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North Anna Unit 3 Chemical Analysis Audit Report

NRC Audit Team

- John McKirgan – Lead Auditor, Containment and Ventilation Branch, Office of New Reactors
- Nan Chien - Team Member, Containment and Ventilation Branch, Office of New Reactors
- Tekia Govan – lead project manager, Division of New Reactor Projects, Office of New Reactors

1.0 SUMMARY

In the period between November 1, 2014 and February 15, 2015 the NRC staff performed an audit of the following documents which support Section 6.4 of the North Anna Unit 3 application for a combined license:

- North Anna Unit 3 chemical analysis reports, “25659-000-HOC-HXYN-00006
- North Anna Unit 3 Onsite Chemical Hazards Analysis, Rev.2”, “25659-000-HOC-HXYN-00003
- North Anna Gasoline Tank Hazards Analysis, Rev.1”, and “25659-000-HOC-HXYN-00004
- North Anna Unit 3 Offsite Chemical Hazards Analysis, Rev 1”.

The audit was performed by accessing the documents from the applicant’s electronic reading room. A site visit was not necessary.

2.0 REGULATORY BASES

- Regulatory Guide 1.78 “Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release”, Rev1
- Criterion 4, “Environmental and Dynamic Effects Design Bases,” of Appendix A, 10 CFR Part 50
- Criterion 19, “Control Room,” of Appendix A, 10 CFR Part 50

3.0 OBSERVATIONS AND RESULTS

The Computer Code ALOHA was used by the applicant to analyze the potential chemical hazards to North Anna Unit 3. In order to compare the results the staff tabulated some selected results of ALOHA runs by the applicant and the staff Table 1 below.

Table 1 - North Anna Unit 3 Chemical Analysis

Chemicals	Nearest Distance to CR Intake	IDLH	MCR Concentration (Applicant)	MCR Concentration (Staff)	Notes
Liquid Hydrogen[(a)]	1004 ft	71,400 ppm[(a)]	12,700 ppm	Appendix A	

Nitrogen [(o)]	806 ft	714,000 ppm[(a)]	36,000 ppm	Appendix B	
Oxygen	1009 ft	235,000 ppm[(b)]	35,700 ppm	Appendix C	
Gasoline	1078 ft	750 ppm	167 ppm	Appendix D	
Ammonium Hydroxide (30%)	1228 ft	300 ppm	33.6 ppm	Appendix E	open country
Ammonium Hydroxide (30%)	1228 ft	300 ppm	14.9 ppm	Appendix F	urban or forest
Carbon Dioxide	1146 ft	40,000 ppm	7090 ppm	Appendix G	
NOVEC 1230	2180 ft	150 ppm (TWA[(c)])	17.5 ppm[(d)]	Appendix H	no IDLH defined

Foot Notes:

(a) Asphyxiating limit
(b) oxygen-enriched limit
(c) TWA is defined as a threshold limit value 8-hour time weighted average whereby an employee's exposure to a substance shall not exceed the 8-hour TWA given for that substance in any 8-hour work shift of a 40-hour work week (29 CRF 1919.1000 2006).
(d) Calculated by the staff.

By studying the analysis results performed by both the Applicant and the Staff, the findings are:

- In the chemical spill case for on-site liquid hydrogen (horizontal transportation tanker), the staff's calculation results match the applicant's calculation results.

- In the chemical spill case for on-site liquid nitrogen, the staff's calculation results match the applicant's calculation results.

- In the chemical spill case for on-site liquid oxygen, the staff's calculation results show that the control room maximum concentration is 71,300 ppm. The applicant's calculation results show that the control room maximum concentration is 35,700 ppm. Since both concentrations are way below the oxygen-enriched limit, 235,000 ppm, the staff concludes that the chemical spill case for liquid oxygen does not constitute a threat to control room operators.

- In the chemical spill case for off-site liquid gasoline (truck leaking at the actual rout), n-Heptane was selected by the applicant as surrogate because gasoline is not an available chemical in ALOHA. The IDLH of n-Heptane, 750 ppm, was used by the

applicant as the IDLH for gasoline calculations. The staff's calculation results match the applicant's calculation results.

- In the chemical spill case for off-site ammonia hydroxide (30%), the staff's calculation results show that the control room maximum concentration is 33.6 ppm (open country), or 4.49 ppm (urban or forest). The applicant's calculation results show that the control room maximum concentration is 33.6 ppm (open country), 14.9 ppm (urban or forest). The staff concludes that the chemical spill case for ammonia hydroxide does not constitute a threat to control room operators even there are some discrepancies between these calculations.

- In the chemical spill case for off-site liquid carbon dioxide, the staff's calculation results show that the control room maximum concentration is 7090 ppm (open country). The applicant's calculation results show that the control room maximum concentration is 7090 ppm (urban or forest). The staff concludes that the chemical spill case for carbon dioxide does not constitute a threat to control room operators even there are some discrepancies between these calculations.

- In the chemical spill case for off-site NOVEC 1230, the staff's calculation results match the applicant's calculation results. The staff's calculation results show that the control room maximum concentration is 17.5 ppm. The applicant's calculation results show that the distance to TWA is 1065 ft that is shorter than the distance to Unit 3 Control Room. Therefore the applicant did not calculate the control room concentration.

4.0 CONCLUTIONS

The Applicant's latest calculations and the Staff's calculations are generally quite consistent. In all cases, the applicant's estimates are well below limits (at least an order of magnitude).

APPENDIX A – Liquid Hydrogen

SITE DATA:
Location: NORTH ANNA, VIRGINIA
Building Air Exchanges Per Hour: 0.49 (user specified)
Time: June 21, 2008 0500 hours EDT (user specified)

CHEMICAL DATA:
Chemical Name: LIQUID HYDROGEN - NORTH ANNA
Molecular Weight: 2.02 g/mol
IDLH: 71400 ppm
Ambient Boiling Point: -423.0° F
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 1 meters/second from w at 10 meters
Ground Roughness: urban or forest Cloud Cover: 0 tenths
Air Temperature: 71.5° F Stability Class: F
No Inversion Height Relative Humidity: 63%

SOURCE STRENGTH:
Leak from hole in horizontal cylindrical tank
Flammable chemical escaping from tank (not burning)
Tank Diameter: 9 feet Tank Length: 27.3 feet
Tank Volume: 13000 gallons
Tank contains liquid Internal Temperature: -423° F
Chemical Mass in Tank: 8,321 pounds Tank is 100% full
Circular Opening Diameter: 6.8 inches
Opening is 0 feet from tank bottom
Release Duration: 10 minutes
Max Average Sustained Release Rate: 1,020 pounds/min
(averaged over a minute or more)
Total Amount Released: 8,320 pounds
Note: The chemical escaped as a mixture of gas and aerosol (two phase flow).

THREAT ZONE:
Model Run: Heavy Gas
Red : 438 yards --- (71400 ppm = IDLH)

THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 1004 feet Off Centerline: 0 feet
Max Concentration:
Outdoor: 148,000 ppm
Indoor: 12,700 ppm

APPENDIX B – Liquid Nitrogen

SITE DATA:
Location: NORTH ANNA, VIRGINIA
Building Air Exchanges Per Hour: 0.49 (user specified)
Time: June 21, 2008 0500 hours EDT (user specified)

CHEMICAL DATA:
Chemical Name: LIQUID NITROGEN Molecular Weight: 28.00 g/mol
AEGL-1 (60 min): 71400 ppm AEGL-2 (60 min): N/A AEGL-3 (60 min): N/A
IDLH: 71400 ppm
Ambient Boiling Point: -320.3° F
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 1 meters/second from w at 10 meters
Ground Roughness: urban or forest Cloud Cover: 0 tenths
Air Temperature: 71.5° F Stability Class: F
No Inversion Height Relative Humidity: 63%

SOURCE STRENGTH:
Direct Source: 16830.5 pounds/min Source Height: 0
Release Duration: 10 minutes
Release Rate: 16,800 pounds/min
Total Amount Released: 168,305 pounds
Note: This chemical may flash boil and/or result in two phase flow.
Use both dispersion modules to investigate its potential behavior.

THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 806 feet Off Centerline: 0 feet
Max Concentration:
Outdoor: 468,000 ppm
Indoor: 36,000 ppm

APPENDIX C - Oxygen

SITE DATA:
Location: NORTH ANNA, VIRGINIA
Building Air Exchanges Per Hour: 0.49 (user specified)
Time: June 21, 2008 0500 hours EDT (user specified)

CHEMICAL DATA:
Chemical Name: OXYGEN Molecular Weight: 16.00 g/mol
IDLH: 235000 ppm
Ambient Boiling Point: -297.5° F
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%
Note: Not enough chemical data to use Heavy Gas option

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 1 meters/second from w at 10 meters
Ground Roughness: open country Cloud Cover: 0 tenths
Air Temperature: 71.5° F Stability Class: F
No Inversion Height Relative Humidity: 63%

SOURCE STRENGTH:
Direct Source: 8559.1 pounds/min Source Height: 0
Release Duration: 10 minutes
Release Rate: 8,560 pounds/min
Total Amount Released: 85,591 pounds
Note: This chemical may flash boil and/or result in two phase flow.

THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 1009 feet Off Centerline: 0 feet
Max Concentration:
Outdoor: 927,000 ppm
Indoor: 71,300 ppm

APPENDIX D – Gasoline

SITE DATA:
Location: NORTH ANNA, VIRGINIA
Building Air Exchanges Per Hour: 0.49 (user specified)
Time: June 21, 2008 0500 hours EDT (user specified)

CHEMICAL DATA:
Chemical Name: N-HEPTANE Molecular Weight: 100.20 g/mol
PAC-1: 440 ppm PAC-2: 440 ppm PAC-3: 5000 ppm
IDLH: 750 ppm LEL: 10500 ppm UEL: 67000 ppm
Ambient Boiling Point: 208.4° F
Vapor Pressure at Ambient Temperature: 0.051 atm
Ambient Saturation Concentration: 51,869 ppm or 5.19%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 2 meters/second from n at 10 meters
Ground Roughness: open country Cloud Cover: 0 tenths
Air Temperature: 71.5° F Stability Class: F
No Inversion Height Relative Humidity: 63%

SOURCE STRENGTH:
Evaporating Puddle (Note: chemical is flammable)
Puddle Area: 3218 square meters Puddle Volume: 8500 gallons
Ground Type: Default soil Ground Temperature: 71.5° F
Initial Puddle Temperature: Air temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 253 pounds/min
(averaged over a minute or more)
Total Amount Released: 14,113 pounds

THREAT ZONE:
Model Run: Heavy Gas
Red : 93 yards --- (5000 ppm = PAC-3)
Orange: 384 yards --- (440 ppm = PAC-2)
Yellow: 384 yards --- (440 ppm = PAC-1)

THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 1078 feet Off Centerline: 0 feet
Max Concentration:
Outdoor: 496 ppm
Indoor: 167 ppm

APPENDIX E – Ammonia Hydroxide (30%) (open country)

SITE DATA:
Location: NORTH ANNA, VIRGINIA
Building Air Exchanges Per Hour: 0.49 (user specified)
Time: June 21, 2008 0500 hours EDT (user specified)

CHEMICAL DATA:
Chemical Name: AQUEOUS AMMONIA
Solution Strength: 30% (by weight)
Ambient Boiling Point: 77.8° F
Partial Pressure at Ambient Temperature: 0.84 atm
Ambient Saturation Concentration: 847,734 ppm or 84.8%
Hazardous Component: AMMONIA Molecular Weight: 17.03 g/mol
AEGL-1 (60 min): 30 ppm AEGL-2 (60 min): 160 ppm AEGL-3 (60 min): 1100 ppm
IDLH: 300 ppm LEL: 150000 ppm UEL: 280000 ppm

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 1 meters/second from w at 10 meters
Ground Roughness: open country Cloud Cover: 0 tenths
Air Temperature: 71.5° F Stability Class: F
No Inversion Height Relative Humidity: 63%

SOURCE STRENGTH:
Evaporating Puddle (Note: chemical is flammable)
Puddle Area: 20.82 square meters Puddle Volume: 55 gallons
Ground Type: Default soil Ground Temperature: 71.5° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 7.74 pounds/min
(averaged over a minute or more)
Total Amount Hazardous Component Released: 84.3 pounds

THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 1228 feet Off Centerline: 0 feet
Max Concentration:
Outdoor: 276 ppm
Indoor: 33.6 ppm

APPENDIX F – Ammonia hydroxide (30%) (urban or forest)

SITE DATA:
Location: NORTH ANNA, VIRGINIA
Building Air Exchanges Per Hour: 0.49 (user specified)
Time: June 21, 2008 0500 hours EDT (user specified)

CHEMICAL DATA:
Chemical Name: AQUEOUS AMMONIA
Solution Strength: 30% (by weight)
Ambient Boiling Point: 77.8° F
Partial Pressure at Ambient Temperature: 0.84 atm
Ambient Saturation Concentration: 847,734 ppm or 84.8%
Hazardous Component: AMMONIA Molecular Weight: 17.03 g/mol
AEGL-1 (60 min): 30 ppm AEGL-2 (60 min): 160 ppm AEGL-3 (60 min): 1100 ppm
IDLH: 300 ppm LEL: 150000 ppm UEL: 280000 ppm

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 3 meters/second from w at 10 meters
Ground Roughness: urban or forest Cloud Cover: 0 tenths
Air Temperature: 71.5° F Stability Class: F
No Inversion Height Relative Humidity: 63%

SOURCE STRENGTH:
Evaporating Puddle (Note: chemical is flammable)
Puddle Area: 20.82 square meters Puddle Volume: 55 gallons
Ground Type: Default soil Ground Temperature: 71.5° F
Initial Puddle Temperature: Ground temperature
Release Duration: ALOHA limited the duration to 1 hour
Max Average Sustained Release Rate: 16.4 pounds/min
(averaged over a minute or more)
Total Amount Hazardous Component Released: 112 pounds

THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 1228 feet Off Centerline: 0 feet
Max Concentration:
Outdoor: 72.8 ppm
Indoor: 4.49 ppm

APPENDIX G – Carbon Dioxide

SITE DATA:
Location: NORTH ANNA, VIRGINIA
Building Air Exchanges Per Hour: 0.49 (user specified)
Time: June 21, 2008 0500 hours EDT (user specified)

CHEMICAL DATA:
Chemical Name: CARBON DIOXIDE Molecular Weight: 44.01 g/mol
PAC-1: 30000 ppm PAC-2: 30000 ppm PAC-3: 50000 ppm
IDLH: 40000 ppm
Ambient Boiling Point: -109.5° F
Vapor Pressure at Ambient Temperature: greater than 1 atm
Ambient Saturation Concentration: 1,000,000 ppm or 100.0%

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 1 meters/second from w at 10 meters
Ground Roughness: open country Cloud Cover: 0 tenths
Air Temperature: 71.5° F Stability Class: F
No Inversion Height Relative Humidity: 63%

SOURCE STRENGTH:
Direct Source: 3400 pounds/min Source Height: 0
Release Duration: 10 minutes
Release Rate: 3,400 pounds/min
Total Amount Released: 34,000 pounds
Note: This chemical may flash boil and/or result in two phase flow.

THREAT ZONE:
Model Run: Heavy Gas
Red : 482 yards --- (40000 ppm = IDLH)

THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 1146 feet Off Centerline: 0 feet
Max Concentration:
Outdoor: 85,000 ppm
Indoor: 7,090 ppm

APPENDIX H – NOVEC 1230

SITE DATA:
Location: NORTH ANNA, VIRGINIA
Building Air Exchanges Per Hour: 0.49 (user specified)
Time: June 21, 2008 0500 hours EDT (user specified)

CHEMICAL DATA:
Chemical Name: NOVEC 1230 Molecular Weight: 316.04 g/mol
AEGL-1 (60 min): 150 ppm AEGL-2 (60 min): N/A AEGL-3 (60 min): N/A
Normal Boiling Point: -unavail-
Note: Not enough chemical data to use Heavy Gas option

ATMOSPHERIC DATA: (MANUAL INPUT OF DATA)
Wind: 1 meters/second from w at 10 meters
Ground Roughness: open country Cloud Cover: 0 tenths
Air Temperature: 71.5° F Stability Class: F
No Inversion Height Relative Humidity: 63%

SOURCE STRENGTH:
Direct Source: 30.4 pounds/min Source Height: 0
Release Duration: 10 minutes
Release Rate: 30.4 pounds/min
Total Amount Released: 304 pounds

THREAT ZONE:
Model Run: Gaussian
Red : 355 yards --- (150 ppm)
Yellow: 356 yards --- (150 ppm = AEGL-1 (60 min))

THREAT AT POINT:
Concentration Estimates at the point:
Downwind: 858 feet Off Centerline: 0 feet
Max Concentration:
Outdoor: 227 ppm
Indoor: 17.5 ppm