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NUCLEAR ENERGY

10 CFR 50.4
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November 11, 2008

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ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: UniStar Nuclear Energy, NRC Docket No. 52-016
Submittal of Response to Requests for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3 – RAI Set No. 9 External Hazards

References: (1) Greg Gibson to Document Control Desk, U.S. Nuclear Regulatory Commission, RAI No. 9 RSAC 946, dated October 6, 2008

(2) John Rycyna (NRC) to George Wrobel (UniStar), "RAI No. 9 RSAC 946.doc," email dated September 5, 2008

The purpose of this letter is to respond to a portion of requests for additional information (RAIs) identified in the NRC e-mail correspondence to UniStar Nuclear, dated September 5, 2008 (Reference 2). These RAIs address hazards in the site vicinity as discussed in Section 2.2.3 of the Final Safety Analysis Report as submitted in Part 2 of the CCNPP Unit 3 Combined License Application (COLA).

The enclosure provides responses to supplemental RAI No. 9, Questions 1, 4 and 6.

If there are any questions regarding this transmittal, please contact me or Mr. George Wrobel at (585) 771-3535.

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NRO

I declare under penalty of perjury that the foregoing is true and correct.

Executed on November 11, 2008

Greg Gibson

Enclosure: Response to RAI Set No. 9 External Hazards, Questions 1, 4 and 6

cc: U.S. NRC Region I
U.S. NRC Resident Inspector, Calvert Cliffs Nuclear Power Plant, Units 1 and 2
NRC Environmental Project Manager, U.S. EPR Combined License Application
NRC Project Manager, U.S. EPR Combined License Application
NRC Project Manager, U.S. EPR Design Certification Application (w/o enclosure)

Enclosure

Response to RAI Set No. 9 External Hazards, Questions 1, 4 and 6

RAI Number 02.02.03-1: **FSAR Section 2.2.3**

RG 1.206 provides guidance regarding the information that is needed to ensure potential hazards in the site vicinity are identified and evaluated to meet the siting criteria in 10 CFR 100.20 and 10 CFR 100.21. FSAR Section 2.2.3 does not provide the information needed by the NRC staff to perform an independent review of that section. The applicant's quantitative assessment of overpressure hazards at the CCNPP3 site, due to operations at the DCPLNG facility is limited to estimates of fatalities probabilities (2.3×10^{-9} and 6.6×10^{-9} per year, for existing and expanded operations respectively (FSAR Section 2.2.3.1, p.2-15)) rather than overpressure events. The probability of occurrence of physical damage to CCNPP3 is stated to be lower, without any quantification or supporting analysis.

According to the blast effect area data with respect to people and structures presented on p.16 Tables 4.2 and 4.3 of the applicant's reference (June 28, 2006 Cove Point LNG Terminal Expansion Project Risk Study, prepared by the Maryland Department of Natural Resources as part of the Power Plant Research Program, PPRP), structural damage generally occurs at significantly lower overpressures. Hence it is expected that the probability of potential LNG events leading to damaging overpressures will be greater than that which is estimated for individual fatalities. Please provide a quantitative estimate and supporting analyses regarding the overpressure hazards to the CCNPP Unit 3 due to the DCPLNG facility.

RESPONSE:

The Cove Point LNG Terminal Expansion Project Risk Study, prepared by the Maryland Department of Natural Resources (PPRP) presents blast effects in Tables 4.1 and 4.2 on people and structures, respectively. As presented in those tables the damage from blast effects on structures occurs at much lower overpressures than the damage from blast effects on people. The study accounted for this difference when estimating the risk from blasts to develop some overpressure harm criteria that accounts for direct blast injuries and injuries from flying debris or collapsing structures (i.e. some compromise between the data presented in Table 4.2 and Table 4.3). This compromise set of impact criteria from blast overpressures is presented in Table 4.4. (MDNR, 2006) It should be noted; however, that the impact criteria established for this compromise set of criteria is set at levels above 1 psi—the overpressure level of concern established for explosions postulated, in Regulatory Guide 1.91. (USNRC, 1978), to occur on transportation routes. That is, in the PPRP report the level of concern—while above 1 psi—was not as high as the fatality level for humans.

Additionally, in regard to determining the fatality probabilities in Tables 5.5 and 5.6 of the PPRP report of 2.3×10^{-9} and 6.6×10^{-9} per year, for existing and expanded operations respectively, the total risk profile for the facility before and after the expansion project was determined by summing the risks from the individual scenarios. The main contributor to the risk from the DCPLNG plant was a scenario consisting of a jet fire from the gas export line—this contributed 98.7 percent to the risk for the pre-expanded operations. Likewise, the main contributor, post expanded operations is also the scenario consisting of a jet fire from the gas export line—this contributed 58.6 percent to the risk, while a jet fire scenario involving the new gas export line contributed 39.8 percent to the risk. (MDNR, 2006) This presents a conservative result in that the risk from the blast overpressure event was presented as the total fatality risk, rather than the risk from the individual scenario. It should be noted that in regards to the jet fire scenarios where the level of concern involves thermal heat flux, the effects on humans occurs at a lower thermal radiation level than that on structures.

However, in recognition that a larger level of concern was utilized for the blast overpressure scenarios in the PPRP versus the level of concern for overpressure events provided in RG 1.91, an analysis of the potential blast effects of the LNG pipeline was performed using the Area Locations of Hazardous Atmospheres (ALOHA) software.

The Cove Point LNG pipeline that connects to the DCPLNG facility was selected for analysis as this pipeline is considered the greatest risk from the facility due to its pressure, diameter, and proximity to the CCNPP Unit 3. The pipeline is located approximately 1.54 miles from the ultimate heat sink, which is the nearest safety related structure. In comparison, the DCPLNG facility is located approximately 3.2 miles from the CCNPP facility. Furthermore, the risk zones presented in the PPRP report show that the pipeline has the greatest potential impact on operations at the CCNPP (MDNR, 2006).

Two scenarios were considered for the release of LNG from the pipeline, a pipe connected to an infinite source and a pipe that is closed-off.

The following input data was obtained from the Dominion Cove Point LNG Terminal:

Gas Releases from Export Pipeline

Pipe diameter, mm [in]	920 [36]
Length to block valve, km [miles]	12.9 [8.03]
Initial pressure, bara [psi]	87 [1250]
Operating temperature, °F	57
Release orifice diameter	Full bore rupture (complete break)

The following assumptions were used in the analysis:

Scenario
Aloha can model two types of gas pipeline leak scenarios--both scenarios were modeled for this calculation:

- A pipeline connected to a very large (infinite) reservoir, so that gas escapes from the broken end of the pipeline at a constant rate for an indefinite period of time. The length of pipeline considered in this scenario is that from the Dominion Cove Point LNG Terminal to the point of the pipeline that is closest to the CCNPP, 3.41 miles (5.49 km). This side was chosen because flow rates are larger due to a smaller friction loss. The other section of pipeline is assumed to be closed off and the resulting flow rate insignificant compared to the flow from the infinite source.
- A finite length of pipeline that is closed-off at the unbroken end (for example, by a shut-off valve). Because the pressure within this section of pipe declines as gas is released, release rate drops over time, and the release continues only until the finite length of pipe is emptied. The length of pipeline considered in this scenario is approximately 6.21 miles (10 km). This length was chosen because the ALOHA domain is limited to 6.21 miles (ALOHA 2006). Sensitivity analyses were performed

to determine the effects of various pipeline lengths and it was found that 6.21 miles is the worst case allowable in ALOHA. For this sensitivity study, the conditions used were those for the worst cases found in the meteorological sensitivity study shown in Table 2. The data was extrapolated to determine the maximum overpressure for an 8 mile (12.9 km) pipeline.

Atmospheric Data
It is assumed that the ambient temperature is 25°C, the relative humidity is 50%, the cloud cover 50%, and the atmospheric pressure is 1 atmosphere. A sensitivity study was performed to determine the worst case wind speed and stability class for each scenario. The sensitivity study for the closed off source was conducted with a pipeline length of 6.21 miles, the maximum allowed input in ALOHA. This data was then extrapolated to 8.03 miles to determine the overpressure at the actual pipeline length. The results of the sensitivity study are shown in Tables 1 and 2. The worst case is highlighted for each scenario. It is assumed that there will be no inversion height for chemicals run with the heavy gas model, as in this calculation. An inversion is an atmospheric condition that serves to trap the gas below the inversion height thereby not allowing it to disperse normally. Inversion height has no affect on the heavy gas model.

Site Data
Seaford Delaware was selected as the location for the meteorological data since it is one of the geographically closest stations to the Constellation site. The time was assumed to be 12:00 pm on July 1, 2007. This day and time were chosen because solar radiation is highest in the summer during midday.

Ground Roughness
The ground roughness was assumed to be that for "open country" which is equivalent to rural topography (ALOHA, 2006).

Pipe Characteristics
The natural gas pipeline was assumed to be "smooth" for conservatism. Rough texture causes turbulence, which reduces the flow rate of the gas in the pipe. A gas will flow more slowly through a rough pipe than through a smooth pipe (ALOHA, 2006).

Vapor Cloud Explosion Parameters
The time of vapor cloud ignition was assumed to be unknown. This provides a composite threat zone from all possible ignition times and allows the depiction of the worst case scenario. The type of vapor cloud ignition was assumed to be "ignited by detonation." A detonation scenario is the worst case condition for a vapor cloud explosion. (ALOHA, 2006)

Table 1. Infinite Source Sensitivity Study

Stability Class	Wind Speed (m/s)	Distance to 1 psi (feet)	Overpressure at Nearest Safety Related Structure (psi)
F	1	5,808	0.627
F	2	5,280	0.574
F	3	5,808	0.602
E	1	5,808	0.622
E	2	5,235	0.563
E	3	5,808	0.604
E	4	5,808	0.614
E	5	5,808	0.613
D	3	5,808	0.623
D	4	5,808	0.625
D	5	5,808	0.618
D	6	5,808	0.608
C	2	5,280	0.591
C	3	5,808	0.622
C	4	5,808	0.618
C	5	5,808	0.602

Table 2. Closed-Off Source Sensitivity Study

Stability Class	Wind Speed (m/s)	Distance to 1 psi (feet)	Overpressure at Nearest Safety Related Structure (psi)
F	1	4,887	0.514
F	2	5,181	0.556
F	3	5,808	0.601
E	1	5,145	0.544
E	2	5,208	0.559
E	3	5,808	0.603
E	4	5,808	0.613
E	5	5,808	0.612
D	3	5,808	0.622
D	4	5,808	0.625
D	5	5,808	0.617
D	6	5,808	0.608
C	2	5,280	0.590
C	3	5,808	0.622
C	4	5,808	0.618
C	5	5,808	0.604

The maximum overpressure at the nearest safety related structure for an infinite source is 0.627 psi and for a closed-off source is 0.625 psi. The overpressure, as determined by extrapolation, for an 8.03 mile pipeline was found to be approximately 0.65 psi. This is not significantly different from the 6.21 mile pipeline length scenario therefore the distance to 1 psi reported in the COLA section is for the 6.21 mile pipeline. Both of these overpressures are well below the threshold overpressure as stated in RG 1.91 (1 psi) (USNRC, 1978). Therefore, there will be no adverse impact to plant operations.

PROPOSED COLA FSAR REVISION:

The following changes will be included in Revision 4 of the CCNPP, Unit 3 COLA.

Paragraph 4 in Section 2.2.2.4.2 of CCNPP, Unit 3 COL FSAR will be revised as shown below:

With the planned expansion of the DCPLNG facility, nearly 200 LNG tankers with a typical capacity of 91,557 to 183,113 yd^3 (70,000 to 140,000 m^3) will transit the Bay to this facility's north and south piers. Transfer of the LNG product to the onshore facility will occur through a 6,400 ft (1,951 m) submerged pipeline tunnel carrying two, 32 in (81 cm) liquid lines and two, 14 in (36 cm) vapor return lines. (MDNR, 2006) The offshore pier, from which the LNG is off loaded, is located in the Chesapeake Bay where the depth is approximately 43 ft (13 m). The offshore pier is accessible from the facility only through an underwater tunnel (NOAA, 2005). **The hazards from the LNG product stored and transported at the DCPLNG facility are bounded by the LNG pipeline that is described in Section 2.2.2.3. The pipeline is considered the greater risk due to its pressure, diameter, and closer proximity to the CCNPP Unit 3. Furthermore, the risk zones presented in the PPRP report show that the pipeline has the greatest potential risk impact on operations at the CCNPP (MDNR, 2006).}**

Paragraph 5 in Section 2.2.3.1.1 of CCNPP, Unit 3 COL FSAR, will be revised as shown below:

Pipelines

{The DCPLNG facility operates a pipeline corridor that passes within the vicinity of the CCNPP site. Section 2.2.3 addresses the overall risk from the DCPLNG facility and pipeline. **Experiments have indicated that detonations of mixtures of methane (greater than 85%) with air do not present a credible outdoor explosion event. (FMIC, 2005) Further, there have been no reported vapor cloud explosions involving natural gas with high methane content—there have been numerous reports of vapor clouds igniting resulting in flash fires without overpressures. (FMIC, 2005) Therefore, an outdoor natural gas explosion resulting from a ruptured gas pipeline is considered an unlikely event. Thus,** the ignition of a natural gas cloud within a confined or congested space, such as woodlands, which may produce damaging explosion overpressures, **was considered the bounding event and is presented in Section 2.2.3.1.2.** ~~Consequently, blast overpressure impacts were taken into account in developing the risks associated with the DCPLNG facility (MDNR, 2006).~~ **Therefore,** it was concluded that damaging overpressures from an explosion from a rupture in the DCPLNG pipeline would not adversely affect the operations of CCNPP Unit 3.}

Paragraph 15 in Section 2.2.3.1.1 of CCNPP, Unit 3 COL FSAR will be revised as shown below:

Nearby Facilities
{The Dominion Cove Point Liquefied Natural Gas (DCPLNG) facility operates within the vicinity of the CCNPP site. **As described in Section 2.2.2.4.2 the DCPLNG facility is bounded for explosions by the LNG pipeline. Furthermore,** Section 2.2.3 addresses the overall risk from the DCPLNG facility. Blast overpressure impacts were taken into account in developing the risk analysis. Damaging overpressures from an explosion resulting from a complete tank failure at the DCPLNG facility would not adversely affect the operations of CCNPP Unit 3 (MDNR, 2006).}

Paragraphs 9 and 10 in Section 2.2.3.1.2 of CCNPP, Unit 3 COL FSAR, will be revised as shown below, and a new paragraph will be added after paragraph 8, as shown below:

The Maryland Power Plant Research Program commissioned an independent risk study (i.e., hazard study) that addressed the overall risk from the facility and pipeline (MDNR, 2006). Looking specifically at the rupture of the gas pipeline, the study indicates that the frequency of occurrence is 3.60E-3 for the existing site (based on 13.1 mi (21.1 km) of existing gas export pipeline) and 7.48E-3 for the expanded site (based on 13.1 mi (21.1 km) of existing and 14.1 mi (22.7 km) of new gas export pipeline).

Therefore, a vapor cloud explosion analysis was conducted in order to obtain the safe distance. The results indicate that the safe distance, the minimum distance required for an explosion to have less than a one psi peak incident pressure, is much less than the shortest distance to the nearest safety-related structure for CCNPP Unit 3. The safe distance for the natural gas pipeline is 1.1 mi (1.8 km).

Further, the Maryland Power Plant Research Program's independent risk study analyzed the consequences of both a jet and pool fire from the rupture of the gas pipeline. The safe distance for exposure to thermal consequences resulting from a rupture of the gas pipeline or for jet fires is 2,362 ft (720 m), or 0.45 mi (0.72 km). The safe distance is identified as the maximum distance where thermal radiation heat flux exceeds 10,000 Btu/hr-sq ft (980 kJ/hr-sq m). At a thermal flux of 10,000 Btu/hr-sq ft (980 kJ/hr-sq m), a high thermal dose is achieved rapidly, offering little chance of escape for exposed individuals. The maximum range for flash fires is 722 ft (220 m), or 0.14 mi (0.22 km), and is measured as the distance to the LFL (MDNR, 2006).

The overpressure, ~~Both the~~ jet fire and flash fire safe distances are significantly less than the distance from the pipeline to the CCNPP site. Therefore, a flammable vapor cloud ignition or explosion from a rupture in the DCPLNG pipeline would not adversely affect operation of CCNPP Unit 3. The results of flammable vapor cloud ignition analyses are summarized in Table 2.2-9.}

Paragraph 35 in Section 2.2.3.1.2 of CCNPP, Unit 3 COL FSAR will be revised as shown below:

Nearby Facilities
{The DCPLNG facility is located approximately 3.2 mi (5.1 km) from the CCNPP site. **As described in Section 2.2.2.4.2 the DCPLNG facility is bounded for flammable vapor clouds by the LNG pipeline. Furthermore,** Section 2.2.3 addresses the overall risk from the DCPLNG facility. This risk evaluation included a worst case scenario where a total loss of the storage tanks was considered. The consequence distance for a pool fire under this worst case scenario is 1,188 ft (362 m) and for flash fires 5,413 ft (1,650 m), both of which are less than the

distance from the storage tanks to CCNPP Unit 3. These distances are measured as the distance to the LFL for a flash fire, and a thermal flux of 10,000 Btu/hr-sq ft (980 kJ/hr sq m) for a pool fire or jet fire (MDNR, 2006). **}**

Table 2.2-8 of CCNPP, Unit 3 COL FSAR, will be revised as shown below:

Table 2.2-8—{Explosion Event Analysis}

{Source	Pollutant Evaluated	Quantity	Heat of Combustion (Btu/lb)/ (kJ/kg)	Distance to Nearest CCNPP Unit3 Safety Related Structure	Distance at 1 psi (6.9 kPa) Peak Incident Pressure
Maryland Route 2/4	Gasoline (Note 1)	8,500 gal/ 32,000 l	18,720/ 43,514	6,119 ft/ 1.9 km	263 ft/ 50.2 m
	Gasoline (aviation) (Note 1)	8,500 gal/ 32,000 l	18,720/ 43,514		260 ft/ 79.2 m
	Propane (Note 2)	50,000 lbs/ 22,679 kg	19,782/ 45,982		3,559 ft/ 1.1 km
Pipeline-DCPLNG	Liquefied Natural Gas (Note 3)				
Navigable Waterway	Gasoline (Notes 1 and 4)	5,200,000 lbs/ 2,400,000 kg	18,720/ 43,514	11,678 ft/ 3.6 km	1,222 ft/ 372.5 m
	Benzene (Notes 1 and 4)	5,200,000 lbs/ 2,400,000 kg	17,460/ 40,585		1,076 ft/ 328 m
	Toluene (Notes 1 and 4)	5,200,000 lbs/ 2,400,000 kg	17,430/ 40,572		1,072 ft/ 326.7 m
On-Site (CCNPP Units 1&2)	Gasoline (Notes 1 and 5) (3,500 gal (15,900 l) tank truck) (Notes 1 and 5)	3,500 gal 13,250 l	18,720/ 43,514	310 ft/ 94.5 m	196 ft 59.7 m
	Hydrazine (35% solution)(Note 1)	350 gal 1,325 l	8,345/ 19,397	891 ft/ 271.6 m	114 ft/ 34.7 m
	Dimethylamine (2% solution)(Note 1)	350 gal 1,325 l	16,800/ 39,051	462 ft/ 140.8 m	85 ft/ 25.9 m
	Hydrogen (Note 2)	460 cu ft/ 13 cu m	50,080/ 116,411	745 ft/ 271.6 m	224 ft/ 68.3 m
On-Site (CCNPP Unit 3)	Argon-Methane (considered as methane (Note 2))	282 scf/ 7.99 Nm^3	21,517/ 50,029	233 ft/ 71 m	119 ft/ 36.2 m
	Hydrogen (Note 2)	278 scf/ 7.87 Nm^3	50,080 120,000	233 ft/ 71 m	133 ft/ 40.5 m
	Oxygen (Note 2)	282 scf/ 7.99 Nm^3	N/A (Note 6)	233 ft/ 71 m	41 ft/ 13 m
Nearby Facilities	DCPLNG (associated hazards) (Note 3)				

scf: Standard cubic feet

Nm^3: Normal cubic meter

Note 1: For atmospheric liquids, the storage vessel was assumed to contain the quantity of fuel vapors in air at the upper explosive limit.

Note 2: For compressed or liquefied gases, the entire content of the storage vessel was conservatively assumed as the flammable mass.

Note 3: ~~Overall risk of fatality from DCPLNG facility and associated pipeline to CCNPP Site was evaluated to be 2.3E-9 per year (present operations) and 6.6E-9 per year (planned expansion). (The risk of physical damage to CCNPP Unit 3 is lower) The impact from blast overpressures was taken into account in developing this risk.~~ **The DCPLNG pipeline explosion and all explosive hazards from the DCPLNG facility are bounded by the DCPLNG pipeline vapor cloud explosion.**

Note 4: The maximum quantity shipped per shipment for gasoline, benzene, and toluene was not available. Therefore, it was assumed that the maximum quantity was 5.2 million lbs. (2.4 million kg) (CRS)
Note 5: The 4,000 gallon gasoline tank is an underground storage tank. The ~~toxicity~~ **explosive** event is bounded by the 3,500 gallon gasoline delivery tank truck.

Note 6: Oxygen is not explosive by ignition and has no reported heat of combustion; therefore it was analyzed for explosion by overpressure (USCG, 2007).

Table 2.2-9 of CCNPP, Unit 3 COL FSAR, will be revised as shown below:

Table 2.2-9—{Flammable Vapor Cloud Events (Delayed Ignition) and Vapor Cloud Explosion Analysis}

DCPLNG Nearby Facility and Pipeline Scenario for Flammable Vapor Clouds (Note 2)

Scenario	Frequency per year (Existing)	Frequency per year (Expansion)	Nearest Safety Related Structure	Maximum Consequence Range
Total loss of ship's tank en route (off CCNPP)	2.18 x 10-7	4.84 x 10-7	**3.4 mi/ 17,925 ft**	1,558 ft- Pool Fire / 13,943 ft- Flash Fire
				475 m—Pool Fire/ 4,250 m—Flash Fire
DCPLNG Gas Pipelines	3.60 x 10-3	7.48 x 10-3	**1.54 mi/ 8,131 ft**	**5,808 ft-overpressure/** 2,362 ft-Jet Fire / 722 ft-Flash Fire
				1,770 m-overpressure/ 720 m—Pool Fire/220 m—Flash Fire
Escalation Event-Total loss of all storage tanks	4.00 x 10-6	4.00 x 10-6	**3.2 mi/**	1,188 ft-Pool Fire / 5,413 ft- Flash Fire
			16,896 ft	362 m—Pool Fire/1,295 m—Flash Fire

REFERENCES:

(MDNR, 2006) Maryland Department of Natural Resources, Cove Point LNG Terminal Expansion Project Risk Study, Maryland Power Plant Research Program Report PPRP-CPT-01/DNR 12-7312006-147, June 28, 2006.

(ALOHA, 2006) National Oceanic and Atmospheric Association, Areal Locations of Hazardous Atmospheres (ALOHA) Version 5.4.1, February 2006.

(USNRC, 1978) U.S. Nuclear Regulatory Commission, Regulatory Guide 1.91, "Evaluations of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants," Revision 1, February 1978.

RAI Number 02.02.03-4: **FSAR Section 2.2.3**

QUESTION:

RG 1.206 provides guidance regarding the information that is needed to ensure potential hazards in the site vicinity are identified and evaluated to meet the siting criteria in 10 CFR 100.20 and 10 CFR 100.21. FSAR Section 2.2.3.1.2 does not provide enough information for the NRC staff to perform an independent review of that section. Please provide a sensitivity analysis demonstrating that the assumed meteorological conditions for ALOHA model maximize evaporation while minimizing dispersion resulting in a conservative minimum separation distance due to explosion. The applicant stated that "the maximum allowable surface area of the spill that ALOHA would allow (31400 m^2) was used". How was the total chemical inventory (i.e., 5,200,000 lbs) accounted for in the calculation?

RESPONSE:

The sensitivity study for each individual chemical is provided below. Worst case conditions are highlighted for clarity. Stability class and wind speed combinations were selected based on the meteorological table provided in the ALOHA program. (ALOHA 2006)

Ammonia (1,200,000 lbs)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)	Peak Overpressure at NSRS (psi)
F	1	4,746	6,864	10,032	0.684
F	2	3,114	4,710	8,448	0.53
F	3	2,421	3,219	5,808	0.319
E	1	2,466	3,771	7,920	0.506
E	2	1,572	2,058	4,863	0.266
E	3	1,266	1,614	3,828	0.194
E	4	1,101	1,398	3,321	0.162
E	5	1,002	1,257	3,018	0.143
D	3	747	951	2,853	0.144
D	4	654	831	2,505	0.123
D	5	591	753	2,274	0.109
D	6	549	696	2,112	No significant overpressure

Argon-Methane Mixture (Gas Cylinder) (282 scf)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)
F	1	39	69	117
F	2	<33	48	99
F	3	<33	39	90
E	1	<33	36	126
E	2	<33	36	108
E	3	<33	36	96
E	4	36	36	108
E	5	36	36	105
D	3	<33	36	102
D	4	36	36	117
D	5	36	36	114
D	6	36	36	114

Aviation Gasoline (50,000 lbs)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)	Peak Overpressure at NSRS (psi)
F	1	237	414	1,002	No significant overpressure
F	2	LOC never exceeded	228	729	No significant overpressure
F	3	LOC never exceeded	165	591	No significant overpressure
E	1	183	300	861	No significant overpressure
E	2	LOC never exceeded	156	600	No significant overpressure
E	3	LOC never exceeded	102	459	No significant overpressure
E	4	LOC never exceeded	LOC never exceeded	345	No significant overpressure
E	5	LOC never exceeded	LOC never exceeded	216	No significant overpressure
D	3	LOC never exceeded	LOC never exceeded	363	No significant overpressure
D	4	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure
D	5	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure
D	6	105	105	No explosion	No significant overpressure

Benzene (5,200,000 lbs)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)	Peak Overpressure at NSRS (psi)
F	1	951	2,172	2,409	No significant overpressure
F	2	756	1,593	1,911	No significant overpressure
F	3	LOC never exceeded	1,065	1,347	No significant overpressure
E	1	786	1,641	2,028	No significant overpressure
E	2	210	999	1,311	No significant overpressure
E	3	LOC never exceeded	729	999	No significant overpressure
E	4	LOC never exceeded	603	864	No significant overpressure
E	5	LOC never exceeded	510	759	No significant overpressure
D	3	LOC never exceeded	564	870	No significant overpressure
D	4	LOC never exceeded	459	732	No significant overpressure
D	5	LOC never exceeded	387	657	No significant overpressure
D	6	LOC never exceeded	342	597	No significant overpressure

Dimethylamine (350 gal)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)	Peak Overpressure at NSRS (psi)
F	1	<33	45	162	0.244
F	2	33	36	156	0.232
F	3	<33	36	144	0.212
E	1	<33	36	180	0.282
E	2	<33	36	168	0.262
E	3	<33	36	153	0.229
E	4	<33	<33	No explosion	No significant overpressure
E	5	<33	<33	No explosion	No significant overpressure
D	3	<33	36	156	0.237
D	4	<33	<33	No explosion	No significant overpressure
D	5	<33	<33	No explosion	No significant overpressure
D	6	<33	<33	No explosion	No significant overpressure

Gasoline (Barge) (5,200,000 lbs)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)	Peak Overpressure at NSRS (psi)
F	1	783	1,464	3,312	0.159
F	2	618	1,122	2,751	0.129
F	3	LOC never exceeded	630	2,052	0.105
E	1	651	1,128	2,883	0.137
E	2	LOC never exceeded	591	2,091	0.109
E	3	LOC never exceeded	396	1,647	No significant overpressure
E	4	LOC never exceeded	249	1,290	No significant overpressure
E	5	LOC never exceeded	LOC never exceeded	978	No significant overpressure
D	3	LOC never exceeded	288	1,401	No significant overpressure
D	4	LOC never exceeded	LOC never exceeded	1,002	No significant overpressure
D	5	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure
D	6	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure

Gasoline (Road) (8,500 gal)

	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)	Peak Overpressure at NSRS (psi)
F	1	234	393	999	No significant overpressure
F	2	LOC never exceeded	204	729	No significant overpressure
F	3	LOC never exceeded	147	588	No significant overpressure
E	1	183	288	861	No significant overpressure
E	2	LOC never exceeded	138	597	No significant overpressure
E	3	LOC never exceeded	84	456	No significant overpressure
E	4	LOC never exceeded	LOC never exceeded	342	No significant overpressure
E	5	LOC never exceeded	LOC never exceeded	228	No significant overpressure
D	3	LOC never exceeded	LOC never exceeded	351	No significant overpressure
D	4	LOC never exceeded	LOC never exceeded	60	No significant overpressure
D	5	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure
D	6	105	105	No explosion	No significant overpressure

Gasoline (Onsite delivery) (3,500 gal)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)	Peak Overpressure at NSRS (psi)
F	1	144	234	648	5.62
F	2	LOC never exceeded	129	477	1.95
F	3	LOC never exceeded	87	378	1.34
E	1	LOC never exceeded	135	522	2.23
E	2	LOC never exceeded	78	378	1.33
E	3	LOC never exceeded	39	282	0.873
E	4	LOC never exceeded	LOC never exceeded	210	0.592
E	5	LOC never exceeded	LOC never exceeded	117	0.268
D	3	LOC never exceeded	LOC never exceeded	213	0.603
D	4	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure
D	5	69	66	No explosion	No significant overpressure
D	6	69	66	No explosion	No significant overpressure

Hydrazine (350 gal)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)	Peak Overpressure at NSRS (psi)
F	1	<33	<33	No explosion	No significant overpressure
F	2	<33	<33	No explosion	No significant overpressure
F	3	<33	<33	No explosion	No significant overpressure
E	1	<33	<33	No explosion	No significant overpressure
E	2	<33	<33	No explosion	No significant overpressure
E	3	<33	<33	No explosion	No significant overpressure
E	4	<33	<33	No explosion	No significant overpressure
E	5	<33	<33	No explosion	No significant overpressure
D	3	<33	<33	No explosion	No significant overpressure
D	4	<33	<33	No explosion	No significant overpressure
D	5	<33	<33	No explosion	No significant overpressure
D	6	<33	<33	No explosion	No significant overpressure

Hydrogen (Tank Farm) (225 lbs)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)	Peak Overpressure at NSRS (psi)
F	1	108	492	738	0.984
F	2	78	342	519	0.544
F	3	63	276	423	0.399
E	1	81	366	606	0.708
E	2	57	255	426	0.416
E	3	48	207	348	0.312
E	4	42	180	300	0.256
E	5	36	159	267	0.221
D	3	<33	126	267	0.234
D	4	<33	111	231	0.195
D	5	<33	99	207	0.169
D	6	<33	90	189	0.151

Hydrogen (Gas Cylinder) (278 scf)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)
F	1	<33	75	132
F	2	<33	54	108
F	3	<33	42	96
E	1	<33	42	138
E	2	<33	36	114
E	3	<33	36	102
E	4	<33	36	99
E	5	<33	36	96
D	3	<33	36	114
D	4	<33	36	108
D	5	<33	36	105
D	6	<33	36	105

Ammonia (1,200,000 lbs)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)	Peak Overpressure at NSRS (psi)
F	1	657	1,362	3,552	0.46
F	2	987	2,274	4,056	0.508
F	3	1,167	2,361	4,185	0.526
E	1	648	1,347	3,543	0.459
E	2	945	2,004	3,930	0.497
E	3	1,032	1,941	3,918	0.496
E	4	918	1,824	3,798	0.481
E	5	810	1,737	3,708	0.466
D	3	990	1,911	3,915	0.497
D	4	813	1,749	3,765	0.481
D	5	699	1,590	3,624	0.459
D	6	627	1,458	3,501	0.44

Toluene (5,200,000 lbs)

Stability Class	Wind Speed (m/s)	Distance to UFL (feet)	Distance to LFL (feet)	Safe Distance for Vapor Cloud Explosions (feet)	Peak Overpressure at NSRS (psi)
F	1	696	1302	1554	No significant overpressure
F	2	LOC never exceeded	711	939	No significant overpressure
F	3	LOC never exceeded	471	696	No significant overpressure
E	1	576	1002	1308	No significant overpressure
E	2	LOC never exceeded	465	696	No significant overpressure
E	3	LOC never exceeded	255	441	No significant overpressure
E	4	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure
E	5	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure
D	3	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure
D	4	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure
D	5	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure
D	6	LOC never exceeded	LOC never exceeded	No explosion	No significant overpressure

The sensitivity studies show that the worst case for all chemicals except the argon-methane mixture (gas cylinder), dimethylamine, hydrogen (gas cylinder), and propane is F stability and 1 m/s wind speed. For the explosive scenario of the argon-methane mixture the worst case is E stability and a wind speed of 1 m/s. For dimethylamine the worst case is E stability and a wind speed of 1 m/s. For the explosive scenario of the hydrogen gas bottle the worst case is E stability and a wind speed of 1 m/s. For propane the worst case is F stability and a wind speed of 3 m/s. As shown in the tables above, neither of these chemicals poses a threat to the safe operations of the CCNPP.

The argon-methane mixture and hydrogen in cylinders do not have maximum nearest safety related structure overpressures because the location of the building that stores these chemicals has not been determined. Therefore the storage distance must be greater than the distance to 1 psi overpressure.

To maximize evaporation, a spill depth of 1 cm is generally assumed. However, in the case of very large spills, such as many of the analyses involving waterway transportation (barge releases), this was not possible due to the large volumes released. That is, the maximum puddle area of 31,400 m^2, equating to a spill radius of approximately 100 meters was assumed—this is the maximum area ALOHA allows for puddle. Note, that the same quantity of chemical is released—the depth of the "puddle" will be larger to accommodate the volume released. This assumption is appropriate to maximize the evaporation rate while minimizing dispersion. Creating a very large puddle will maximize evaporation, but the puddle is now dispersed or "spread out" over a larger area; hence, the concentration per unit area in the vapor cloud will be less. Additionally, it is extremely unlikely that a puddle that large will form in a waterway. ALOHA will automatically increase the depth of the puddle as necessary to account for the liquid volume and evaporation rate.

While conducting the sensitivity study, different assumptions were noted in the analyses of benzene and toluene. The quantities used in this sensitivity study for these chemicals are based off of a Congressional Research Service report for Congress detailing maximum shipping quantities for various chemical types (CRS Report). The updated information was used and the new results are shown in this response and in the provided COLA impact statement.

REFERENCES:

(ALOHA 2006) Areal Locations of Hazardous Atmospheres (ALOHA) User's Manual, EPA and NOAA, February 2006.

(CRS Report) Parfomak, Paul W. and John R. Fritelli, Resources, Science, and Industry Division of the Congressional Research Service, The Library of Congress. "Marine Security of Hazardous Chemical Cargo." CRS Report for Congress. 26 Aug 2005.

COLA IMPACT:

FSAR Section 2.2.3.1.1 paragraph 14 will be changed in the next revision to read:
The results using this methodology indicate that the minimum separation distances (i.e., safe distances) are less than the shortest distance to a safety-related CCNPP Unit 3 structures and the storage location of any of the identified chemicals. Therefore, an explosion from any of the

onsite hazardous materials evaluated would not adversely affect operation of CCNPP Unit 3. The safe distance for gasoline is 196 ft (60 m); for hydrazine (35% solution), 114 ft (35 m); for dimethylamine (2% solution), 85 ft (26 m); for hydrogen, 224 ft (68 m). Gasoline is stored approximately 310 ft (94 m); hydrazine (35% solution) approximately 891 ft (272 m); dimethylamine (2% solution) approximately 462 ft (141 m); and hydrogen 745 ft (227 m)~~; argon-methane gas cylinder 233 ft (71 m); hydrogen gas cylinder 233 ft (71 m); and oxygen gas cylinder 233 ft (71 m)~~ from the nearest safety-related structure for CCNPP Unit 3 (Table 2.2-9). **The location of the argon-methane gas cylinder, hydrogen gas cylinder, and oxygen gas cylinder is not yet determined. These chemicals must be stored at distances greater than those reported in Table 2.2-9.}**

FSAR Section 2.2.3.1.2 paragraph 4 should be changed to read:

Conservative assumptions were used in both ALOHA analyses with regard to meteorological inputs and identified scenarios. **Sensitivity analyses were performed to determine the worst case combination of stability class and wind speed—unless otherwise noted, the determined worst case meteorological conditions from the sensitivity analysis, were: Pasquill stability class F(stable), with a wind speed of 1 m/sec. Along with the determined worst case meteorological condition,** the following meteorological assumptions **were** used as inputs to the computer model, ALOHA: ~~Pasquill stability class F(stable), with a wind speed of 1 m/sec;~~ ambient temperature of 25 °C; relative humidity 50%; cloud cover 50%; and an atmospheric pressure of 1 atmosphere. ~~Pasquill Stability class F represents the most limiting 5% of meteorological conditions observed at a majority of nuclear plant sites.~~ For each of the identified chemicals, it was conservatively assumed that the entire contents of the vessel leaked forming a 1 cm thick puddle. This provides a significant surface area to maximize evaporation and the formation of a vapor cloud.

FSAR Section 2.2.3.1.2 paragraphs 17 and 18 should be changed to read:
For the identified chemicals, the distances to the LFL, which is the safe distance for: gasoline, 1,464 ft (446 m); benzene, ~~2,373 ft (723 m)~~ **2,172 ft (662 m)**; toluene, ~~1,515 ft (462 m)~~ **1,302 ft (397 m)**; and ammonia, 6,864 ft (2,092 m). Each of these distances is less than the minimum distance to the nearest safety related CCNPP Unit 3 structure from a probable release point on a navigable portion of the Chesapeake Bay. Therefore, a flammable vapor cloud with the possibility of ignition from a transported hazardous material on the Chesapeake Bay, would not adversely affect the safe operation of CCNPP Unit 3.}

Additionally, because each of the identified chemicals has the potential to explode, a vapor cloud explosion analysis was performed as described in Section 2.2.3.1.2. The results of the vapor cloud explosion analysis indicate that the safe distances, the minimum distances, with drift taken into consideration, required for an explosion to have less than a 1 psi (6.9 kPa) peak incident pressure, are less than the shortest distance to the nearest safety related structure for CCNPP Unit 3, the intake structure, and a probable release point on the Chesapeake Bay. The safe distance for gasoline is 3,312 ft (1,009 m); for benzene, ~~4,437 ft (1,352 m)~~ **2,409 ft (734 m);** for toluene, ~~3,003 ft (915 m)~~ **1,554 ft (474 m)**; and for ammonia, 10,032 ft (3,058 m). (Table 2.2-9) Therefore, a flammable vapor cloud with the possibility of explosion from a transported hazardous material on the Chesapeake Bay would not adversely affect the safe operation of CCNPP Unit 3.}

FSAR Section 2.2.3.1.2 paragraphs 21 and 22 should be changed to read:

The results for the selected hazardous materials indicate that any plausible vapor cloud that may form and mix sufficiently under stable atmospheric conditions will be below LFL concentrations (i.e., the safe distance for the possibility of ignition and potential thermal radiation effects) prior to reaching the CCNPP Unit 3 site boundary. The distance to the LFL boundary for gasoline is 393 ft (120 m); for aviation gasoline, 414 ft (126 m); and for propane, ~~1,362 ft (415 m)~~ **2,361 ft (720 m).** Therefore, a flammable vapor cloud ignition involving hazardous materials with the potential to be transported on MD 2/4, would not adversely affect the safe operation of CCNPP Unit 3.

Each of the identified hazardous materials was also evaluated, using the methodology presented previously in this section, to determine the effects of a possible vapor cloud explosion. The minimum separation distances (i.e., safe distance) for gasoline is 999 ft (304 m); for aviation gasoline, 1,002 ft (305 m); and for liquid propane, ~~3,552 ft (1,083 m)~~ **4,185 ft (1,276 m)**. The minimum separation distances for explosions involving the identified chemicals to have less than a 1 psi (6.9 kPa) peak incident pressure from a drifted vapor cloud are less than the shortest distance to safety-related CCNPP Unit 3 structures and any point on MD 2/4. Therefore, a delayed flammable vapor cloud explosion involving the identified hazardous material with the potential to be transported on MD 2/4, would not adversely affect the safe operation of CCNPP Unit 3}.

FSAR Section 2.2.3.1.2 paragraph 25 should be changed to read:

As described previously in Section 2.2.3.1.2, the ALOHA dispersion model was used to determine the distance a vapor cloud can travel before reaching the LFL boundary (i.e., the safe distance for exposure to thermal radiation heat flux) once a vapor cloud has formed from release of the identified chemical. {The distances to the LFL boundary from the release point for the identified chemicals are: gasoline, 234 ft (71 m); hydrazine (35% solution), less than 33 ft (10 m); dimethylamine (2% solution), ~~45 ft (14 m)~~ **36 ft (11 m)**; hydrogen; 96 ft (29 m); argon-methane gas cylinder ~~66 ft (20 m)~~ **69 ft (21 m)**; and hydrogen gas cylinder ~~72 ft (22 m)~~ **75 ft (23 m).** Each of these distances is less than the distance from a potential release site to the nearest safety-related CCNPP Unit 3 structure. **The location of the argon-methane gas cylinder and hydrogen gas cylinder is not yet determined therefore they should be stored at distances greater than those reported above and in Table 2.2-9.}**

FSAR Section 2.2.3.1.2 paragraph 27 should be changed to read:

The minimum separation distance for the 3,500 gallon (13,250 l) gasoline tank truck is 648 ft (198 m). Minimum separation distance for other identified chemicals are: hydrazine (35% solution), N/A (no explosion can occur at resulting concentrations); dimethylamine (2% solution), ~~162 ft (49 m)~~ **180 ft (55 m);** hydrogen, 114 ft (35 m); argon-methane gas cylinder ~~102 ft (31 m)~~ **126 ft (38 m)**; hydrogen gas cylinder ~~87 ft (27 m)~~ **138 ft (42 m)**. Except for gasoline, each of these chemicals is stored further away from CCNPP Unit 3 than the minimum separation distance. The filling operation for gasoline occurs approximately 310 ft (95 m) from the nearest safety-related CCNPP Unit 3 structure, which is the Ultimate Heat Sink. The storage of other identified chemicals stored at CCNPP Units 1 and 2 relative to the nearest safety related CCNPP Unit 3 structure, which is the Ultimate Heat Sink makeup intake structure, are: hydrazine, approximately 891 ft (272 m); dimethylamine (2% solution), 462 ft; and hydrogen, 745 ft (227 m). ~~The storage of gas cylinders at Unit 3 relative to the nearest safety-related structure, the CCNPP Unit 3 main control room, are argon-methane, 233 ft (71 m) and hydrogen, 233 ft (71 m).~~

FSAR Table 2.2-9 should be changed to read:

Table 2.2-9—{Flammable Vapor Cloud Events (Delayed Ignition) and Vapor Cloud Explosion Analysis}

Source	Pollutant Evaluated & Quantity	Distance to Nearest Safety Related CCNPP Unit 3 Structure	Distance to UFL	Distance to LFL	Safe Distance for Vapor Cloud Explosions	Peak Over pressure at Nearest Safety Related CCNPP Unit 3 Structure
Maryland Route 2/4	Gasoline (8,500 gal)/ 32,176 l (Note 7)	6,119 ft/ 1,865 m to Ultimate Heat Sink (UHS)	234 ft/ 71.3 m	393 ft/ 119.8 m	999 ft/ 304.5 m	Not Significant (Note 5)
	Gasoline (aviation) (8, 500 gal)/ 32,176 l (Note 7)		237 ft/ 72.2 m	414 ft/ 126.2 m	1,002 ft/ 305.4 m	Not Significant (Note 5)
	Propane (50,000 lbs)/ 22,680 kg **(Note 8)**		**1,167 ft/ 356 m**	**2,361 ft/ 720 m**	**4,185 ft/ 1,276 m**	**0.526 psi/ 3.63 kPa**
Waterway (Chesapeake Bay)	Gasoline (5,200,000 lbs)/ 2,360,000 kg (Note 6)	11,678 ft/ 3,560 m to UHS makeup intake water structure	783 ft/ 239 m	1,464 ft/ 446 m	3,312 ft/ 1,009 m	0.159 psi/ 1.10 kPa
	Benzene (5,200,000 lbs)/ 2,360,000 kg (Note 6)		**951 ft/ 290 m**	**2,172 ft/ 662 m**	**2,409 ft/ 734 m**	**Not Significant (Note 5)**
	Toluene (5,200,000 lbs)/ 2,360,000 kg (Note 6)		**696 ft/ 212 m**	**1,302 ft/ 397 m**	**1,554 ft/ 474 m**	**Not Significant (Note 5)**
	Ammonia (1,200,000 lbs)/ 544,311 kg (Note 3)		4,746 ft/ 1,447 m	6,864 ft/ 2,092 m	10,032 ft/ 3,058 m	0.684 psi/ 4.72 kPa
On-site (CCNPP Units	Gasoline (3,500 gal)/ 13,249 l (Note 4)	310 ft/ 94.5 m	144 ft/ 44 m	234 ft/ 71 m	648 ft/ 198 m	5.62 psi/ 38.7 kPa (Note 1)

1 & 2)	Hydrazine (35% solution) (350 gal)/1,325 l	891 ft/ 272 m	<33 ft/ <10.1 m	<33 ft/ <10.1 m	No explosion	No explosion
	Dimethylamine **(Note 9)** (2% solution) (350 gal)/1,325 l	462 ft/ 141 m	<33 ft/ <10.1 m	**36 ft/ 11 m**	**180 ft/ 55 m**	**0.282 psi/ 1.94 kPa**
	Hydrogen (460 cu ft)/ 13 cu m	745 ft/ 227.1 m	< 33 ft/ <10.1 m	96 ft/ 29 m	114 ft/ 35 m	**0.984 psi/ 6.78 kPa**
On-site (CCNPP Unit 3)	Argon-Methane **(note 10)** (282 scf)/ 7.99 Nm3 (considered as Methane)		39 ft/ 11.9 m	**69 ft/ 21 m**	**126 ft/ 38 m**	
	Hydrogen **(note 11)** (278 scf)/ 7.87 Nm3		< 33 ft/ <10.1 m	**75 ft/ 23 m**	**138 ft/ 42 m**	

DCPLNG Nearby Facility and Pipeline Scenario for Flammable Vapor Clouds (Note 2)

Scenario	**Frequency per year (Existing)**	**Frequency per year (Expansion)**	**Distance to Nearest Safety Related Structure**	**Maximum Consequence Range**
Total loss of ship's tank en route (off CCNPP)	2.18 x 10-7	4.84 x 10-7	50,735 ft/ 15,464 m	1,558 ft- Pool Fire / 13,943 ft- Flash Fire 475 m—Pool Fire/ 4,250 m—Flash Fire
DCPLNG Gas Pipelines	3.60 x 10-3	7.48 x 10-3	40,940 ft/ 12,478 m	2,362 ft-Jet Fire / 722 ft-Flash Fire 720 m—Pool Fire/220 m—Flash Fire
Escalation Event-Total loss of all storage tanks	4.00 x 10-6	4.00 x 10-6	16,900 ft/ 5,150 m	1,188 ft-Pool Fire / 5,413 ft- Flash Fire 362 m—Pool Fire/1,295 m—Flash Fire

scf: Standard cubic feet

Nm3: Normal cubic meter

Note 1: This event was determined not to be a credible event based on an event probability of less than 1.

E-7. Refer to Section 2.2.3.2.4 for the analysis of this event.

Note 2: Overall risk of fatality from DCPLNG facility and associated pipeline to CCNPP Site was evaluated to be 2.3E-9 per year (present operations) and 6.6E-9 per year (planned expansion). (The risk of physical damage to CCNPP Unit 3 is lower). The impact from blast overpressures was taken into account in developing this risk.

Note 3: The annual quantity of ammonia transported in proximity to the CCNPP Unit 3 site is 2.0 million pounds (0.9 million kg). The frequency of transport was not available; consequently, it was conservatively assumed that the entire 2.0 million pounds (0.9 million kg) was transported in one shipment and released. A 0.6 reduction factor was applied to the 2.0 million pounds (0.9 million kg) in the analysis to account for the high rate at which ammonia dissolves in water as ALOHA does not account for this phenomena.

Note 4: The 4,000 gallon gasoline tank is an underground storage tank. Therefore, the toxicity event is bounded by the 3,500 gallon gasoline delivery tank truck.

Note 5: ALOHA output results indicate "not significant" when the peak overpressure is <0.1 psi.

Note 6: The maximum quantity shipped for gasoline, benzene, and toluene was not available. Therefore, it was assumed that the maximum quantity was 5,200,000 lbs. (CRS, 2005)

Note 7: Gasoline and aviation gasoline were modeled in ALOHA as n-heptane. N-heptane is used as a substitute for gasoline because the molecular weight and physical properties are similar.

Note 8: The worst case combination of stability class and wind speed is F stability and a wind speed of 3 m/sec for propane.

Note 9: The worst case combination of stability class and wind speed is E stability and a wind speed of 1 m/sec for dimethylamine.

Note 10: The worst case combination of stability class and wind speed is E stability and a wind speed of 1 m/sec for argon-methane.

Note 11: The worst case combination of stability class and wind speed is E stability and a wind speed of 1 m/sec for the CCNPP Unit 3 hydrogen.

RAI Number 02.02.03-6: **FSAR Section 2.2.3**

QUESTION:

RG 1.206 provides guidance regarding the information that is needed to ensure potential hazards in the site vicinity are identified and evaluated to meet the siting criteria in 10 CFR 100.20 and 10 CFR 100.21. FSAR Section 2.2.3.1.3 does not provide enough information for the NRC staff to perform an independent review of that section. Please explain the reason why there are different amounts of gasoline, benzene, toluene and ammonia for flammable vapor cloud and toxic vapor concentration analysis for waterway (Chesapeake Bay) transport. How was the total inventory of each chemical accounted for in the ALOHA model which has a 31,400 m^2 spill surface area limitation? RG 1.78 references the HABIT EXTRAN model for calculating control room intake concentration. How does ALOHA compare in results with the surface area limitation noted above?

RESPONSE:

This RAI response can be broken into three sections: specifying the quantities utilized for the analyses and how they were derived, describing how ALOHA accounts for the limitation for spill areas of 31,400 m2, and comparing the ALOHA results to a similar analysis with the HABIT EXTRAN model.

I. Chemical Quantities

The quantities of gasoline, benzene, toluene and ammonia vary depending on the analysis and the associated regulatory guidance. These variances are due to several specific reasons.

Gasoline used a quantity of 5,200,000 lbs per shipment for both the toxic and flammable/explosive analyses. An annual value of 1,497,000 short tons per year was reported (USACE, 2004a) however no frequency data was given. The quantity used was taken from a Congressional Research Service Report (CRS, 2005), stating that the largest determined capacity for a chemical parcel tanker was 5,200,000 lbs.

Benzene and toluene had two different values used for the toxic analysis and the flammable/explosive analysis, 560,000 lbs and 5,200,000 lbs respectively for both the chemicals. Benzene and toluene quantities were reported as 28,000 short tons per year combined for 2004 (USACE, 2004a). No values were given for quantities per shipment or number of shipments per year, so for the toxicity analysis, the 28,000 short tons was equally divided among the two chemicals, yielding 14,000 short tons per year for each chemical. Regulatory Guide (RG) 1.78 provides the screening criteria for mobile sources stating that if a chemical is shipped by barge less than 50 times per year, it is not considered frequent and therefore no toxic analysis is necessary. Unfortunately no data on the number of shipments per year existed, so the number of benzene and toluene shipments were conservatively estimated at 50 shipments per year for each chemical. The 14,000 short tons per chemical were assumed to be distributed evenly per 50 shipments shipment resulting in 560,000 pounds per chemical per shipment. RG 1.78 does not apply to flammable or explosive analyses, so the annual value could not be divided among 50 shipments, and applying the same logic as was applied to the gasoline analysis, 14,000 short tons per shipment is not a feasible assumption for the capacity of a single shipment, so the maximum quantity per chemical parcel tanker, 5,200,000 lbs was used for each chemical. In addition to this analysis reported in the FSAR Section 2.2.3.1.3, additional analyses using 10,000,000 lbs quantities for benzene and toluene were conducted. Regulatory Guide 1.91 states that 10,000,000 lbs is the largest probable quantity of explosive material that could be transported by ship. In these analyses, the maximum distance the IDLH travelled from the spill location was 1.5 miles for benzene and 0.8 miles for toluene, both well short of the 2.2 mile distance to the control room.

The annual quantity of ammonia transported on the Chesapeake was reported as 2,000,000 pounds for 2004 (USACE, 2004a). No value was given for quantity per shipment or number of shipments per year. Utilizing the same method for the toxic analysis as that for benzene and toluene, this number was divided by 50 resulting in 40,000 pounds per shipment. Ammonia is also very soluble in water, with spills resulting in both dissolution and vapor evolution. Studies suggest that 60 percent of the spilled ammonia is assumed to dissolve in the water with 40 percent available for evaporation for spills above the water (Raj, 1974). ALOHA does not account for this phenomena therefore a partition coefficient of 0.6 was applied to the volume of ammonia released reducing the amount to 16,000 pounds. Because RG 1.78 is only applicable to toxic releases, for the flammable analysis, the largest capacity of an ammonia carrying barge, 3,000,000 lbs was assumed to spill (CRS, 2005). Then the partition coefficient of 0.6 due to dissolution was applied thus lowering the amount to 1,200,000 lbs (Raj, 1974).

Using information subsequently received from the Army Corps of Engineers, the actual number of shipments was estimated to be 5 or less shipments per year for 2006. Despite the fact that this number would preclude the need to perform a toxicity analysis as it is less than 50 shipments per year (RG 1.78, 2001), a probability calculation was conducted in addition to the values reported in the FSAR section 2.2.3. Utilizing conservative assumptions for the annual accident rate on the Chesapeake, exposure distance and the conditional probability that a significant incident will occur given an accident, the probability of an ammonia accident on a barge in Chesapeake Bay affecting CCNPP was determined to be 6.41x10-7 accidents per year, less than the probability required for analysis by RG 1.78: 10-6 accidents per year.

II. Accounting for ALOHA's Spill Area Limitation.

To maximize evaporation, a spill depth of 1 cm is generally assumed (Wing 1979). However, in the case of very large spills, such as many of the analyses involving waterway transportation (barge releases), this was not possible due to the large volumes released. For these cases a puddle area of 31,400 m2 was assumed, this is the maximum area ALOHA allows for puddle. The same quantity of chemical is released; the depth of the puddle is increased to accommodate the volume released. This assumption is appropriate to maximize the evaporation rate while minimizing dispersion. Creating a very large puddle will maximize evaporation, but the puddle is now dispersed or "spread out" over a larger area; hence, the concentration per unit area in the vapor cloud will be less. ALOHA will automatically increase the depth of the puddle as necessary to account for the liquid volume and evaporation rate.

III. HABIT Analysis of Same Scenarios.

The same scenarios as those used in ALOHA were inputted into the NRC recommended HABIT model to compare their values and determine if the HABIT model output presented an increase in the concentration at the CCNPP control room when the puddle diameter was allowed to grow beyond 31,400 m2. HABIT calculates a spill depth dependant on the spill volume over time, assuming an initial radius equal to the volume divided by pi raised to the 1/3. The area then spreads out over time while evaporation is simultaneously occurring; the depth is dependant on the area versus the volume.

For this analysis, the output for HABIT is limited to only 42 minutes after the initial release and 22.5 minutes after the plume reaches the control room. This is due to the limitations of the EXTRAN code within HABIT. The EXTRAN logic determined a puff time period of 30 seconds for these particular scenarios and a time step of one half that, 15 seconds. It then carried out 90 time steps from the time the plume reached the control room intake, this equated to 22.5 minutes before EXTRAN ceased to report data (NUREG/CR-6210).

It is difficult to provide a direct comparison between the two model outputs due to ALOHA's limitation of 1 hour of data and HABIT's previously mentioned time limitation of 42 minutes for the given conditions. ALOHA was designed to provide plume estimates and HABIT was designed to provide concentrations for the first two minutes that a contaminant enters the control room. Due to these design limitations, a direct comparison is difficult to present. Table 1 provides the maximum outside concentrations at the control room reported by each model. Based on these values, ALOHA is generally more conservative in comparison to HABIT despite having a puddle area limited to 31,400 m2. Also, ALOHA is able to report minimum safe distances, that is, the furthest that the LFL, UFL and IDLH concentrations travel from the source, making it the preferred model to conduct risk analysis.

Table 1: Maximum Concentrations at the Control Room for different stability classes and wind speeds (Flammable Analysis Quantities).

Met Conditions	Chemical	Quantity	HABIT Concentration (ppm)	Status*	ALOHA Concentration (ppm)	Status*
F Stability Class, 1 m/s	Ammonia	1,200,000 lbs	547	Rising	50,724	Peak
	Benzene	5,200,000 lbs	16.1	Rising	232	Peak
	Toluene	5,200,000 lbs	4.78	Rising	63	Peak
	Gasoline	5,200,000 lbs	5.23	Rising	90	Peak
F Stability Class, 2 m/s	Ammonia	1,200,000 lbs	1,720	Peak	45,200	Peak
	Benzene	5,200,000 lbs	0.503	Rising	173	Peak
	Toluene	5,200,000 lbs	48.9	Rising	72	Peak
	Gasoline	5,200,000 lbs	73.9	Rising	82	Peak
E Stability Class, 5 m/s	Ammonia	1,200,000 lbs	1.48	Peak	8,970	Peak
	Benzene	5,200,000 lbs	0.562	Rising	108	Peak
	Toluene	5,200,000 lbs	57.7	Rising	56	Peak
	Gasoline	5,200,000 lbs	84.3	Rising	59.9	Peak

*Peak means the concentration reached a peak during the model analysis, rising means the concentration was still increasing at conclusion of model analysis.

FSAR IMPACT:

No changes will be made to the FSAR as a result of the response to this RAI.

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