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SURRY OFFSITE TOXIC CHEMICAL RELEASE ANALYSIS

Volume II

Prepared for

VIRGINIA ELECTRIC AND POWER COMPANY

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by

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1.0 INTRODUCTION AND SUMMARY

The chemicals transported and stored within 5 miles of the Surry Nuclear Power Station are shown in Figure 2-1. The chemicals classified as potentially hazardous are shown in Table 2-3, 2-4, and 2-5. An analysis of the consequences of releasing the contents of a single container of these chemicals was performed. The analysis considered the release of the chemical, its atmospheric dispersion and subsequent buildup in the control room air. The quantities, distances, and properties of each chemical considered revealed that the toxicity limit and the estimated cloud center concentration at the control room air intake of most chemicals were not cause for concern. The cloud center concentration at the control room intake, and the control room concentration for gasoline exceed the toxicity limit.

2.0 SURVEY FOR POTENTIAL HAZARDOUS MATERIALS

A survey of the Surry site was conducted to identify locations of chemical compounds transportated, stored and/or used within five miles of the plant which, if accidently released, might present a hazard to control room operators.

The focus of the survey was the determination of locations, quantities, transportation, storage, and use of the toxic chemicals listed in the Appendix of NUREG-0570. The survey was conducted out to approximately eight miles from the plant to ensure identification of potential hazards adjacent to the five mile radius of the required study area.

General characteristics and significant features of the Surry site are described in the FSAR. The James River comprises most of the study area, with marsh/swampy contributaries, farm land on the southern boundries and residential and recreation areas on the northern boundry.

As the figure 2-1 reveals, there are no major built-up areas or communities within five miles of the plant. The James River and Virginia Highway 10 are the only two transportation arteries serving the areas which pass within five miles of the plant.

The survey began by initial telephone contacts with local business, industry, transportation, and governmental representatives to identify potential chemical hazards by use, storage, and/or transportation thereof.

The U.S. Coast Guard and the Commonwealth of Virginia, State Office of Emergency and Energy Services were the initial contacts which provided substantial information regarding the identification of tug-boat/barge operators and trucking companies. Table 2-1 provides a list of Federal, State, and local governmental agencies contacted during the course of this study. Table 2-2 contains a list of companies/businesses which were contacted and provided inputs for this study.

Information concerning the number of moves and types of materials shipped on the James River, provided by the various businesses and operators, was corroborated by statistical information provided by the Virginia Port Authority, the U.S. Coast Guard logs of hazardous material shipped, and the U.S. Army Core of Engineers Part I Water Ways and Harbors, Waterborne Commerce of the U.S.

Tables 2-3, 2-4 and 2-5 summarizes the key sources of information on hazardous chemicals identified in this study. Figure 2-1 presents the information graphically.

- The greatest number of chemical compounds transported within five miles of the plant is on the James River, Table 2-3. This list was compiled from information provided by tug boat/barge operators, some of whom refused to identify specific chemicals and/or their destination, and information provided by the manufacturers located in Hopewell and Richmond Virginia who did reveal what chemicals they were using and producing and how they were received and shipped. The list includes only the largest shipment of the indicated chemical compounds.

- The ocean vessels originating from and destined for foreign ports do also report to the U.S. Coast Guard any hazardous compounds transported on U.S. waterways. Comparisons of the U.S. Coast Guard lists with those of the Richmond Deepwater Terminal operators provided the data shown and revealed no unusually dangerous chemical compounds.

- It should be noted that U.S. and International Maritime Laws are very stringent concerning the packaging, handling, and transportation of hazardous compounds. Compliance with these Maritime laws is indicated by U.S. Coast Guard statistics which revealed that between 1970 and 1979, of the 68 casualties (accidents) reported in the James River area, only 24 involved vessel or property damage. Further, that for the period 1978 and 1979, there were no chemical spills reported in the James River area.

- Table 2-4 provides the list of chemical compounds transported by truck on Virginia Highway 10. This list does not include shipments of small amounts of chemical compounds shipped to and used by the local farmers and merchants in the Surry and Isle of Wight counties. There are many shipments of 4 to 6-55 gallon barrels of isecticides, pesticides, caustic cleaning supplies, and/or up to 5 tons of commercial fertilizers.

- Interviews with local officials, Fire Marshall's, Sheriff's, County Emergency Services, and Social Services personnel, revealed no incidents involving toxic or hazardous chemicals. Additionally, the Commonwealth of Virginia, Traffic and Safety Division statistical data did not reveal any unusual highway accident information.

- Table 2-5 lists the chemicals stored and used at the only major industry located within five miles of the Plant.

- The Badische Corporation employs approximately 500 people, produces acrylic fibers and yarn and, because of the process, operates continually. The plant is located across the James River to the east-northeast of Surry and lies just inside the five mile arc as shown in figure 2-1. In the five to eight mile area there are other manufacturing/processing industries such as Busch, a Pepsicola bottling plant, and others, but none utilize or manufacture hazardous chemicals in large enough amounts to the extent that would cause concern for the Surry Plant.

TABLE 2-1

LIST OF FEDERAL, STATE, LOCAL GOVERNMENTAL AGENCIES CONTACTED

CONTACT	LOCATION	INFORMATION
National Highway Traffic Safety Administration	Washington, D.C.	Hazardous Shipments Highways
U. S. Coast Guard, Commanding Officer Port Safety Branch	Norfolk, VA	Hazardous Shipments James River
Commandant G-MA-16, Marine Safety Information and Analysis Staff	Washington, D.C.	Casualty (accident) Statistics
Commonwealth of Virginia State Department of Transportation Safety	Culpepper, VA	Highway Statistics
State Office of Emergency and Energy Services, Hazardous Materials	Richmond, VA	Hazardous Materials Shipped in State
State Office of Enviornmental Affairs	Richmond, VA	Hazardous Materials Monitoring
State Department of Highways and Transportation, Traffic Safety Division	Richmond, VA	Highway Accident Statistics
State Health Department	Richmond, VA	Toxicological Incident Reports
State Department of Agriculture	Richmond, VA	Product and Industry Regulation
State Department of Transportation and Safety - Port Authority Research Department	Norfolk, VA	Hazardous Materials Shipped on James River

TABLE 2-1 (Continued)

CONTACT	LOCATION	INFORMATION
Portsmouth Marine Terminal	Norfolk, VA	Hazardous Materials Shipped on James River
Surry County Director of Emergency Services Director of Social Services Sheriff County Fire Marshall	Surry, VA	Knowledge of Hazardous Materials used/stored or transported in county and/or problems encountered with such materials.
Isle of Wight County Director of Emergency Services Director of Social Services Sheriff County Fire Marshall	Lawson, VA	SAME AS ABOVE
James City County Director of Emergency Services Director of Social Services Sheriff County Fire Marshall	Williamsburg, VA	SAME AS ABOVE

TABLE 2-2

LIST OF COMPANIES AND BUSINESSES CONTACTED

CONTACT	LOCATION	INFORMATION
Contract Marine Carriers	Charleston, S.C.	Chemicals Shipped
Allied Towing Corporation	Norfold, VA	Chemicals Shipped
Texasgulf Chemical Company	Raleigh, N.C.	Chemicals Shipped
Exxon Company, USA	Richmond, VA	Chemicals/Petroleum Shipped
Allied Chemical, Fibers Division	Hopewell, VA	Chemicals Received and Shipped
Wilson Trucking Corporation	Fishersville, VA	Chemicals Shipped
E. I. duPont deNemours & Company	Richmond, VA	Chemicals Received and Shipped
Bralley-Willett (Trucking)	Richmond, VA	Chemicals Shipped
Thurston Motor Lines	Richmond, VA	Chemicals Shipped
Timlaph	Richmond, VA	Chemicals Shipped
Pilot Freight Carriers	Winston Salem, N.C.	Chemicals Shipped
Lonestar Industries (Barge)	Richmond, VA	Chemicals Shipped
Wallace Edwards & Sons (Meat Packer)	Surry, VA	Chemicals Used
Interstate and Ocean Transport	Philadelphia, PA	Chemicals Shipped

TABLE 2-2 (Continued)

CONTACT	LOCATION	INFORMATION
Harbor Towing	Baltimore, MD	Chemicals Shipped
Steuart Transportation Co.	Piney Point, MD	Chemicals Shipped
Portsmouth Marine Terminal	Norfolk, VA	Chemicals Shipped
Badische Corporation	Williamsburg, VA	Chemicals Used

TABLE 2-2 (Continued)

CONTACT	LOCATION	INFORMATION
Harbor Towing	Baltimore, MD	Chemicals Shipped
Steuart Transportation Co.	Piney Point, MD	Chemicals Shipped
Portsmouth Marine Terminal	Norfolk, VA	Chemicals Shipped
Badische Corporation	Williamsburg, VA	Chemicals Used

TABLE 2-3

CHEMICAL COMPOUNDS SHIPPED ON THE JAMES RIVER

CHEMICAL	SIZE CONTAINER	QUANTITY PER UNIT	TYPE CONTAINER	DISTANCE MILES
Diaminocyclo Hexane Corrosive Liquid	55 gal/barrels 80 to 140	4,400 to 7,700 gals.	Closed Van Ocean Vessel	1½
Ethanol/Inflammable Liquid	55 gal/barrels 80 to 140	4,400 to 7,700 gals.	Closed Van Ocean Vessel	1½
Tiazinetrione Dry Oxidizer	50 lb. bags Palletized	40,000 to 60,000 lbs.	Closed Van Ocean Vessel	1½
Napthyl Methyl Carbonate - Poison	50 lb. bags Palletized	40,000 to 60,000 lbs.	Closed Van Ocean Vessel	1½
Ethyl Alcohol Flammable Liquid	55 gal/barrels 80 to 140	4,400 to 7,700 gals.	Closed Van Ocean Vessel	1½
Sodium Meta Periodate - Oxidizer	50 lb. bags Palletized	40,000 to 60,000 lbs.	Closed Van Ocean Vessel	1½
Nitro Imidayol Poison - Solid	50 lb. bags Palletized	40,000 to 60,000 lbs.	Closed Van Ocean Vessel	1½
Ethyacloxysilane Corrosive Liquid	55 gal/barrels 80 to 140	4,400 to 7,700 gals.	Closed Van Ocean Vessel	1½
Dinitrochloro Benzene - Poison	50 lb. bags Palletized	40,000 to 60,000 lbs.	Closed Van Ocean Vessel	1½
Monochloracetic Acid Corrosive	50 lb. bags Palletized	40,000 to 60,000 lbs.	Closed Van Ocean Vessel	1½
2-Methox 4-2-3 Dyhydro 4-H Inflammable Liquid	55 gal/barrels 80 to 140	4,400 to 7,700 gals.	Closed Van Ocean Vessel	1½

TABLE 2-3 (Continued)

CHEMICAL	SIZE CONTAINER	PER UNIT	TYPE CONTAINER	DISTANCE MILES
Ortho-Phenylenediamine Poison	50 lb. bags Palletized	40,000 to 60,000 lbs.	Closed Van Ocean Vessel	1½
Chloro Benzo Tri Floride Inflammable Liquid	55 gal/barrels 80 to 140	4,400 to 7,700 gals.	Closed Van Ocean Vessel	1½
Caustic Alkali Liquid Corrosive	55 gal/barrels 80 to 140	4,400 to 7,700 gals.	Closed Van Ocean Vessel	1½
Thionyl Chloride Corrosive	55 gal/barrels 80 to 140	4,400 to 7,700 gals.	Closed Van Ocean Vessel	1½
Gasoline, #6 oil, diesel oil, #2 oil	Steel tanks 8 compartments	168,000 gal. ea. 1,300,000 total	Barge	1½
Phenol	Steel tanks 2 compartments	1,325 tons ea. 2,650 total	Barge	1½
Oleum	Steel tanks 2 compartments	1,500 tons ea. 3,000 total	Barge	1½
Sulfur (Liquid @ 260°F to 275°F)	Steel tanks 2 compartments	10,000 tons ea. 20,000 total	Barge	1½
Liquid Fertilizer (Uran)	Steel tanks 2 compartments	5,000 tons ea. 10,000 total	Barge	1½
Ammonium Sulfate	50 lb. bags Palletized	1,500 to 12,000 tons	Barge	1½
Ammonium Sulfate	50 lb. bags Palletized	8,000 to 25,000 tons	Closed Van Ocean Vessel	1½

TABLE 2-4

CHEMICAL COMPOUNDS TRANSPORTED BY TRUCK ON VIRGINIA HIGHWAY 10

CHEMICAL	SIZE CONTAINER	QUANTITY PER UNIT	TYPE CONTAINER	DISTANCE MILES
Sulfuric Acid	25 Ton Truck Tank	3,300 gals.	Metal Tank	4½
Nitric Acid	25 Ton Truck Tank	4,000 gals.	Metal Tank	4½
Muratic Acid	25 Ton Truck Tank	5,000 gals.	Metal Tank	4½
Petroleums Gasoline, Oil	25 Ton Truck Tank	8,500 gals.	Metal Tank	4½

TABLE 2-5

CHEMICAL COMPOUNDS USED AND/OR STORED NEAR SURRY

CHEMICAL	SIZE CONTAINER	QUANTITY PER UNIT	TYPE CONTAINER	DISTANCE MILES	BERM
Acrylonitrile	50,000 gal. (5,000 gal.)	1 4 ea.	Metal Tank	4.9	50'x30'x4.5' (30'x15'x4.5')
Methyl Acrylate	25,000 gal. (5,000 gal.)	1 1	Metal Tank	4.9	30'x20'x5.5' (30'x15'x4.5')
Sulfuric Acid	5,000 gal.	3 ea.	Metal Tank	4.9	40'x20'x2'
Hydrochloric Acid	5,000 gal.	3 ea.	Metal Tank	4.9	40'x20'x2'

3.0 METHOD OF ANALYSIS

The release and subsequent atmospheric dispersion of all liquid chemicals were calculated using an evaporation model, since their boiling points are well above ambient temperatures, and they have moderate vapor pressures at ambient conditions.

3.1 Release to Atmosphere

The rate at which material is released to the atmosphere is dependent on the size of the pool of liquid formed, the physical characteristics of the material, and the meteorological conditions at the time of the spill. The release of materials which have a boiling point greater than the ambient temperature is limited by mass transfer considerations. A brief description of the models used is given below. These models are based on the concepts presented by Bird, Stewart and Lightfoot[3].

The size of pool of liquid formed by the spill is estimated by assuming a square shaped pool with a minimum depth of one centimeter. The lateral extent of the pool is limited by the topography when berms or other size restrictions exist.

The evaporation rates were calculated as:

$$W_a = 3.471 \times 10^{-2} M_a A D_{ab}^{2/3} \sqrt{\frac{u}{L}} \ln\left(\frac{P_a}{P-P_a} + 1\right) \qquad (3\text{-}1)$$

or (3-2)

$$W_a = 1.397 \times 10^{-3} M_a A D_{ab}^{2/3} (2.305\, u^{0.8} L^{-0.2} - 12800/L) \ln\left(\frac{P_a}{P-P_a} + 1\right)$$

Equation 3-1 is applicable to laminar flow regimes (Re 5×10^5) while equation 3-2 is applicable to turbulent flow regimes. The symbols used in these equations are defined in Table 3-1 (Nomenclature).

3.2 Atmospheric Dispersion

An atmospheric dispersion analysis using standard Gaussian Plume Model[4] was performed for offsite continuous releases of toxic chemicals near the Surry Nuclear Power Plant. Onsite Surry meteorological data for the period 3/3/74 -3/2/75 was evaluated to determine a representatively conservative meteorological condition (approximately worst 5% conditions) in order to provide the wind speed, σ_y and σ_z values needed. For releases on the James River a meteorological condition of Pasquil Class F and 1.0 m/s (2.2 mph) was selected for use in this analysis. The parameters used in the analysis are listed in Table 3-2.

3.3 Concentration Buildup in Control Room

The differential equation governing the concentration in the control room is:

$$V_R \dot{C}_R = q\chi - qC_R \qquad (3\text{-}3)$$

after rearranging terms:

$$\dot{C}_R = \frac{q}{V_R}\chi - \frac{q}{V_R}C_R \qquad (3\text{-}4)$$

(see Table 3-1 for description of terms).

This equation is solved numerically using a Runge-Kutta procedure derived by Gill [5].

TABLE 3-1

NOMENCLATURE

A	=	Area of spill (cm^2 or ft^2)
D_{ab}	=	Binary diffusivity of species a into species b (cm^2/s)
L	=	Characteristic length of spill (cm)
M_a	=	Molecular Weight of Material spilled (g/g-mole)
P	=	Atmospheric pressure (torr)
P_a	=	Vapor Pressure of material spilled (torr)
Re	=	Reynolds number = $u\ L/\nu$
u	=	Wind speed (cm/s)
W_a	=	Evaporation rate or boiling rate (mg/s)
χ	=	Concentration of chemical in air (mg/m^3)
q	=	Control room air intake rate (cfm)
V_R	=	Control room volume (cu ft)
C_R	=	Concentration of chemical in control room air (mg/m^3)
$\dot{C}_R$	=	Time rate of change of C_R

TABLE 3-2

PARAMETERS FOR ATMOSPHERIC DISPERSIONS

RELEASE LOCATION	DISTANCE FROM CONTROL ROOM (Mi)	σ_y (m)	σ_z (m)	χ/Q* (sec/m^3)
James River (Gasoline)	1.5	82.5	23.6	1.6×10^{-4}

* $\frac{\chi}{Q} = \frac{1}{\pi \sigma_y \sigma_z u}$ with u = wind speed (1.0 m/sec).

4.0 RESULTS

The rate of evaporation of gasoline is evaluated based on the model described in Section 3.1. The resultant evaporation rate at a wind speed of 1.0 m/sec is listed in Table 4-1 along with the parameters used in their determination.

The resulting peak concentration in the control room is 44,000 mg/cu-m which exceeds the toxicity limit of 1500 mg/cu-m. Our analysis of the time required to reach the toxicity limit in the control room shows that Control room personnel would have 2390 seconds of warning if notified immediately of the accident. This time includes the time required for the vapor cloud to drift to the air intake and then to build up to the toxicity limit in the control room. The amount of warning available if detectors which can sense gasoline at its toxicity limit are placed at the air intake is 192 seconds. Furthermore, 157 seconds warning is provided by detection of gasoline at its odor threshold (approximately 60 mg/cu-m) in the control room air. All of these times provide ample opportunity for the control room personnel to don protective breathing appartus. (Regulatory Guide 1.78 specfies a minimum requirement of two minutes.)

TABLE 4-1

EVAPORATION RATE

Chemical	Q	D_{ab}	M_a	P_a	A	W_a
Gasoline	1.68×10^5	0.1	114.2	517	6.8×10^5	2.7×10^8

NOTES:

Q = quantity of chemical spilled (gallons)

D_{ab} = diffusivity of chemical in air (cm 2/sec)

M_a = molecular weight of chemical (grams/gram-mole)

P_a = vapor pressure of chemical (torr) at 100°f

A = spill area (ft^2)

W_a = evaporation rate (mg/sec)

5.0 REFERENCES

1. "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment," American Conference of Governmental Industrial Hygienists, Cincinatti, Ohio (1979).

2. "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release," Regulatory Guide 1.78 (June 1974).

3. Bird, R. B., Stewart, W. E., and Lightfoot, E. N., Transport Phenomena, John Wiley and Sons, New York (1942).

4. Slade, D. H., "Meteorology and Atomic Energy," TID-24190 (1968).

5. Romanelli, M. J., "Runge-Kutta Methods for the Solution of Ordinary Differential Equations," pgs. 110-120 in Numerical Methods for Digital Computers, Vol. 1, Ralston, A. and Wilf, H. S., eds, Wiley (New York) 1967.