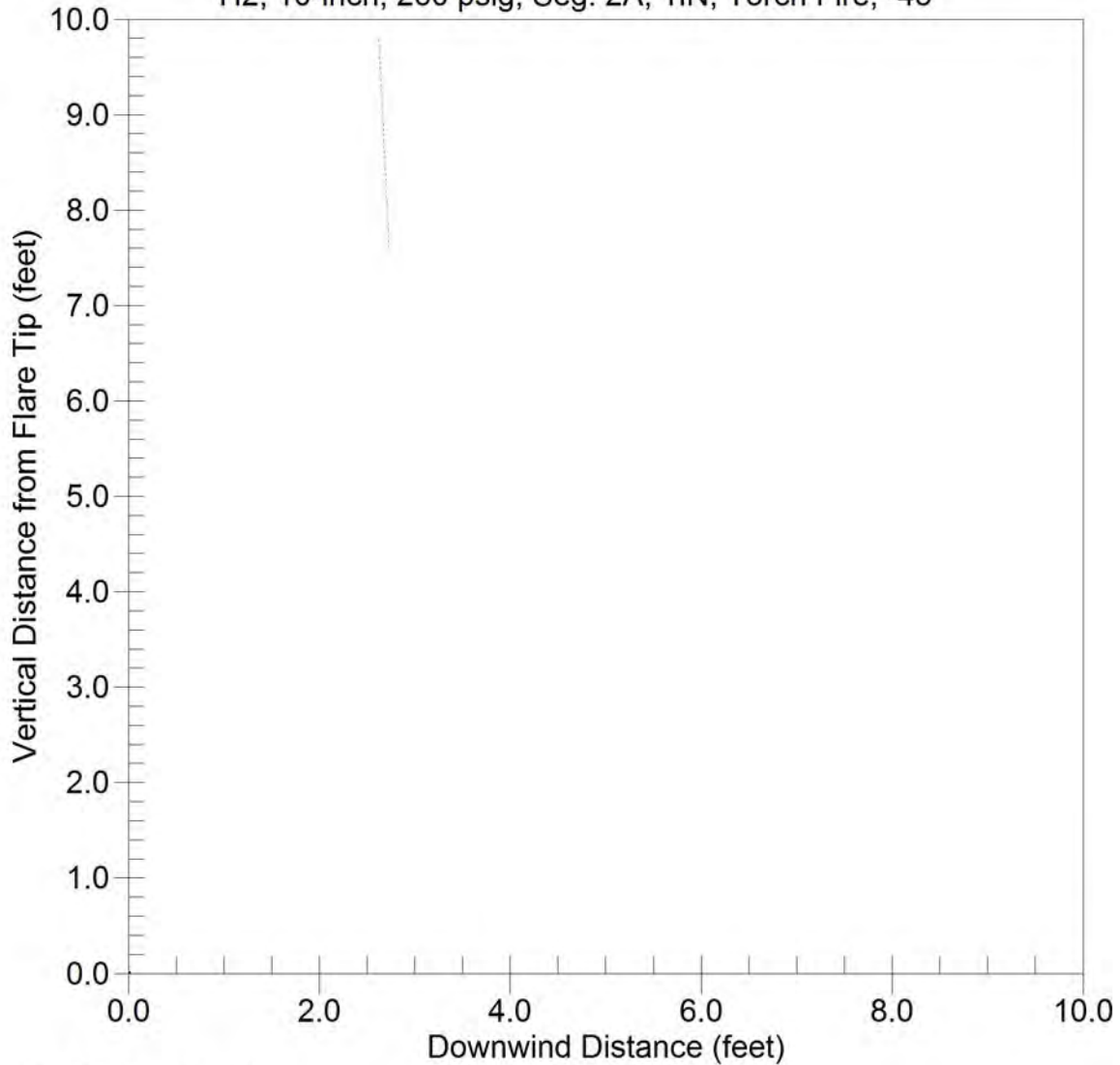
windspeed = 20.0 mph

Mon Sep 2 16:24:45 2019

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 260 psig, Seg. 2A, 1IN, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=10D1INTF260S2A-45_7MMSCFD

windspeed = 20.0 mph

Mon Sep 2 16:24:45 2019

CANARY by Quest



Torch Fire Modeling Results, Segment 2B

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10DTF260S2B+45_7MMSCFD                |
|           Mon Sep  2 16:21:03 2019                          |
|           Quest Consultants Inc., Norman, Oklahoma, USA      |
| www.questconsult.com           canary@questconsult.com      |
| telephone (405) 329-7475       fax (405) 329-7734          |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, Torch Fire, +45

```

Case Type       : Fire Radiation
Case Name      : 10DTF260S2B+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) 0.0 feet
Elevation of target (from grade) 6.0 feet
Diameter of jet fire tip 0.8350 feet
Flow rate 6.74 lb/sec
Angle of release from horizontal 45.0 degrees

Fire radiation flux values
Radiation endpoint 1 12000 Btu/hr-sq.ft
Radiation endpoint 2 8000 Btu/hr-sq.ft
Radiation endpoint 3 5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 10DTF260S2B+45_7MMSCFD
Mon Sep  2 16:21:03 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 10-inch, 260 psig, Seg. 2B, Torch Fire, +45

```

Length of Flame      : 51.3 feet
Flame Tilt from Horizontal: 28.6 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
13.1	***
14.5	***
16.0	***
17.6	***
19.5	***
21.5	32702
23.7	47665
26.2	41839
28.9	37272
31.9	33393
35.2	29632
38.9	25437
42.9	20388
47.3	14998
52.2	10223
57.7	6700
63.6	4390
70.2	2935
77.5	2014
85.6	1416
94.5	1017
104.2	743
115.1	551
127.0	414
140.2	314

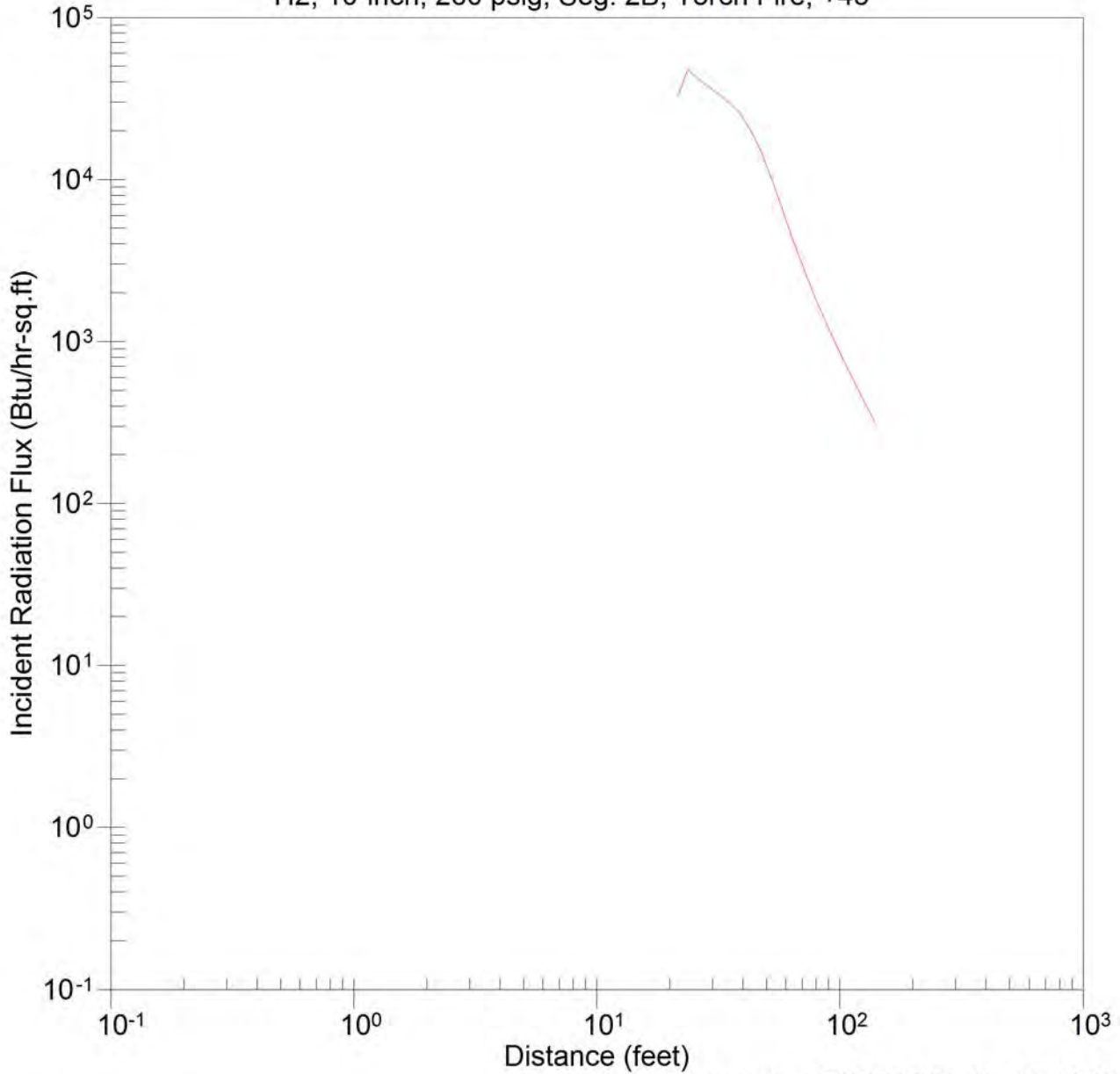
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
50.1	12000
55.3	8000
61.7	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 10-inch, 260 psig, Seg. 2B, Torch Fire, +45



CANARY by Quest

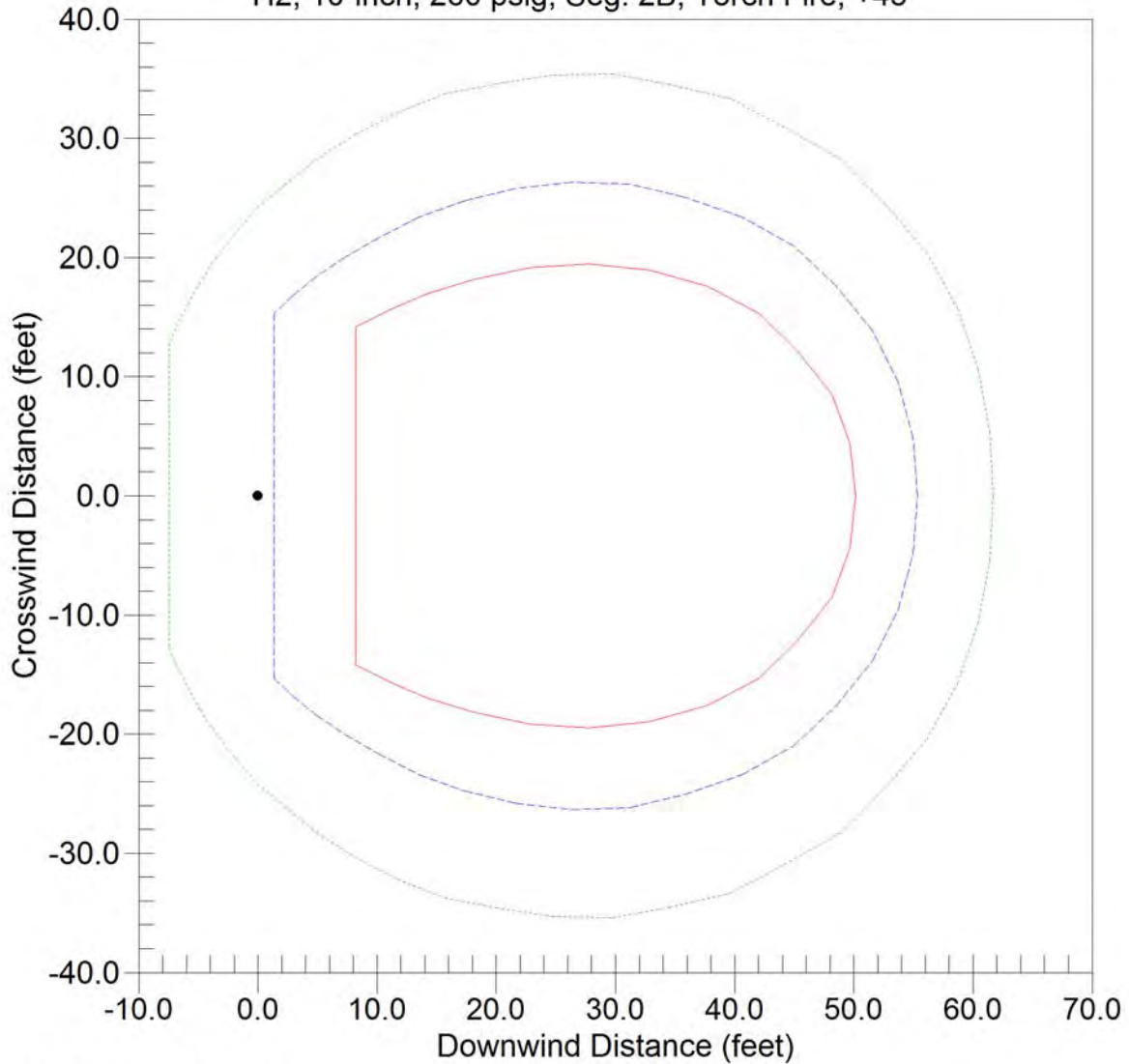
casename=10DTF260S2B+45_7MMSCFD

windspeed = 20.0 mph

Mon Sep 2 16:21:03 2019

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 10-inch, 260 psig, Seg. 2B, Torch Fire, +45



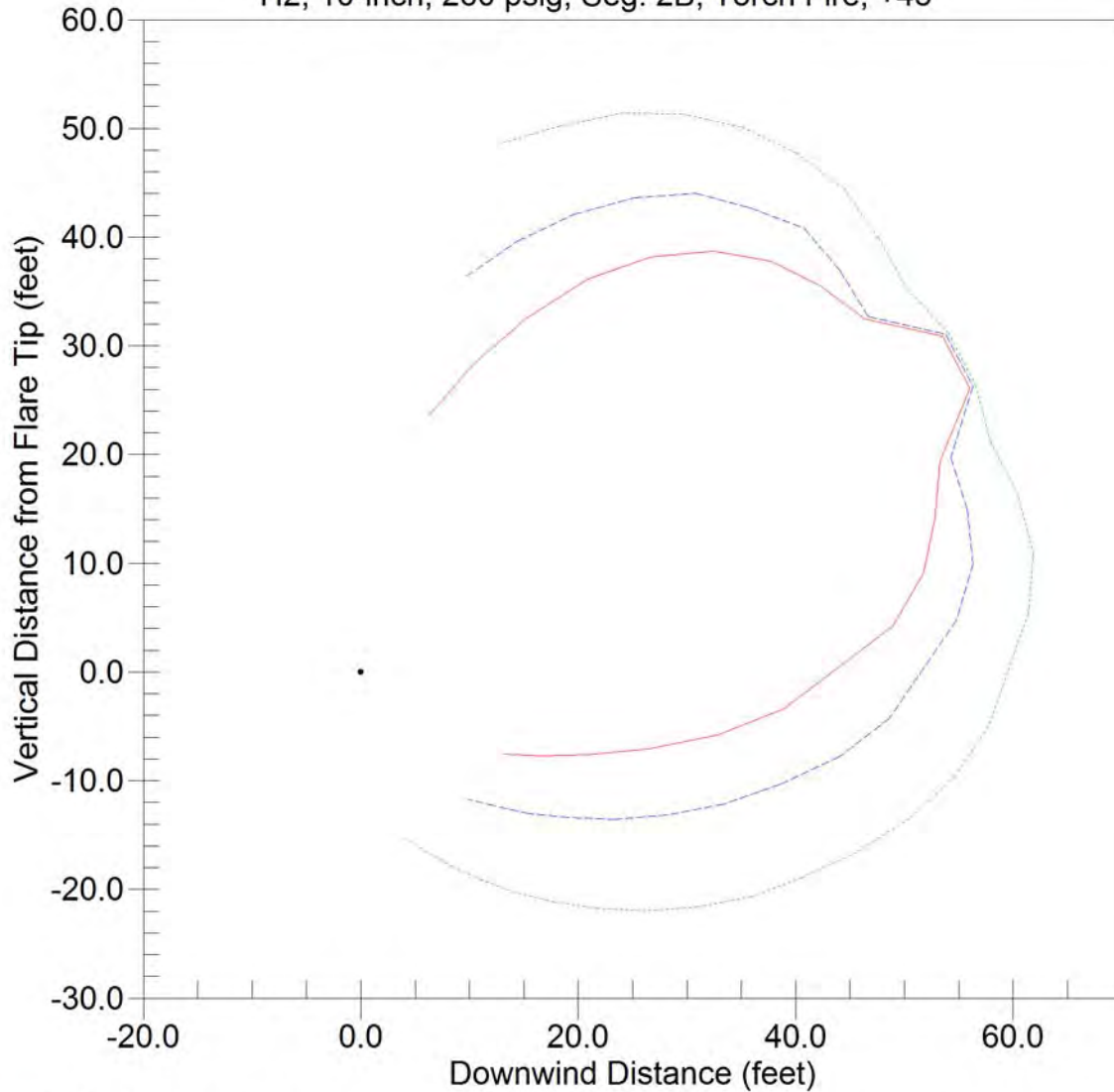
- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

CANARY by Quest

casename=10DTF260S2B+45_7MMSCFD
windspeed = 20.0 mph
Mon Sep 2 16:21:03 2019

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 260 psig, Seg. 2B, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

CANARY by Quest

casename=10DTF260S2B+45_7MMSCFD
windspeed = 20.0 mph
Mon Sep 2 16:21:03 2019


```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10DTF260S2B-45_7MMSCFD              |
|           Mon Sep  2 16:21:59 2019                        |
|           Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734         |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, Torch Fire, -45

```

Case Type       : Fire Radiation
Case Name      : 10DTF260S2B-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) 0.0 feet
Elevation of target (from grade) 6.0 feet
Diameter of jet fire tip 0.8350 feet
Flow rate 6.74 lb/sec
Angle of release from horizontal 135.0 degrees

Fire radiation flux values
Radiation endpoint 1 12000 Btu/hr-sq.ft
Radiation endpoint 2 8000 Btu/hr-sq.ft
Radiation endpoint 3 5000 Btu/hr-sq.ft

```

NOTES:

CANARY by Quest - Version 4.6.2
 Jet Fire Radiation Model
 Case Name - 10DTF260S2B-45_7MMSCFD
 Mon Sep 2 16:21:59 2019
 Quest Consultants Inc., Norman, Oklahoma, USA
 www.questconsult.com canary@questconsult.com
 telephone (405) 329-7475 fax (405) 329-7734

Title: H2, 10-inch, 260 psig, Seg. 2B, Torch Fire, -45

Length of Flame : 51.3 feet
 Flame Tilt from Horizontal: 56.2 degrees
 Release Angle : 135.0 degrees
 Release Point Elevation : 0.0 feet
 Target Elevation : 6.0 feet
 Wind Speed : 20.0 mph

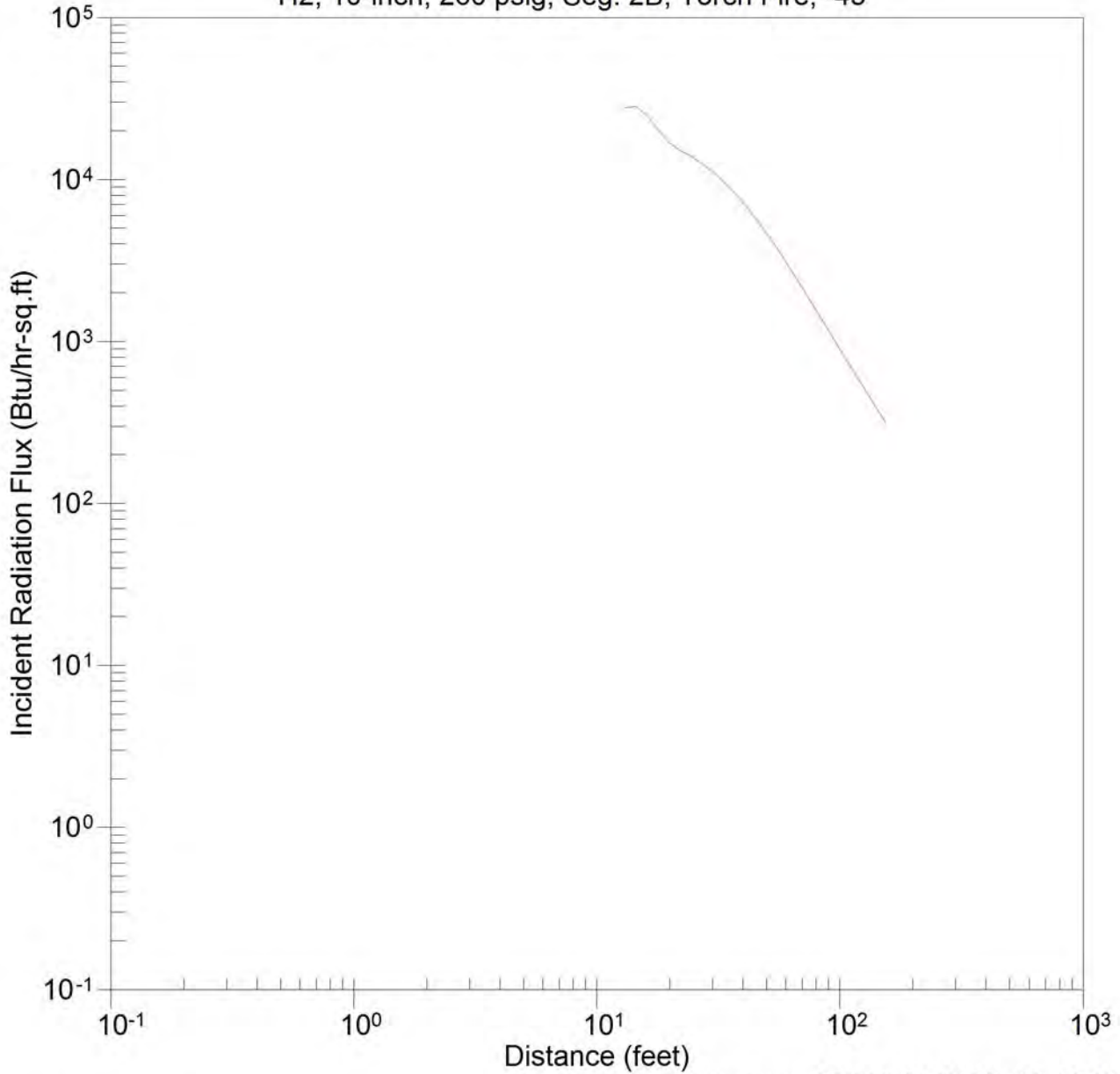
Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
13.1	27712
14.5	28123
16.1	24691
17.9	20379
19.8	16843
22.0	15078
24.3	13911
27.0	12606
29.9	11173
33.1	9709
36.7	8286
40.7	6943
45.1	5712
50.0	4623
55.4	3692
61.4	2918
68.1	2289
75.5	1786
83.7	1390
92.7	1080
102.8	840
113.9	654
126.3	510
140.0	398
155.2	312

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
28.1	12000
37.5	8000
48.0	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 10-inch, 260 psig, Seg. 2B, Torch Fire, -45



CANARY by Quest

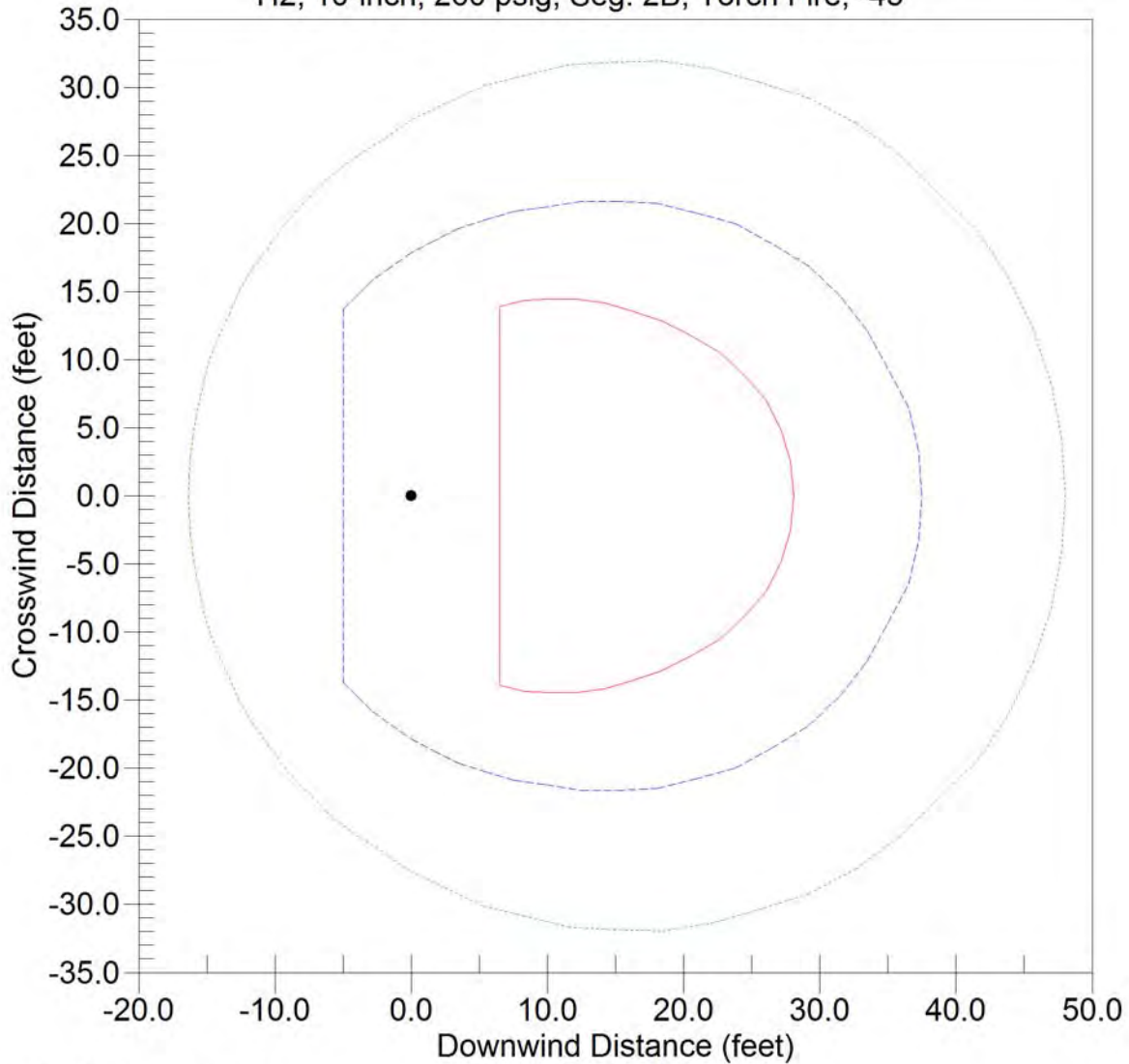
casename=10DTF260S2B-45_7MMSCFD

windspeed = 20.0 mph

Mon Sep 2 16:21:59 2019

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 10-inch, 260 psig, Seg. 2B, Torch Fire, -45



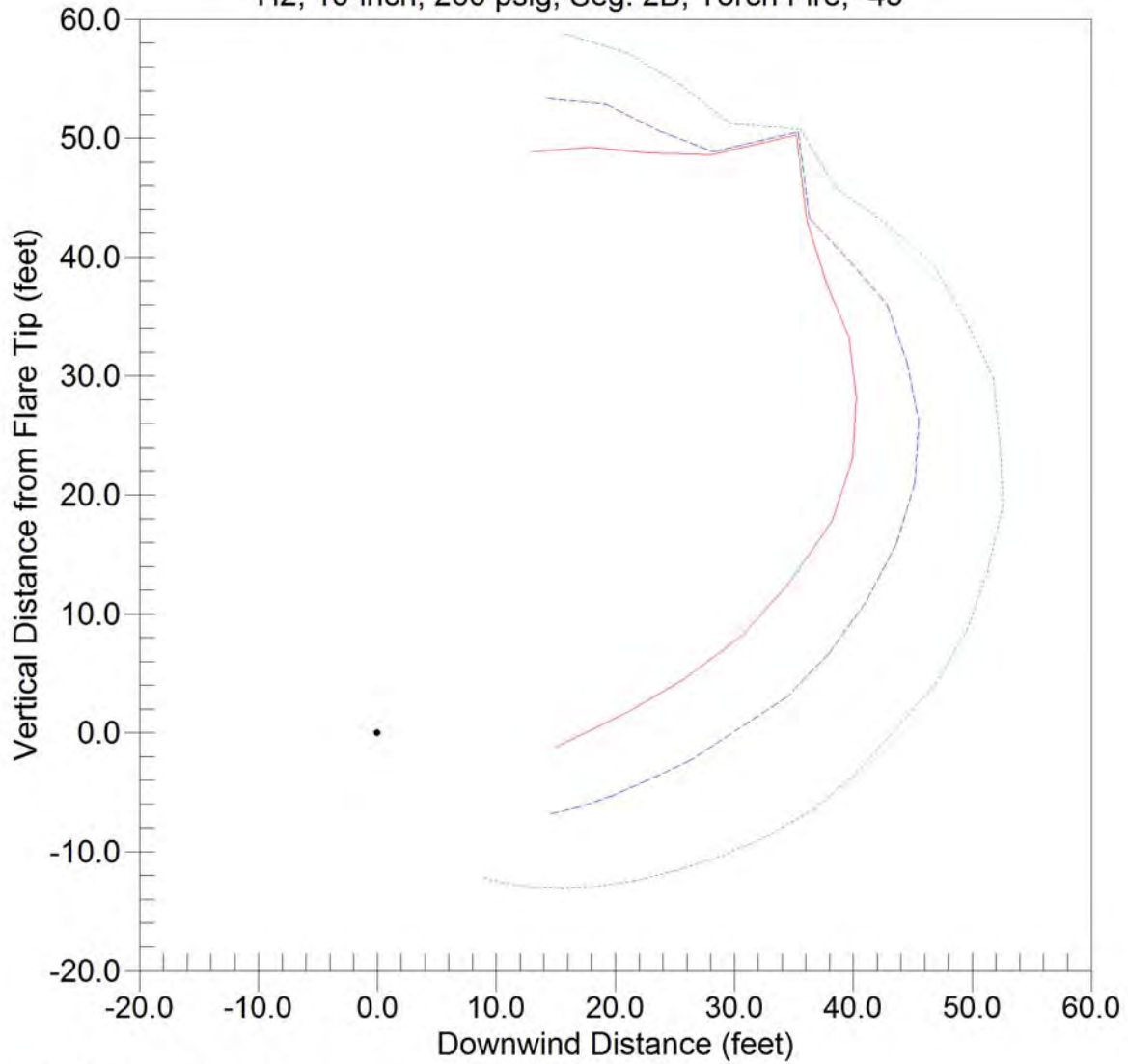
- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=10DTF260S2B-45_7MMSCFD
windspeed = 20.0 mph
Mon Sep 2 16:21:59 2019

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 260 psig, Seg. 2B, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=10DTF260S2B-45_7MMSCFD
windspeed = 20.0 mph
Mon Sep 2 16:21:59 2019

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D1INTF260S2B+45_7MMSCFD           |
|           Mon Sep  2 16:25:30 2019                         |
|           Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734         |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Torch Fire, +45

```

Case Type       : Fire Radiation
Case Name       : 10D1INTF260S2B+45_7MMSCFD
User ID        : BLPayne
Project Number  : Job 2134
Type of Units   : English Units

```

NOTES: Segment 2B

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed              20.00 mph
Relative humidity       70 %
Air temperature         72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)          6.0 feet
Diameter of jet fire tip                   0.0833 feet
Flow rate                                  0.91 lb/sec
Angle of release from horizontal           45.0 degrees

Fire radiation flux values
Radiation endpoint 1      12000 Btu/hr-sq.ft
Radiation endpoint 2      8000 Btu/hr-sq.ft
Radiation endpoint 3      5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 10D1INTF260S2B+45_7MMSCFD
Mon Sep  2 16:25:30 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Torch Fire, +45

```

Length of Flame      : 26.2 feet
Flame Tilt from Horizontal: 42.2 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	***
7.2	***
7.9	***
8.6	***
9.4	***
10.3	1342
11.3	13530
12.3	28352
13.5	24325
14.8	13207
16.2	9161
17.7	9574
19.4	8606
21.2	6799
23.2	5128
25.4	3820
27.8	2830
30.4	2092
33.3	1551
36.4	1159
39.9	873
43.6	664
47.7	509
52.2	394
57.2	307

*** Target Location inside Flame

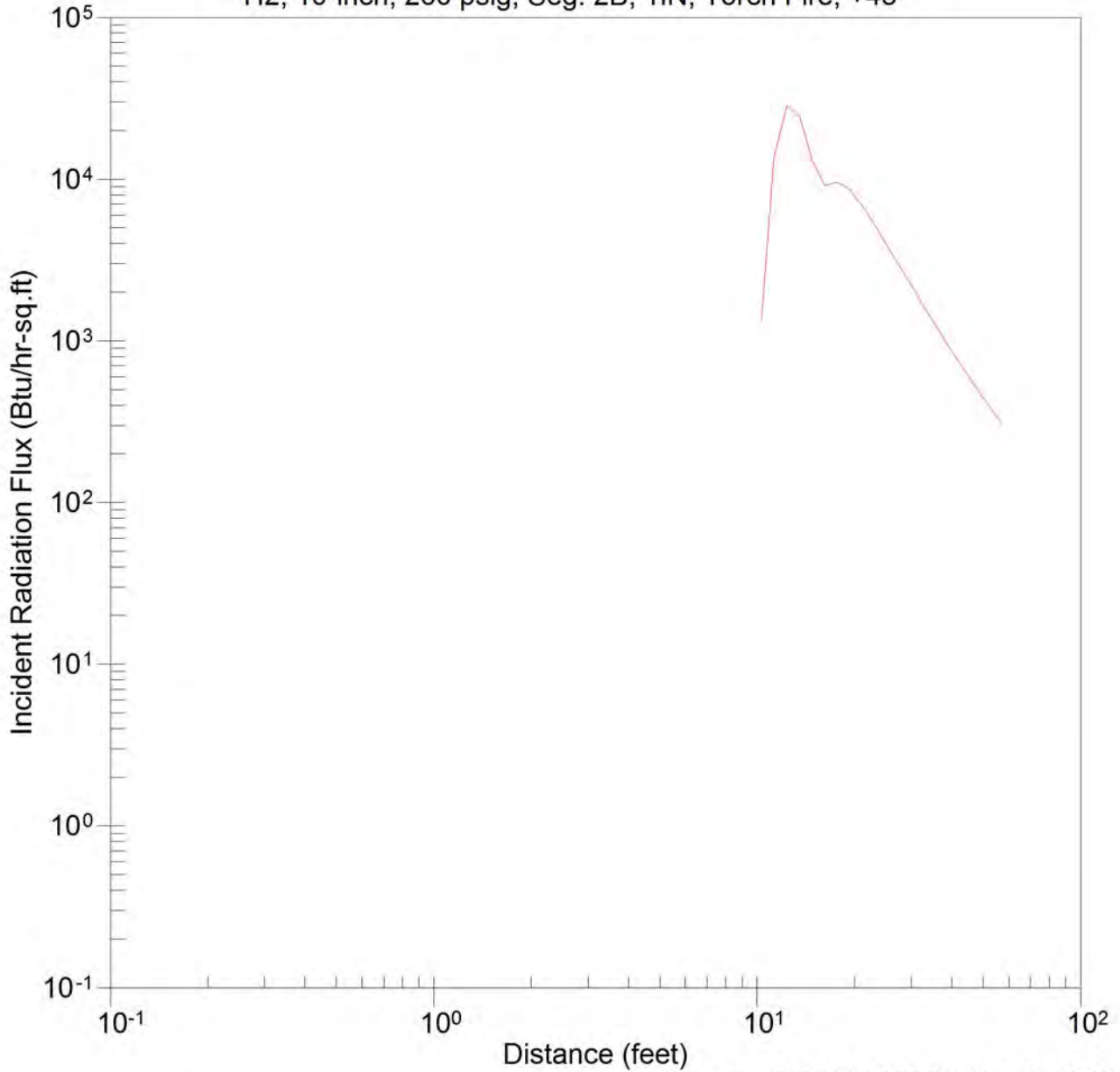
Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
15.2	12000
19.9	8000
23.4	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point

H2, 10-inch, 260 psig, Seg. 2B, 1IN, Torch Fire, +45



CANARY by Quest

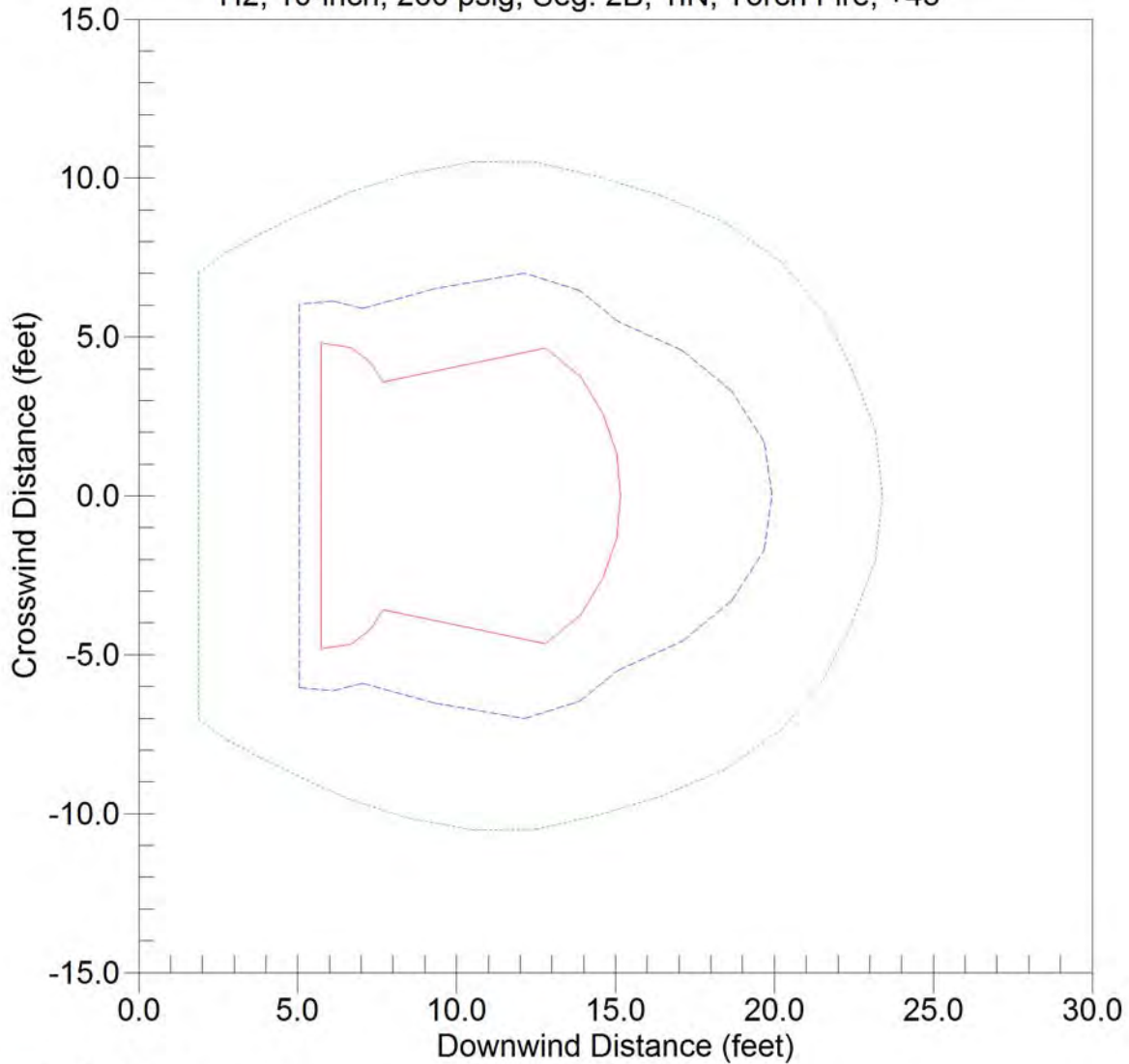
casename=10D1INTF260S2B+45_7MMSCFD

windspeed = 20.0 mph

Mon Sep 2 16:25:30 2019

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 10-inch, 260 psig, Seg. 2B, 1IN, Torch Fire, +45



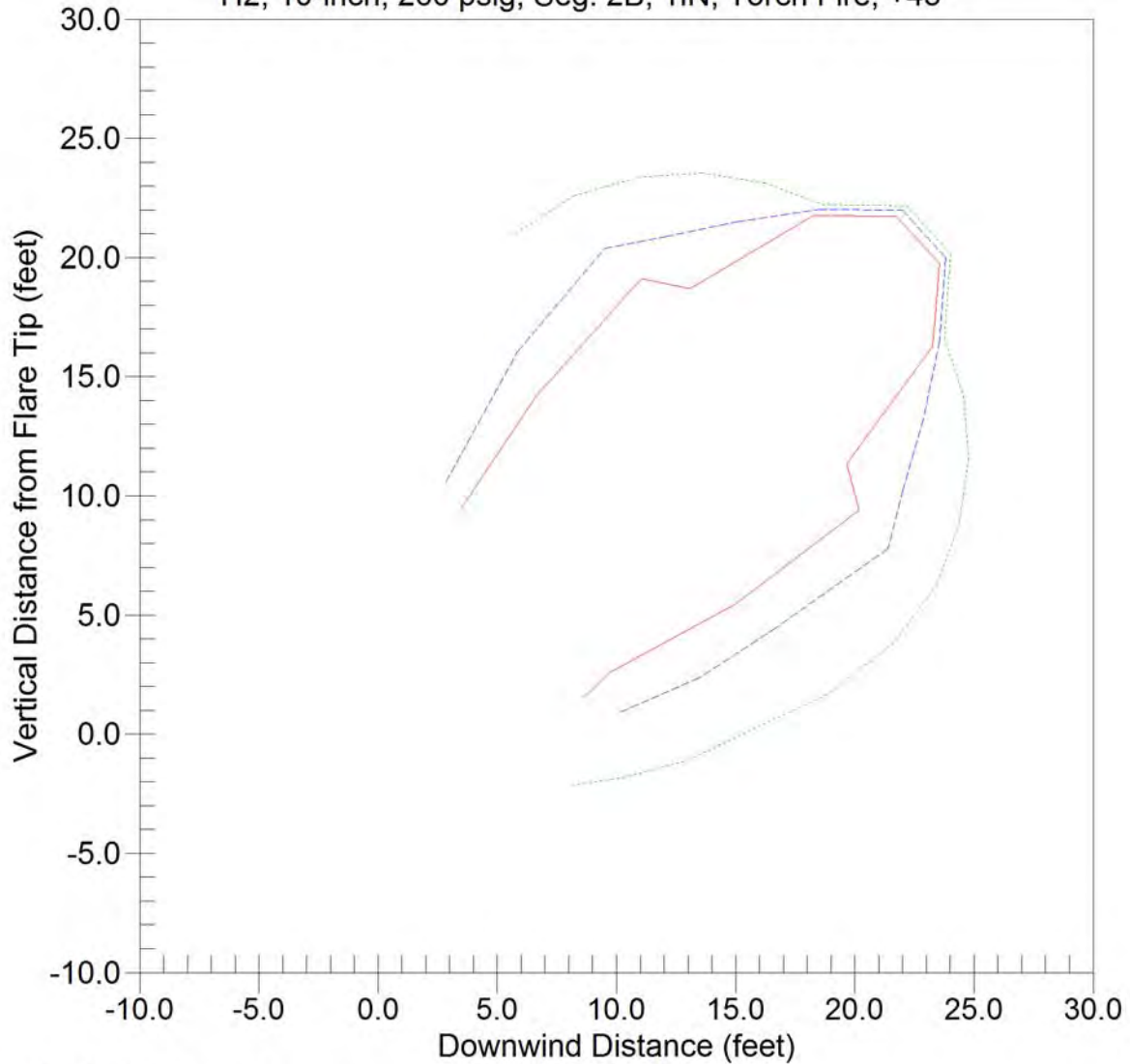
- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=10D1INTF260S2B+45_7MMSCFD
windspeed = 20.0 mph
Mon Sep 2 16:25:30 2019

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 260 psig, Seg. 2B, 1IN, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=10D1INTF260S2B+45_7MMSCFD

windspeed = 20.0 mph

Mon Sep 2 16:25:30 2019

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D1INTF260S2B-45_7MMSCFD           |
|           Mon Sep  2 16:25:58 2019                         |
|           Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734         |
+-----+

```

Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Torch Fire, -45

```

Case Type       : Fire Radiation
Case Name      : 10D1INTF260S2B-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 260.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) 0.0 feet
Elevation of target (from grade) 6.0 feet
Diameter of jet fire tip 0.0833 feet
Flow rate 0.91 lb/sec
Angle of release from horizontal 135.0 degrees

Fire radiation flux values
Radiation endpoint 1 12000 Btu/hr-sq.ft
Radiation endpoint 2 8000 Btu/hr-sq.ft
Radiation endpoint 3 5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 10D1INTF260S2B-45_7MMSCFD
Mon Sep 2 16:25:58 2019
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

Title: H2, 10-inch, 260 psig, Seg. 2B, 1IN, Torch Fire, -45

```

Length of Flame      : 26.2 feet
Flame Tilt from Horizontal: 128.0 degrees
Release Angle       : 135.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	2821
7.1	2634
7.6	2452
8.2	2279
8.8	2115
9.4	1958
10.1	1809
10.9	1668
11.7	1534
12.6	1408
13.6	1290
14.6	1179
15.7	1077
16.8	982
18.1	893
19.5	811
20.9	734
22.5	664
24.2	598
26.0	538
28.0	484
30.1	433
32.3	388
34.8	346
37.4	308

Downwind Distances to Endpoints

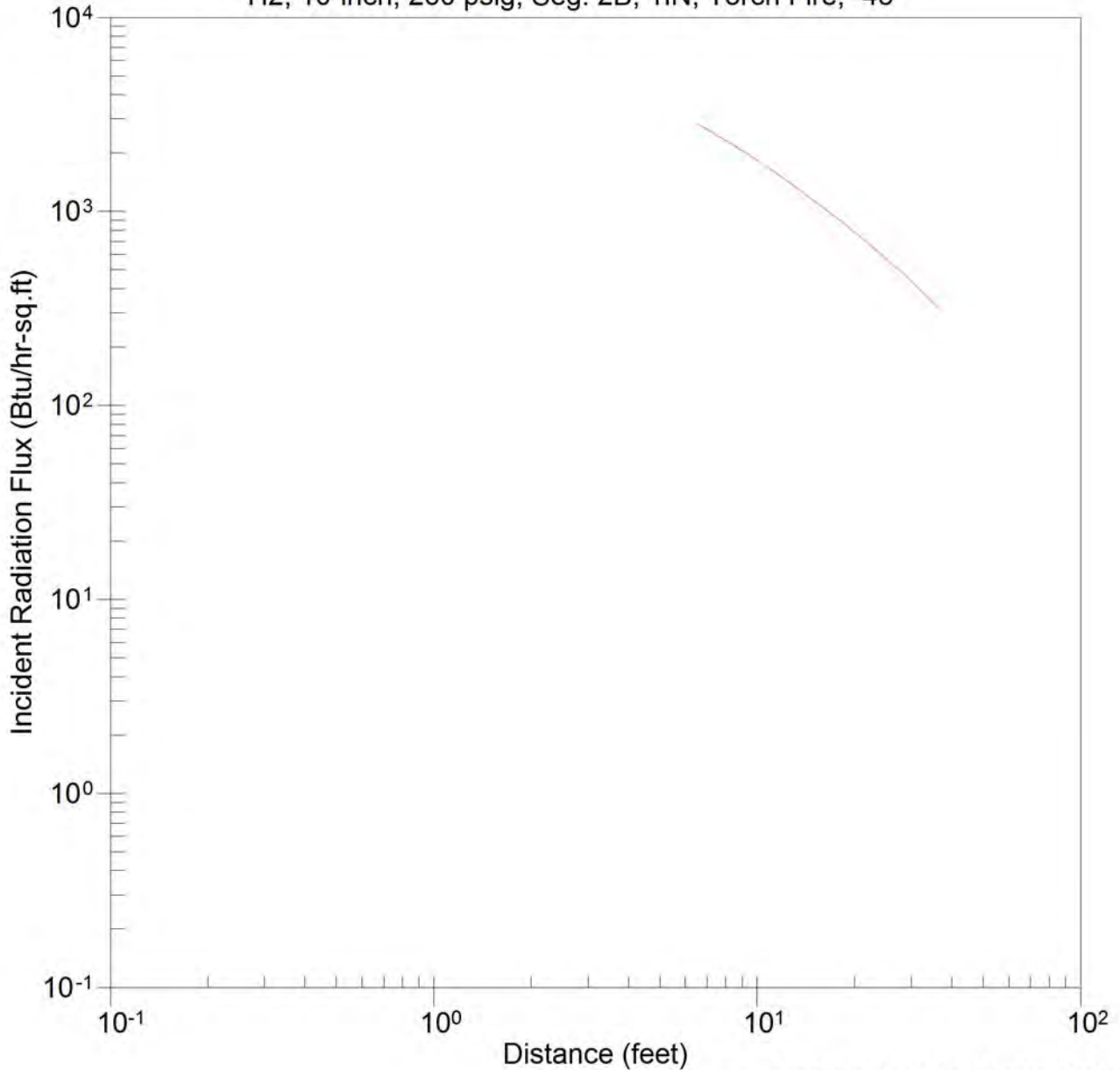
Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
**	12000
**	8000
**	5000

** Endpoint does not exist at this elevation

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point

H2, 10-inch, 260 psig, Seg. 2B, 1IN, Torch Fire, -45



casename=10D1INTF260S2B-45_7MMSCFD

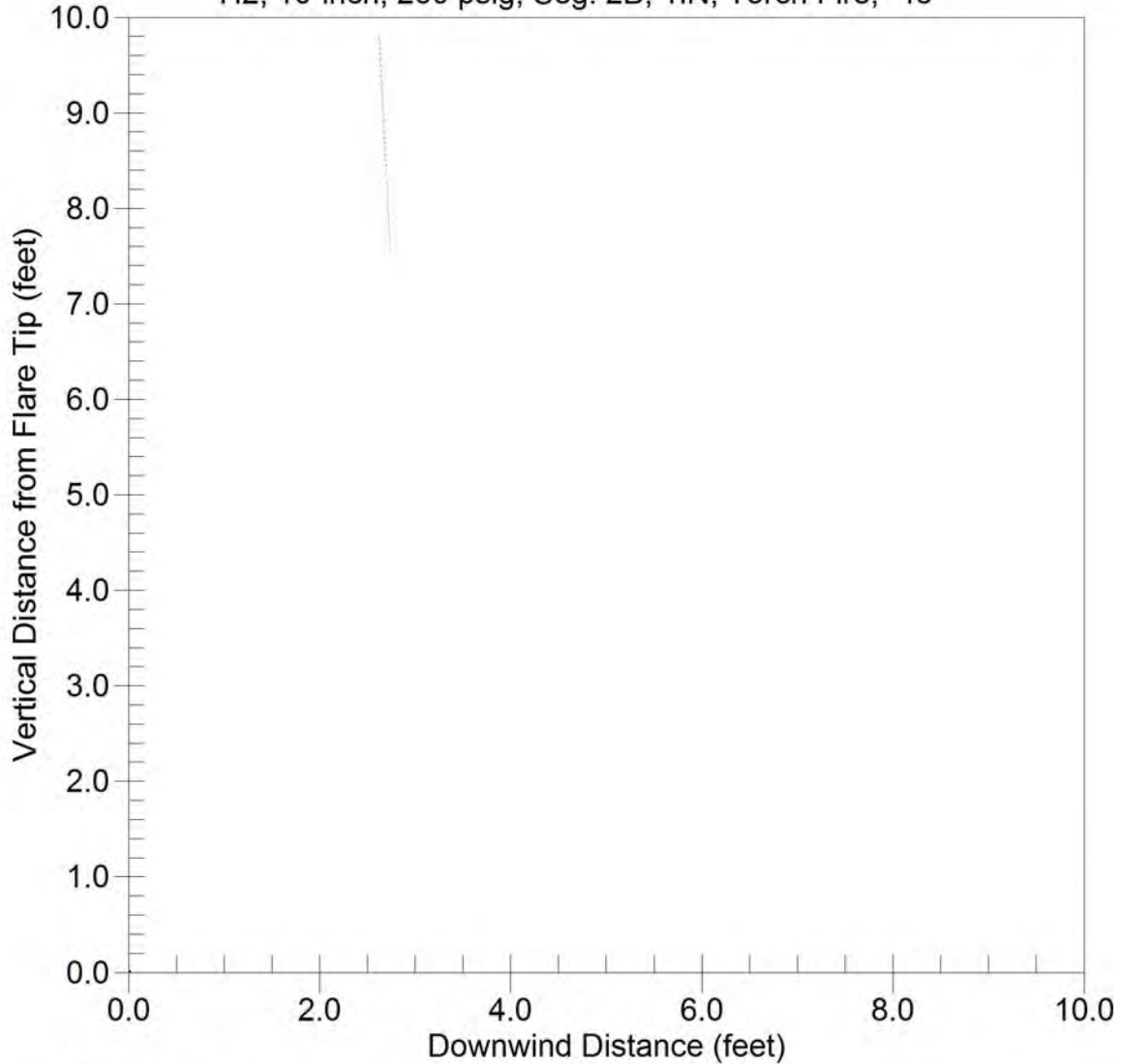
windspeed = 20.0 mph

Mon Sep 2 16:25:58 2019

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 260 psig, Seg. 2B, 1IN, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=10D1INTF260S2B-45_7MMSCFD

windspeed = 20.0 mph

Mon Sep 2 16:25:58 2019

CANARY by Quest



Vapor Dispersion Modeling Results, Segment 1



Appendix F – Release Modeling Results for 160 psig


```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|   CANARY Case Input                 |
|   Case Name - 8DFB160S1+45_7MMSCFD |
|   Thu Jan 23 14:32:23 2020         |
|   Quest Consultants Inc., Norman, Oklahoma, USA |
|   www.questconsult.com             canary@questconsult.com |
|   telephone (405) 329-7475         fax (405) 329-7734   |
|               |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°

```

Case Type       : Vapor Dispersion
Case Name      : 8DFB160S1+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: 7MMSCFD, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	72.0 °F
Spill surface temperature	72.0 °F
Substrate name	Medium density concrete
Substrate thermal conductivity	0.2698 Btu/hr-ft-F
Substrate density	80 lb/cu.ft
Substrate heat Capacity	0.22 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Wooded area or urban area

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 8DFB160S1+45_7MMSCFD |
| Thu Jan 23 14:32:23 2020 |
|               |
+-----+

```

Page 2 Title: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°

RELEASE MENU

Type of release: Unregulated, Continuous release
 Release duration 120 min
 Normal flow rate 0.43 lb/sec
 Duration of normal flow 5 min
 Volume of vessel 0.00 cu.ft
 Pipe inner diameter 7.98 inches
 Equivalent release diameter 7.98 inches
 Pipe length upstream of break 1464.0 feet
 Pipe length downstream of break 1464.0 feet
 Height of release point 0.0 feet
 Angle of release from horizontal 45.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation, dispersion and cloud explosion - Flammable calculation
 Concentration endpoint 1 UFL mol%
 Concentration endpoint 2 LFL mol%
 Concentration endpoint 3 1/2 LFL mol%

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

Fuel reactivity High
 Obstacle density Low
 Flame expansion 3-D

Overpressure values

Overpressure endpoint 1 1.00 psi
 Overpressure endpoint 2 0.70 psi
 Overpressure endpoint 3 0.10 psi

NOTES:

```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 8DFB160S1+45_7MMSCFD
Thu Jan 23 14:32:23 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

TITLE: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	36.49405	0.000000	0.000000	36.49405
0.100000	19.71480	0.000000	0.000000	19.71480
0.300000	12.65382	0.000000	0.000000	12.65382
0.500000	8.853824	0.000000	0.000000	8.853824
0.700000	8.190311	0.000000	0.000000	8.190311
1.000000	7.291034	0.000000	0.000000	7.291034
3.000000	3.352031	0.000000	0.000000	3.352031
5.000000	1.568995	0.000000	0.000000	1.568995
7.000000	.7740961	0.000000	0.000000	.7740961
10.00000	.4514938	0.000000	0.000000	.4514938
20.00000	.4312341	0.000000	0.000000	.4312341
30.00000	.4312341	0.000000	0.000000	.4312341
40.00000	.4312341	0.000000	0.000000	.4312341
50.00000	.4312341	0.000000	0.000000	.4312341
60.00000	.4312341	0.000000	0.000000	.4312341
70.00000	.4312341	0.000000	0.000000	.4312341
85.00000	.4312341	0.000000	0.000000	.4312341
100.0000	.4312341	0.000000	0.000000	.4312341
200.0000	.4312341	0.000000	0.000000	.4312341
300.0000	.4312341	0.000000	0.000000	.4312341
315.3235	0.000000	0.000000	0.000000	0.000000
Totals (lb)	160.3842	0.000000	0.000000	160.3842

Flowrate for Torch Fire [immediate ignition] = 0.8658726 lb/sec.
Torch Fire [delayed ignition] = 0.4312341 lb/sec.

Reason for Ending: No Mass Left in System


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions               |
|           Case Name - 8DFB160S1+45_7MMSCFD         |
|           Thu Jan 23 14:32:23 2020                 |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com           canary@questconsult.com |
|           telephone (405) 329-7475           fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 8DFB160S1+45_7MMSCFD                     |
|      Thu Jan 23 14:32:23 2020                               |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

TITLE: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.7	0.7	0.2	0.1
0.5	0.717755	0.219178	1.0	0.9	0.0	0.6
1.0	0.580914	0.036634	1.2	1.0	0.0	1.1
1.5	0.491143	0.006877	1.4	1.2	0.0	1.6
2.0	0.425970	0.001572	1.5	1.3	0.0	2.1
2.5	0.375789	0.000444	1.7	1.5	0.0	2.6
3.0	0.335898	0.000153	1.9	1.6	0.0	3.1
3.5	0.302841	0.000062	2.0	1.7	0.0	3.6
4.0	0.274963	0.000031	2.2	1.9	0.0	4.0
4.5	0.250623	0.000018	2.3	2.0	0.0	4.5
5.0	0.229565	0.000011	2.5	2.1	0.0	5.0
5.5	0.210944	0.000009	2.7	2.2	0.0	5.5
6.0	0.194403	0.000007	2.8	2.4	0.0	6.0
6.5	0.179676	0.000006	3.0	2.5	0.0	6.5
7.0	0.166466	0.000006	3.2	2.6	0.0	7.0
7.5	0.154430	0.000006	3.3	2.7	0.0	7.5
8.0	0.143602	0.000007	3.5	2.8	0.0	7.9
8.5	0.133836	0.000007	3.7	2.9	0.0	8.4
9.0	0.125006	0.000008	3.9	3.1	0.0	8.9
9.5	0.116804	0.000010	4.0	3.2	0.0	9.3
10.0	0.109353	0.000012	4.2	3.3	0.0	9.8
10.5	0.102538	0.000014	4.4	3.3	0.0	10.2
11.0	0.096244	0.000017	4.6	3.4	0.0	10.7
11.5	0.090524	0.000021	4.7	3.5	0.0	11.1
12.0	0.085166	0.000026	4.9	3.5	0.0	11.6
12.5	0.080329	0.000032	5.1	3.6	0.0	12.0
13.0	0.075763	0.000039	5.2	3.6	0.0	12.4
13.5	0.071596	0.000048	5.4	3.6	0.0	12.9
14.0	0.067723	0.000058	5.5	3.6	0.0	13.3
14.5	0.064099	0.000070	5.6	3.6	0.0	13.7
15.0	0.060797	0.000084	5.8	3.5	0.0	14.1
15.5	0.057658	0.000099	5.9	3.5	0.0	14.5
16.0	0.054788	0.000118	6.0	3.4	0.0	14.8
16.5	0.052112	0.000138	6.1	3.2	0.0	15.2
17.0	0.049588	0.000160	6.2	3.0	0.0	15.6

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
17.5	0.047263	0.000186	6.3	2.8	0.0	16.0
18.0	0.045086	0.000213	6.4	2.4	0.0	16.3
18.5	0.043026	0.000242	6.4	2.0	0.0	16.7
19.0	0.041113	0.000274	6.4	1.2	0.0	17.0
19.5	0.039337	0.000309	6.5	0.0	0.0	17.3
20.0	0.037635	0.000345	6.5	0.0	0.0	17.7
20.5	0.036056	0.000384	6.5	0.0	0.0	18.0
21.0	0.034574	0.000423	6.5	0.0	0.0	18.3
21.5	0.033172	0.000466	6.4	0.0	0.0	18.6
22.0	0.031844	0.000508	6.3	0.0	0.0	18.9
22.5	0.030598	0.000553	6.3	0.0	0.0	19.2
23.0	0.029429	0.000599	6.1	0.0	0.0	19.5
23.5	0.028322	0.000646	6.0	0.0	0.0	19.8
24.0	0.027262	0.000693	5.8	0.0	0.0	20.1
24.5	0.026264	0.000741	5.6	0.0	0.0	20.3
25.0	0.025325	0.000790	5.4	0.0	0.0	20.6
25.5	0.024431	0.000837	5.1	0.0	0.0	20.9
26.0	0.023586	0.000886	4.7	0.0	0.0	21.1
26.5	0.022778	0.000934	4.3	0.0	0.0	21.4
27.0	0.022030	0.000983	3.8	0.0	0.0	21.6
27.5	0.021288	0.001029	3.1	0.0	0.0	21.9
28.0	0.020596	0.001076	2.2	0.0	0.0	22.1
28.5	0.019936	0.001122	0.0	0.0	0.0	22.3

The downwind distance to c3 is 0.41 ft after about 0 seconds
The downwind distance to c2 is 19.31 ft after about 0 seconds
The downwind distance to c1 is 28.45 ft after about 1 seconds

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Cloud Explosion                      |
|      Case Name - 8DFB160S1+45_7MMSCFD                     |
|      Thu Jan 23 14:32:23 2020                               |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°

```

Fuel Reactivity: High           Obstacle Density: Low
Flame Expansion: 3-D           Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.415356 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0412
2.0	3.36	0.0412
2.4	3.36	0.0412
2.9	3.36	0.0412
3.5	3.36	0.0359
4.2	3.36	0.0299
5.1	3.36	0.0248
6.2	3.36	0.0206
7.5	3.36	0.0171
9.0	3.06	0.0142
10.9	2.54	0.0118
13.1	2.11	0.0098
15.9	1.75	0.0082
19.2	1.45	0.0068
23.1	1.20	0.0057
27.9	0.99	0.0047
33.7	0.82	0.0039
40.7	0.68	0.0032
49.2	0.56	0.0027
59.4	0.47	0.0022
71.8	0.38	0.0019
86.7	0.32	0.0015
104.7	0.26	0.0013
126.5	0.22	0.0011
274.1	0.10	0.0005

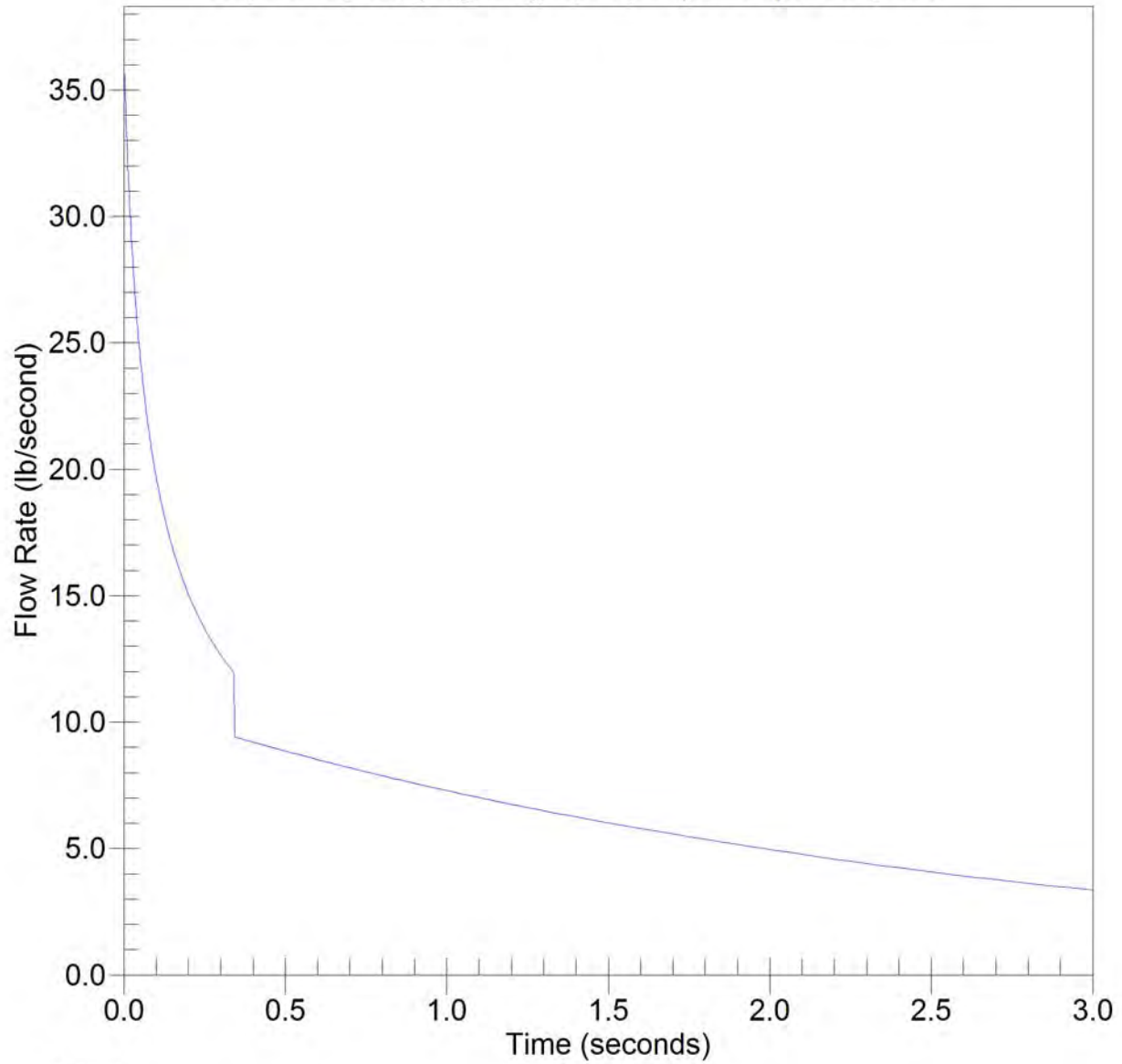
```

The downwind distance to dp3 is      27.8 feet
The downwind distance to dp2 is      39.8 feet
The downwind distance to dp1 is     274.1 feet

```


MASS RELEASE RATE

H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°



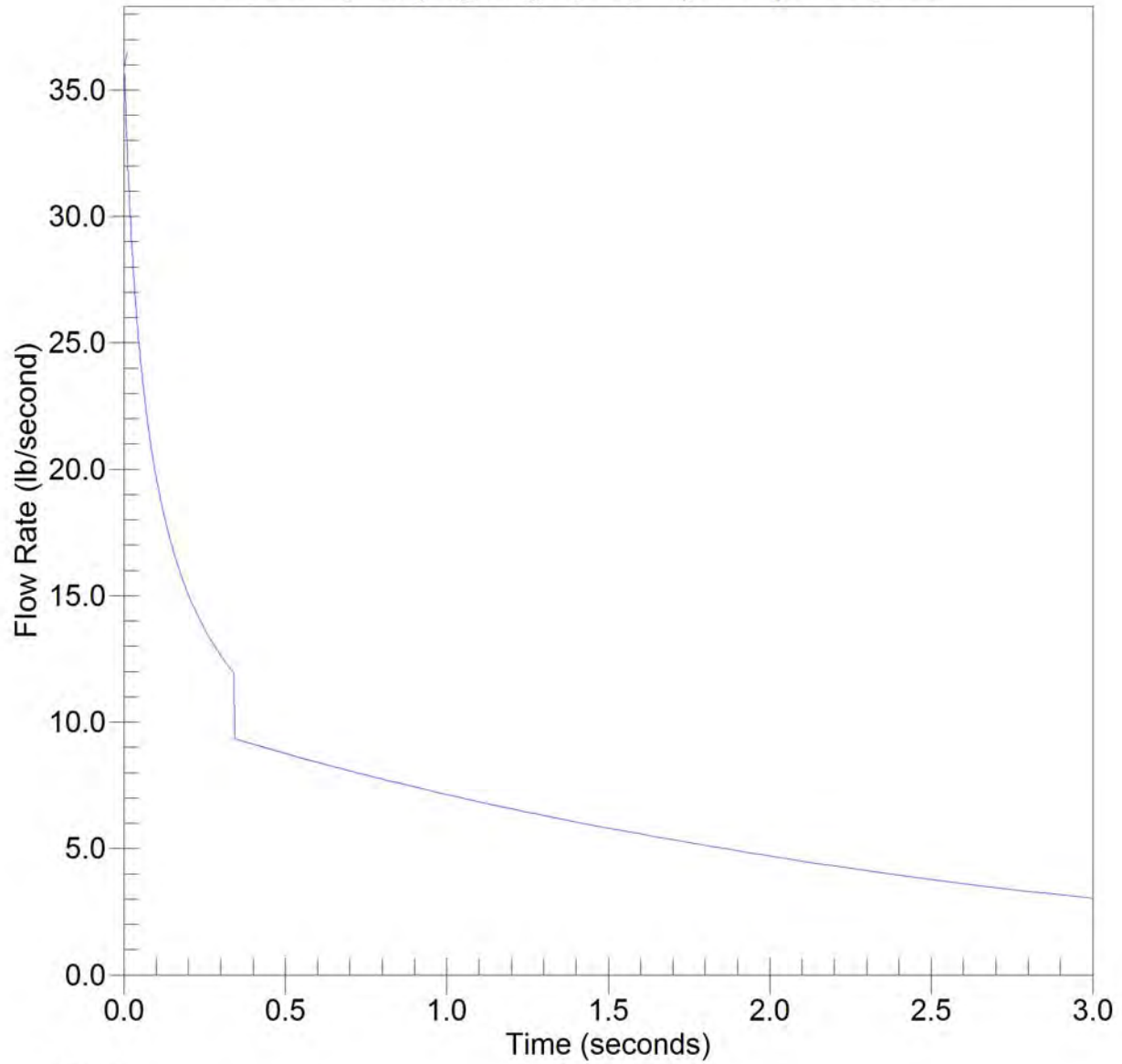
— Total
— Vapor

CANARY by Quest

casename=8DFB160S1+45_7MMSCFD
Thu Jan 23 14:32:23 2020

MASS RELEASE RATE - DOWNSTREAM PIPING

H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°

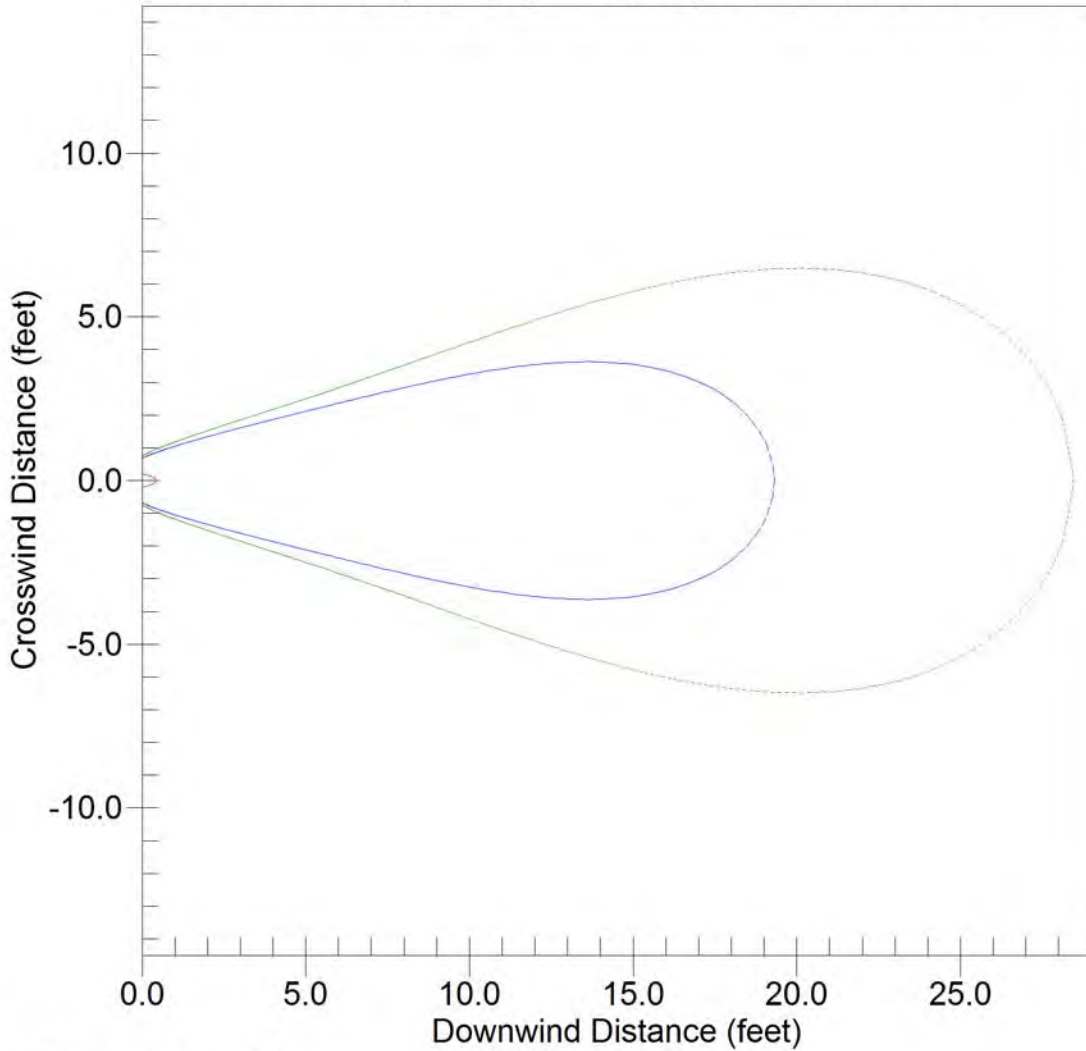


— Total
— Vapor

CANARY by Quest

casename=8DFB160S1+45_7MMSCFD
Thu Jan 23 14:32:23 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°

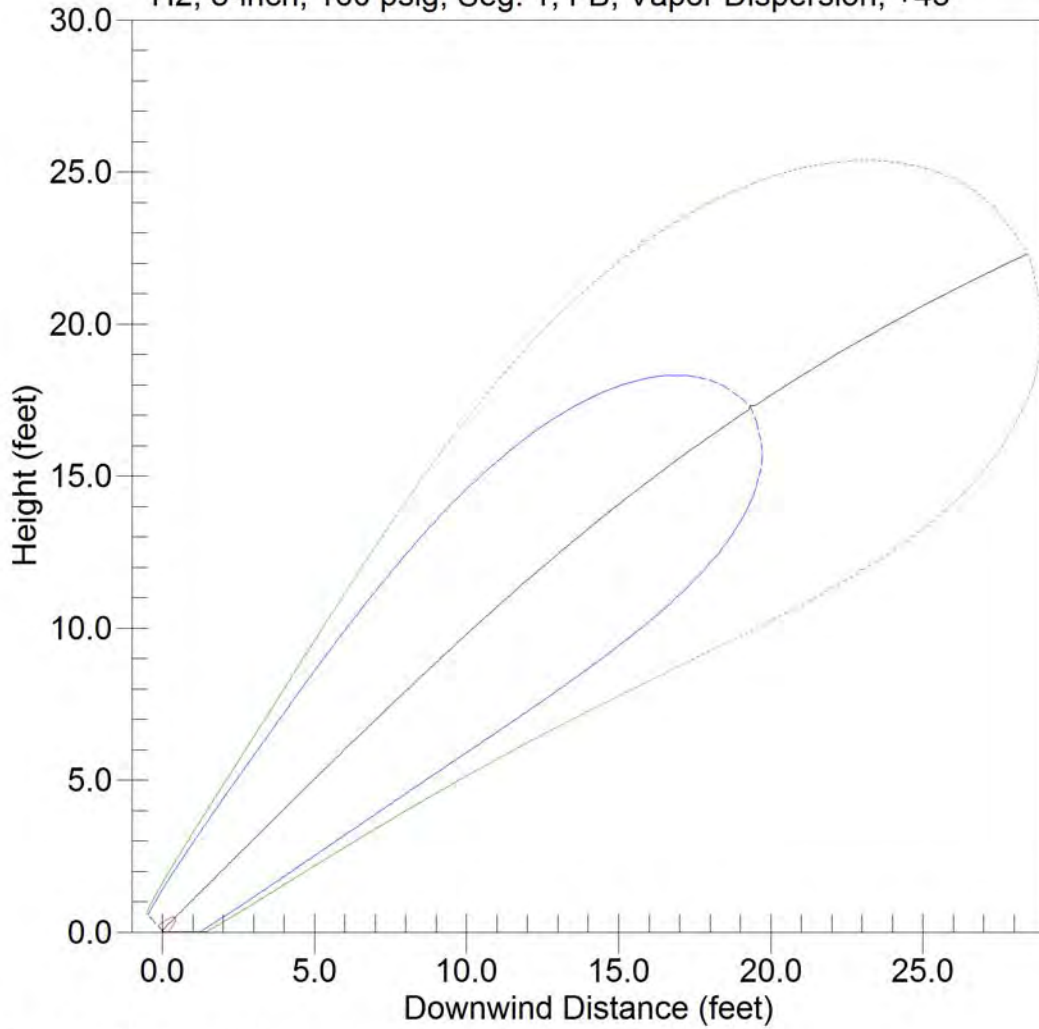


- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=8DFB160S1+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:32:23 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°

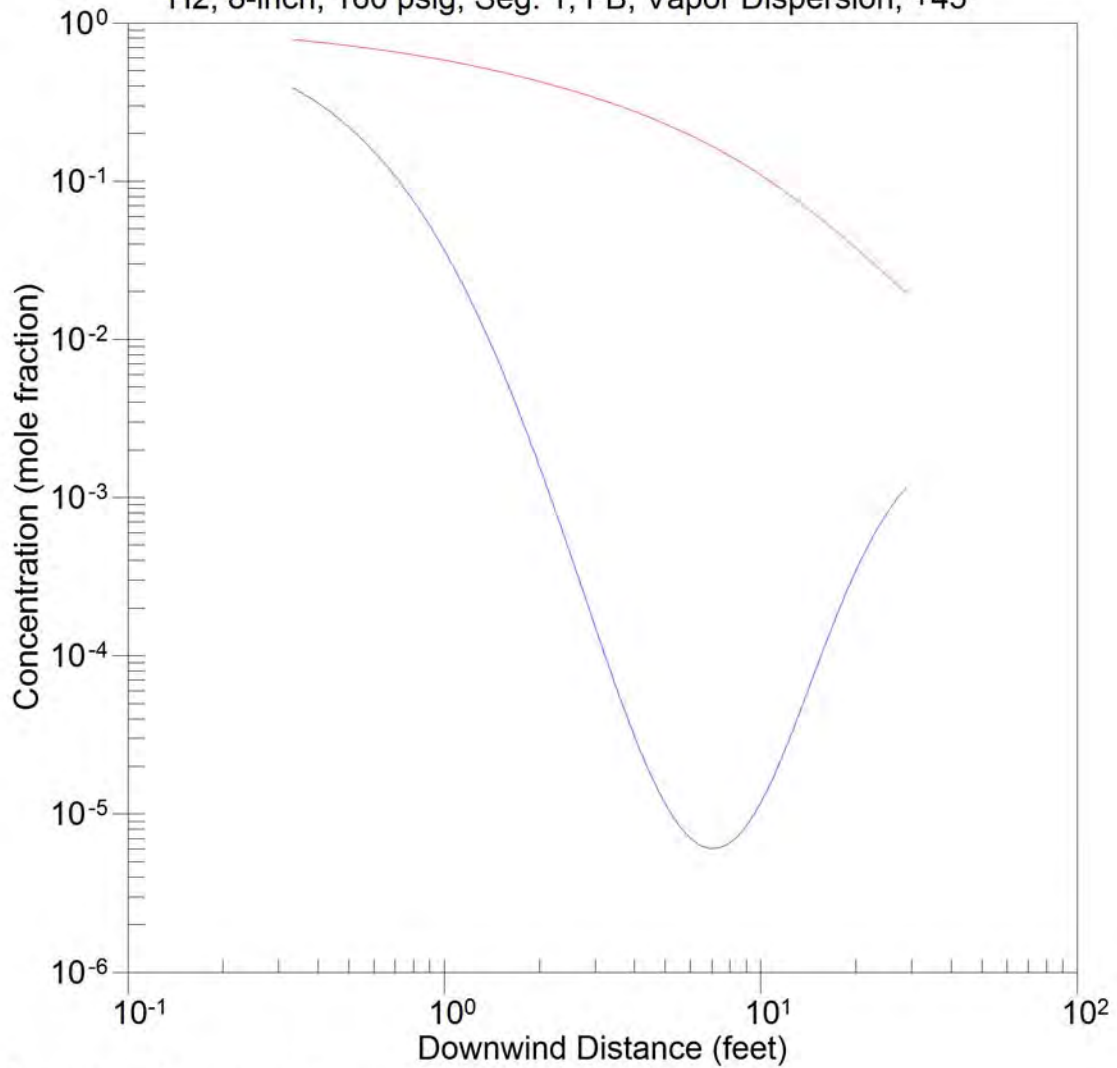


- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=8DFB160S1+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:32:23 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION vs. DISTANCE
H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°



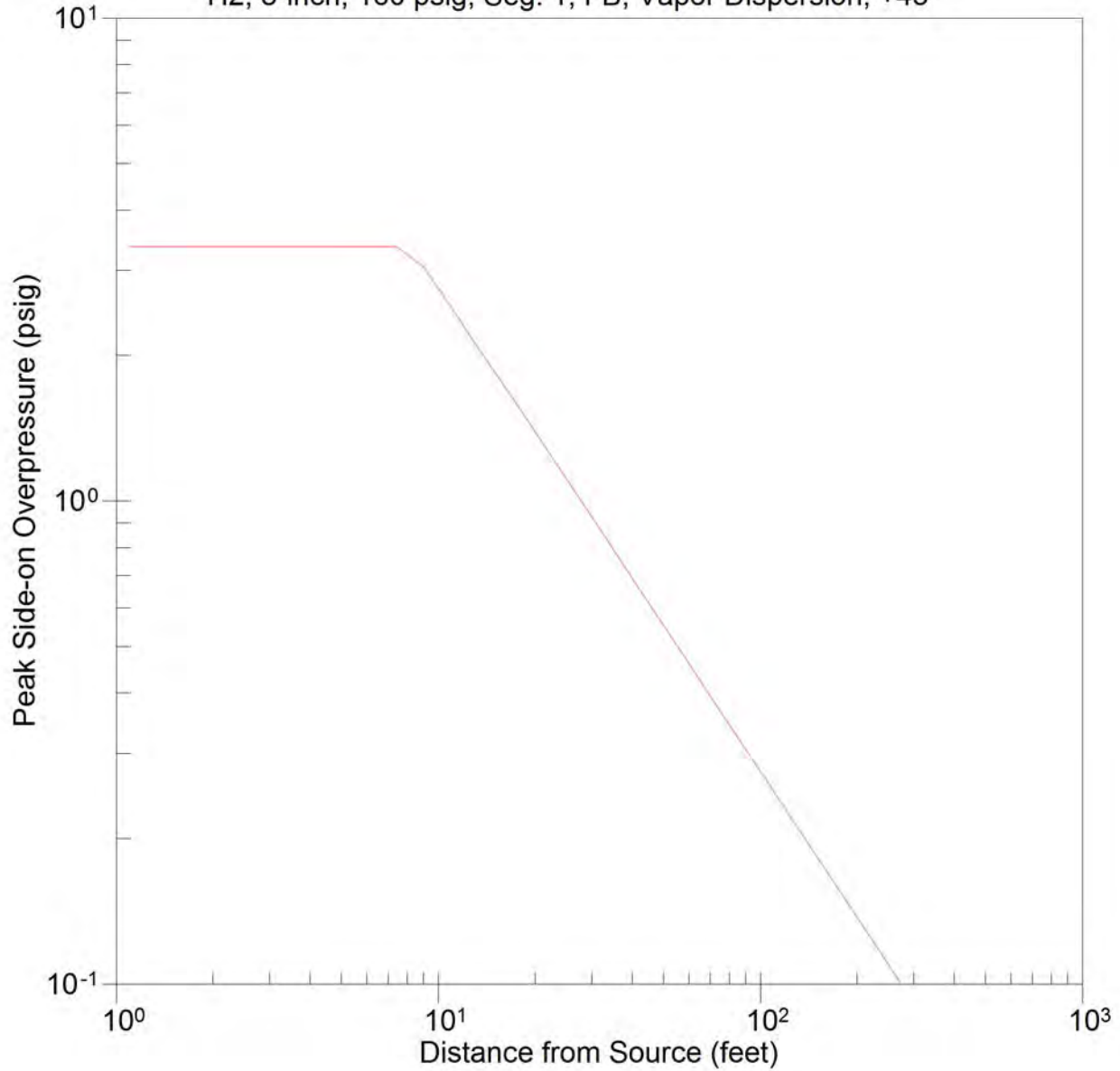
— Centerline Concentration
— Ground Level Concentration

casename=8DFB160S1+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:32:23 2020

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, +45°



CANARY by Quest

casename=8DFB160S1+45_7MMSCFD
Thu Jan 23 14:32:23 2020

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|               Case Name - 8DFB160S1-45_7MMSCFD             |
|               Thu Jan 23 14:37:41 2020                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, -45°

```

Case Type       : Vapor Dispersion
Case Name      : 8DFB160S1-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: 7MMSCFD, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity        0.22 Btu/lb-F
Substrate delay time           0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|                                     |
| CANARY by Quest - Version 4.6.2    |
| CANARY Case Input                  |
| Case Name - 8DFB160S1-45_7MMSCFD  |
| Thu Jan 23 14:37:41 2020          |
|                                     |
+-----+

```

Page 2 Title: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, -45°

RELEASE MENU

Type of release: Unregulated, Continuous release
 Release duration 120 min
 Normal flow rate 0.43 lb/sec
 Duration of normal flow 5 min
 Volume of vessel 0.00 cu.ft
 Pipe inner diameter 7.98 inches
 Equivalent release diameter 7.98 inches
 Pipe length upstream of break 1464.0 feet
 Pipe length downstream of break 1464.0 feet
 Height of release point 0.0 feet
 Angle of release from horizontal 135.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation, dispersion and cloud explosion - Flammable calculation
 Concentration endpoint 1 UFL mol%
 Concentration endpoint 2 LFL mol%
 Concentration endpoint 3 1/2 LFL mol%

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

Fuel reactivity High
 Obstacle density Low
 Flame expansion 3-D

Overpressure values

Overpressure endpoint 1 1.00 psi
 Overpressure endpoint 2 0.70 psi
 Overpressure endpoint 3 0.10 psi

NOTES:


```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 8DFB160S1-45_7MMSCFD
Thu Jan 23 14:37:41 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

TITLE: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	36.49405	0.000000	0.000000	36.49405
0.100000	19.71480	0.000000	0.000000	19.71480
0.300000	12.65382	0.000000	0.000000	12.65382
0.500000	8.853824	0.000000	0.000000	8.853824
0.700000	8.190311	0.000000	0.000000	8.190311
1.000000	7.291034	0.000000	0.000000	7.291034
3.000000	3.352031	0.000000	0.000000	3.352031
5.000000	1.568995	0.000000	0.000000	1.568995
7.000000	.7740961	0.000000	0.000000	.7740961
10.00000	.4514938	0.000000	0.000000	.4514938
20.00000	.4312341	0.000000	0.000000	.4312341
30.00000	.4312341	0.000000	0.000000	.4312341
40.00000	.4312341	0.000000	0.000000	.4312341
50.00000	.4312341	0.000000	0.000000	.4312341
60.00000	.4312341	0.000000	0.000000	.4312341
70.00000	.4312341	0.000000	0.000000	.4312341
85.00000	.4312341	0.000000	0.000000	.4312341
100.0000	.4312341	0.000000	0.000000	.4312341
200.0000	.4312341	0.000000	0.000000	.4312341
300.0000	.4312341	0.000000	0.000000	.4312341
315.3235	0.000000	0.000000	0.000000	0.000000
Totals (lb)	160.3842	0.000000	0.000000	160.3842

Flowrate for Torch Fire [immediate ignition] = 0.8658726 lb/sec.
Torch Fire [delayed ignition] = 0.4312341 lb/sec.

Reason for Ending: No Mass Left in System


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions               |
|           Case Name - 8DFB160S1-45_7MMSCFD         |
|           Thu Jan 23 14:37:41 2020                 |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com           canary@questconsult.com |
|           telephone (405) 329-7475           fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, -45°

Component Number Component Name, Formula

```

-----
51      Hydrogen(equilibrium), H2
43      Carbon Monoxide, CO
17      Carbon Dioxide, CO2
1      Methane, CH4
299     pseudo Water, H2O
28      Oxygen, O2

```

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 8DFB160S1-45_7MMSCFD                     |
|      Thu Jan 23 14:37:41 2020                               |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

TITLE: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.7	0.7	0.2	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is      0.00 ft after about      2 seconds
The downwind distance to c2 is      0.00 ft after about      2 seconds
The downwind distance to c1 is      0.00 ft after about      2 seconds

```

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
| Momentum Jet Vapor Cloud Explosion                |
| Case Name - 8DFB160S1-45_7MMSCFD                |
| Thu Jan 23 14:37:41 2020                          |
| Quest Consultants Inc., Norman, Oklahoma, USA      |
| www.questconsult.com          canary@questconsult.com |
| telephone (405) 329-7475      fax (405) 329-7734   |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, -45°

```

Fuel Reactivity: High          Obstacle Density: Low
Flame Expansion: 3-D           Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.398385 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0406
2.0	3.36	0.0406
2.4	3.36	0.0406
2.9	3.36	0.0406
3.4	3.36	0.0355
4.2	3.36	0.0295
5.0	3.36	0.0246
6.1	3.36	0.0204
7.3	3.36	0.0170
8.8	3.07	0.0141
10.7	2.55	0.0117
12.9	2.12	0.0098
15.5	1.76	0.0081
18.8	1.46	0.0068
22.6	1.21	0.0056
27.3	1.00	0.0047
33.0	0.83	0.0039
39.8	0.69	0.0032
48.0	0.57	0.0027
58.0	0.47	0.0022
70.0	0.39	0.0019
84.5	0.32	0.0015
102.0	0.27	0.0013
123.1	0.22	0.0011
270.3	0.10	0.0005

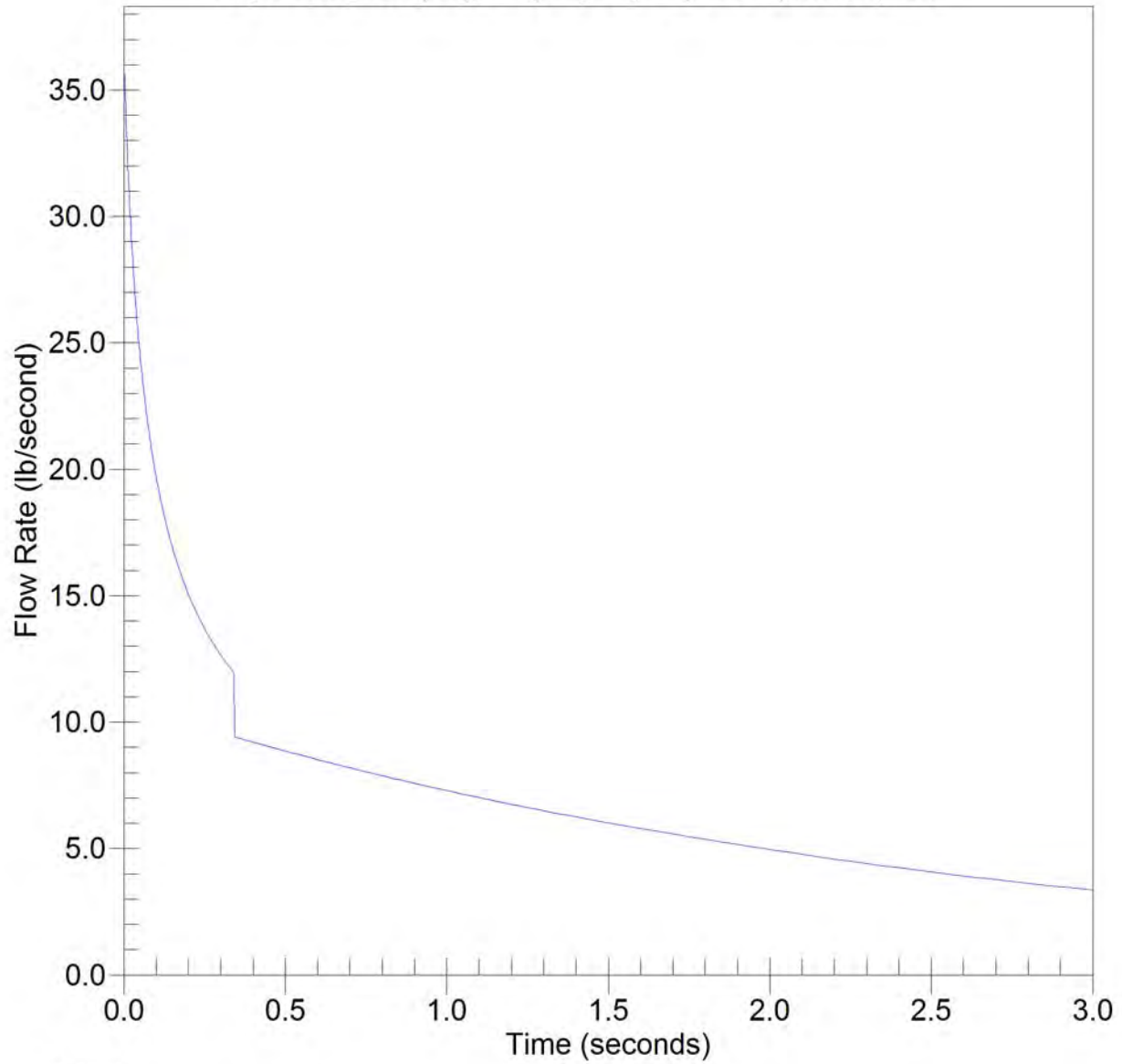
```

The downwind distance to dp3 is 27.4 feet
The downwind distance to dp2 is 39.2 feet
The downwind distance to dp1 is 270.3 feet

```

MASS RELEASE RATE

H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, -45°



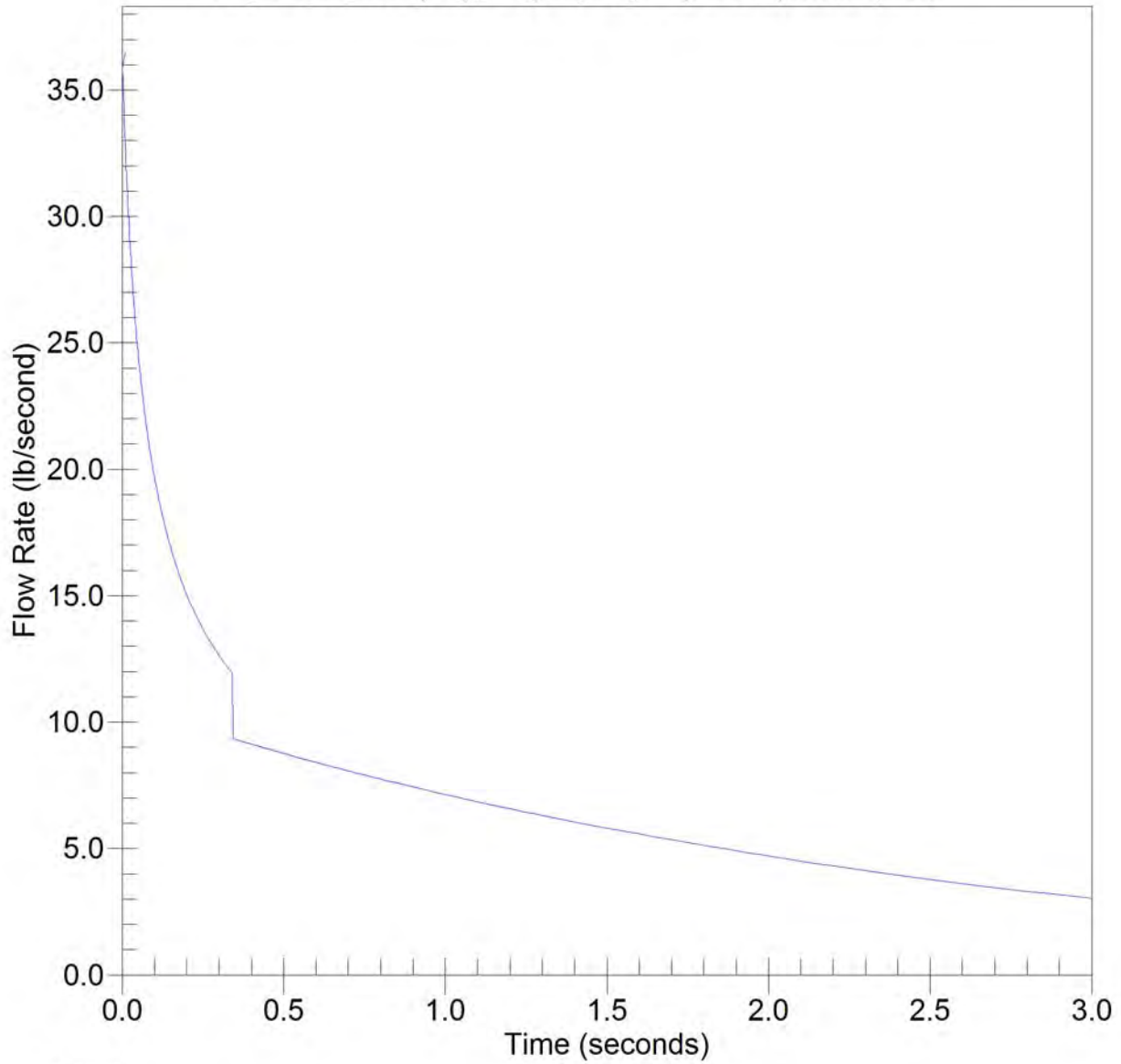
— Total
— Vapor

CANARY by Quest

casename=8DFB160S1-45_7MMSCFD
Thu Jan 23 14:37:41 2020

MASS RELEASE RATE - DOWNSTREAM PIPING

H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, -45°

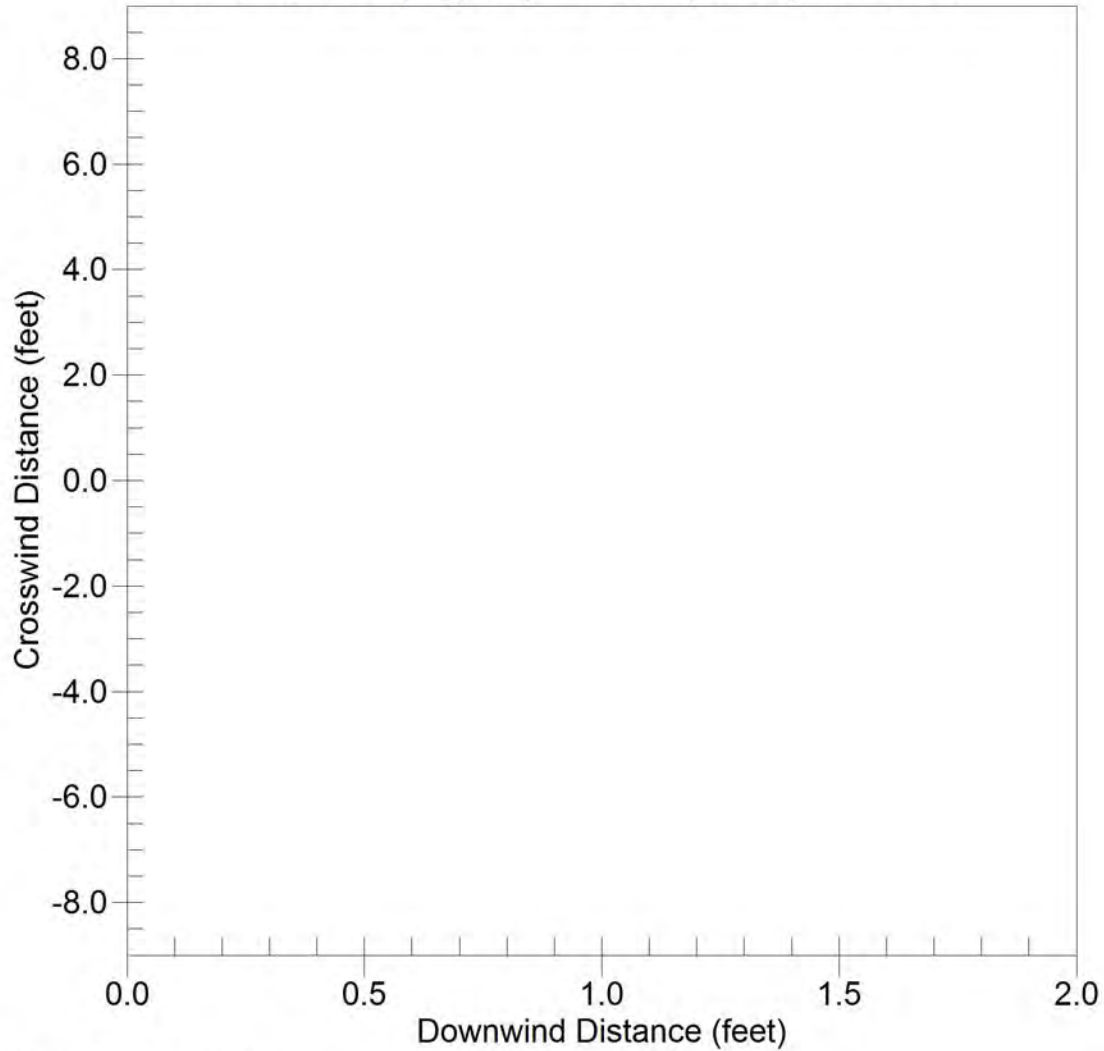


— Total
— Vapor

CANARY by Quest

casename=8DFB160S1-45_7MMSCFD
Thu Jan 23 14:37:41 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, -45°

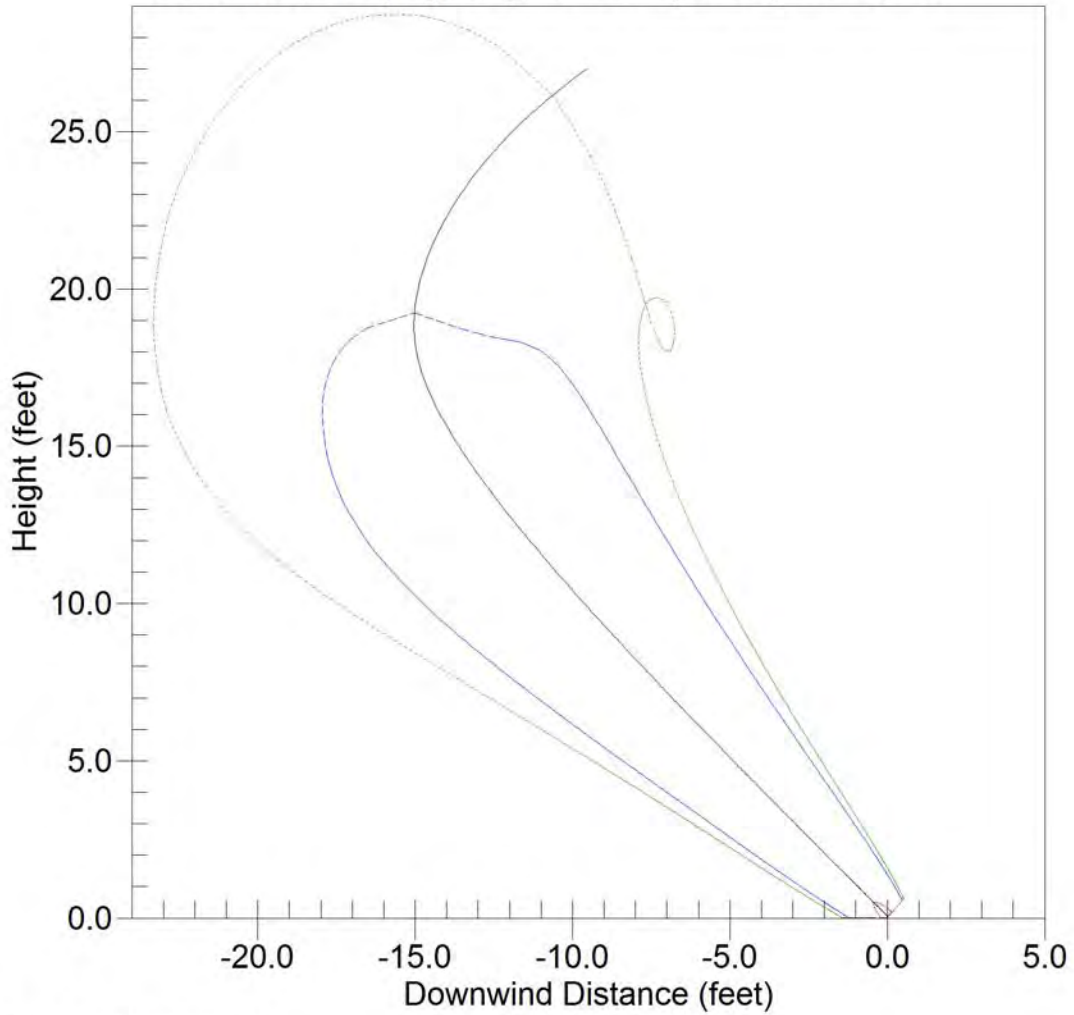


- 75.0 mole percent
- 4.00 mole percent
- 2.00 mole percent

casename=8DFB160S1-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:37:41 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, -45°



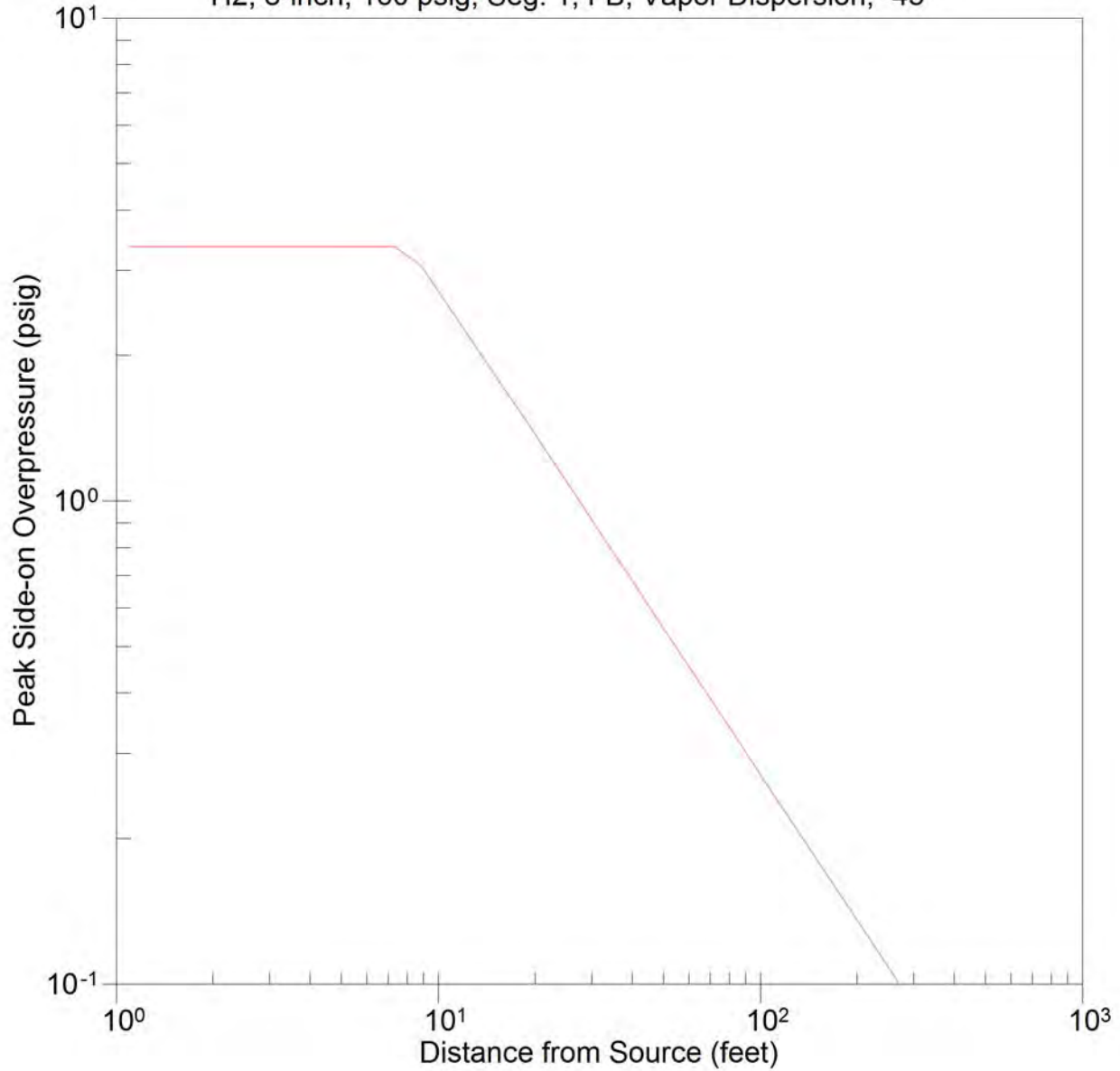
- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=8DFB160S1-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:37:41 2020

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 8-inch, 160 psig, Seg. 1, FB, Vapor Dispersion, -45°



CANARY by Quest

casename=8DFB160S1-45_7MMSCFD
Thu Jan 23 14:37:41 2020

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|               Case Name - 8D1IN160S1+45_7MMSCFD           |
|               Thu Jan 23 14:36:19 2020                    |
|               Quest Consultants Inc., Norman, Oklahoma, USA |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

```

Case Type       : Vapor Dispersion
Case Name      : 8D1IN160S1+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: 7MMSCFD, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	: 51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	: 43	= CO	Carbon Monoxide	0.000010
Component 3	: 17	= CO2	Carbon Dioxide	0.000010
Component 4	: 1	= CH4	Methane	0.000010
Component 5	: 299	= H2O	Psuedo Water	0.000020
Component 6	: 28	= O2	Oxygen	0.000005
Component 7	:			
Component 8	:			
Component 9	:			
Component 10	:			

```

Temperature      :      70.00 °F
Pressure         :      160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity       0.22 Btu/lb-F
Substrate delay time          0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 8D1IN160S1+45_7MMSCFD |
| Thu Jan 23 14:36:19 2020 |
|               |
+-----+

```

Page 2 Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration                120 min
Normal flow rate                0.43 lb/sec
Duration of normal flow        5 min
Volume of vessel                0.00 cu.ft
Pipe inner diameter            7.98 inches
Equivalent release diameter     1.00 inches
Pipe length upstream of break  1464.0 feet
Height of release point        0.0 feet
Angle of release from horizontal 45.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1      UFL mol%
Concentration endpoint 2      LFL mol%
Concentration endpoint 3      1/2 LFL mol%

```

```

Dispersion coefficient averaging time      1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity                High
Obstacle density               Low
Flame expansion                 3-D

```

Overpressure values

```

Overpressure endpoint 1      1.00 psi
Overpressure endpoint 2      0.70 psi
Overpressure endpoint 3      0.10 psi

```

NOTES:

```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 8D1IN160S1+45_7MMSCFD
Thu Jan 23 14:36:19 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

TITLE: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.5730355	0.000000	0.000000	.5730355
0.100000	.5729098	0.000000	0.000000	.5729098
0.300000	.5727392	0.000000	0.000000	.5727392
0.500000	.5713120	0.000000	0.000000	.5713120
0.700000	.5707660	0.000000	0.000000	.5707660
1.000000	.5699511	0.000000	0.000000	.5699511
3.000000	.5646367	0.000000	0.000000	.5646367
5.000000	.5595234	0.000000	0.000000	.5595234
7.000000	.5546045	0.000000	0.000000	.5546045
10.00000	.5475735	0.000000	0.000000	.5475735
20.00000	.5268441	0.000000	0.000000	.5268441
30.00000	.5098019	0.000000	0.000000	.5098019
40.00000	.4957713	0.000000	0.000000	.4957713
50.00000	.4842204	0.000000	0.000000	.4842204
60.00000	.4747185	0.000000	0.000000	.4747185
70.00000	.4669041	0.000000	0.000000	.4669041
85.00000	.4576739	0.000000	0.000000	.4576739
100.0000	.4508336	0.000000	0.000000	.4508336
200.0000	.4338263	0.000000	0.000000	.4338263
300.0000	.4315389	0.000000	0.000000	.4315389
400.0000	.3854504E-01	0.000000	0.000000	.3854504E-01
414.5701	0.000000	0.000000	0.000000	0.000000
Totals (lb)	157.3986	0.000000	0.000000	157.3986

Flowrate for Torch Fire [immediate ignition] = 0.5143903 lb/sec.
Torch Fire [delayed ignition] = 0.4388613 lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions             |
|           Case Name - 8D1IN160S1+45_7MMSCFD      |
|           Thu Jan 23 14:36:19 2020              |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com                   |
|           telephone (405) 329-7475               |
|           canary@questconsult.com                 |
|           fax (405) 329-7734                     |
|                                     |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 8D1IN160S1+45_7MMSCFD                    |
|      Thu Jan 23 14:36:19 2020                               |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

TITLE: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.2	0.2	0.1	0.1
0.5	0.498011	0.000087	0.3	0.3	0.0	0.6
1.0	0.356052	0.000000	0.5	0.4	0.0	1.1
1.5	0.280482	0.000000	0.6	0.5	0.0	1.6
2.0	0.232201	0.000000	0.6	0.5	0.0	2.1
2.5	0.198302	0.000000	0.7	0.6	0.0	2.6
3.0	0.173116	0.000000	0.8	0.7	0.0	3.1
3.5	0.153358	0.000000	0.9	0.7	0.0	3.6
4.0	0.137632	0.000000	1.0	0.8	0.0	4.1
4.5	0.124490	0.000000	1.0	0.8	0.0	4.6
5.0	0.113562	0.000000	1.1	0.9	0.0	5.1
5.5	0.104104	0.000000	1.2	0.9	0.0	5.6
6.0	0.096038	0.000000	1.2	0.9	0.0	6.1
6.5	0.088970	0.000000	1.3	0.9	0.0	6.6
7.0	0.082711	0.000000	1.4	1.0	0.0	7.1
7.5	0.077151	0.000000	1.4	1.0	0.0	7.5
8.0	0.072192	0.000000	1.5	1.0	0.0	8.0
8.5	0.067714	0.000000	1.5	1.0	0.0	8.5
9.0	0.063678	0.000000	1.6	1.0	0.0	9.0
9.5	0.059997	0.000000	1.6	1.0	0.0	9.5
10.0	0.056635	0.000000	1.7	1.0	0.0	10.0
10.5	0.053574	0.000000	1.7	0.9	0.0	10.5
11.0	0.050731	0.000000	1.8	0.9	0.0	11.0
11.5	0.048117	0.000000	1.8	0.8	0.0	11.5
12.0	0.045702	0.000000	1.9	0.7	0.0	12.0
12.5	0.043465	0.000000	1.9	0.6	0.0	12.5
13.0	0.041377	0.000000	1.9	0.4	0.0	13.0
13.5	0.039446	0.000000	1.9	0.0	0.0	13.4
14.0	0.037613	0.000000	2.0	0.0	0.0	13.9
14.5	0.035923	0.000000	2.0	0.0	0.0	14.4
15.0	0.034320	0.000000	2.0	0.0	0.0	14.9
15.5	0.032823	0.000000	2.0	0.0	0.0	15.4
16.0	0.031425	0.000000	2.0	0.0	0.0	15.9
16.5	0.030088	0.000000	2.0	0.0	0.0	16.3
17.0	0.028856	0.000000	1.9	0.0	0.0	16.8

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
17.5	0.027670	0.000000	1.9	0.0	0.0	17.3
18.0	0.026549	0.000000	1.8	0.0	0.0	17.8
18.5	0.025509	0.000000	1.8	0.0	0.0	18.2
19.0	0.024502	0.000000	1.7	0.0	0.0	18.7
19.5	0.023555	0.000000	1.6	0.0	0.0	19.2
20.0	0.022662	0.000000	1.4	0.0	0.0	19.6
20.5	0.021807	0.000000	1.2	0.0	0.0	20.1
21.0	0.020992	0.000000	0.9	0.0	0.0	20.5
21.5	0.020223	0.000000	0.5	0.0	0.0	21.0

The downwind distance to c3 is 0.13 ft after about 0 seconds
The downwind distance to c2 is 13.35 ft after about 0 seconds
The downwind distance to c1 is 21.65 ft after about 0 seconds


```

+-----+
|               CANARY by Quest - Version 4.6.2               |
| Momentum Jet Vapor Cloud Explosion                          |
| Case Name - 8D1IN160S1+45_7MMSCFD                          |
| Thu Jan 23 14:36:19 2020                                    |
| Quest Consultants Inc., Norman, Oklahoma, USA                |
| www.questconsult.com          canary@questconsult.com        |
| telephone (405) 329-7475      fax (405) 329-7734            |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

Fuel Reactivity: High Obstacle Density: Low
 Flame Expansion: 3-D Flame Speed: 0.36

Overpressure levels:

```

-----
dp3 =        1.00 psi gauge
dp2 =        0.70 psi gauge
dp1 =        0.10 psi gauge

```

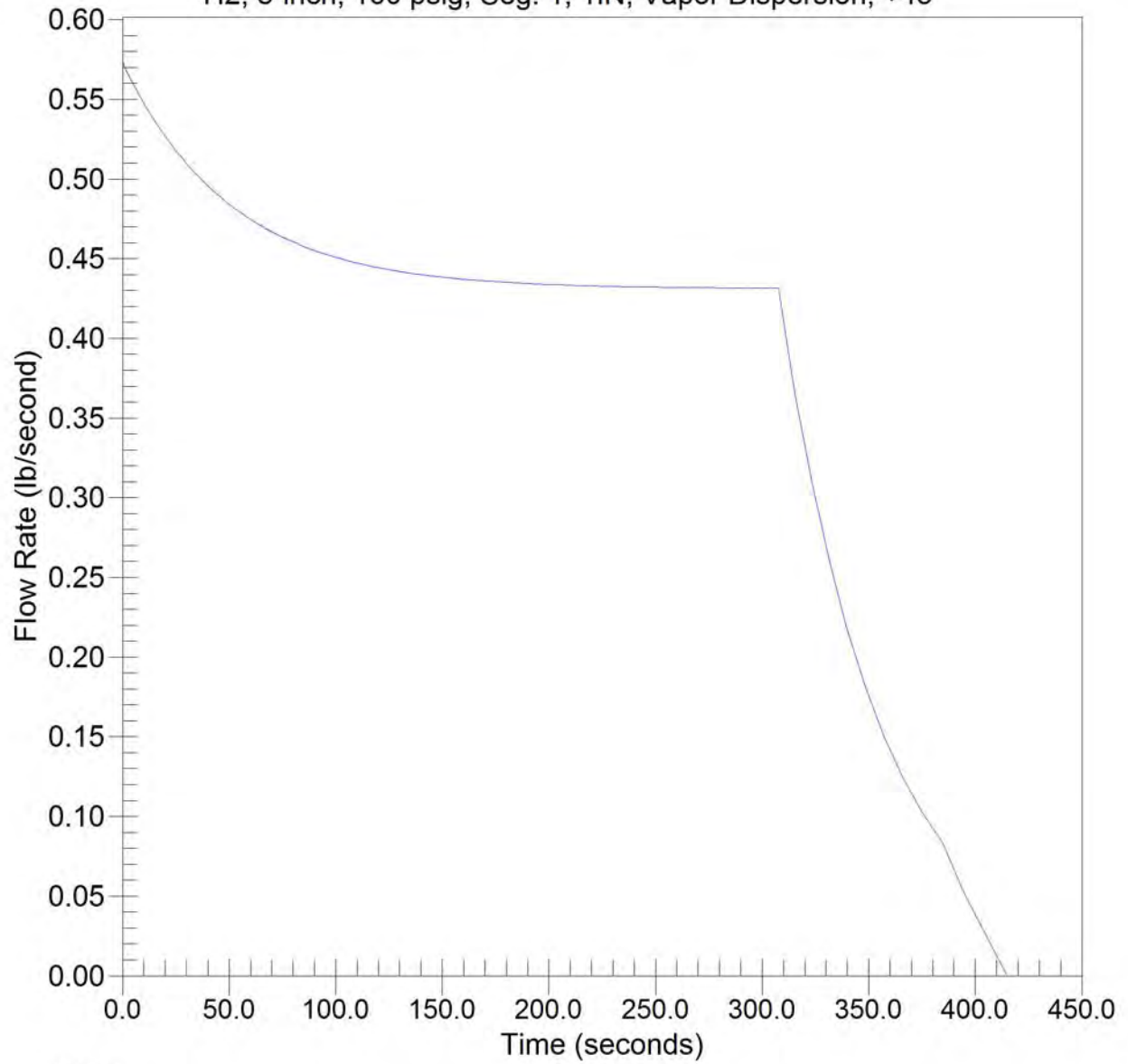
Mass of released material in explosive range: 0.0266759 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0165
0.8	3.36	0.0165
0.9	3.36	0.0165
1.1	3.36	0.0165
1.2	3.36	0.0161
1.4	3.36	0.0139
1.7	3.36	0.0120
2.0	3.36	0.0104
2.3	3.36	0.0090
2.6	3.36	0.0077
3.1	3.36	0.0067
3.6	3.09	0.0058
4.1	2.67	0.0050
4.8	2.30	0.0043
5.6	1.99	0.0037
6.5	1.71	0.0032
7.5	1.48	0.0028
8.7	1.27	0.0024
10.2	1.10	0.0021
11.8	0.94	0.0018
13.7	0.81	0.0015
15.9	0.70	0.0013
18.5	0.60	0.0011
21.5	0.52	0.0010
109.8	0.10	0.0002

The downwind distance to dp3 is 11.2 feet
 The downwind distance to dp2 is 15.9 feet
 The downwind distance to dp1 is 109.8 feet

MASS RELEASE RATE

H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

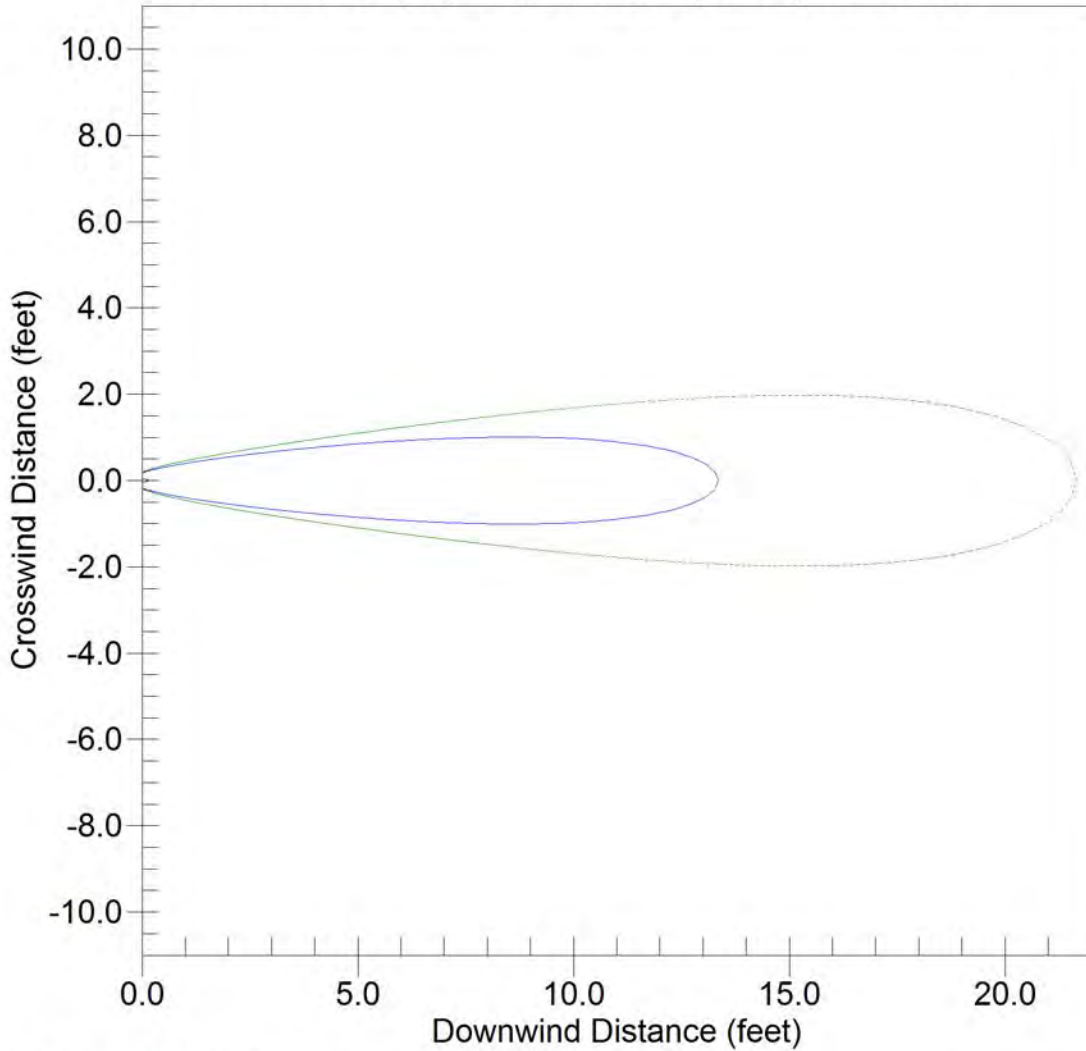


— Total
— Vapor

CANARY by Quest

casename=8D1IN160S1+45_7MMSCFD
Thu Jan 23 14:36:19 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, +45°

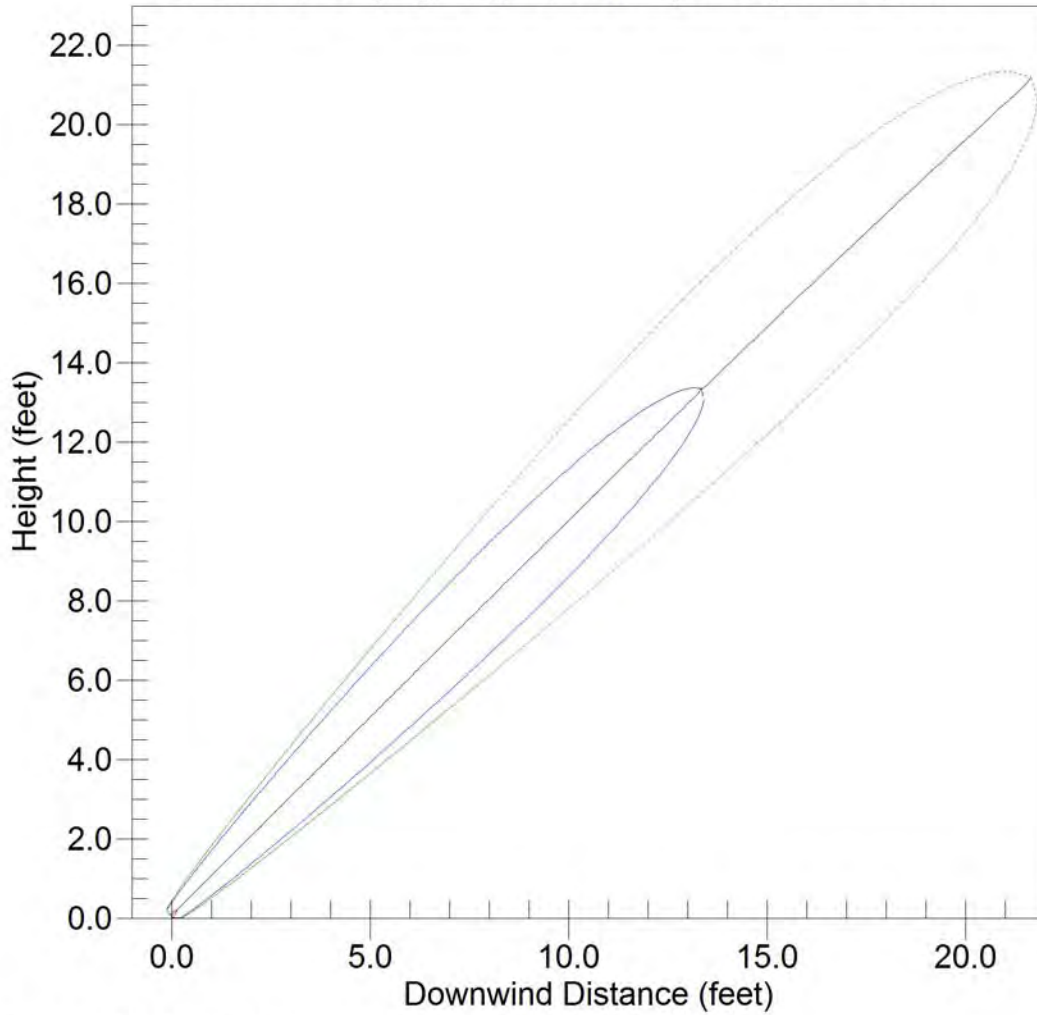


- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=8D1IN160S1+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:36:19 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, +45°



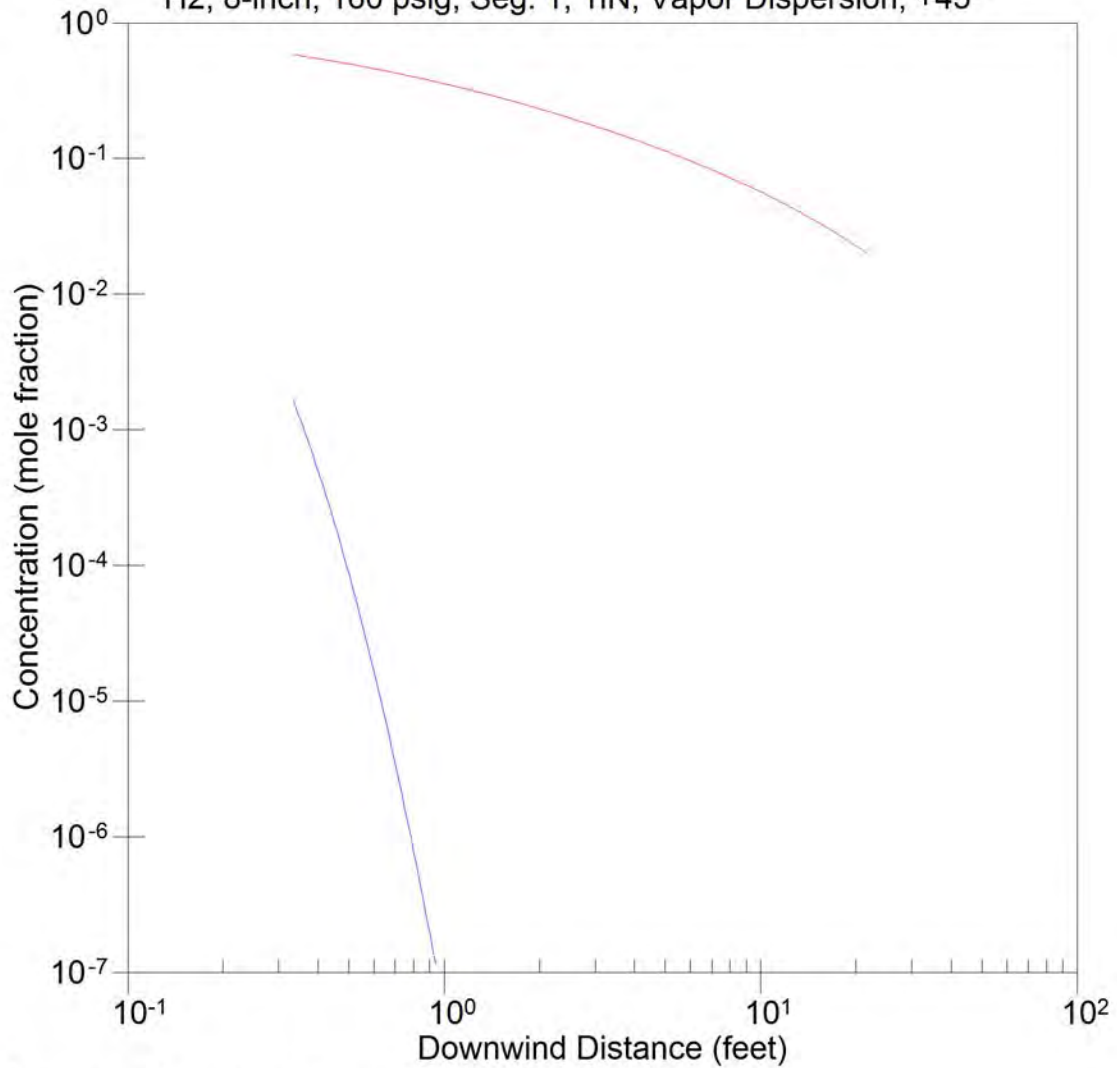
- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=8D1IN160S1+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:36:19 2020

CANARY by Quest

Momentum Jet Cloud CONCENTRATION vs. DISTANCE

H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, +45°



— Centerline Concentration
— Ground Level Concentration

casename=8D1IN160S1+45_7MMSCFD

windspeed = 4.5 mph

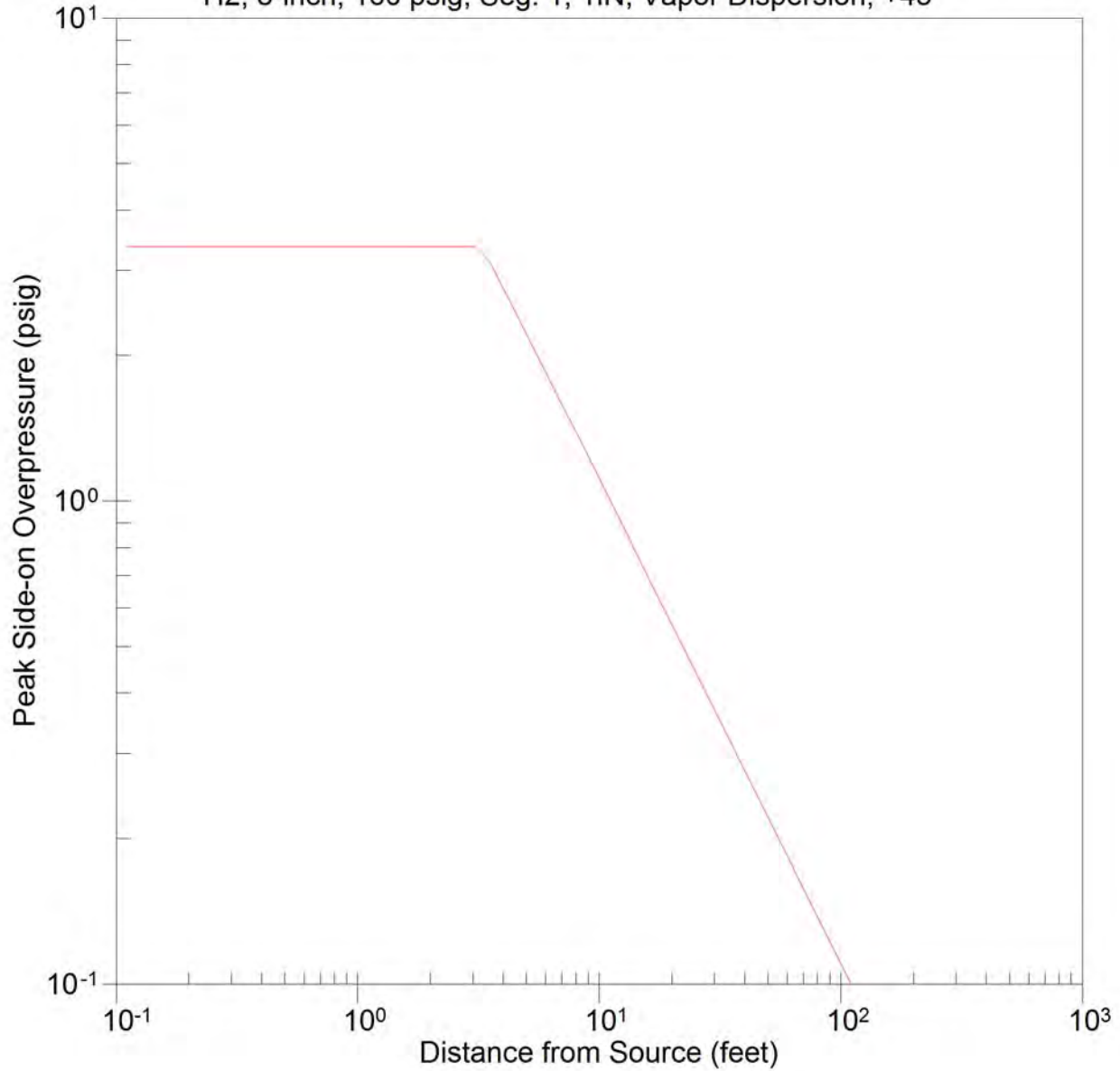
D stability

Thu Jan 23 14:36:19 2020

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, +45°



CANARY by Quest

casename=8D1IN160S1+45_7MMSCFD
Thu Jan 23 14:36:19 2020

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 8D1IN160S1-45_7MMSCFD                 |
|           Thu Jan 23 14:36:55 2020                         |
|   Quest Consultants Inc., Norman, Oklahoma, USA             |
| www.questconsult.com           canary@questconsult.com      |
| telephone (405) 329-7475       fax (405) 329-7734         |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

```

Case Type       : Vapor Dispersion
Case Name      : 8D1IN160S1-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: 7MMSCFD, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
  Substrate thermal conductivity 0.2698 Btu/hr-ft-F
  Substrate density              80 lb/cu.ft
  Substrate heat Capacity        0.22 Btu/lb-F
  Substrate delay time           0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 8D1IN160S1-45_7MMSCFD |
| Thu Jan 23 14:36:55 2020 |
|               |
+-----+

```

Page 2 Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration                120 min
Normal flow rate                0.43 lb/sec
Duration of normal flow        5 min
Volume of vessel                0.00 cu.ft
Pipe inner diameter            7.98 inches
Equivalent release diameter     1.00 inches
Pipe length upstream of break  1464.0 feet
Height of release point        0.0 feet
Angle of release from horizontal 135.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1      UFL mol%
Concentration endpoint 2      LFL mol%
Concentration endpoint 3      1/2 LFL mol%

```

```

Dispersion coefficient averaging time      1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity                High
Obstacle density               Low
Flame expansion                 3-D

```

Overpressure values

```

Overpressure endpoint 1        1.00 psi
Overpressure endpoint 2        0.70 psi
Overpressure endpoint 3        0.10 psi

```

NOTES:


```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 8D1IN160S1-45_7MMSCFD
Thu Jan 23 14:36:55 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

TITLE: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.5730355	0.000000	0.000000	.5730355
0.100000	.5729098	0.000000	0.000000	.5729098
0.300000	.5727392	0.000000	0.000000	.5727392
0.500000	.5713120	0.000000	0.000000	.5713120
0.700000	.5707660	0.000000	0.000000	.5707660
1.000000	.5699511	0.000000	0.000000	.5699511
3.000000	.5646367	0.000000	0.000000	.5646367
5.000000	.5595235	0.000000	0.000000	.5595235
7.000000	.5546046	0.000000	0.000000	.5546046
10.00000	.5475737	0.000000	0.000000	.5475737
20.00000	.5268444	0.000000	0.000000	.5268444
30.00000	.5098023	0.000000	0.000000	.5098023
40.00000	.4957718	0.000000	0.000000	.4957718
50.00000	.4842210	0.000000	0.000000	.4842210
60.00000	.4747191	0.000000	0.000000	.4747191
70.00000	.4669048	0.000000	0.000000	.4669048
85.00000	.4576746	0.000000	0.000000	.4576746
100.0000	.4508344	0.000000	0.000000	.4508344
200.0000	.4338272	0.000000	0.000000	.4338272
300.0000	.4315398	0.000000	0.000000	.4315398
400.0000	.3854525E-01	0.000000	0.000000	.3854525E-01
414.5701	0.000000	0.000000	0.000000	0.000000
Totals (lb)	157.3988	0.000000	0.000000	157.3988

Flowrate for Torch Fire [immediate ignition] = 0.5143906 lb/sec.
Torch Fire [delayed ignition] = 0.4388621 lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
|          Release Stream Compositions              |
|          Case Name - 8D1IN160S1-45_7MMSCFD      |
|          Thu Jan 23 14:36:55 2020               |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
|          www.questconsult.com                    |
|          telephone (405) 329-7475                |
|          canary@questconsult.com                 |
|          fax (405) 329-7734                      |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 8D1IN160S1-45_7MMSCFD                     |
|      Thu Jan 23 14:36:55 2020                               |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

TITLE: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance	centerline conc.	ground conc.	y(c1) 1/2 width	y(c2) 1/2 width	y(c3) 1/2 width	centerline height
x(ft)	c(mole frac.)	c(mole frac.)	(ft)	(ft)	(ft)	(ft)
0	1.000000	0.000000	0.2	0.2	0.1	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is 0.00 ft after about 0 seconds
The downwind distance to c2 is 0.00 ft after about 0 seconds
The downwind distance to c1 is 0.00 ft after about 0 seconds

```

```

+-----+
|           CANARY by Quest - Version 4.6.2           |
| Momentum Jet Vapor Cloud Explosion                 |
| Case Name - 8D1IN160S1-45_7MMSCFD                 |
| Thu Jan 23 14:36:55 2020                           |
| Quest Consultants Inc., Norman, Oklahoma, USA       |
| www.questconsult.com           canary@questconsult.com |
| telephone (405) 329-7475       fax (405) 329-7734   |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

```

Fuel Reactivity: High           Obstacle Density: Low
Flame Expansion: 3-D            Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.0270565 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0166
0.8	3.36	0.0166
0.9	3.36	0.0166
1.1	3.36	0.0166
1.3	3.36	0.0162
1.5	3.36	0.0140
1.7	3.36	0.0121
2.0	3.36	0.0104
2.3	3.36	0.0090
2.7	3.36	0.0078
3.1	3.36	0.0067
3.6	3.09	0.0058
4.2	2.66	0.0050
4.8	2.30	0.0043
5.6	1.98	0.0037
6.5	1.71	0.0032
7.6	1.48	0.0028
8.8	1.27	0.0024
10.2	1.09	0.0021
11.9	0.94	0.0018
13.8	0.81	0.0015
16.0	0.69	0.0013
18.6	0.60	0.0012
21.7	0.51	0.0010
110.3	0.10	0.0002

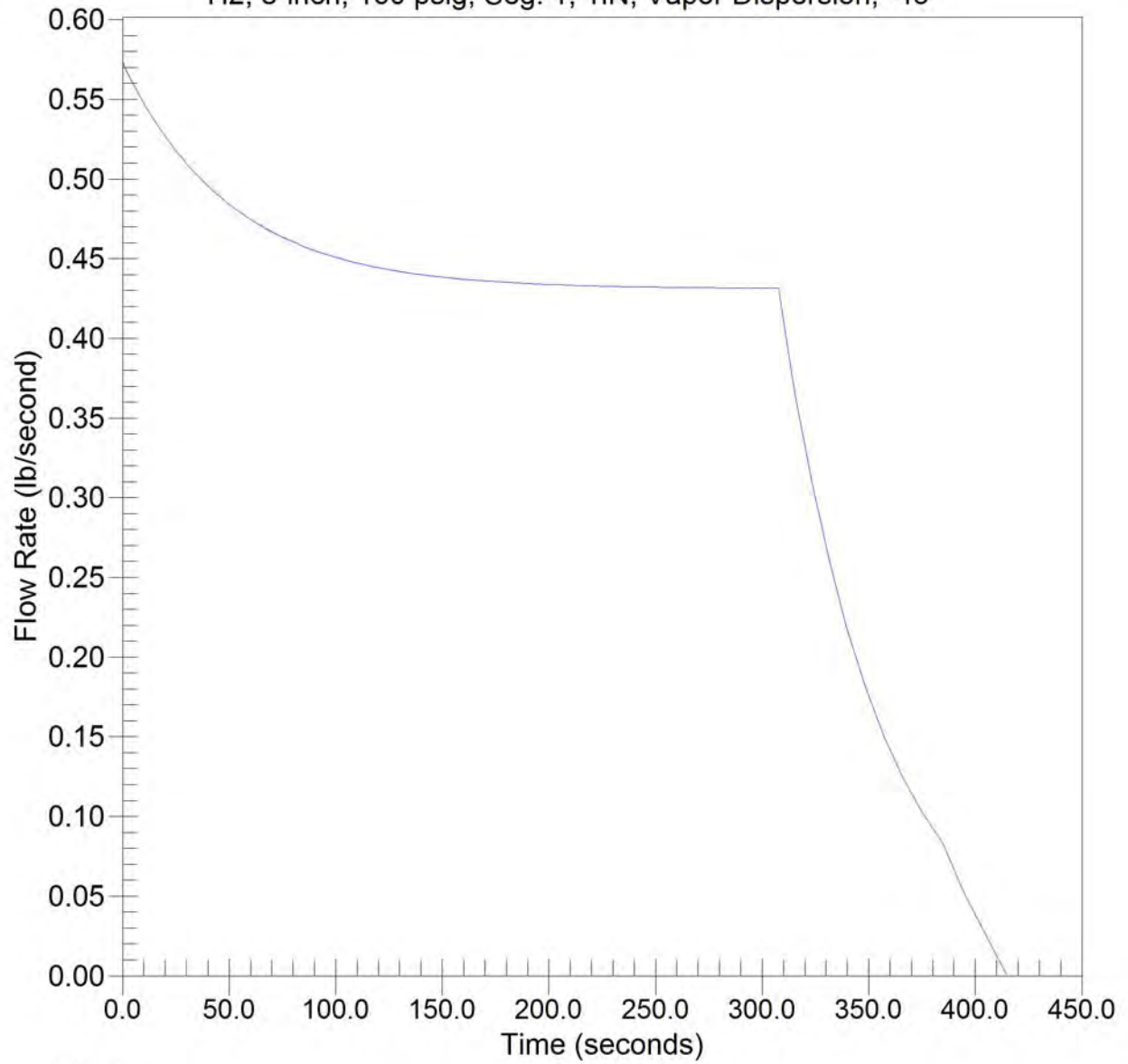
```

The downwind distance to dp3 is 11.2 feet
The downwind distance to dp2 is 15.9 feet
The downwind distance to dp1 is 110.3 feet

```

MASS RELEASE RATE

H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

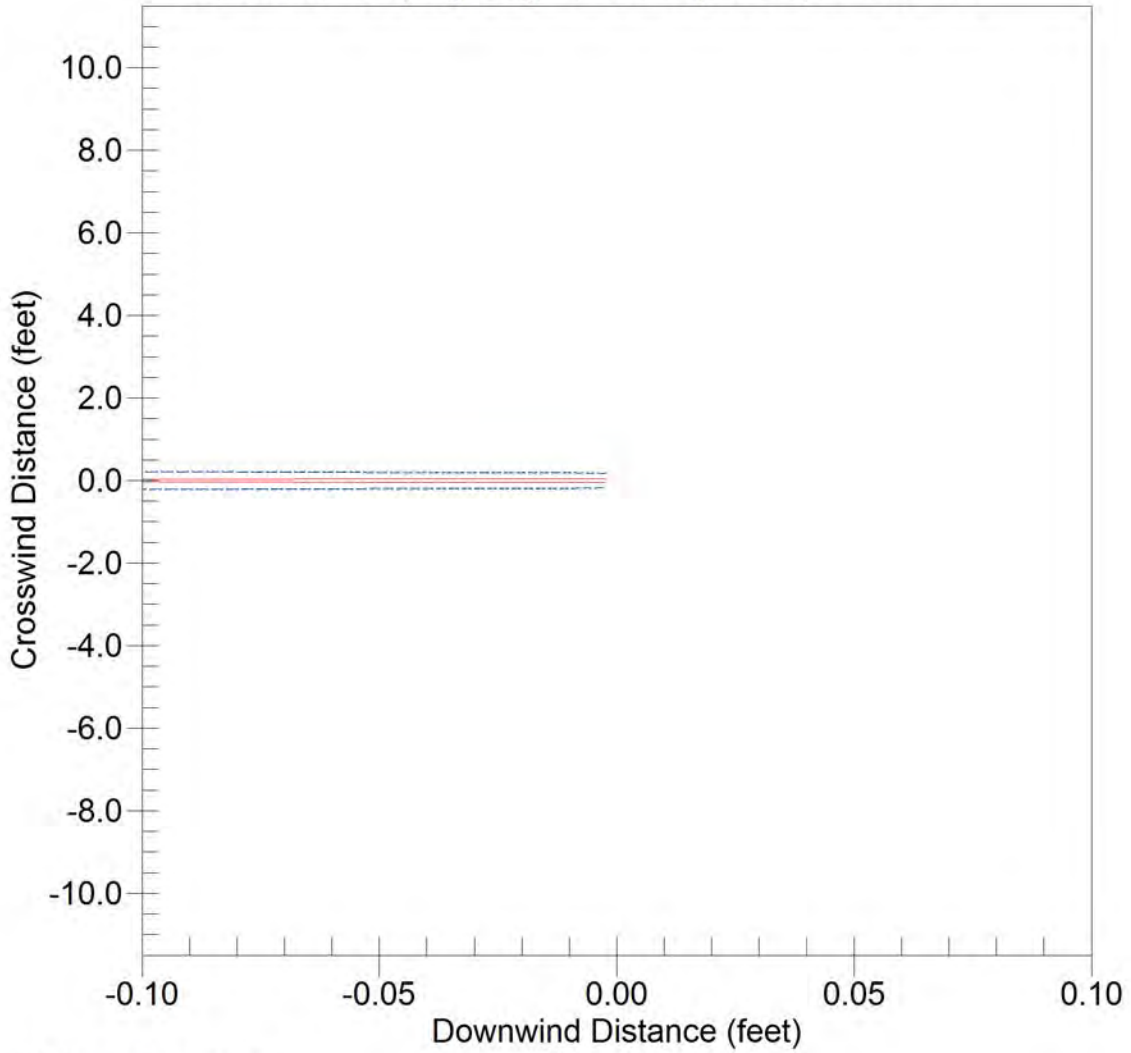


— Total
— Vapor

CANARY by Quest

casename=8D1IN160S1-45_7MMSCFD
Thu Jan 23 14:36:55 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, -45°

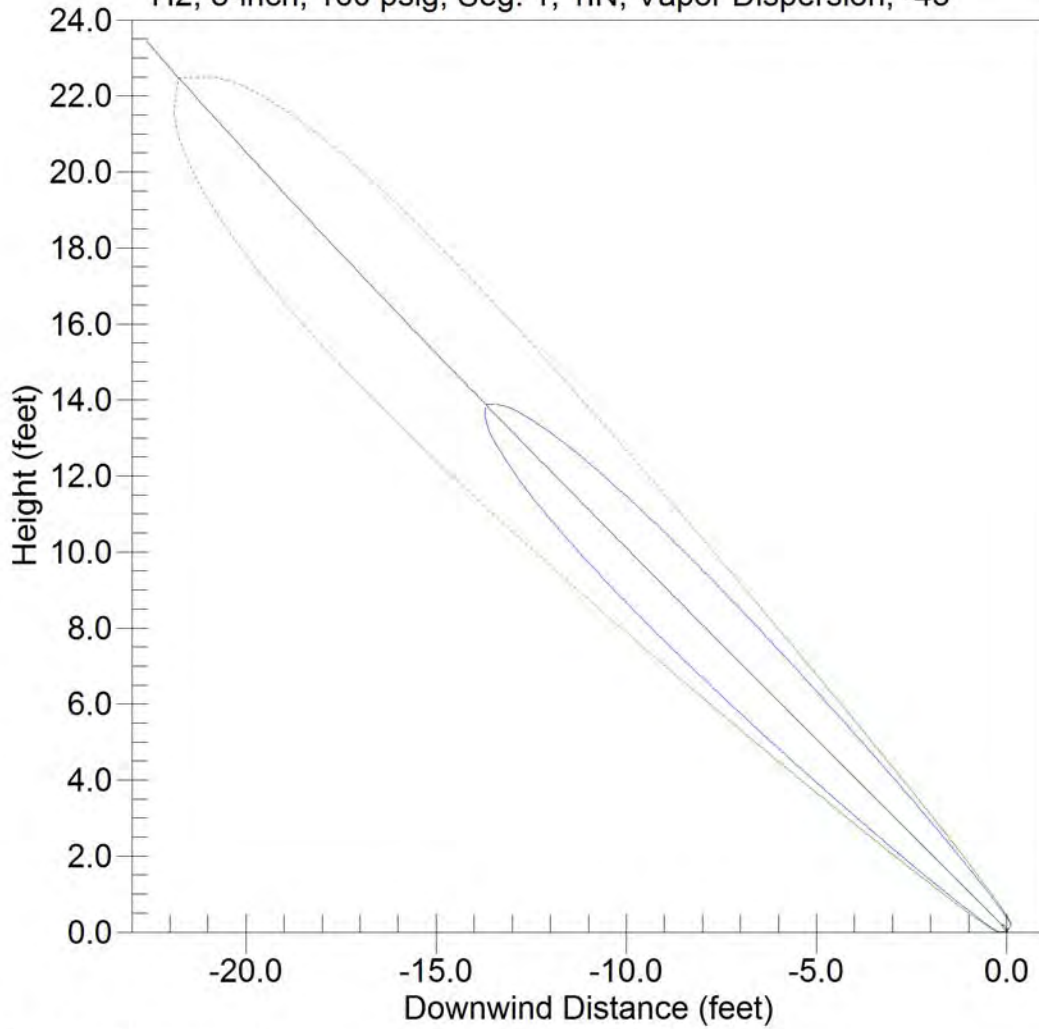


- 75.0 mole percent
- - 4.00 mole percent
- 2.00 mole percent

casename=8D1IN160S1-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:36:55 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, -45°



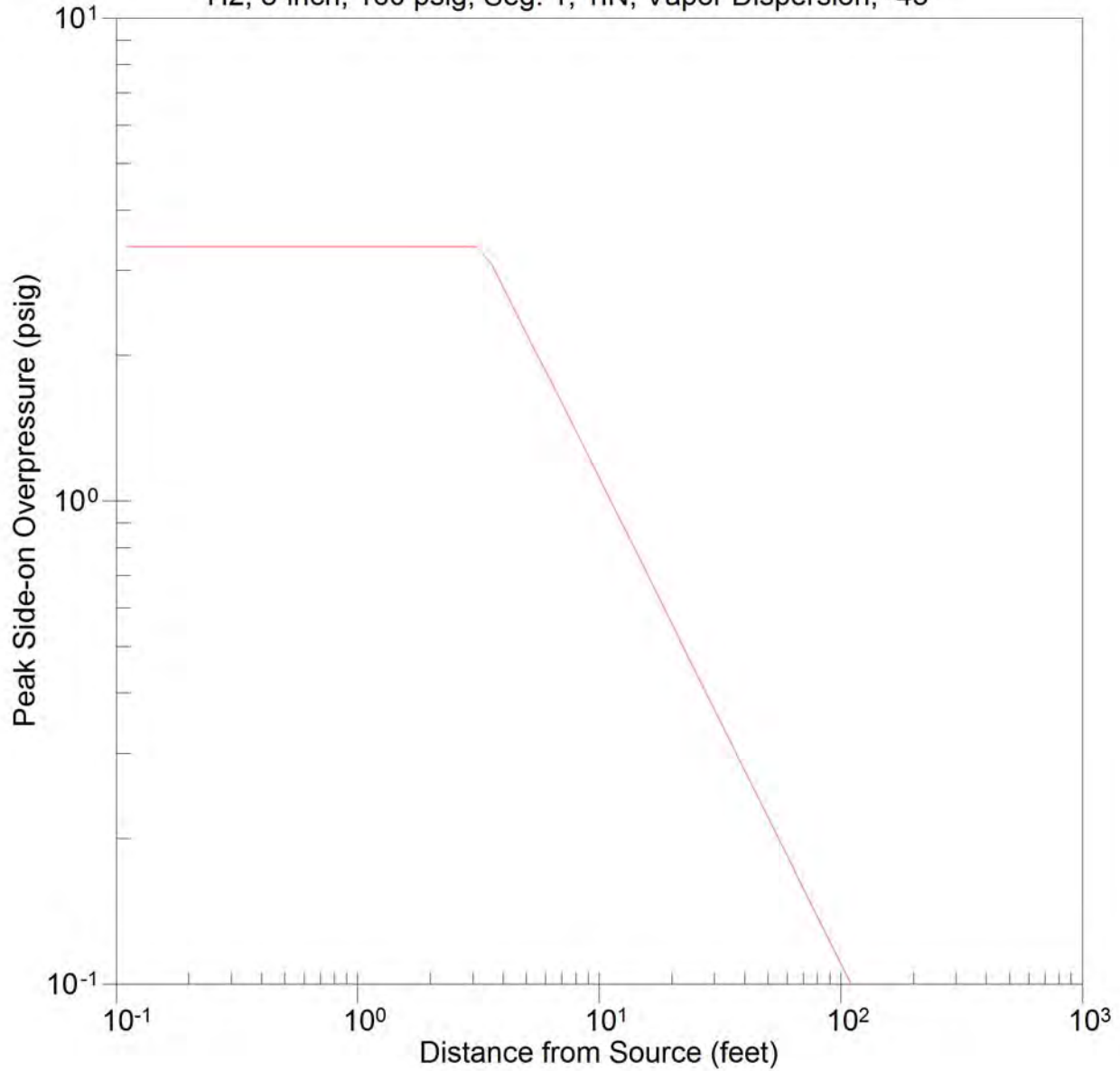
- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=8D1IN160S1-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:36:55 2020

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 8-inch, 160 psig, Seg. 1, 1IN, Vapor Dispersion, -45°



CANARY by Quest

casename=8D1IN160S1-45_7MMSCFD
Thu Jan 23 14:36:55 2020



Vapor Dispersion Modeling Results, Segment 2A

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 10D8IN160S2A+45_7MMSCFD     |
|           Thu Jan 23 14:55:23 2020                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

```

Case Type       : Vapor Dispersion
Case Name      : 10D8IN160S2A+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A - 8-inch Hole, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Psuedo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity        0.22 Btu/lb-F
Substrate delay time           0 sec
Surrounding terrain            Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|   CANARY Case Input                 |
| Case Name - 10D8IN160S2A+45_7MMSCFD |
|   Thu Jan 23 14:55:23 2020         |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration           120 min
Normal flow rate          0.43 lb/sec
Duration of normal flow   5 min
Volume of vessel          0.00 cu.ft
Pipe inner diameter       10.02 inches
Equivalent release diameter 8.00 inches
Pipe length upstream of break 20416.0 feet
Height of release point   0.0 feet
Angle of release from horizontal 45.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1          UFL mol%
Concentration endpoint 2          LFL mol%
Concentration endpoint 3          1/2 LFL mol%

```

```

Dispersion coefficient averaging time          1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity          High
Obstacle density         Low
Flame expansion          3-D

```

Overpressure values

```

Overpressure endpoint 1          1.00 psi
Overpressure endpoint 2          0.70 psi
Overpressure endpoint 3          0.10 psi

```

NOTES:

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               General Release Model UPSTREAM                 |
|               Case Name - 10D8IN160S2A+45_7MMSCFD          |
|               Thu Jan 23 14:55:23 2020                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	36.57771	0.000000	0.000000	36.57771
0.100000	27.51743	0.000000	0.000000	27.51743
0.300000	20.13704	0.000000	0.000000	20.13704
0.500000	16.64055	0.000000	0.000000	16.64055
0.700000	14.49734	0.000000	0.000000	14.49734
1.000000	12.41841	0.000000	0.000000	12.41841
3.000000	7.430959	0.000000	0.000000	7.430959
5.000000	5.463600	0.000000	0.000000	5.463600
7.000000	5.369868	0.000000	0.000000	5.369868
10.00000	5.231342	0.000000	0.000000	5.231342
20.00000	4.795772	0.000000	0.000000	4.795772
30.00000	4.399487	0.000000	0.000000	4.399487
40.00000	4.038789	0.000000	0.000000	4.038789
50.00000	3.710545	0.000000	0.000000	3.710545
60.00000	3.411596	0.000000	0.000000	3.411596
70.00000	3.139648	0.000000	0.000000	3.139648
85.00000	2.776527	0.000000	0.000000	2.776527
100.0000	2.461201	0.000000	0.000000	2.461201
200.0000	1.187157	0.000000	0.000000	1.187157
300.0000	.6737134	0.000000	0.000000	.6737134
400.0000	.1339042	0.000000	0.000000	.1339042
424.1341	0.000000	0.000000	0.000000	0.000000
Totals (lb)	709.0336	0.000000	0.000000	709.0336

Flowrate for Torch Fire [immediate ignition] = 4.822770 lb/sec.
Torch Fire [delayed ignition] = 1.695828 lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

CANARY by Quest - Version 4.6.2
Release Stream Compositions
Case Name - 10D8IN160S2A+45_7MMSCFD
Thu Jan 23 14:55:23 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

Component Number	Component Name, Formula
------------------	-------------------------

51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
| Momentum Jet Vapor Dispersion Model                         |
| Case Name - 10D8IN160S2A+45_7MMSCFD                       |
| Thu Jan 23 14:55:23 2020                                    |
| Quest Consultants Inc., Norman, Oklahoma, USA                |
| www.questconsult.com    canary@questconsult.com             |
| telephone (405) 329-7475    fax (405) 329-7734             |
+-----+

```

TITLE: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

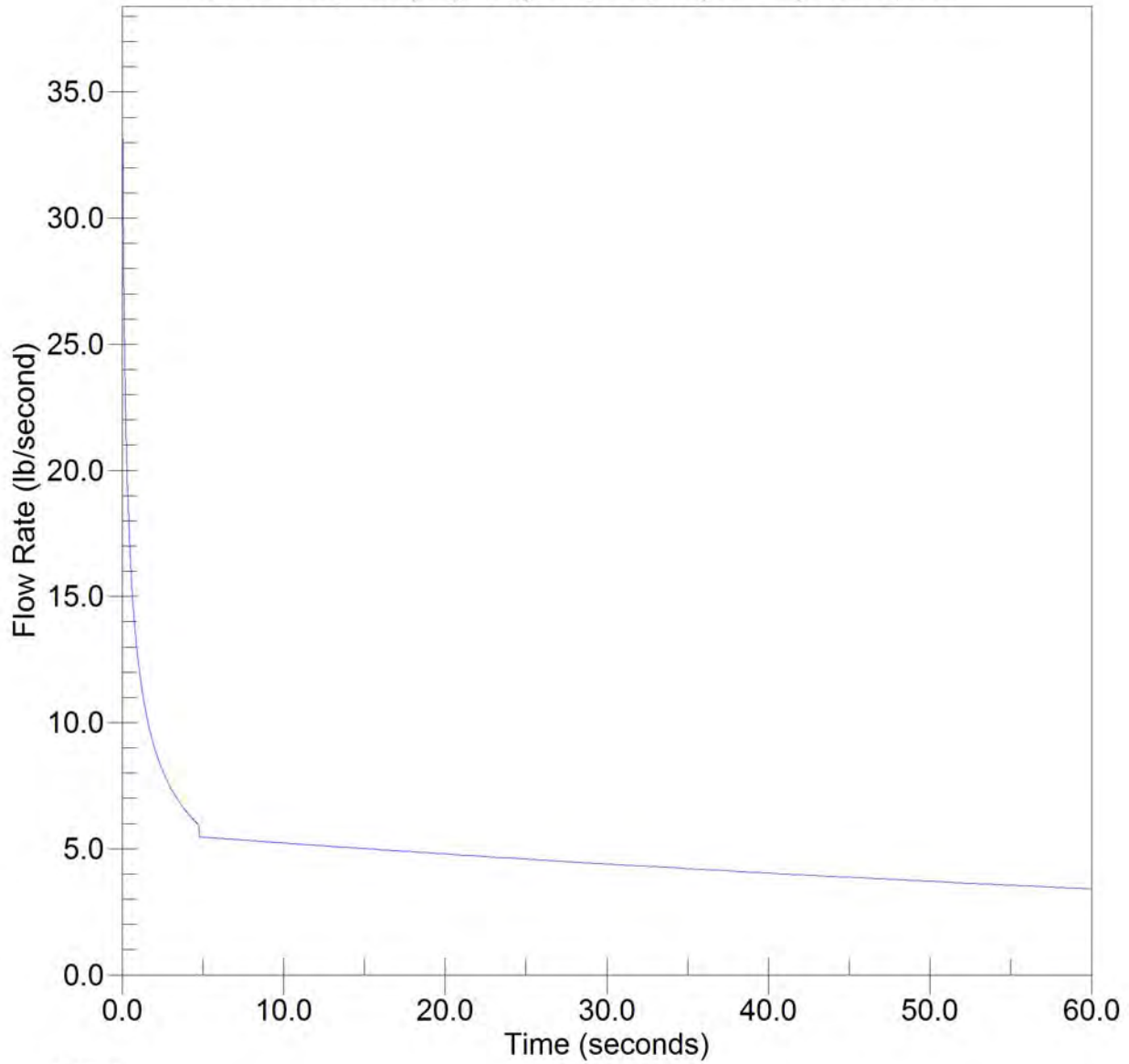
downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.7	0.7	0.2	0.1
1	0.630397	0.024722	1.1	1.0	0.0	1.1
2	0.487473	0.000335	1.4	1.2	0.0	2.1
3	0.402565	0.000007	1.6	1.4	0.0	3.1
4	0.344594	0.000000	1.8	1.6	0.0	4.1
5	0.301590	0.000000	2.0	1.8	0.0	5.1
6	0.268129	0.000000	2.2	1.9	0.0	6.1
7	0.241166	0.000000	2.4	2.1	0.0	7.1
8	0.219000	0.000000	2.6	2.2	0.0	8.0
9	0.200243	0.000000	2.8	2.3	0.0	9.0
10	0.184200	0.000000	3.0	2.5	0.0	10.0
11	0.170339	0.000000	3.2	2.6	0.0	11.0
12	0.158131	0.000000	3.4	2.7	0.0	12.0
13	0.147409	0.000000	3.5	2.9	0.0	13.0
14	0.137892	0.000000	3.7	3.0	0.0	14.0
15	0.129347	0.000000	3.9	3.1	0.0	15.0
16	0.121558	0.000000	4.1	3.2	0.0	16.0
17	0.114567	0.000000	4.2	3.3	0.0	17.0
18	0.108185	0.000000	4.4	3.4	0.0	17.9
19	0.102327	0.000000	4.6	3.5	0.0	18.9
20	0.096939	0.000000	4.7	3.5	0.0	19.9
21	0.091992	0.000000	4.9	3.6	0.0	20.9
22	0.087406	0.000000	5.1	3.7	0.0	21.8
23	0.083180	0.000000	5.2	3.7	0.0	22.8
24	0.079193	0.000000	5.4	3.8	0.0	23.8
25	0.075582	0.000000	5.5	3.8	0.0	24.7
26	0.072089	0.000000	5.7	3.9	0.0	25.7
27	0.068888	0.000000	5.8	3.9	0.0	26.6
28	0.065926	0.000000	6.0	3.9	0.0	27.6
29	0.063054	0.000000	6.1	3.9	0.0	28.5
30	0.060402	0.000000	6.3	3.8	0.0	29.5
31	0.057944	0.000000	6.4	3.8	0.0	30.4
32	0.055564	0.000000	6.5	3.7	0.0	31.3
33	0.053304	0.000000	6.6	3.6	0.0	32.3
34	0.051235	0.000000	6.8	3.5	0.0	33.2

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
35	0.049222	0.000000	6.9	3.3	0.0	34.1
36	0.047315	0.000000	7.0	3.1	0.0	35.0
37	0.045545	0.000000	7.1	2.8	0.0	36.0
38	0.043889	0.000000	7.1	2.5	0.0	36.8
39	0.042219	0.000000	7.2	1.9	0.0	37.8
40	0.040669	0.000000	7.3	1.1	0.0	38.6
41	0.039256	0.000000	7.3	0.0	0.0	39.5
42	0.037889	0.000000	7.4	0.0	0.0	40.4
43	0.036542	0.000000	7.4	0.0	0.0	41.3
44	0.035280	0.000000	7.4	0.0	0.0	42.1
45	0.034067	0.000000	7.4	0.0	0.0	43.0
46	0.032971	0.000000	7.4	0.0	0.0	43.9
47	0.031870	0.000000	7.4	0.0	0.0	44.7
48	0.030786	0.000000	7.3	0.0	0.0	45.6
49	0.029782	0.000000	7.3	0.0	0.0	46.4
50	0.028815	0.000000	7.2	0.0	0.0	47.2
51	0.027928	0.000000	7.1	0.0	0.0	48.0
52	0.027056	0.000000	6.9	0.0	0.0	48.9
53	0.026194	0.000000	6.7	0.0	0.0	49.7
54	0.025397	0.000000	6.5	0.0	0.0	50.5
55	0.024603	0.000000	6.2	0.0	0.0	51.3
56	0.023875	0.000000	5.9	0.0	0.0	52.1
57	0.023171	0.000000	5.5	0.0	0.0	52.9
58	0.022494	0.000000	5.1	0.0	0.0	53.6
59	0.021824	0.000000	4.5	0.0	0.0	54.4
60	0.021201	0.000000	3.8	0.0	0.0	55.2
61	0.020595	0.000000	2.7	0.0	0.0	55.9
62	0.020002	0.000000	0.0	0.0	0.0	56.7

The downwind distance to c3 is 0.51 ft after about 0 seconds
The downwind distance to c2 is 40.47 ft after about 0 seconds
The downwind distance to c1 is 62.00 ft after about 1 seconds

MASS RELEASE RATE

H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

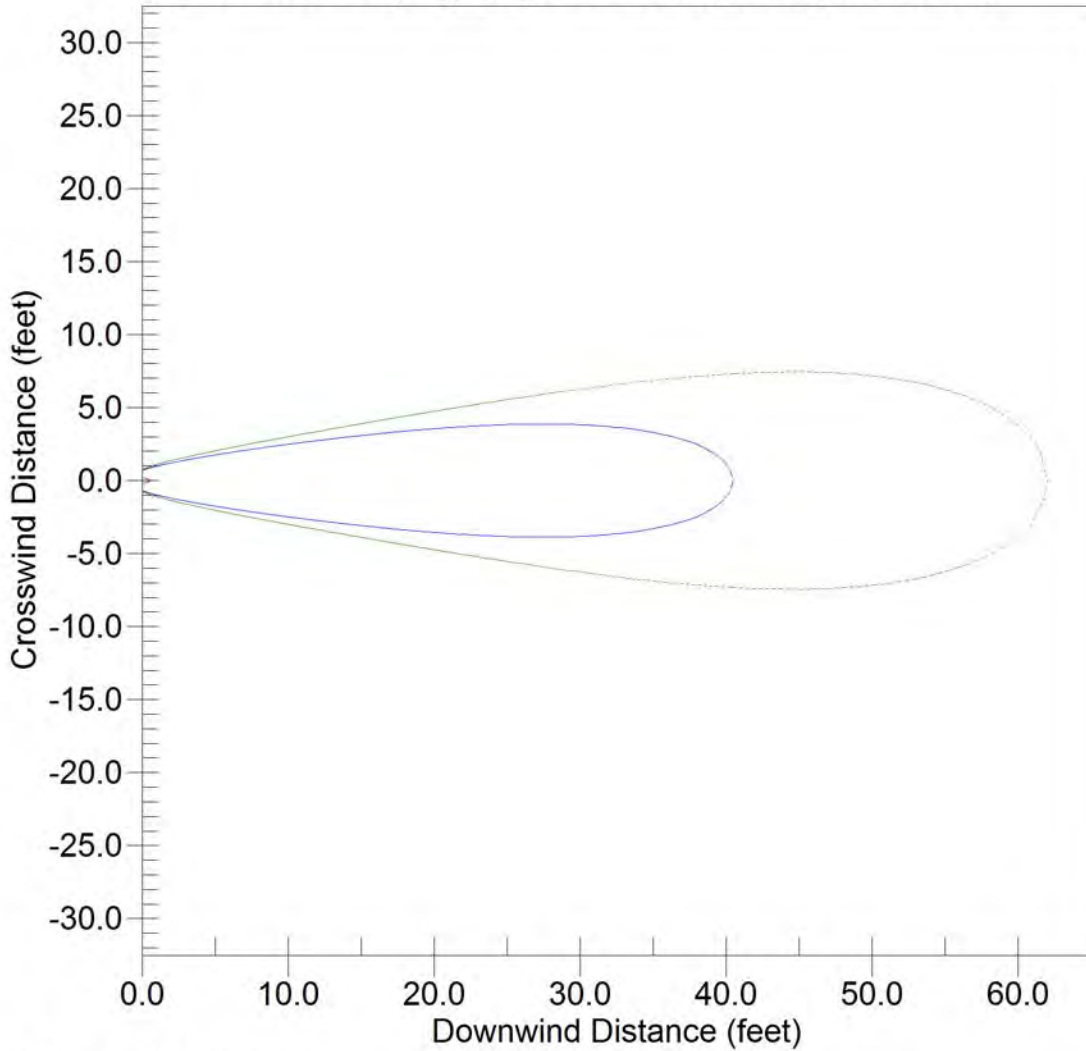


— Total
— Vapor

CANARY by Quest

casename=10D8IN160S2A+45_7MMSCFD
Thu Jan 23 14:55:23 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°

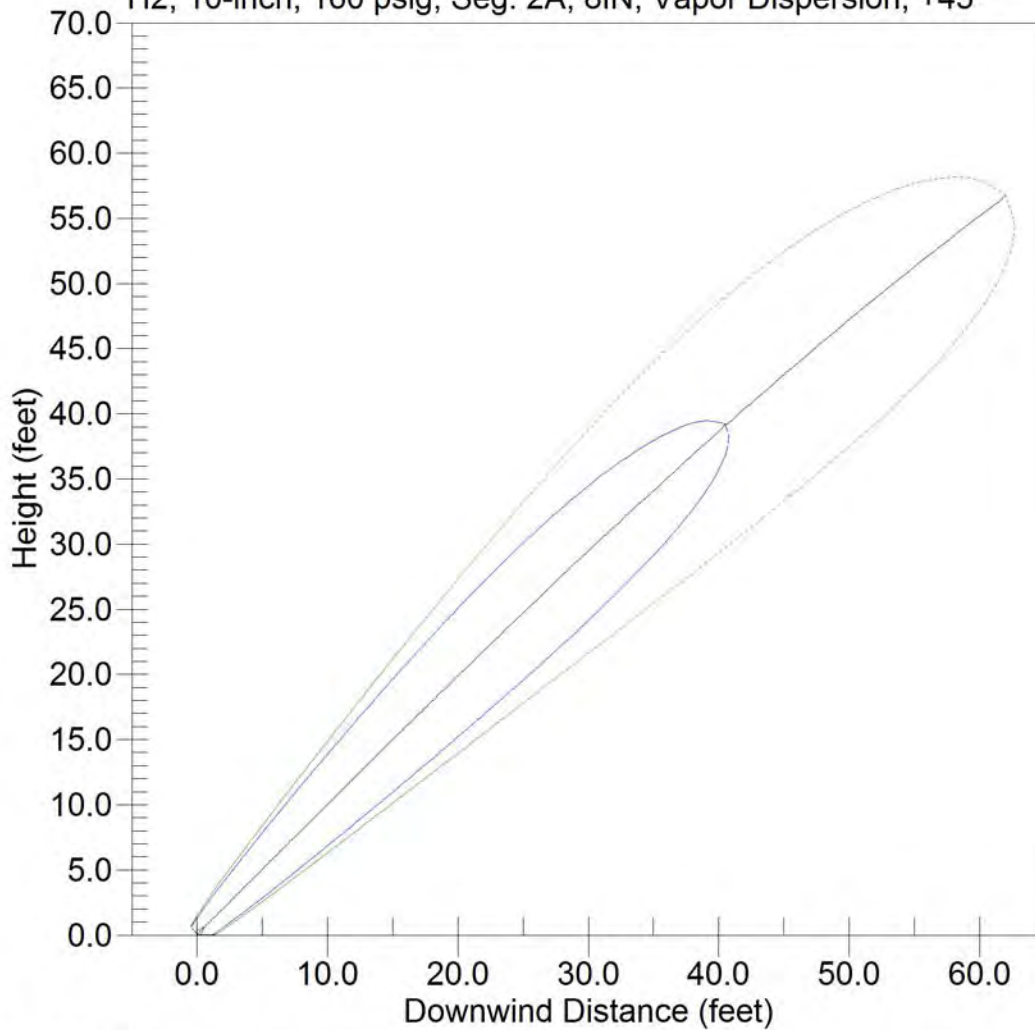


- 75.0 mole percent
- 4.00 mole percent
- 2.00 mole percent

casename=10D8IN160S2A+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:55:23 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°



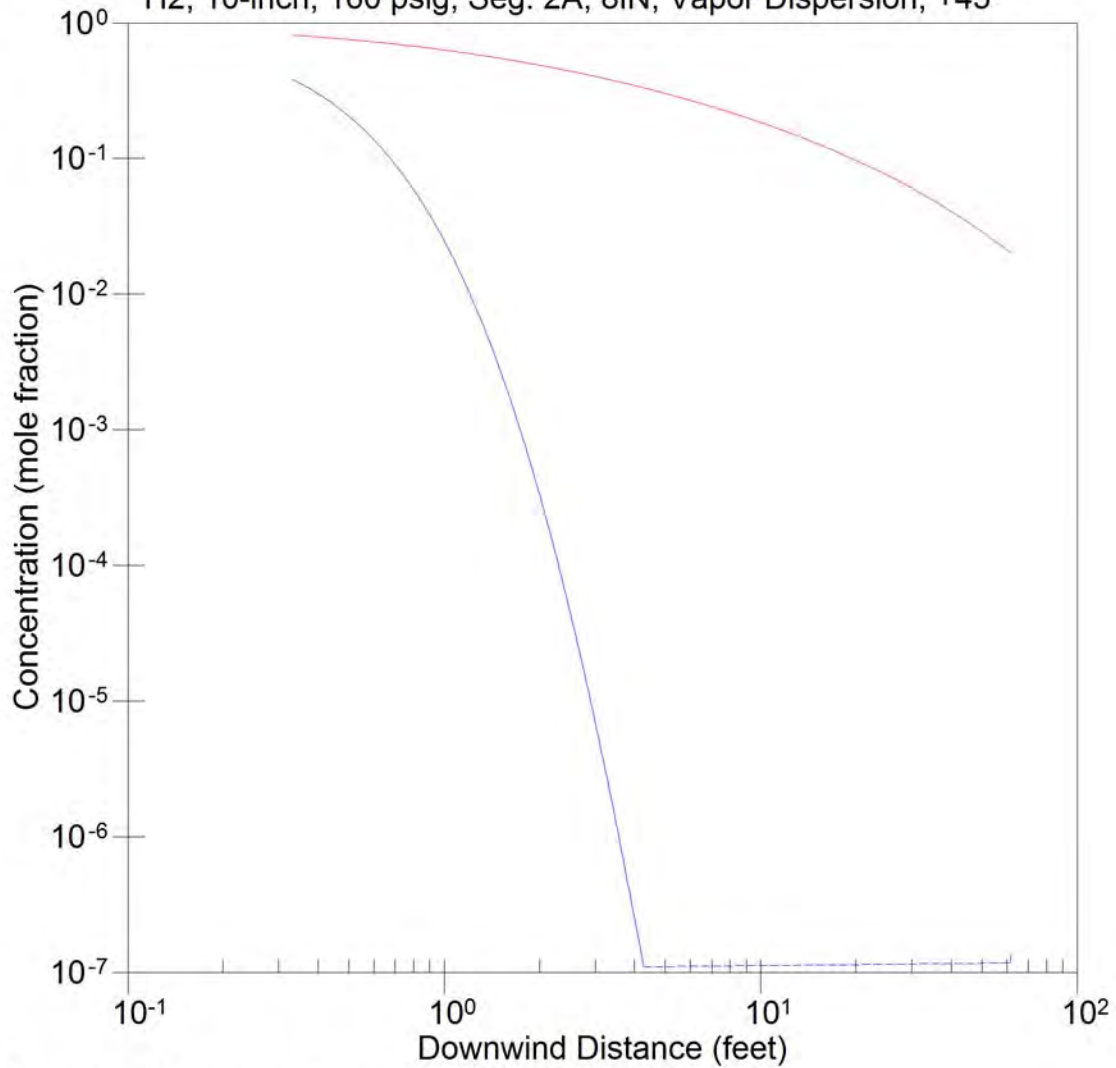
- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=10D8IN160S2A+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:55:23 2020

CANARY by Quest

Momentum Jet Cloud CONCENTRATION vs. DISTANCE

H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°



— Centerline Concentration
- - - Ground Level Concentration

casename=10D8IN160S2A+45_7MMSCFD

windspeed = 4.5 mph

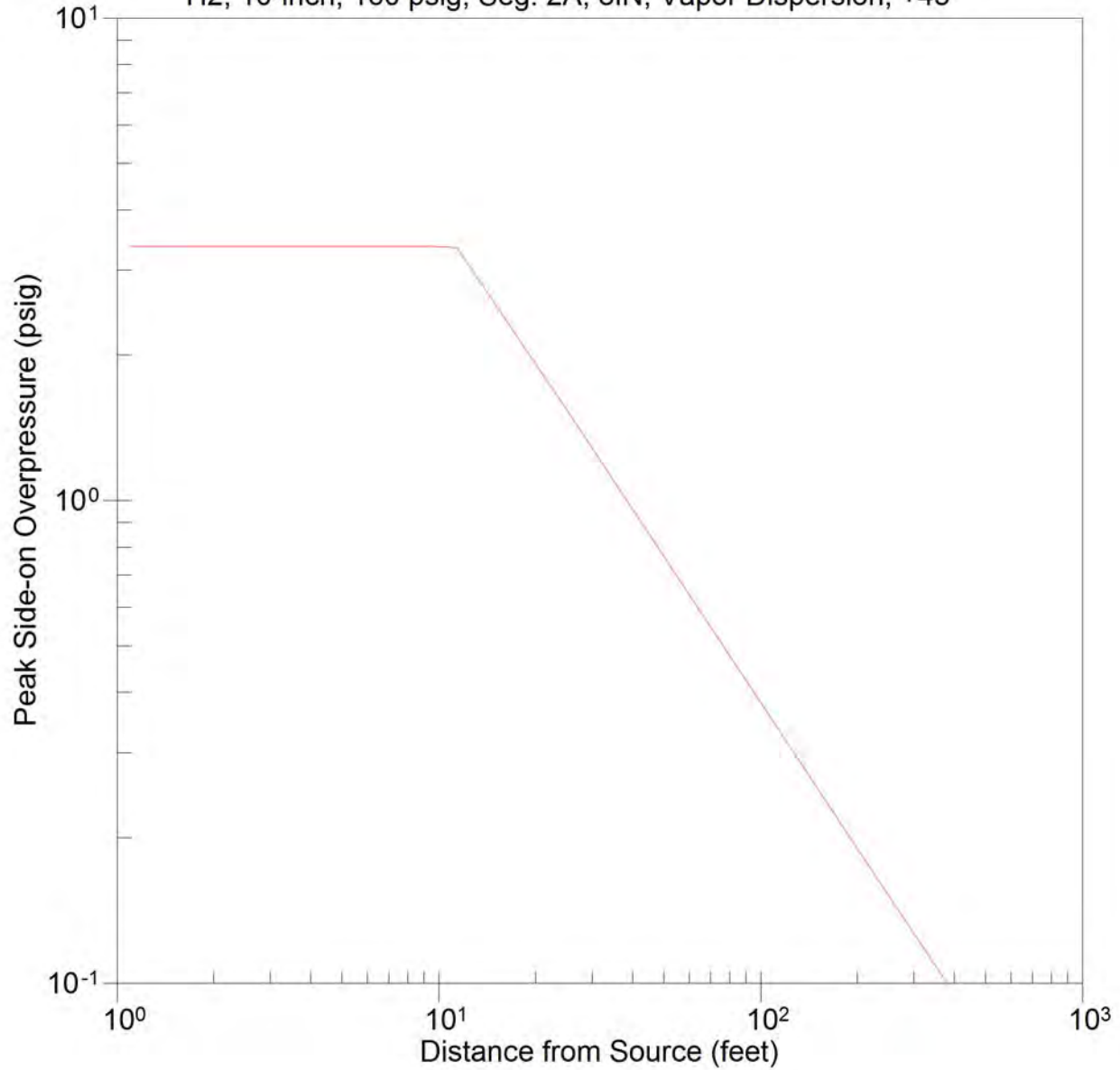
D stability

Thu Jan 23 14:55:23 2020

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, +45°



CANARY by Quest

casename=10D8IN160S2A+45_7MMSCFD
Thu Jan 23 14:55:23 2020

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 10D8IN160S2A-45_7MMSCFD     |
|           Thu Jan 23 16:00:54 2020                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

```

Case Type       : Vapor Dispersion
Case Name      : 10D8IN160S2A-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A - 8-inch Hole, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity       0.22 Btu/lb-F
Substrate delay time          0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 10D8IN160S2A-45_7MMSCFD |
| Thu Jan 23 16:00:54 2020 |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

RELEASE MENU

Type of release: Unregulated, Continuous release
 Release duration 120 min
 Normal flow rate 0.43 lb/sec
 Duration of normal flow 5 min
 Volume of vessel 0.00 cu.ft
 Pipe inner diameter 10.02 inches
 Equivalent release diameter 8.00 inches
 Pipe length upstream of break 20416.0 feet
 Height of release point 0.0 feet
 Angle of release from horizontal 135.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation, dispersion and cloud explosion - Flammable calculation
 Concentration endpoint 1 UFL mol%
 Concentration endpoint 2 LFL mol%
 Concentration endpoint 3 1/2 LFL mol%

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

Fuel reactivity High
 Obstacle density Low
 Flame expansion 3-D

Overpressure values

Overpressure endpoint 1 1.00 psi
 Overpressure endpoint 2 0.70 psi
 Overpressure endpoint 3 0.10 psi

NOTES:

```

CANARY by Quest - Version 4.6.2
General Release Model UPSTREAM
Case Name - 10D8IN160S2A-45_7MMSCFD
Thu Jan 23 16:00:54 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

TITLE: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	36.57771	0.000000	0.000000	36.57771
0.100000	27.51743	0.000000	0.000000	27.51743
0.300000	20.13704	0.000000	0.000000	20.13704
0.500000	16.64055	0.000000	0.000000	16.64055
0.700000	14.49734	0.000000	0.000000	14.49734
1.000000	12.41841	0.000000	0.000000	12.41841
3.000000	7.430959	0.000000	0.000000	7.430959
5.000000	5.463600	0.000000	0.000000	5.463600
7.000000	5.369868	0.000000	0.000000	5.369868
10.00000	5.231342	0.000000	0.000000	5.231342
20.00000	4.795772	0.000000	0.000000	4.795772
30.00000	4.399487	0.000000	0.000000	4.399487
40.00000	4.038789	0.000000	0.000000	4.038789
50.00000	3.710545	0.000000	0.000000	3.710545
60.00000	3.411596	0.000000	0.000000	3.411596
70.00000	3.139648	0.000000	0.000000	3.139648
85.00000	2.776527	0.000000	0.000000	2.776527
100.0000	2.461201	0.000000	0.000000	2.461201
200.0000	1.187157	0.000000	0.000000	1.187157
300.0000	.6737134	0.000000	0.000000	.6737134
400.0000	.1339042	0.000000	0.000000	.1339042
424.1341	0.000000	0.000000	0.000000	0.000000
Totals (lb)	709.0336	0.000000	0.000000	709.0336

Flowrate for Torch Fire [immediate ignition] = 4.822770 lb/sec.
Torch Fire [delayed ignition] = 1.695828 lb/sec.

Reason for Ending: Pressure Near Atmospheric


```

CANARY by Quest - Version 4.6.2
Release Stream Compositions
Case Name - 10D8IN160S2A-45_7MMSCFD
Thu Jan 23 16:00:54 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
| Momentum Jet Vapor Dispersion Model |
| Case Name - 10D8IN160S2A-45_7MMSCFD |
|   Thu Jan 23 16:00:54 2020         |
| Quest Consultants Inc., Norman, Oklahoma, USA |
| www.questconsult.com   canary@questconsult.com |
| telephone (405) 329-7475   fax (405) 329-7734 |
|               |
+-----+

```

TITLE: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance	centerline conc.	ground conc.	y(c1) 1/2 width	y(c2) 1/2 width	y(c3) 1/2 width	centerline height
x(ft)	c(mole frac.)	c(mole frac.)	(ft)	(ft)	(ft)	(ft)
0	1.000000	0.000000	0.7	0.7	0.2	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is 0.00 ft after about 1 seconds
The downwind distance to c2 is 0.00 ft after about 1 seconds
The downwind distance to c1 is 0.00 ft after about 1 seconds

```

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Cloud Explosion                     |
|      Case Name - 10D8IN160S2A-45_7MMSCFD                   |
|              Thu Jan 23 16:00:54 2020                       |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

Fuel Reactivity: High Obstacle Density: Low
 Flame Expansion: 3-D Flame Speed: 0.36

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

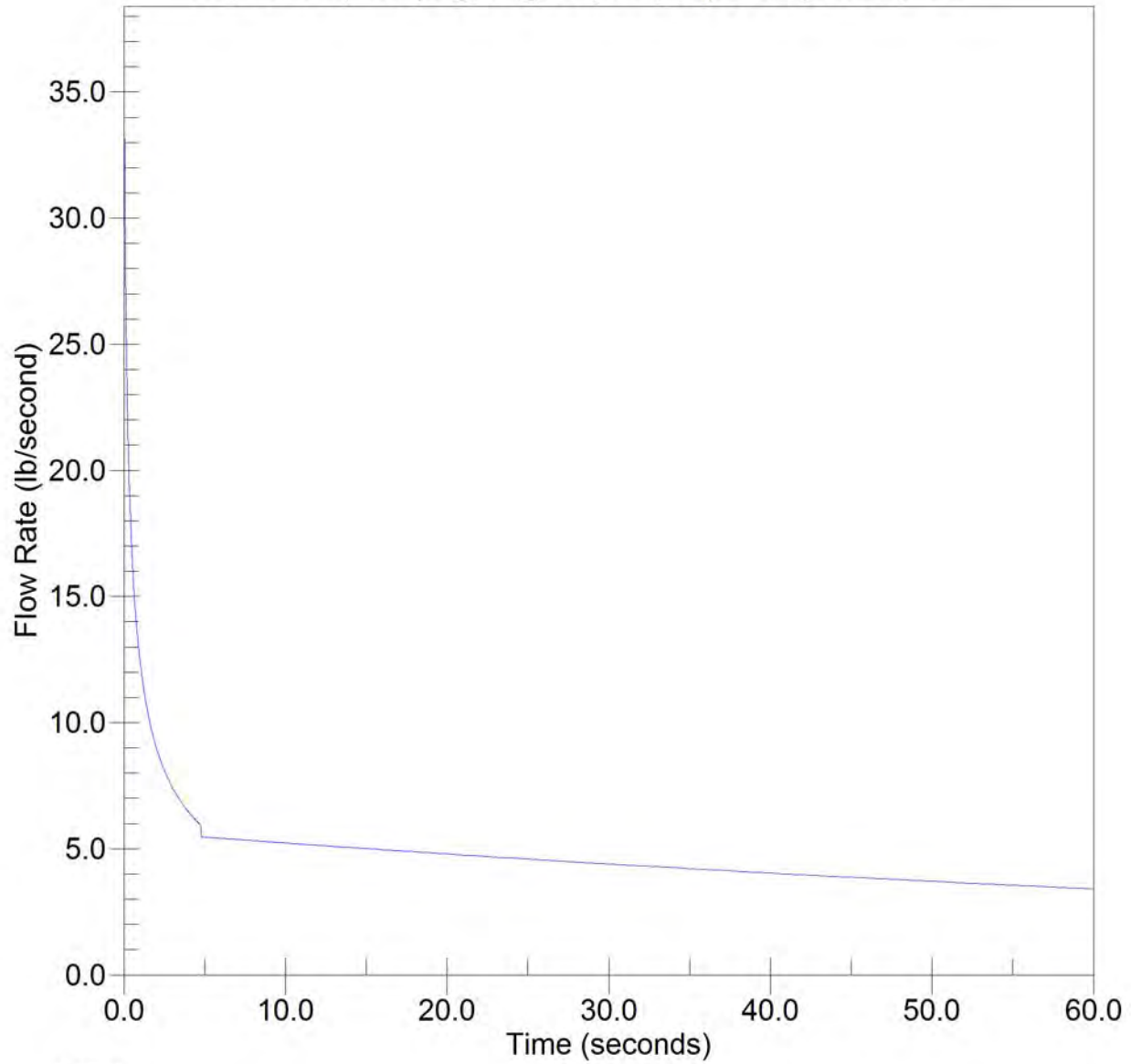
Mass of released material in explosive range: 1.13095 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0575
2.8	3.36	0.0575
3.4	3.36	0.0575
4.2	3.36	0.0575
5.1	3.36	0.0481
6.3	3.36	0.0394
7.7	3.36	0.0323
9.4	3.36	0.0265
11.5	3.33	0.0217
14.1	2.73	0.0178
17.3	2.23	0.0146
21.2	1.83	0.0119
25.9	1.50	0.0098
31.8	1.22	0.0080
38.9	1.00	0.0066
47.7	0.81	0.0054
58.4	0.66	0.0044
71.6	0.54	0.0036
87.7	0.44	0.0030
107.5	0.36	0.0024
131.7	0.29	0.0020
161.4	0.24	0.0016
197.8	0.19	0.0013
242.3	0.16	0.0011
382.7	0.10	0.0007

The downwind distance to dp3 is 38.8 feet
 The downwind distance to dp2 is 55.7 feet
 The downwind distance to dp1 is 382.7 feet

MASS RELEASE RATE

H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

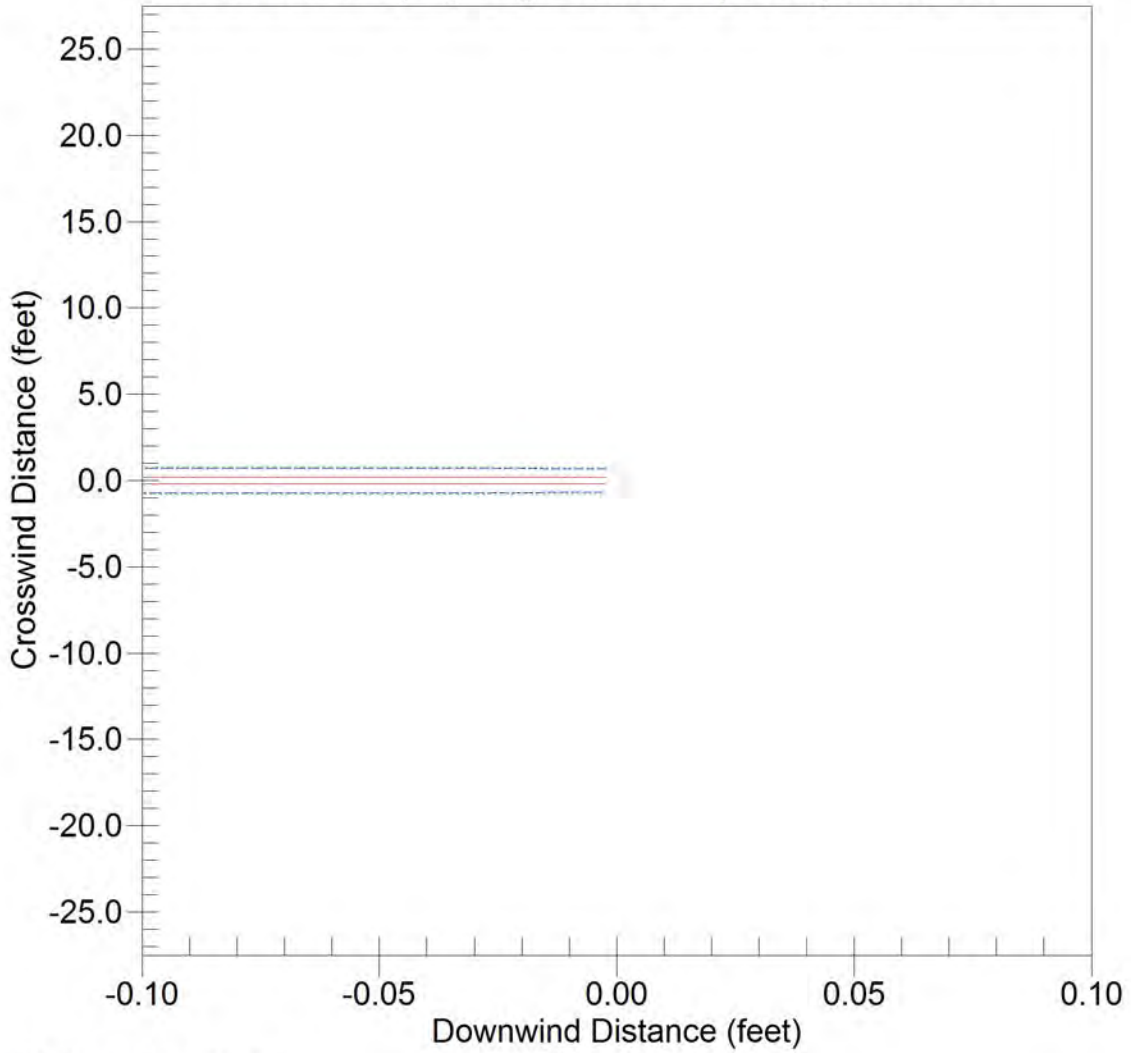


— Total
— Vapor

CANARY by Quest

casename=10D8IN160S2A-45_7MMSCFD
Thu Jan 23 16:00:54 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°

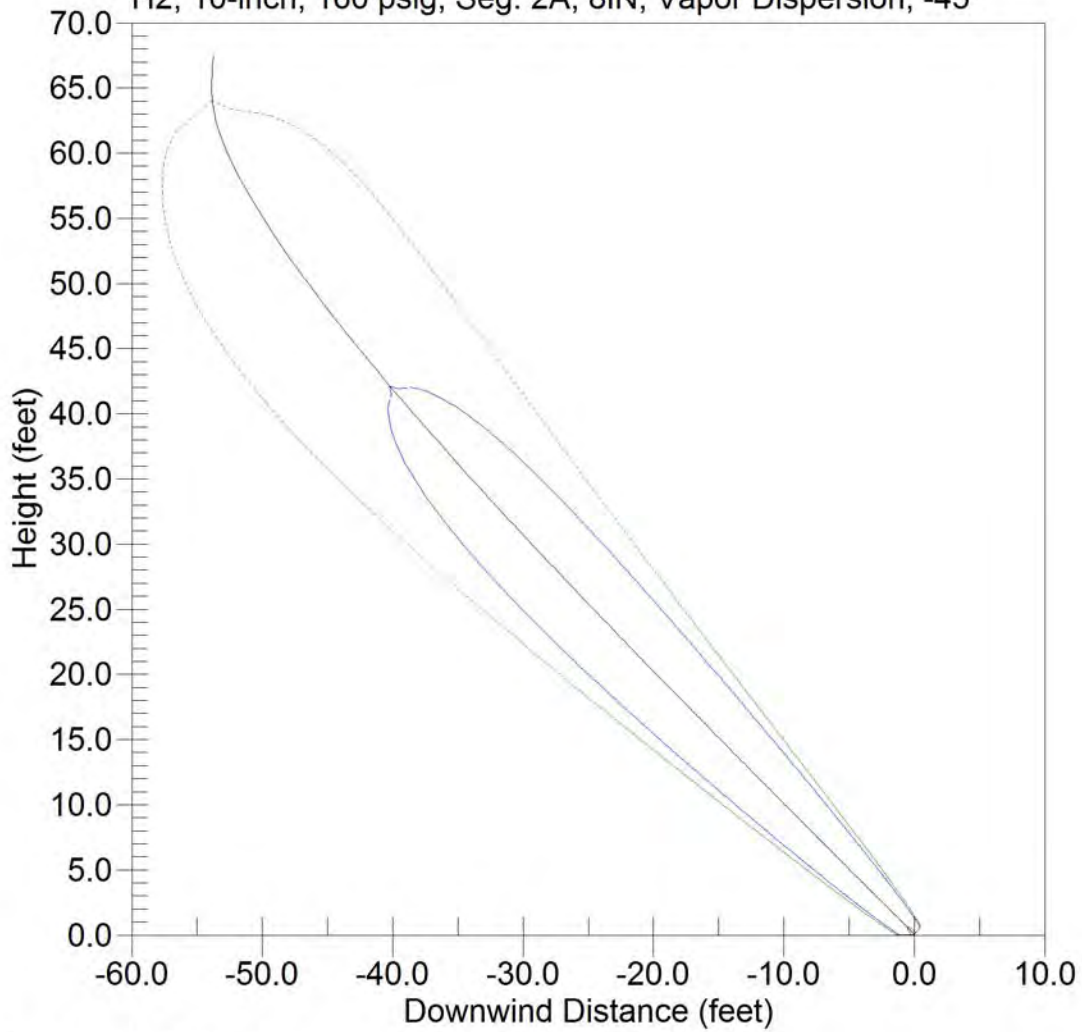


- 75.0 mole percent
- - - 4.00 mole percent
- 2.00 mole percent

casename=10D8IN160S2A-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 16:00:54 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°



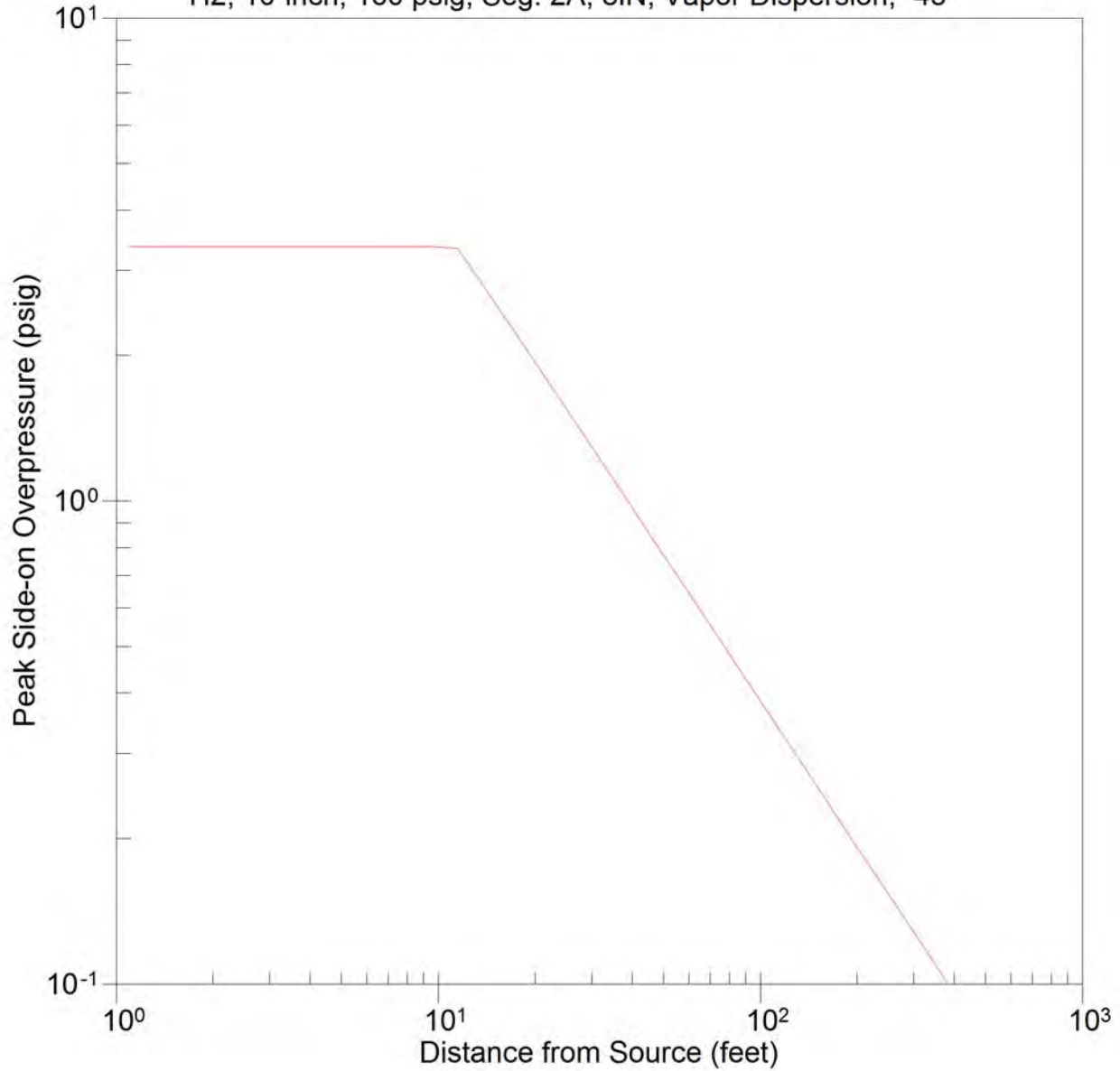
- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=10D8IN160S2A-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 16:00:54 2020

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 160 psig, Seg. 2A, 8IN, Vapor Dispersion, -45°



CANARY by Quest

casename=10D8IN160S2A-45_7MMSCFD
Thu Jan 23 16:00:54 2020

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 10D1IN160S2A+45_7MMSCFD     |
|           Thu Jan 23 14:58:46 2020                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com           canary@questconsult.com |
|           telephone (405) 329-7475       fax (405) 329-7734   |
|                                     |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

```

Case Type           : Vapor Dispersion
Case Name           : 10D1IN160S2A+45_7MMSCFD
User ID             : BLPayne
Project Number      : Job 2134
Type of Units       : English Units

```

NOTES: Segment 2A, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature         :          70.00 °F
Pressure             :          160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity     70 %
Air temperature       72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name           Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density         80 lb/cu.ft
Substrate heat Capacity   0.22 Btu/lb-F
Substrate delay time      0 sec
Surrounding terrain       Wooded area or urban area

```

NOTES:

Case continued on page 2.


```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|   CANARY Case Input                 |
| Case Name - 10D1IN160S2A+45_7MMSCFD |
|   Thu Jan 23 14:58:46 2020         |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration           120 min
Normal flow rate          0.43 lb/sec
Duration of normal flow   5 min
Volume of vessel          0.00 cu.ft
Pipe inner diameter       10.02 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 20416.0 feet
Height of release point   0.0 feet
Angle of release from horizontal 45.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1           UFL mol%
Concentration endpoint 2           LFL mol%
Concentration endpoint 3           1/2 LFL mol%

```

```

Dispersion coefficient averaging time           1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity           High
Obstacle density          Low
Flame expansion           3-D

```

Overpressure values

```

Overpressure endpoint 1           1.00 psi
Overpressure endpoint 2           0.70 psi
Overpressure endpoint 3           0.10 psi

```

NOTES:

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
| Case Name - 10D1IN160S2A+45_7MMSCFD              |
|           Thu Jan 23 14:58:46 2020                |
| Quest Consultants Inc., Norman, Oklahoma, USA      |
| www.questconsult.com           canary@questconsult.com |
| telephone (405) 329-7475       fax (405) 329-7734   |
|                                     |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

```

Case Type       : Vapor Dispersion
Case Name      : 10D1IN160S2A+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity        0.22 Btu/lb-F
Substrate delay time           0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|   CANARY Case Input                 |
| Case Name - 10D1IN160S2A+45_7MMSCFD |
|   Thu Jan 23 14:58:46 2020         |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration           120 min
Normal flow rate          0.43 lb/sec
Duration of normal flow   5 min
Volume of vessel          0.00 cu.ft
Pipe inner diameter       10.02 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 20416.0 feet
Height of release point   0.0 feet
Angle of release from horizontal 45.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1           UFL mol%
Concentration endpoint 2           LFL mol%
Concentration endpoint 3           1/2 LFL mol%

```

```

Dispersion coefficient averaging time           1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity           High
Obstacle density         Low
Flame expansion           3-D

```

Overpressure values

```

Overpressure endpoint 1           1.00 psi
Overpressure endpoint 2           0.70 psi
Overpressure endpoint 3           0.10 psi

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Release Stream Compositions
Case Name - 10D1IN160S2A+45_7MMSCFD
Thu Jan 23 14:58:46 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

Component Number	Component Name, Formula
------------------	-------------------------

51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
| Momentum Jet Vapor Dispersion Model                       |
| Case Name - 10D1IN160S2A+45_7MMSCFD                     |
| Thu Jan 23 14:58:46 2020                                  |
| Quest Consultants Inc., Norman, Oklahoma, USA              |
| www.questconsult.com   canary@questconsult.com            |
| telephone (405) 329-7475   fax (405) 329-7734            |
+-----+

```

TITLE: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.2	0.2	0.1	0.1
0.5	0.508151	0.000143	0.4	0.3	0.0	0.6
1.0	0.365577	0.000000	0.5	0.4	0.0	1.1
1.5	0.289053	0.000000	0.6	0.5	0.0	1.6
2.0	0.240001	0.000000	0.7	0.6	0.0	2.1
2.5	0.205340	0.000000	0.7	0.6	0.0	2.6
3.0	0.179625	0.000000	0.8	0.7	0.0	3.1
3.5	0.159402	0.000000	0.9	0.7	0.0	3.6
4.0	0.143224	0.000000	1.0	0.8	0.0	4.1
4.5	0.129738	0.000000	1.0	0.8	0.0	4.6
5.0	0.118459	0.000000	1.1	0.9	0.0	5.1
5.5	0.108749	0.000000	1.2	0.9	0.0	5.6
6.0	0.100368	0.000000	1.3	0.9	0.0	6.1
6.5	0.093109	0.000000	1.3	1.0	0.0	6.6
7.0	0.086645	0.000000	1.4	1.0	0.0	7.1
7.5	0.080909	0.000000	1.4	1.0	0.0	7.5
8.0	0.075777	0.000000	1.5	1.0	0.0	8.0
8.5	0.071141	0.000000	1.6	1.1	0.0	8.5
9.0	0.066958	0.000000	1.6	1.1	0.0	9.0
9.5	0.063148	0.000000	1.7	1.1	0.0	9.5
10.0	0.059665	0.000000	1.7	1.0	0.0	10.0
10.5	0.056491	0.000000	1.8	1.0	0.0	10.5
11.0	0.053526	0.000000	1.8	1.0	0.0	11.0
11.5	0.050833	0.000000	1.9	0.9	0.0	11.5
12.0	0.048309	0.000000	1.9	0.9	0.0	12.0
12.5	0.045983	0.000000	1.9	0.8	0.0	12.5
13.0	0.043809	0.000000	2.0	0.7	0.0	13.0
13.5	0.041799	0.000000	2.0	0.5	0.0	13.5
14.0	0.039886	0.000000	2.0	0.0	0.0	13.9
14.5	0.038137	0.000000	2.1	0.0	0.0	14.4
15.0	0.036458	0.000000	2.1	0.0	0.0	14.9
15.5	0.034905	0.000000	2.1	0.0	0.0	15.4
16.0	0.033439	0.000000	2.1	0.0	0.0	15.9
16.5	0.032043	0.000000	2.1	0.0	0.0	16.4
17.0	0.030753	0.000000	2.1	0.0	0.0	16.8

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
17.5	0.029507	0.000000	2.0	0.0	0.0	17.3
18.0	0.028336	0.000000	2.0	0.0	0.0	17.8
18.5	0.027249	0.000000	2.0	0.0	0.0	18.2
19.0	0.026195	0.000000	1.9	0.0	0.0	18.7
19.5	0.025196	0.000000	1.8	0.0	0.0	19.2
20.0	0.024265	0.000000	1.7	0.0	0.0	19.7
20.5	0.023363	0.000000	1.6	0.0	0.0	20.1
21.0	0.022504	0.000000	1.5	0.0	0.0	20.6
21.5	0.021697	0.000000	1.2	0.0	0.0	21.0
22.0	0.020931	0.000000	1.0	0.0	0.0	21.5
22.5	0.020188	0.000000	0.3	0.0	0.0	21.9

The downwind distance to c3 is 0.14 ft after about 0 seconds
The downwind distance to c2 is 13.97 ft after about 0 seconds
The downwind distance to c1 is 22.63 ft after about 0 seconds

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
|          Momentum Jet Vapor Cloud Explosion      |
|          Case Name - 10D1IN160S2A+45_7MMSCFD    |
|          Thu Jan 23 14:58:46 2020              |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
|          www.questconsult.com          canary@questconsult.com |
|          telephone (405) 329-7475          fax (405) 329-7734 |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

```

Fuel Reactivity: High          Obstacle Density: Low
Flame Expansion: 3-D          Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.0310389 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0173
0.8	3.36	0.0173
1.0	3.36	0.0173
1.1	3.36	0.0173
1.3	3.36	0.0169
1.5	3.36	0.0145
1.8	3.36	0.0125
2.1	3.36	0.0108
2.4	3.36	0.0093
2.8	3.36	0.0080
3.3	3.36	0.0069
3.8	3.03	0.0060
4.5	2.61	0.0051
5.2	2.25	0.0044
6.0	1.93	0.0038
7.0	1.66	0.0033
8.2	1.43	0.0028
9.5	1.23	0.0024
11.1	1.06	0.0021
12.9	0.91	0.0018
15.0	0.78	0.0016
17.5	0.67	0.0013
20.3	0.57	0.0012
23.7	0.49	0.0010
115.4	0.10	0.0002

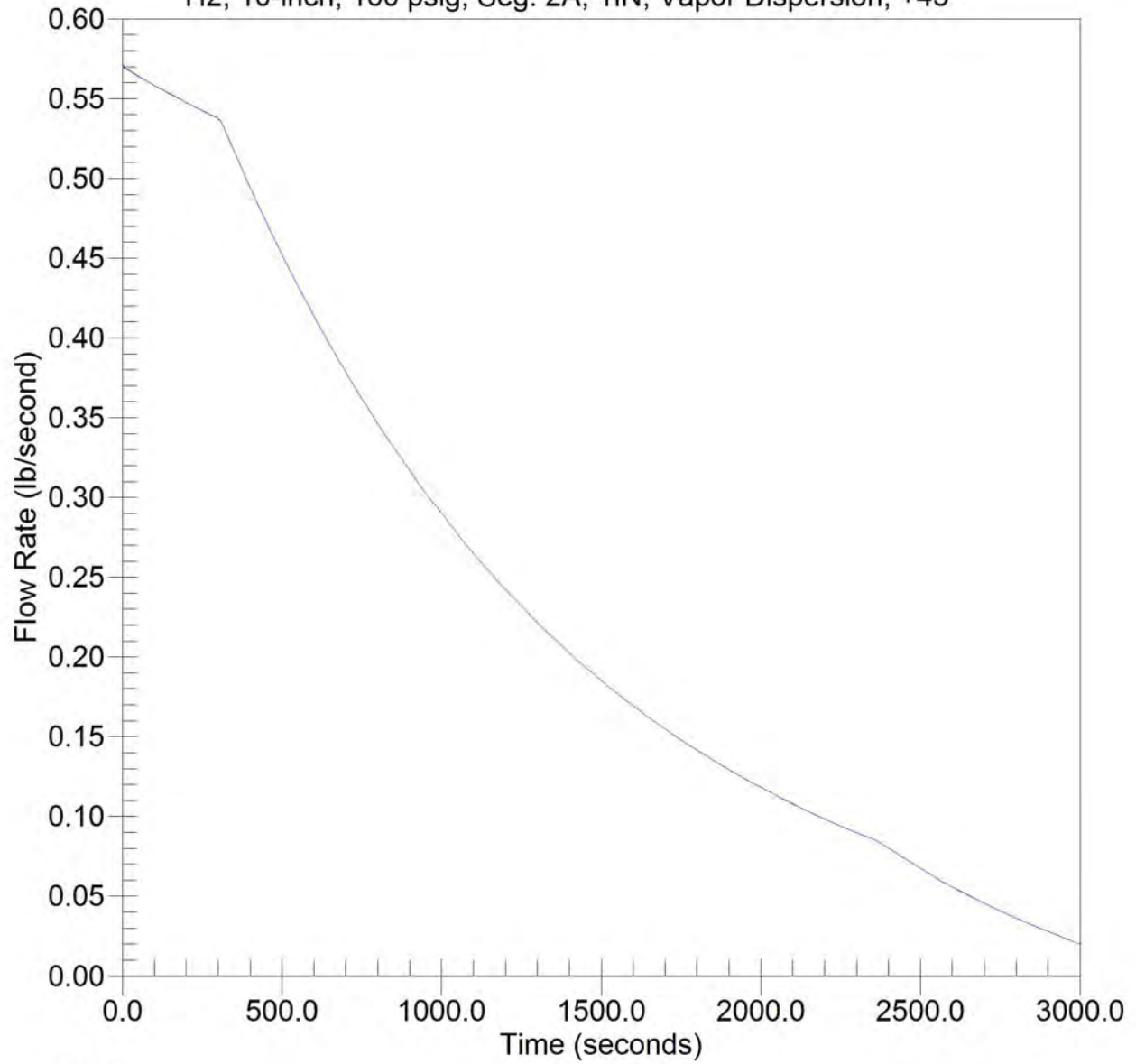
```

The downwind distance to dp3 is      11.8 feet
The downwind distance to dp2 is      16.8 feet
The downwind distance to dp1 is     115.4 feet

```

MASS RELEASE RATE

H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

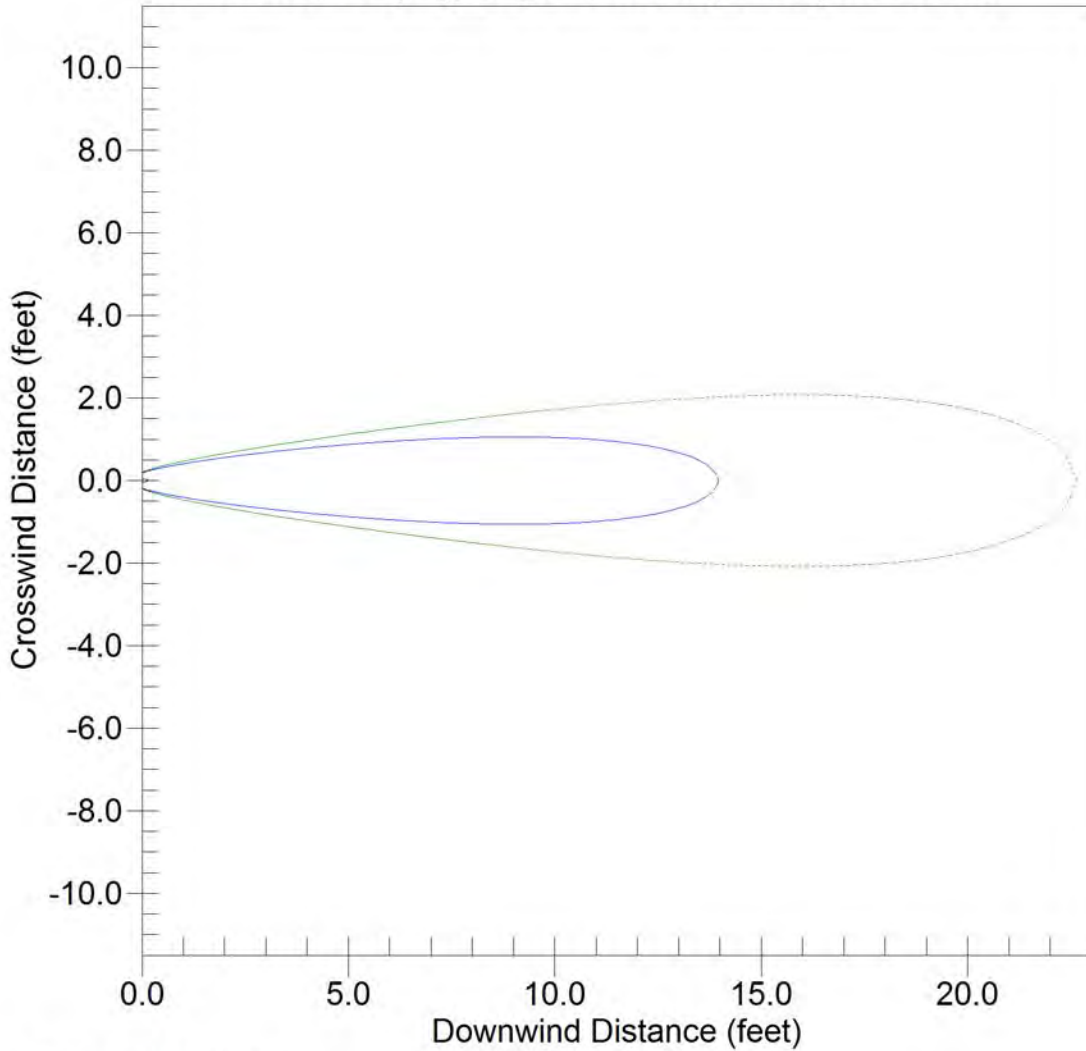


— Total
— Vapor

CANARY by Quest

casename=10D1IN160S2A+45_7MMSCFD
Thu Jan 23 14:58:46 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°

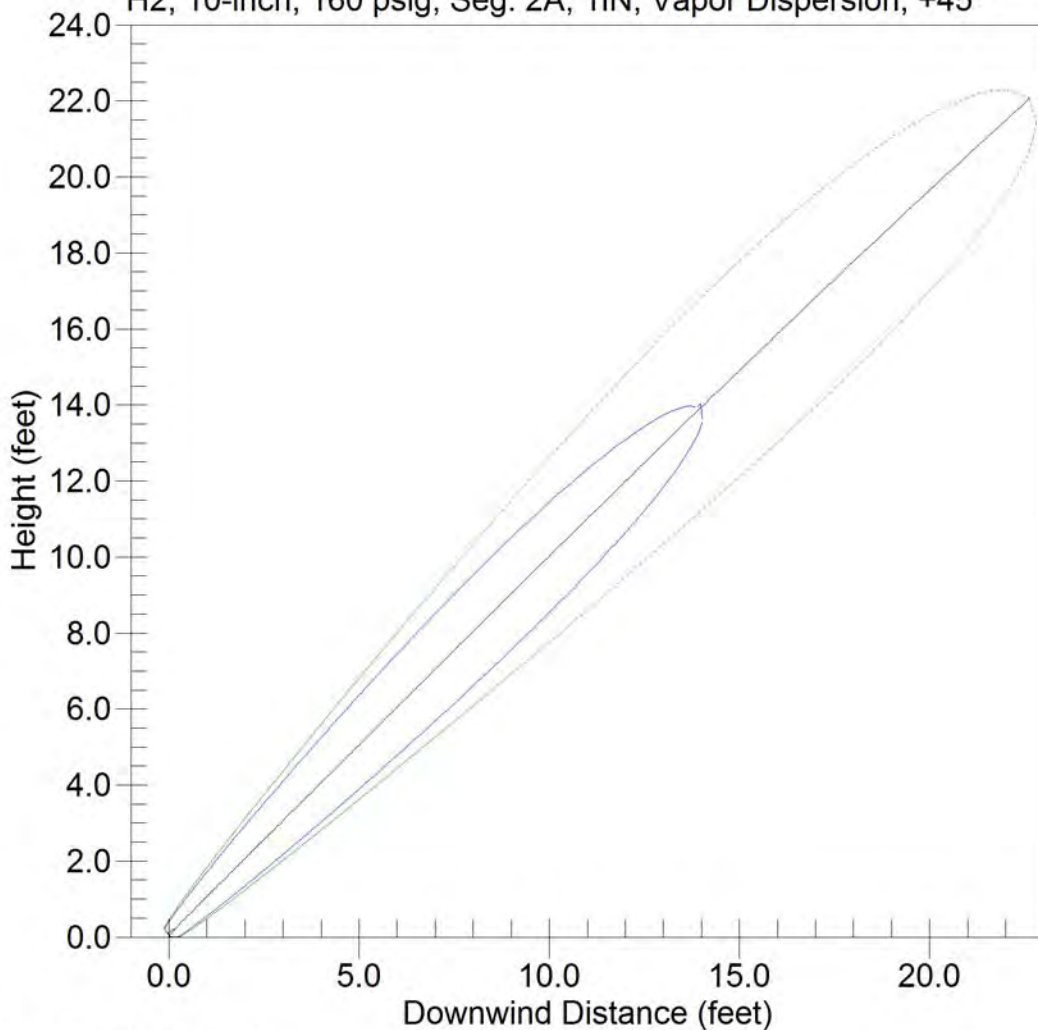


- 75.0 mole percent
- - - 4.00 mole percent
- 2.00 mole percent

casename=10D1IN160S2A+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:58:46 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°



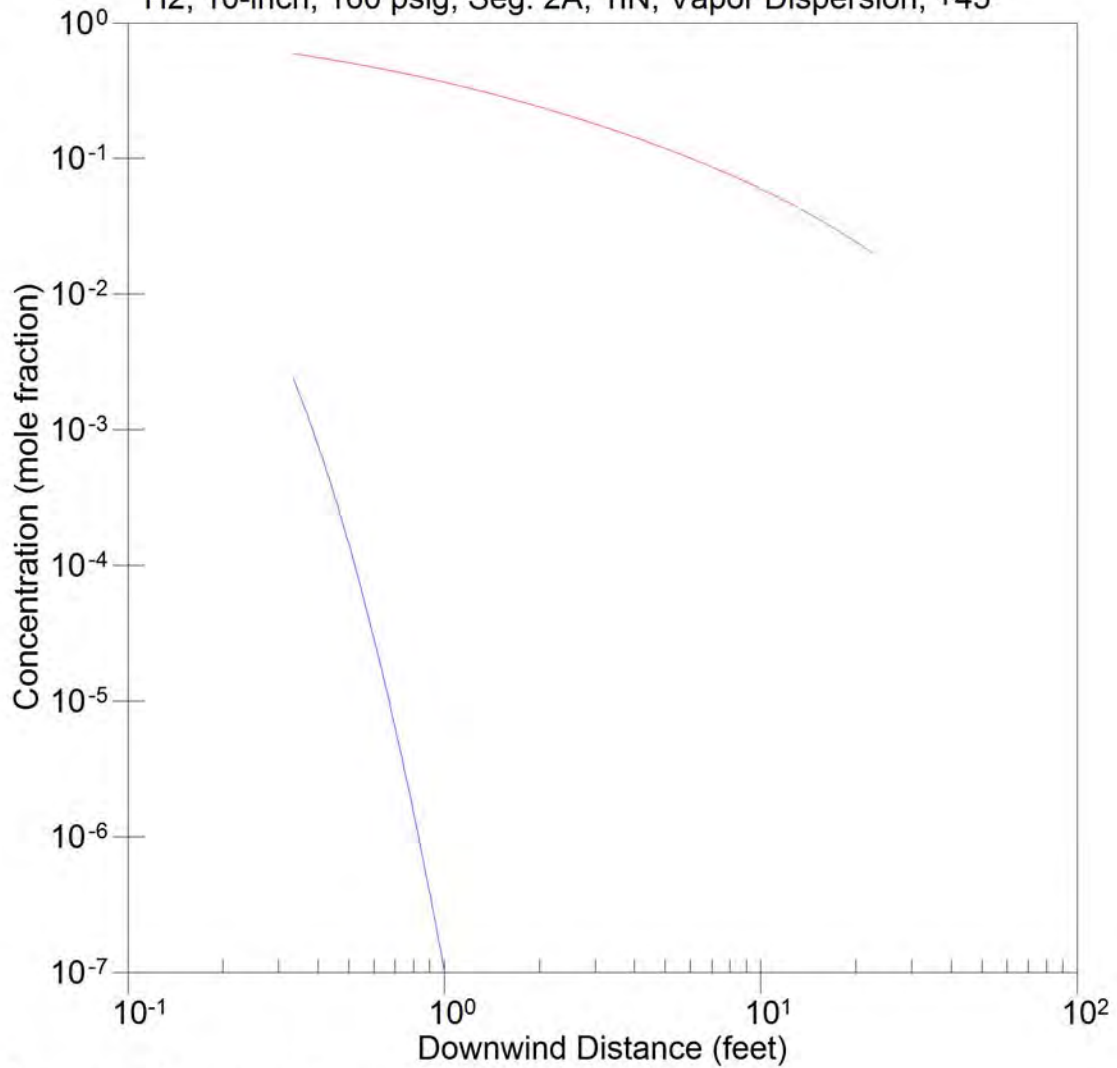
- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=10D1IN160S2A+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:58:46 2020

CANARY by Quest

Momentum Jet Cloud CONCENTRATION vs. DISTANCE

H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°



— Centerline Concentration
— Ground Level Concentration

casename=10D1IN160S2A+45_7MMSCFD

windspeed = 4.5 mph

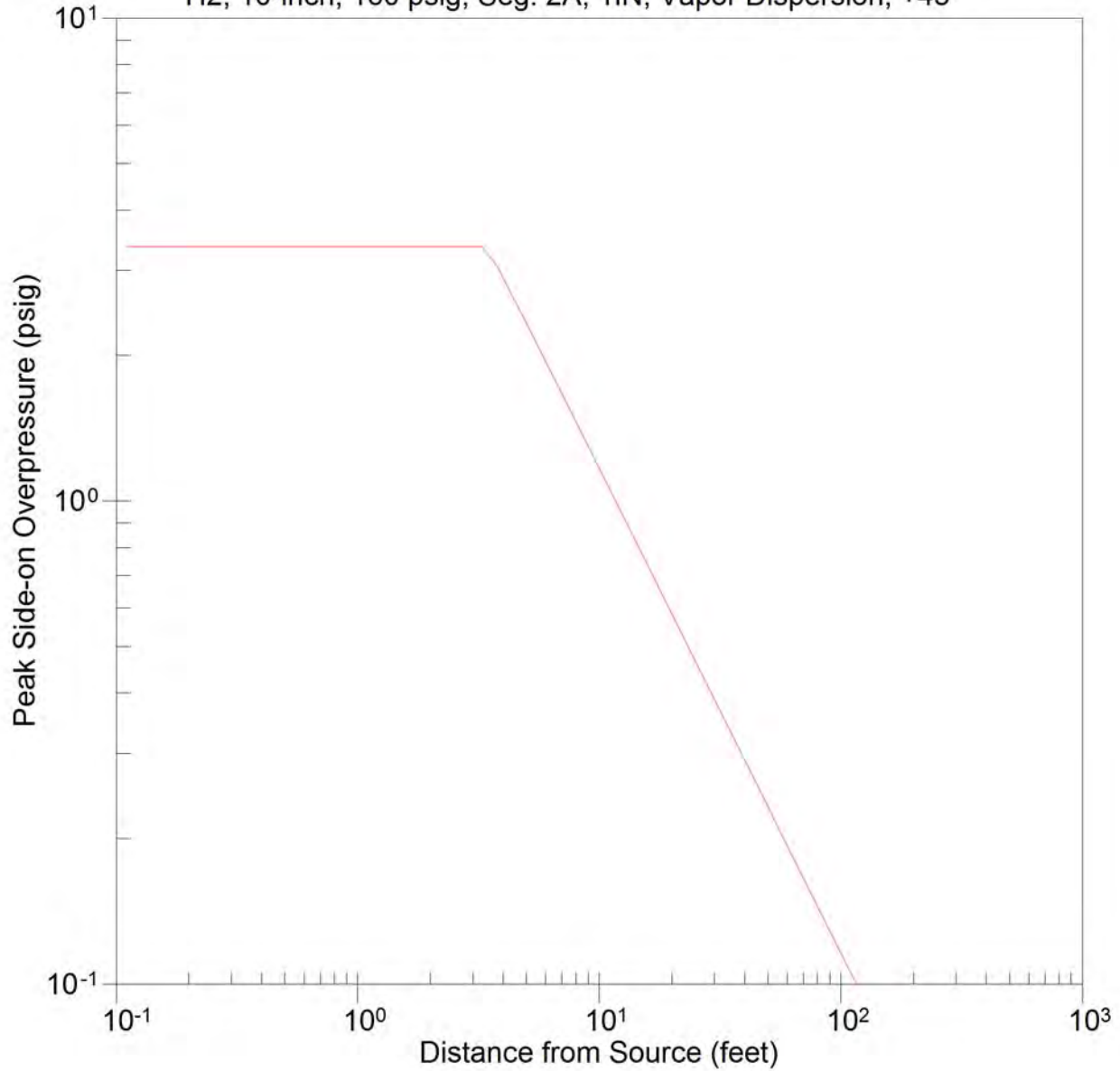
D stability

Thu Jan 23 14:58:46 2020

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, +45°



CANARY by Quest

casename=10D1IN160S2A+45_7MMSCFD
Thu Jan 23 14:58:46 2020

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D1IN160S2A-45_7MMSCFD             |
|           Thu Jan 23 14:59:21 2020                         |
|   Quest Consultants Inc., Norman, Oklahoma, USA            |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734        |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

```

Case Type       : Vapor Dispersion
Case Name      : 10D1IN160S2A-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A, psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity        0.22 Btu/lb-F
Substrate delay time           0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|   CANARY Case Input                 |
| Case Name - 10D1IN160S2A-45_7MMSCFD |
|   Thu Jan 23 14:59:21 2020         |
|               |
+-----+

```

Page 2 Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration           120 min
Normal flow rate          0.43 lb/sec
Duration of normal flow   5 min
Volume of vessel          0.00 cu.ft
Pipe inner diameter       10.02 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 20416.0 feet
Height of release point   0.0 feet
Angle of release from horizontal 135.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1          UFL mol%
Concentration endpoint 2          LFL mol%
Concentration endpoint 3          1/2 LFL mol%

```

```

Dispersion coefficient averaging time          1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity          High
Obstacle density         Low
Flame expansion          3-D

```

Overpressure values

```

Overpressure endpoint 1          1.00 psi
Overpressure endpoint 2          0.70 psi
Overpressure endpoint 3          0.10 psi

```

NOTES:

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               General Release Model UPSTREAM                 |
|               Case Name - 10D1IN160S2A-45_7MMSCFD          |
|               Thu Jan 23 14:59:21 2020                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	.5715267	0.000000	0.000000	.5715267
0.100000	.5714569	0.000000	0.000000	.5714569
0.300000	.5714050	0.000000	0.000000	.5714050
0.500000	.5713474	0.000000	0.000000	.5713474
0.700000	.5712927	0.000000	0.000000	.5712927
1.000000	.5712092	0.000000	0.000000	.5712092
3.000000	.5706580	0.000000	0.000000	.5706580
5.000000	.5695466	0.000000	0.000000	.5695466
7.000000	.5693023	0.000000	0.000000	.5693023
10.00000	.5689367	0.000000	0.000000	.5689367
20.00000	.5677249	0.000000	0.000000	.5677249
30.00000	.5665237	0.000000	0.000000	.5665237
40.00000	.5653329	0.000000	0.000000	.5653329
50.00000	.5641525	0.000000	0.000000	.5641525
60.00000	.5629823	0.000000	0.000000	.5629823
70.00000	.5618223	0.000000	0.000000	.5618223
85.00000	.5601012	0.000000	0.000000	.5601012
100.0000	.5584023	0.000000	0.000000	.5584023
200.0000	.5475894	0.000000	0.000000	.5475894
300.0000	.5372916	0.000000	0.000000	.5372916
400.0000	.4942727	0.000000	0.000000	.4942727
500.0000	.4522515	0.000000	0.000000	.4522515
600.0000	.4137486	0.000000	0.000000	.4137486
700.0000	.3785389	0.000000	0.000000	.3785389
850.0000	.3311894	0.000000	0.000000	.3311894
1000.000	.2900627	0.000000	0.000000	.2900627
2000.000	.1183041	0.000000	0.000000	.1183041
3000.000	.1993638E-01	0.000000	0.000000	.1993638E-01
3261.777	0.000000	0.000000	0.000000	0.000000

Totals (lb) 709.3732 0.000000 0.000000 709.3732

Flowrate for Torch Fire [immediate ignition] = 0.5666177 lb/sec.
 Torch Fire [delayed ignition] = 0.5529317 lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

CANARY by Quest - Version 4.6.2
Release Stream Compositions
Case Name - 10D1IN160S2A-45_7MMSCFD
Thu Jan 23 14:59:21 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	


```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 10D1IN160S2A-45_7MMSCFD                  |
|              Thu Jan 23 14:59:21 2020                      |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

TITLE: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance	centerline conc.	ground conc.	y(c1) 1/2 width	y(c2) 1/2 width	y(c3) 1/2 width	centerline height
x(ft)	c(mole frac.)	c(mole frac.)	(ft)	(ft)	(ft)	(ft)
0	1.000000	0.000000	0.2	0.2	0.1	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is      0.00 ft after about      0 seconds
The downwind distance to c2 is      0.00 ft after about      0 seconds
The downwind distance to c1 is      0.00 ft after about      0 seconds

```

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
| Momentum Jet Vapor Cloud Explosion                |
| Case Name - 10D1IN160S2A-45_7MMSCFD             |
| Thu Jan 23 14:59:21 2020                         |
| Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com      canary@questconsult.com |
| telephone (405) 329-7475    fax (405) 329-7734  |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

Fuel Reactivity: High Obstacle Density: Low
 Flame Expansion: 3-D Flame Speed: 0.36

Overpressure levels:

```

-----
dp3 =        1.00 psi gauge
dp2 =        0.70 psi gauge
dp1 =        0.10 psi gauge

```

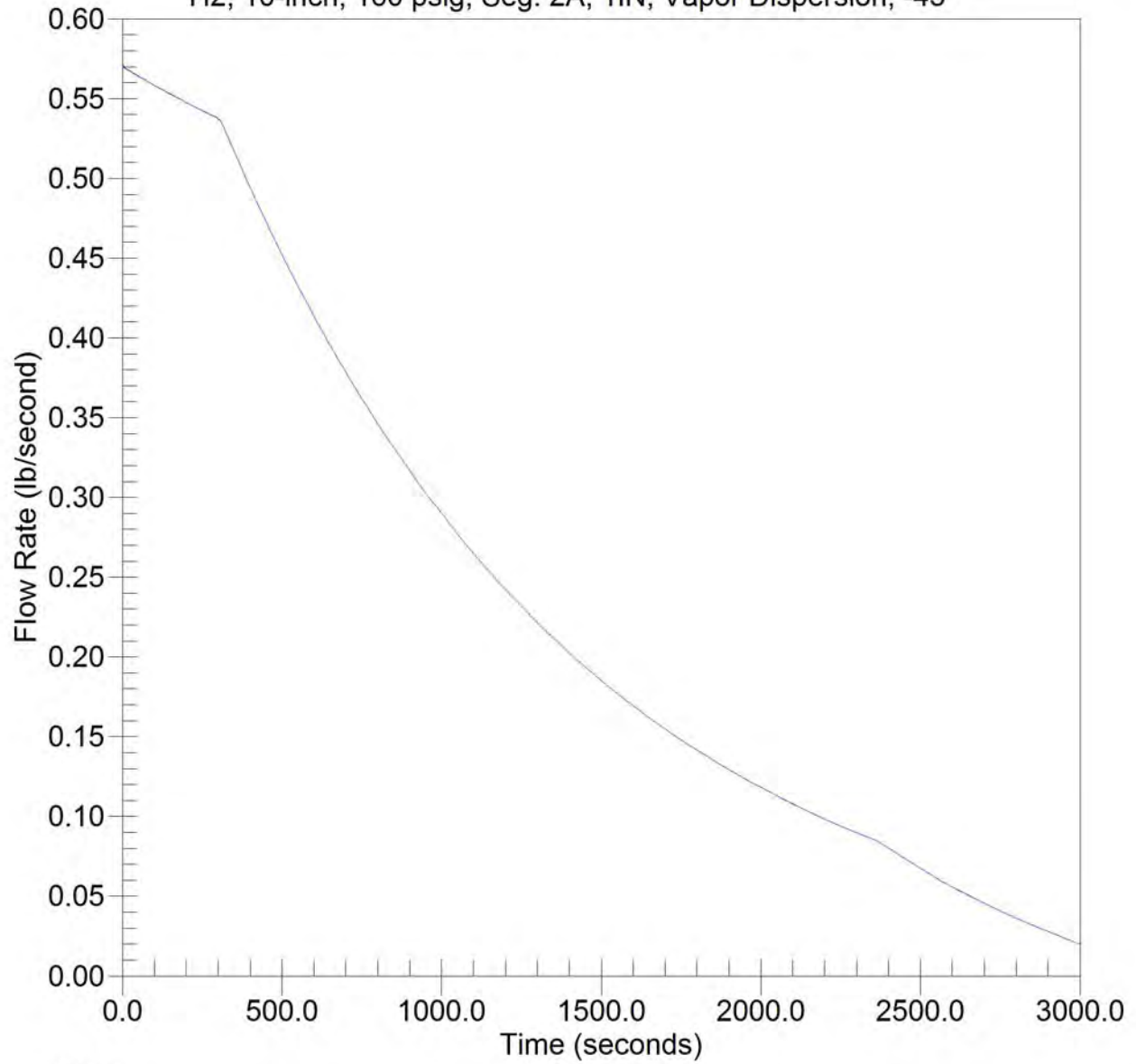
Mass of released material in explosive range: 0.0314809 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0174
0.8	3.36	0.0174
1.0	3.36	0.0174
1.1	3.36	0.0174
1.3	3.36	0.0169
1.5	3.36	0.0146
1.8	3.36	0.0126
2.1	3.36	0.0108
2.4	3.36	0.0093
2.8	3.36	0.0080
3.3	3.36	0.0069
3.8	3.02	0.0060
4.5	2.60	0.0051
5.2	2.24	0.0044
6.1	1.93	0.0038
7.1	1.66	0.0033
8.2	1.43	0.0028
9.6	1.23	0.0024
11.2	1.05	0.0021
13.0	0.90	0.0018
15.1	0.78	0.0016
17.6	0.67	0.0013
20.5	0.57	0.0012
23.9	0.49	0.0010
116.0	0.10	0.0002

The downwind distance to dp3 is 11.8 feet
 The downwind distance to dp2 is 16.8 feet
 The downwind distance to dp1 is 116.0 feet

MASS RELEASE RATE

H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

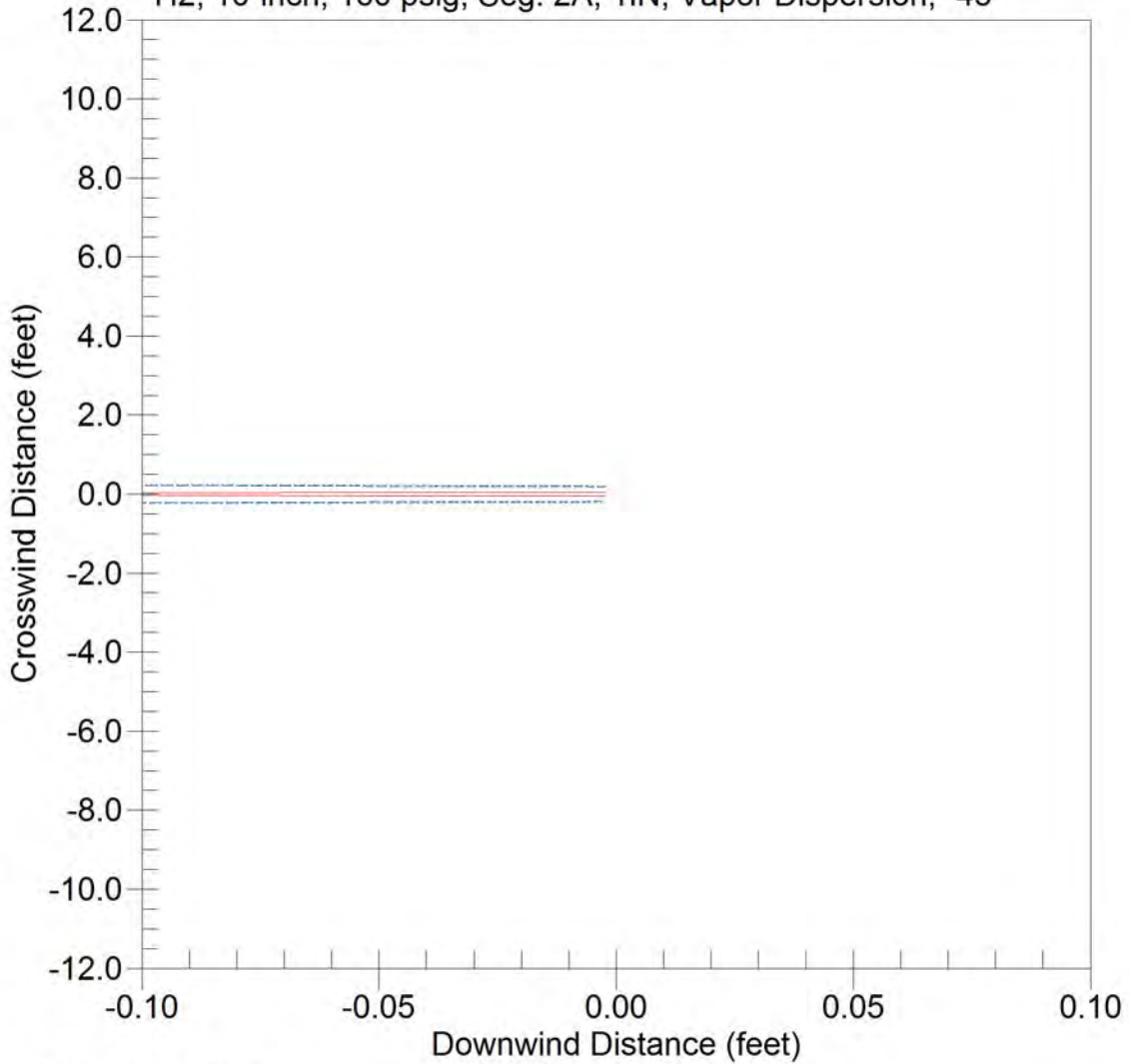


— Total
— Vapor

CANARY by Quest

casename=10D1IN160S2A-45_7MMSCFD
Thu Jan 23 14:59:21 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°

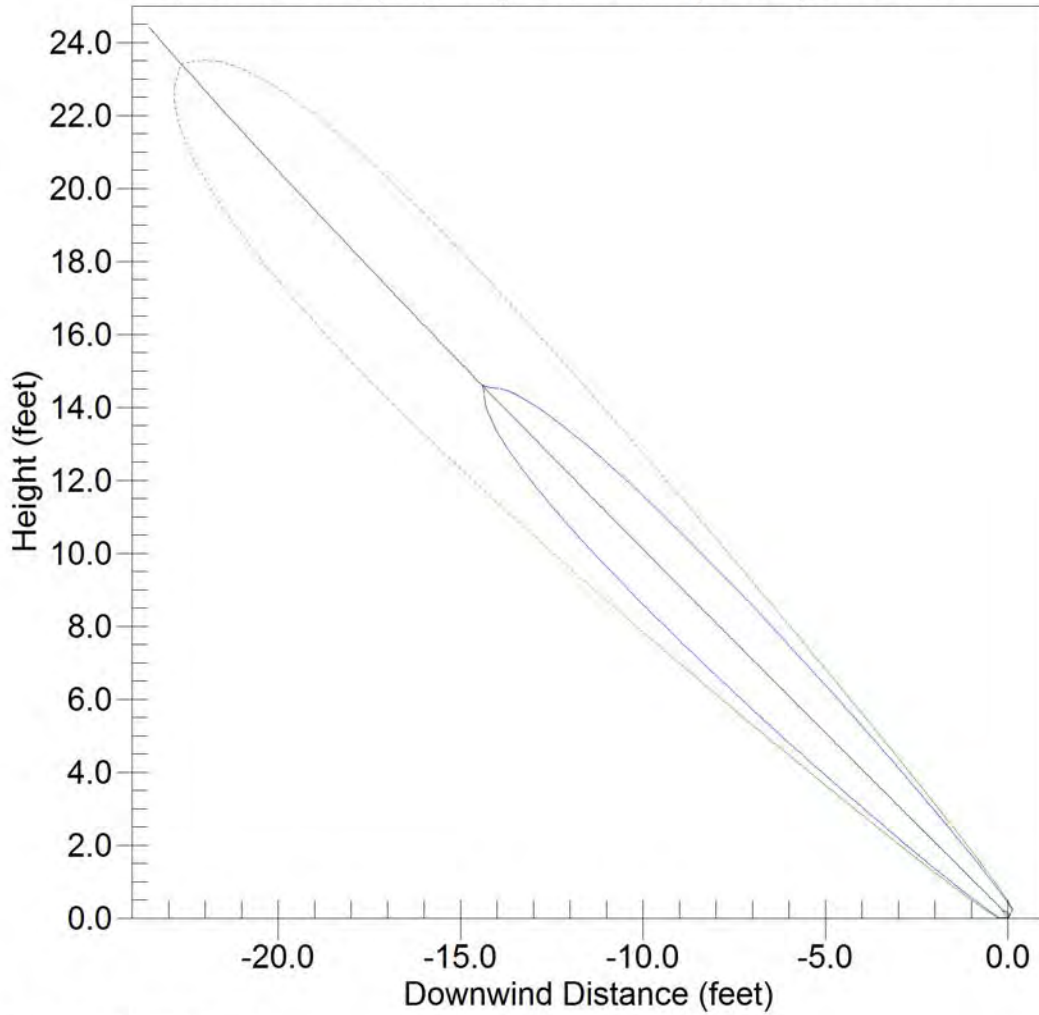


- 75.0 mole percent
- - - 4.00 mole percent
- 2.00 mole percent

casename=10D1IN160S2A-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:59:21 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°



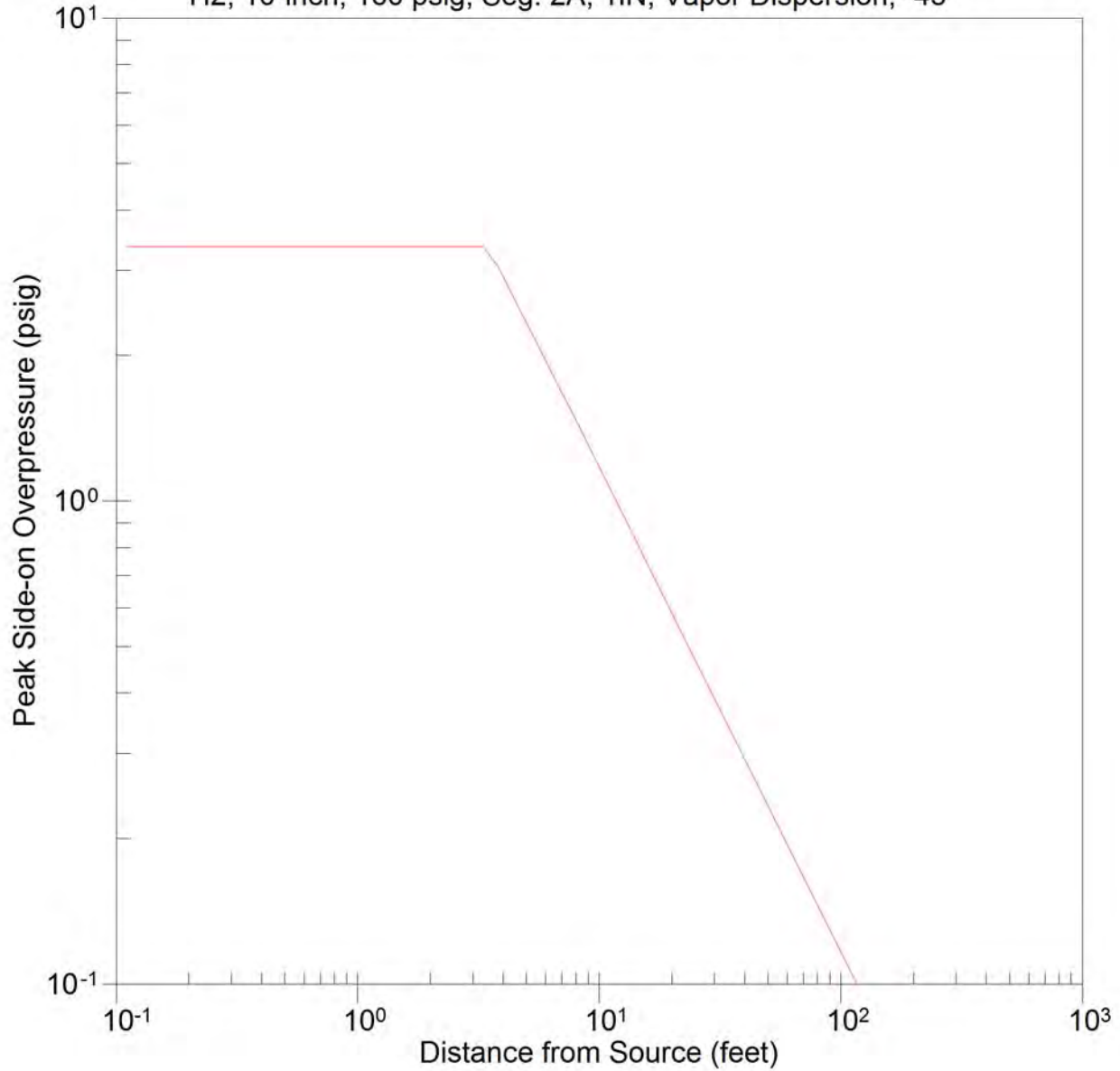
- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=10D1IN160S2A-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 14:59:21 2020

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 10-inch, 160 psig, Seg. 2A, 1IN, Vapor Dispersion, -45°



CANARY by Quest

casename=10D1IN160S2A-45_7MMSCFD
Thu Jan 23 14:59:21 2020



Vapor Dispersion Modeling Results, Segment 2B

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 12DFB160S2B+45_7MMSCFD     |
|           Thu Jan 23 15:23:17 2020               |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°

```

Case Type       : Vapor Dispersion
Case Name      : 12DFB160S2B+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B - 12-inch Pipe, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	72.0 °F
Spill surface temperature	72.0 °F
Substrate name	Medium density concrete
Substrate thermal conductivity	0.2698 Btu/hr-ft-F
Substrate density	80 lb/cu.ft
Substrate heat Capacity	0.22 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Wooded area or urban area

NOTES:

Case continued on page 2.


```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|   CANARY Case Input                 |
| Case Name - 12DFB160S2B+45_7MMSCFD |
|   Thu Jan 23 15:23:17 2020         |
|               |
+-----+

```

Page 2 Title: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration           120 min
Normal flow rate          0.43 lb/sec
Duration of normal flow   5 min
Volume of vessel          0.00 cu.ft
Pipe inner diameter       12.00 inches
Equivalent release diameter 12.00 inches
Pipe length upstream of break 50225.0 feet
Pipe length downstream of break 9397.0 feet
Height of release point   0.0 feet
Angle of release from horizontal 45.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1           UFL mol%
Concentration endpoint 2           LFL mol%
Concentration endpoint 3           1/2 LFL mol%

```

```

Dispersion coefficient averaging time           1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity           High
Obstacle density          Low
Flame expansion           3-D

```

Overpressure values

```

Overpressure endpoint 1           1.00 psi
Overpressure endpoint 2           0.70 psi
Overpressure endpoint 3           0.10 psi

```

NOTES:

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               General Release Model UPSTREAM                 |
|               Case Name - 12DFB160S2B+45_7MMSCFD           |
|               Thu Jan 23 15:23:17 2020                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	82.29391	0.000000	0.000000	82.29391
0.100000	50.48268	0.000000	0.000000	50.48268
0.300000	34.21999	0.000000	0.000000	34.21999
0.500000	27.63496	0.000000	0.000000	27.63496
0.700000	23.81131	0.000000	0.000000	23.81131
1.000000	20.22947	0.000000	0.000000	20.22947
3.000000	11.94585	0.000000	0.000000	11.94585
5.000000	9.261098	0.000000	0.000000	9.261098
7.000000	7.820574	0.000000	0.000000	7.820574
10.00000	6.530803	0.000000	0.000000	6.530803
20.00000	5.550473	0.000000	0.000000	5.550473
30.00000	5.411391	0.000000	0.000000	5.411391
40.00000	5.276684	0.000000	0.000000	5.276684
50.00000	5.145195	0.000000	0.000000	5.145195
60.00000	5.017306	0.000000	0.000000	5.017306
70.00000	4.892805	0.000000	0.000000	4.892805
85.00000	4.712312	0.000000	0.000000	4.712312
100.0000	4.539094	0.000000	0.000000	4.539094
200.0000	3.549396	0.000000	0.000000	3.549396
300.0000	2.754257	0.000000	0.000000	2.754257
400.0000	2.091785	0.000000	0.000000	2.091785
500.0000	1.576983	0.000000	0.000000	1.576983
600.0000	1.181819	0.000000	0.000000	1.181819
700.0000	.8760047	0.000000	0.000000	.8760047
850.0000	.5378305	0.000000	0.000000	.5378305
1000.000	.2910716	0.000000	0.000000	.2910716
1185.571	0.000000	0.000000	0.000000	0.000000
Totals (lb)	2160.075	0.000000	0.000000	2160.075

Flowrate for Torch Fire [immediate ignition] = 6.499102 lb/sec.
Torch Fire [delayed ignition] = 4.014300 lb/sec.

Reason for Ending: Pressure Near Atmospheric


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions               |
|           Case Name - 12DFB160S2B+45_7MMSCFD      |
|           Thu Jan 23 15:23:17 2020                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com           canary@questconsult.com |
|           telephone (405) 329-7475           fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 12DFB160S2B+45_7MMSCFD                   |
|      Thu Jan 23 15:23:17 2020                               |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

TITLE: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	1.1	1.0	0.3	0.1
1	0.699866	0.119026	1.5	1.4	0.0	1.1
2	0.564005	0.007437	1.8	1.6	0.0	2.1
3	0.477858	0.000505	2.1	1.8	0.0	3.1
4	0.416567	0.000044	2.3	2.1	0.0	4.1
5	0.369523	0.000005	2.6	2.3	0.0	5.1
6	0.332076	0.000001	2.8	2.4	0.0	6.1
7	0.301210	0.000000	3.0	2.6	0.0	7.1
8	0.275382	0.000000	3.3	2.8	0.0	8.0
9	0.253351	0.000000	3.5	3.0	0.0	9.0
10	0.234236	0.000000	3.7	3.2	0.0	10.0
11	0.217496	0.000000	3.9	3.3	0.0	11.0
12	0.202701	0.000000	4.2	3.5	0.0	12.0
13	0.189477	0.000000	4.4	3.6	0.0	13.0
14	0.177619	0.000000	4.6	3.8	0.0	14.0
15	0.166984	0.000000	4.8	4.0	0.0	15.0
16	0.157277	0.000000	5.0	4.1	0.0	15.9
17	0.148507	0.000000	5.3	4.2	0.0	16.9
18	0.140357	0.000000	5.5	4.4	0.0	17.9
19	0.132922	0.000000	5.7	4.5	0.0	18.9
20	0.126067	0.000000	5.9	4.7	0.0	19.8
21	0.119750	0.000000	6.1	4.8	0.0	20.8
22	0.113866	0.000000	6.3	4.9	0.0	21.8
23	0.108453	0.000000	6.5	5.0	0.0	22.7
24	0.103279	0.000000	6.7	5.1	0.0	23.7
25	0.098581	0.000000	7.0	5.2	0.0	24.6
26	0.094038	0.000000	7.2	5.3	0.0	25.6
27	0.089887	0.000000	7.4	5.4	0.0	26.5
28	0.086038	0.000000	7.6	5.5	0.0	27.4
29	0.082279	0.000000	7.8	5.6	0.0	28.4
30	0.078826	0.000000	8.0	5.6	0.0	29.3
31	0.075630	0.000000	8.2	5.7	0.0	30.2
32	0.072501	0.000000	8.4	5.7	0.0	31.1
33	0.069600	0.000000	8.6	5.7	0.0	32.0
34	0.066830	0.000000	8.7	5.7	0.0	32.9

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
35	0.064198	0.000000	8.9	5.7	0.0	33.8
36	0.061727	0.000000	9.1	5.6	0.0	34.7
37	0.059391	0.000000	9.3	5.6	0.0	35.6
38	0.057202	0.000000	9.4	5.5	0.0	36.5
39	0.055049	0.000000	9.6	5.4	0.0	37.4
40	0.052981	0.000000	9.7	5.2	0.0	38.3
41	0.051113	0.000000	9.9	5.0	0.0	39.1
42	0.049357	0.000000	10.0	4.8	0.0	40.0
43	0.047611	0.000000	10.1	4.5	0.0	40.8
44	0.045930	0.000000	10.2	4.2	0.0	41.6
45	0.044339	0.000000	10.3	3.7	0.0	42.5
46	0.042893	0.000000	10.4	3.2	0.0	43.3
47	0.041474	0.000000	10.5	2.3	0.0	44.1
48	0.040098	0.000000	10.6	0.4	0.0	44.9
49	0.038740	0.000000	10.6	0.0	0.0	45.7
50	0.037482	0.000000	10.7	0.0	0.0	46.5
51	0.036300	0.000000	10.7	0.0	0.0	47.3
52	0.035180	0.000000	10.7	0.0	0.0	48.1
53	0.034058	0.000001	10.7	0.0	0.0	48.9
54	0.032991	0.000001	10.7	0.0	0.0	49.6
55	0.031985	0.000001	10.6	0.0	0.0	50.4
56	0.031021	0.000001	10.5	0.0	0.0	51.2
57	0.030130	0.000001	10.4	0.0	0.0	51.9
58	0.029246	0.000001	10.3	0.0	0.0	52.6
59	0.028369	0.000002	10.2	0.0	0.0	53.4
60	0.027538	0.000002	10.0	0.0	0.0	54.1
61	0.026751	0.000003	9.7	0.0	0.0	54.8
62	0.025981	0.000003	9.5	0.0	0.0	55.5
63	0.025267	0.000004	9.2	0.0	0.0	56.2
64	0.024563	0.000005	8.8	0.0	0.0	56.9
65	0.023908	0.000005	8.4	0.0	0.0	57.6
66	0.023237	0.000006	7.9	0.0	0.0	58.3
67	0.022613	0.000007	7.3	0.0	0.0	59.0
68	0.022019	0.000009	6.6	0.0	0.0	59.6
69	0.021430	0.000010	5.7	0.0	0.0	60.3
70	0.020879	0.000011	4.6	0.0	0.0	60.9
71	0.020356	0.000013	2.9	0.0	0.0	61.6

The downwind distance to c3 is 0.74 ft after about 0 seconds
The downwind distance to c2 is 48.06 ft after about 0 seconds
The downwind distance to c1 is 71.68 ft after about 1 seconds

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
| Momentum Jet Vapor Cloud Explosion                          |
| Case Name - 12DFB160S2B+45_7MMSCFD                        |
| Thu Jan 23 15:23:17 2020                                    |
| Quest Consultants Inc., Norman, Oklahoma, USA              |
| www.questconsult.com          canary@questconsult.com      |
| telephone (405) 329-7475      fax (405) 329-7734          |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°

Fuel Reactivity: High Obstacle Density: Low
 Flame Expansion: 3-D Flame Speed: 0.36

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

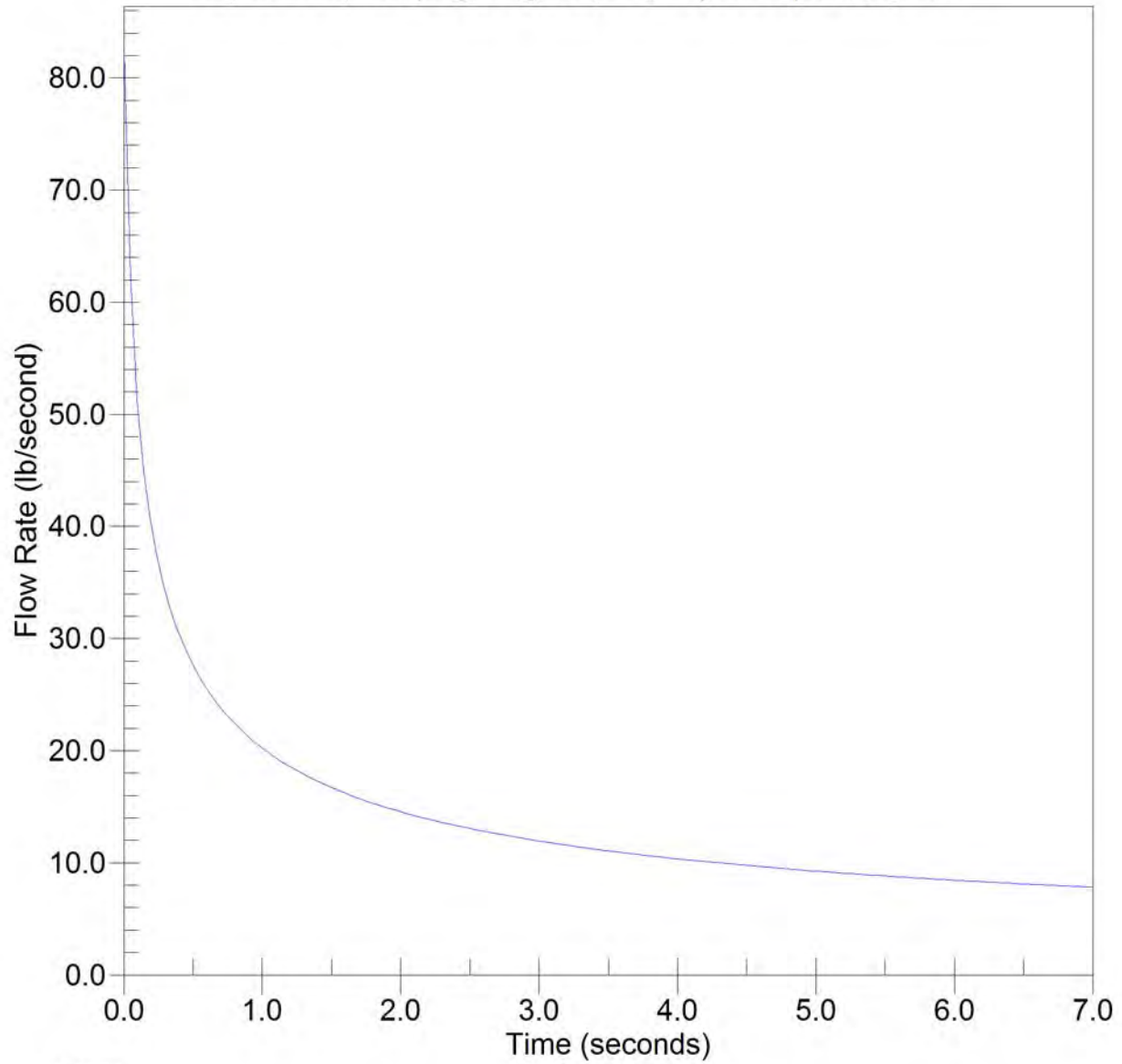
Mass of released material in explosive range: 2.69124 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0768
3.7	3.36	0.0768
4.6	3.36	0.0768
5.7	3.36	0.0766
7.1	3.36	0.0621
8.7	3.36	0.0503
10.8	3.36	0.0408
13.4	3.36	0.0331
16.6	3.08	0.0268
20.6	2.50	0.0217
25.5	2.02	0.0176
31.6	1.64	0.0143
39.2	1.32	0.0116
48.6	1.07	0.0094
60.2	0.86	0.0076
74.6	0.69	0.0062
92.5	0.56	0.0050
114.6	0.45	0.0040
142.0	0.36	0.0033
176.0	0.29	0.0027
218.1	0.24	0.0022
270.2	0.19	0.0017
334.9	0.15	0.0014
415.0	0.12	0.0011
637.2	0.08	0.0008

The downwind distance to dp3 is 52.3 feet
 The downwind distance to dp2 is 74.0 feet
 The downwind distance to dp1 is 534.7 feet

MASS RELEASE RATE

H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°



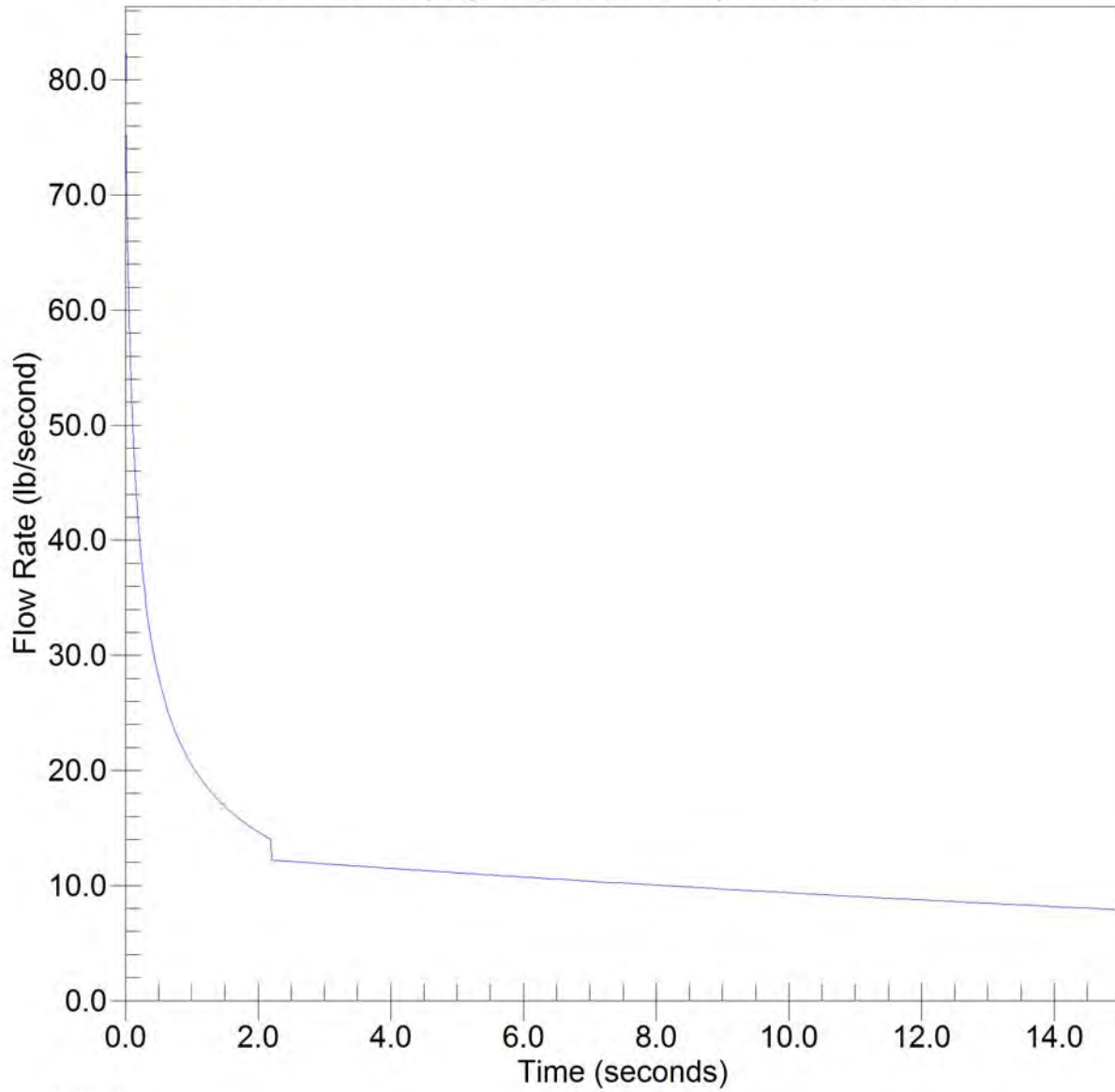
— Total
— Vapor

CANARY by Quest

casename=12DFB160S2B+45_7MMSCFD
Thu Jan 23 15:23:17 2020

MASS RELEASE RATE - DOWNSTREAM PIPING

H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°



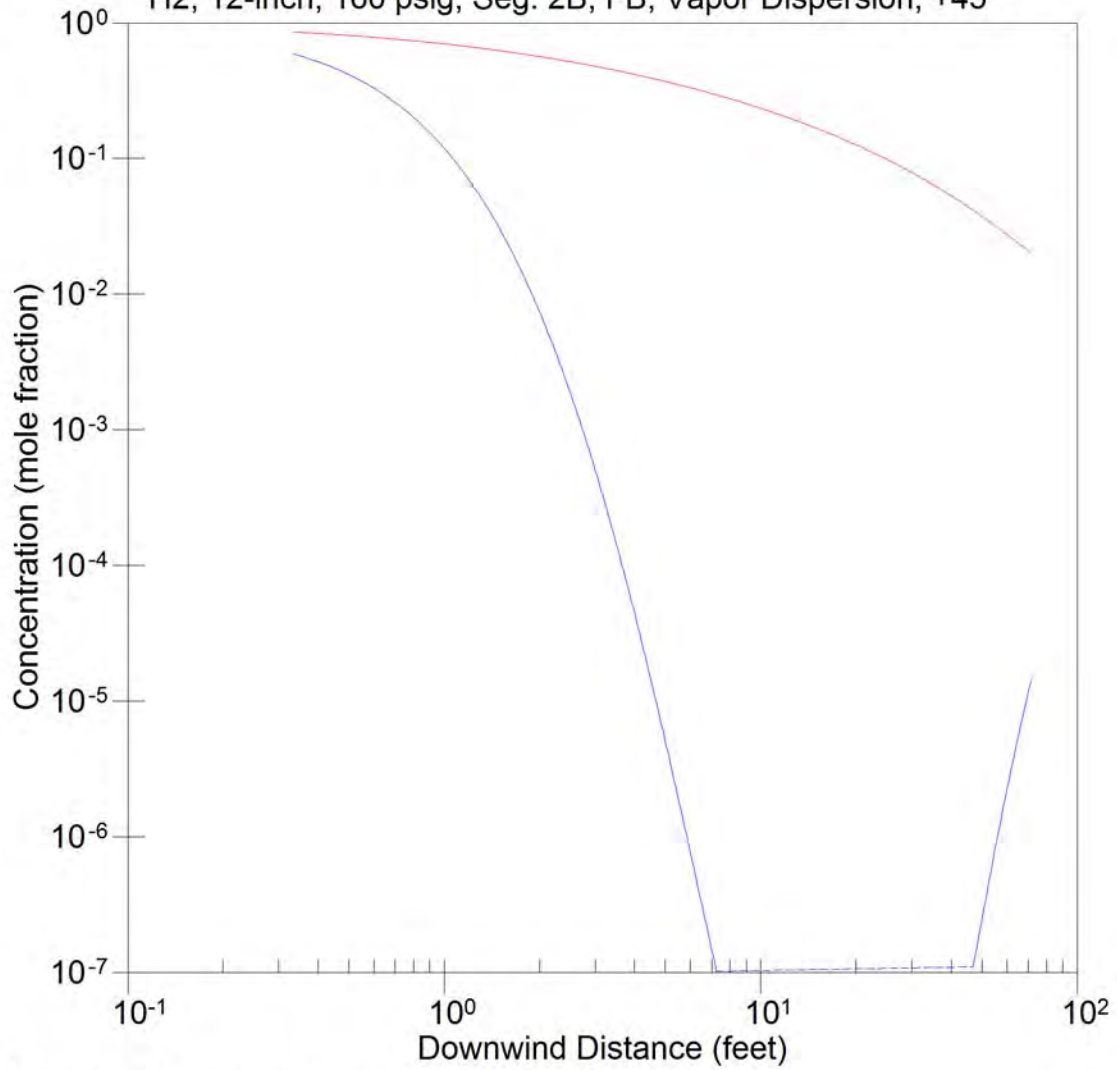
— Total
— Vapor

CANARY by Quest

casename=12DFB160S2B+45_7MMSCFD
Thu Jan 23 15:23:17 2020

Momentum Jet Cloud CONCENTRATION vs. DISTANCE

H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°



— Centerline Concentration
- - - Ground Level Concentration

casename=12DFB160S2B+45_7MMSCFD

windspeed = 4.5 mph

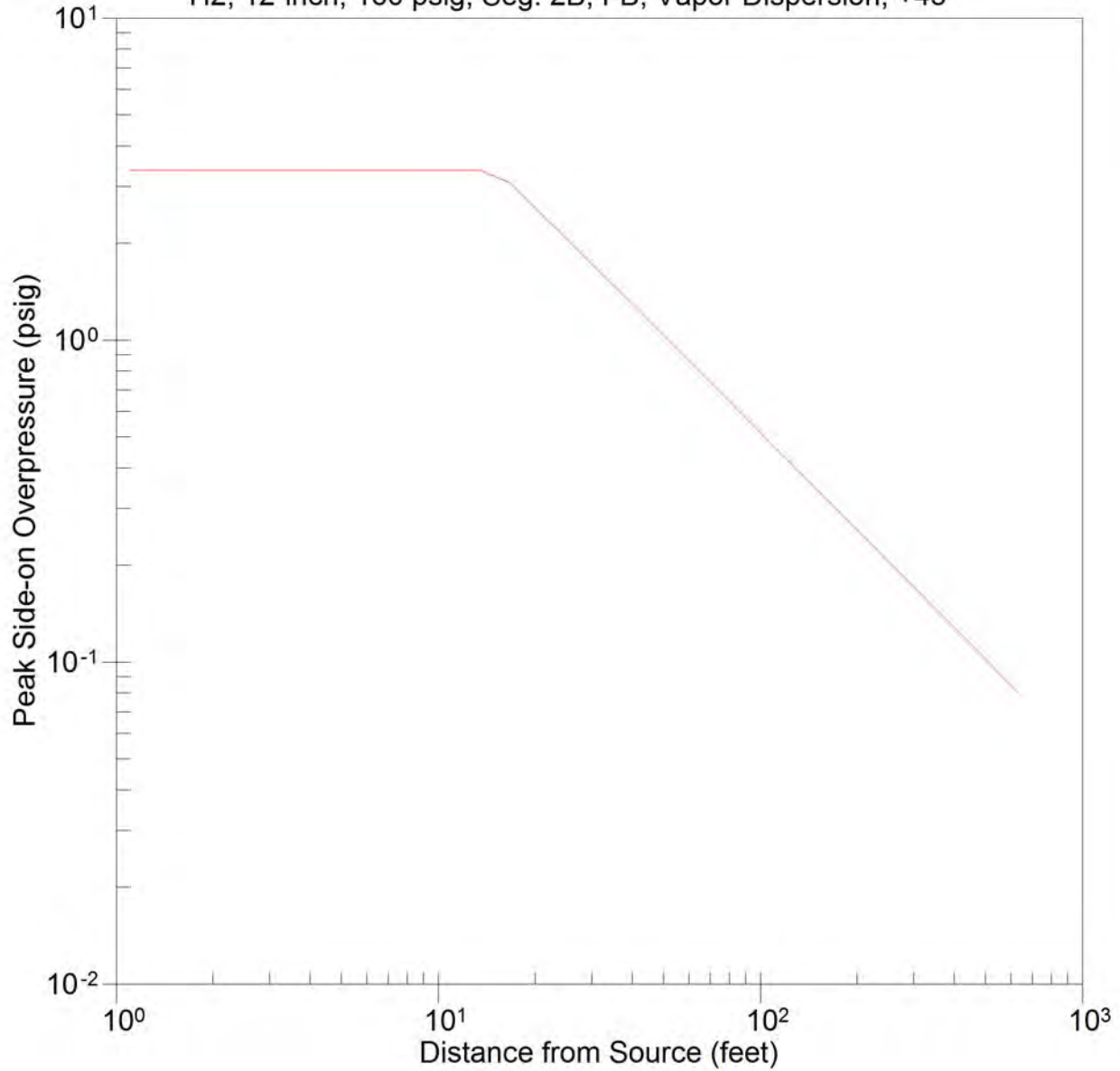
D stability

Thu Jan 23 15:23:17 2020

CANARY by Quest

Momentum Jet VCE

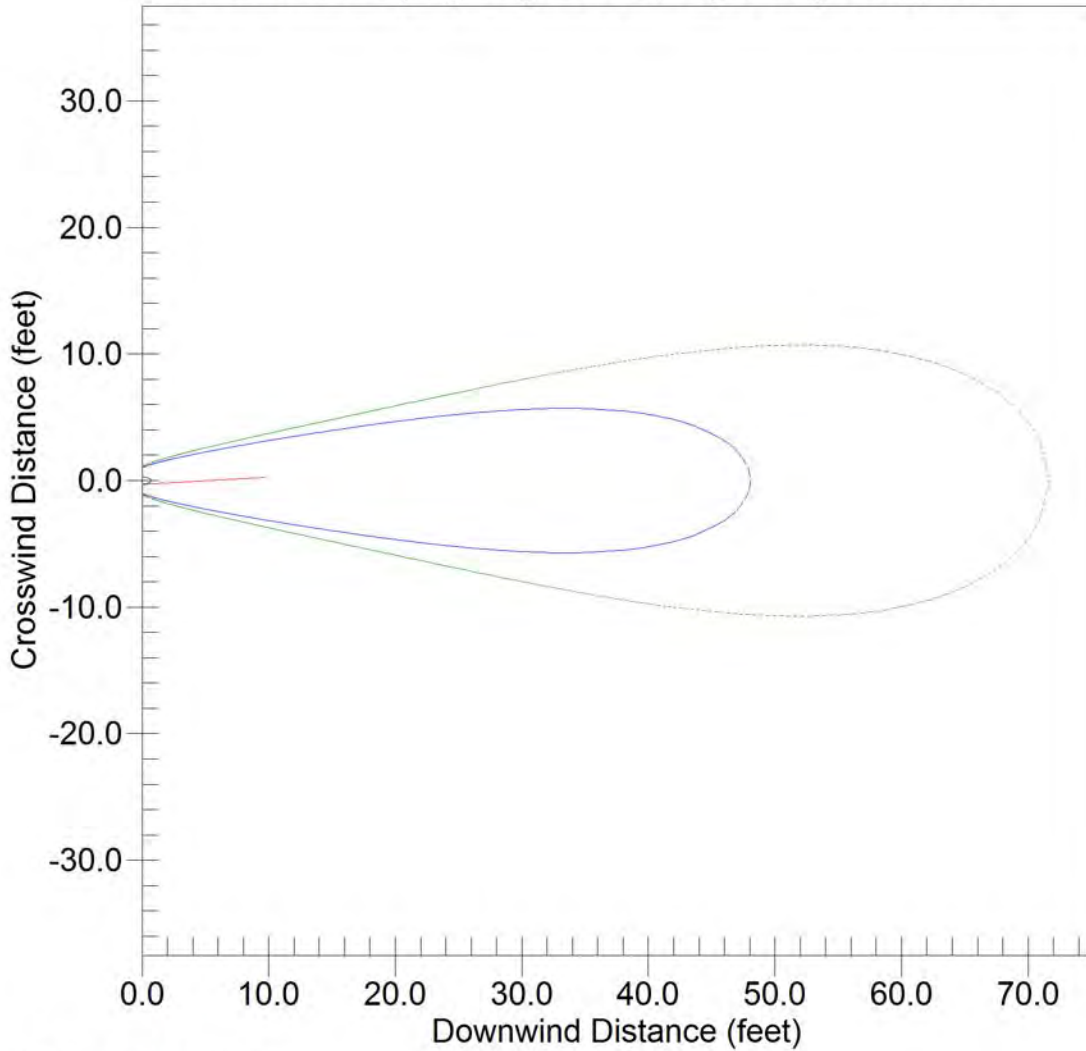
BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°



CANARY by Quest

casename=12DFB160S2B+45_7MMSCFD
Thu Jan 23 15:23:17 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°

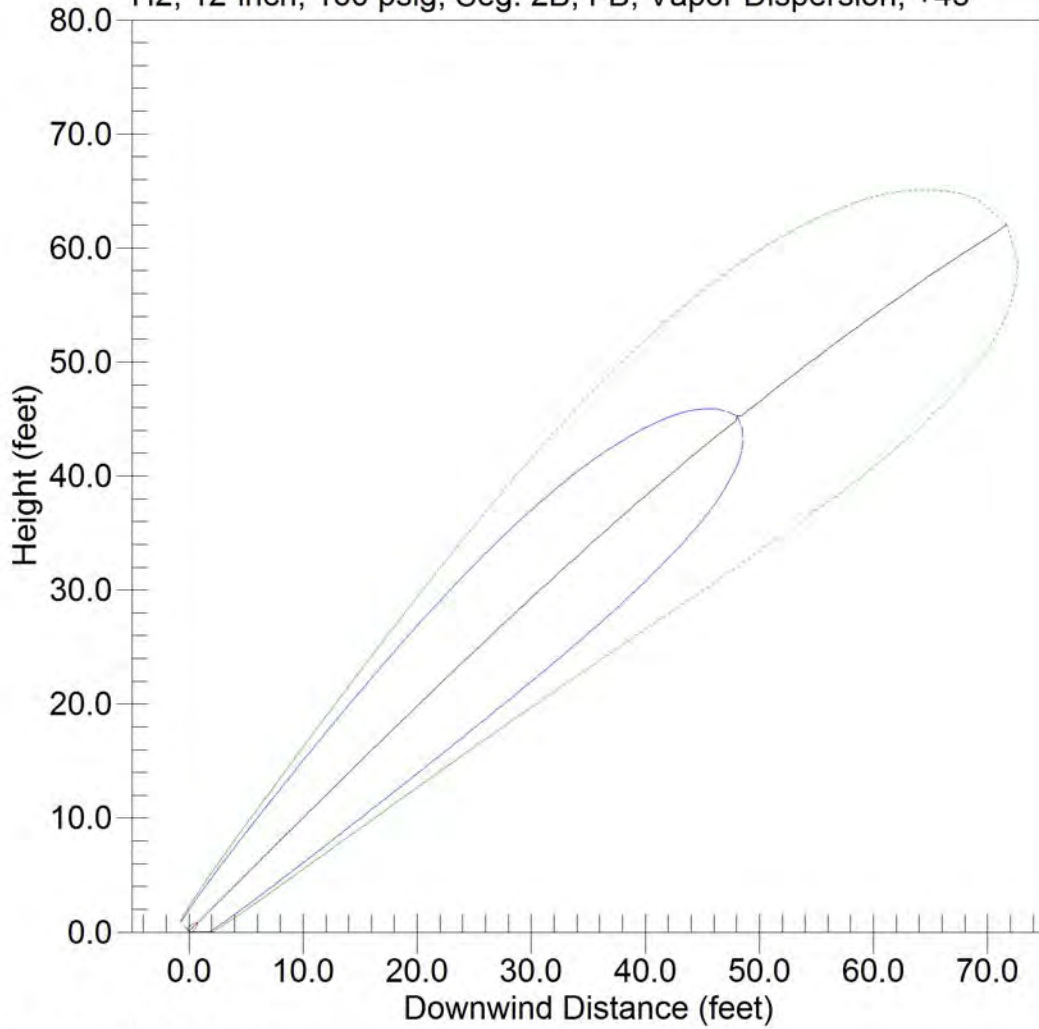


- 75.0 mole percent
- - - 4.00 mole percent
- · - · 2.00 mole percent

casename=12DFB160S2B+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 15:23:17 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, +45°



- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=12DFB160S2B+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 15:23:17 2020

CANARY by Quest

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 12DFB160S2B-45_7MMSCFD      |
|           Thu Jan 23 15:23:43 2020                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°

```

Case Type       : Vapor Dispersion
Case Name      : 12DFB160S2B-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B - 12-inch Pipe, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed                4.47 mph
Wind speed measurement height 32.8 feet
Stability class <A-F>      D
Relative humidity         70 %
Air temperature           72.0 °F
Spill surface temperature 72.0 °F

```

```

Substrate name                Medium density concrete
Substrate thermal conductivity 0.2698 Btu/hr-ft-F
Substrate density              80 lb/cu.ft
Substrate heat Capacity       0.22 Btu/lb-F
Substrate delay time          0 sec
Surrounding terrain           Wooded area or urban area

```

NOTES:

Case continued on page 2.

```

+-----+
|               |
| CANARY by Quest - Version 4.6.2 |
| CANARY Case Input |
| Case Name - 12DFB160S2B-45_7MMSCFD |
| Thu Jan 23 15:23:43 2020 |
|               |
+-----+

```

Page 2 Title: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration          120 min
Normal flow rate         0.43 lb/sec
Duration of normal flow  5 min
Volume of vessel         0.00 cu.ft
Pipe inner diameter      12.00 inches
Equivalent release diameter 12.00 inches
Pipe length upstream of break 50225.0 feet
Pipe length downstream of break 9397.0 feet
Height of release point  0.0 feet
Angle of release from horizontal 135.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1      UFL mol%
Concentration endpoint 2      LFL mol%
Concentration endpoint 3      1/2 LFL mol%

```

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

```

Fuel reactivity      High
Obstacle density     Low
Flame expansion      3-D

```

Overpressure values

```

Overpressure endpoint 1  1.00 psi
Overpressure endpoint 2  0.70 psi
Overpressure endpoint 3  0.10 psi

```

NOTES:

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               General Release Model UPSTREAM                 |
|               Case Name - 12DFB160S2B-45_7MMSCFD           |
|               Thu Jan 23 15:23:43 2020                      |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	82.29391	0.000000	0.000000	82.29391
0.100000	50.48268	0.000000	0.000000	50.48268
0.300000	34.21999	0.000000	0.000000	34.21999
0.500000	27.63496	0.000000	0.000000	27.63496
0.700000	23.81131	0.000000	0.000000	23.81131
1.000000	20.22947	0.000000	0.000000	20.22947
3.000000	11.94585	0.000000	0.000000	11.94585
5.000000	9.261098	0.000000	0.000000	9.261098
7.000000	7.820574	0.000000	0.000000	7.820574
10.00000	6.530803	0.000000	0.000000	6.530803
20.00000	5.550473	0.000000	0.000000	5.550473
30.00000	5.411391	0.000000	0.000000	5.411391
40.00000	5.276684	0.000000	0.000000	5.276684
50.00000	5.145195	0.000000	0.000000	5.145195
60.00000	5.017306	0.000000	0.000000	5.017306
70.00000	4.892805	0.000000	0.000000	4.892805
85.00000	4.712312	0.000000	0.000000	4.712312
100.0000	4.539094	0.000000	0.000000	4.539094
200.0000	3.549396	0.000000	0.000000	3.549396
300.0000	2.754257	0.000000	0.000000	2.754257
400.0000	2.091785	0.000000	0.000000	2.091785
500.0000	1.576983	0.000000	0.000000	1.576983
600.0000	1.181819	0.000000	0.000000	1.181819
700.0000	.8760047	0.000000	0.000000	.8760047
850.0000	.5378305	0.000000	0.000000	.5378305
1000.000	.2910716	0.000000	0.000000	.2910716
1185.571	0.000000	0.000000	0.000000	0.000000
Totals (lb)	2160.075	0.000000	0.000000	2160.075

Flowrate for Torch Fire [immediate ignition] = 6.499102 lb/sec.
Torch Fire [delayed ignition] = 4.014300 lb/sec.

Reason for Ending: Pressure Near Atmospheric


```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               General Release Model DOWNSTREAM               |
|               Case Name - 12DFB160S2B-45_7MMSCFD           |
|               Thu Jan 23 15:23:43 2020                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA  |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

TITLE: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°

Time (sec)	Vapor (lb/sec)	Aerosol Rate (lb/sec)	Liquid Rate (lb/sec)	Total Rate (lb/sec)
0.000000	82.29391	0.000000	0.000000	82.29391
0.100000	51.95470	0.000000	0.000000	51.95470
0.300000	35.02799	0.000000	0.000000	35.02799
0.500000	28.16411	0.000000	0.000000	28.16411
0.700000	24.19821	0.000000	0.000000	24.19821
1.000000	20.48935	0.000000	0.000000	20.48935
3.000000	11.88747	0.000000	0.000000	11.88747
5.000000	11.10561	0.000000	0.000000	11.10561
7.000000	10.37472	0.000000	0.000000	10.37472
10.00000	9.366539	0.000000	0.000000	9.366539
20.00000	6.650560	0.000000	0.000000	6.650560
30.00000	4.703304	0.000000	0.000000	4.703304
40.00000	3.299546	0.000000	0.000000	3.299546
50.00000	2.279276	0.000000	0.000000	2.279276
60.00000	1.525700	0.000000	0.000000	1.525700
70.00000	.9546170	0.000000	0.000000	.9546170
85.00000	.3068805	0.000000	0.000000	.3068805
92.76926	0.000000	0.000000	0.000000	0.000000

Totals (lb) 380.9680 0.000000 0.000000 380.9680

Flowrate for Torch Fire [immediate ignition] = 5.970440 lb/sec.
 Torch Fire [delayed ignition] = 0.000000 lb/sec.

Reason for Ending: Pressure Near Atmospheric

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions             |
|           Case Name - 12DFB160S2B-45_7MMSCFD     |
|           Thu Jan 23 15:23:43 2020              |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com                   |
|           telephone (405) 329-7475               |
|           canary@questconsult.com                |
|           fax (405) 329-7734                     |
|                                     |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 12DFB160S2B-45_7MMSCFD                   |
|      Thu Jan 23 15:23:43 2020                               |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

TITLE: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance	centerline conc.	ground conc.	y(c1) 1/2 width	y(c2) 1/2 width	y(c3) 1/2 width	centerline height
x(ft)	c(mole frac.)	c(mole frac.)	(ft)	(ft)	(ft)	(ft)
0	1.000000	0.000000	1.1	1.0	0.3	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is 0.00 ft after about 1 seconds
The downwind distance to c2 is 0.00 ft after about 1 seconds
The downwind distance to c1 is 0.00 ft after about 1 seconds

```

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
| Momentum Jet Vapor Cloud Explosion                |
| Case Name - 12DFB160S2B-45_7MMSCFD              |
| Thu Jan 23 15:23:43 2020                          |
| Quest Consultants Inc., Norman, Oklahoma, USA      |
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| telephone (405) 329-7475      fax (405) 329-7734  |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°

```

Fuel Reactivity: High          Obstacle Density: Low
Flame Expansion: 3-D           Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 2.67109 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0766
3.7	3.36	0.0766
4.6	3.36	0.0766
5.7	3.36	0.0765
7.0	3.36	0.0620
8.7	3.36	0.0502
10.8	3.36	0.0407
13.4	3.36	0.0330
16.6	3.08	0.0267
20.6	2.50	0.0217
25.5	2.02	0.0176
31.6	1.64	0.0142
39.1	1.32	0.0115
48.5	1.07	0.0093
60.1	0.86	0.0076
74.4	0.69	0.0061
92.2	0.56	0.0050
114.3	0.45	0.0040
141.6	0.36	0.0033
175.5	0.29	0.0026
217.5	0.24	0.0021
269.5	0.19	0.0017
334.0	0.15	0.0014
413.9	0.12	0.0011
635.6	0.08	0.0008

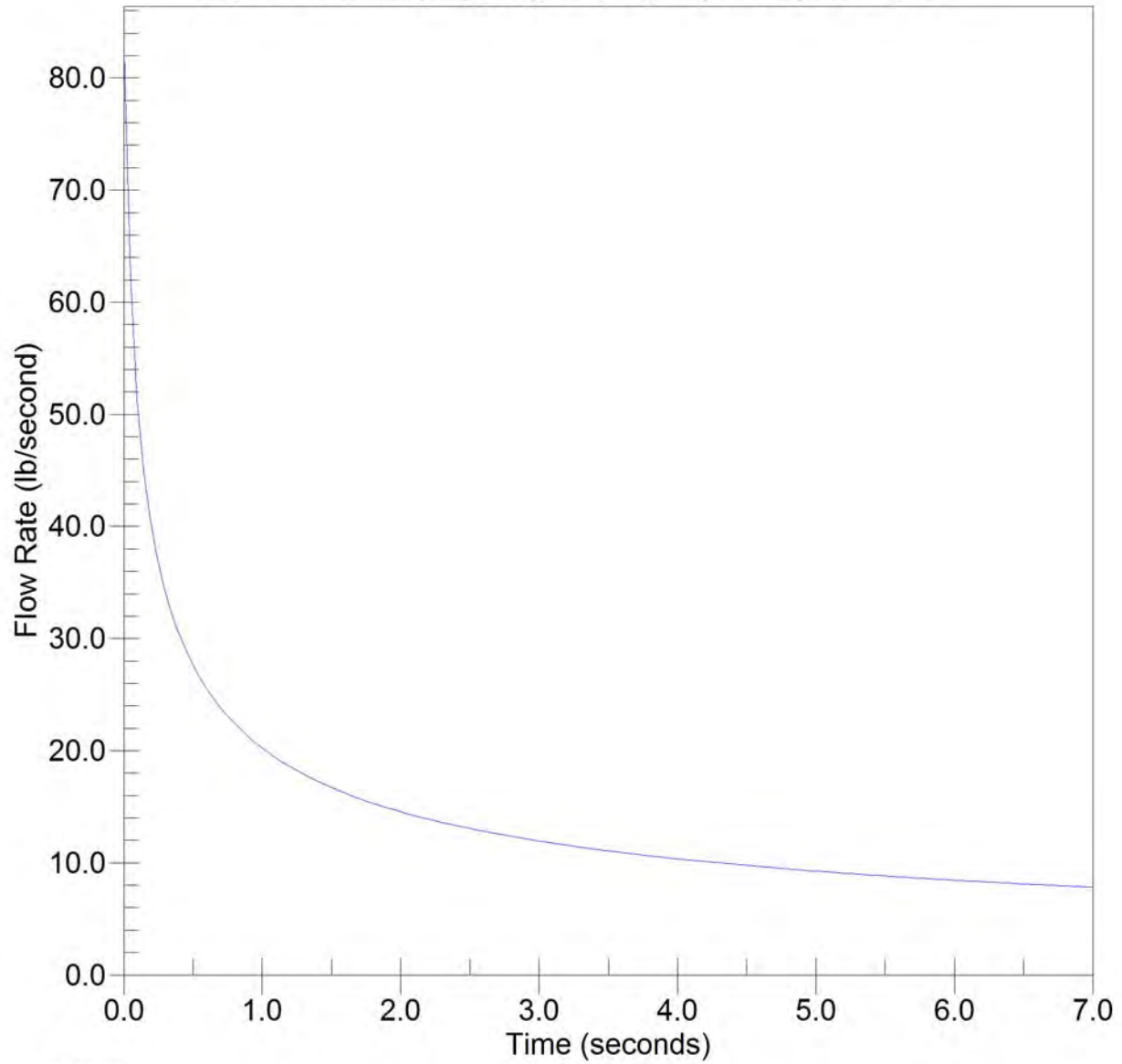
```

The downwind distance to dp3 is  52.2 feet
The downwind distance to dp2 is  73.8 feet
The downwind distance to dp1 is 533.4 feet

```

MASS RELEASE RATE

H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°



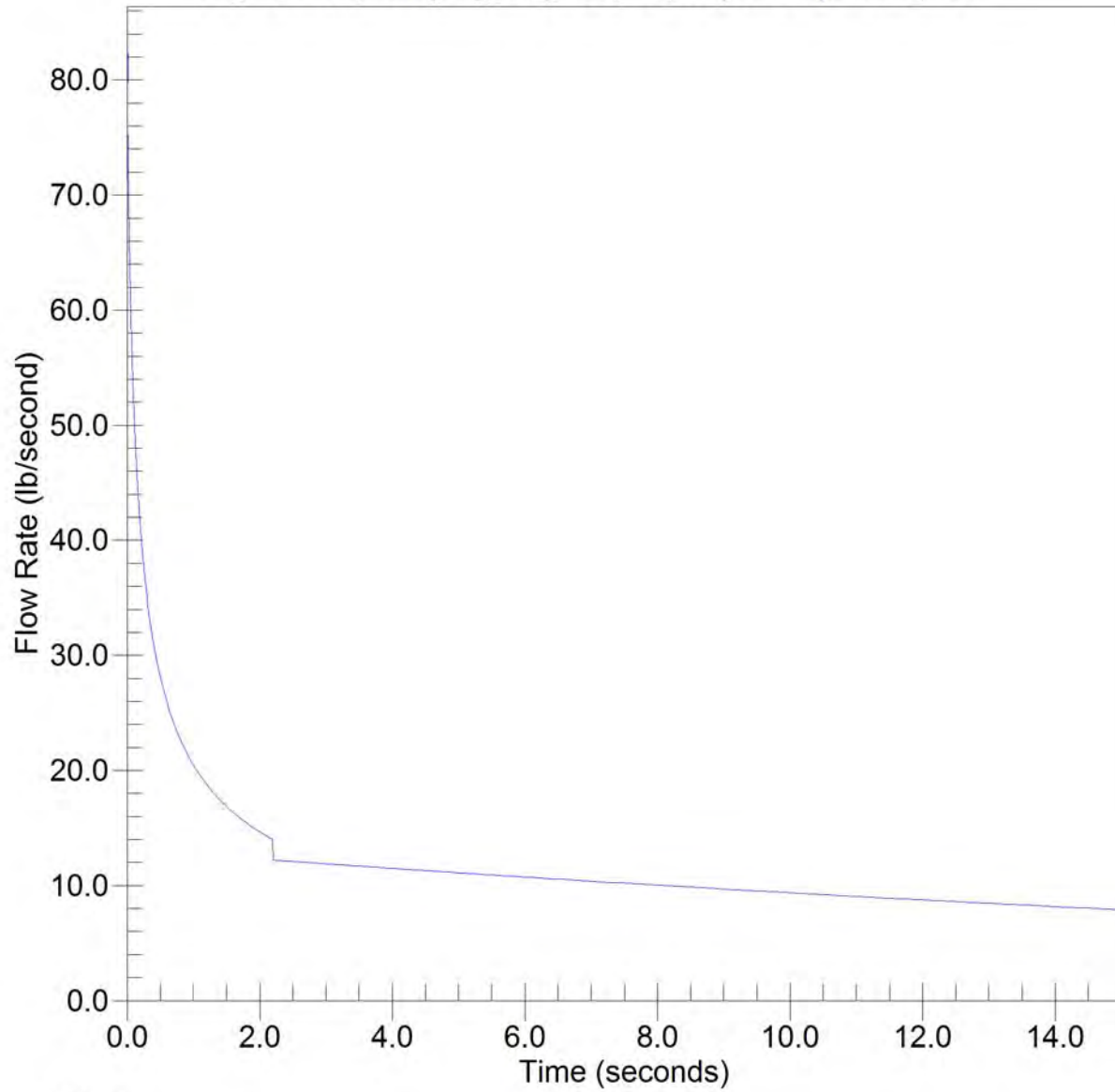
— Total
— Vapor

CANARY by Quest

casename=12DFB160S2B-45_7MMSCFD
Thu Jan 23 15:23:43 2020

MASS RELEASE RATE - DOWNSTREAM PIPING

H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°

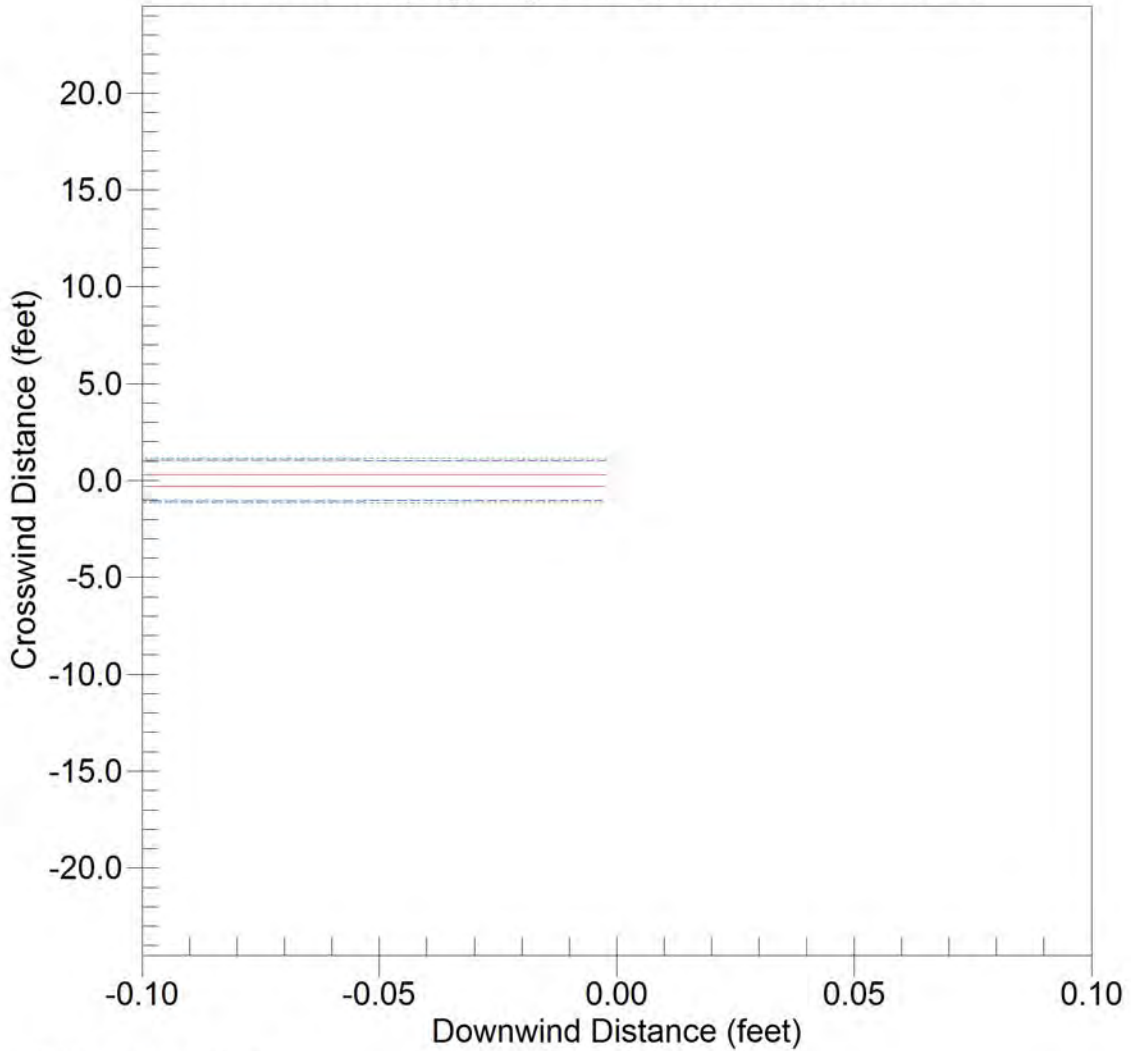


— Total
— Vapor

CANARY by Quest

casename=12DFB160S2B-45_7MMSCFD
Thu Jan 23 15:23:43 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°

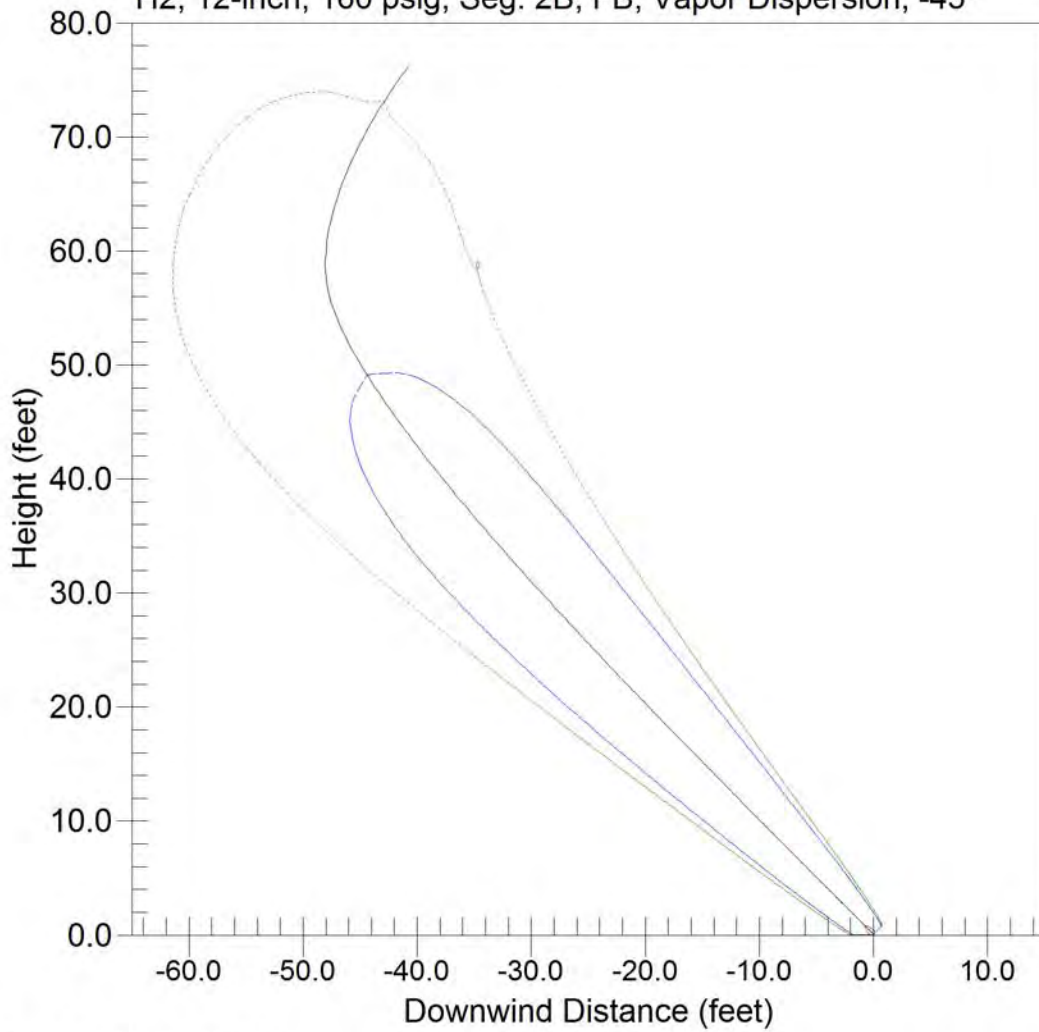


- 75.0 mole percent
- 4.00 mole percent
- 2.00 mole percent

casename=12DFB160S2B-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 15:23:43 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°



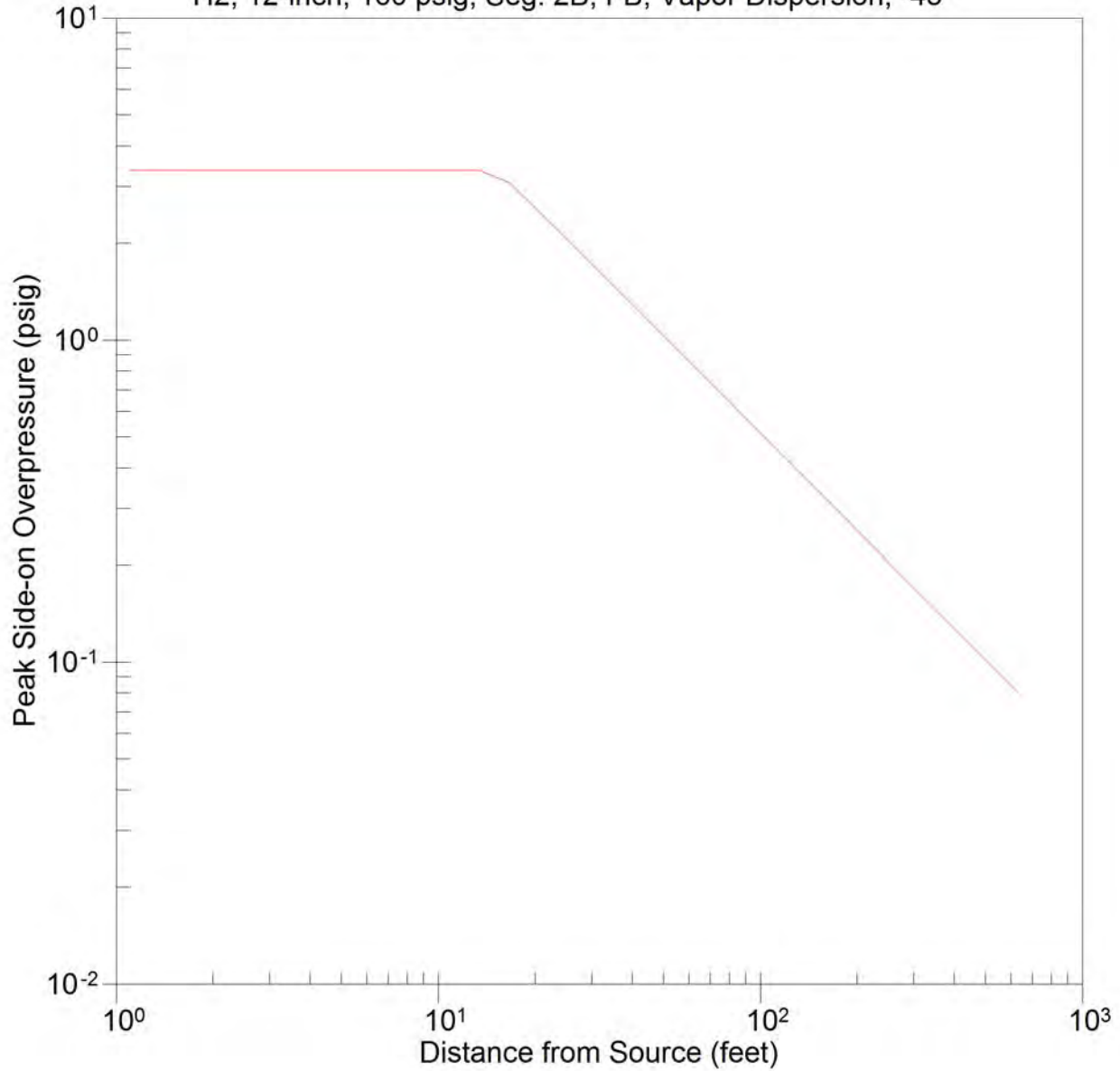
- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=12DFB160S2B-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 15:23:43 2020

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 12-inch, 160 psig, Seg. 2B, FB, Vapor Dispersion, -45°



CANARY by Quest

casename=12DFB160S2B-45_7MMSCFD
Thu Jan 23 15:23:43 2020

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
| Case Name - 12D1IN160S2B+45_7MMSCFD             |
|           Thu Jan 23 16:10:48 2020                |
| Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com           canary@questconsult.com |
| telephone (405) 329-7475       fax (405) 329-7734   |
|                                     |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

```

Case Type       : Vapor Dispersion
Case Name       : 12D1IN160S2B+45_7MMSCFD
User ID        : BLPayne
Project Number  : Job 2134
Type of Units   : English Units

```

NOTES: Segment 2B - 12-inch Pipe, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Psuedo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	72.0 °F
Spill surface temperature	72.0 °F
Substrate name	Medium density concrete
Substrate thermal conductivity	0.2698 Btu/hr-ft-F
Substrate density	80 lb/cu.ft
Substrate heat Capacity	0.22 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Wooded area or urban area

NOTES:

Case continued on page 2.

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|   CANARY Case Input                 |
| Case Name - 12D1IN160S2B+45_7MMSCFD |
|   Thu Jan 23 16:10:48 2020         |
|               |
+-----+

```

Page 2 Title: H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

RELEASE MENU

```

Type of release: Unregulated, Continuous release
Release duration           120 min
Normal flow rate          0.43 lb/sec
Duration of normal flow   5 min
Volume of vessel          0.00 cu.ft
Pipe inner diameter       12.00 inches
Equivalent release diameter 1.00 inches
Pipe length upstream of break 50225.0 feet
Height of release point   0.0 feet
Angle of release from horizontal 45.0 degrees

```

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

```

Vapor generation, dispersion and cloud explosion - Flammable calculation
Concentration endpoint 1           UFL mol%
Concentration endpoint 2           LFL mol%
Concentration endpoint 3           1/2 LFL mol%

```

```

Dispersion coefficient averaging time           1 min

```

Baker-Strehlow-Tang parameters

```

Fuel reactivity           High
Obstacle density          Low
Flame expansion           3-D

```

Overpressure values

```

Overpressure endpoint 1           1.00 psi
Overpressure endpoint 2           0.70 psi
Overpressure endpoint 3           0.10 psi

```

NOTES:


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions               |
|           Case Name - 12D1IN160S2B+45_7MMSCFD      |
|           Thu Jan 23 16:10:48 2020                 |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com           canary@questconsult.com |
|           telephone (405) 329-7475           fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
| Momentum Jet Vapor Dispersion Model                         |
| Case Name - 12D1IN160S2B+45_7MMSCFD                       |
| Thu Jan 23 16:10:48 2020                                    |
| Quest Consultants Inc., Norman, Oklahoma, USA               |
| www.questconsult.com    canary@questconsult.com            |
| telephone (405) 329-7475    fax (405) 329-7734            |
+-----+

```

TITLE: H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
0	1.000000	0.000000	0.2	0.2	0.1	0.1
0.5	0.508651	0.000147	0.4	0.3	0.0	0.6
1.0	0.366078	0.000000	0.5	0.4	0.0	1.1
1.5	0.289453	0.000000	0.6	0.5	0.0	1.6
2.0	0.240401	0.000000	0.7	0.6	0.0	2.1
2.5	0.205740	0.000000	0.7	0.6	0.0	2.6
3.0	0.179916	0.000000	0.8	0.7	0.0	3.1
3.5	0.159702	0.000000	0.9	0.7	0.0	3.6
4.0	0.143461	0.000000	1.0	0.8	0.0	4.1
4.5	0.130038	0.000000	1.0	0.8	0.0	4.6
5.0	0.118659	0.000000	1.1	0.9	0.0	5.1
5.5	0.108967	0.000000	1.2	0.9	0.0	5.6
6.0	0.100648	0.000000	1.3	0.9	0.0	6.1
6.5	0.093315	0.000000	1.3	1.0	0.0	6.6
7.0	0.086835	0.000000	1.4	1.0	0.0	7.1
7.5	0.081090	0.000000	1.4	1.0	0.0	7.5
8.0	0.075950	0.000000	1.5	1.0	0.0	8.0
8.5	0.071306	0.000000	1.6	1.1	0.0	8.5
9.0	0.067117	0.000000	1.6	1.1	0.0	9.0
9.5	0.063300	0.000000	1.7	1.1	0.0	9.5
10.0	0.059810	0.000000	1.7	1.0	0.0	10.0
10.5	0.056630	0.000000	1.8	1.0	0.0	10.5
11.0	0.053660	0.000000	1.8	1.0	0.0	11.0
11.5	0.050962	0.000000	1.9	0.9	0.0	11.5
12.0	0.048432	0.000000	1.9	0.9	0.0	12.0
12.5	0.046103	0.000000	1.9	0.8	0.0	12.5
13.0	0.043929	0.000000	2.0	0.7	0.0	13.0
13.5	0.041918	0.000000	2.0	0.5	0.0	13.5
14.0	0.040001	0.000000	2.0	0.0	0.0	13.9
14.5	0.038248	0.000000	2.1	0.0	0.0	14.4
15.0	0.036564	0.000000	2.1	0.0	0.0	14.9
15.5	0.035000	0.000000	2.1	0.0	0.0	15.4
16.0	0.033533	0.000000	2.1	0.0	0.0	15.9
16.5	0.032143	0.000000	2.1	0.0	0.0	16.4
17.0	0.030853	0.000000	2.1	0.0	0.0	16.8

downwind distance x(ft)	centerline conc. c(mole frac.)	ground conc. c(mole frac.)	y(c1) 1/2 width (ft)	y(c2) 1/2 width (ft)	y(c3) 1/2 width (ft)	centerline height (ft)
17.5	0.029604	0.000000	2.0	0.0	0.0	17.3
18.0	0.028430	0.000000	2.0	0.0	0.0	17.8
18.5	0.027332	0.000000	2.0	0.0	0.0	18.3
19.0	0.026276	0.000000	1.9	0.0	0.0	18.7
19.5	0.025280	0.000000	1.8	0.0	0.0	19.2
20.0	0.024346	0.000000	1.7	0.0	0.0	19.7
20.5	0.023441	0.000000	1.6	0.0	0.0	20.1
21.0	0.022584	0.000000	1.5	0.0	0.0	20.6
21.5	0.021772	0.000000	1.3	0.0	0.0	21.0
22.0	0.021011	0.000000	1.0	0.0	0.0	21.5
22.5	0.020259	0.000000	0.5	0.0	0.0	21.9

The downwind distance to c3 is 0.14 ft after about 0 seconds
The downwind distance to c2 is 14.00 ft after about 0 seconds
The downwind distance to c1 is 22.68 ft after about 0 seconds

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
| Momentum Jet Vapor Cloud Explosion                |
| Case Name - 12D1IN160S2B+45_7MMSCFD             |
| Thu Jan 23 16:10:48 2020                         |
| Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com      canary@questconsult.com |
| telephone (405) 329-7475   fax (405) 329-7734   |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

Fuel Reactivity: High Obstacle Density: Low
 Flame Expansion: 3-D Flame Speed: 0.36

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

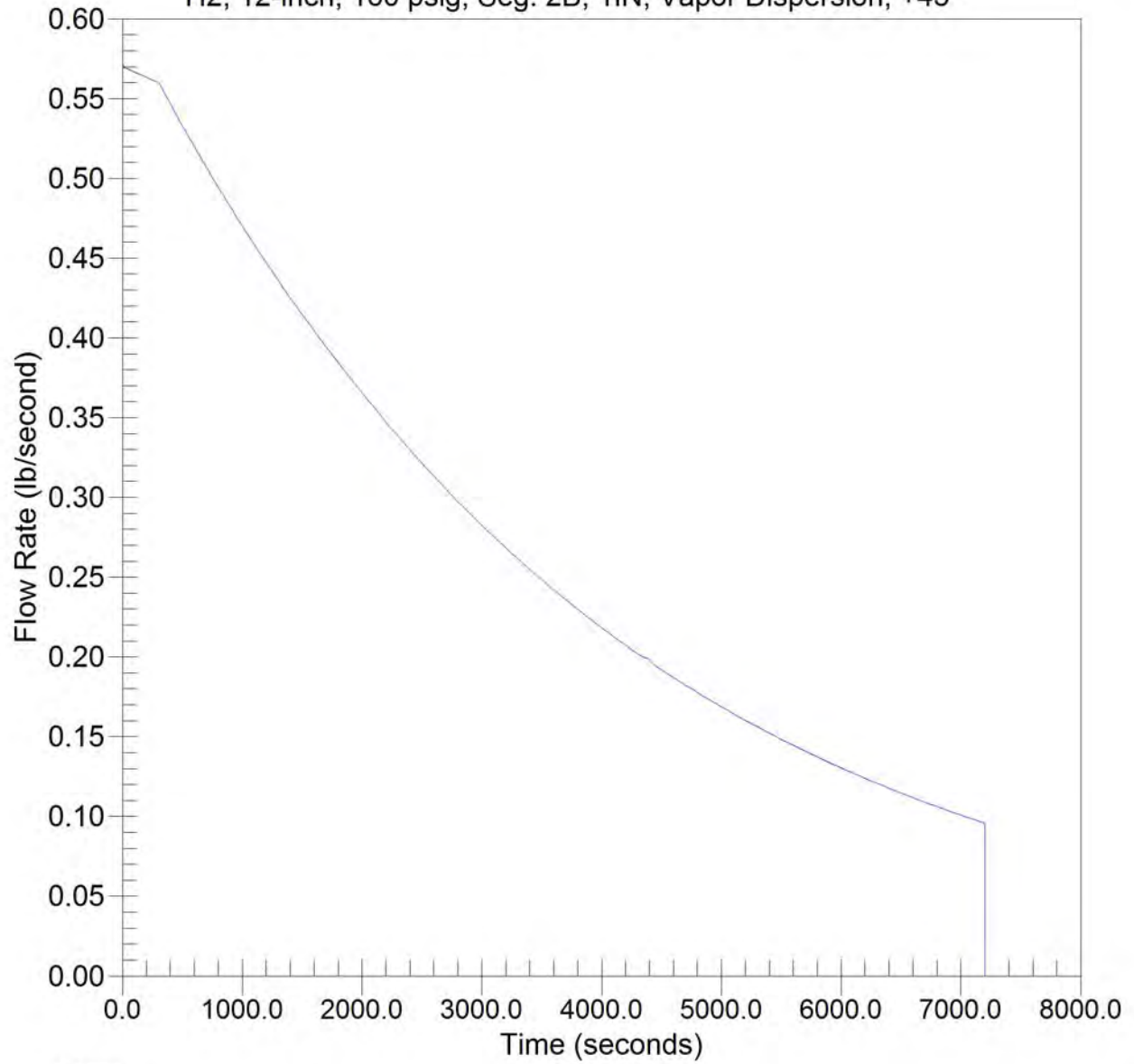
Mass of released material in explosive range: 0.0311098 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0174
0.8	3.36	0.0174
1.0	3.36	0.0174
1.1	3.36	0.0174
1.3	3.36	0.0169
1.5	3.36	0.0145
1.8	3.36	0.0125
2.1	3.36	0.0108
2.4	3.36	0.0093
2.8	3.36	0.0080
3.3	3.36	0.0069
3.8	3.03	0.0060
4.5	2.61	0.0051
5.2	2.25	0.0044
6.0	1.93	0.0038
7.0	1.66	0.0033
8.2	1.43	0.0028
9.5	1.23	0.0024
11.1	1.06	0.0021
12.9	0.91	0.0018
15.0	0.78	0.0016
17.5	0.67	0.0013
20.4	0.57	0.0012
23.7	0.49	0.0010
115.5	0.10	0.0002

The downwind distance to dp3 is 11.8 feet
 The downwind distance to dp2 is 16.8 feet
 The downwind distance to dp1 is 115.5 feet

MASS RELEASE RATE

H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

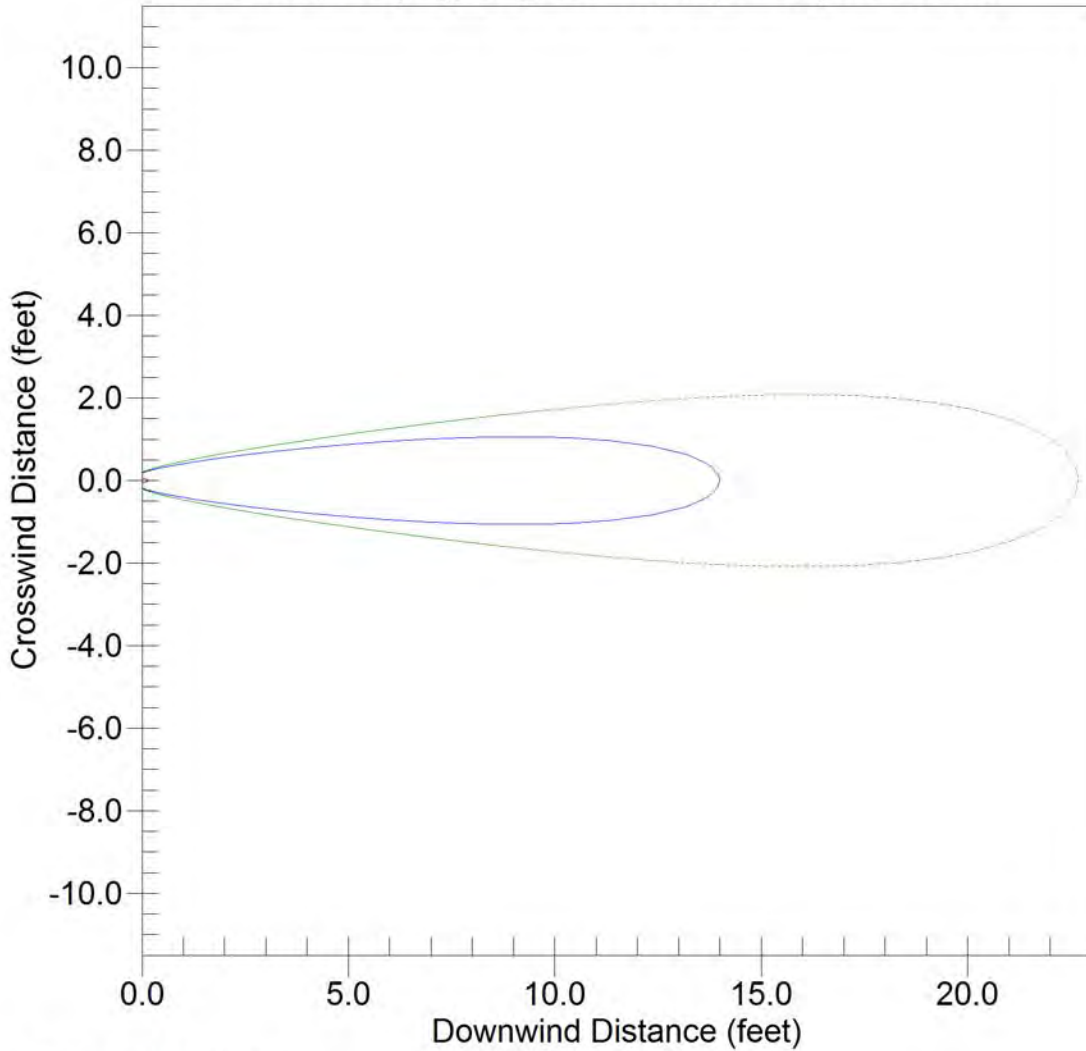


— Total
— Vapor

CANARY by Quest

casename=12D1IN160S2B+45_7MMSCFD
Thu Jan 23 16:10:48 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°

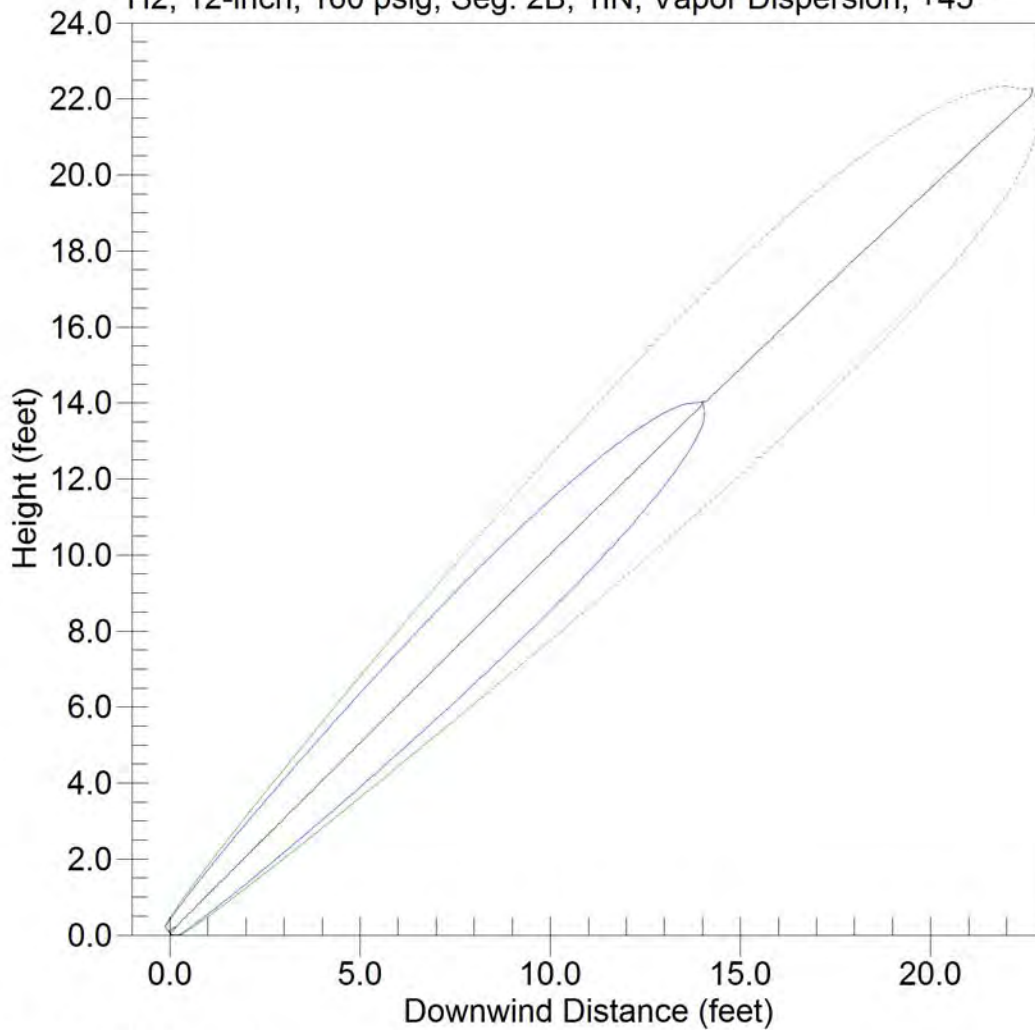


- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=12D1IN160S2B+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 16:10:48 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°



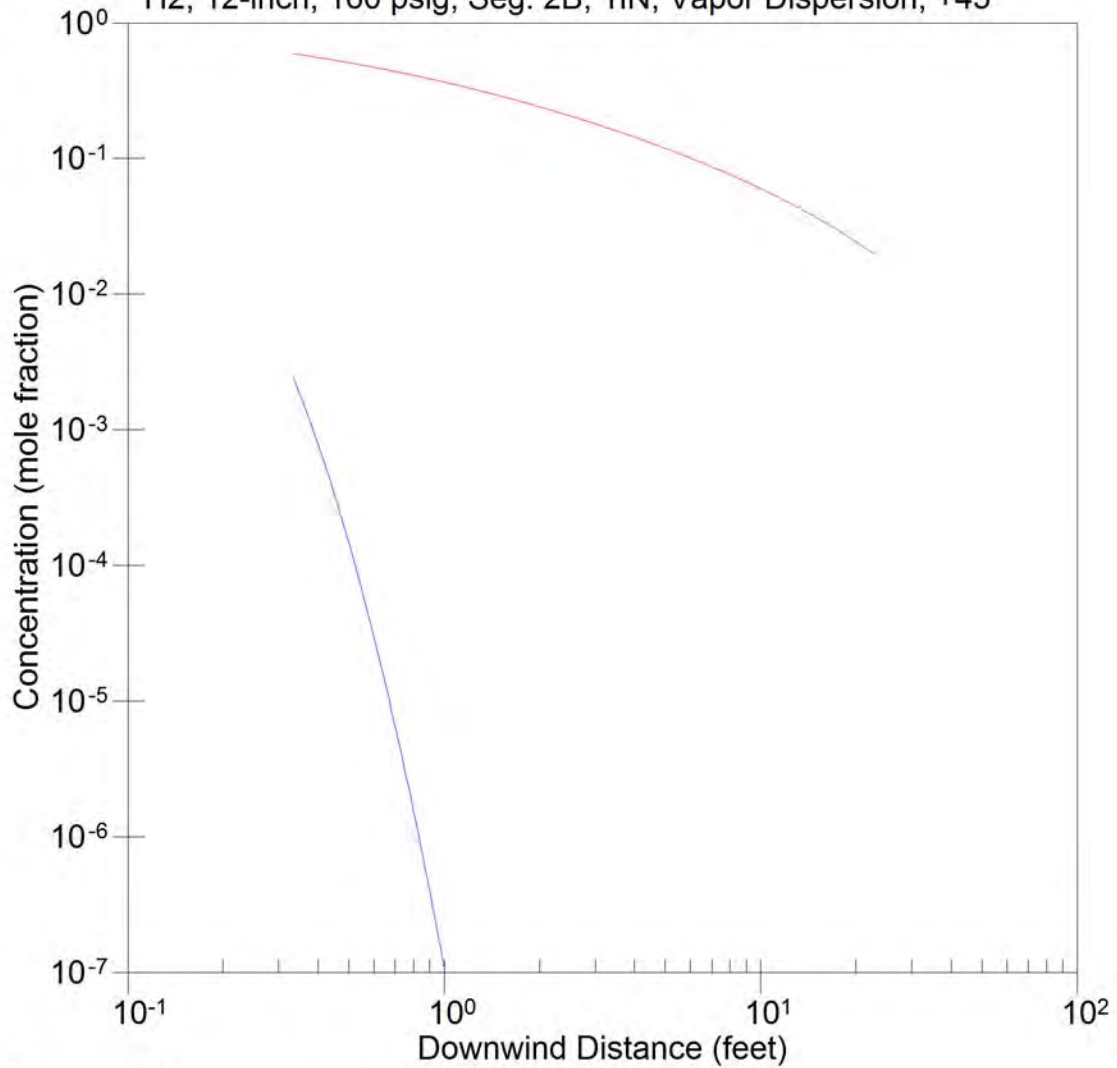
- 75.0 mole percent
- - - 4.00 mole percent
- · · 2.00 mole percent

casename=12D1IN160S2B+45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 16:10:48 2020

CANARY by Quest

Momentum Jet Cloud CONCENTRATION vs. DISTANCE

H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°



— Centerline Concentration
— Ground Level Concentration

casename=12D1IN160S2B+45_7MMSCFD

windspeed = 4.5 mph

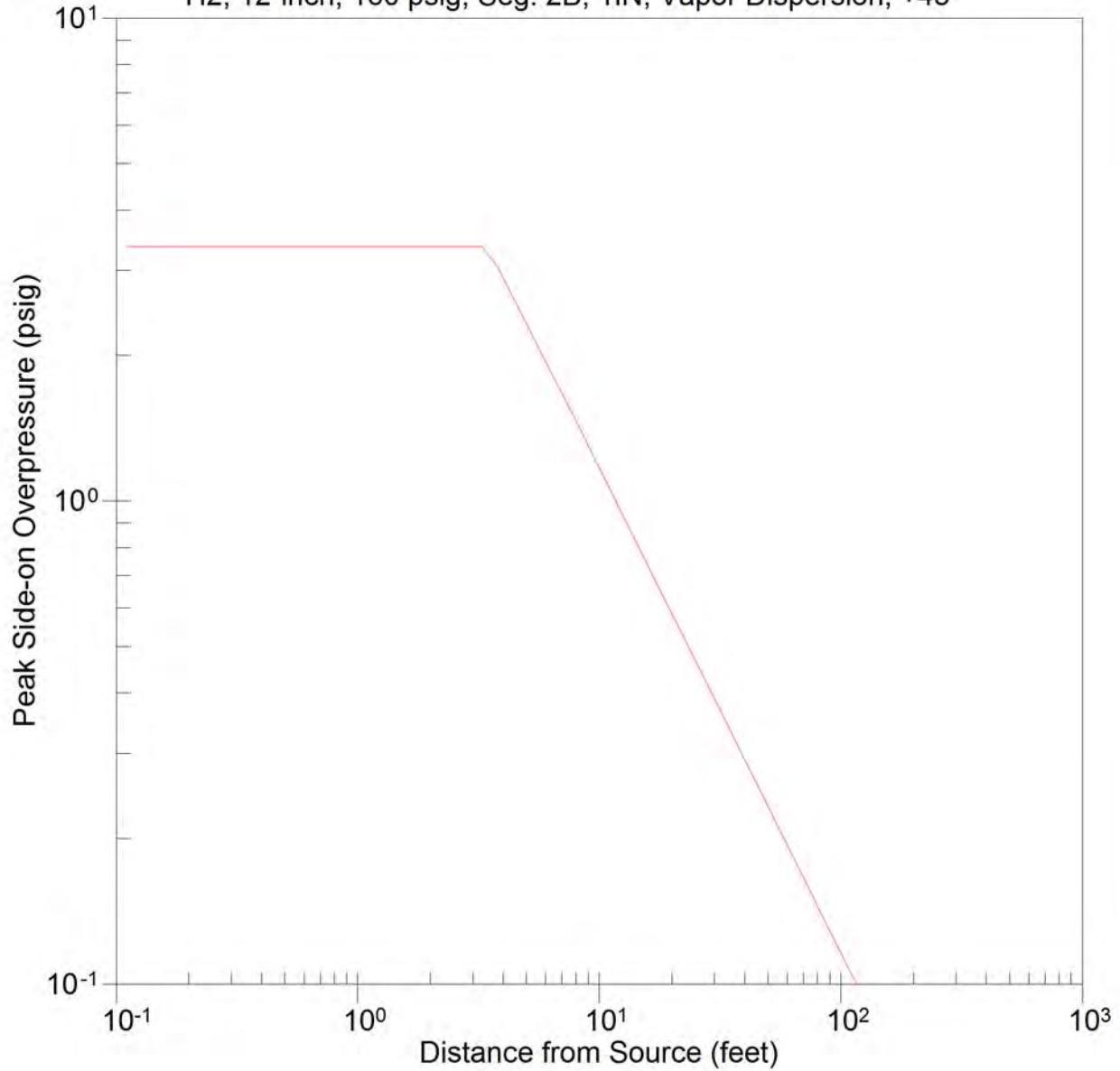
D stability

Thu Jan 23 16:10:48 2020

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, +45°



CANARY by Quest

casename=12D1IN160S2B+45_7MMSCFD
Thu Jan 23 16:10:48 2020

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
| Case Name - 12D1IN160S2B-45_7MMSCFD             |
|           Thu Jan 23 16:11:01 2020               |
| Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com       canary@questconsult.com |
| telephone (405) 329-7475   fax (405) 329-7734   |
|                                     |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

```

Case Type       : Vapor Dispersion
Case Name      : 12D1IN160S2B-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B - 12-inch Pipe, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Psuedo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

Wind speed	4.47 mph
Wind speed measurement height	32.8 feet
Stability class <A-F>	D
Relative humidity	70 %
Air temperature	72.0 °F
Spill surface temperature	72.0 °F
Substrate name	Medium density concrete
Substrate thermal conductivity	0.2698 Btu/hr-ft-F
Substrate density	80 lb/cu.ft
Substrate heat Capacity	0.22 Btu/lb-F
Substrate delay time	0 sec
Surrounding terrain	Wooded area or urban area

NOTES:

Case continued on page 2.

```

+-----+
|               |
|   CANARY by Quest - Version 4.6.2   |
|   CANARY Case Input                 |
| Case Name - 12D1IN160S2B-45_7MMSCFD |
|   Thu Jan 23 16:11:01 2020         |
|               |
+-----+

```

Page 2 Title: H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

RELEASE MENU

Type of release: Unregulated, Continuous release
 Release duration 120 min
 Normal flow rate 0.43 lb/sec
 Duration of normal flow 5 min
 Volume of vessel 0.00 cu.ft
 Pipe inner diameter 12.00 inches
 Equivalent release diameter 1.00 inches
 Pipe length upstream of break 50225.0 feet
 Height of release point 0.0 feet
 Angle of release from horizontal 135.0 degrees

NOTES:

IMPOUNDMENT MENU

Unconfined

NOTES:

VDVE MENU

Vapor generation, dispersion and cloud explosion - Flammable calculation
 Concentration endpoint 1 UFL mol%
 Concentration endpoint 2 LFL mol%
 Concentration endpoint 3 1/2 LFL mol%

Dispersion coefficient averaging time 1 min

Baker-Strehlow-Tang parameters

Fuel reactivity High
 Obstacle density Low
 Flame expansion 3-D

Overpressure values

Overpressure endpoint 1 1.00 psi
 Overpressure endpoint 2 0.70 psi
 Overpressure endpoint 3 0.10 psi

NOTES:


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           Release Stream Compositions               |
|           Case Name - 12D1IN160S2B-45_7MMSCFD     |
|           Thu Jan 23 16:11:01 2020                 |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com                     |
|           telephone (405) 329-7475                 |
|           canary@questconsult.com                  |
|           fax (405) 329-7734                       |
|                                     |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

Component Number	Component Name, Formula
51	Hydrogen(equilibrium), H2
43	Carbon Monoxide, CO
17	Carbon Dioxide, CO2
1	Methane, CH4
299	pseudo Water, H2O
28	Oxygen, O2

Composition (Mole Fraction) of Fluid Streams

Comp. No.	Feed Stream	Momentum Jet Stream			Total Stream	Liquid Pool Stream
		Flashed Vapor	Evaporated Vapor	Aerosol Liquid		
51	0.999945	0.999945	0.000000	0.000000	0.999945	0.000000
43	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
17	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
1	0.000010	0.000010	0.000000	0.000000	0.000010	0.000000
299	0.000020	0.000020	0.000000	0.000000	0.000020	0.000000
28	0.000005	0.000005	0.000000	0.000000	0.000005	0.000000
-----		-----	-----	-----	-----	-----
	1.000000	1.000000	0.000000	0.000000	1.000000	0.000000

Flammable Limits (Mole %) of Fluid Streams

Limit	Feed Stream	Momentum Jet Stream	Liquid Pool Stream
LFL	4.00	4.00	
UFL	75.00	75.00	
LBV		3.01 m/s	

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|      Momentum Jet Vapor Dispersion Model                    |
|      Case Name - 12D1IN160S2B-45_7MMSCFD                  |
|              Thu Jan 23 16:11:01 2020                      |
|      Quest Consultants Inc., Norman, Oklahoma, USA          |
|      www.questconsult.com      canary@questconsult.com      |
|      telephone (405) 329-7475      fax (405) 329-7734      |
+-----+

```

TITLE: H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

concentration limits

```

concentration 3 (highest) = 0.749959 mole fraction
concentration 2 (middle)  = 0.040002 mole fraction
concentration 1 (lowest)  = 0.020001 mole fraction

```

downwind distance	centerline conc.	ground conc.	y(c1) 1/2 width	y(c2) 1/2 width	y(c3) 1/2 width	centerline height
x(ft)	c(mole frac.)	c(mole frac.)	(ft)	(ft)	(ft)	(ft)
0	1.000000	0.000000	0.2	0.2	0.1	0.1

Concentrations of concern do not exist downwind of the release location. If this was an upwind release (release angle > 90 deg. or < -90 deg) check the side-view plot.

```

The downwind distance to c3 is      0.00 ft after about      0 seconds
The downwind distance to c2 is      0.00 ft after about      0 seconds
The downwind distance to c1 is      0.00 ft after about      0 seconds

```

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
| Momentum Jet Vapor Cloud Explosion              |
| Case Name - 12D1IN160S2B-45_7MMSCFD           |
| Thu Jan 23 16:11:01 2020                       |
| Quest Consultants Inc., Norman, Oklahoma, USA   |
| www.questconsult.com       canary@questconsult.com |
| telephone (405) 329-7475   fax (405) 329-7734   |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

```

Fuel Reactivity: High           Obstacle Density: Low
Flame Expansion: 3-D           Flame Speed:      0.36

```

Overpressure levels:

```

-----
dp3 =      1.00 psi gauge
dp2 =      0.70 psi gauge
dp1 =      0.10 psi gauge

```

Mass of released material in explosive range: 0.0315538 lbs.

Distance from Center of Flammable Cloud (feet)	Overpressure (psi gauge)	Impulse (psi-s)
0.0	3.36	0.0174
0.8	3.36	0.0174
1.0	3.36	0.0174
1.1	3.36	0.0174
1.3	3.36	0.0170
1.5	3.36	0.0146
1.8	3.36	0.0126
2.1	3.36	0.0108
2.4	3.36	0.0093
2.8	3.36	0.0080
3.3	3.36	0.0069
3.9	3.02	0.0060
4.5	2.60	0.0051
5.2	2.24	0.0044
6.1	1.93	0.0038
7.1	1.66	0.0033
8.2	1.43	0.0028
9.6	1.23	0.0024
11.2	1.05	0.0021
13.0	0.90	0.0018
15.2	0.78	0.0016
17.6	0.67	0.0013
20.5	0.57	0.0012
23.9	0.49	0.0010
116.1	0.10	0.0002

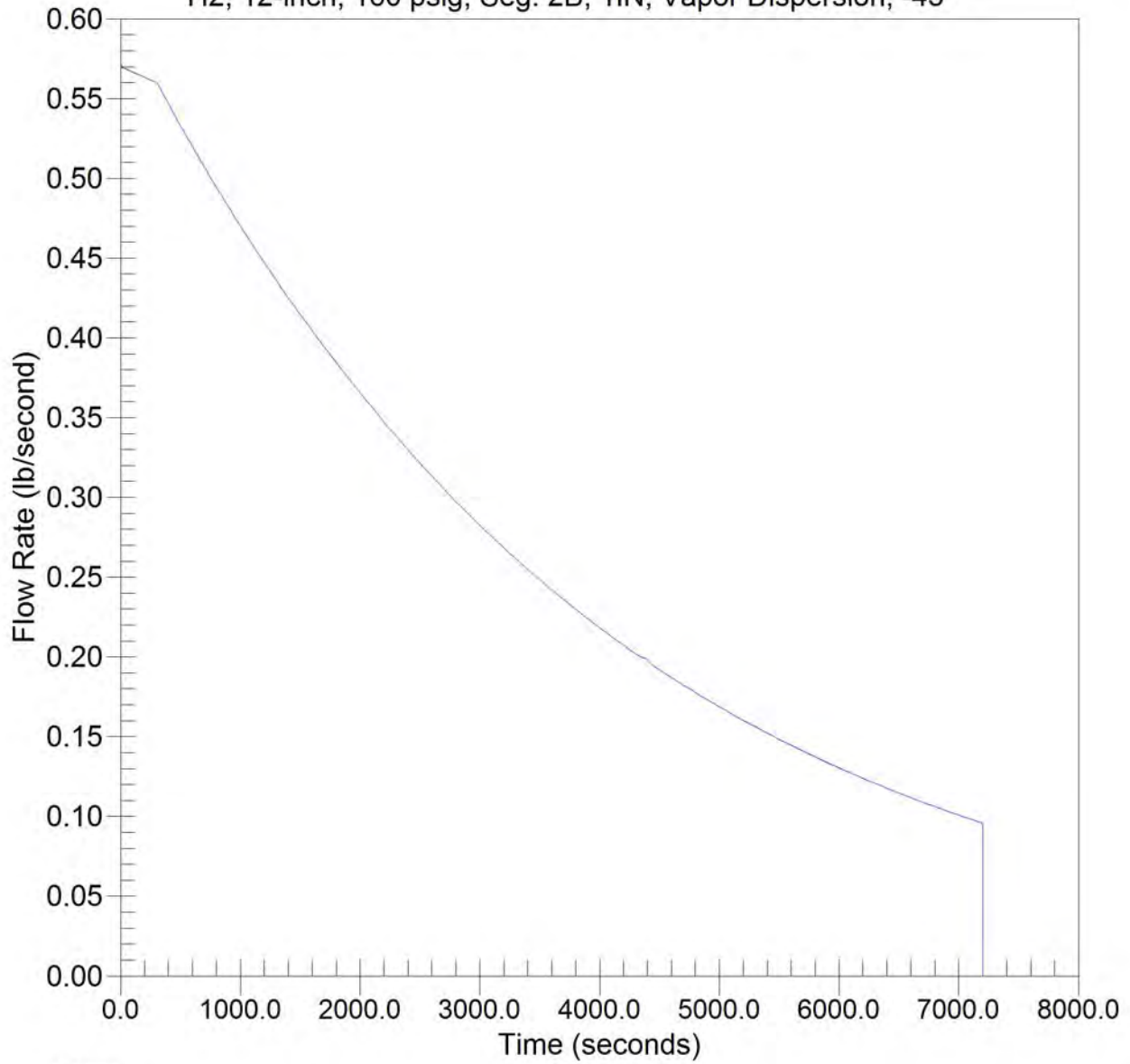
```

The downwind distance to dp3 is 11.8 feet
The downwind distance to dp2 is 16.9 feet
The downwind distance to dp1 is 116.1 feet

```

MASS RELEASE RATE

H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

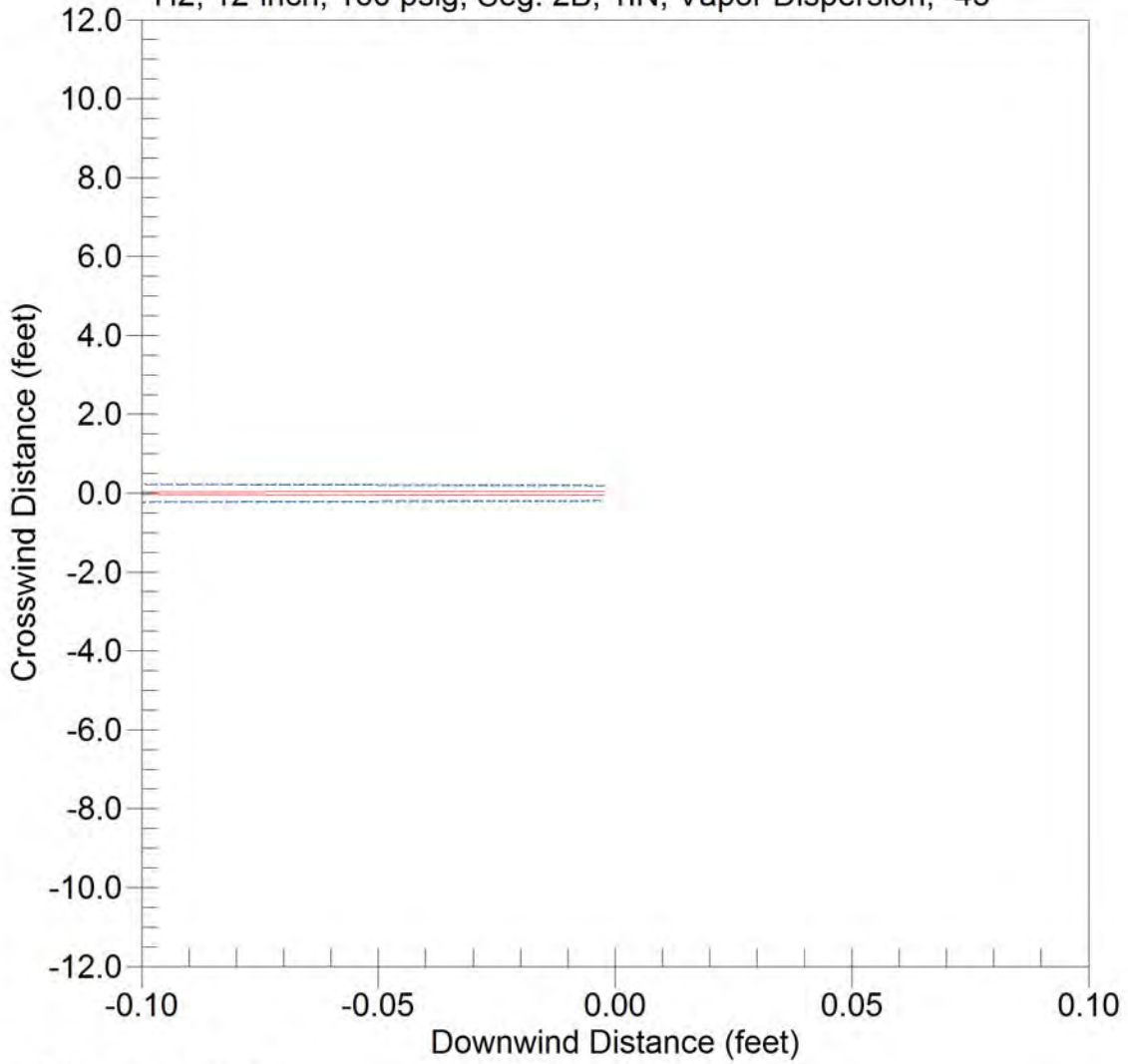


— Total
— Vapor

CANARY by Quest

casename=12D1IN160S2B-45_7MMSCFD
Thu Jan 23 16:11:01 2020

Momentum Jet Cloud
CONCENTRATION CONTOURS: OVERHEAD VIEW
H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°

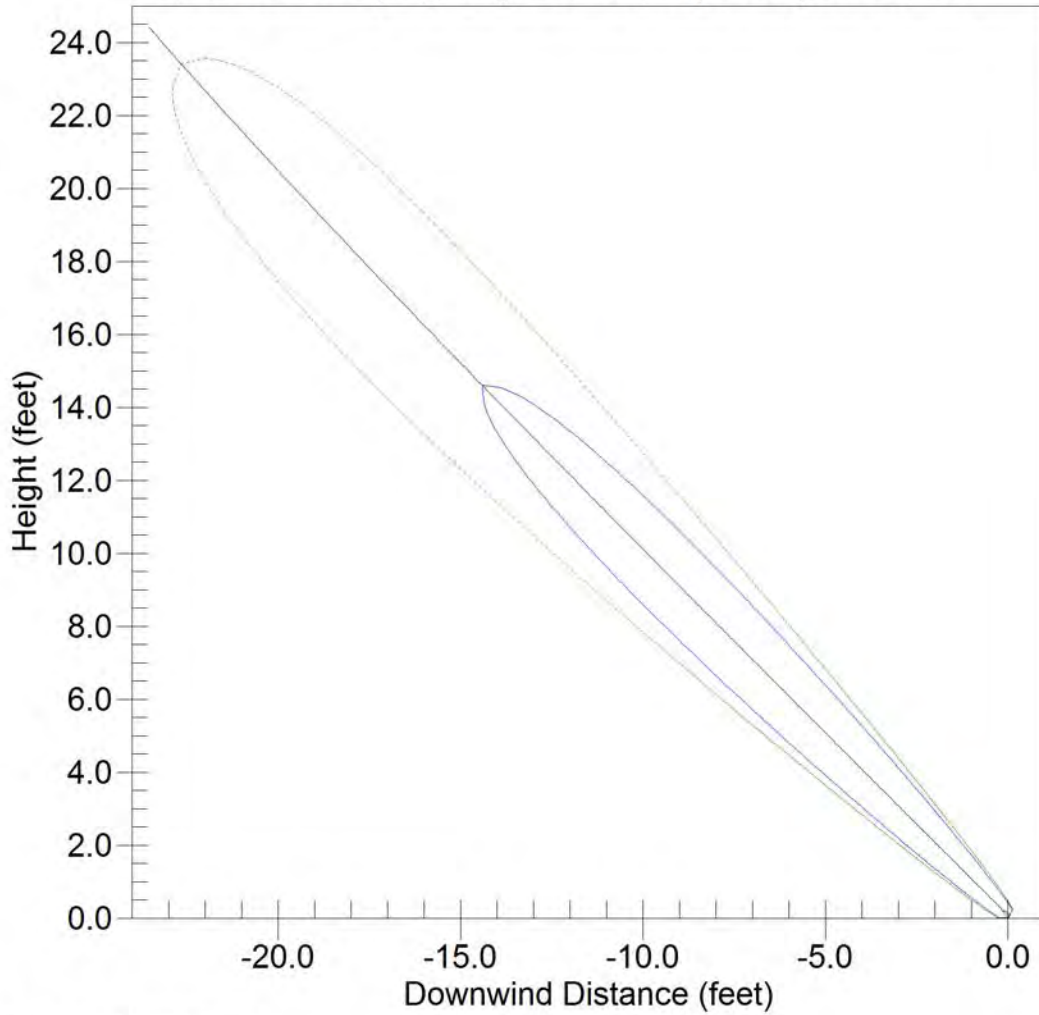


- 75.0 mole percent
- - 4.00 mole percent
- 2.00 mole percent

casename=12D1IN160S2B-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 16:11:01 2020

CANARY by Quest

Momentum Jet Cloud
CONCENTRATION CONTOURS: SIDE VIEW
H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°



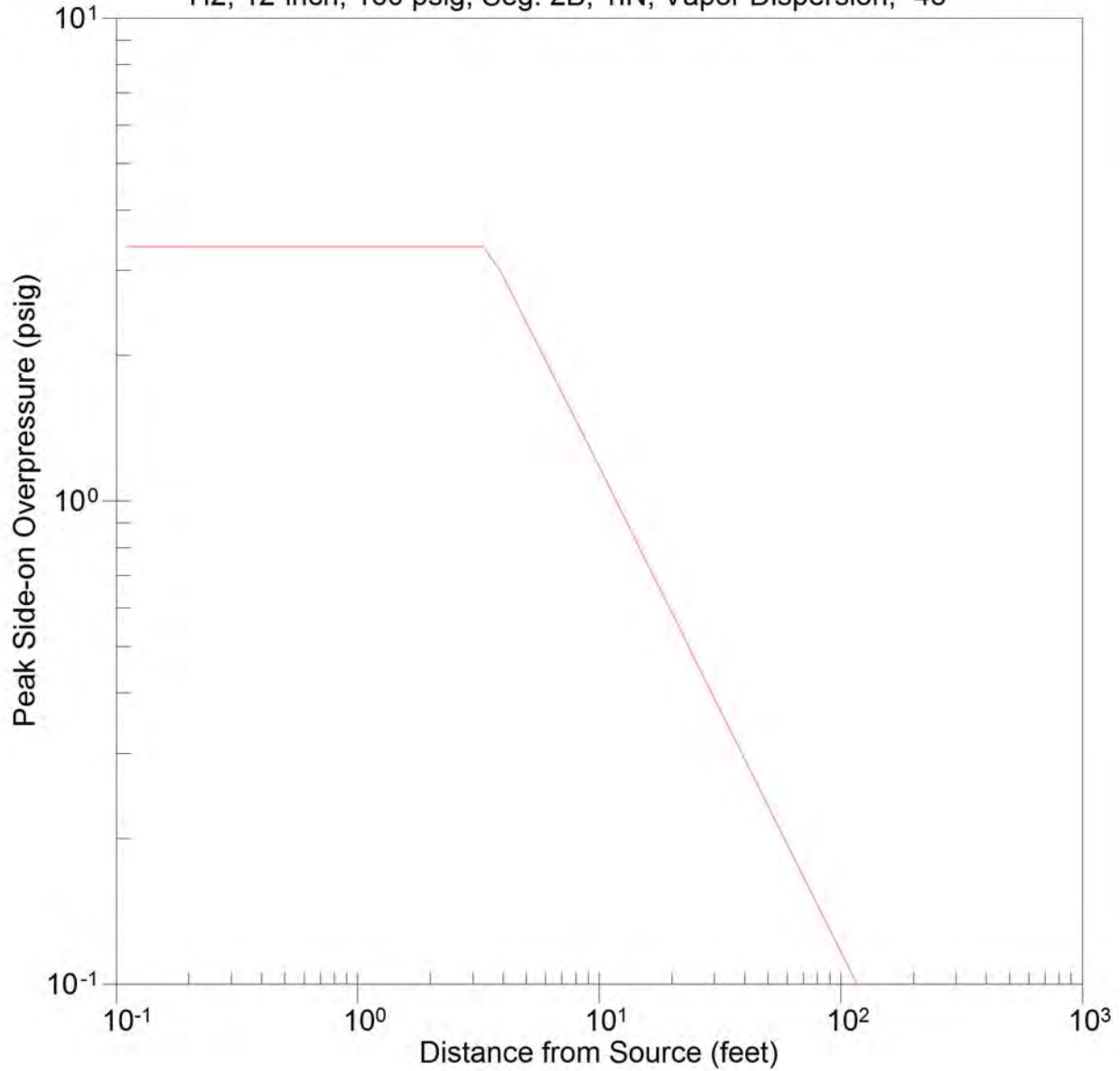
- 75.0 mole percent
- - - 4.00 mole percent
- ... 2.00 mole percent

casename=12D1IN160S2B-45_7MMSCFD
windspeed = 4.5 mph
D stability
Thu Jan 23 16:11:01 2020

CANARY by Quest

Momentum Jet VCE

BAKER-STREHLOW-TANG EXPLOSION OVERPRESSURE vs. DISTANCE
H2, 12-inch, 160 psig, Seg. 2B, 1IN, Vapor Dispersion, -45°



CANARY by Quest

casename=12D1IN160S2B-45_7MMSCFD
Thu Jan 23 16:11:01 2020



Torch Fire Modeling Results, Segment 1


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                         |
|           Case Name - 8DTF160S1+45_7MMSCFD         |
|           Thu Jan 23 17:55:41 2020                 |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com           canary@questconsult.com |
|           telephone (405) 329-7475           fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, Torch Fire, +45

```

Case Type           : Fire Radiation
Case Name           : 8DTF160S1+45_7MMSCFD
User ID             : BLPayne
Project Number      : Job 2134
Type of Units       : English Units

```

NOTES: 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Pseudo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature       : 70.00 °F
Pressure           : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity     70 %
Air temperature       72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) 0.0 feet
Elevation of target (from grade) 6.0 feet
Diameter of jet fire tip 0.6667 feet
Flow rate 0.87 lb/sec
Angle of release from horizontal 45.0 degrees

Fire radiation flux values
Radiation endpoint 1 12000 Btu/hr-sq.ft
Radiation endpoint 2 8000 Btu/hr-sq.ft
Radiation endpoint 3 5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 8DTF160S1+45_7MMSCFD
Thu Jan 23 17:55:41 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

Title: H2, 8-inch, 160 psig, Seg. 1, Torch Fire, +45

```

Length of Flame      : 20.3 feet
Flame Tilt from Horizontal: 20.6 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	13204
7.1	18383
7.8	30490
8.4	56392
9.2	***
10.0	***
10.9	***
11.8	***
12.9	***
14.0	***
15.2	***
16.6	***
18.0	***
19.6	***
21.3	***
23.2	5240
25.3	3398
27.5	2285
29.9	1585
32.5	1147
35.4	856
38.5	653
41.9	505
45.5	396
49.5	313

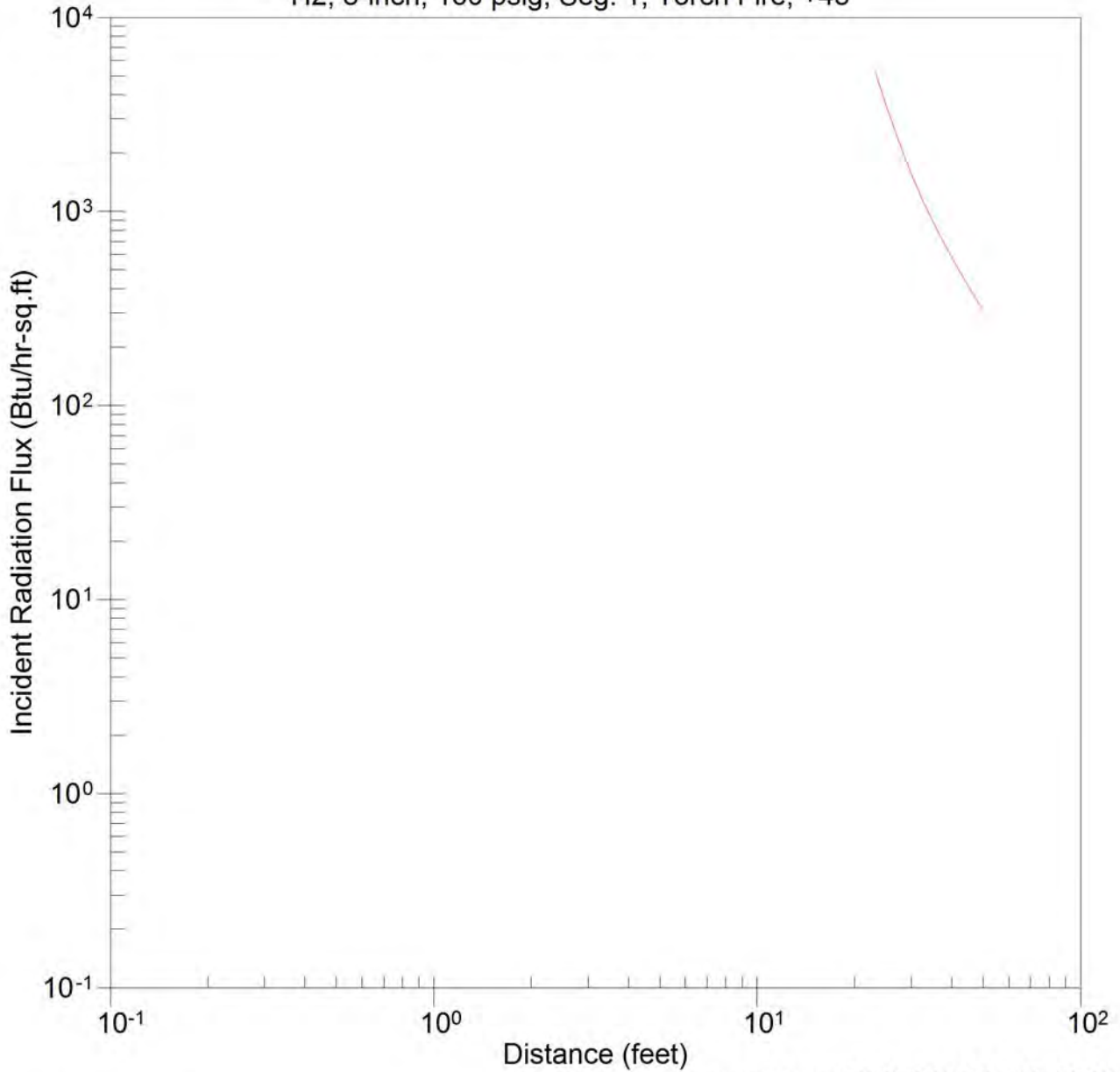
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
22.8	12000
23.0	8000
23.5	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 8-inch, 160 psig, Seg. 1, Torch Fire, +45



casename=8DTF160S1+45_7MMSCFD

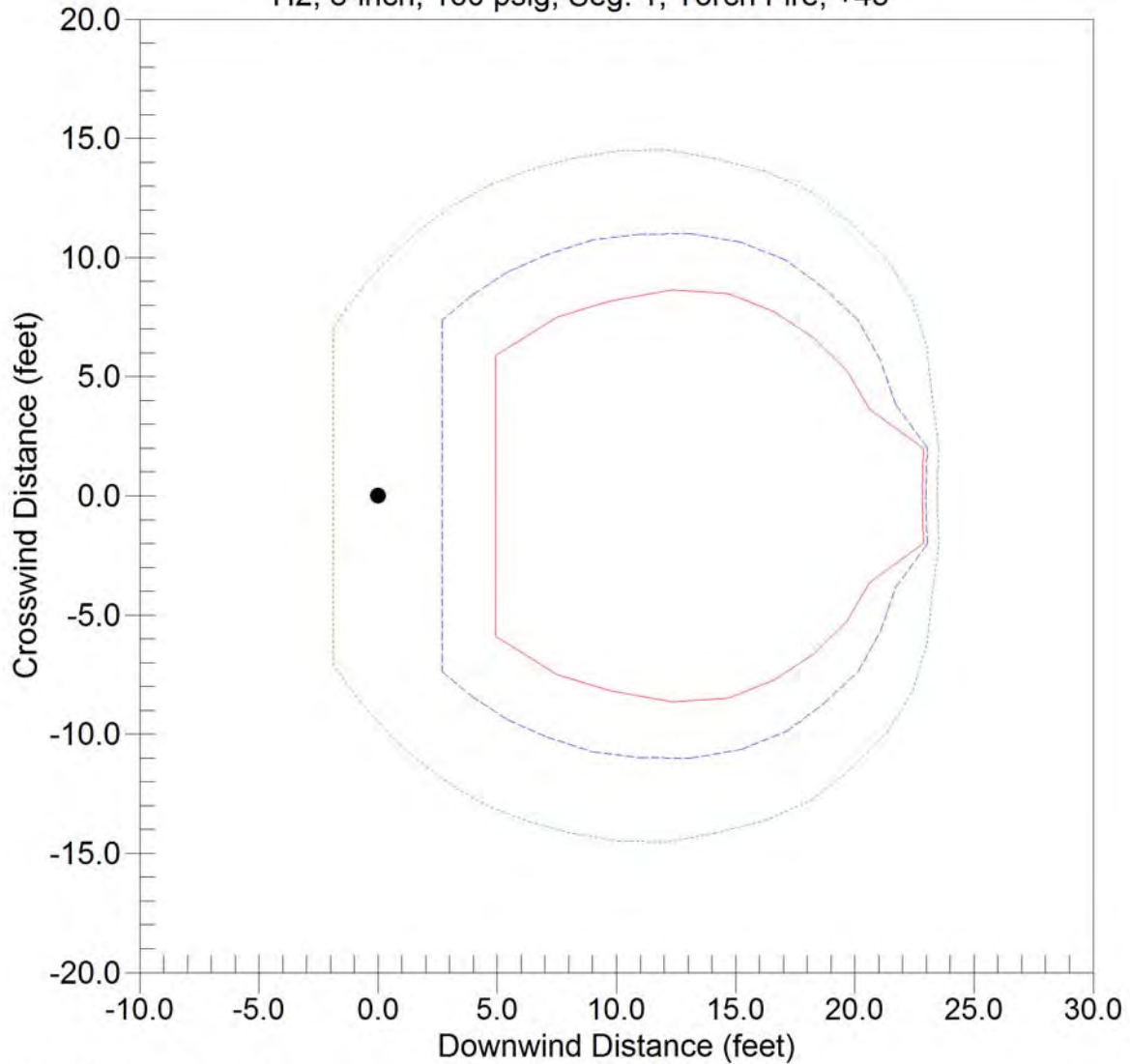
windspeed = 20.0 mph

Thu Jan 23 17:55:41 2020

CANARY by Quest

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 8-inch, 160 psig, Seg. 1, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=8DTF160S1+45_7MMSCFD

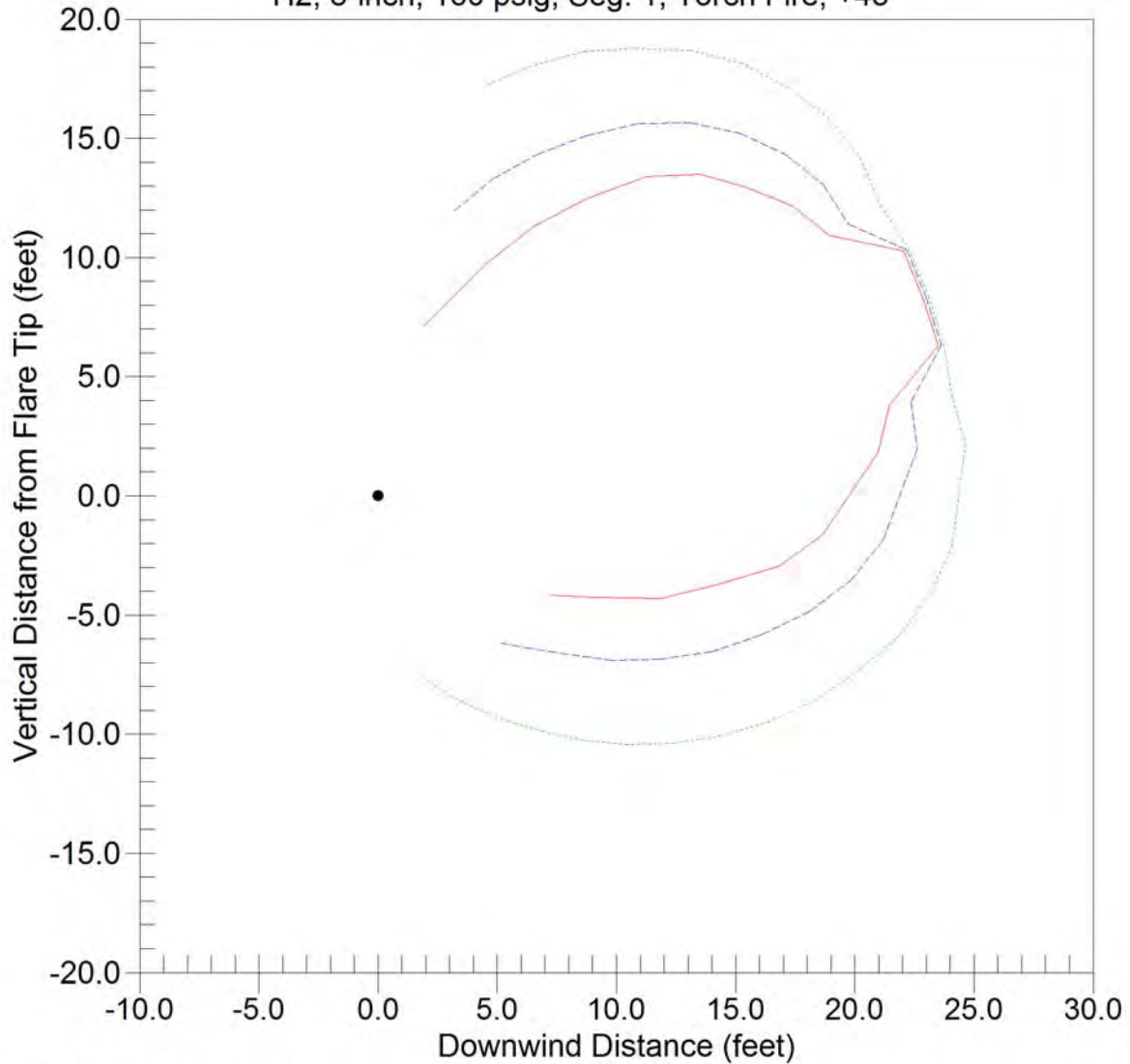
windspeed = 20.0 mph

Thu Jan 23 17:55:41 2020

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 8-inch, 160 psig, Seg. 1, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=8DTF160S1+45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 17:55:41 2020

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|               Case Name - 8DTF160S1-45_7MMSCFD             |
|               Thu Jan 23 17:56:31 2020                     |
|               Quest Consultants Inc., Norman, Oklahoma, USA |
|               www.questconsult.com   canary@questconsult.com |
|               telephone (405) 329-7475   fax (405) 329-7734 |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, Torch Fire, -45

```

Case Type       : Fire Radiation
Case Name      : 8DTF160S1-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)          6.0 feet
Diameter of jet fire tip                   0.6667 feet
Flow rate                                   0.87 lb/sec
Angle of release from horizontal           135.0 degrees

Fire radiation flux values
Radiation endpoint 1      12000 Btu/hr-sq.ft
Radiation endpoint 2      8000 Btu/hr-sq.ft
Radiation endpoint 3      5000 Btu/hr-sq.ft

```

NOTES:

```

+-----+
|          CANARY by Quest - Version 4.6.2          |
|          Jet Fire Radiation Model                 |
|          Case Name - 8DTF160S1-45_7MMSCFD       |
|          Thu Jan 23 17:56:31 2020               |
|          Quest Consultants Inc., Norman, Oklahoma, USA |
|          www.questconsult.com                    |
|          canary@questconsult.com                 |
|          telephone (405) 329-7475                |
|          fax (405) 329-7734                     |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, Torch Fire, -45

```

Length of Flame      : 20.3 feet
Flame Tilt from Horizontal: 25.7 degrees
Release Angle       : 135.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	9096
7.2	8406
7.8	***
8.5	***
9.3	***
10.1	***
11.0	***
12.0	***
13.1	***
14.3	***
15.6	***
17.0	***
18.6	***
20.2	14953
22.1	7545
24.1	4526
26.3	2981
28.6	2075
31.2	1498
34.0	1111
37.1	839
40.5	645
44.2	501
48.1	393
52.5	311

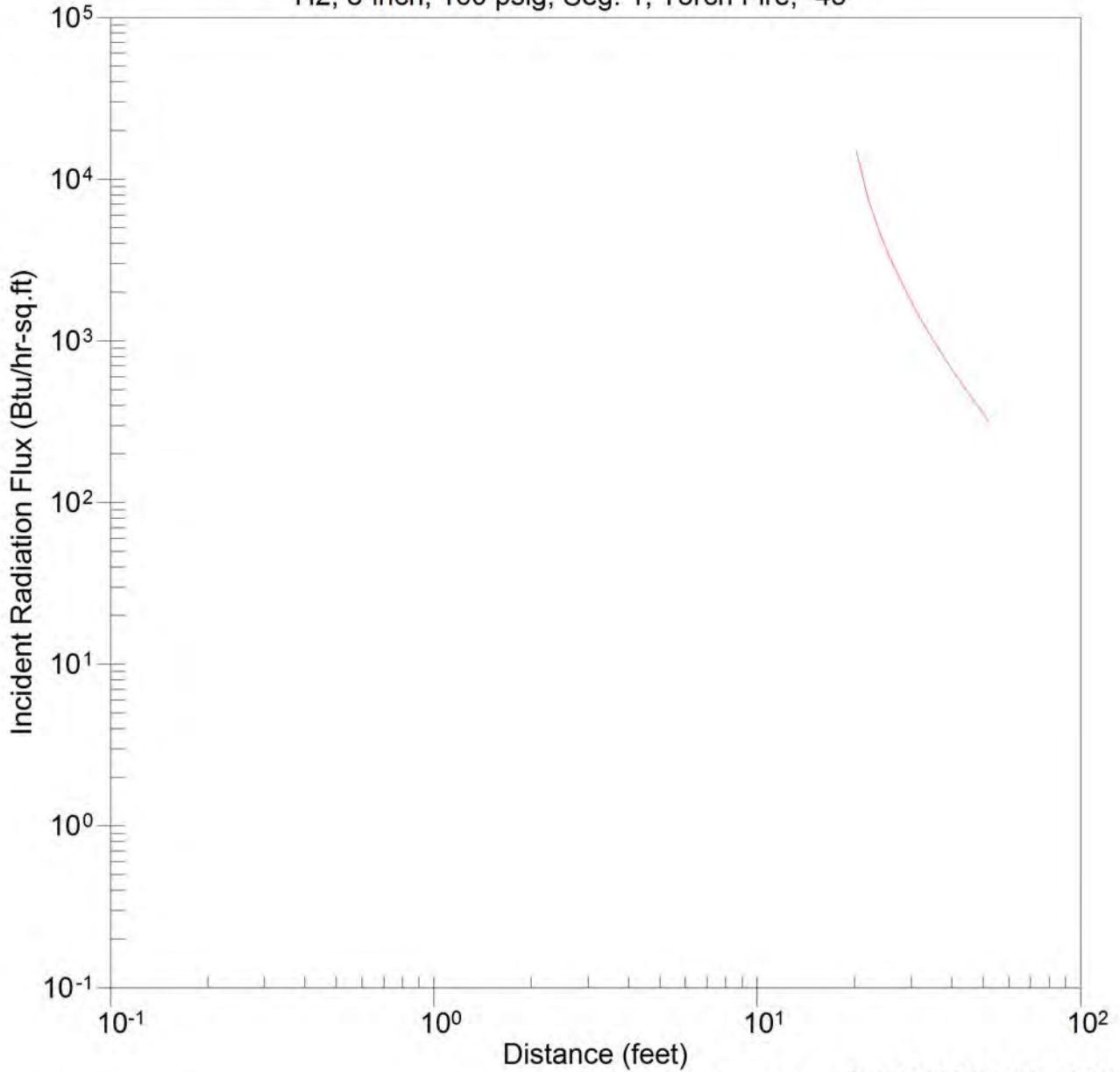
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
20.9	12000
21.8	8000
23.6	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 8-inch, 160 psig, Seg. 1, Torch Fire, -45



casename=8DTF160S1-45_7MMSCFD

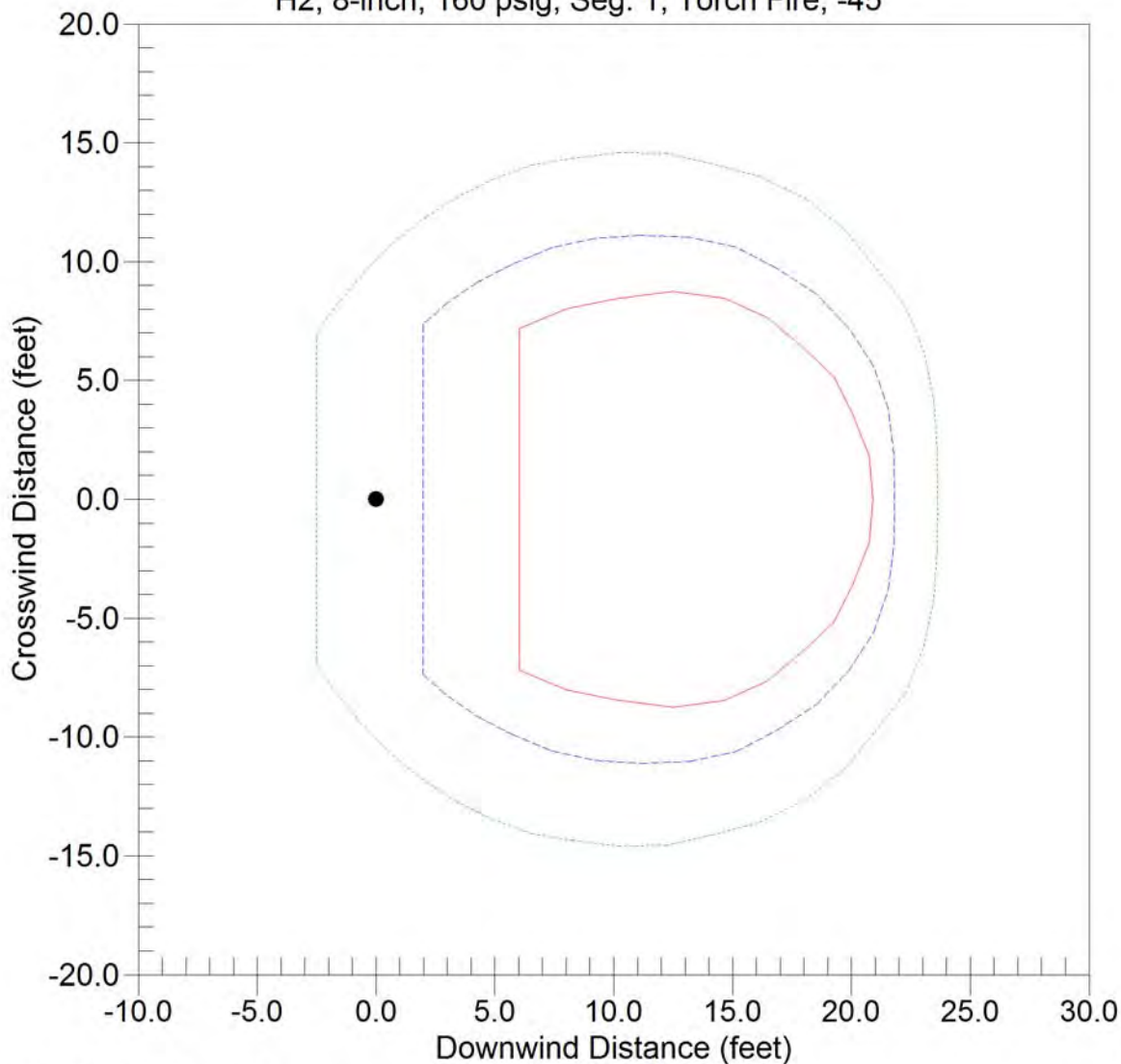
windspeed = 20.0 mph

Thu Jan 23 17:56:31 2020

CANARY by Quest

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 8-inch, 160 psig, Seg. 1, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- ... 5000 Btu/hr-sq.ft

casename=8DTF160S1-45_7MMSCFD

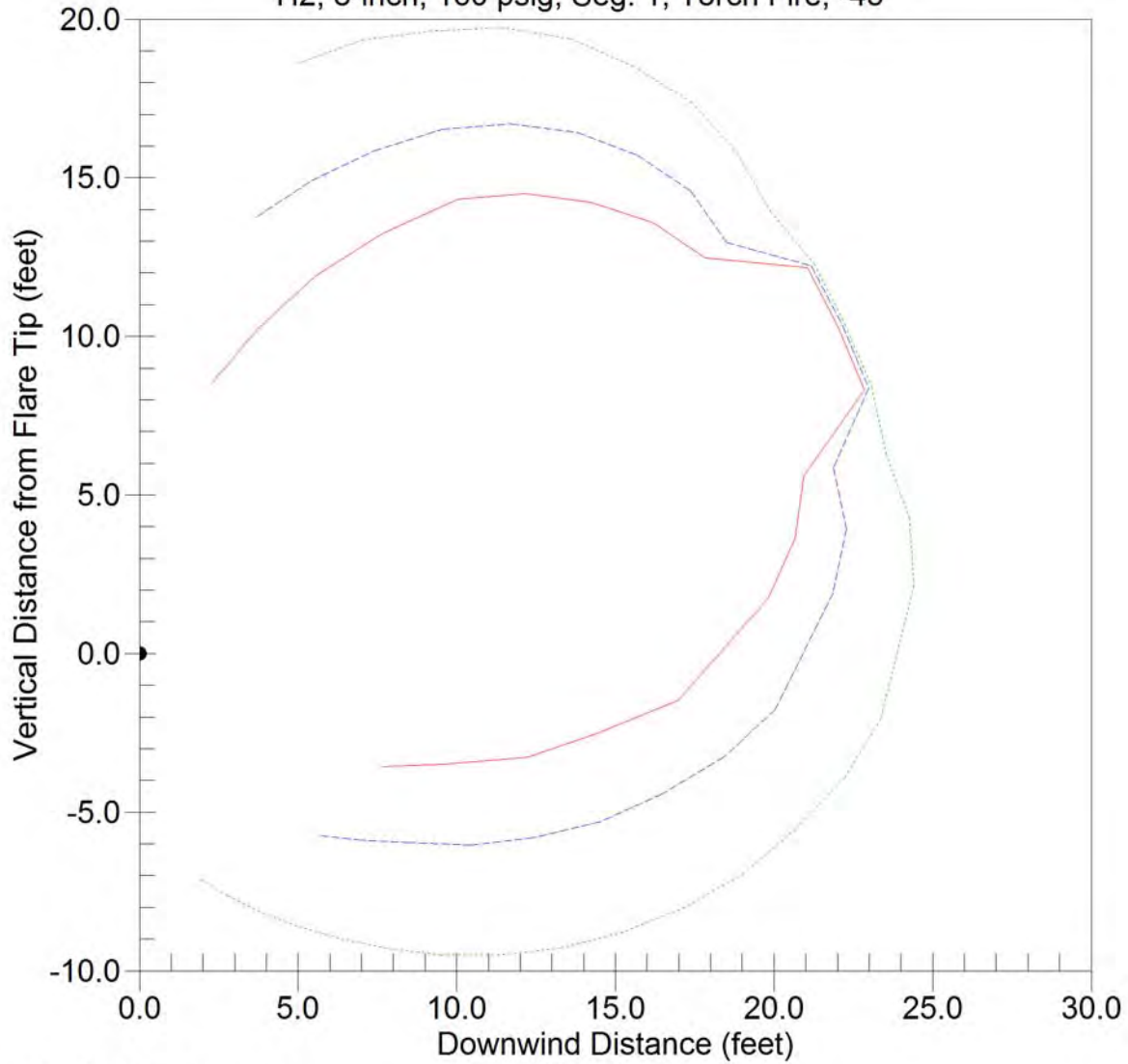
windspeed = 20.0 mph

Thu Jan 23 17:56:31 2020

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 8-inch, 160 psig, Seg. 1, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

CANARY by Quest

casename=8DTF160S1-45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 17:56:31 2020

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 8D1INTF160S1+45_7MMSCFD             |
|           Thu Jan 23 17:57:49 2020                         |
|           Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734         |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Torch Fire, +45

```

Case Type           : Fire Radiation
Case Name           : 8D1INTF160S1+45_7MMSCFD
User ID             : BLPayne
Project Number      : Job 2134
Type of Units       : English Units

```

NOTES: 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature       : 70.00 °F
Pressure          : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

Wind speed	20.00 mph
Relative humidity	70 %
Air temperature	72.0 °F

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)          6.0 feet
Diameter of jet fire tip                   0.0833 feet
Flow rate                                  0.51 lb/sec
Angle of release from horizontal           45.0 degrees

```

Fire radiation flux values

Radiation endpoint 1	12000 Btu/hr-sq.ft
Radiation endpoint 2	8000 Btu/hr-sq.ft
Radiation endpoint 3	5000 Btu/hr-sq.ft

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 8D1INTF160S1+45_7MMSCFD
Thu Jan 23 17:57:49 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Torch Fire, +45

```

Length of Flame      : 21.8 feet
Flame Tilt from Horizontal: 40.4 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	***
7.1	***
7.7	***
8.3	***
9.0	***
9.8	***
10.6	***
11.4	17520
12.4	7548
13.4	7280
14.5	11838
15.7	11623
17.0	8542
18.4	6110
19.9	4492
21.5	3330
23.3	2472
25.2	1842
27.3	1383
29.6	1050
32.0	805
34.7	624
37.5	489
40.6	386
44.0	307

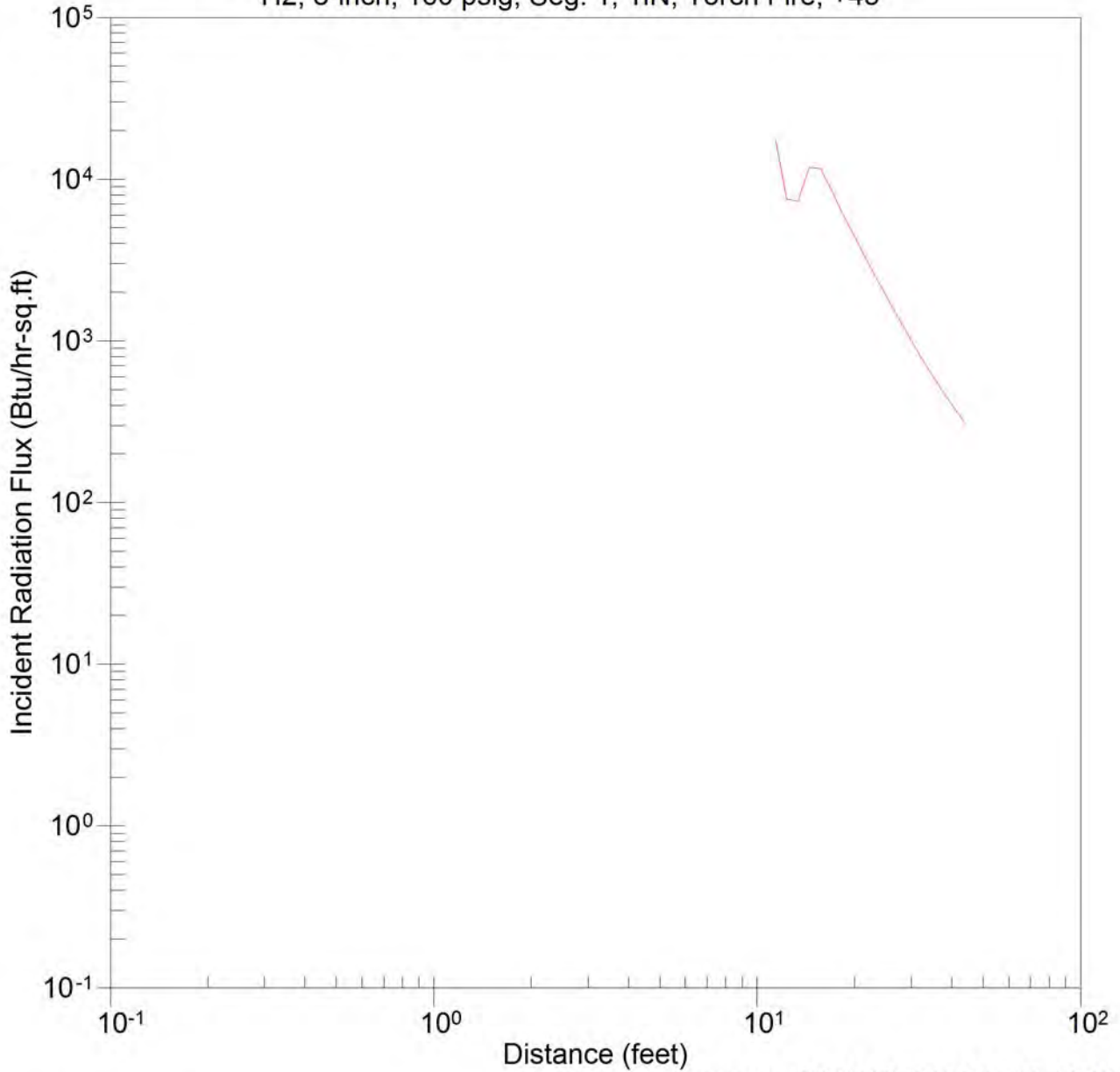
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
11.9	12000
17.3	8000
19.3	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 8-inch, 160 psig, Seg. 1, 1IN, Torch Fire, +45



CANARY by Quest

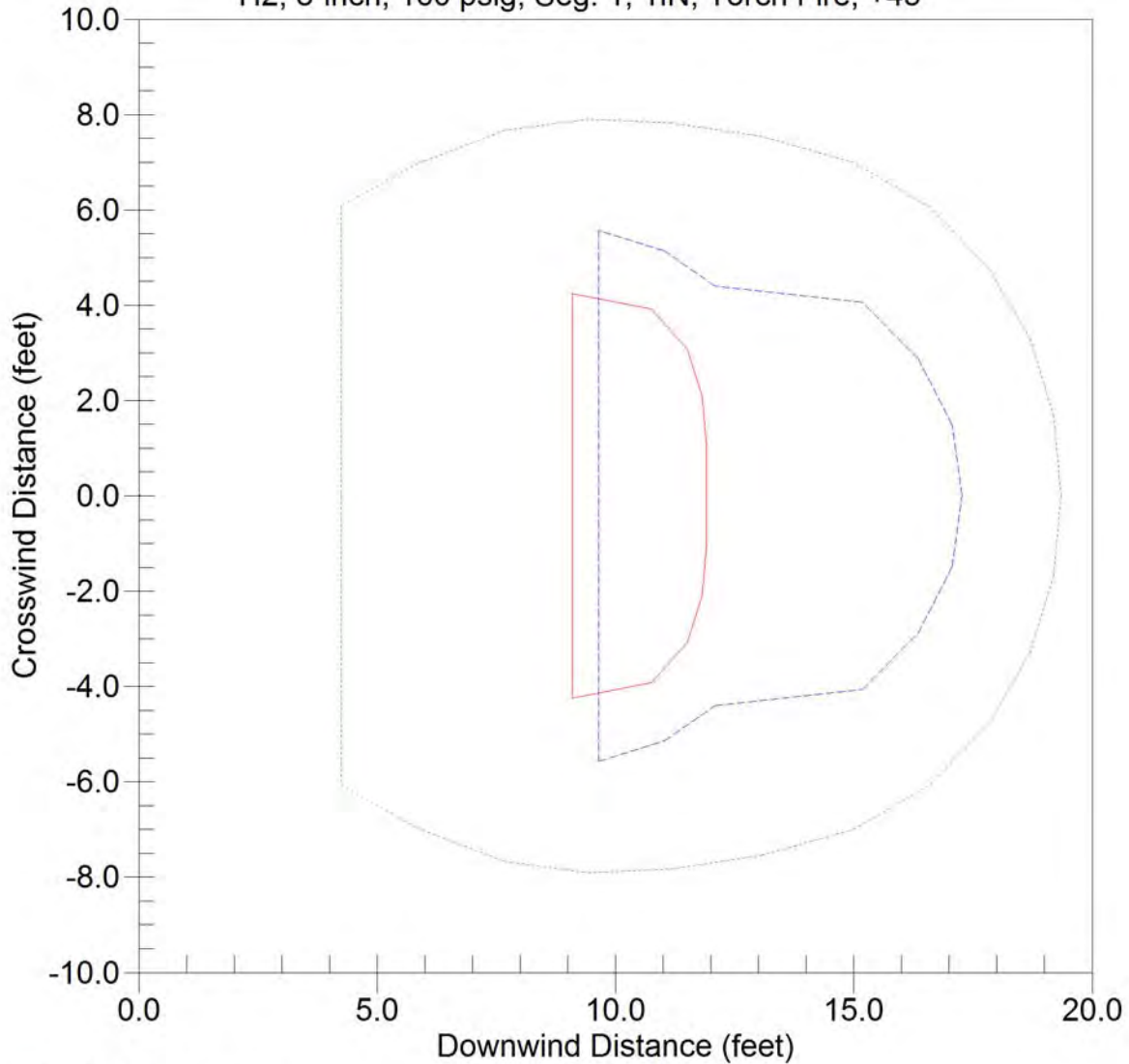
casename=8D1INTF160S1+45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 17:57:49 2020

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 8-inch, 160 psig, Seg. 1, 1IN, Torch Fire, +45



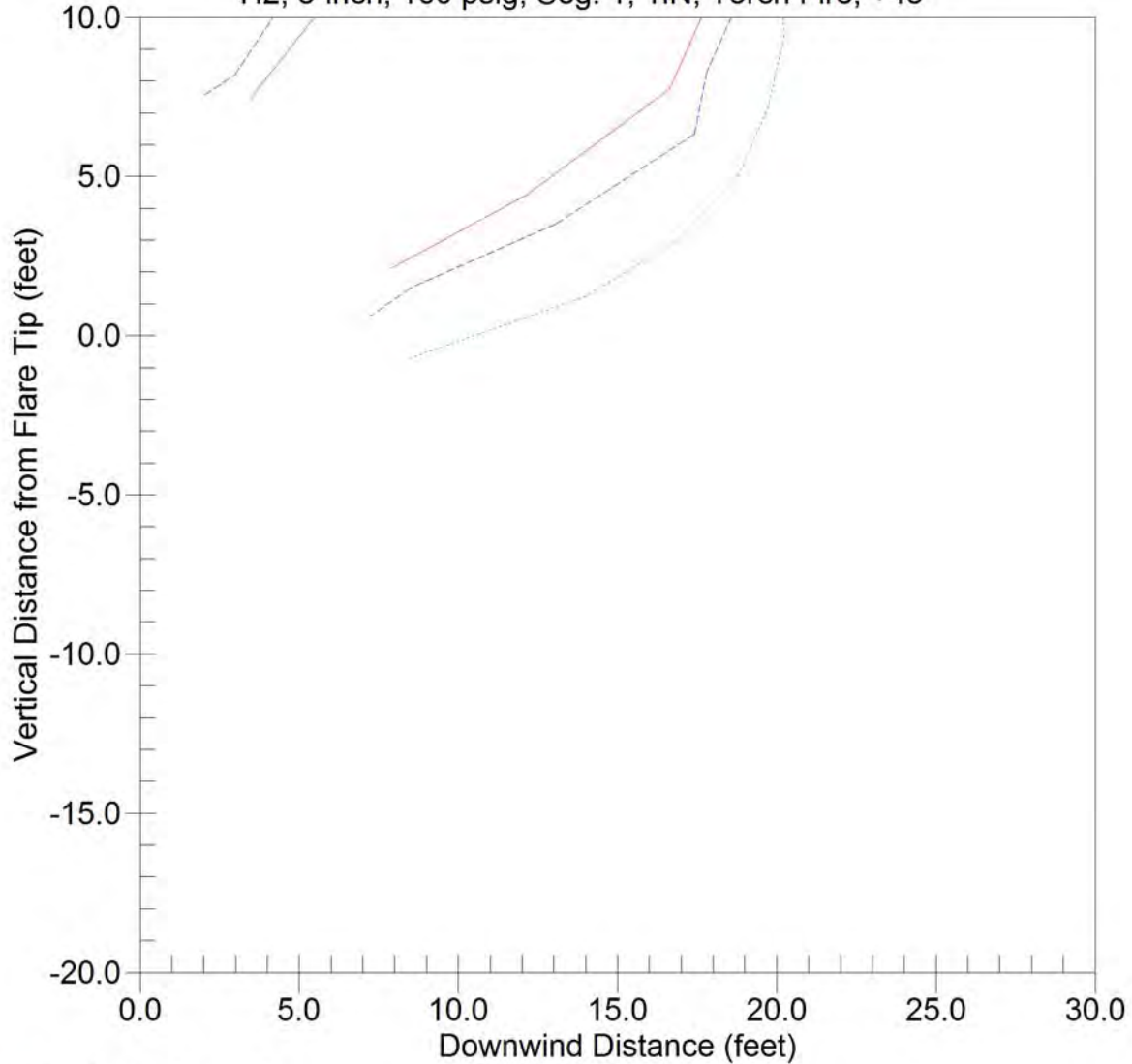
- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=8D1INTF160S1+45_7MMSCFD
windspeed = 20.0 mph
Thu Jan 23 17:57:49 2020

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 8-inch, 160 psig, Seg. 1, 1IN, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - 8000 Btu/hr-sq.ft
- ... 5000 Btu/hr-sq.ft

casename=8D1INTF160S1+45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 17:57:49 2020

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 8D1INTF160S1-45_7MMSCFD             |
|           Thu Jan 23 17:58:44 2020                         |
|           Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734         |
+-----+

```

Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Torch Fire, -45

```

Case Type           : Fire Radiation
Case Name           : 8D1INTF160S1-45_7MMSCFD
User ID             : BLPayne
Project Number      : Job 2134
Type of Units       : English Units

```

NOTES: 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature       : 70.00 °F
Pressure           : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed         : 20.00 mph
Relative humidity   : 70 %
Air temperature    : 72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) : 0.0 feet
Elevation of target (from grade)      : 6.0 feet
Diameter of jet fire tip              : 0.0833 feet
Flow rate                             : 0.51 lb/sec
Angle of release from horizontal       : 135.0 degrees

Fire radiation flux values
Radiation endpoint 1 : 12000 Btu/hr-sq.ft
Radiation endpoint 2 : 8000 Btu/hr-sq.ft
Radiation endpoint 3 : 5000 Btu/hr-sq.ft

```

NOTES:


```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 8D1INTF160S1-45_7MMSCFD
Thu Jan 23 17:58:44 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 8-inch, 160 psig, Seg. 1, 1IN, Torch Fire, -45

```

Length of Flame      : 21.8 feet
Flame Tilt from Horizontal: 122.4 degrees
Release Angle       : 135.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	2218
7.0	2083
7.4	1953
7.9	1827
8.4	1707
9.0	1592
9.6	1481
10.2	1377
10.8	1278
11.5	1185
12.3	1098
13.1	1014
13.9	935
14.8	861
15.8	791
16.8	725
17.9	664
19.1	607
20.3	554
21.6	504
23.0	459
24.5	416
26.1	377
27.8	342
29.6	309

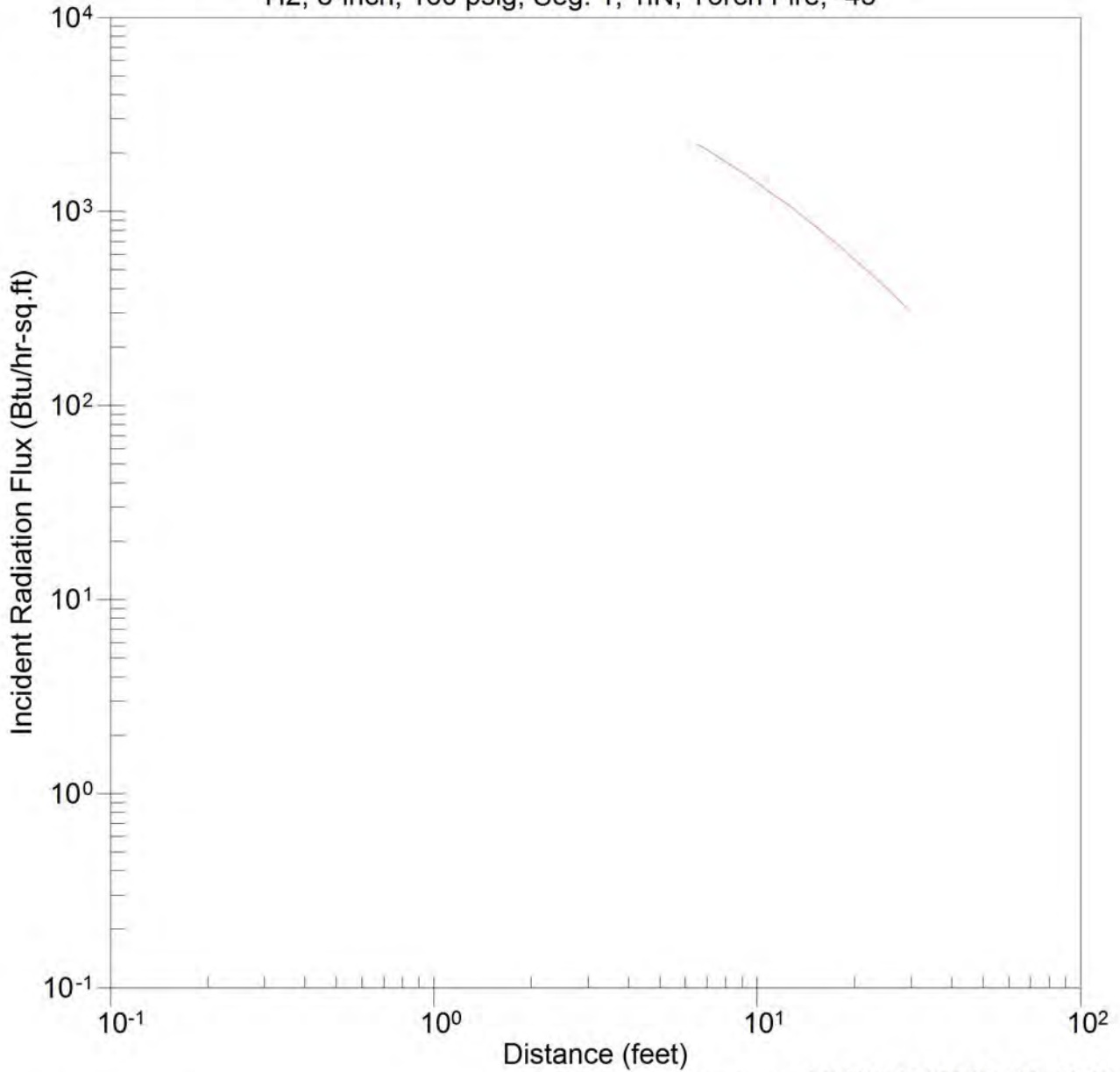
Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
**	12000
**	8000
**	5000

** Endpoint does not exist at this elevation

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 8-inch, 160 psig, Seg. 1, 1IN, Torch Fire, -45



CANARY by Quest

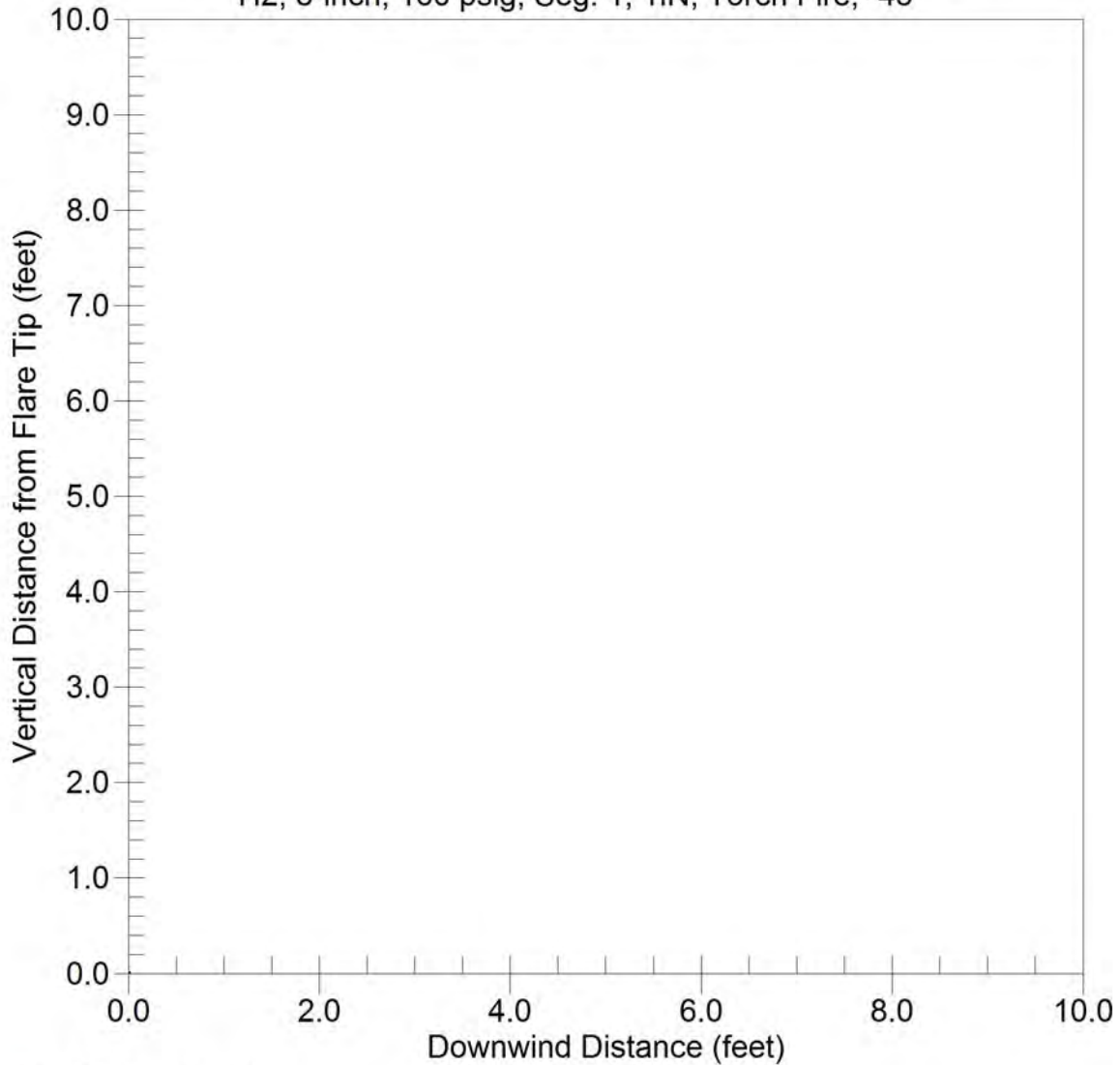
casename=8D1INTF160S1-45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 17:58:44 2020

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 8-inch, 160 psig, Seg. 1, 1IN, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=8D1INTF160S1-45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 17:58:44 2020

CANARY by Quest



Torch Fire Modeling Results, Segment 2A

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D8INTF160S2A+45_7MMSCFD           |
|           Thu Jan 23 18:00:31 2020                         |
|           Quest Consultants Inc., Norman, Oklahoma, USA     |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734         |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Torch Fire, +45

```

Case Type       : Fire Radiation
Case Name      : 10D8INTF160S2A+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A - 8-inch Release, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) 0.0 feet
Elevation of target (from grade) 6.0 feet
Diameter of jet fire tip 0.6667 feet
Flow rate 4.82 lb/sec
Angle of release from horizontal 45.0 degrees

Fire radiation flux values
Radiation endpoint 1 12000 Btu/hr-sq.ft
Radiation endpoint 2 8000 Btu/hr-sq.ft
Radiation endpoint 3 5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 10D8INTF160S2A+45_7MMSCFD
Thu Jan 23 18:00:31 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Torch Fire, +45

```

Length of Flame      : 45.1 feet
Flame Tilt from Horizontal: 29.4 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
9.8	***
10.9	***
12.1	***
13.4	***
14.9	***
16.5	***
18.4	***
20.4	7170
22.6	56055
25.1	56055
27.8	18488
30.9	24565
34.3	29660
38.0	18972
42.2	12399
46.8	8222
51.9	5314
57.6	3452
63.9	2295
70.9	1569
78.7	1099
87.3	786
96.8	571
107.4	422
119.2	315

*** Target Location inside Flame

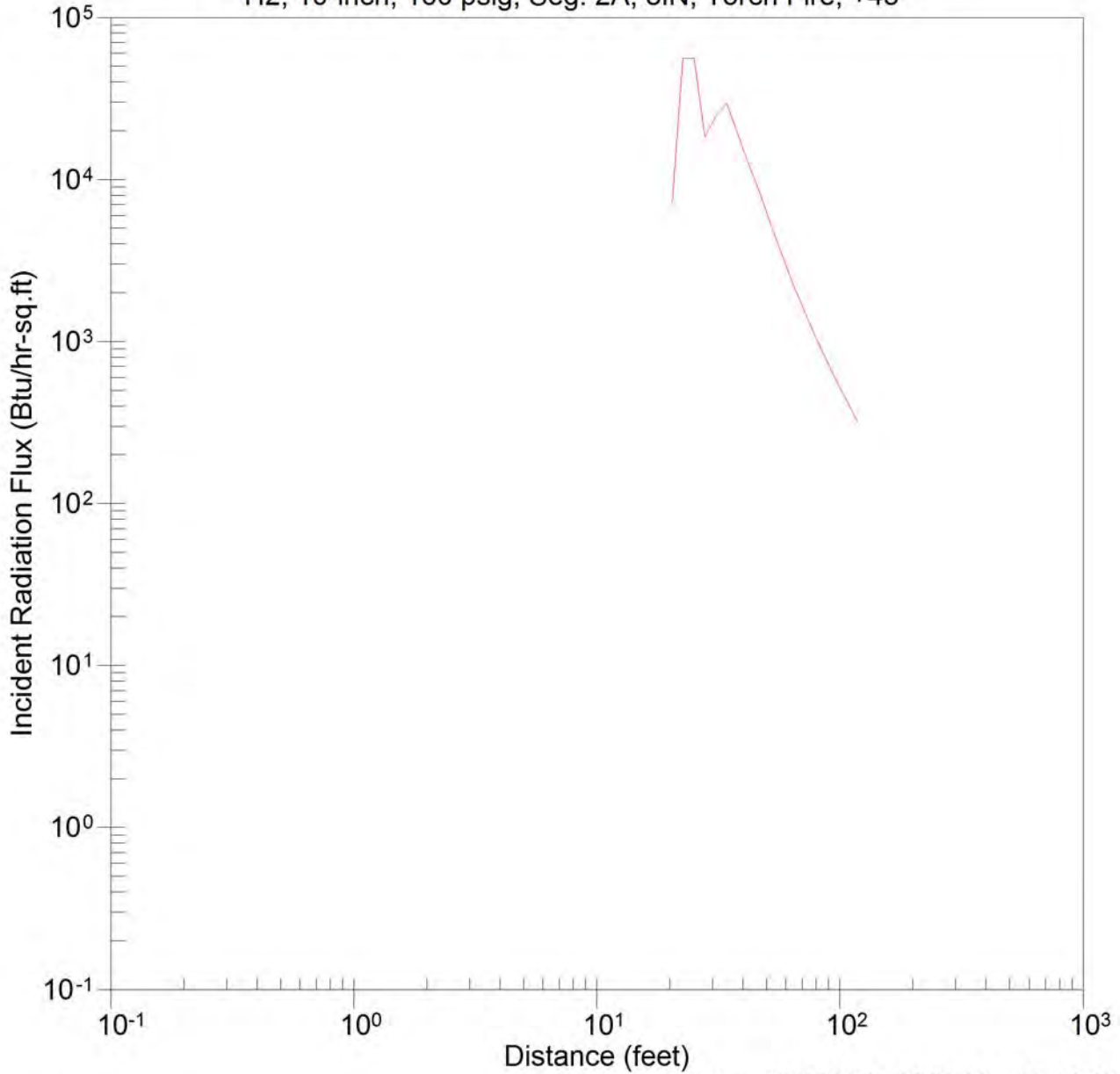
Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
42.6	12000
47.1	8000
52.8	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point

H2, 10-inch, 160 psig, Seg. 2A, 8IN, Torch Fire, +45



casename=10D8INTF160S2A+45_7MMSCFD

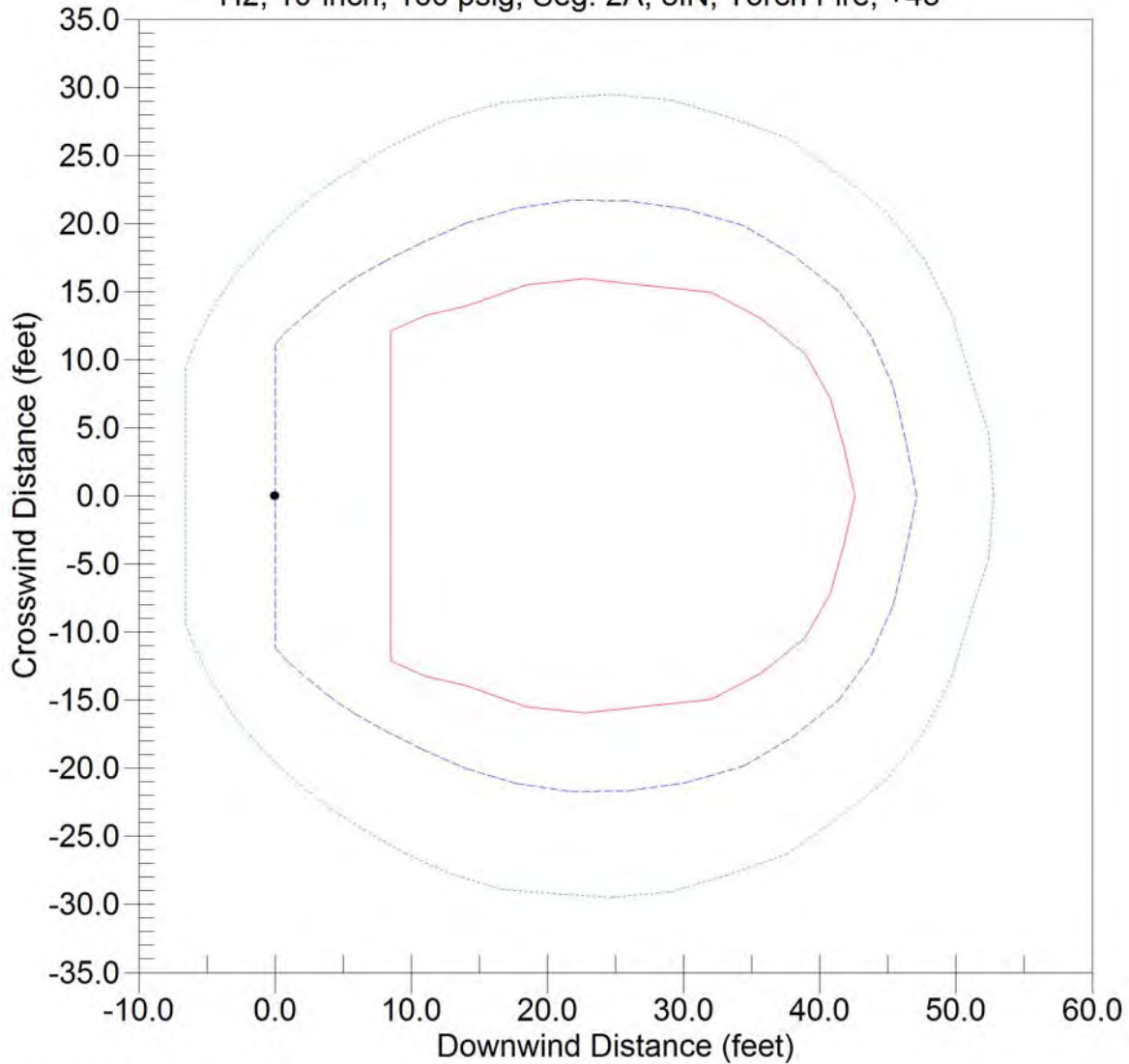
windspeed = 20.0 mph

Thu Jan 23 18:00:31 2020

CANARY by Quest

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 10-inch, 160 psig, Seg. 2A, 8IN, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=10D8INTF160S2A+45_7MMSCFD

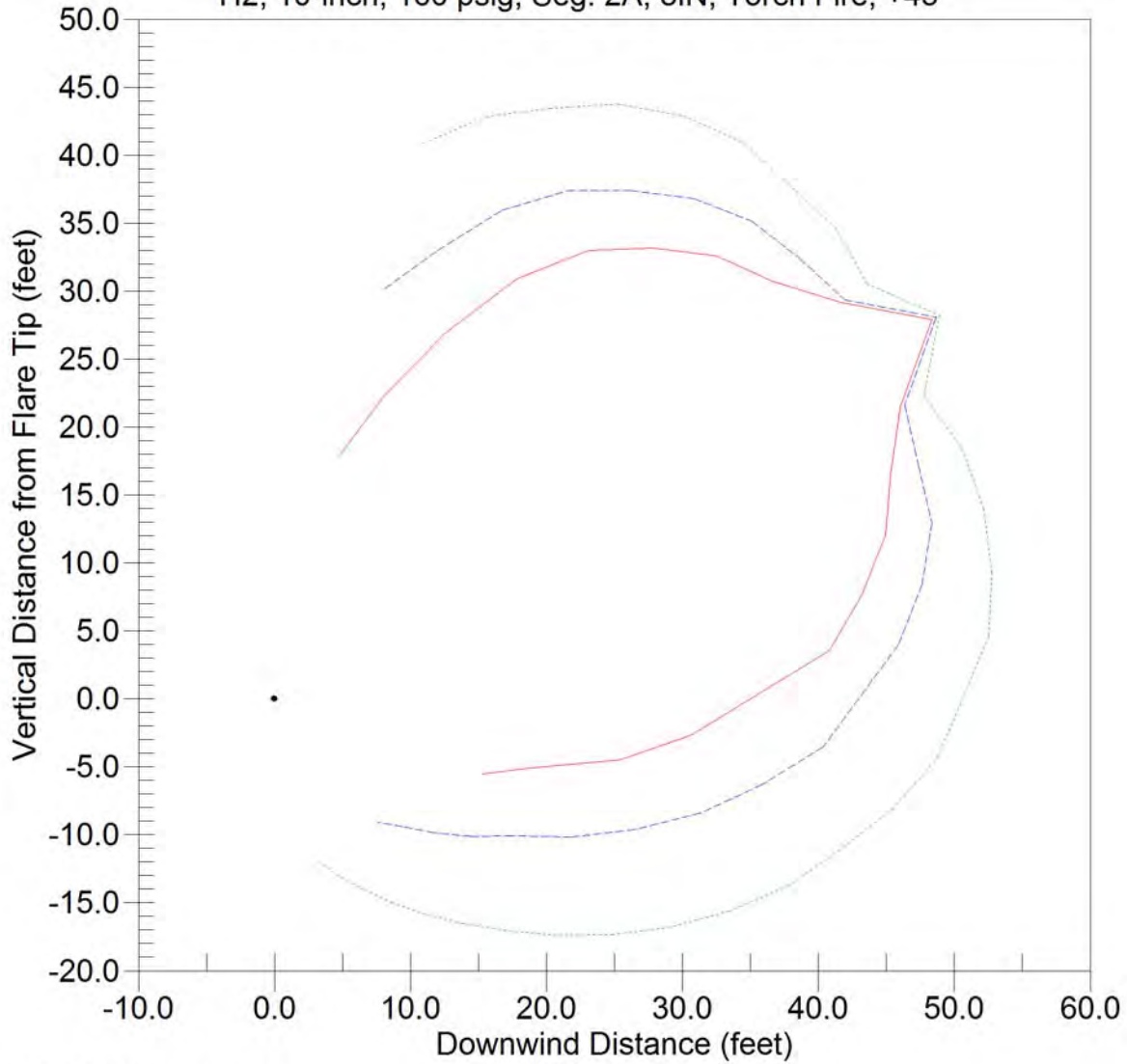
windspeed = 20.0 mph

Thu Jan 23 18:00:31 2020

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 160 psig, Seg. 2A, 8IN, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=10D8INTF160S2A+45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:00:31 2020

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D8INTF160S2A-45_7MMSCFD           |
|           Thu Jan 23 18:01:07 2020                         |
|   Quest Consultants Inc., Norman, Oklahoma, USA            |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734        |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Torch Fire, -45

```

Case Type       : Fire Radiation
Case Name      : 10D8INTF160S2A-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A - 8-inch Release, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) 0.0 feet
Elevation of target (from grade) 6.0 feet
Diameter of jet fire tip 0.6667 feet
Flow rate 4.82 lb/sec
Angle of release from horizontal 135.0 degrees

Fire radiation flux values
Radiation endpoint 1 12000 Btu/hr-sq.ft
Radiation endpoint 2 8000 Btu/hr-sq.ft
Radiation endpoint 3 5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 10D8INTF160S2A-45_7MMSCFD
Thu Jan 23 18:01:07 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 8IN, Torch Fire, -45

```

Length of Flame      : 45.1 feet
Flame Tilt from Horizontal: 60.7 degrees
Release Angle       : 135.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
9.8	20563
11.0	24045
12.2	24224
13.6	21405
15.2	17854
16.9	14857
18.8	13096
21.0	11909
23.3	10665
26.0	9364
29.0	8069
32.3	6830
35.9	5681
40.0	4649
44.6	3747
49.7	2982
55.4	2350
61.7	1839
68.7	1431
76.5	1112
85.3	862
95.0	668
105.8	518
117.9	403
131.3	313

*** Target Location inside Flame

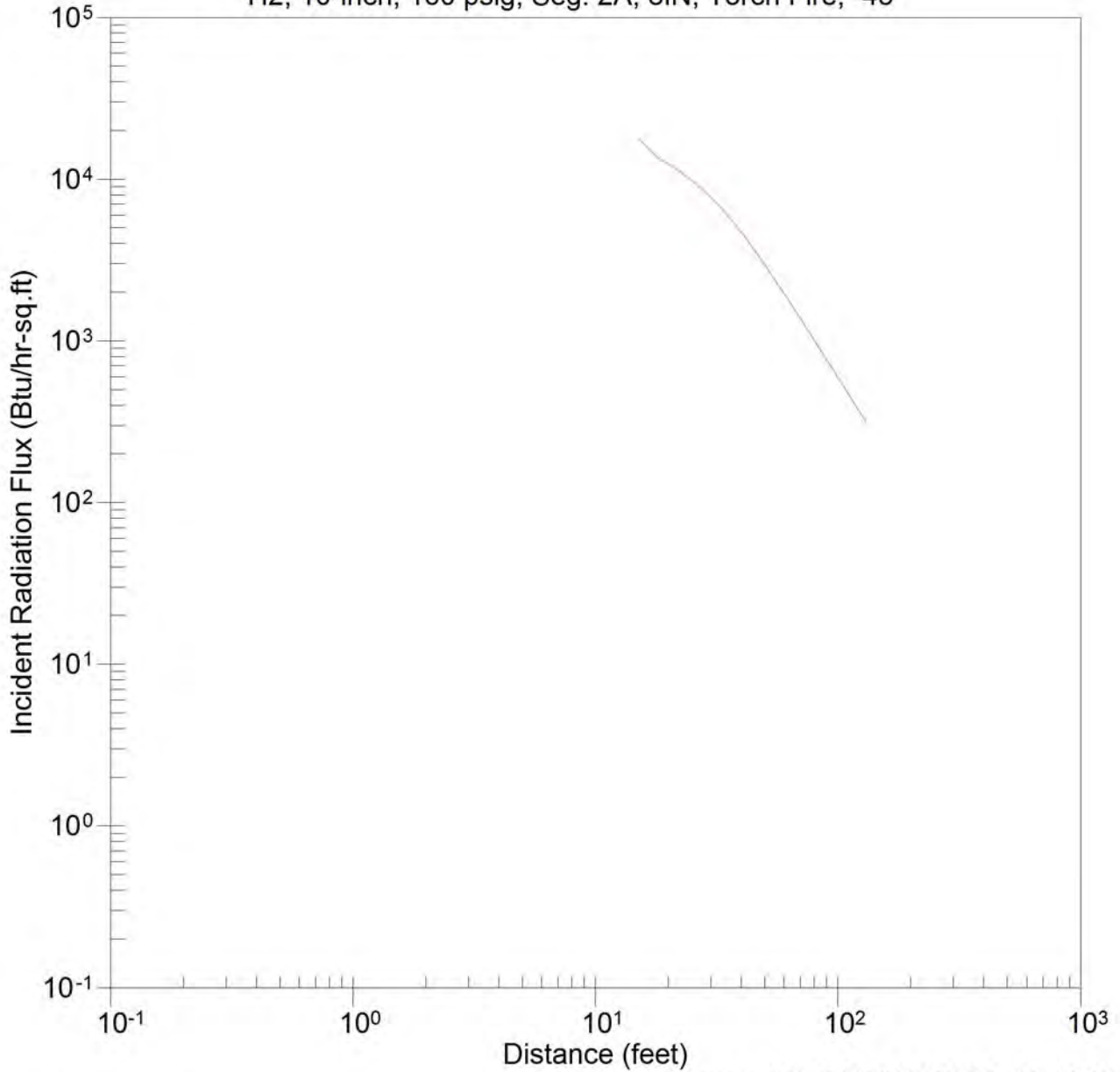
Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
20.6	12000
29.1	8000
38.4	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point

H2, 10-inch, 160 psig, Seg. 2A, 8IN, Torch Fire, -45



casename=10D8INTF160S2A-45_7MMSCFD

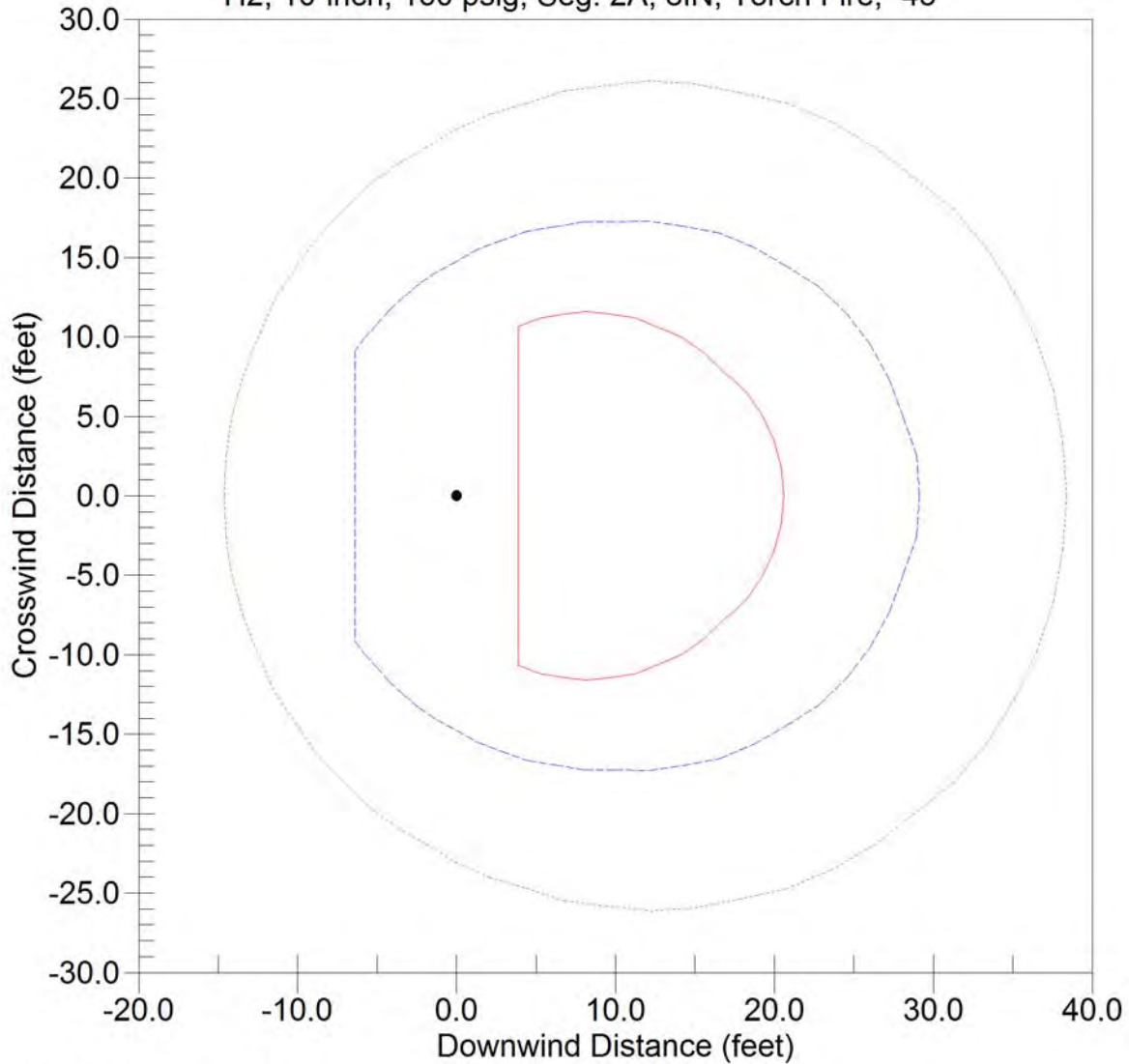
windspeed = 20.0 mph

Thu Jan 23 18:01:07 2020

CANARY by Quest

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 10-inch, 160 psig, Seg. 2A, 8IN, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=10D8INTF160S2A-45_7MMSCFD

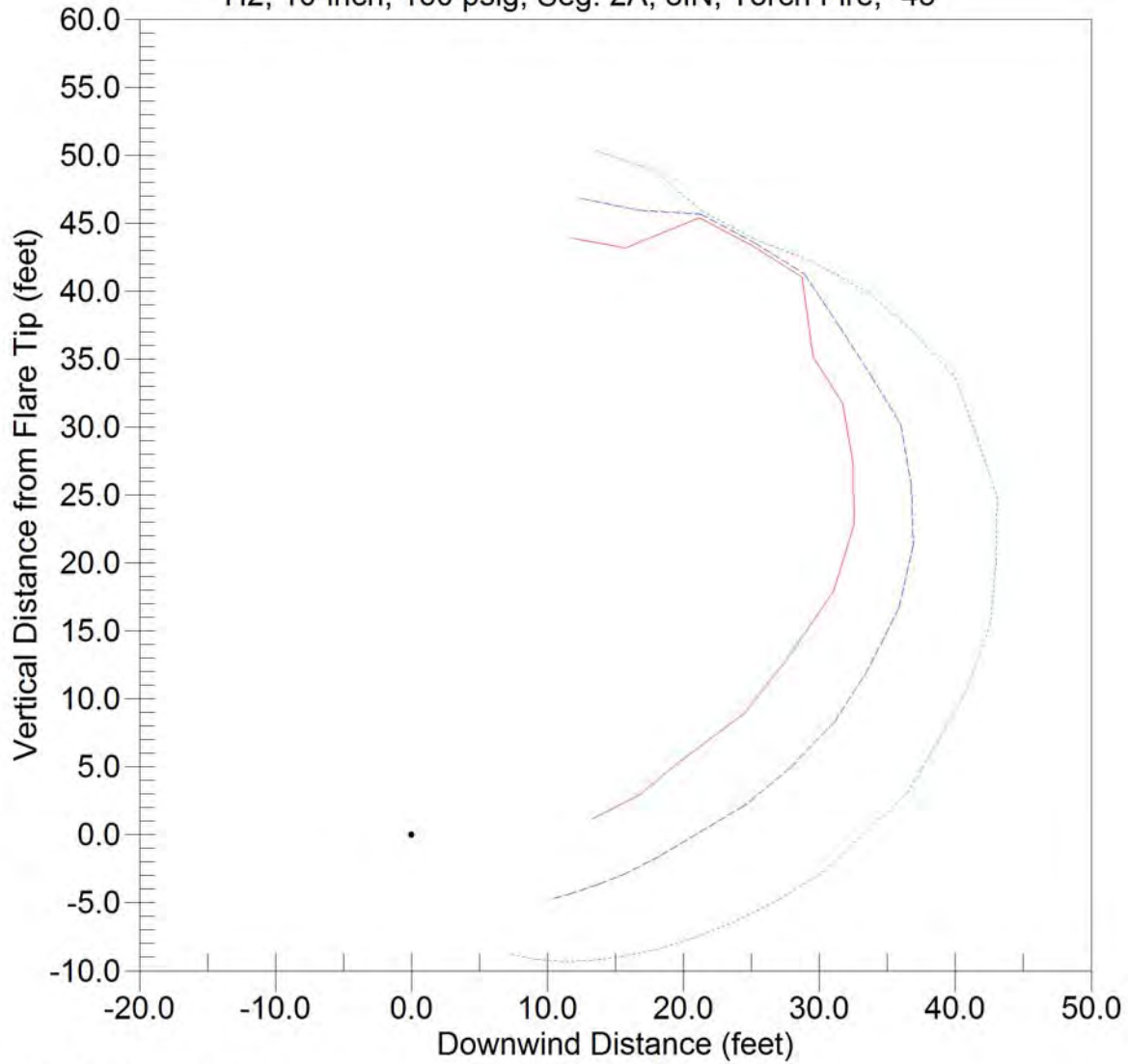
windspeed = 20.0 mph

Thu Jan 23 18:01:07 2020

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 160 psig, Seg. 2A, 8IN, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=10D8INTF160S2A-45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:01:07 2020

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D1INTF160S2A+45_7MMSCFD           |
|           Thu Jan 23 18:02:48 2020                         |
|   Quest Consultants Inc., Norman, Oklahoma, USA            |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734        |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Torch Fire, +45

```

Case Type       : Fire Radiation
Case Name      : 10D1INTF160S2A+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)          6.0 feet
Diameter of jet fire tip                   0.0833 feet
Flow rate                                  0.57 lb/sec
Angle of release from horizontal           45.0 degrees

Fire radiation flux values
Radiation endpoint 1      12000 Btu/hr-sq.ft
Radiation endpoint 2      8000 Btu/hr-sq.ft
Radiation endpoint 3      5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 10D1INTF160S2A+45_7MMSCFD
Thu Jan 23 18:02:48 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Torch Fire, +45

```

Length of Flame      : 22.5 feet
Flame Tilt from Horizontal: 40.8 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	***
7.1	***
7.7	***
8.4	***
9.1	***
9.8	***
10.7	24318
11.6	24318
12.5	10232
13.6	6952
14.7	10763
16.0	11180
17.3	8666
18.8	6291
20.4	4633
22.1	3439
23.9	2555
26.0	1903
28.1	1427
30.5	1080
33.1	826
35.9	639
38.9	498
42.2	392
45.7	311

*** Target Location inside Flame

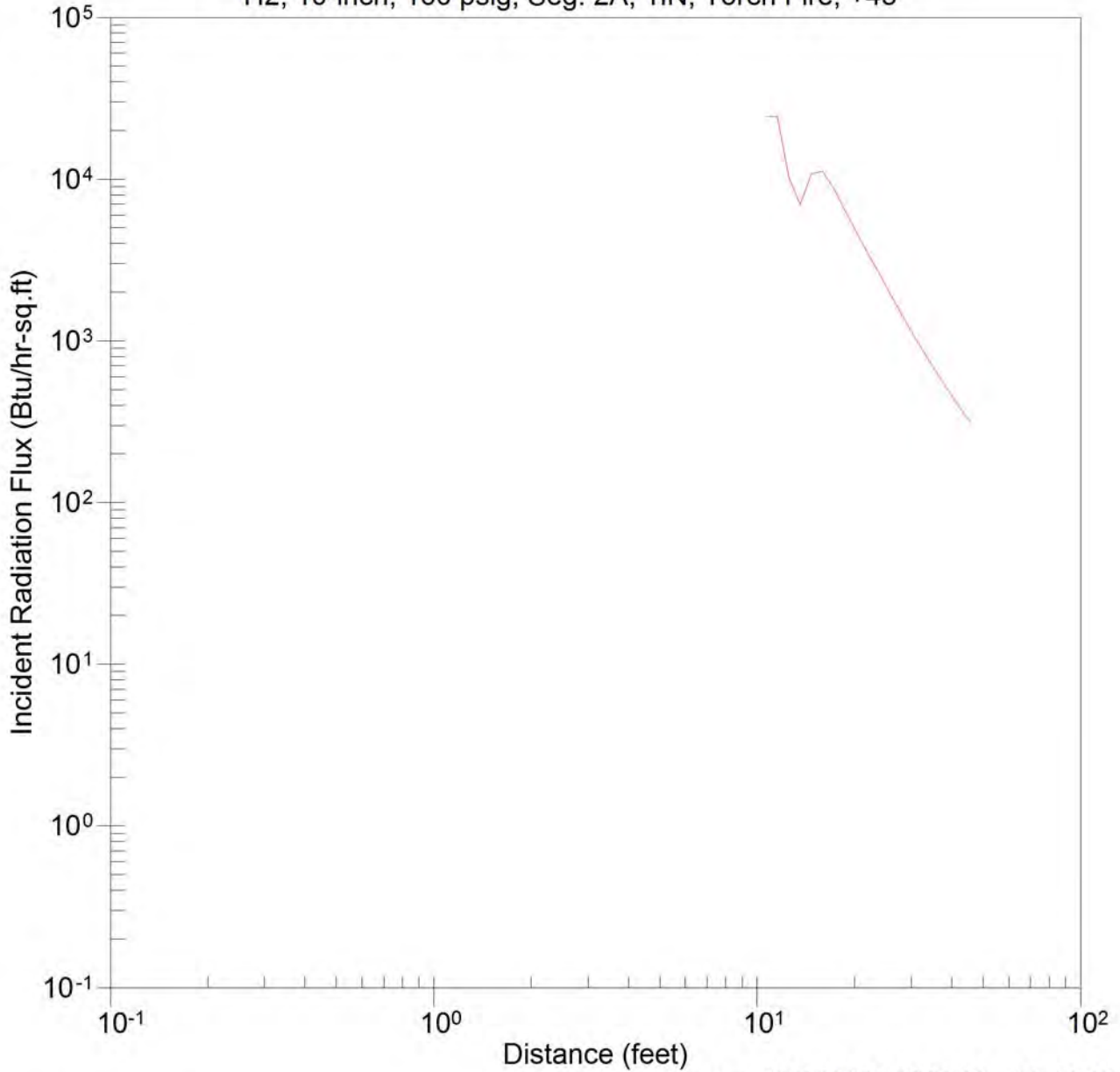
Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
12.3	12000
17.7	8000
19.9	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point

H2, 10-inch, 160 psig, Seg. 2A, 1IN, Torch Fire, +45



CANARY by Quest

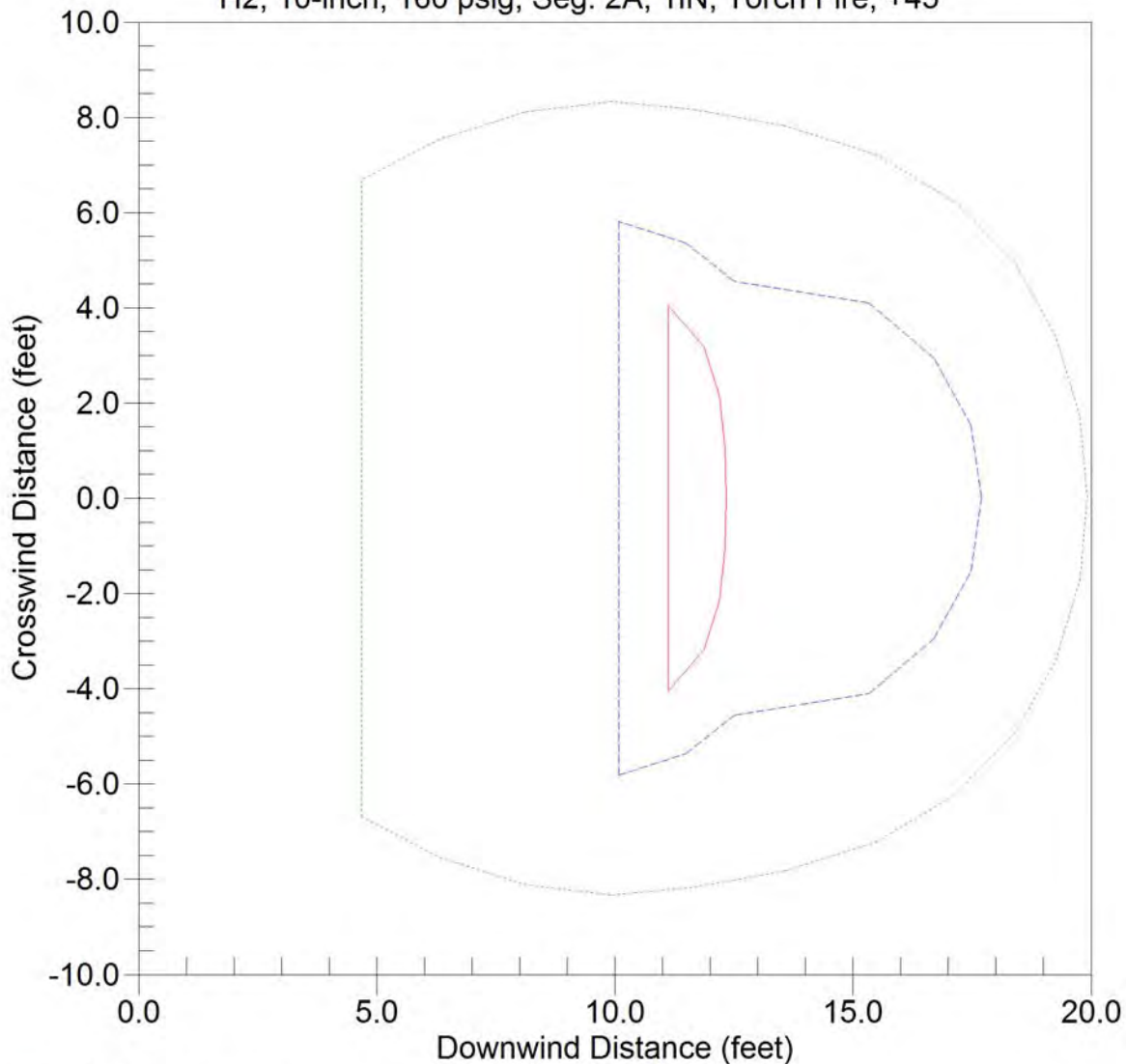
casename=10D1INTF160S2A+45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:02:48 2020

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 10-inch, 160 psig, Seg. 2A, 1IN, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=10D1INTF160S2A+45_7MMSCFD

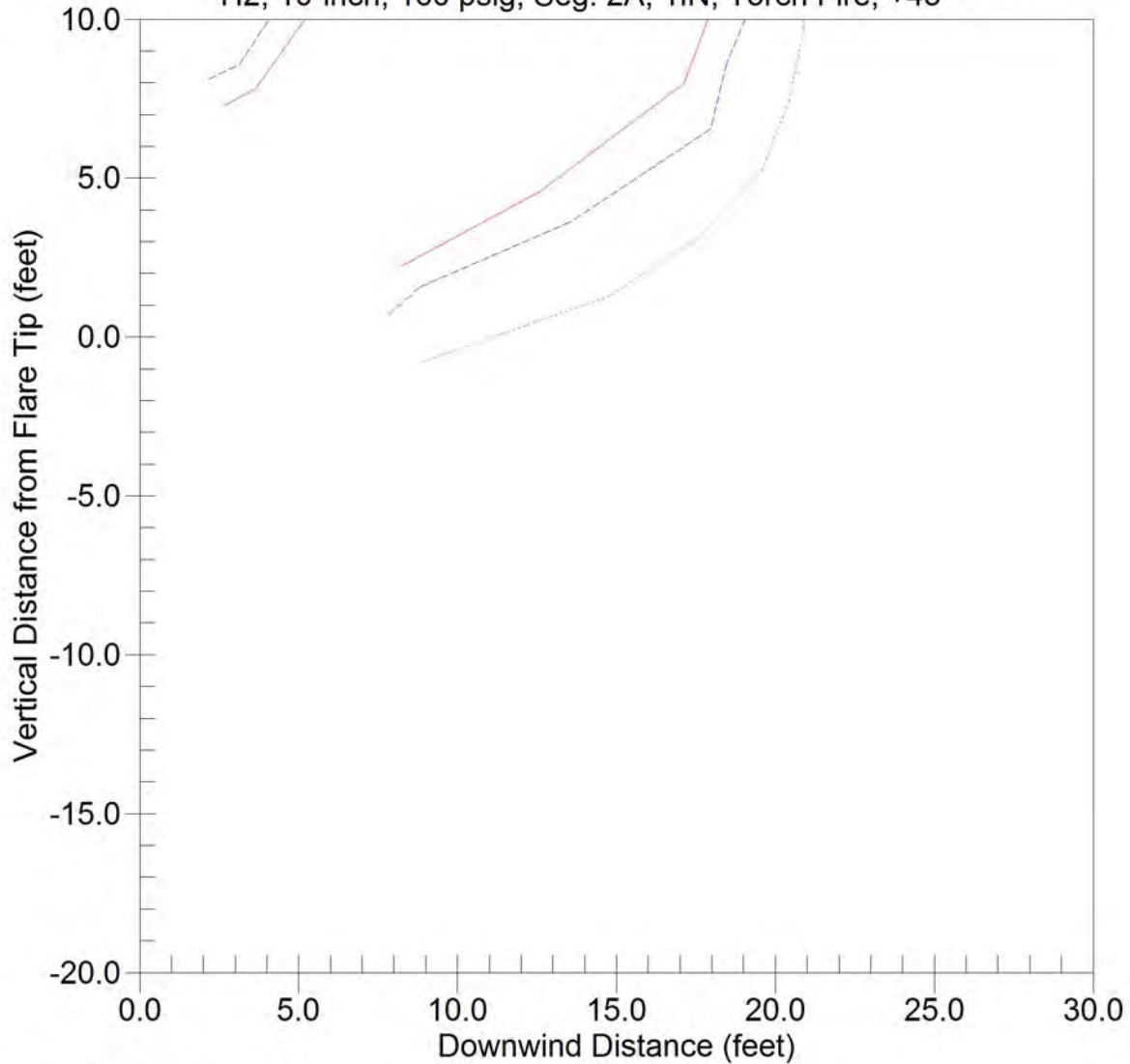
windspeed = 20.0 mph

Thu Jan 23 18:02:48 2020

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 160 psig, Seg. 2A, 1IN, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=10D1INTF160S2A+45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:02:48 2020

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 10D1INTF160S2A-45_7MMSCFD           |
|           Thu Jan 23 18:03:24 2020                         |
|   Quest Consultants Inc., Norman, Oklahoma, USA            |
| www.questconsult.com           canary@questconsult.com     |
| telephone (405) 329-7475       fax (405) 329-7734        |
+-----+

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Torch Fire, -45

```

Case Type       : Fire Radiation
Case Name      : 10D1INTF160S2A-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2A, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) 0.0 feet
Elevation of target (from grade) 6.0 feet
Diameter of jet fire tip 0.0833 feet
Flow rate 0.57 lb/sec
Angle of release from horizontal 135.0 degrees

Fire radiation flux values
Radiation endpoint 1 12000 Btu/hr-sq.ft
Radiation endpoint 2 8000 Btu/hr-sq.ft
Radiation endpoint 3 5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 10D1INTF160S2A-45_7MMSCFD
Thu Jan 23 18:03:24 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

Title: H2, 10-inch, 160 psig, Seg. 2A, 1IN, Torch Fire, -45

```

Length of Flame      : 22.5 feet
Flame Tilt from Horizontal: 123.6 degrees
Release Angle       : 135.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	2301
7.0	2161
7.5	2025
7.9	1893
8.5	1767
9.0	1647
9.6	1533
10.3	1424
10.9	1320
11.7	1222
12.4	1131
13.2	1044
14.1	963
15.1	885
16.0	813
17.1	745
18.2	681
19.4	622
20.7	567
22.1	516
23.5	469
25.1	425
26.7	385
28.5	348
30.4	314

Downwind Distances to Endpoints

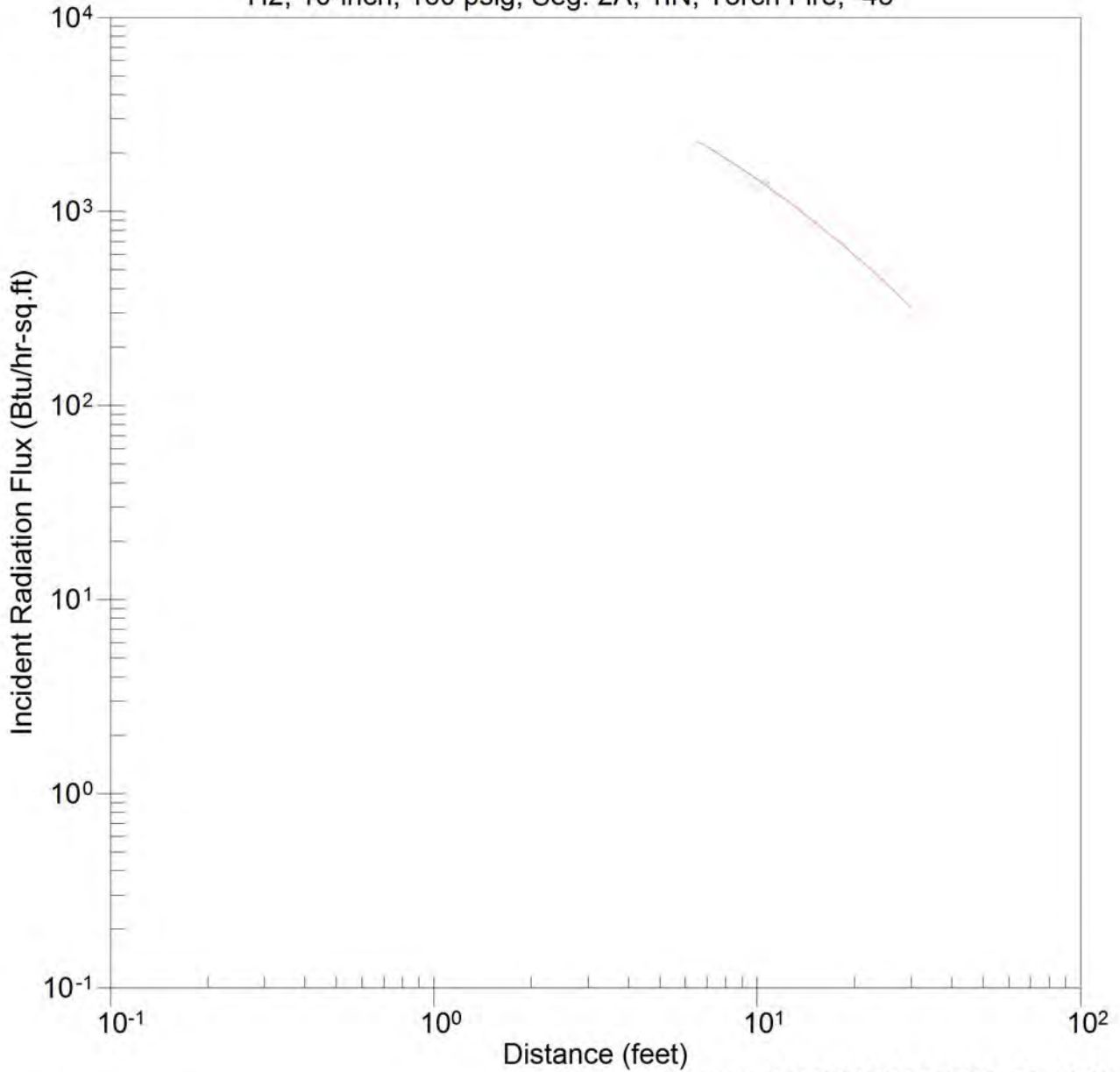
Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
**	12000
**	8000
**	5000

** Endpoint does not exist at this elevation

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point

H2, 10-inch, 160 psig, Seg. 2A, 1IN, Torch Fire, -45



casename=10D1INTF160S2A-45_7MMSCFD

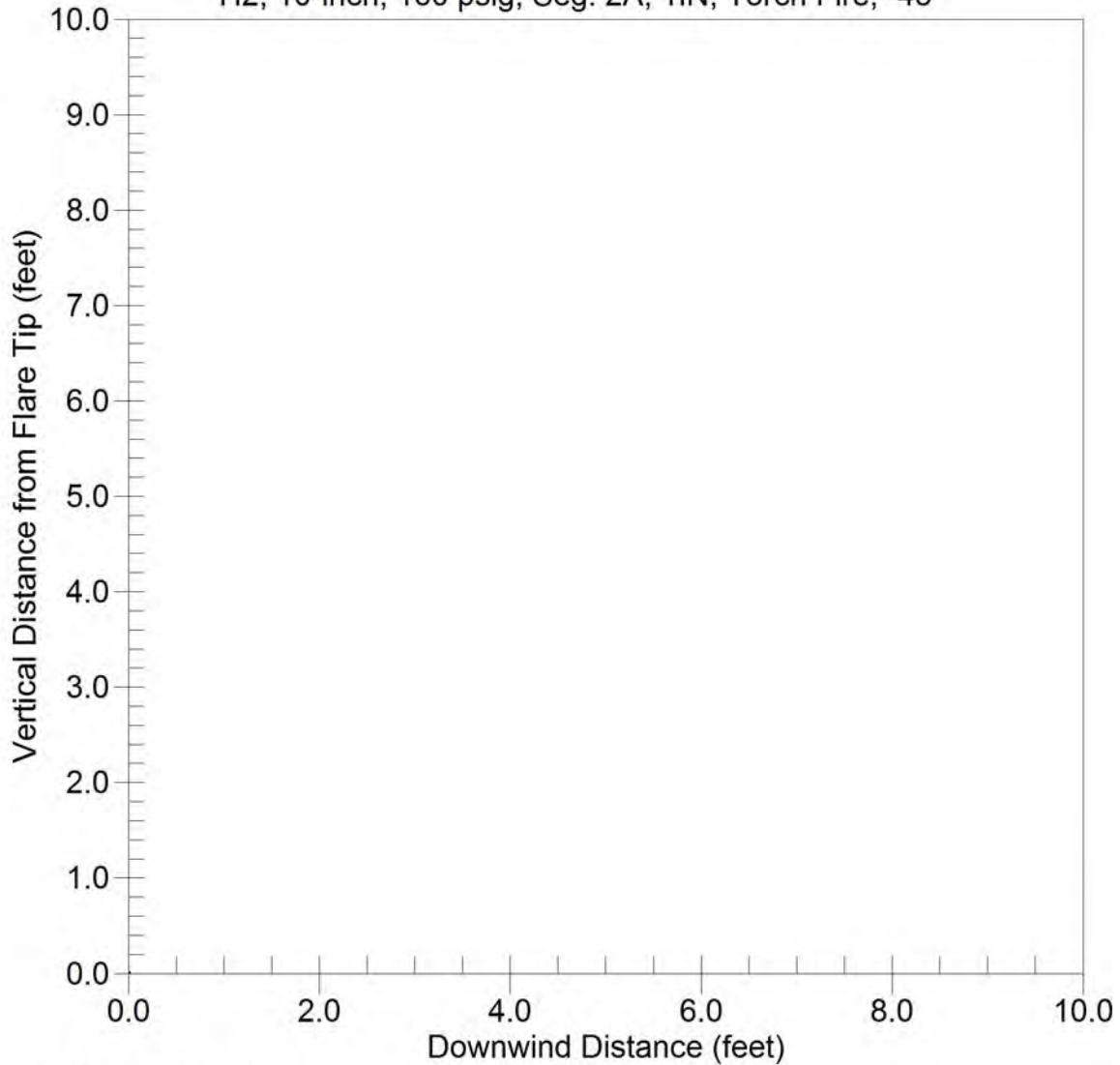
windspeed = 20.0 mph

Thu Jan 23 18:03:24 2020

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 10-inch, 160 psig, Seg. 2A, 1IN, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=10D1INTF160S2A-45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:03:24 2020

CANARY by Quest



Torch Fire Modeling Results, Segment 2B


```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 12DTF160S2B+45_7MMSCFD      |
|           Thu Jan 23 18:04:49 2020                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com                     |
|           telephone (405) 329-7475                 |
|           canary@questconsult.com                  |
|           fax (405) 329-7734                       |
|                                     |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, +45

```

Case Type       : Fire Radiation
Case Name      : 12DTF160S2B+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B - 12-inch, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Pseudo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature    : 70.00 °F
Pressure       : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

Wind speed	20.00 mph
Relative humidity	70 %
Air temperature	72.0 °F

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)         6.0 feet
Diameter of jet fire tip                 1.0000 feet
Flow rate                                 5.97 lb/sec
Angle of release from horizontal          45.0 degrees

```

Fire radiation flux values

Radiation endpoint 1	12000 Btu/hr-sq.ft
Radiation endpoint 2	8000 Btu/hr-sq.ft
Radiation endpoint 3	5000 Btu/hr-sq.ft

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 12DTF160S2B+45_7MMSCFD
Thu Jan 23 18:04:49 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, +45

```

Length of Flame      : 46.7 feet
Flame Tilt from Horizontal: 25.8 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
9.8	***
11.0	***
12.2	***
13.6	***
15.2	***
16.9	***
18.8	***
21.0	***
23.4	***
26.0	70082
29.0	15264
32.3	37844
36.0	58459
40.1	25524
44.6	16941
49.7	10468
55.4	6239
61.7	3839
68.8	2470
76.6	1651
85.4	1138
95.1	804
105.9	578
118.0	423
131.5	313

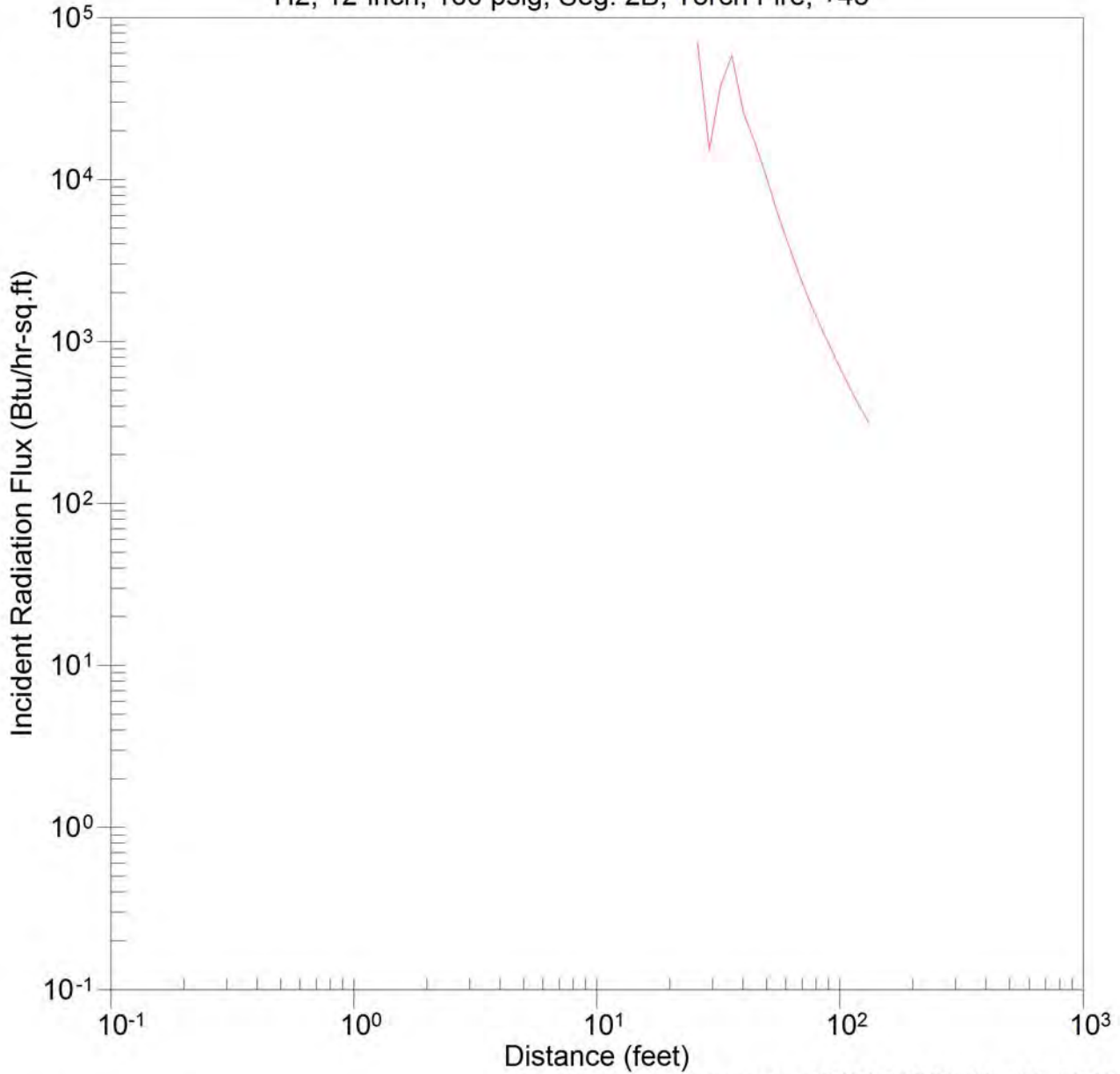
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
48.1	12000
52.7	8000
58.3	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, +45



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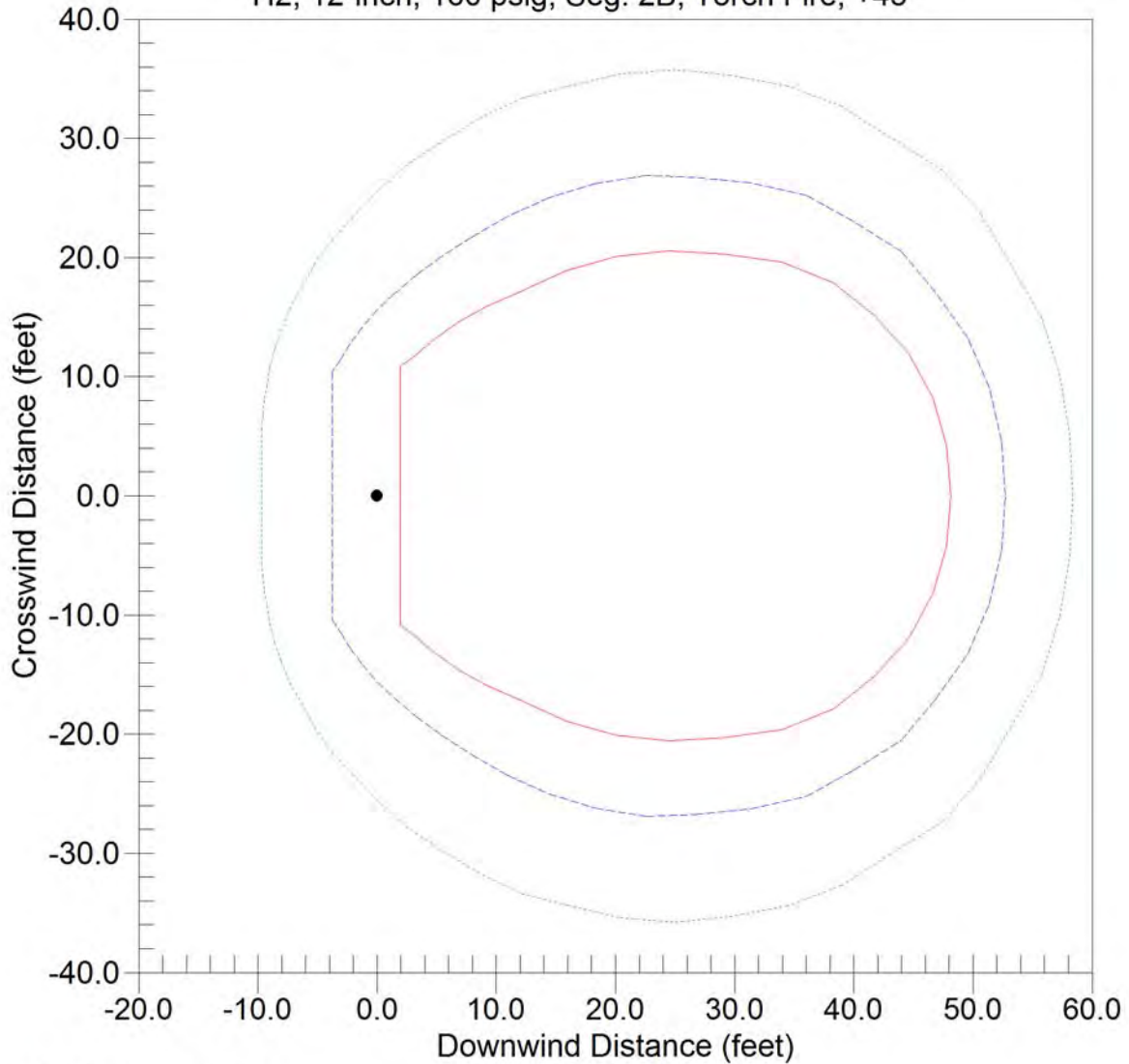
casename=12DTF160S2B+45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:04:49 2020

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

CANARY by Quest

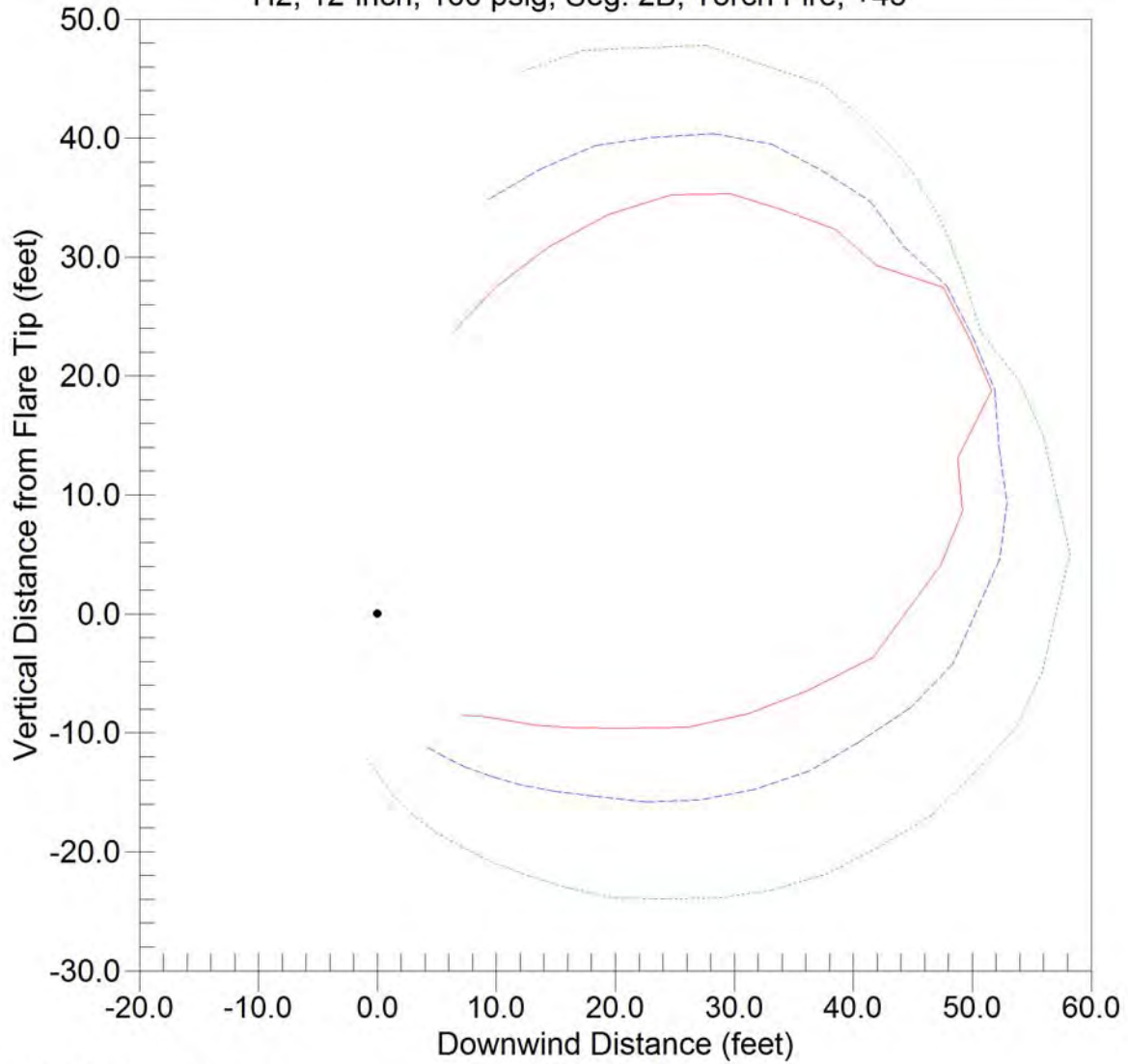
casename=12DTF160S2B+45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:04:49 2020

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=12DTF160S2B+45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:04:49 2020

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 12DTF160S2B-45_7MMSCFD                |
|           Thu Jan 23 18:07:10 2020                          |
|           Quest Consultants Inc., Norman, Oklahoma, USA      |
| www.questconsult.com           canary@questconsult.com      |
| telephone (405) 329-7475       fax (405) 329-7734          |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, -45

```

Case Type           : Fire Radiation
Case Name           : 12DTF160S2B-45_7MMSCFD
User ID             : BLPayne
Project Number      : Job 2134
Type of Units       : English Units

```

NOTES: Segment 2B - 12-inch, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature         : 70.00 °F
Pressure             : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           : 20.00 mph
Relative humidity     : 70 %
Air temperature       : 72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) : 0.0 feet
Elevation of target (from grade)     : 6.0 feet
Diameter of jet fire tip              : 1.0000 feet
Flow rate                             : 6.50 lb/sec
Angle of release from horizontal      : 135.0 degrees

Fire radiation flux values
Radiation endpoint 1 : 12000 Btu/hr-sq.ft
Radiation endpoint 2 : 8000 Btu/hr-sq.ft
Radiation endpoint 3 : 5000 Btu/hr-sq.ft

```

NOTES:

CANARY by Quest - Version 4.6.2
 Jet Fire Radiation Model
 Case Name - 12DTF160S2B-45_7MMSCFD
 Thu Jan 23 18:07:10 2020
 Quest Consultants Inc., Norman, Oklahoma, USA
 www.questconsult.com canary@questconsult.com
 telephone (405) 329-7475 fax (405) 329-7734

Title: H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, -45

Length of Flame : 48.6 feet
 Flame Tilt from Horizontal: 44.5 degrees
 Release Angle : 135.0 degrees
 Release Point Elevation : 0.0 feet
 Target Elevation : 6.0 feet
 Wind Speed : 20.0 mph

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
9.8	***
11.0	***
12.4	58191
13.9	73571
15.5	70853
17.4	34845
19.5	21170
21.9	23713
24.5	23955
27.5	20931
30.8	17436
34.5	14597
38.7	11969
43.3	9292
48.6	6952
54.4	5086
61.0	3680
68.4	2653
76.6	1917
85.9	1392
96.3	1018
107.9	750
120.9	557
135.5	416
151.9	312

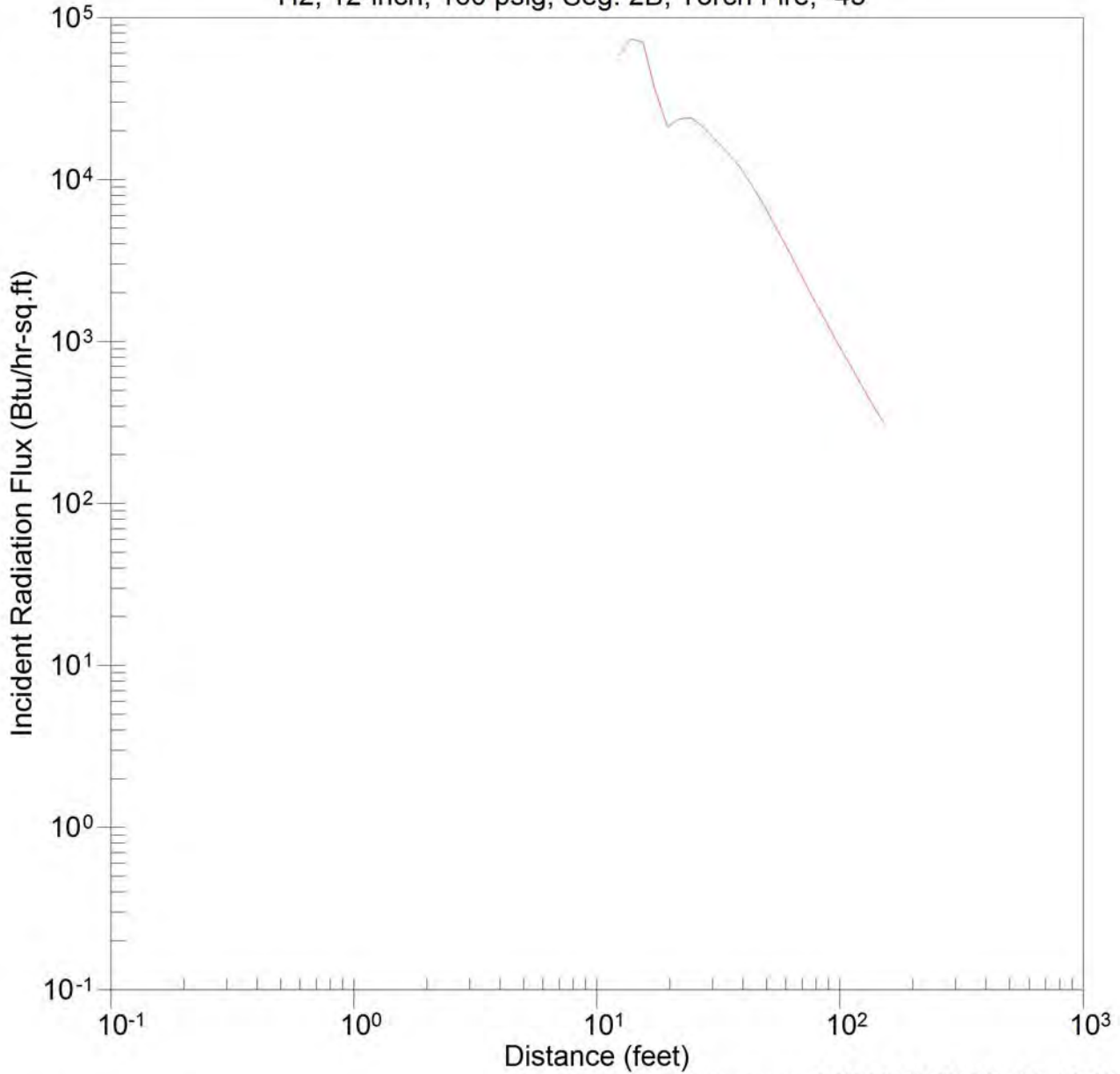
*** Target Location inside Flame

Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
38.2	12000
45.9	8000
54.8	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, -45



casename=12DTF160S2B-45_7MMSCFD

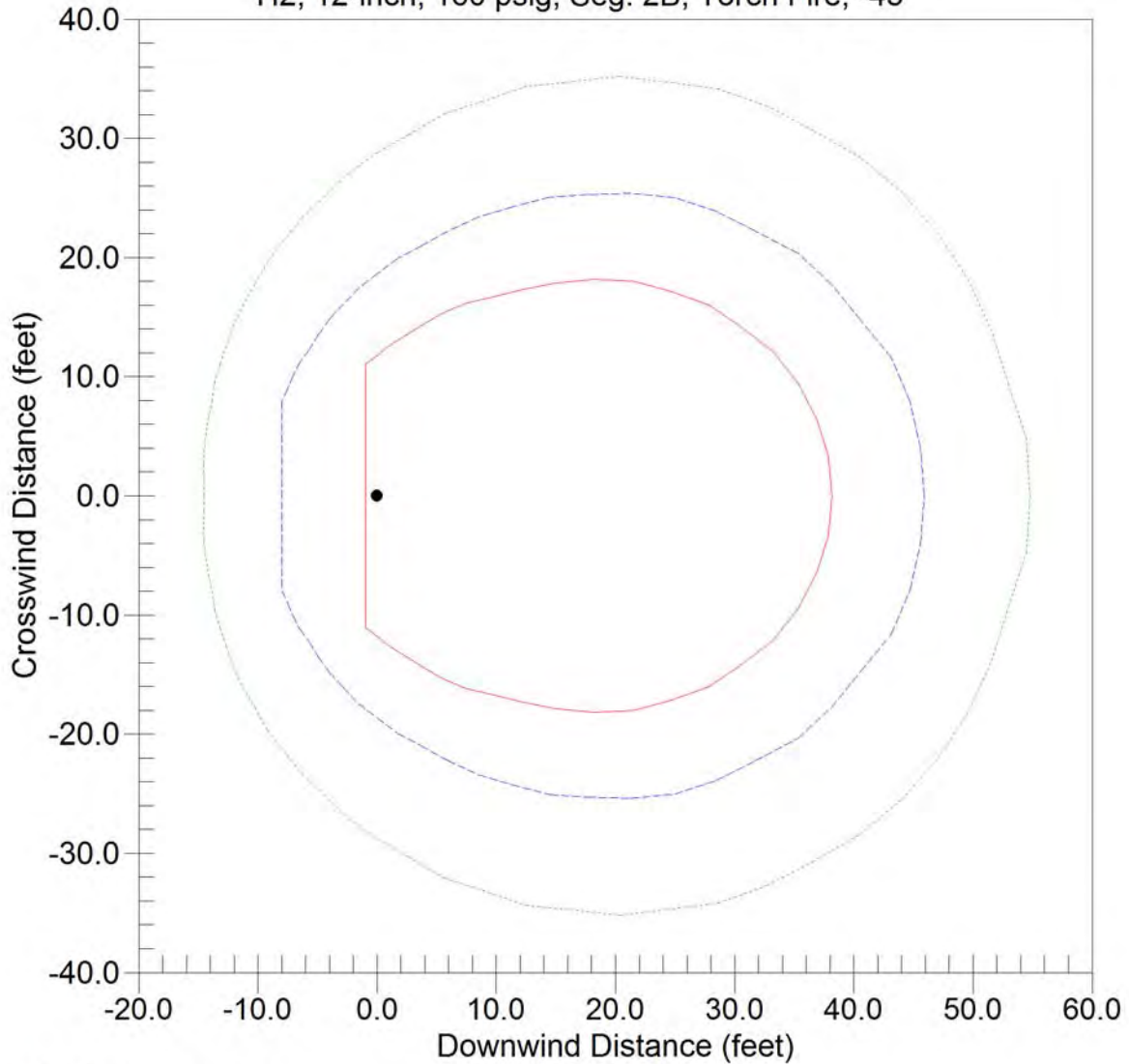
windspeed = 20.0 mph

Thu Jan 23 18:07:10 2020

CANARY by Quest

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, -45



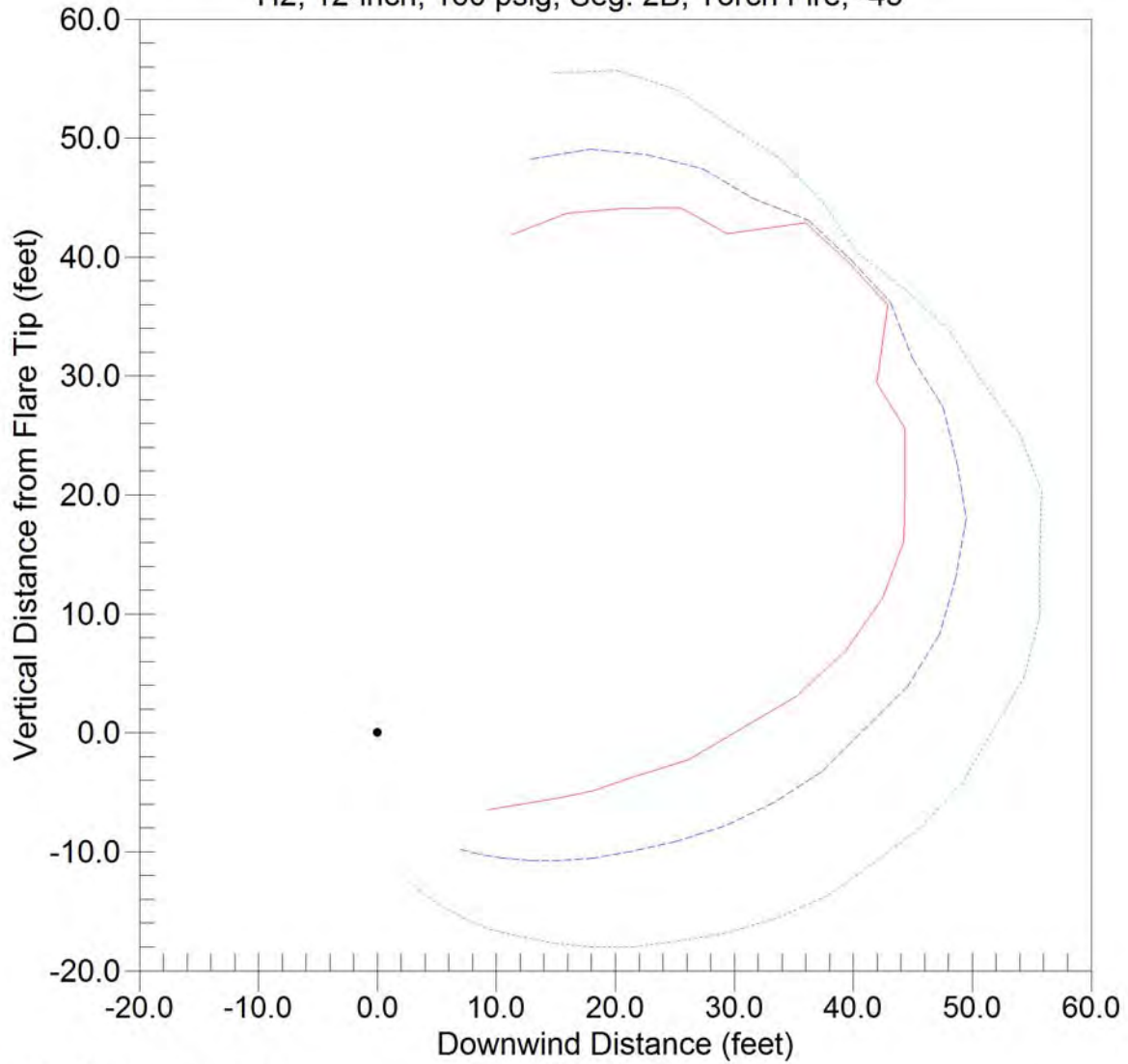
- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

CANARY by Quest

casename=12DTF160S2B-45_7MMSCFD
windspeed = 20.0 mph
Thu Jan 23 18:07:10 2020

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, -45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- · · 5000 Btu/hr-sq.ft

casename=12DTF160S2B-45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:07:10 2020

CANARY by Quest

```

+-----+
|               CANARY by Quest - Version 4.6.2               |
|               CANARY Case Input                             |
|           Case Name - 12DTF1IN160S2B+45_7MMSCFD           |
|           Thu Jan 23 18:08:42 2020                         |
|   Quest Consultants Inc., Norman, Oklahoma, USA            |
| www.questconsult.com           canary@questconsult.com      |
| telephone (405) 329-7475       fax (405) 329-7734         |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, 1IN, +45

```

Case Type       : Fire Radiation
Case Name      : 12DTF1IN160S2B+45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B - 12-inch, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	= H2	Hydrogen(equilibrium)	0.999945
Component 2	43	= CO	Carbon Monoxide	0.000010
Component 3	17	= CO2	Carbon Dioxide	0.000010
Component 4	1	= CH4	Methane	0.000010
Component 5	299	= H2O	Psuedo Water	0.000020
Component 6	28	= O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      :      70.00 °F
Pressure         :      160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade)      0.0 feet
Elevation of target (from grade)          6.0 feet
Diameter of jet fire tip                   0.0833 feet
Flow rate                                  0.57 lb/sec
Angle of release from horizontal           45.0 degrees

Fire radiation flux values
Radiation endpoint 1      12000 Btu/hr-sq.ft
Radiation endpoint 2      8000 Btu/hr-sq.ft
Radiation endpoint 3      5000 Btu/hr-sq.ft

```

NOTES:

```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 12DTF1IN160S2B+45_7MMSCFD
Thu Jan 23 18:08:42 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com    canary@questconsult.com
telephone (405) 329-7475    fax (405) 329-7734

```

Title: H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, 1IN, +45

```

Length of Flame      : 22.5 feet
Flame Tilt from Horizontal: 40.8 degrees
Release Angle       : 45.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	***
7.1	***
7.7	***
8.4	***
9.1	***
9.8	***
10.7	24357
11.6	24357
12.5	10386
13.6	6934
14.7	10712
16.0	11164
17.3	8681
18.8	6307
20.4	4645
22.1	3449
24.0	2562
26.0	1908
28.2	1431
30.5	1083
33.1	828
35.9	640
38.9	500
42.2	393
45.8	312

*** Target Location inside Flame

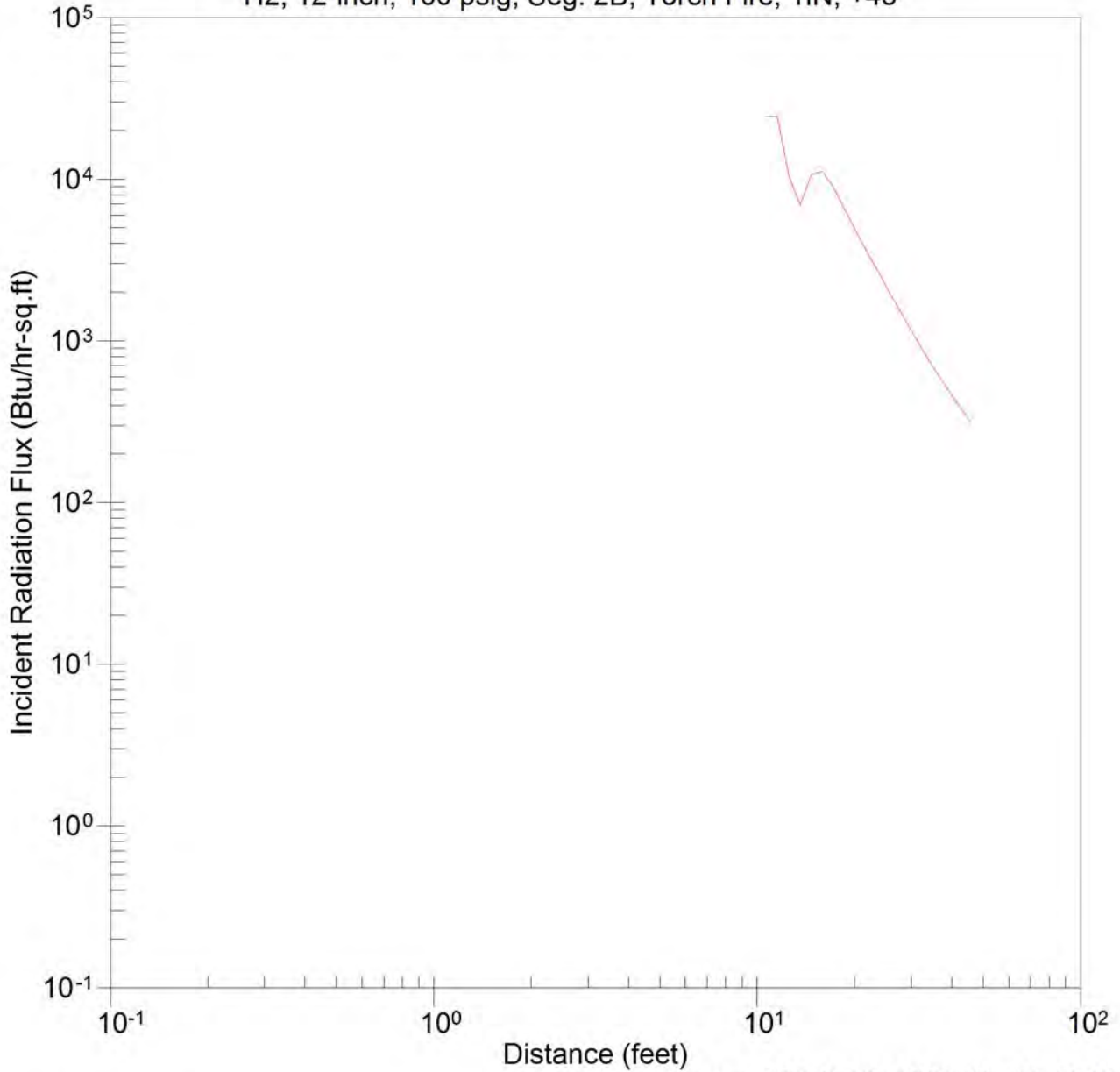
Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
12.4	12000
17.7	8000
19.9	5000

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point

H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, 1IN, +45



CANARY by Quest

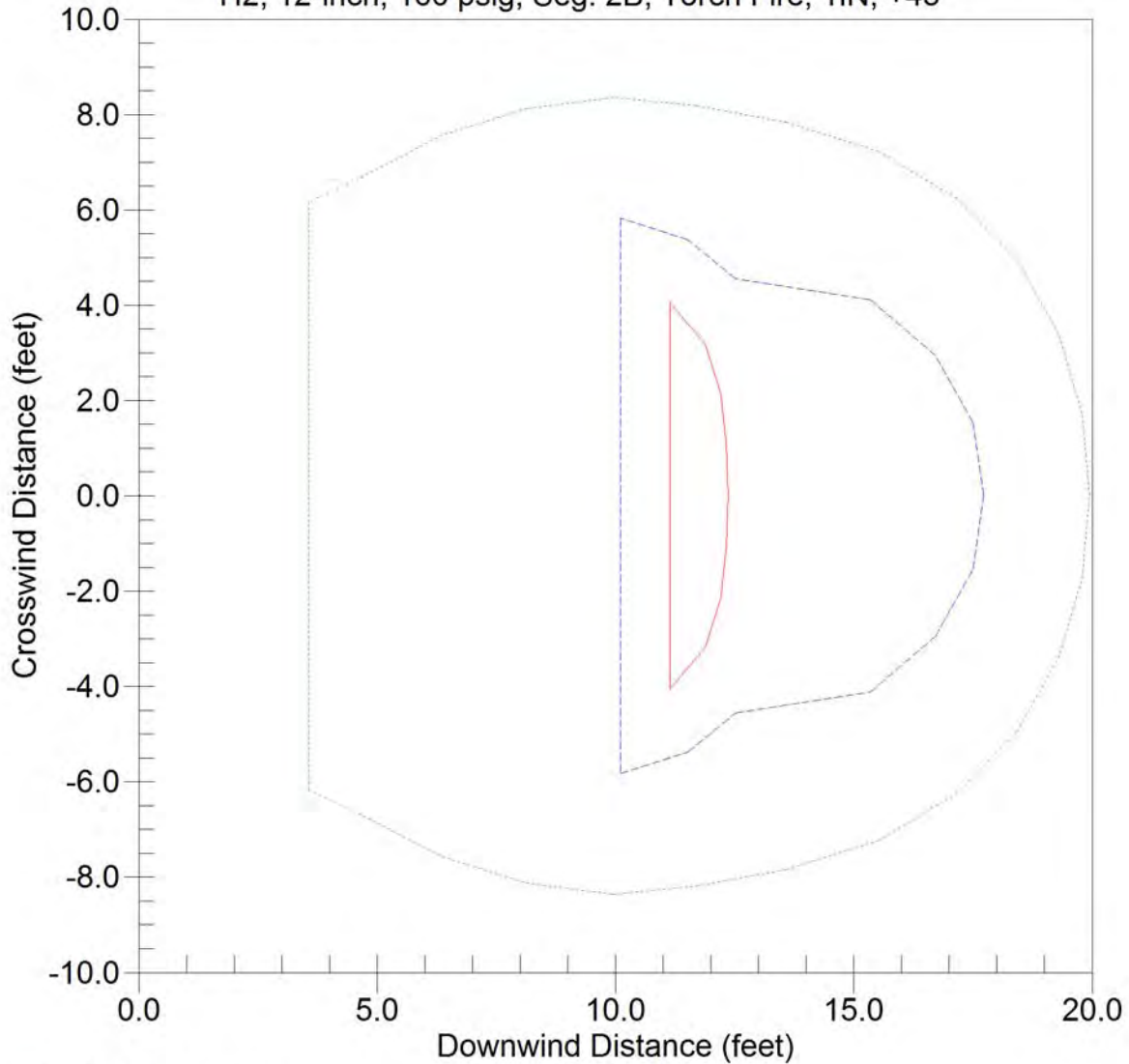
casename=12DTF1IN160S2B+45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:08:42 2020

JET FIRE RADIATION ISOPLETHS

Target is 6.0 feet Above the Release Point
H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, 1IN, +45



- 12000 Btu/hr-sq.ft
- - - 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=12DTF1IN160S2B+45_7MMSCFD

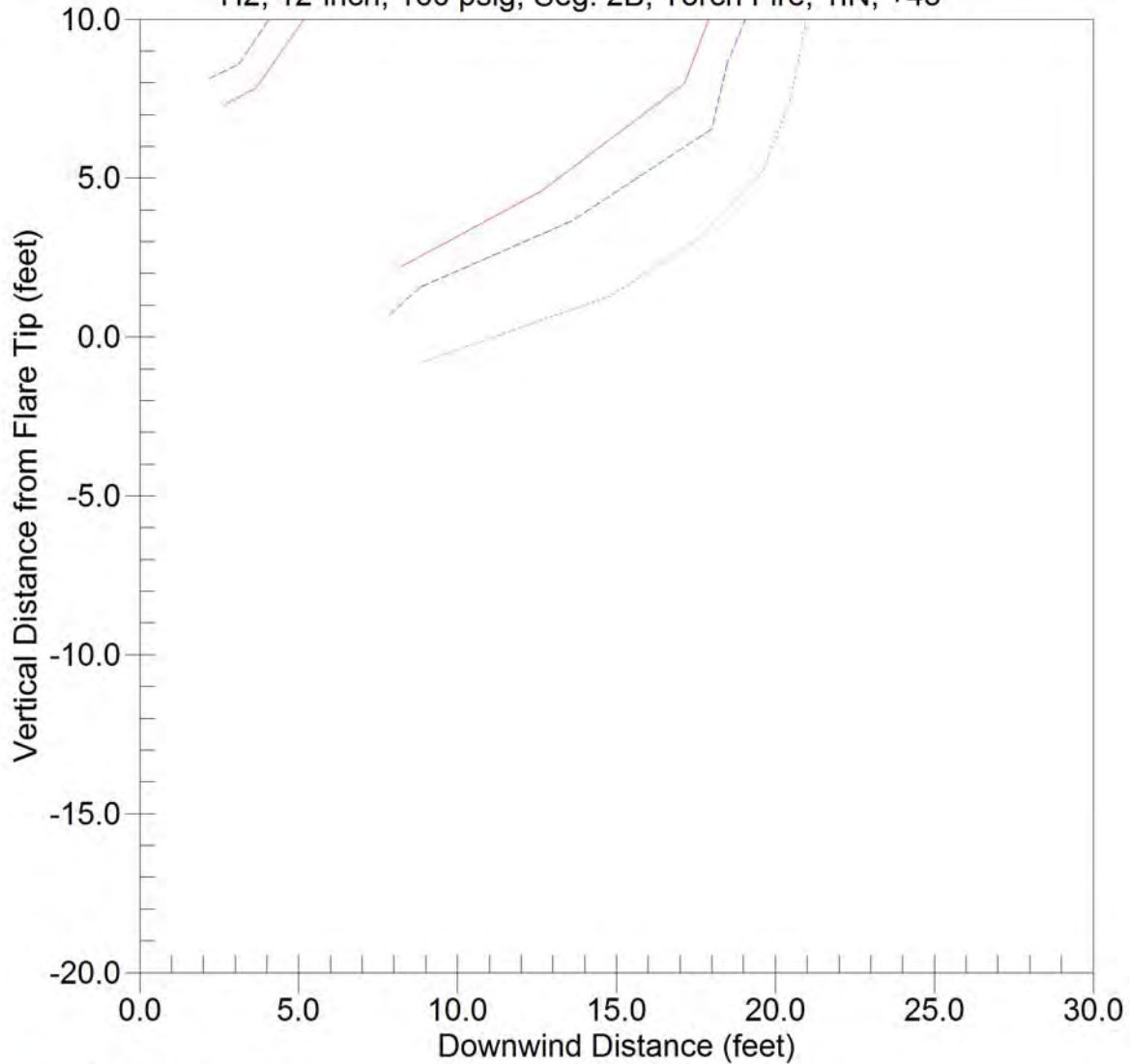
windspeed = 20.0 mph

Thu Jan 23 18:08:42 2020

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, 1IN, +45



- 12000 Btu/hr-sq.ft
- - 8000 Btu/hr-sq.ft
- ... 5000 Btu/hr-sq.ft

casename=12DTF1IN160S2B+45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:08:42 2020

CANARY by Quest

```

+-----+
|                                     |
|           CANARY by Quest - Version 4.6.2           |
|           CANARY Case Input                       |
|           Case Name - 12DTF1IN160S2B-45_7MMSCFD   |
|           Thu Jan 23 18:09:21 2020                |
|           Quest Consultants Inc., Norman, Oklahoma, USA |
|           www.questconsult.com   canary@questconsult.com |
|           telephone (405) 329-7475   fax (405) 329-7734 |
|                                     |
+-----+

```

Title: H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, 1IN, -45

```

Case Type       : Fire Radiation
Case Name      : 12DTF1IN160S2B-45_7MMSCFD
User ID       : BLPayne
Project Number : Job 2134
Type of Units  : English Units

```

NOTES: Segment 2B - 12-inch, 160 psig

MATERIAL MENU

Materials Released	Number	Formula	Name	Fraction
Component 1	51	H2	Hydrogen(equilibrium)	0.999945
Component 2	43	CO	Carbon Monoxide	0.000010
Component 3	17	CO2	Carbon Dioxide	0.000010
Component 4	1	CH4	Methane	0.000010
Component 5	299	H2O	Pseudo Water	0.000020
Component 6	28	O2	Oxygen	0.000005
Component 7				
Component 8				
Component 9				
Component 10				

```

Temperature      : 70.00 °F
Pressure         : 160.00 psia
The material is indeterminate

```

NOTES:

ENVIRONMENT MENU

```

Wind speed           20.00 mph
Relative humidity    70 %
Air temperature      72.0 °F

```

NOTES:

FIRE TYPE MENU

```

Fire radiation division: Jet fire
Vertical and horizontal isopleths
Elevation of flame base (from grade) 0.0 feet
Elevation of target (from grade) 6.0 feet
Diameter of jet fire tip 0.0833 feet
Flow rate 0.57 lb/sec
Angle of release from horizontal 135.0 degrees

Fire radiation flux values
Radiation endpoint 1 12000 Btu/hr-sq.ft
Radiation endpoint 2 8000 Btu/hr-sq.ft
Radiation endpoint 3 5000 Btu/hr-sq.ft

```

NOTES:


```

CANARY by Quest - Version 4.6.2
Jet Fire Radiation Model
Case Name - 12DTF1IN160S2B-45_7MMSCFD
Thu Jan 23 18:09:21 2020
Quest Consultants Inc., Norman, Oklahoma, USA
www.questconsult.com      canary@questconsult.com
telephone (405) 329-7475   fax (405) 329-7734

```

Title: H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, 1IN, -45

```

Length of Flame      : 22.5 feet
Flame Tilt from Horizontal: 123.7 degrees
Release Angle       : 135.0 degrees
Release Point Elevation : 0.0 feet
Target Elevation    : 6.0 feet
Wind Speed          : 20.0 mph

```

Downwind Distance at Target Height (feet)	Maximum Flux (Btu/hr-sq.ft)
6.6	2305
7.0	2165
7.5	2028
7.9	1897
8.5	1771
9.0	1650
9.6	1535
10.3	1426
10.9	1322
11.7	1224
12.4	1133
13.3	1046
14.1	964
15.1	887
16.1	814
17.1	746
18.2	682
19.4	623
20.7	568
22.1	517
23.6	469
25.1	426
26.8	385
28.5	348
30.4	315

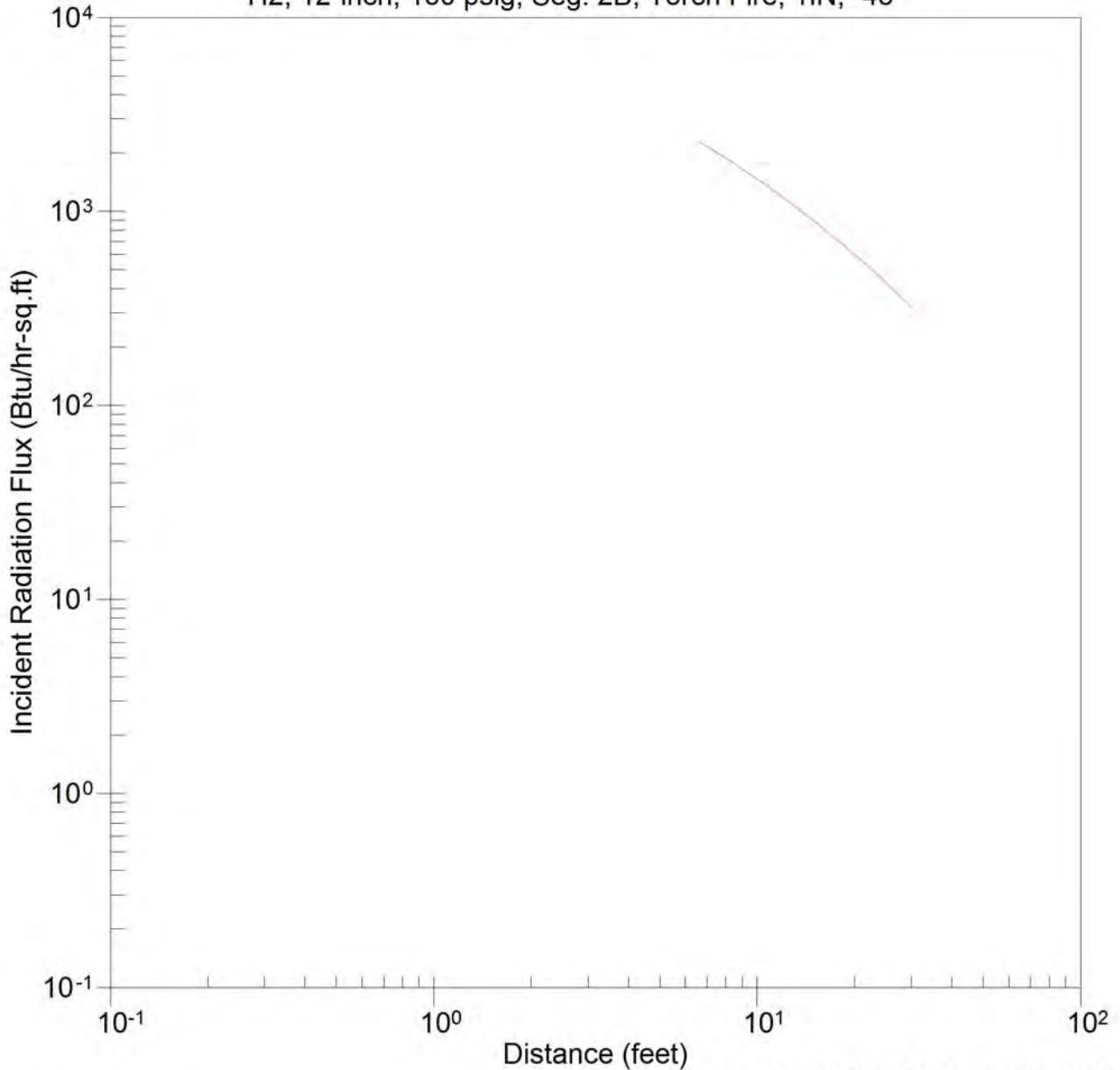
Downwind Distances to Endpoints

Distance (feet)	Maximum Flux (Btu/hr-sq.ft)
**	12000
**	8000
**	5000

** Endpoint does not exist at this elevation

JET FIRE RADIATION FLUX vs. DISTANCE

Target is 6.0 feet Above the Release Point
H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, 1IN, -45



casename=12DTF1IN160S2B-45_7MMSCFD

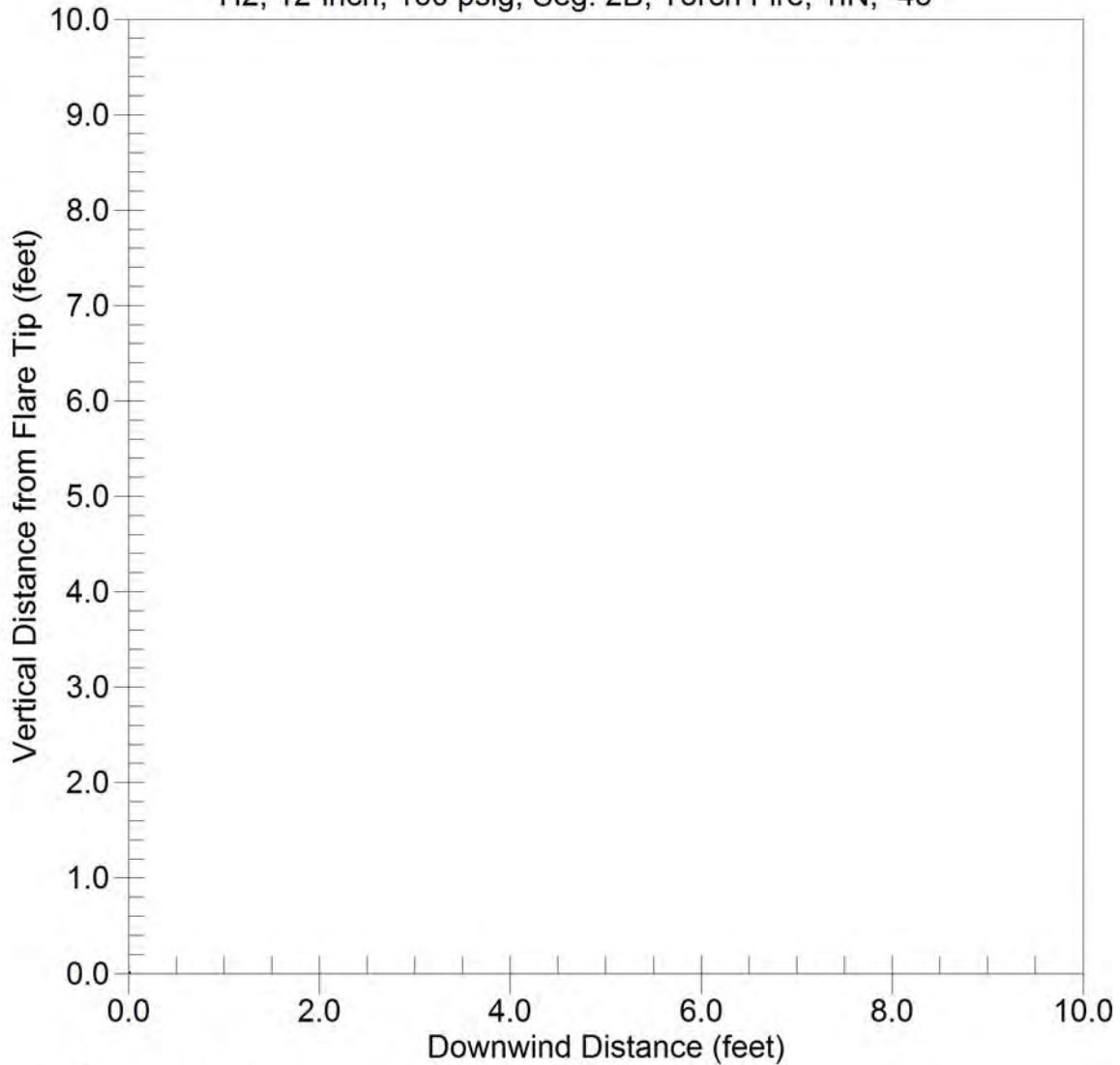
windspeed = 20.0 mph

Thu Jan 23 18:09:21 2020

CANARY by Quest

JET FIRE VERTICAL RADIATION ISOPLETHS

H2, 12-inch, 160 psig, Seg. 2B, Torch Fire, 1IN, -45



- 12000 Btu/hr-sq.ft
- 8000 Btu/hr-sq.ft
- 5000 Btu/hr-sq.ft

casename=12DTF1IN160S2B-45_7MMSCFD

windspeed = 20.0 mph

Thu Jan 23 18:09:21 2020

CANARY by Quest